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SURVIVAL AND GROWTH OF MUSKELLUNGE FINGERLINGS STOCKED IN FOUR VILAS COUNTY, WISCONSIN LAKES

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ABSTRACT

Four-, eight- and twelve-inch muskellunge fingerlings were stocked at the rate of 4/acre in four Vilas County lakes in 1976 and 1977, and their subsequent survival and growth were evaluated. Short- and long-term survival of all three size groups was similar in Arrowhead Lake for fish stocked in 1976, while short- and long-term survival for muskellunge fingerlings stocked in Arrowhead Lake in 1977 was highest for stocked 12-inch fingerlings. Survival was also highest for the 12-inch fingerlings stocked in Brandy and Johnson lakes in both 1976 and 1977, while survival of all three size groups in Sparkling Lake was negligible both years. Growth of the muskellunge fingerlings stocked in Arrowhead Lake was better than the growth of fingerlings in hatchery rearing ponds. The good survival and growth of fingerlings stocked in Arrowhead Lake can probably be attributed to the low density of northern pike and other potential predators, and an abundant supply of young-of-the-year yellow perch in 1976 and 1977. The yellow perch probably provided a food source for the stocked muskellunge and served as a buffer from would-be predators.

This study indicated that small muskellunge fingerlings (approximately 4 inches) can contribute to a sport fishery when stocked in a lake with a low density of predators and a good supply of suitable forage. It is recommended that only large (12 inches or larger) fingerlings be stocked where there is a moderate-to-large northern pike (predator) population.

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INTRODUCTION

The increasing expense of hatchery production requires that fish management techniques be investigated and developed to reduce propagation costs without sacrificing the contribution of the hatchery product to angling. One way to decrease the costs of the current muskellunge (Esox masquinongy) propagation program in Wisconsin would be to harvest and distribute the hatchery-reared fingerlings at smaller sizes. Much of the expense of the program is the result of obtaining live food to raise the fingerlings to larger lengths.

Until recently, little research was conducted to determine the survival of muskellunge fingerlings in relation to their size at stocking. Johnson (1982) reported no significant difference between the survival of small muskellunge fingerlings (6.5- to 11.0-inch) vs. large muskellunge fingerlings (8.5- to 13.0-inch) in several studies conducted between 1972 and 1975. The difference in total length between the maximum length of the "small fish group" and the minimum length of the "large fish group" was usually only 0.1 inch in most of the trials and may have confounded the results of the study. In other work, Johnson (1982) reported better survival of 9.5-inch fingerlings when compared with 2.5-inch fish in eight lakes ranging in size from 42 to 5,000 acres.

The present study was designed to evaluate the survival of 4-, 8- and 12-inch stocked muskellunge fingerlings in four Vilas County lakes and determine what factors may have been important to their subsequent survival. The size groups were chosen for two reasons. First, the number of muskellunge in the hatchery ponds is usually reduced in late June by stocking the fish when they are approximately 4 inches long. This procedure decreases losses due to cannibalism and reduces the amount of food that the hatchery must supply to fish. Secondly, in the past few years most of the fish managers have requested fingerlings that are at least 8 inches in length, and many request fish up to 12 inches long.

STUDY AREA

Four Vilas County lakes were selected for this study because of their similar size (<150 acres), easy access, proximity to Woodruff, and similar water chemistries (Table 1). Arrowhead, Brandy and Johnson lakes have similar chemical and physical characteristics and are connected by a stream which flows out of Arrowhead Lake, through Brandy Lake, and into Johnson Lake. Sparkling Lake is similar in size and water hardness (as indicated by alkalinity and conductivity values) to the other lakes but is a seepage (landlocked) lake having water of much higher transparency.

Brandy Lake had the greatest density of rooted aquatic vegetation when compared to the other study lakes, followed by Johnson, Arrowhead and Sparkling lakes (Table 2). Only six macrophyte species were observed in Sparkling Lake and each was classified as scarce.

The fish communities observed during spring and fall boom-shocking collections (fall 1976 through fall 1979) varied considerably among the study lakes (Table 3). The fisheries of Brandy and Johnson lakes could be characterized mostly as Esocid-Centrarchid-Catostomid complexes, while the fish community of Arrowhead Lake was dominated by Esocid-Percid species. The Sparkling Lake fishery was basically an Esocid-Percid-Centrarchid community.

