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A Review of Fish Control Projects

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Abstract.—We searched the fisheries literature to assess the success of fish control projects. We reviewed 250 control projects from 131 papers. Usually each treated body of water was considered a project. Fish control treatments were divided into four categories: chemical applications (145), physical removal and reservoir drawdowns (70), stocking of fish (29), and any combination of chemical and physical methods (6). Success was judged by changes in standing stock, growth, proportional stock density, relative weight values, catch or harvest rates, and other benefits, such as angler satisfaction. Reduction in standing stock was the most common determinant of success. Of the 250 projects, we considered 107 (43%) to be successful, 74 (29%) to be unsuccessful, and 69 (28%) to have insufficient data to determine success. The most successful projects targeted rough fish. Total elimination was more successful (63%) than partial reduction (40%) in 221 waters. Success was not strongly related to size of water body. Success of chemical application was similar for treatment with rotenone (48%) and with antimycin (45%). Success rates for physical removal methods (nets, traps, seines, electrofishing, drawdowns, and combinations of physical treatments) ranged from 33 to 57%. Stocking certain species of fish to control others was the least successful, 7 of 29 water bodies (24%). Combined chemical and physical methods were successful in 4 of 6 projects (66%). Stocking after chemical or physical treatment may have increased success of fish control projects; 10 of 17 such projects (59%) were successful, a higher percentage than for chemical treatments, physical treatments, or stocking alone. An overall success rate of less than 50% for such a large number and wide variety of projects indicates that there is considerable room for improvement of fish control projects. The large percentage of unsuccessful projects and the complexity of factors influencing fish communities suggest that control projects should include critical evaluation of assumptions and of suspected causes of problems, explicit rationale and objectives, and pretreatment and long-term posttreatment study.

Eradication or reduction of undesirable fish species is a common management practice. Large populations of rough fish or "stunted" panfish are often considered undesirable by management agencies and are subjected to fish control projects.

Lennon et al. (1970) reviewed the status of chemical control efforts up to 1970. They identified many successful and unsuccessful projects, as well as problems frequently affecting success, but they did not address success rates. We conducted a search of the fisheries literature to determine success rates of chemical and physical fish control methods, stocking, and combinations of these methods. We reviewed the results of 250 fish control projects reported in 131 papers from professional journals and agency publications and reports. The projects occurred on water bodies ranging from 0.2 to 55,752 ha and were located in 36 states and 3 countries.

Methods

We searched the fisheries literature using the following keywords: antimycin, rotenone, reclamation, rehabilitation, predator stocking, fish control, poisoning, removal, and thinning. Keyword searches were made on the National Information Services Corporation Wildlife Review and Fisheries Review, 1971–February 1994 (Baltimore, Maryland); the Fish and Wildlife Reference Service, 1953–1993 (Bethesda, Maryland); and the Cumulative Subject Index to the Monthly Catalog of United States Government Publications, 1900–1971. We also searched the contents of four journals: *North American Journal of Fisheries Management*, 1983–1993; *Transactions of the American Fisheries Society*, 1923–January 1994; *Progressive*

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Fish-Culturist, 1935–January 1994; and *Proceedings of the Southeastern Association of Game and Fish Commissioners,* 1947–1975, and subsequently, *Proceedings of the Southeastern Association of Fish and Wildlife Agencies,* 1976–1991. We conducted a search of the General Science Index and the computerized record holdings of the University of Wisconsin in Stevens Point, and we read pertinent literature cited in various papers.

Fish species were designated as game fish, panfish, or rough fish for this review (Table 1). Chemical treatments included those with rotenone, antimycin, copper sulfate, squoxin, and toxaphene. Physical treatments included removal of fish by nets and traps, seines, electrofishing, and subjecting target species to increased predation by means of reservoir drawdown.

