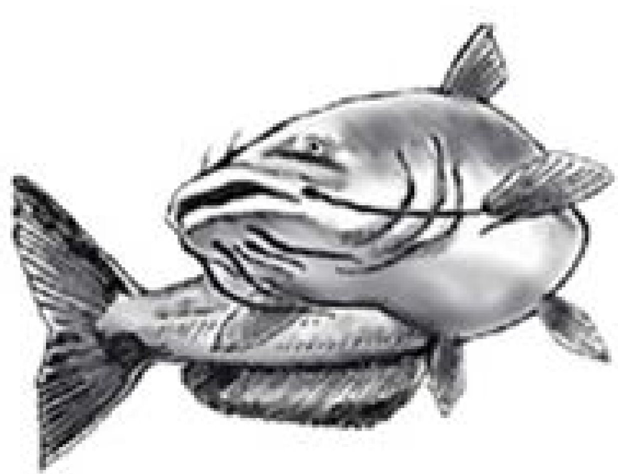
Distribution, Biology, and Management of Wisconsin's Ictalurids

Statewide catfish management plan



April 2016

INTRODUCTION

Wisconsin's Ictalurids can be classed into three broad groups. The bullheads – yellow, brown and black – are closely related members of the genus Ameiurus. The madtoms – slender, tadpole and stonecat – all belong to the genus Noturus. The two large catfish – the channel catfish and flathead catfish – are not closely related, but are linked by their importance as recreational and commercial species. Ictalurids are found in all three of Wisconsin's major drainages – the Mississippi River, Lake Michigan, and Lake Superior. Wisconsin has over 3,000 river miles of catfish water, along with several lakes and reservoirs that also support populations. They are most common in the Mississippi River and in the southern parts of the state.

Although Wisconsin's Ictalurids, such as channel catfish, do not enjoy the widespread glamour and status that they do in the southern United States, they are becoming more popular with Wisconsin's anglers. A 2006-2007 mail survey revealed nearly 800,000 channel catfish were caught, while the harvest rate was nearly 70%. This harvest rate was highest among fish species targeted by Wisconsin anglers. Channel catfish are also an important commercial fishery on the Mississippi River, while setline anglers are active in many rivers of the state. As for flathead catfish, anecdotal evidence suggests that Wisconsin's largest predatory fish is becoming a highly sought after trophy specimen. Given anglers' increased propensity to fish for a food source as well as to fish for trophies, channel catfish and flathead catfish do not appear to have peaked in popularity. In addition, there will likely be more waters conducive to having fishable channel catfish populations; climate change predictor models indicate a 17% to 33% increase in the number of miles of water with a majority of the increase in northern Wisconsin (John Lyons, WI DNR, personal communication). This increasing channel catfish range and their associated populations will likely increase the number of anglers that pursue them.

Catfish management in Wisconsin has a long history of no formal organization or communication. Knowledge gained in one part of the state often did not transfer to other areas. Management and research projects have often been completed independent of one another. Even within management, standards in areas such as sampling and ageing have not been incorporated. To provide solutions to some of these issues, a statewide Catfish Species Team was formed and tasked to provide direction to the management of Wisconsin's catfish. This document provides fisheries management and research personnel several areas of emphasis including the distribution, biology and management of each Wisconsin Ictalurid. Sampling methods are discussed, and standard protocol recommendations for sampling and ageing have been formulated for key species. Readers will also note that information gaps exist for Wisconsin's Ictalurids; basic life history parameters are often recommended for study. This document can be used as a reference guide and should be reviewed and updated as needed.

WISCONSIN'S ICTALURIDS

Species: Flathead Catfish *Pylodictis olivaris*

Identification: Flathead catfish have no scales, and their body is dorsal-ventrally flattened with a broad flat head. Their lower jaw clearly extends beyond their upper jaw. Their color can be brown, dark yellow or dark olive and mottled with irregular brown or black blotches (mottling may be faint in turbid water). Their belly is cream or tan. Juveniles are similar in appearance to adults, but often exhibit a light patch on the upper lobe of their caudal fin that disappears with age (http://www.wiscfish.org/fishid; Becker 1983). Male and female flathead catfish may be identified by the number of urogenital openings behind the anus; males have one opening, while females have two (Moen 1959; Norton et al. 1976).

Size range and age: Flathead catfish are the largest member of the catfish family in Wisconsin (Photo 1). The current Wisconsin hook and line record is 74 lbs. 5 oz. (Mississippi River, Vernon County). Flathead catfish are long-lived; Paruch (1979) aged flatheads to 24 years in Wisconsin. More recently, flatheads were aged to 30 years on the Wolf River (Alan Niebur, WI DNR, personal communication). During the same study on the Wolf River, Niebur found flathead catfish to be near 760 mm (30 in) by age 10 and near 1016 mm (40 in) by age 20. Flathead catfish have been found to range to over 1200 mm (48 in). Surveys on the Mississippi River found most flathead catfish ranged from 330-610 mm (13-24 in) TL.


Photo 1

Age determination: Catfish age estimation has historically used thin sections of the pectoral spine (Sneed 1951; Turner 1980). The method involved clipping the pectoral spine as close to the body as possible. While ages can be determined using this method, accurate ages are affected by the basal recess portion of the pectoral spine (Jearld 1983). Even on fish as young as age-1, the basal recess can cause the reader to underestimate the age of the fish due to erosion of the lumen and difficulty in interpreting annuli at the edge (Buckmeier et al. 2002). To improve accuracy and determine the true age of catfish, two other methods have been employed. The first, thin sectioning the articulating process, is discussed within the channel catfish section of this document and can be used to age flathead catfish. However, to obtain the most precise and usually more accurate age estimations for flathead catfish, a microstructural examination of a sagittal otolith (Photo 2) is the preferred method (Nash and Irwin 1999).


Photo 2

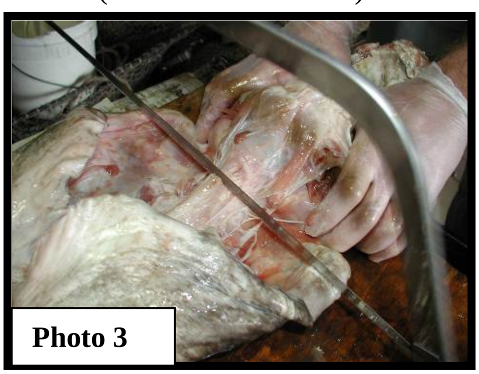


Photo 3

Sagittal otoliths are located in the bone near where the first or second pharyngeal gill arches connect to the base of the skull. To retrieve these otoliths in smaller fish, a side cutter can crack the bone and break it open. For larger flatheads, a bone saw should be used to make a shallow cut into the bone (Photo 3). Once the bone has been opened, small cavities on each side will hold a fluid filled sac containing each otolith. After removal, otoliths should be immediately cleaned, placed in a vented vial or protective container, and labeled.

Once the microstructure is dry, two methods can be used for processing: (1) grind the otolith to the nucleus and view with reflected light (Maceina 1988) or (2) thin section the otolith and view with transmitted light (Secor et al. 1992). Thin sectioning is suggested because it obtains the best possible estimate. Thin sectioning is accomplished by first embedding the whole otolith in epoxy (e.g. Buehler EpoKwick). A low speed saw (e.g. South Bay Technology or Buehler) set at 3-4 revolutions/minute is used to cut a 30-35 micron thick section. A "coarse/high" diamond blade (South Bay Technology part number DWH4121) is used and dressed frequently to obtain more polished cuts. The section is then viewed under a stereoscope (e.g. Olympus SZX7) at a 10X50 magnification with a transmitted light source. A drop of immersion oil on the structure can improve image clarity. Annuli appear as opaque concentric rings separated by clear translucent zones (Photo 4).