TABLE 1. Morphological, chemical and physical data on the four study lakes in Vilas County, Wisconsin.*

Lake	Surface Area (acres)	Maximum Depth (ft)	Water Source	Methyl Orange Alkalinity (ppm)	pH	Conductivity (μmhos @ 77 F)	Secchi Disc Transparency (ft)
Arrowhead	99	43	spring	38	6.8	99	10.5
Brandy	110	44	drainage	36	6.6	87	9.5
Johnson	78	42	drainage	45	7.4	98	6.0
Sparkling	127	64	seepage	25	7.4	92	30.5

*Data from Black et al. (1963).

TABLE 2. The relative abundance of rooted aquatic macrophytes in the study lakes on 20 July 1976.*

Scientific name	Common Name	Lake			
		Arrowhead	Brandy	Johnson	Sparkling
Equisetum sp.	Horsetail	s	-	-	-
Isoetes sp.	Quillwort	-	-	c	s
Typha sp.	Cattail	c	c	c	-
Sparganium sp.	Burreed	s		c	
Najas flexilis	Slender naiad	a	a	c	s
Potamogeton pectinatus	Comb pondweed	c	c	-	-
P. amplifolius	Largeleaf pondweed	a	a	a	-
P. gramineus	Grassleaf pondweed	c	c	s	s
P. epihydrus	Ribbonleaf pondweed	a	c	s	-
P. Robbinsii	Fern pondweed	-	a	a	-
P. praelongus	Whitestem pondweed	-	a	s	-
P. zosteriformis	Flatstem pondweed	c	c	c	-
Sagittaria sp.	Arrowhead	c	c	s	-
Elodea canadensis	Waterweed	s	c	a	-
Vallisneria americana	Eel grass	s	-	-	-
Dulichium arundinaceum	Pond sedge	s	-	s	-
Eleocharis sp.	Spikerush	s	-	s	-
Scirpus sp.	Bulrush	s	s	s	-
Calla palustris	Water arum	-	-	-	s
Eriocaulon septangulare	Pipewort	-	-	s	-
Pontederia cordata	Pickerel weed	c	c	-	-
Juncus spp.	Rush	s	a	-	-
Polygonum amphibium	Water knotweed	-	-	s	s
Ceratophyllum demersum	Hornwort	-	c	c	-
Nymphaea odorata	Fragrant water lily	a	-	a	-
Nuphar variegatum	Bullhead pond lily	c	c	-	-
Myriophyllum exalbescens	Spiked water milfoil	-	a	a	-
Utricularia vulgaris	Great bladderwort	s	-	-	-
Lobelia sp.	Lobelia	-	-	-	s
Relative abundance of all rooted aquatic macrophytes		c	a	c-a	s

*s = scarce, c = common, a = abundant.

TABLE 3. Relative abundance of the gamefishes and panfishes observed in the study lakes during fall electrofishing runs from 1977-79.

Species Observed*	Relative Abundance** of Fish in Study Lakes			
	Arrowhead	Brandy	Johnson	Sparkling
Cisco	p	no	p	no
Northern pike	p	a	c	no
Muskellunge	c	p	c	c
Bluegill	p	a	a	no
Smallmouth bass	no	no	no	c
Largemouth bass	p	c	c	no
Black crappie	c	a	c	no
Yellow perch	a	p	c	c
Walleye	p	p	p	c

*Common names from Scott and Crossman (1973).
**no = none observed, p = present, c = common, a = abundant.

METHODS

Each lake was stocked in 1976 and 1977 with 4-, 8- and 12-inch muskellunge fingerlings (Table 4). All fingerlings were fin clipped without anesthesia and were held overnight in a hatchery trough before stocking. At the time of planting, a sample of the fingerlings (thirty 4-inch, twenty 8-inch, and ten 12-inch) were held in a 4x3x3-ft cage in each lake without food to assess immediate mortality as a result of stress from fin clipping, transportation, handling and stocking. Surface water temperatures were recorded to the nearest 0.5 F in each lake on each stocking date.