Each paper was critically reviewed to determine success of the project. We judged success from changes in standing stock, growth, proportional stock density (PSD; Anderson 1976), relative weight (W_r; Wege and Anderson 1978), catch or harvest rates, other benefits (e.g., angler satisfaction), and the authors' conclusions (although we did not always agree). We drew our conclusions concerning success from evidence of the effectiveness of a control procedure that was provided in each paper. We did not use quantitative criteria for success, such as a certain percentage reduction or statistically significant change in standing stock or increase in PSD, because sufficient data were often lacking.

Sometimes authors considered a project successful when it was based on data collected for less than 1 year after treatment. We considered such short-term assessments to be successful only if the standing stock of the target species was reduced substantially. We considered reduction of standing stock a success if that was an objective of a project and evidence was provided that reduction occurred (e.g., reduction in estimates of weight per unit area or catch per effort). For the other measures of success, we required evidence of improvement obtained over a period exceeding 1 year after treatment.

Results

We considered 43% of the 250 projects successful, 29% unsuccessful, and 28% as having insufficient data to determine success or failure (Appendix Table A.1), whereas authors considered 54% of the projects successful, 29% unsuccessful, and 17% lacked sufficient data. Usually the reason for the difference was our judgment that evidence

TABLE 1.—Species in target categories of game fish, panfish, and rough fish.

Common name	Scientific name
Game fish	
Channel catfish	*Ictalurus punctatus*
Flathead catfish	*Pylodictis olivaris*
Northern pike	*Esox lucius*
Muskellunge	*Esox masquinongy*
Chain pickerel	*Esox niger*
Cutthroat trout	*Oncorhynchus clarki*
Rainbow trout	*Oncorhynchus mykiss*
Brown trout	*Salmo trutta*
Brook trout	*Salvelinus fontinalis*
Striped bass	*Morone saxatilis*
Smallmouth bass	*Micropterus dolomieu*
Largemouth bass	*Micropterus salmoides*
Walleye	*Stizostedion vitreum*
Panfish	
Black bullhead	*Ameiurus melas*
Yellow bullhead	*Ameiurus natalis*
Brown bullhead	*Ameiurus nebulosus*
White perch	*Morone americana*
Rock bass	*Ambloplites rupestris*
Redbreast sunfish	*Lepomis auritus*
Green sunfish	*Lepomis cyanellus*
Pumpkinseed	*Lepomis gibbosus*
Warmouth	*Lepomis gulosus*
Orangespotted sunfish	*Lepomis humilis*
Bluegill	*Lepomis macrochirus*
Redear sunfish	*Lepomis microlophus*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Yellow perch	*Perca flavescens*
Rough fish	
Paddlefish	*Polyodon spathula*
Gar	*Lepisosteus* spp.
Bowfin	*Amia calva*
Skipjack herring	*Alosa chrysochloris*
Alewife	*Alosa pseudoharengus*
Gizzard shad	*Dorosoma cepedianum*
Threadfin shad	*Dorosoma petenense*
Goldfish	*Carassius auratus*
Redside dace	*Clinostomus elongatus*
Common carp	*Cyprinus carpio*
Golden shiner	*Notemigonus crysoleucas*
Spottail shiner	*Notropis hudsonius*
Northern squawfish	*Ptychocheilus oregonensis*
River carpsucker	*Carpiodes carpio*
Quillback	*Carpiodes cyprinus*
Longnose sucker	*Catostomus catostomus*
White sucker	*Catostomus commersoni*
Lake chubsucker	*Erimyzon sucetta*
Northern hog sucker	*Hypentelium nigricans*
Smallmouth buffalo	*Ictiobus bubalus*
Spotted sucker	*Minytrema melanops*
Shorthead redhorse	*Moxostoma macrolepidotum*
Flathead catfish[a]	
Channel catfish[a]	
Banded killifish	*Fundulus diaphanus*
Western mosquitofish	*Gambusia affinis*
Brook stickleback	*Culaea inconstans*
Central stoneroller	*Campostoma anomalum*
Burbot	*Lota lota*
Mottled sculpin	*Cottus bairdi*
Freshwater drum	*Aplodinotus grunniens*

[a] Channel catfish and flathead catfish appear in the rough fish category as well as the game fish category because they were included in rough fish removal projects.