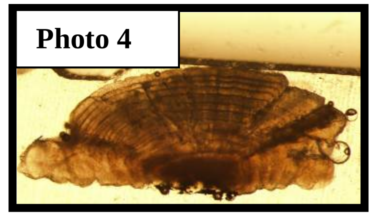


Photo 4

Status and distribution: Flathead catfish are considered secure with an uncommon to occasional abundance (Lyons et al. 2000). Historic flathead distribution was limited to the Mississippi River and large tributaries within the Mississippi River drainage system (Becker 1983). In the Mississippi River basin, flathead catfish are found in the St. Croix, Red Cedar, Chippewa, La Crosse, Black, Trempealeau, Wisconsin, Pecatonica, Sugar, Mississippi, and Rock rivers (Figure 1). Flatheads also occur in the Lake Michigan drainage system in the Fox and lower Wolf Rivers downstream to Green Bay, but are believed to be relatively recent to the drainage system; they are thought to have entered the Fox River from the Wisconsin River near Portage within the past 100 years. There have been a few recent records of flathead catfish from the Milwaukee River. It is not certain whether there is a very small population in the Milwaukee River or whether these are migrants from the Fox and lower Wolf Rivers or angler stockings. More recently flatheads have been introduced into Lac Labelle in south-eastern Wisconsin to control rough fish and panfish populations.

Habitat: Although capable of surviving in lakes and reservoirs, flathead catfish flourish in large turbid rivers with an abundance of large woody structure and complex habitats (Photos 5 and 6). Seasonal habitat preferences have been noted for flatheads. Studies have shown that adult preferred summer habitat is medium to deep runs with complex large woody structure, deep cut banks, or the upper ends of medium pools, within or adjacent to main flows (Piette and Niebur 2011). Insaurralde (1992) also found large woody structure to be important to flathead catfish in rivers. He concluded that the number of larger flathead catfish was positively related to the proportion of riparian zone in mature forest and the number of large snags located in streams. The preferred summer habitat for juvenile flatheads (age 2 and greater) is similar to adults but can also include coarse riprap. Information is sketchy with regard to young-of-year habitat preference for flathead catfish. This is due, in part, to the difficulties of sampling large turbid rivers. However, young flatheads have been reported to use rock/riffle habitat when present (Becker 1983) and have been observed using near shore rootwads adjacent to main flows (Randal Piette, WI DNR, personal observations).


Photo 5


Photo 6

Flathead catfish winter habitat preference is quite different than summer preference. During winter, flatheads may remain within the river system or move downstream to reservoirs or natural lakes. Within rivers, they have been found to use deep holes with large bottom obstructions that create current breaks (Hawkinson and Grunwald 1979; Vokoun and Rabeni 2005; Piette and Niebur 2011; Photo 7). These areas have been found to have a firm sand or fine gravel substrate and enough current to keep the substrate free of silt deposition. Observations by Wisconsin Department of Natural Resources personnel indicate flatheads are selective in their riverine overwintering sites; many potential locations did not have any flathead catfish present even though depth was adequate. Individual fish have also been found returning to the same wintering location for multiple years.


Photo 7

Spawning: Flathead catfish mature at 4-7 years of age when they reach 400-600 cm (16-24 in) TL (Munger et al. 1994). Spawning occurs during late June and early July when water temperatures approach 22-24˚ C (Becker 1983). Spawning sites tend to be cavities in the bank or sheltered areas behind large wood or other structure adjacent to main channel currents in river systems. If suitable spawning sites are limited, populations may be suppressed. The female deposits eggs in a gelatinous compact golden-yellow mass. Once laid, eggs are cared for and guarded by the male who aggressively defends the nest. Guarding and care continues until the eggs hatch in six to nine days and the yolk sac is absorbed several days later. After this time, the young disperse and are on their own. Recent findings by the WDNR suggest that flathead catfish in Wisconsin waters mature at older ages and larger sizes than in other parts of their range. Female flathead catfish over much of their range have been shown to spawn every year. However, recent observations in Wisconsin indicate females may not spawn on an annual basis.

Food habits: Young flathead catfish have been found to prey mostly upon aquatic insects and crayfish switching to fish as they mature (Minckley and Deacon 1959). This may partially explain why younger flatheads are commonly found near riprap areas during electrofishing surveys. Adult flatheads are ambush predators feeding almost exclusively on live prey with fish making up the majority of their diet. Prey selectivity appears to be random and relative to prey abundance (Pine et al. 2005). Flatheads feed most actively from May to October when water temperatures are above 10˚ C. Little or no feeding occurs from November through the winter period as flathead catfish become very lethargic when water temperatures drop below 6˚ C. During the winter months, flathead catfish enter a state of inactivity and seldom move unless disturbed; it is unlikely that any feeding occurs until water temperatures increase during spring.

Movement patterns: Flathead catfish were once considered relatively immobile, traveling only short distances (Funk 1957; Robinson 1977; Jackson 1999; Pugh and Schramm 1999). However, recent radio-telemetry studies in their northern range have found flatheads to be very mobile within river systems. They have been found to often cover long distances between over-winter locations and summer spawning and feeding grounds (Stauffer et al. 1996; Vokoun and Rabeni 2005, Piette and Niebur 2011). Flatheads have also shown strong site fidelity with individuals returning to the same summer and winter locations for consecutive years. Spring movements are generally upstream and begin when water temperatures approach 10˚ C (Piette and Niebur 2011). Movement during the spawning period may be erratic as fish search for suitable spawning locations. Fall movements are generally downstream and occur when water temperatures decrease sharply below 15˚ C. Once fish reach their wintering locales, limited movement occurs.

Ecological importance: Flathead catfish are top predators in large river systems and may play key roles in fish community structure. As a top predator, flathead catfish do not appear to be prey selective with their diet being proportional to prey availability (Pine et al. 2005; Photo 8). Flathead catfish have had negative impacts on fish communities when introduced outside their native geographic range. After an introduction to rivers in Georgia, flatheads were shown to decrease several native gamefish populations (Thomas 1995). Flathead catfish are an important host fish for glochidia of several freshwater mussel species including buckhorn *Tritogonia verrucosa*, a state threatened species, along with washboard *Megalonaias gigantea*, pimpleback *Quadrula pustulosa*, and mapleleaf *Quadrula quadrula*. Long distance dispersal of buckhorn and other mussels relies on glochidia-infested host fish.


Photo 8

Sampling methods: Developing a standardized flathead catfish sampling protocol may be challenging. Using Wisconsin's traditional sampling methods, flathead catfish have been shown to be difficult to collect. The following summarizes flathead catfish sampling methods that have had some success in Midwestern waters along with specific methods used in Wisconsin. Survey gears have been shown to be size selective and seasonal in their effectiveness. An effective sampling approach may utilize a combination of gear methods depending on data needs.

***Electrofishing*:** Standard direct current (DC), low frequency pulsed DC, and low-voltage alternating current (AC) boat electrofishing methods are commonly used to survey flathead catfish populations (Weeks and Combs 1981; Gilliland 1988; Cunningham 2004; Daugherty and Sutton 2005). Some earlier sampling methods consisted of low voltage AC telephone generators (Morris and Novak 1968). More recently, many state agencies have adopted low frequency pulsed DC as standard sampling gear for flathead catfish (Robinson 1994, Arterburn 2001).

In Wisconsin, DNR personnel rigged a pulsed DC boom shocker to sample flatheads with low frequency settings in the Wolf and Fox Rivers (Photo 9). A single anode dropper was insulated with neoprene or electrical tape so only one inch of the anode was exposed to the water (Photo 10). Control box settings consisted of a pulse rate range of 13-15 Hz and duty cycle of 12-13%. Between four hundred and five hundred volts and 1.5 – 2.0 amps were needed to collect flatheads effectively with conductivities ranging from 300-415 umhos/cm.


Photo 9

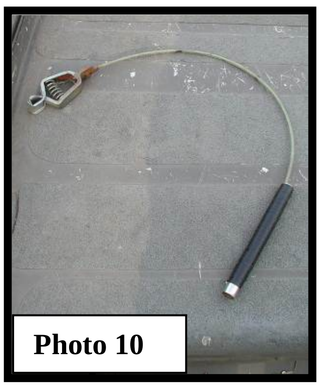


Photo 10

In general, low frequency electrofishing proceeds in a downstream direction and surveys the river's main thalweg. It is recommended that electrofishing be conducted during daylight hours and during summer months when water temperatures exceed 72˚ F (Quinn 1986, Justus 1994). For many Wisconsin waters, the appropriate water temperatures are during July and August. Water depth and flow rate usually determine electrofishing boat speed. Generally, boat speed should match or be slightly faster than the velocity of the river current (i.e. faster in shallow runs and slower in deep run/pool type habitat). In order to increase capture rates, a non-electrofishing chase boat that safely follows the electrofishing boat and captures incapacitated fish is recommended (Daugherty and Sutton 2005). All chase boat captured fish should be recorded separately so comparisons can be made to non-chase boat surveys.