During 1976 the entire shoreline of each lake was electrofished with a 230-volt AC boom shocker approximately one month after each size group was stocked to determine mortality during the first month. In addition, the number of surviving muskellunge of each size group stocked in 1976 was estimated in each lake every fall and spring beginning with the fall of 1976 and continuing through the fall of 1979. The survival of muskellunge of each length group stocked in 1977 was estimated in the fall of 1977 and the spring and fall of 1978 and 1979 using the Schnabel multiple mark-recapture method (Ricker 1975). Dates of spring and fall electrofishing from the fall of 1976 through the fall of 1979 were: fall 1976 -- 19 October-4 November; spring 1977 -- 5-16 May; fall 1977 -- 18 October-1 November; spring 1978 -- 15-18 May; fall 1978 -- 24 October-1 November; spring 1979 -- 21-23 May; fall 1979 -- 6-8 November.

TABLE 4. Data on the fingerlings belonging to each size group that were stocked in each of the study lakes in 1976 and 1977.

Year Stocked	Date Stocked	Size Group (inches)	Mean Length (± 2 SD) at Stocking (inches)	Fin Clip**	No. stocked (@ 4/surface acre) in Study Lakes* A	B	J	S
1976	6/29	4	3.9 ± 0.6	LV	396	440	312	508
	8/10	8	8.0 ∓ 1.2	RV	396	440	312	508
	9/21	12	11.6 ∓ 1.6	BV	396	440	312	508
1977	6/29	4	5.5 ± 0.6	RP	396	440	312	508
	7/20	8	8.4 ∓ 0.6	LP	396	440	312	508
	9/14	12	12.1 ∓ 1.0	AN	396	440	312	508

*A = Arrowhead, B = Brandy, J = Johnson, and S = Sparkling.
**LV = left ventral, RV = right ventral, BV = both ventrals, RP = right pectoral, LP = left pectoral, and AN = anal.

Annual survival rates and monthly instantaneous total mortality rates from the time of stocking to each subsequent sampling date were determined for each size group in each lake (Ricker 1975). Catch/effort (number caught/net-day) data were determined for adult muskellunge from the 1976 and 1977 stockings in spring fyke net (1-inch^2 mesh) surveys conducted in 1981 and 1982.

All stocked fish captured for the first time in any electrofishing survey from 1976-79 or a fyke netting survey in 1981 (12-30 April) and 1982 (4-10 May) were measured for total length to the nearest 0.1 inch and given a temporary fin clip. For each sampling date, the mean length of each size group stocked and the growth increment from stocking to subsequent recapture were determined.

RESULTS

There was little immediate mortality in any size group of fingerlings held in live cages for 48 hours after planting (1976 and 1977), indicating mortality due to stress from handling, fin clipping and stocking procedures was minimal (Table 5).

An attempt was made to capture the stocked fingerlings by electrofishing one month after they were introduced. However, none of the 4-inch fingerlings were captured in late July and not enough 4- or 8-inch fingerlings were caught in early September in any of the study lakes to allow for an estimation of population size. Several of the fingerlings stocked at 4 and 8 inches were caught during the autumn shocking period (late October-early November); thus it appears that these fish were not inhabiting inshore areas during the summer collecting period.

Initial survival of 4- and 8-inch fingerlings and long-term survival of 12-inch fingerlings was higher in Arrowhead Lake than in the other three bodies of water (Tables 6 and 7). While initial survival of 12-inch fingerlings was good in Johnson and Brandy lakes, few of these fish were alive by the fall of the year following stocking and few were caught as adults in the springs of 1981 and 1982. Both short- and long-term survival of muskellunge fingerlings in Sparkling Lake was marginal.

TABLE 5. Immediate mortality (within 48 hours) of muskellunge fingerlings held in live cages in Arrowhead, Brandy, Johnson and Sparkling lakes, Vilas County, in 1976 and 1977.

Year	Size Group (inches)	No. of Fingerlings In Live Cages In Each Lake	No. of Caged Fingerlings Dying Within 48 hours* A	B	J	S
1976	4	30	0 (0)**	2 (6)	0 (0)	1 (3)
	8	20	0 (0)	1 (5)	0 (0)	0 (0)
	12	10	0 (0)	0 (0)	0 (0)	2 (20)
1977	4	30	0 (0)	0 (0)	0 (0)	0 (0)
	8	20	0 (0)	0 (0)	0 (0)	0 (0)
	12	10	0 (0)	0 (0)	0 (0)	0 (0)

*A = Arrowhead, B = Brandy, J = Johnson, and S = Sparkling.
**Percentages in parentheses.

