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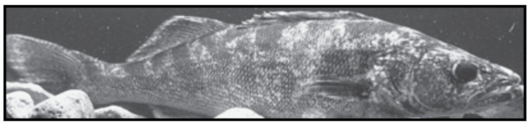

An Evaluation of the Efficacy of a 14-18 Inch Slot Limit for Walleyes in Northern Wisconsin

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Abstract

The Wisconsin Department of Natural Resources enacted a 14-18 inch slot limit for walleyes in a number of lakes in northern Wisconsin in 1997 and 1998. In addition to the slot limit, only one walleye greater than 18 inches in length could be harvested. The intent of these regulations was to increase harvest on smaller walleyes while also protecting the spawning stock. The slot limit regulation was placed on lakes with walleye populations that were deemed to be abundant and slow growing, and the regulation was expected to result in a smaller fishable stock size, larger spawning stock size, lower catch rate, and higher harvest rate when compared to the statewide 15-inch minimum length limit regulation. We examined fisheries metrics obtained from creel surveys and population estimates from a number of lakes that received the slot limit regulation, both before and after the regulation was put into place, and compared them to other lakes that were sampled in the same time period but which retained the 15-inch minimum regulation to determine if management goals had been met. We also carried out a power analysis to estimate the sample size required to detect a 30% change in fisheries metrics associated with northern Wisconsin walleye populations using two-tailed paired *t*-tests. In general, walleye populations that received the slot limit were characterized correctly as having slow growth and relatively high density walleye populations as indicated by significantly shorter age-4 males and higher catch and harvest rates compared to lakes that retained the 15-inch minimum length limit. Angler effort decreased significantly over time in all lakes. The slot limit had the effect of significantly increasing harvest per acre and decreasing the mean length harvested. Not all of the expected outcomes were realized. Additional harvest opportunities, however, were available in lakes with the slot limit without any detectable change to the walleye populations. Sample sizes to detect a 30% change in fisheries metrics were generally high and ranged from 3 to 1,491, with a median value of 71.

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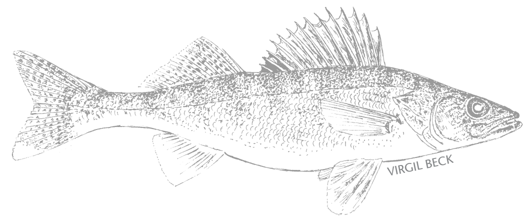
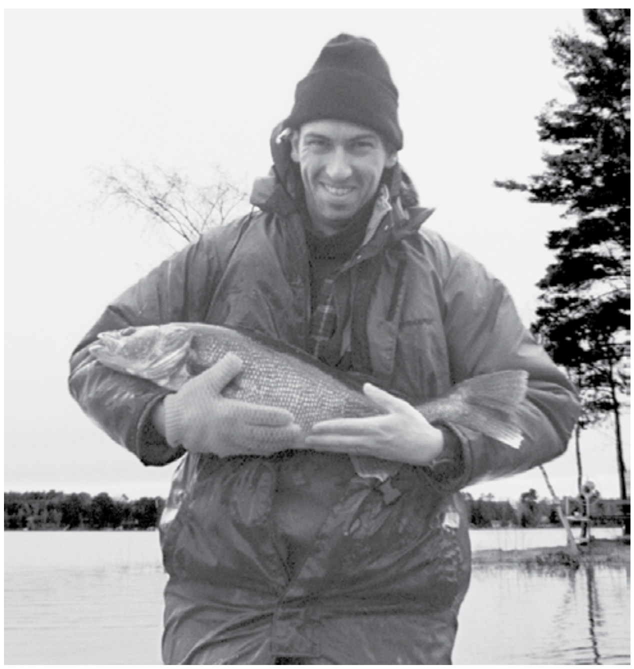


Introduction

Walleye populations in Wisconsin are protected from overharvest by season closures, daily bag limits, and length-based harvest regulations. Walleye populations have remained stable in the Ceded Territory of Wisconsin in the past two decades (Hansen and Hennessy 2006). However, in addition to protecting walleye stocks from collapse, there has been a desire to restructure walleye populations in a manner that is more desirable for anglers and also to allow additional harvest opportunities in populations where such harvest can be sustained (Brousseau and Armstrong 1987). There has been an increase in more subtle regulations, including slot limit regulations, in the past two decades in an effort to achieve these goals.