Due to its ease in replication between waters, electrofishing may be the most appropriate standardized gear to assess flathead catfish relative abundance (CPE). In addition, all WDNR electrofishing boats can be quickly modified to utilize low frequency/low pulse settings. However, one limitation of using this gear is its possible size selection towards smaller flatheads (Robinson 1994). If this size selectivity leads to an inaccurate depiction of the flathead size and age structure for Wisconsin waters, other methods may need to be utilized.

***Hoop Nets*:** Hoop net effectiveness for flathead catfish has had varying degrees of success in Midwestern waters (Robinson 1994; Stauffer et al. 1996; Arterburn 2001). In Minnesota, Stauffer et al. (1996) found that hoop nets were ineffective due to strong river currents and debris rendering nets useless. In Missouri, Robinson (1994) had good success capturing channel catfish but not flatheads. During both studies, net design and deployment issues may have affected flathead catfish catch rates. On the Mississippi River, WDNR personnel have employed hoop nets and found typical river currents and debris not to be an issue (David Heath, WI DNR, personal communication).

Hoop net surveys conducted in Wisconsin on the Wolf and Upper Fox Rivers have resulted in capture rates ranging as high as 7.2 fish per net night. This hoop netting has been particularly effective at capturing large adult size fish that are not as readily sampled with electrofishing gear (Photo 11). The highest catch rates on these rivers are correlated to pre-spawn movements. Typically, these pre-spawn movements occur during late May to early July when water temperatures range from 60-70˚ F. The hoop nets consisted of seven-hoops (42 inch diameter) with a 17 inch opening and a bar mesh of 1.25-1.5

inches. It has been found that for increased effectiveness nets should be deployed within low velocity areas slightly off the main river channel thalweg. Higher catch rates have also been found when female flathead catfish have been placed in the net. This is also known as "seeding" a net and is meant to attract other adult fish. If seeding is used, seeded fish should be changed daily to minimize injuries and stress.


Photo 11

Hoop netting has been found to be highly selective for adult fish. This is likely a temporal issue, as mature adults are strongly attracted to each other during pre-spawn and spawning periods. In addition, smaller flatheads may avoid areas where larger adults are concentrated.

***Baited Lines*:** The use of baited lines to survey flathead catfish has been widely used by many state agencies (Robinson 1994; Stauffer et al. 1996). Baited line methods include trotlines, setlines and various limb line configurations.

In Wisconsin, baited limb lines with circle hooks have been used in the Fox River with good success (Dave Bartz, WI DNR, personal communication). Limb lines consisted of a single line employing a 12/0 circle hook attached terminally. A 2-4 ounce weight was attached approximately 10-12 inches above the hook. Each limb line was baited with a 7-10 inch bullhead which was hooked through the mouth. Limb lines were attached to overhanging trees or their branches. The line length was adjusted that allowed the bait to be placed 6-12 inches above the river bottom or submerged woody debris. Limb lines were checked daily with bait replaced as necessary; live bait is critical in order to target flatheads and minimize capture of channel catfish.

Limb lines tend to capture larger fish and size captured may fluctuate with bait size. However, limb line catch size structure is comparable to hoop net catch. If a large flathead catfish sample is marked after hoop netting or electrofishing, a limb line survey may provide a useful recapture sample for population estimates or insights into angler exploitation. Using limb lines to determine angler exploitation may be especially useful in areas where setlines and bank poles are legal gear.

Using limb lines to survey flathead catfish is an expensive effort. In order to capture a sufficient sample size, a large number of hooks must be deployed. In addition to the cost to maintaining the limb lines, bait cost can also be an issue. In previous years it was possible to capture bullheads fyke netting or electrofishing and use them during limb line surveys. However, VHS concerns have essentially ended this practice; bait now needs to be purchased.


Photo 12

***Hand Capture*:** Capturing flathead catfish by hand using scuba divers is an additional survey method that has proven useful (Randal Piette and Alan Niebur, WI DNR, personal communication; Photo 12). These surveys have been done at wintering sites in rivers at areas that are typically deep lateral scour pools or deeper tail-outs of a dam structure. Sampling is conducted when water temperatures drop to below 42˚ F and water clarity is suitable for safe diving. Scuba divers begin at the downstream end of the pool and work their way upstream. Divers typically work in teams of two with one diver capturing fish and the other holding a large mesh bag (Photo 13). When the dive is complete, the team brings the fish to the surface where another crew processes the fish. Because the flatheads are too lethargic to return to their habitat, a diver must return the fish back to the bottom after processing.

Photo 13

Because river conditions such as water clarity and velocity are extremely variable between seasons, hand capture is not suited for standardized sampling. However, this method could provide useful insights into size structure and winter habitat use. It has been shown that large numbers of flatheads can be captured, with an experienced dive team able to collect several dozen fish in one dive.

Other Methods**:** In the upriver lakes of the Lake Winnebago System, commercial seines that targeted carp in late fall and early winter have shown effectiveness in capturing adult flatheads (Ron Bruch, WI DNR, personal communication). Although flatheads were considered incidental catch, this gear shows promise for sampling large numbers of wintering flathead catfish in specific areas.

Gill nets have also been used to target flatheads with some success. However, limitations that include high mortality, high incidental catch of other species, and decreased efficiencies due to debris likely preclude gill nets from being a survey method of choice

On the Mississippi River, buffalo nets set during spring targeting shovelnose sturgeon have also been shown to be effective at catching large flathead catfish.

Propagation and stocking: Flathead catfish can only be raised in very low numbers within a hatchery environment due to their piscivorous nature. The return for the investment is very low and not justifiable (Missouri Department of Conservation, personal communication). Stocking needs should be filled through field transfers. Recommended rate for adult transfers is 0.5 per acre.

Management considerations: Flathead catfish management must include increased emphasis on habitat. Although summer habitat is generally not limiting, management plans should incorporate actions that prevent or reduce removal of large woody structure both within rivers and the riparian corridor. Even though flatheads spend nearly half their lives in winter locations, little is known about suitable winter habitat and the micro-habitat needed for winter survival. Further research is needed to determine why fish are selecting specific winter habitat locations. Management plans need to protect critical overwintering sites from detrimental change, and regulations should protect fish while at wintering sites. Opportunities to create wintering sites where they are limited should also be examined.

Studies to establish length and age at maturity, fecundity and spawning periodicity, and angler exploitation must begin for Wisconsin flathead catfish. Although documented elsewhere in the United States, detailing these basic parameters for Wisconsin's flatheads is an important first step in developing management regulations for this species in its northern range. It may also be important to study these parameters across Wisconsin to determine if there are any regional differences.

Habitat use by age-1 and young-of-year flathead catfish must be determined. Currently, little habitat use information exists for these young fish as they are infrequently encountered using existing sampling methods for older juvenile and adult flatheads. It is uncertain if this is a result of gear selectivity or if habitat partitioning actually occurs. If targeting young-of-year and age-1 individuals is possible, an index of annual variability in recruitment may be produced.

Species: Channel Catfish *Ictalurus punctatus*

Identification: Channel catfish have no scales, and their body is dorsal-ventrally flattened with a tapered head. Their upper jaw extends slightly beyond their lower jaw. Their tail fin is deeply forked. Channel catfish juvenile and small adults have irregular small black spots on their sides. The spots fade with size and age yielding a solid bluish grey or bluish olive color as large adults. Their belly is white (http://www.wiscfish.org/fishid; Becker 1983). Adult male channel catfish may become very dark in color and be mistakenly called "blue catfish." Male and female channel catfish may be identified by the number of urogenital openings behind the anus; males have one opening, while females have two (Moen 1959; Norton et al. 1976).