TABLE 2.—Number and percentage of critiria that we considered successful. The authors of some studies listed more than one criterion that would be used to determine success: parenthetical values are the number or percentage of projects that used a second criterion.

Criteria for success	Number of successes: Target species	Other species	Percentage
Reduction of:			
Standing stock	53		33
Catch or harvest	4	1	3
Other		1	1
Improvement of:			
Growth or average size	11	13	15
Standing stock	7	12 (2)	12 (10)
PSD or W_r values	10 (1)	9	12 (5)
Catch or harvest	7 (2)	19 (8)	16 (53)
Other	6 (4)	8 (2)	8 (32)

from short-term assessments was insufficient to determine success.

The most common determinant of success was a reduction in standing stock of the target species, but the other criteria for success—improved growth, standing stock, PSD, W_r, catch, and harvest for both target and other species—were also important (Table 2). Usually success was based on only one of these criteria; however, in several studies success was based on changes in two of the criteria, with the most important second criterion being improved catch or harvest. In some cases the only evidence of success offered was reduction of a target species. Our assessment that such projects were successful could be considered an overestimate if there was no improvement of desired species or the sport fishery following the reduction of standing stock of the undesired species. Overestimation of success would also be caused by any tendency not to publish the results of unsuccessful fish control projects.

Panfish were the target species in 124 of the 250 treatments, rough fish in 92, and game fish in 12; 22 projects targeted more than one of these groups (Table 3). Success was greater for control of rough fish than for the other categories. Success rates were 40% for panfish, 53% for rough fish, 42% for game fish, and 23% for mixed categories. Usually game fish were reduced to benefit other species (Schmitz and Hetfeld 1965; Shetter and Alexander 1970; McHugh 1990; Goeman and Spencer 1992) or to increase their growth rate (Stephens and Beadles 1980), and in four projects brook trout were considered less desirable than other species (Klein 1960, 1961; Walters and Vincent 1973; Gresswell 1991).

TABLE 3.—Numbers of fish control projects that we considered successful or unsuccessful or that had insufficient data to determine success, by category of target species. Numbers in parentheses are percentages of the total number of projects targeting that category.

Target category	Successful	Unsuccessful	Insufficient data	Total
Panfish	49 (40)	38 (31)	37 (29)	124 (50)
Rough fish	48 (53)	19 (20)	25 (27)	92 (36)
Game fish	5 (42)	7 (58)	0 (0)	12 (5)
Mixed	5 (23)	10 (45)	7 (32)	22 (9)
All	107 (43)	74 (29)	69 (28)	250 (100)

Of 221 fish control projects in which the target species were reduced without stocking piscivores, 170 (77%) attempted partial reductions, and 51 (23%) sought total elimination (Table 4). Projects that attempted total elimination had a greater mean success rate (63%) than those attempting partial elimination (40%). Success rates were greater for rough fish than for the other categories for both total and partial eliminations.

Success with chemical or physical treatment was not strongly related to size of water body (Table 5). For 48 physical removal projects in which size of water body was specified, success appeared greatest for waters exceeding 400 ha, but no trend was evident over four smaller size categories (Table 5). For stocking projects, size was specified

TABLE 4.—Numbers of fish control projects designed to reduce or eliminate target fish without stocking piscivores and percentage of projects considered successful or unsuccessful or that had insufficient data to determine success.