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We examined the effects of slot limit regulations to determine if management expectations were met.

The general intent of slot limit regulations is to increase harvest on smaller fish. This provides additional harvest opportunities for anglers and makes additional resources available for fish within the slot limit (Noble and Jones 1993). Slot limits are seen as an appropriate management option in walleye populations with good natural recruitment and relatively slow growth (Kerr et al. 2004).

In 1997 and 1998, the Wisconsin Department of Natural Resources (Wisconsin DNR) enacted a 14-18 inch slot limit for walleye on a number of lakes in northern Wisconsin. In addition to the length restriction, only one walleye greater than 18 inches could be harvested. The slot limit regulation was placed on lakes with walleye populations that were deemed to be abundant and slow growing. The purpose of the regulation was to increase harvest on smaller walleyes while simultaneously protecting spawning stock. Previous modeling efforts predicted a decrease in fishable stock size, increase in spawning stock size, decrease in catch rate, and increase in harvest rate in walleye populations with relatively high density and slow growth when compared to lakes with the statewide regulation of a 15-inch minimum length limit (Hewett and Simonson 1998). Our objective was to examine the effects of the slot limit on walleye populations to determine whether management expectations were met and if other changes occurred.

Methods

We examined fisheries metrics in order to determine whether there was evidence that 1) walleye populations were affected by the 14-18 inch slot limit, 2) there were inherent differences between walleye populations in lakes that received the 14-18 inch slot limit and those that retained the 15-inch minimum length limit, and 3) whether there were changes in walleye populations over time.

Available information was collected from lakes during the time period from 1990 to 2008 and came from three sources: 1) creel surveys, 2) length-specific population estimates, and 3) length-at-age estimates. Creel survey information included catch per hour, harvest per hour, mean length harvested, total angling effort, directed angling effort, catch per acre, and harvest per acre. Population estimate information included number of adults per acre, number of walleye 0-12 inches in length per acre, number of walleye 12-15 inches in length per acre, number of walleye 15-20 inches per acre, and number of walleye greater than 20 inches per acre. We used mean length of age-4 males as an indicator of growth (Fayram et al. 2000). We examined creel, length at age, and density information in lakes that received the 14-18 inch slot limit and those that retained the 15-inch minimum length limit that were sampled both before (hereafter referred to as the "pre" regulation time period) and again at least three years after (hereafter referred to as the "post" regulation time period) the implementation of the slot regulation. In the event that more than one sampling event occurred in the post regulation time period, only the sampling event that was temporally most distant from the regulation implementation was included in order to increase the portion of the walleye population exposed only to the slot limit. In the event that a lake was sampled on more than one occasion prior to the implementation of the slot limit, we used mean values for comparisons.

To characterize the effects of the 14-18 inch slot limit on walleye populations, we used analysis of variance (ANOVA) to test variable estimates for effects of time, regulation type, and their interaction. Significant interaction between time and regulation type suggested an effect of the slot limit regulation. In other words, the lakes that received the slot limit regulation responded differently over time compared to lakes that retained the 15-inch minimum regulation with respect to a given variable. If the interaction term was not significant, it was dropped and the data were reanalyzed using ANOVA for main effects of time and regulation type. A significant effect of time would suggest that the variable changed between the two time periods in a similar way in both lakes that received the slot limit regulation and those that retained the 15-inch minimum regulation. A significant effect of regulation type would suggest that the variable differed significantly between lakes that were selected to receive the slot limit regulation and those that retained the 15-inch minimum regulation. An α level of 0.05 was used to evaluate significance.