TABLE 6. Population, percent annual survival, and monthly instantaneous total mortality (Z) rate estimates calculated for muskellunge fingerlings stocked in 1976 and 1977 and sampled spring and fall through 1979.

Lake	Size Group at Stocking (inches)	No. Stocked	Date Stocked	Mean Length at Stocking (inches)	Sampling Period** Fall 1976	Spring 1977	Fall 1977	Spring 1978	Fall 1978	Spring 1979	Fall 1979
Arrowhead	4	396	6/29/76	3.9	91 (23) 0.37	91 (23) 0.14	6 (2) 0.26	24 (6) 0.13	14 (4) 0.12	*	*
	8	396	8/10/76	8.0	124 (31) 0.46	131 (33) 0.12	33 (8) 0.22	17 (4) 0.15	11 (3) 0.15	*	*
	12	396	9/21/76	11.6	164 (41) 0.88	161 (41) 0.12	24 (6) 0.22	22 (6) 0.15	9 (2) 0.15	*	*
	4	396	6/29/77	5.5			60 (15) 0.47	7 (2) 0.38	18 (5) 0.19	5 (1) 0.20	*
	8	396	7/26/77	8.4			135 (34) 0.36	26 (7) 0.30	30 (8) 0.17	10 (3) 0.18	*
	12	396	9/14/77	12.1			254 (64) 0.44	108 (27) 0.17	70 (18) 0.13	54 (14) 0.10	*
Johnson	4	312	6/29/76	3.9	21 (7) 0.67	4 (1) 0.42	*	*	*	*	*

TABLE 6 Continued.

Lake	Size Group at Stocking (Inches)	No. Stocked	Date Stocked	Mean Length at Stocking (Inches)	Sampling Period** Fall 1976	Spring 1977	Fall 1977	Spring 1978	Fall 1978	Spring 1979	Fall 1979
	8	312	8/10/76	8.0	111 (36) 0.41	80 (26) 0.15	12 (4) 0.22	*	12 (4) 0.12	*	*
	12	312	9/21/76	11.6	186 (59) 0.51	62 (20) 0.22	*	*	*	*	*
	4	312	6/29/77	5.5			*	*	9 (3) 0.22	*	*
	8	312	7/26/77	8.4			23 (7) 0.87	9 (3) 0.39	8 (3) 0.24	*	*
	12	312	9/14/77	12.1			178 (57) 0.56	67 (21) 0.21	27 (9) 0.18	*	*
Brandy	4	440	6/29/76	3.9	*	*	*	*	*	*	*
	8	440	8/10/76	8.0	32 (7) 1.05	4 (1) 0.45	*	*	*	*	*
	12	440	9/21/76	11.6	265 (60) 0.51	36 (8) 0.31	*	*	*	*	*
	4	440	6/29/77	5.5			*	*	*	*	*
	8	440	7/26/77	8.4			69 (16) 0.62	46 (10) 0.25	5 (1) 0.30		
	12	440	9/14/77	12.1			335 (76) 0.27	125 (28) 0.17	6 (1) 0.32	*	*
Sparkling	4	508	6/29/76	3.9	*	*	*	*	*	*	*
	8	508	8/10/76	8.0	*	*	*	*	*	*	*
	12	508	9/21/76	11.6	*	*	*	*	*	*	*
	4	508	6/29/77	5.5	*	*	*	*	*	*	*
	8	508	7/26/77	8.4	*	*	*	*	*	*	*
	12	508	9/14/77	12.1	*	*	*	*	*	*	*

*Too few captured to allow an estimate of density using multiple mark-recapture techniques.
**Listed from top to bottom for each fall and spring sampling period are population (Schnabel), percent annual survival (in parentheses), and monthly instantaneous total mortality (Z) estimates.