Target category	Number of projects	Percentage: Successful	Unsuccessful	Insufficient data
Reduction of target species				
Panfish	68	35	35	30
Rough fish	80	49	21	30
Game fish	10	40	60	0
Mixed	12	8	50	42
Subtotal	170	40	31	29
Elimination of target species				
Panfish	32	63	6	31
Rough fish	11	73	18	9
Game fish	1	0	100	0
Mixed	7	57	29	14
Subtotal	51	63	14	23
Total	221	45	27	28

TABLE 5.—Numbers (percentages) of fish control projects in which chemical treatment or physical removal was considered successful and unsuccessful, by size of water body treated.

Water body surface area (ha)	Chemical (N = 55)		Physical (N = 48)	
	Successful	Unsuccessful	Successful	Unsuccessful
0.2–5	16 (94)	1 (6)	1 (11)	8 (89)
5–20	15 (75)	5 (25)	3 (43)	4 (57)
20–40	2 (40)	3 (60)	1 (20)	4 (80)
40–400	5 (63)	3 (37)	6 (43)	8 (57)
>400	4 (80)	1 (20)	12 (92)	1 (8)

for only 11 water bodies—too few to reveal a relation between success and water body size.

Chemical treatment, used in 145 (58%) projects, was the most commonly identified method of fish control, followed by physical removal or drawdown (70 projects, 28%), introduced fish species (29 projects, 12%), and a combination of treatments (6 projects, 2%). Rotenone and antimycin, used in the majority of chemical treatments, resulted in 48 and 45% success rates (Table 6). Rotenone was used more often for rough fish, and antimycin for panfish. Both chemicals generally were less effective for controlling mixed categories. A combination of two or more chemicals, usually rotenone and antimycin, was used in four projects with a success rate of 25% (Table 6). Brook trout (game fish) were successfully eliminated with rotenone from two lakes (Klein 1960), unsuccessfully reduced in a river (Klein 1961), and successfully reduced with antimycin in a stream (Gresswell 1991). Copper sulfate was used unsuccessfully to treat bluegill (panfish) nests in one project (Beyerle and Williams 1967). Squoxin successfully reduced northern squawfish (rough fish) in three projects (Lindland 1973), and toxaphene was unsuccessful for control of rough fish in a reservoir (Johnson 1966).

Of 70 projects that entailed physical removal of fish or reservoir drawdown, 43% were successful, 45% were unsuccessful, and 12% had insufficient data to determine an outcome (Table 7). Success for seines, traps, nets, and electrofishing ranged from 33 to 57%; similar success rates were calculated for drawdowns (45%) and combinations of physical treatments (36%). At a 57% success rate, nets were the most effective physical treatment used. Traps alone were used successfully in one of three projects (Wanie and Hopkins 1951; Johnson 1975; Warnick 1977), and electrofishing was also successful in one of three (Sullivan 1955; Spencer 1967; Shetter and Alexander 1970).

TABLE 6.—Numbers of fish control projects in which chemicals were used to remove target fish and percentage of projects considered successful or unsuccessful or that had insufficient data to determine success.

Target category	Number of projects	Percentage		
		Successful	Unsuccessful	Insufficient data
Rotenone				
Panfish	20	60	15	25
Rough fish	39	49	15	36
Game fish	3	67	33	0
Mixed	7	0	57	43
Subtotal	69	48	20	32
Antimycin				
Panfish	47	43	9	49
Rough fish	9	56	22	22
Game fish	1	100	0	0
Mixed	10	40	30	30
Subtotal	67	45	14	42
Combination[a]				
Panfish	1	0	0	100
Rough fish	3	33	67	0
Subtotal	4	25	50	25
Miscellaneous[b]				
Panfish	1	0	100	0
Rough fish	4	75	25	0
Subtotal	5	60	40	0
Total	145	46	19	35

[a] Usually rotenone and antimycin.
[b] Includes squoxin, toxaphene, and copper sulfate.