In regulation evaluations, statistical power is often too low to detect effects of different regulations (Isermann 2007). We conducted a power analysis to determine the sample size that would be needed to detect a 30% change in the mean value of each variable sampled in the pre-regulation time period using a paired *t*-test given $\alpha = 0.05$ and $\beta = 0.20$. ANOVA that includes a control group is a more powerful test than a paired *t*-test. Management actions, however, often lack control replicates and, as a result, an examination of sample sizes required to detect changes in fisheries metrics with a paired *t*-test seemed applicable and of interest.

Lakes included in this analysis are located throughout the Ceded Territory of northern Wisconsin. Lakes with slot limits range in area from 244 to 6,300 acres (mean = 1,336 acres) and in maximum depth from 8 to 117 ft (mean = 51.8 ft) (Table 1). The reference lakes that retained the 15-inch minimum regulation range in area from 112 to 6,830 acres (mean 1,272 acres) and in maximum depth from 30 to 96 ft (mean = 55.4 ft) (Table 1). The lakes exhibit a wide range of physical, chemical, and

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Table 1. Data available from lakes included in this investigation and general lake characteristics. "Treatment" refers to lakes that received the 14-18 inch slot regulation and "Control" refers to lakes that retained the 15-inch minimum length limit.

			Available Data			Characteristics	
County	**Lake Name**	**Treatment/ Control**	**Population Estimate**	**Creel Survey**	**Length Age-4 Males**	**Lake Acres**	**Maximum Depth**
Barron	Bear Lake	Control	x	x	x	1358	87
Barron	Beaver Dam Lake	Control	x	x	x	1112	106
Bayfield	Crystal Lake	Control	x			111	29
Bayfield	Lake Owen	Control	x			1323	95
Bayfield	Upper Eau Claire Lake	Control	x	x		1030	84
Burnett	Big McKenzie Lake	Control	x			1185	71
Burnett	Devils Lake	Control	x	x	x	1001	24
Burnett	Lipsett Lake	Control	x	x	x	393	24
Burnett	Sand Lake	Control	x	x	x	962	73
Burnett	Yellow Lake	Control	x			2287	31
Douglas	Lake Nebagamon	Control	x	x	x	914	56
Douglas	Lower Eau Claire Lake	Control	x			802	41
Douglas	Whitefish Lake	Control	x		x	832	102
Florence	Keyes Lake	Control	x			202	77
Forest	Lake Metonga	Control	x	x	x	1991	79
Forest	Pine Lake	Control	x			1670	14
Lincoln	Bridge Lake	Control		x		418	17
Lincoln	Deer Lake	Control		x		152	53
Lincoln	Lake Nokomis	Control		x		2433	33
Lincoln	Rice River Flowage	Control		x		920	26
Lincoln	Seven Island Lake	Control	x			138	31
Marathon	Big Eau Pleine Reservoir	Control	x			6830	46
Marathon	Pike Lake	Control	x			205	34
Oconto	Wheeler Lake	Control	x			293	35
Oneida	Carrol Lake	Control		x		352	27
Oneida	Clear Lake	Control	x	x	x	846	95
Oneida	Lake Thompson	Control	x	x		382	35
Oneida	Madeline Lake	Control		x		159	17
Oneida	Two Sisters Lake	Control	x	x		719	63
Polk	Balsam Lake	Control	x	x	x	2054	37
Polk	Big Butternut Lake	Control	x	x	x	378	19
Polk	Half Moon Lake	Control	x	x	x	579	60
Polk	Pipe Lake	Control	x			270	68
Sawyer	Lac Court Oreilles	Control	x	x	x	5039	90
Sawyer	Nelson Lake	Control	x			2503	33
Sawyer	Whitefish Lake	Control	x	x	x	786	105
St. Croix	Cedar Lake	Control	x		x	1107	28
Vilas	Ballard Lake	Control	x	x	x	505	25
Vilas	Big Lake	Control	x			790	30
Vilas	Black Oak Lake	Control	x			584	85
Vilas	Irving Lake	Control	x	x	x	403	8
Vilas	Lac Vieux Desert	Control		x		2853	38
Vilas	Long Lake	Control	x		x	872	95
Vilas	Papoose Lake	Control	x			428	65
Vilas	Snipe Lake	Control	x	x	x	239	15
Vilas	Trout Lake	Control	x	x	x	3816	117
Vilas	White Birch Lake	Control	x	x	x	117	27
Vilas	Wolf Lake	Control	x			393	28
Washburn	Gilmore Lake	Control	x	x		389	36
Washburn	Long Lake	Control	x	x	x	3290	74
Washburn	Middle McKenzie Lake	Control	x		x	530	45
Ashland	English Lake	Treatment	x	x		244	40
Chippewa	Lake Wissota	Treatment	x	x	x	6300	72
Chippewa	Long Lake	Treatment	x	x	x	1052	96
Forest	Butternut Lake	Treatment	x	x	x	1292	42
Iron	Long Lake	Treatment	x	x	x	373	30
Sawyer	Grindstone Lake	Treatment	x	x	x	3111	60
Vilas	Big Portage Lake	Treatment	x	x		638	40
Vilas	Forest Lake	Treatment	x		x	466	60
Vilas	Lost Canoe Lake	Treatment	x			249	41
Vilas	Plum Lake	Treatment	x	x	x	1108	57
Vilas	White Sand Lake	Treatment	x			728	71

