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Evidence of interactions between walleye and yellow perch in New York State lakes

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We believe that the population dynamics of walleye (*Stizostedion vitreum vitreum*) and yellow perch (*Perca flavescens*) are strongly affected by biotic interactions: abundant walleye populations limit perch recruitment, resulting in fast perch and slow walleye growth rates; sparse walleye populations allow for strong perch recruitment resulting in slow yellow perch and fast walleye growth rates. If these mechanisms are important, we would expect a negative correlation between perch and walleye growth rates. Mean length at age 4 for walleye and yellow perch in 23 New York waters were negatively correlated. Further, changes over time in length at age of both species as walleye populations increased in Canadarago and Silver Lakes follow the regression from the whole data set. This indicates a strong interaction between these two percid species in New York waters. The residuals were affected by lake productivity, but not lake area or mean depth. Waters with very low productivity had smaller walleye and yellow perch than expected from the regression.

1. Introduction

Walleye (*Stizostedion vitreum vitreum*) and yellow perch (*Perca flavescens*) co-occur in many central North American lakes and often form a tightly coupled predator-prey species pair (Forney 1980, Post & Rudstam 1992). Our current understanding of these species' interactions is based partly on long term studies in Oneida Lake, New York, by John Forney and co-workers (e.g. Forney 1976, 1977, 1980, Mills & Forney 1988). When walleye are abundant (as in Oneida Lake), they are the main predator on young-of-year yellow perch (YOY perch). YOY perch are vulnerable to walleye predation once they reach a total length of 18 mm and walleye often consume a large portion of the YOY perch population during

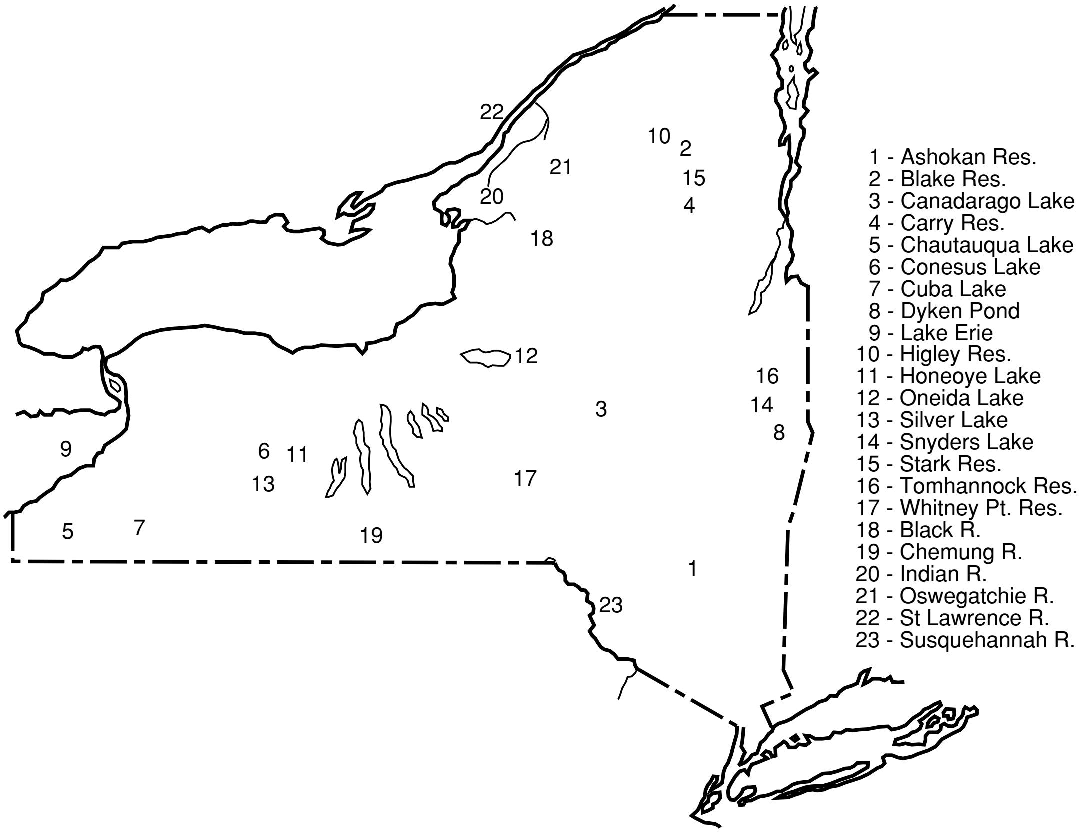

Fig. 1. Map of New York State, USA, indicating the location of the study waters.

summer and fall. Walleye growth rate slows after YOY fish have been depleted. Few yellow perch survive the first year, and those that do grow well. An increase in predator biomass is often followed by a decline in yellow perch recruitment (Gammon & Hasler 1965, Kempinger & Carline 1977). Although larger yellow perch may be piscivorous (Tarby 1974), they generally feed more on zooplankton and benthic invertebrates and their growth rate is not dependent on abundance of small fish. Conversely, when walleye are rare, they have little impact on YOY yellow perch populations and we expect good perch survival, strong intraspecific competition for zooplankton, and poor growth (Mills & Forney 1988). Walleye on the other hand grow well feeding on an abundant, slow growing perch population. The result of these interactions should be relatively small walleye and large perch when walleye are abundant and relatively large walleye and small perch when walleye are rare.