Stocking various species of fish to control others was not as successful as chemical and physical treatments. We considered 7 of 29 (24%) stocking projects to be successful and 16 (49%) unsuccessful (Table 8). Game fish (excluding ictalurids and salmonids) usually were stocked to control panfish, and 4 of 19 (21%) such projects were successful. The most common species stocked were largemouth bass (8 water bodies), northern pike (6), walleye (3), and muskellunge (3). In three projects, catfish alone (flathead, white, and blue catfish) were stocked to control bluegills, and in one project, both flathead catfish and largemouth bass were stocked (Swingle et al. 1965). We considered all four projects unsuccessful. In another project stocked flathead catfish successfully controled black bullheads (U.S. Fish and Wildlife Service 1992). Salmonids were used successfully in two projects. In one, coho salmon were stocked to control alewives (Beeton 1969), and in the other, cutthroat trout were stocked to control brook trout (Walters and Vincent 1973).

We found six projects that used a combination of chemical treatment and physical methods (Table

TABLE 7.—Numbers of fish control projects in which various gears, drawdowns, or combinations of these treatments[a] were used to remove target species and percentages considered successful or unsuccessful or that had insufficient data to determine success.

Target category	Number of projects	Percentage: Successful	Unsuccessful	Insufficient data
Seines				
Panfish	1	0	100	0
Rough fish	9	56	22	22
Game fish	3	0	100	0
Subtotal	13	39	46	15
Traps				
Rough fish	3	33	67	0
Subtotal	3	33	67	0
Nets				
Panfish	9	67	33	0
Rough fish	5	60	20	20
Game fish	2	0	100	0
Subtotal	16	57	37	6
Electrofishing				
Panfish	1	100	0	0
Rough fish	1	0	100	0
Game fish	1	0	100	0
Subtotal	3	33	66	0
Drawdown				
Panfish	8	25	75	0
Rough fish	2	100	0	0
Mixed	1	100	0	0
Subtotal	11	45	55	0
Combination				
Panfish	9[b]	22	78	0
Rough fish	13	46	15	38
Subtotal	22	36	41	23
Total	68	43	45	12

[a] In addition, a trawl was used unsuccessfully to remove rough fish from one water body (Otis 1988), and dynamite was used in one water body to remove gars, but insufficient data were available to determine success (Copeland 1958).

[b] Includes one study of effects of winterkill on panfish growth (Beckman 1950); we considered control unsuccessful.

9); four (66%) were successful (Lambou and Stern 1959; Riel 1967; Keith 1968; McHugh 1990), one (17%) was unsuccessful (Houser and Grinstead 1961), and one (17%) had insufficient data to determine the outcome (Cooper et al. 1971).

Stocking various fish species after chemical or physical treatment may have increased the success of fish control projects. In 17 projects, chemical or physical treatment was followed by supplemental stocking of certain species of fish to control other species (Table 10). Ten (59%) of these projects were successful and 7 (41%) were not. This

TABLE 8.—Numbers of fish control projects in which various fish species were introduced to control fish in target categories and percentages of projects considered successful or unsuccessful or that had insufficient data to determine success.

Target categories	Number of projects	Percentage: Successful	Unsuccessful	Insufficient data
Introduced game fish[a]				
Panfish	19	21	42	37
Mixed	3	0	67	33
Subtotal	22	18	46	36
Introduced ictalurids				
Panfish	4	25	75	0
Subtotal	4	25	75	0
Introduced salmonids				
Rough fish	1	100	0	0
Game fish	1	100	0	0
Subtotal	2	100	0	0
Mixed species[b]				
Panfish	1	0	100	0
Subtotal	1	0	100	0
Total	29	24	49	27

[a] Excluding ictalurids and salmonids.

[b] Flathead catfish and largemouth bass.

success rate exceeds that of chemical treatments alone (46%; Table 6), physical treatments alone (43%; Table 7), and stocking alone (24%; Table 8). Only combined chemical and physical treatments yielded a greater success rate (66%; Table 9); however, only six such projects were identified and evaluated. Supplemental stocking of game fish and mixed categories after chemical or physical treatments to control panfish and rough fish appeared to be the most successful procedure (Table 10). Stocking salmonids after chemical treatment for control of rough fish resulted in poor success; three out of four (75%) such projects failed.