Size range and age: Channel catfish are the second largest member of the catfish family in Wisconsin. The current Wisconsin hook and line record is 44 lbs. 0 oz (Wisconsin River, Columbia County). Channel catfish are capable of living 20 years or longer. Channel catfish have been found to range to over 760 mm (30 in). Surveys on the Mississippi River found nearly 60% of channel catfish hoop netted ranged from 254-356 mm (10-14 in) TL while averaging near 320 mm (12.6 in) TL. Slat traps on the Mississippi River tended to catch larger channel catfish as 60% of those caught were between 330-457 mm (13-18 in) TL. Male and female channel catfish have been shown to grow at similar rates; slower growth and older ages have been found in their northern range (Elrod 1974; Gerhardt and Hubert 1991; Hubert 1999; Haxton and Punt 2004).

Age determination: Channel catfish ages have historically been determined by reading the basal or distal sections of the pectoral spine (Photo 14). Accuracy limitations using this method were discussed in the flathead catfish section. To improve accuracy and determine the true age of channel catfish, the entire spine must be removed and sectioned at the articulating process. For removal, first grasp the spine when it is not locked in place and hold it tight to its body. Applying downward pressure, slowly push the spine along the body until it dislocates. The spine is then placed in an envelope with the tip down, to allow proper drying of the articulating process.

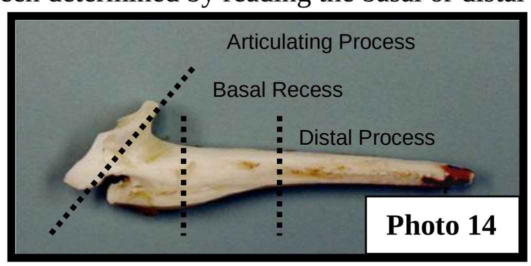


Photo 14

Once properly dried, spines are thin-sectioned through the articulating process with a cut from the dorsal process to the anterior process. A South Bay Technology slow speed saw is used to cut a section between 0.25 mm to 0.35 mm using a 4" x 0.012" medium/high density diamond cutting wheel (Photo 15). The cut can be made slightly toward the ventral process; this decreases cut time, but the cut must be made outside the basal recess. To further reduce cut time, some labs use two blades separated with a spacer; two blades allow a section to be removed with a single cut. The spine can be mounted in a vice on the saw arm or a jig can be made from a camera mount ball-joint (Photo 16; GIOTTOS MH-1304-110C). The jig attaches to the arm and allows for precise orientation of the spine in relation to the cutting wheel.

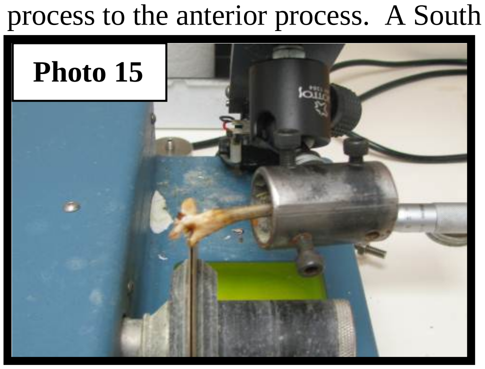


Photo 15

The spine section does not typically need much additional preparation, only a slight coating of oil. However, if polishing is desired, 400 grit wet/dry sandpaper can be used along with a drop of water to gently polish the section. Once the spine section has been prepared, it


Photo 16

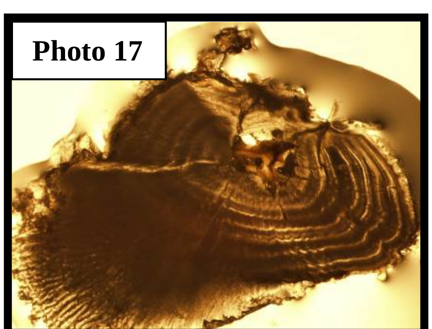


Photo 17

can be viewed through a stereo microscope (Photo 17). The Wisconsin Rapids Fisheries Lab uses an Olympus stereo microscope (SZX-ZB7) (0.8x to 5.6x magnification) fitted with a 2.0X Plan Achromat Objective and 10x eyepiece. The microscope can also be fitted with a Trinocular Observation Tube (SZX-TR30) for use with an adapter and camera, such as an Infinity2-1C Color Camera. After images are taken, they can be viewed on a computer monitor by multiple readers. The only drawback of this microscope, and possibly others, is the limited field of view. A wider field of view would allow the entire articulating process to be viewed without the need to adjust the slide. However, this is a minor distraction in the age determination process.

Status and distribution: Channel catfish are considered secure with an occasional to common abundance in rivers in the southern half of the state (Figure 1). They are uncommon to occasional in rivers of northwestern Wisconsin and uncommon in inland lakes and Lake Michigan. They are absent from the Lake Superior basin and north-central and northeastern Wisconsin (Lyons et al. 2000). Channel catfish in Wisconsin are near their northern extent of their geographic range. Recent re-introductions have helped expand their distribution within the Wisconsin River in central Wisconsin. Channel catfish introduced into Lake Michigan tributaries from 1957-1969 have established self-sustaining populations (Becker 1983). Dams may limit upstream distribution of channel catfish within river systems.

Habitat: Channel catfish are found in a wide variety of habitats including clear rocky streams, turbid sluggish waters, lakes and reservoirs. However, they generally flourish in large, moderately turbid warmwater rivers that exhibit an abundance of large woody structure and complex habitats. Adults spend daytime hours near large structures like log jams and boulders or in deep water pools. They enter shallow water to forage at night. Juveniles may be found in shallow riffle areas and sand bars in rivers and streams. Little is known about habitat use by juvenile channel catfish in lakes. Adult channel catfish during winter concentrate in large numbers and select large deep pools within lower river reaches or deeper parts of lakes and reservoirs. Large schools of juveniles have also been found within the deep pools of big rivers during winter months.

Spawning: Channel catfish begin to mature at 3-5 years of age when they reach 330-400 mm (13-16 in) TL (Becker 1983; Raibley and Jahn 1991). Channel catfish spawn when temperatures range from 21-28˚ C (Holland-Bartels and Duval 1988). Becker (1983) reported that spawning occurs from late May to July with an optimum water temperature of 26.7˚ C. Preferred spawning sites include dark cavities or crevices in the bank and under rootwads or other structure. However, spawning may occur without any structure if sufficient depth, turbidity and flow conditions exist. Nests may be constructed directly on the bottom in highly turbid waters. Current does not appear to be necessary for successful reproduction as channel catfish are able to reproduce readily in lakes and ponds. Egg count varies greatly with female size. For channel catfish in the upper Mississippi River, Helms (1975) established an average of 6,088 eggs/lb of body weight, with a standard deviation of 1,858 eggs. Males prepare the nest where the female deposits the eggs in a gelatinous mass. After fertilization, males fan and guard the incubating eggs which hatch in 5-10 days in water temperatures between 21.1-29.4˚ C. The fry remain near the nest site for 5-7 days until the yolk-sac is absorbed and then begin to disperse in small schools (Photo 18). Protracted spawning periods and spawning during high flows have been shown to have negative affects on spawning success (Holland-Bartels and Duval 1988).


Photo 18

Food habits: Channel catfish feed primarily on aquatic insects when very young and gradually become omnivorous and piscivorous as they mature (Bailey and Harrison 1948; Armstrong and Brown 1983). Adult channel catfish generally feed near the bottom locating food by smell or touch but have been observed feeding on the surface during mayfly hatches. It does not appear channel catfish are prey selective but eat whatever is available (invertebrate, fish, plant or carrion). Feeding activity varies temporally with water clarity; feeding primarily occurs after dark in clear water, whereas in turbid water feeding occurs throughout the day. Feeding by channel catfish tapers off with decreasing temperature in the fall with little feeding occurring below 10˚ C. However, channel catfish on rare occasions may be caught while ice fishing. Incidental snagging, and in some cases intentional snagging, of channel catfish during the winter months has been shown to be a law enforcement issue.

Movement patterns: In contrast to channel catfish in their southern range, channel catfish in Wisconsin have been found to be more mobile while migrating considerable distances between spawning, feeding and wintering habitats (Ranthum 1971; Pellett et al. 1998). As evidence of their migratory behavior, channel catfish have been found to overwinter in the Mississippi River, whereas spawning and feeding occurs in tributary rivers (Larson and Ranthum 1977, Pellett et al. 1998; Fago 1999). Movements of these fish from wintering locations to the tributaries began during late April to May, with fish returning to winter locations during September and October. Inland rivers may have similar migrations as reported on the Mississippi River. Floy tagged fish from the Pecatonica River in Wisconsin migrated up to 75 miles downstream into Illinois to overwinter (Photo 19). The migration towards overwintering areas occurred post-spawn and as early as mid- to late-August. Migration back to Wisconsin occurred in early to mid-April when water temperatures were greater than 50˚ F. Migratory habits may develop early in life as Floyd et al. (1984) captured larval channel catfish in drift nets.