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biological parameters. However, Nate et al. (2003) suggest that while physical factors in Wisconsin lakes are effective at predicting lakes where walleyes are present versus those where they are absent, these factors are not effective at separating walleye populations that are supported by stocking from those that are supported through natural reproduction. This conclusion suggests that all lakes that contain walleyes in northern Wisconsin are at least roughly similar with regard to physical variables.

Population estimate information was available from 44 lakes that retained the 15-inch minimum length limit and 11 lakes where the slot limit was in place. Creel survey information was available from 30 lakes that retained the 15-inch minimum length limit and eight lakes where the slot limit was in place. Two lakes had no records of harvested walleyes in the post regulation time period so these were excluded from comparisons of mean length of walleye harvested. Finally, length of age-4 males was available from 23 lakes that retained the 15-inch minimum length limit and seven lakes where the slot limit was in place.

The inclusion of a variety of lake types accurately represented natural variability in the region and facilitated determination of mean effects of the regulation and tribal harvest intensity. Throughout the study period, the maximum bag limit on all lakes was five. However, bag limits were less than five on many lakes based on the level of tribal harvest for each specific lake and year.

Data for this study were obtained from creel surveys and fish sampling efforts during 1990-2008. During this time period, approximately 10-20 lakes were randomly selected for sampling from all lakes that contained walleyes in the Ceded Territory. Fish sampling was conducted shortly after ice out. Walleyes were captured with fyke nets, marked, measured to the nearest 0.5 inch, and released. All walleyes whose sex could be determined and all walleyes greater than or equal to 15 inches (the length at which most walleyes mature) were marked with a lake-specific fin clip (Beard et al. 1997). Walleyes of unknown sex and shorter than 15 inches in length were marked by partial removal of a different fin. One to two days after marking was completed, the entire shoreline was electrofished and all unmarked walleyes were marked and measured to the nearest 0.5 inch. Approximately 2-3 weeks later, the entire shoreline was electrofished a second time to estimate the total walleye population. Walleye population estimates were calculated using the Chapman modification of a Petersen population estimate (Ricker 1975) for fish of four length categories.

During sampling, bony structures were removed for age estimation from a subset of fish (up to five walleyes of each sex per 0.5-inch interval for each lake). Scales were removed from walleyes less than 12 inches in length, and a dorsal spine was removed from walleyes 12 inches in length or greater. These walleyes were measured to the nearest 0.1 inch.