There appeared to be little difference in survival of the three size groups stocked in Arrowhead Lake in 1976; however, the 12-inch fingerlings stocked in 1977 exhibited better survival than either the 4-inch or 8-inch fingerlings. Monthly instantaneous mortality rates were highest for 12-inch fish sampled in fall 1976 (approximately 1.5 months after stocking) when compared to rates for 8-inch fish (3 months after stocking) and 4-inch fish (5 months after stocking). However, in subsequent samplings monthly estimates of instantaneous mortality were similar for the three size groups. Estimates of monthly instantaneous mortality were similar for the three size groups stocked in 1977 when sampled in the fall of that year, but were lower for the 12-inch fish during subsequent sampling periods (Table 6).

Water temperatures at the time of stocking (Table 8) did not appear to affect survival of the muskellunge fingerlings in this study (Tables 6 and 7). For instance, short- and long-term survival was higher for 4-inch muskellunge fingerlings stocked at warmer temperatures in 1976 than for the 1977 stocking in Arrowhead Lake. However, the 8-inch fish from the 1976 plant also survived better than the 1977 stocking, but the water temperatures at the time they were stocked in 1976 were cooler than in 1977 (Tables 6, 7 and 8).

Mean total lengths of muskellunge collected in Arrowhead Lake at various times after stocking were higher for the fingerlings stocked at 4 inches than those stocked at 8 and 12 inches. In the other three lakes, no one group had higher mean lengths than another when sampled at various time intervals after stocking (Table 9).

TABLE 7. Total catch of muskellunge stocked in 1976 and 1977 in spring fyke net surveys conducted in 1981 and 1982.

Lake	Size Group at Stocking (Inches)	No. Stocked	Date Stocked	Spring 1981		Spring 1982	
				Catch	Net-days Effort	Catch	Net-days Effort
Arrowhead	4	396	6/29/76	7	35	15	42
	8	396	8/10/76	6	35	16	42
	12	396	9/21/76	3	35	11	42
	4	396	6/29/77	0	35	8	42
	8	396	7/26/77	3	35	11	42
	12	396	9/14/77	5	35	27	42
Johnson	4	312	6/29/76	*		2	12
	8	312	8/10/76	*		2	12
	12	312	9/21/76	*		0	12
	4	312	6/29/77	*		0	12
	8	312	7/26/77	*		0	12
	12	312	9/14/77	*		2	12
Brandy	4	440	6/29/76	0	18	0	12
	8	440	8/10/76	0	18	0	12
	12	440	9/21/76	0	18	1	12
	4	440	6/29/77	2	18	0	12
	8	440	7/26/77	0	18	0	12
	12	440	9/14/77	0	18	1	12
Sparkling	4	508	6/29/76	0	14	1	15
	8	508	8/10/76	0	14	0	15
	12	508	9/21/76	0	14	0	15
	4	508	6/29/77	0	14	0	15
	8	508	7/26/77	0	14	0	15
	12	508	9/14/77	0	14	0	15

*No netting done.

TABLE 8. Surface water temperatures at time of stocking in the four lakes, 1976 and 1977.

Year	Size Group at Stocking (inches)	Date Stocked	Water Temperature (°F)			
			Arrowhead	Brandy	Johnson	Sparkling
1976	4	6/29	73.0	69.5	73.0	70.0
	8	8/10	70.0	73.0	71.5	72.0
	12	9/21	60.0	58.5	62.0	62.0
1977	4	6/29	68.0	68.0	70.0	63.5
	8	7/27	74.0	72.0	75.0	74.0
	12	9/14	61.0	60.0	62.0	62.0

TABLE 9. Mean total lengths at capture, number measured, and growth increments since stocking for recaptured muskellunge (stocked as 4-, 8- or 12-inch fingerlings) in 1976 and 1977.