Photo 19

Ecological importance: Young channel catfish are food for many fish species as well as mammalian and avian predators. As they grow, they become less vulnerable to predation and begin to be a top predator on other organisms. Channel catfish are also scavengers and thought to help to keep waters clean. Channel catfish are an important host fish for glochidia of several freshwater mussel species including purple wartyback Cyclonaias tuberculata and winged mapleleaf *Quadrula fragosa*, both state endangered species, along with washboard *Megalonaias gigantea*, pimpleback *Quadrula pustulosa*, mapleleaf *Quadrula quadrula*, flat floater *Anodonta suborbiculata*, creeper *Strophitus undulatus*, paper pondshell *Utterbackia imbecillis*, and the state threatened rock-pocketbook *Arcidens confragosus*. Long distance dispersal of these and other mussel species rely on glochidia-infested host fish.

Sampling methods: Many methods have been implemented that successfully sample channel catfish in Wisconsin. Hoop nets, fyke nets, gill nets, slat traps, standard electrofishing, low pulse electrofishing, set-lines, bank poles, and trawling have all been used. The following summarizes three sampling methods that cover variable conditions found within non-wadable streams, wadable streams and lakes. Although difficult to establish a single standard sampling method, a sampling protocol has been offered that standardizes hoop netting within non-wadable streams.


Photo 20

***Hoop Nets*:** Hoop nets are a widely cited technique and well documented for being effective for sampling channel catfish (Vokoun and Rabeni, 1999). In Wisconsin, they have been popular when surveying non-wadable streams (Photo 20). Among other things, hoop netting provides data for structural characteristics of the population and the ability to analyze population trends (Photo 21; Table 1). The


Photo 21

following is a standardized netting protocol for the Wisconsin Baseline Monitoring Program. It is recognized that traditional hoop netting surveys may not conform to this protocol and may continue in ways previously established.

1) The recommended hoop net has seven to nine hoops tapering in size from 42 inches to 34 inches outside diameter (Photo 22). Standard mesh size is one-inch bar which generally starts sampling channel catfish around eight inches TL (Holland and Peters 1992). Within the hoops, crow foot or finger style throats are typically tied at the second and fourth hoops. Hoop material may be fiberglass, steel or a combination of both. Netting material is a treated nylon.


Photo 22

2) Each net is baited with three pounds (dry weight) of pressed soy cake. Dry soy cake should be presoaked by placing it in a container of water overnight. Place wetted bait into a mesh bag with 1/8 to 1/4 inch mesh size (e.g. onion bag or laundry-style bag; Photo 23). Place bait bag into pot end of hoop net. Bait bag may be fastened to net or left loose. Although cheese baits may be used, Flammang and Schultz (2007) found them to be less effective than soy cake. In addition, cheese baits are more expensive, require increased handling, and increase safety issues due to the slippery residue left within boats.


Photo 23

3) Hoop nets are set with the mouth of the net facing downstream. Bait and close the net in the boat prior to setting. Stake or anchor the pot of the hoop net and proceed downstream while stretching the net with the mouth open downstream. A small anchor can secure the downstream end of the net. To retrieve the nets, buoy markers or net drags may be used. Some traditional surveys in Wisconsin have employed a slat trap that replaces the anchor; the slat trap is tied to a rope that is attached to the hoop net mouth. The slat trap may also be baited. This protocol does not recommend slat traps be used as anchors but realizes some surveys may continue their use.
4) Nets should be set three per mile of stream or river. For larger rivers, knowledge of channel catfish behavior and their related movements will be important to efficiently capture greater numbers of fish. For smaller rivers, available netting locations will be decreased.
5) Netting effort should be continued through 100 net nights or until 250 channel catfish are sampled. If survey goals and objectives dictate, the number of net nights or the maximum number of fish may be increased.
6) Nets should be checked every 24 hours and baited as needed. If ages are needed, structures should be taken from 5-10 fish per inch group. Weights should be taken as needed.
7) Surveys should be conducted post spawn when water temperatures are greater than 70°F. Depending on latitude this may occur from mid-June through August. It is not recommended to sample beyond August; while temperatures may be appropriate, fish may have already begun their migration from their summer habitats.

The above protocol calls for post spawn hoop netting. However, hoop net surveys during the spring migration period on the Wolf River have produced good channel catfish catch rates (Photo 24). In these cases, hoop nets have been deployed without bait. This occurs from late-March thru early May when water temperatures near 50° F. The migration sampling period may range from a few days to several weeks. Water body size, population densities and weather patterns can affect the migration period length. Use of unbaited nets during this time can also reduce the nets effectiveness on non-targeted species such as buffalo and carp.


Photo 24

***Fyke Nets*:** While typically not cited in the literature as an efficient method for sampling channel catfish, fyke nets have seen some success in Wisconsin lakes. Channel catfish catches with fyke nets became apparent during spring walleye netting when large incidental catches were found. The use of fyke nets has proven to be an efficient method for sampling channel catfish with some catch rates exceeding 150 fish per net night (Kurt Welke and Bradd Sims, WI DNR, personal communications; Photo 25). Fyke netting for channel catfish should occur during early spring periods when water temperatures approach 50° F. Adequate catch rates may linger for several weeks. Fyke nets are deployed using standard fyke netting protocol with no bait required. When targeting channel catfish, survey shallow silt/clay bottom flats, creek mouths and large backwater bays. Fyke netting these areas will sample males, females and immature fish. Immature fish sampled will typically not be less than 280 mm (11 in) TL.

Photo 25

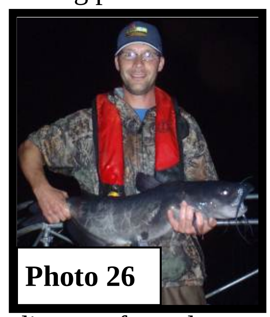


Photo 26

***Electrofishing*:** Channel catfish have been surveyed by electrofishing during lake and stream surveys (Photo 26). However, low channel catfish numbers indicate this method may be best suited for use as a presence/absence indicator and not an indicator of trends. Electrofishing using low frequency settings may need additional study as young-of-year channel catfish have been captured with this method.

Propagation and stocking: Currently the Wisconsin Department of Natural Resources propagation system does not raise channel catfish. Stocking needs should be filled through purchases with the private aquaculture industry or field transfers. Recommended stocking rates are 75 per acre small fingerling (4 inches), 25 per acre large fingerling (8 inches), and 1 per acre for adult transfers. Channel catfish should be stocked at a minimum of 8 inches in waters with existing predator species.

Management considerations: Channel catfish management must include increased emphasis on habitat use that determines needs for spawning, feeding and wintering. This will help provide a basis for managing channel catfish now and into the future, either regionally or on a statewide scale.

It is important to establish or continue long-term trend monitoring sites for juvenile channel catfish throughout Wisconsin where populations exist. Recruitment variability will be determined while habitat and environmental conditions that produce strong year classes may be studied.

Studies to establish length and age at maturity, fecundity and spawning periodicity should continue or begin where needed for Wisconsin channel catfish. Studying these important parameters across Wisconsin may be needed to determine if regional differences are apparent.

Recent surveys have shown adult catfish densities over 20 per acre for lakes. Information is needed to define what the normal range of adult channel catfish per acre is in Wisconsin Lakes.

Studies should be conducted to determine the use of channel catfish in urban ponds. Initial costs may exceed current cost of stocking trout but the long term investment may be greater as channel catfish may carry over and sustain a fishable population.