Additional data used to evaluate the slot limit were collected through creel surveys. Surveys began the first Saturday in May (the walleye angling season opening in Wisconsin) and continued through March 1 of the following year (the closure of the walleye angling season in most Wisconsin waters). The month of November was excluded in all years due to extremely low effort. A random stratified creel design was used (Pollock et al. 1994, Rasmussen et al. 1998). The surveys were stratified by month and day type (weekend and holidays or weekday). All weekend days and holidays, and 2-3 randomly selected weekdays per week were sampled. During the open-water season, sampling occurred each day that was selected for one-half of the period from 0.5 hours before sunrise to 0.5 hours after sunset. One of these clerk shifts was randomly selected for each day sampled. During the ice-fishing season, clerks sampled the entire day due to the relatively short day length. Clerks recorded effort, catch, harvest, and lengths and marks of harvested fish. Effort was estimated by random instantaneous counts of anglers (Rasmussen et al. 1998). Information from these counts and interviews was expanded over the appropriate strata to estimate total effort, catch, and harvest.

Results

Comparisons of walleye populations over time and between regulation categories showed few significant differences. There were no significant differences in the abundance of walleyes of any of the length classes we examined either over time or between regulation categories. There were four significant differences between lakes that received the slot limit regulation and those that retained the 15-inch minimum length limit. Harvest per hour, catch per hour, and catch per acre were all higher and mean length of age-4 males was lower in the set of lakes selected to receive the slot limit regulation compared to those that retained the 15-inch minimum length limit (Table 2). There was one significant difference between the time periods we examined. There was significantly less directed effort per acre in the post regulation time period than in the pre-regulation time period (Table 2). Finally, there were two instances where the interaction between time and regulation was significant. The significance of the interaction term suggests that these changes were caused by, or are at least associated with, the slot limit regulation. Mean length harvested decreased significantly and harvest per acre increased over time in lakes that received the slot limit regulation when compared to those that retained the 15-inch minimum length limit (Table 2).

The sample sizes necessary to detect a 30% change in the variables with $\alpha = 0.05$ and $\beta = 0.20$ are relatively large. Sample sizes range from 3 to 1,491, with a median value of 71 (Table 3).

Table 2. ANOVA results. Significant results are shown in **bold**.

Survey Type	Fisheries Metric	Effect	Difference	df	*F*	*P*
Population Estimate	Adults/acre	Regulation	0.08	54	0.01	0.92
		Time	0.31	54	0.63	0.43
	0-12-inch adults/acre	Regulation	0.12	54	0.09	0.76
		Time	0.05	54	0.22	0.64
	12-15-inch adults/acre	Regulation	-0.24	54	0.35	0.56
		Time	0.02	54	0.56	0.46
	15-20-inch adults/acre	Regulation	-0.06	54	0.07	0.79
		Time	0.14	54	0.81	0.37
	>20-inch adults/acre	Regulation	0.25	54	2.9	0.09
		Time	-0.09	54	1.09	0.3
Creel	**Catch/hr**	**Regulation**	**-0.27**	**37**	**14.57**	**<0.01**
		Time	-0.04	37	0.94	0.34
	Harvest/hr	**Regulation**	**-0.03**	**37**	**7.01**	**0.01**
		Time	-0.02	37	4.04	0.05
	Mean length harvested (in)	**Interaction**	**-1.82**	**34**	**6.31**	**0.02**
	Total effort (hr/acre)	Regulation	10.78	37	2.68	0.11
		Time	2.41	37	0.9	0.35
	Directed effort (hr/acre)	Regulation	-2.07	37	1.17	0.29
		Time	**2.93**	**37**	**8.16**	**<0.01**
	Mean length of age-4 males (mm)	**Regulation**	**1.14**	**29**	**5.68**	**0.0239**
		Time	-0.24	29	0.85	0.364
	Catch/acre	**Regulation**	**-2.91**	**37**	**16.03**	**<0.01**
		Time	**0.28**	**37**	**0.26**	0.61
	Harvest/acre	**Interaction**	**0.51**	**36**	**5.89**	**0.02**

Table 3. Sample sizes necessary to detect a change of 30% from the mean value for fisheries metrics of interest when employing a two-tailed *t*-test.