We hypothesize that these biotic interactions determine the population dynamics of walleye and yellow perch in New York State which is in the central part of the geographic distribution of the two species (Collette & Banarescu 1977). It follows from this hypothesis that the size at age of walleye and yellow perch should be inversely related over a range of lake types and that lakes with both species growing rapidly or both species growing slowly should not exist in this region. Further, if walleye are introduced into lakes with abundant perch populations, walleye growth rates should decrease and yellow perch growth rate should increase over time. We tested this hypothesis by reviewing available data on length at age 4 of walleye and yellow perch in New York State and by investigating the development over time of walleye and perch growth rates in Canadarago Lake and Silver Lake, New York, two lakes where abundant walleye populations have been established through fingerling stocking.

2. Materials and methods

Data included in this study come from 17 lakes and reservoirs and 6 rivers throughout New York State (Fig. 1). These waters include a wide variety of lake types from oligotrophic Adirondack reservoirs to eutrophic inland lakes ranging in size from 45 to over 20 000 ha (Table 1). To aid analysis, we classified lakes and reservoirs into three size groups (< 400 ha, 400–2 000 ha, > 2 000 ha), three groups based on mean depth (< 5 m, 5–7 m, > 7 m) and three groups based on productivity (oligotrophic, mesotrophic, and eutrophic).

Oneida, Canadarago and Silver Lakes are given special consideration because of the long term records available from these lakes. Oneida Lake is a 20 700 ha eutrophic shallow lake in central New York State (Mills *et al*. 1978). The fish populations, particularly the walleye and yellow perch populations, have been studied in this lake since 1957 and these investigations continue (Forney 1980, VanDeValk *et al*. 1994). Recently (1991), zebra mussels (*Dreissena polymorpha*) invaded the lake causing higher water clarity in the summer and yet to be determined effects on walleye and perch populations.

Canadarago Lake is a 809 ha eutrophic lake in central New York State (Harr *et al*. 1980). It has been studied by D. M. Green and co-workers since 1972. Originally the lake had a large number of slow growing yellow perch (biomass of yellow perch larger than 127 mm of 44 to 110 kg/ha, Green unpubl. data). Thirty-five years of repeated stocking of walleye fry did not result in the establishment of a viable population. In 1973 a tertiary sewage treatment plant began operation and the phosphorus content of the water, as well as the occurrence of algal blooms, decreased (Harr *et al*. 1980). Fingerling walleye were introduced from 1977 to 1982 resulting in a viable, naturally reproducing population (Green 1986). By 1987, the walleye population had increased to 12–15 kg/ha. Growth rates of walleye and yellow perch were followed throughout these changes and data on length at age for both species are available for odd numbered years 1981–1989.

Silver Lake is a 338 ha eutrophic lake in western New York State. Fingerling walleye were introduced beginning in 1986 to produce a walleye fishery and to improve the size structure of the panfish population (Evans 1993). Data on growth rates of walleye and yellow perch is available for 1986 to 1992.

Most of our analysis is based on length-at-age of age 4 walleye and yellow perch (averaged for males and females). We chose to analyze total length at age 4 for both species because the range of lengths expected in New York State at age 4 (250–500 mm for walleye, 130–270 mm for yellow perch, Forney *et al*. 1994) are within the range of lengths vulnerable to standard gill nets used by New York State Department of Environmental Conservation (Forney *et al*. 1994). Younger fish may be under-represented in standard gill nets and older fish are more difficult to age. Fish were caught with varying combinations of trap nets, gill nets and/or electrofishing. Ages were determined by various investigators based on scales; a large proportion of the aging was done by J. Forney, A. VanDeValk, D. Green and J. Evans.

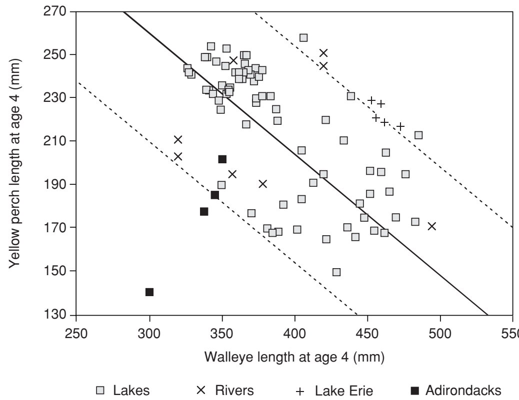

Fig. 2. Relationship between the length of walleye and perch at age 4 in 23 waters in New York State. The solid line represent the functional regression between perch and walleye length at age 4. Dashed lines suggest the range of length at age for walleye and yellow perch that can be expected in New York State.