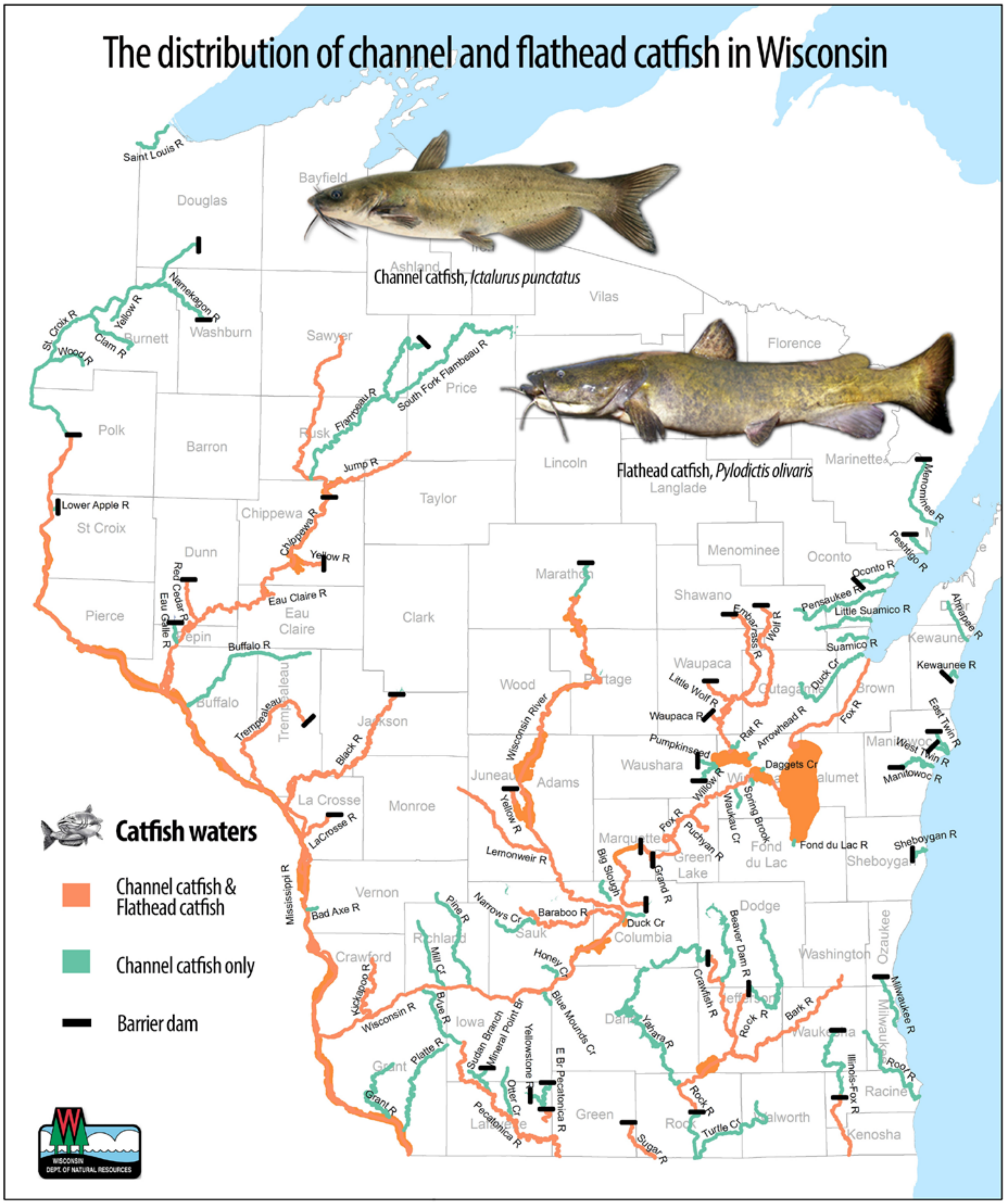


Figure 1. Distribution of channel catfish (*Ictalurus punctatus)* and flathead catfish (*Pylodictis olivaris*) in Wisconsin.

Table 1. Proportional stock density (PSD_{16}), relative stock density (RSD_{24}), and catch-per-unit-effort (CPUE; number per net night) for channel catfish captured hoop netting in various Wisconsin water bodies.

Water Body	Location and/or Year	PSD_{16}	RSD_{24}	CPUE
Upper Wisconsin River	Wausau 2012	98	45	5.4
	Mosinee 2010	68	6	4.8
	Mosinee 2007	22	6	22.4
	Dubay 2007	68	6	4.8
	Stevens Point 2005	95	33	2.1
	Stevens Point 2006	97	29	3.8
	Stevens Point 2008	44	16	5.5
	Whiting 2005	22	3	54.0
	Whiting 2006	50	1	34.0
	Biron 2005	74	4	34.0
	Biron 2006	92	3	38.0
	Biron 2008	90	5	24.0
	Wisconsin Rapids 2007	92	7	30.0
	Centralia 2007	93	34	11.0
	Petenwell 2009	67	12	20.9
	Arena 2011	71	5	11.0
	Gotham 2012	82	10	3.0
	Average	**75.8**	**12.9**	**17.9**
Lower Wisconsin River	Gotham 2012	74	8	5.5
	Mazomanie 2012	81	8	3.0
	Arena 2011	71	6	11.0
	Average	**75**	**7**	**6.5**
Baraboo River	2000	87	32	*
	2001	78	23	*
	2002	55	15	*
	2003	66	14	*
	Average	**72**	**21**	
Mississippi River	Pool 8 2008	28	4	9.4
	Pool 10 2008	17	0	*
	Pool 8 2007	43	1	6.1
	Pool 10 2007	66	1	*
	Pool 4 2007	52	8	*
	Average	**41**	**3**	**7.8**
LaCrosse River	Hwy 16 to Miss. R. 2003	78	27	0.8
	Hwy 16 to Miss. R. 2004	6	0	0.3
	Average	**42**	**14**	**0.6**
St. Croix River	Boomsite-HighBridge 2011	50	17	1.2
	HighBridge-Marine 2012	70	15	1.3
	Marine-Swingbridge 2013	76	14	1.5
	Swingbridge-Osceola 2014	52	13	1.2
	Osceola-Interstate Park 2015	56	16	2.5
	Average	**60.8**	**15.0**	**1.5**

continued

Table 1 continued.

Water Body	Location and/or Year	PSD_{16}	RSD_{24}	CPUE
Menominee River	1998	95	68	2.1
	1999	100	78	3.6
	2000	97	59	3.9
	2002	100	90	5.7
	Average	**98**	**74**	**3.8**
Chippewa River	Wissota 1997	100	81	*
	Dells Pond 1997	100	61	*
	Chip and Jump Rivers 1995	86	24	*
	Chip and Flamb. Rivers 1994	100	13	*
	Average	**97**	**45**	
Wolf River	1988	84	8	0.2
	1989	46	2	18.6
	2002	90	3	2.2
	2003	91	10	1.4
	2005			1.9
	2007	96	17	3.1
	2008	94	10	3.2
	Average	**84**	**8**	**4.4**
Pecatonica River	Browntown 2002	70	6	2.3
Pecatonica River	Darlington 2002	68	4	2.7
East Branch Pecatonica	Above Argyle Dam 2002	73	9	5.5
East Branch Pecatonica	Below Argyle Dam 2002	49	1	8.5
Pecatonica River	Browntown 2004	89	20	3.2
Pecatonica River	Below Gratiot 2004	77	12	3.7
Pecatonica River	Above Gratiot 2004	88	10	6.2
Yellowstone Lake	2007	82	10	24.9
Yellowstone Lake	2008	96	16	14.8
Grant River	2014	50	4	3.1
Platte River	2013	33	6.0	1.5
	Average	**73**	**17.5**	**10.2**

Species: Brown Bullhead *Ameiurus nebulosus*
Black Bullhead *Ameiurus melas*
Yellow Bullhead *Ameiurus natalis*

Identification: The three bullhead species found in Wisconsin are scaleless and have a similar appearance to each other but can be readily identified. Although fin rays can be hard to count in the field, anal fin ray numbers are a very reliable identifying character. Black bullheads have 15-21 rays, brown bullheads have 21-24, while yellow bullheads have 24-27. When counting, make certain to include all elements. Although these counts have some overlap, few specimens have either 21 or 24 rays, and those that do can be distinguished using other features that follow. Yellow bullheads are distinguished from brown or black bullheads by their cream or white colored barbels under their chin; brown and black bullheads have dark grey, brown or black barbels. The pectoral spine may also aid identification as brown and yellow bullheads have a rough saw-like posterior edge while black bullheads have smoother small barbed edge (http://www.wiscfish.org/fishid; Becker 1983). Although body color may also aid identification, it is not always reliable. All three species may be a uniform solid dark color on the back with a whitish to yellowish belly. Black bullheads often have a faint vertical bar at the base of their tail, while yellow bullheads resemble black bullheads but do exhibit the pale vertical bar. While brown bullheads may have a solid dark color appearance on their back and sides, they typically exhibit dark mottling. Similar to catfishes, male and female bullheads may be identified by the number of urogenital openings behind the anus; males have one opening, while females have two (Moen 1959).