Lake	Size Group at Stocking (inches)	No. Stocked	Date Stocked	Mean Length at Stocking (inches)	Sampling Period**								
					Fall 1976	Spring 1977	Fall 1977	Spring 1978	Fall 1978	Spring 1979	Fall 1979	Spring 1981	Spring 1982
Arrowhead	4	396	6/29/76	3.9	12.5 (41) 8.6	13.1 (41) 9.2	17.9 (4) 14.0	19.2 (11) 15.3	23.6 (6) 19.7	28.3 (3) 19.9	*	30.4 (7) 26.5	32.6 (15) 28.7
	8	396	8/10/76	8.0	11.7 (73) 3.7	12.4 (57) 4.4	17.5 (15) 9.5	17.6 (11) 9.6	22.2 (6) 14.2	23.2 (5) 15.2	27.0 (1) 19.0	28.3 (6) 20.3	31.6 (16) 23.6
	12	396	9/21/76	11.6	12.0 (111) 0.4	12.3 (54) 0.7	17.3 (10) 5.7	18.3 (14) 6.7	23.1 (5) 11.5	23.3 (4) 11.7	*	27.9 (3) 16.3	31.2 (11) 19.6
	4	396	6/29/77	5.5			11.8 (31) 6.3	12.3 (7) 6.8	18.8 (6) 13.3	18.4 (5) 12.9	24.0 (1) 18.5	*	30.4 (8) 24.9
	8	396	7/26/77	8.4			11.8 (80) 3.4	12.2 (18) 3.8	18.4 (14) 10.0	18.3 (6) 9.9	*	26.6 (3) 18.2	29.4 (11) 21.0
	12	396	9/14/77	12.1			12.3 (227) 0.2	12.6 (63) 0.5	17.7 (43) 5.6	17.2 (23) 5.1	22.1 (2) 10.0	23.8 (5) 11.7	28.3 (27) 16.2
Johnson	4	312	6/29/76	3.9	10.7 (12) 6.8	11.0 (3) 7.1	15.5 (1) 11.6	15.8 (2) 11.9	*	*	*		32.1 (2) 28.2
	8	312	8/10/76	8.0	10.7 (61) 2.7	11.1 (29) 3.1	15.6 (6) 7.6	14.5 (4) 6.5	20.3 (6) 12.3	*	23.3 (1) 15.3		32.3 (2) 24.3
	12	312	9/21/76	11.6	11.9 (117) 0.3	12.1 (34) 0.5	15.8 (2) 4.2	14.8 (1) 3.2	22.1 (1) 10.5	*	*		*
	4	312	6/29/77	5.5			10.4 (4) 4.9	10.7 (3) 5.2	16.6 (5) 11.1	*	*		*
	8	312	7/26/77	8.4			10.3 (21) 1.9	10.6 (5) 2.2	16.1 (4) 7.7	*	*		*

TABLE 9 Continued.

Lake	Size Group at Stocking (inches)	No. Stocked	Date Stocked	Mean Length at Stocking (inches)	Sampling Period**								
					Fall 1976	Spring 1977	Fall 1977	Spring 1978	Fall 1978	Spring 1979	Fall 1979	Spring 1981	Spring 1982
	12	312	9/14/77	12.1			12.2 (112) 0.1	12.4 (35) 0.3	16.3 (16) 4.2	*	21.1 (4) 9.0		30.2 (2) 18.1
Brandy	4	440	6/29/76	3.9	10.7 (1) 6.8	*	*	*	*	*	*	*	*
	8	440	8/10/76	8.0	10.6 (14) 2.6	12.0 (4) 4.0	15.2 (2) 7.2	14.7 (2) 6.7	20.0 (1) 12.0	*	*	29.8 (2) 21.8	*
	12	440	9/21/76	11.6	11.8 (97) 0.2	12.2 (12) 0.6	14.4 (1) 2.8	14.8 (1) 3.2	20. (1) 8.4	*	*	*	32.7 (1) 20.9
	4	440	6/29/77	5.5			9.7 (1) 4.2	11.0 (2) 5.5	17.2 (1) 11.7	*	*	*	*
	8	440	7/26/77	8.4			10.8 (11) 2.4	10.8 (7) 2.4	15.1 (3) 6.7	*	*	*	*
	12	440	9/14/77	12.1			12.4 (125) 0.3	12.5 (62) 0.4	16.3 (4) 4.2	*	*	*	28.2 (1) 16.1
Sparkling	4	508	6/29/76	3.9	10.7 (2) 6.8	*	*	*	*	*	*	*	25.7 (1) 21.8
	8	508	8/10/76	8.0	11.3 (3) 3.3	18.1 (4) 10.1	23.6 (1) 15.6	*	*	*	*	*	*
	12	508	9/21/76	11.6	12.6 (5) 0.9		*	*	*	*	*	*	*
	4	508	6/29/77	5.5			12.4 (2) 6.9	12.6 (1) 7.1	17.9 (1) 12.4	*	*	*	*

TABLE 9 Continued.