Survey Type	Fisheries Metric	Mean	Standard Deviation	30% of Mean	Sample Size Required
Population Estimate	Adults/acre	2.87	2.79	0.86	84
	0-12-inch adults/acre	0.35	1.46	0.11	1491
	12-15-inch adults/acre	1.10	1.53	0.33	181
	15-20-inch adults/acre	1.10	0.97	0.33	71
	>20-inch adults/acre	0.34	0.32	0.10	81
Creel	Catch/hr	0.16	0.21	0.05	146
	Harvest/hr	0.03	0.02	0.01	41
	Mean length harvested (in)	18.03	1.27	5.41	3
	Total effort (hr/acre)	31.20	20.76	9.36	40
	Directed effort (hr/acre)	10.69	6.99	3.21	40
	Mean length of age-4 males (in)	14.02	1.20	4.21	3
	Catch/acre	2.16	3.26	0.65	200
	Harvest/acre	0.37	0.33	0.11	71

Discussion

Correct assessment of the characteristics of walleye populations prior to the point in time when an angling regulation is implemented is an important component in achieving management goals. Selection of walleye populations that do not have characteristics that are requisite for a particular regulation category can result in management goals not being achieved (Fayram and Schmalz 2006). For example, if a length-based regulation is intended to increase growth in slow growing walleye populations but the walleye populations that receive the regulation are actually not experiencing slow growth, the management goal is less likely to be met. Kerr et al. (2004) stated that the rationale for many length-based regulations was poor for a number of regulations in Ontario. It appears that lakes that received the slot limit regulation, however, did in fact have most of the characteristics that were used to include these lakes for a regulation change. The lakes that received the slot limit had somewhat slow growing (as evidenced by the significantly smaller length of age-4 males) and possibly high density walleye populations (as evidenced by the significantly higher catch rate and harvest rate). However, the lakes that received the slot limit were probably not dramatically higher in density given the lack of significant differences in population estimate variables.

The intended and expected changes to walleye populations experiencing the slot limit were realized for some variables and were not detected for others. Harvest increased as a result of the slot limit regulation and the spawning stock was generally protected, results similar to those obtained by Fayram et al. (2000) who found that the institution of a 15-inch minimum length limit for walleyes reduced harvest but generally found no changes in walleye population density when compared to the absence of any length-based regulation. Since the slot limit allows the harvest of walleyes shorter than 14 inches in length, it stands to reason that the population density response would be similar to the absence of a minimum length regulation. However, modeling efforts (Hewett and Simonson 1998) suggested that the slot limit would result in an increase in spawning stock size, a decrease in catch rate, and an increase in harvest per hour, none of which were detected.

Population level effects of the slot limit were generally not evident. The inability to detect population level effects could have been due to the relatively small changes that were expected, low power to detect changes, absence of changes, or changes in angler effort. The expected changes associated with the slot limit were a 7% increase in spawning stock, a 16% decrease in catch per hour, and a 44% increase in harvest per hour (Hewett and Simonson 1998). Given the relatively low power available to detect these rather small changes, it is possible that the slot limit was achieving the stated management goals, but we were unable to detect them. In addition, some of the population metrics included in this investigation were obtained in as little as three years after the implementation of the slot limit. Data collected from a longer time period after the regulation had been implemented would have a greater chance of detecting significant changes (Allen and Pine 2000). Similarly, Isermann (2007) detected no changes in abundance, size structure, or age structure in two walleye populations subject to a 14-inch minimum length limit and a 15-inch minimum length limit and suggested that in light of recruitment variability, long-term sampling efforts would be required to adequately evaluate length limits. Population level effects of the slot limit were potentially not realized due to the fact that while harvest did increase after the slot limit was enacted, it did not increase as much as might have been expected because angler effort declined by almost 3 hours per acre over time. Fayram and Schmalz (2006) also documented a decrease of 1.6 hours per acre between 1990 and 2003 and attributed the fact that many of the management goals associated with a modified bag limit were not met in part due to this decrease in angler effort.