Size range: All three species are similar in size and typically range from 150 mm to 300 mm (6-12 in) TL. The current Wisconsin hook and line records are as follows: black bullhead, 5 lbs. 8 oz. (Big Falls Flowage, Rusk County), brown bullhead, 4 lbs. 2 oz. (Little Green Lake, Green Lake County) and yellow bullhead, 3 lbs. 5 oz. (Nelson Lake, Sawyer County). Black bullheads typically range from 150-250 mm (6-10 in) TL and have a maximum length of about 330 mm (13 in). Brown bullheads typically range from 200-300 mm (8-12 in) TL and have a maximum length of about 380 mm (15 in). Yellow bullheads typically range from 175-275 mm (7-11 in) TL and have a maximum length of about 350 mm (14 in).

Status and distribution: The status of each bullhead species is considered secure, with an occasional to common abundance (Lyons et al. 2000). Black bullheads are found in lakes, streams and rivers statewide, and are the most widely distributed and common of the three species. Yellow bullheads, are found widespread in lakes, streams and rivers statewide but considered uncommon in the Lake Superior basin. Brown bullheads are common in lakes but considered uncommon in streams and rivers. Similar to yellow bullheads, brown bullheads are absent from the Lake Superior basin.

Habitat: Given their ubiquitous statewide presence, bullheads are found in a wide variety of habitats. However, they generally prefer shallow lakes and slow-moving streams with soft bottoms and abundant vegetation (Stuber 1982; Becker 1983; Blumer 1985). Bullheads are often found in slackwater habitats of large rivers but are scarce within their flowing water environments. Bullheads are capable of surviving highly turbid waters (Stuber 1982) and waters low in oxygen concentrations (Cooper and Washburn 1946). Large bullhead populations can often be found in lakes that routinely winterkill, surviving where other species cannot.

Spawning: Because bullheads are widely distributed throughout Wisconsin, spawning occurs over an extended period from May to late July. Peak spawning occurs as the water temperature approaches 20-21˚ C (Stuber 1982; Becker 1983; Blumer 1985). All three species use nests for spawning. The nests are built in 2-4 feet of water. Nest locations vary and may be found in open areas, in depressions, under matted vegetation or overhanging banks, within woody debris, near artificial structure, or in burrows. Eggs are laid in clusters within the nest and carefully tended by one or both parents. Varying with water temperatures, the eggs hatch within 8-13 days. Newly hatched bullheads form tight schools that are guarded by their parents for several weeks until dispersal. In regards to fecundity, Sinnot and Ringler (1987) reported a mean fecundity of 2,169 eggs per female brown bullhead within a New York lake and also found that the gonadosomatic index decreased with increasing size. Within an Iowa lake, Forney (1955) estimated black bullhead fecundity averaged 3,283 eggs for females 203-226 mm TL and 3,845 eggs for fish 229-251 mm TL.

Food habits: Bullhead species are considered opportunistic feeders. They feed mainly on aquatic insects and other macro-invertebrates when young and become more omnivorous as they grow larger, even preying occasionally on small fish (Becker 1983). Angler catch of yellow and brown bullhead after dusk seems to correspond with the thought that these species are most active foraging after dusk.

Movement patterns: Diurnal movements have been observed for black bullheads (Darnell and Meierotto 1965) and brown bullheads (Blumer 1985) with adults moving into shallow waters to forage and seek spawning locations after dark. Contrary to finding adult black bullheads active after dark, Darnell and Meierotto (1965) reported young black bullheads to be most active during the day. Seasonal bullhead movement information is limited within lakes or rivers. Brown bullheads in the Anacostia River (Washington, D.C.) exhibited limited movements during the winter with their greatest movement occurring during spring (Sakaris et al. 2005); the fish used deeper water areas during the winter then moved upstream into shallow water during the spawning period.

Ecological importance: Bullheads are important forage for large predator fish including walleye, black bass, northern pike and flathead catfish. Young bullheads are also important forage for a wide variety of mammalian and avian predators, often in winterkill lakes. Brown bullheads are a known host fish for washboard *Megalonaias gigantea* and pimpleback *Quadrula pustulosa* mussel glochidia, while yellow bullheads are a host fish for glochidia from the giant floater *Pyganodon grandis* (Hart and Fuller 1974).

M**anagement considerations:** In order to ensure sound management decisions, life history studies need to be conducted that concentrate on food habits, age and growth, habitat use and seasonal movements for each species. In addition, reproductive history is generally absent for yellow bullhead and needs attention. While this basic information is collected, existing data should be used to determine annual variability of bullhead populations. More consideration should be provided to bullhead populations that may be impacted in waters managed for top predators. Another management issue worth addressing is stunting, particularly in wetlands and winterkill lakes where predators are scarce and bullhead densities are high.

Species: Stonecat *Noturus flavus*
Tadpole Madtom *Noturus gyrinus*
Slender Madtom *Noturus exilis*

Identification: Madtoms are the smallest members of the catfish family and appear similar to small bullheads. They are distinguished from other ictalurids by their adipose fin, which is attached to the back and caudal fin. Stonecats and slender madtoms have a similar scaleless appearance but are distinguished by comparing their tooth patch located on their mouth roof; the stonecat's tooth patch has horn-like backward lateral extensions present, while the slender and tadpole madtoms have no horn-like extensions (http://www.wiscfish.org/fishid; Becker 1983). The slender madtom has a pectoral fin spine with a strongly serrated posterior edge, while the stonecat and tadpole madtom have little or no serration. Tadpole madtoms have a pot-bellied appearance often with a pencil-thin dark lateral stripe. All three species have poison glands at the base of their pectoral and dorsal spines that can produce a painful sting if mishandled.

Size range: The stonecat is the largest madtom and ranges in size from 100-175 mm (4-7 in) TL and have a maximum length of about 300 mm (12 in; Photo 27). Slender madtoms typically range from 75-115 mm (3-4.5 in) TL and have a maximum length of 125 mm (5 in). Tadpole madtoms typically range from 40-75 mm (1.5-3 in) TL and have a maximum length of about 115 mm (4.5 in). Using pectoral spines in Wisconsin, Paruch (1979) aged stonecats to age five, while slender and tadpole madtoms were aged to age three.


Photo 27

Status and distribution: Stonecats are considered secure with an occasional abundance in rocky streams and rivers in southern Wisconsin and an uncommon abundance at scattered locations in northern Wisconsin (Lyons et al 2000). Tadpole madtoms are considered secure with an occasional abundance in low gradient rivers and streams statewide and an uncommon abundance in lakes (Lyons et al. 2000). Slender madtoms are a Wisconsin listed endangered species (Les 1979) and are only found in a few locations in the Rock River (Lyons et al 2000). Slender madtoms experienced a dramatic decline in distribution and abundance from the 1970s to the 1990s; they disappeared from 67% of the sites and 81% of the streams where it was formally found (Lyons 1996).

Habitat: Wisconsin madtoms are secretive, hiding in cavities or debris during the day and actively searching for prey after dark. Stonecats are a riverine species that commonly occur in medium-sized warmwater streams with moderate current. Within these streams, they are usually found in riffle or run habitat with cobble and rubble substrate that provide abundant crevices for hiding (Becker 1983). Slender madtoms occur in clear, small to medium-sized streams in the Rock River system; preferred habitat includes coarse, rocky riffles with moderate to swift current. Tadpole madtoms are common in medium to large rivers and occasionally in lakes. Tadpole madtoms prefer areas of little current with abundant vegetation, organic debris, and other structure with a sand, gravel or mud substrate.