Lake	Size Group at Stocking (inches)	No. Stocked	Date Stocked	Mean Length at Stocking (inches)	Sampling Period**								
					Fall 1976	Spring 1977	Fall 1977	Spring 1978	Fall 1978	Spring 1979	Fall 1979	Spring 1981	Spring 1982
	8	508	7/26/77	8.4			*	*	*	*	*	*	*
	12	508	9/14/77	12.1			12.6 (13) 0.5	12.8 (1) 0.7	19.1 (3) 7.0	*	*	*	*

*None captured on sampling date.
**Listed from top to bottom for each fall and spring sampling are mean total length at capture (inches), number captured (in parentheses), and mean growth increments since stocking (inches).

DISCUSSION

Immediate Mortality

The immediate mortality among fish confined to holding cages (48 hours) was negligible and indicated that fin clipping, handling and transport of the fingerlings were not traumatic. Miles et al. (1974) found that stress caused by fin clipping and transport of muskellunge fingerlings was minor compared with stress associated with initial pond seining.

Survival

Factors which have been associated with the survival of stocked muskellunge fingerlings in previous studies are: density of potential predators, density of rooted aquatic vegetation, forage availability, and water temperature at the time of stocking (Belusz 1978, Johnson 1982). Increased density of adult northern pike (Esox lucius) has been implicated in the decline of muskellunge populations and also in the survival of stocked muskellunge fingerlings (Oehmcke 1951, Scott and Crossman 1973, Johnson 1981). In laboratory studies, Caplan (1982) found that young-of-the-year northern pike compete with young-of-the-year muskellunge for food and they prey on the muskellunge as well.

In Arrowhead Lake, the low density of adult northern pike (<0.1 adult/net-day in spring netting surveys in 1981 and 1982), moderate aquatic vegetation density, and presence of large numbers of young-of-the-year perch in 1976 may be related to the superior survival of muskellunge fingerlings stocked in this lake in 1976 when compared with survival in the other study lakes.

Flickinger and Clark (1978) reported that the stocking success of 50-mm (2-inch) northern pike appeared to be directly related to availability of small forage fish, whereas these correlations were not evident with 377-mm (15-inch) northern pike. The poorer survival of the smaller (4- and 8-inch) fingerlings in Arrowhead Lake after stocking in 1977 may be due, in part, to the presence of large numbers of the surviving muskellunge stocked in 1976, as the other factors mentioned previously (i.e., large numbers of young-of-the-year yellow perch and few, if any, adult northern pike) appeared similar in both years.

The presence of high numbers of adult northern pike in Brandy Lake (12.7/net-day in 1981 and 4.3/net-day in 1982) and in Johnson Lake (4.2/net-day in 1982) and the shortage of small forage fishes (observed during electrofishing runs in 1976 and 1977) may have contributed to the poor initial survival of the 4- and 8-inch muskellunge fingerlings and the poor long-term survival of the 12-inch fingerlings in these lakes. Several muskellunge collected in the falls of 1976 and 1977 had open wounds on them, presumably from attacks by the abundant adult northern pike. Apparently, the large numbers of adult northern pike and low numbers of forage fish outweighed the benefit of dense rooted aquatic vegetation that should have helped protect muskellunge fingerlings in these two lakes.

The poorer survival of the 4- and 8-inch fingerlings stocked in Arrowhead Lake in 1977 versus those stocked in 1976 may have been due to the use of pectoral fin clips instead of pelvic (ventral) clips used on fish stocked in 1976. McNeil and Crossman (1979) found that removal of a pectoral fin had a more adverse effect on subsequent survival than excision of a pelvic fin. However, in Brandy Lake, survival of 4- and 8-inch fish stocked in 1977 (pectoral clipped) was greater than for fish of the same length stocked in 1976 (pelvic clipped). Johnson (1982) reported no differences in the survival rates of pelvic- and pectoral-clipped muskellunge fingerlings.