TABLE 9.—Numbers of fish control projects in which combinations of chemical and physical treatments were employed to control fish in target categories and percentages of projects considered successful or unsuccessful or that had insufficient data to determine success.

Target category	Number of projects	Percentage: Successful	Unsuccessful	Insufficient data
Panfish	2	50	0	50
Rough fish	2	100	0	0
Game fish	1	100	0	0
Mixed	1	0	100	0
Total	6	66	17	17

TABLE 10.—Numbers of successful projects that entailed supplemental stocking of predaceous game fish, mixed species, or salmonids after a chemical or physical treatment. Numbers of unsuccessful stockings are in parentheses.

Target category and initial treatment	Fish stocked		
	Game fish	Mixed species	Salmonids
Panfish			
Chemical	2	1	
Physical	2		
Rough fish			
Chemical	1	3 (1)	1 (3)
Gamefish			
Physical		(1)	
Mixed			
Physical	(1)	(1)	
Total	5 (1)	4 (3)	1 (3)

Discussion and Recommendations

This review suggests that there is considerable room for improvement of fish control projects. Control has been attempted for many species, by many methods, and by many workers, and success has been determined by various criteria. Yet less than 50% of 250 fish control projects we examined were considered successful.

The seminal reason for the failure of projects was not evident, even though authors often stated the proximate reason for failure. For example, several authors stated that a project was unsuccessful because of inadequate reduction (removal or kill) of a target species, but insufficient information was provided to determine why the level of reduction achieved was inadequate.

We believe fish control projects can be effective or ineffective for many reasons. In situations in which one species or group of species are directly and substantially detrimental to others, removal or marked reduction of the detrimental species can benefit the others. Other fish communities can have such complex interactions among species that removal of some species has little apparent effect on the remaining species (e.g., Nilsson 1967). Moreover, fish communities are profoundly influenced by habitat and water quality. If a species or group of species is "overabundant" because of deleterious environmental conditions, a fish control project can be ineffective or short-lived because it treats the symptom rather than the cause of the problem. Furthermore, exploited species can be affected by the fishery. A control program designed simply to eradicate or reduce the number of stunted panfish, for example, would not address problems associated with high exploitation of panfish predators or the effects of a fishery that is selective for the larger panfish in the population (Coble 1988).

Because of the complexity of factors that influence fish communities, we recommend that fish control projects be preceded by critical evaluation of the assumptions involved and of the suspected causes of problems. We also recommend that fish control projects include explicit rationale, objectives, and pretreatment and long-term posttreatment study. This review would have been improved if more reports had included sufficient data to determine success. About 25% of the projects we reviewed lacked adequate information to determine success. Our assessments of success or nonsuccess are underestimated to the extent that projects of undetermined status would have contributed to either of those categories. Collection and analysis of pretreatment and posttreatment data could allow objective determination of success of fish control projects and determination of the reasons for failure of unsuccessful projects.

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Appendix follows

Appendix: Fish Control Project References

TABLE A1.—References to fish control projects that were considered successful or unsuccessful or that provided insufficient data to determine success.