Spawning: Madtoms spawn in small cavities or under objects and have been known to favor small cans. Nests are guarded by one or both parents. The madtoms can be identified by sex during the spawning season by observing their genital papillae (Mayden and Burr 1981; Walsh and Burr 1985; Whiteside and Burr 1986).

Tadpole madtom spawning occurs mainly in June and July when water temperatures exceed 25˚ C. They prefer to nest in small cavities or within cavities excavated under objects; they have also been found nesting within small cans when available. Both male and female tadpole madtoms mature at age two (Whiteside and Burr 1986). A study at Dutchman Creek in Illinois found mature females averaged 151 eggs, with the number of eggs correlated to size (Whiteside and Burr 1986). Eggs are laid in a gelatinous mass and cared for by one or both parents until hatching.

Stonecat spawning occurs mainly in June and July when water temperatures exceed 25˚ C. They prefer to nest in cavities excavated by the male beneath large rocks. Both male and female stonecats are generally mature at age three (Walsh and Burr 1985). Walsh and Burr (1985) found mature females averaged 378 eggs, with the number of eggs correlated to size. Eggs are laid in a gelatinous mass and cared for by the male until hatching.

Slender madtom spawning occurs mainly in June and July when water temperatures exceed 26˚ C. They prefer to nest in cavities excavated by the male beneath large rocks. Both male and female slender madtoms are mature at age two (Mayden and Burr 1981). Mayden and Burr (1981) found mature females averaged 85 eggs, with the number of eggs correlated to size. Females may deposit their eggs in more than one nest, as the number of eggs in a nest was generally half of those observed in mature females (Mayden and Burr 1981). Eggs are laid in a gelatinous mass and cared for by the male.

Food habits: Madtoms are nocturnal predators with peak feeding periods just after dusk and before dawn. A tadpole madtom's diet consists primarily of dipteran larvae and pupae, micro crustaceans and isopods (Whiteside and Burr 1986). A stonecat's diet consists mainly of aquatic larval insects, along with decapod crustaceans and small fish for larger individuals (Walsh and Burr 1985). A slender madtom's diet consists primarily of dipteran larvae and pupae, ephemeropteran naiads, trichoptera larvae and some crustaceans (Mayden and Burr 1981).

Movement patterns: The madtom species in Wisconsin exhibit diurnal movement patterns, being most active from dusk to dawn. Due to their small size and secretive habits, little is know about seasonal longitudinal migration within waters. However, Mayden and Burr (1981) reported a season shift for slender madtoms; they moved from deeper pools to shallow riffles during the spawning season. Brown and Armstrong (1985) found slender madtom alevins abundant in riffle studies but absent form drift samples, indicating a low dispersal potential.

Ecological importance: Due to their small size, madtoms are likely forage for piscivorous fish. Tadpole madtoms are reported to be choice bait for walleye anglers along the Mississippi River (Becker 1983). Stonecats are considered an important food for smallmouth bass and an indicator of smallmouth bass abundance (Trautman 1957). Slender madtoms are protected in Wisconsin, but have been reported as a baitfish where common in its southern range. Tadpole madtoms are a known host fish for mucket *Actinonaias ligamentina* and fat mucket *Lampsilis siloquoidea* mussel glochidia (Hart and Fuller 1974).

Management considerations: As a Wisconsin endangered species, slender madtoms should be monitored to determine population status. Slender madtoms are known to be intolerant of silt and non-point pollution from agriculture; they have disappeared from stream reaches impacted by such disturbances (Lyons 1996). Riparian and watershed best management practices should be implemented in reaches where slender madtom populations occur to minimize species impacts. Slender madtoms have been eliminated by improper operation of a small hydroelectric dam from portions of the Rock River (Lyons 1996); due to this finding, it is thought maintaining run-of-the-river flows would benefit this Wisconsin endangered species. Where slender madtoms have disappeared, reintroductions may be needed for reestablishment.

Life history studies have been conducted in other states for the three madtom species found in Wisconsin. However, information is lacking for Wisconsin's madtom populations. Due to their secretive nature and their close affiliation to hiding in crevices, madtom populations are likely underestimated in most sampling situations. Developing sampling protocols that target madtoms would provide valuable population information. Additional studies should determine movement patterns, critical habitat needs, and spawning, feeding and wintering locales for each Wisconsin madtom species.

Parasites and diseases: Wisconsin's ictalurids are susceptible to several parasites including Protozoa, Monogenea (flatworms), Tremetoda, Cestoidea (tapeworms), Nematoda (round worms) Acanthocephala (thorny-headed worms), Hirudinea (leeches), Mollusca (freshwater mussel glochidea) and Crustacea (fish lice). For a more comprehensive fish parasite list, including keys to identification and life cycles see Hoffman (1999). Regulations and boater education to stop the transfer of live fish or water within Wisconsin is necessary to help prevent the spread of parasites and diseases. In addition, parasites and diseases from fish and water from outside Wisconsin, including other states, countries and continents, needs to be closely monitored and regulated to prevent introduction.

The following is a list of viruses, bacteria and parasites that may affect ictalurids species (Sue Marcquenski, WI DNR, personal communication).

<u>Viruses</u>
Channel catfish virus - channel catfish
VHS - channel catfish and bullheads

<u>Bacteria</u>
motile Aeromonas sp. - probably all species of ictalurids
Edwardsiella ictaluri - enteric septicemia of catfish; mostly channel catfish
Flavobacterium columnare - columnaris; all ictalurids

Other bacteria are present in water and sediments, such as Pseudomonas, and can become pathogenic when fish are stressed. The bacteria list is likely longer than the above.

<u>Parasites</u>
Heterosporis - lab experiment with channel catfish
Uvulifer amblopitis - black spot
Clinostomum marginatum - yellow grub
Ich
Ambiphrya and likely other ciliate parasites
Hennegya - proliferative gill disease; channel cats typically in hatcheries

The following are parasites from Great Lakes ictalurids
Ligictaluridus pricei (gills) brown bullhead (BB)
L. monticellii (nasal cavity) BB
Megalogonia ictaluri (intestine) BB, channel catfish (CC)
Diplostomum spathaceum (eye) BB, CC
Acetodextra amiuri (swim bladder) BB, CC
Leptorhynchoides thecatus (intestine) BB
Gyrodactylus sp. (fins) BB, CC
Phyllodistomum sp. (ureters) BB, CC
Corallobothrium fimbriatum (intestine) BB, CC
Ergasilus versicolor (gills) BB, CC
Pomporhynchus bulbocolli (intestine) BB, CC
Corallotaenia minutia (intestine) BB
Microphallus opacus (intestine) BB, CC
Spiroxys (mesenteries) BB
Tetracotyle sp (mesenteries) BB

L. floridanus (gills) CC
Megathylacoides giganteum (intestine) CC

Parasites and diseases **continued**

Alloglossidium corti (intestine) CC
Bothriocephalus sp. (intestine CC
Proteocephalus ambloplitis (liver) CC
Argulus biramosus (fins) CC
Eustrongylides tubifex (mesentery) CC
Achteres pimelodi (gills) CC
Myzobdella moorei (leech) CC

Appendix 1. Photo credits.

Photo number	Credit
1	Steve Gospodarek, Wisconsin DNR
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7	Al Niebur, Wisconsin DNR
8	Scott Bunde, Wisconsin DNR
9	Al Niebur, Wisconsin DNR
10	Al Niebur, Wisconsin DNR
11	Bradd Sims, Wisconsin DNR
12	Randal Piette, Wisconsin DNR
13	Randal Piette, Wisconsin DNR
14	Tom Meronek, Wisconsin DNR
15	Tom Meronek, Wisconsin DNR
16	Tom Meronek, Wisconsin DNR
17	Al Niebur, Wisconsin DNR
18	John Lyons, Wisconsion DNR
19	Bradd Sims, Wisconsin DNR
20	Bradd Sims, Wisconsin DNR
21	Bradd Sims, Wisconsin DNR
22	Bradd Sims, Wisconsin DNR
23	Bradd Sims, Wisconsin DNR
24	Al Niebur, Wisconsin DNR
25	Bradd Sims, Wisconsin DNR
26	Laura Stremick-Thompson, Wisconsin DNR
27	Bradd Sims, Wisconsin DNR

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