The short- and long-term survival rates of all three size groups of muskellunge fingerlings stocked in Sparkling Lake were negligible and may have been due to the paucity of rooted aquatic vegetation and lack of small forage fish (both as a food source and as a buffer from predators) in both 1976 and 1977. Northern pike predation did not contribute to the poor fingerling survival since no northerns were captured in 29 net-days of effort in the springs of 1981 and 1982 and none were observed in electrofishing runs conducted from 1976-79. Other potential predators, walleye (Stizostedion vitreum), smallmouth bass (Micropterus dolomieui) and burbot (Lota lota) were present and may have contributed to the low muskellunge survival.

Growth

Growth of muskellunge fingerlings, as indicated by mean lengths of recaptured fish collected at various intervals after stocking, appeared to be highest in Arrowhead Lake. Four-inch muskellunge stocked in this lake in 1976 and 1977 had consistently higher mean lengths when recaptured than their 8- and 12-inch counterparts. Perhaps the high density of forage fish (mainly young-of-the-year yellow perch (Perca flavescens)) allowed them to grow better in the lake than the 8- and 12-inch fish in the hatchery rearing ponds where there was probably more intense competition for the food resource. Mean lengths at capture of 4-, 8- and 12-inch fish in the other three lakes did not appear to be consistently higher for one group when they were captured on subsequent sampling dates. The lack of small forage fish in each of these lakes probably contributed to the slower growth.

SUMMARY

1) During 1976 and 1977, differentially fin clipped 4-, 8- and 12-inch muskellunge fingerlings were stocked in four Vilas County lakes at the rate of 4/acre of each size group.

2) Electrofishing surveys conducted one month after each stocking of 4- and 8-inch fingerlings in late June and early August, respectively, were unsuccessful at capturing these fish, yet electrofishing in late October to early November resulted in the collection of several of these fish.

3) A sample of the fingerlings (thirty 4-inch, twenty 8-inch, and ten 12-inch) held in live cages in the lakes for a 48-hour period after stocking exhibited negligible mortality. Immediate mortality after stocking as a result of handling, fin clipping and transportation and stocking was probably minimal.

4) Short- and long-term survival of all three size groups stocked in 1976 and the 12-inch fish stocked in 1977 was better in Arrowhead Lake than in Brandy, Johnson or Sparkling lakes. Factors that may have contributed to the higher survival of fingerlings in Arrowhead Lake were the lack of northern pike, good cover in the form of rooted aquatic vegetation, and abundant numbers of small forage. In the other lakes, one or more of these factors were absent.

5) The better short- and long-term survival of 12-inch fingerlings vs. 4- and 8-inch fish in Brandy and Johnson lakes may have been due to the larger fish's ability to withstand predation by the dense northern pike populations in these lakes.

6. Growth of the 4-inch fingerlings in Arrowhead Lake was better than in the Woodruff Hatchery rearing ponds, as these fish had higher mean lengths at capture in the autumns following stocking and in all subsequent samplings than those fingerlings stocked at 8 and 12 inches. This good growth was probably due to the abundant small forage supply both in 1976 and 1977 (mainly in the form of young-of-the-year yellow perch).

MANAGEMENT IMPLICATIONS

1) When assessing the survival of stocked muskellunge fingerlings, electrofishing surveys should not be conducted until mid- to late fall. In this study, the fingerlings were evidently not inshore during late July and early September samplings but were captured in mid October-early November and were inshore even when ice was beginning to form along the shoreline.

2) Small muskellunge fingerlings can contribute to a fishery if stocked in lakes where the numbers of large potential predators (particularly northern pike) are low, the presence of small available forage is high, and there is adequate cover. Beyerle (1981) stated that it may be biologically and economically more advantageous to stock small (3.5-inch) rather than large (7.0-inch) tiger muskellunge (Esox masquinongy x Esox lucius) in lakes with low predator densities. Gillen et al (1981), in a study of tiger muskellunge predation on minnows and bluegills, stated that stocking programs using small predators must be coordinated with the size and abundance of prey available because of the narrow size range of prey vulnerable to small predators. Lakes that do not meet the criteria to stock with small fingerlings should be stocked with larger fingerlings.

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