The sample sizes needed to detect changes in parameters depend both on whether a 30% change represents a small or large change in a biological context and on the variability of the parameter. Very low sample sizes were required to detect 30% change in indices related to the length of walleyes. A 30% change in mean length of age-4 males and mean length harvested is between 3 and 5 inches. This change is biologically a very large one and roughly equates to one year of growth in Wisconsin (Becker 1983). Very large sample sizes are associated with population level metrics. Allen and Pine (2000) also found that changes in fisheries metrics such as catch and population density information were less likely to be detectable than other measures such as proportional stock density.

Although the predicted responses to the slot limit were not all realized, additional harvest opportunities were available without any detectable change to the populations. Providing additional harvest opportunities would be particularly desirable for walleye fisheries since a relatively high proportion of legal length walleye are harvested when compared to other species (Fayram 2003).

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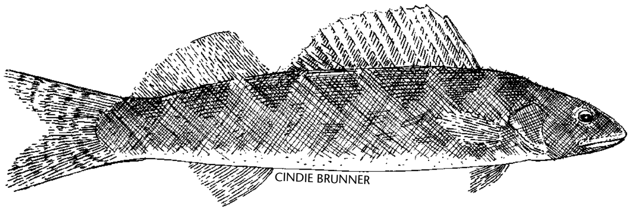

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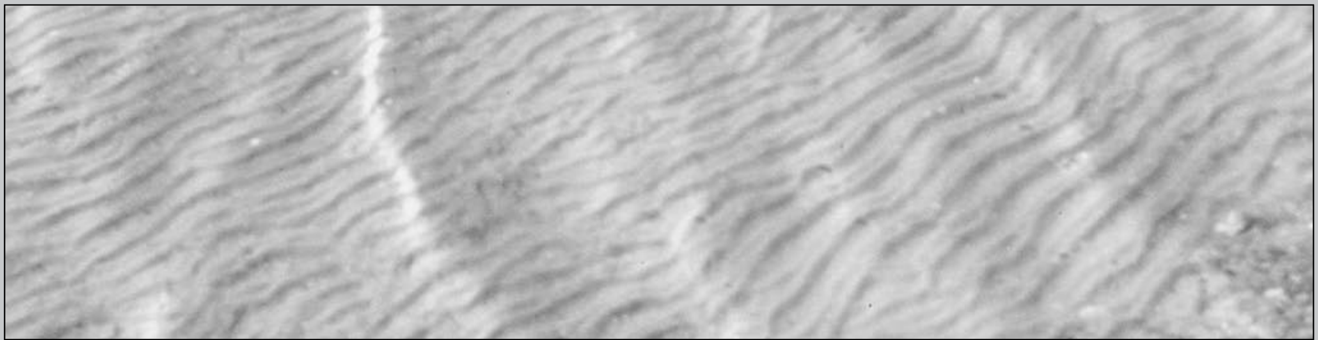

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Center for Excellence –
providing expertise for science-based decision-making

We develop and deliver science-based information, technologies, and applications to help people make well-informed decisions about natural resource management, conservation, and environmental protection.

Our Mission: The Bureau of Science Services supports the Wisconsin Department of Natural Resources and its partners by:

- conducting research and acquiring original knowledge.
- analyzing new information and emerging technologies.
- synthesizing information for policy and management decisions.
- applying the scientific method to the solution of environmental and natural resources problems.
- providing science-based support services for department initiatives.
- collaborating with local, state, regional, and federal agencies and academic institutions in Wisconsin and around the world.

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