Successful control	Unsuccessful control	Insufficient data
Avery (1978)	Baumann (1975)	Avault and Radonski (1968)
Beckman (1941)	Beckman (1950)	Burress (1971)
Beeton (1969)	Beyerle (1971)	Burress and Luhning (1969): Biggers Pond
Berry (1982)	Beyerle (1977): ponds 1 and 3	Cooper et al. (1971)
Beyerle (1977): pond 2	Beyerle and Williams (1967, 1972)	Copeand (1958)
Bowers (1955)	Binns (1967)	Dequine (1952)
Boxrucker (1982)	Boussu (1955)	Ellis and Thomaston (1975): water bodies unknown
Burress and Luhning (1969): five ponds	Brynildson (1970)	Engstrom-Heg and Loeb (1971)
Cahoon (1953)	Carlander (1958)	Farrell (1980)
Clothier and Boussu (1953)	Carter (1956)	Fillipek (1982): Lakes Charles, Greenlee, Mallard, Harris
Davis (1979): Lake Mary	Charles (1957)	Flint (1980)
Ellis and Thomaston (1975): water bodies unknown	Clemens and Martin (1953)	Gammon and Hasler (1965)
Essbach (1958)	Crabtree (1967)	Gerking (1950)
Ezell (1962)	Davis (1979)	Goodson (1966): water bodies unknown
Flipek (1982): Lakes Atkins, Cathrine, Carrwary	Ellis and Thomaston (1975): water bodies unknown	Greenbank (1941)
Foye (1956)	Fast (1966)	Holcomb (1967)
Gresswell (1991)	Germann and Sandow (1976)	Horel and Huish (1960)
Grice (1958): Indian Lake	Goeman and Spencer (1992)	Huish (1958a, 1958b)
Hanson et al. (1983)	Goodson (1966): water bodies unknown	Lawson (1985)
Hayes and Livingstone (1955)	Grice (1958): Billington Sea, Jordan Pond	Moody (1957)
Heman et al. (1969)	Helms (1967)	Moyle et al. (1950)
Hoffarth and Conder (1967)	Hooper and Crance (1960): Lakes Barbour, Crenshaw, Cullman	Philippy (1967)
Hooper and Crance (1960): Lakes Pike and Coffee	Houser and Grinstead (1961)	Pierce et al. (1965): ABAC Pond
Jackson (1966)	Jenkins (1956): Ardmore City Lake	Pintler and Johnson (1958)
Jenkins (1956): Franklin Pond, South Rod and Gun Lake, Mountain Lake	Johnson (1966)	Rose and Moen (1953)
Johnson (1975)	Kinman (1983)	Ryan (1977)
Johnson (1977)	Kirk et al. (1986)	Scott (1968)
Johnson and Osborn (1977)	Klein (1961)	Snyder (1923)
Keith (1968)	Laarman (1979): one section of the Huron River	Swingle and Smith (1942)
Klein (1960)	Lamb (1960)	Thomaston (1965): three ponds
Laarman (1979): two sections of the Huron River	Layzer and Clady (1984)	Threinen (1952)
Lamb (1963)	Lewis and Robinson (1968)	Tompkins and Mullan (1958)
Lambou and Stern (1959)	Moyle et al. (1983)	
Lantz et al. (1967)	Neess et al. (1957)	
Lindland (1973)	Otis (1988)	
Mathis and Hulsey (1959)	Pierce et al. (1965): J. E. Taylor Pond	
McHugh (1990)	Rawson and Elsey (1950)	
Moyle and Clothier (1959)	Robinson (1961)	
Panek (1978)	Rutledge and Barron (1972)	
Parker (1958)	Schmitz and Hetfeld (1965)	
Pierce et al. (1965): Bear Camp Lake	Scidmore (1959)	
Powell (1973)	Shetter and Alexander (1970)	
Priegle (1971)	Snow (1962, 1968, 1974)	
Ricker and Gottschalk (1941)	Stephens and Beadles (1980)	
Riel (1965, 1967)	Sullivan (1955)	
Rose and Moen (1951)	Swingle et al. (1965)	
Rost (1989)	Wanie and Hopkins (1951)	
Sayre (1969)	Warnick (1977)	
Scarnecchia (1988)	Wesloh (1959)	
Schneider (1981)		
Spencer (1967)		
Stephen (1986)		
Thomaston (1965): four ponds		
U.S. Fish and Wildlife Service (1992)		
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Walters and Vincent (1973)		
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