We used available data from each of these water bodies to estimate the size of walleye and yellow perch after four growing seasons (at the formation of the fourth annulus). Back-calculated lengths were used when available. When only length at capture were known, we used the average of lengths at age 3+ and 4+ when fish were collected from June through September. Fish collected in September–October were assumed to have completed their annual growth and fish collected in the spring (April–May) were assumed not to have grown since annulus formation.

3. Results and discussion

Mean length at age 4 for walleye in the 23 waters ranged from 301 to 495 mm and for yellow perch from 141 to 260 mm. The smallest age-4 individuals of both species (301 mm for walleye and 141 mm for perch) were found in Carry Reservoir, a highly oligotrophic impoundment of the Raquette River. The fastest growing yellow perch were observed in Canadarago Lake in 1987 (258 mm at age 4); the fastest growing walleye were observed in the St. Lawrence River in 1988 (495 mm at age 4).

Overall, there was a negative correlation between length at age 4 of walleye and yellow perch in these lakes, although the regression explained only about 20% of the variance (Fig. 2, $r^2 = 0.201$, $N = 90$, $p < 0.001$). However, with the exception of one Adirondack reservoir, no waters displayed slow growth for both walleye and yellow perch or fast growth for both species. Interestingly, growth rates in rivers did not deviate more from the regression line than lakes and there are rivers with both faster and slower gorwing populations than expected from the regression line (Fig. 2, Table 1). Growth rates in Lake Erie were high for both walleye and perch. The New York portion of Lake Erie is partly dependent on walleye migrating into this region from the western basin and walleye length at age may be more dependent on conditions in the western than in the eastern basin of Lake Erie. Excluding Adirondack impoundments and Lake Erie from the analysis resulted in a better fit to the regression equation ($r^2 = 0.350, N = 81, p < 0.001$). The line in Fig. 2 is the functional regression (Ricker 1973) between perch length at age 4 (P_{IV}) and walleye length at age 4 (W_{IV}) using all data points ($P_{IV} = 428 - 0.558\ W_{IV}$). The functional regression excluding Lake Erie and Adirondack impoundments is almost identical ($P_{IV} = 431 - 0.566 W_{IV}$).

Length at age 4 was relatively constant from 1958 to 1994 in Oneida Lake (Fig. 3), 327–388 mm for walleye and 218–254 mm for yellow perch. During this time, walleye were abundant in Oneida Lake (average biomass of age 4 and older walleye 20 kg/ha, range 5–36 kg/ha) relative to the biomass of adult perch (average 26 kg/ha, range 7–59 kg/ha, Mills & Forney 1988, VanDeValk *et al*. 1994). Most of each year-class of perch were consumed by walleye preventing the formation of an abundant, slow growing yellow perch population (Forney 1977, 1980).

This relative stability in length at age 4 over a 37 year period in Oneida Lake contrasts with changes observed over time when walleye were introduced into two lakes with abundant slow growing perch population (Canadarago and Silver Lakes, Fig. 3).

Table 1. Characteristics of water bodies used in the analyses. Area, maximum depth, mean depth, total phosphorus and alkalinity are also given when known. Productivity classification (O – oligotrophic, M – mesotrophic and E – eutrophic) is based on total-P, alkalinity, and notes in the sources. Average residual is the average perpendicular distance between the data points and the functional regression line in Fig. 2.

Water	Years included	Area (ha)	Max. depth (m)	Mean depth (m)	Total-P (µg/l) or alkalinity (mg/l)	Productivity	Average residual	Source
Lakes and Reservoirs								
Ashokan Res.	76	3 365	48.8	> 10	A: 7–21	M	– 39.3	1
Blake Res.	93	287	13.7	2.1	TP < 0.10	O	– 62.8	2
Canadarago L.	81, 83, 85, 87, 89	809	13.4	7.5	A: 124 TP: 30–50	E	15.5	3, 16
Carry Res.	90,91,93	1 295	17.7	5.5	TP < 0.10	O	– 122.4	2
Chautauqua L.	85–89, 93	5 324	23.0	5.7	TP: 20–40	E	– 37.3	4
Conesus L.	95	1 290	20.2	11.5	TP:40	E	10.0	5,17
Cuba L.	46, 53, 82	180	14.0	6.1		E	– 18.3	6
Dyken Pond	90	72	12.8	3.0	A: 17	M	15.5	7
L. Erie (NY sect.)	87–91	500 000	60	20		M	53.5	8
Higley Res.	91, 93	282	9.7	3.6	TP < 0.10	O	– 30.9	2
Honeoye L.	52, 63, 76, 83–87	705	9.2	4.9	TP: 16–20	M	22.7	3
Oneida L.	58–94	20 700	16.8	6.8	TP: 100–300 A: 70–80	E	– 2.2	3
Silver L.	86–92	338	11.3	7.3		E	2.9	9
Snyders L.	88	45	11.9	5.5	A: 86	E	– 27.8	10
Stark Res.	93	285	15.8	7.3	TP < 0.10	O	– 50.7	2
Tomhannock Res.	91	696	16.1	7.0	A: 51–86 TP: 35	E	49.6	11
Whitney Pt Res.	84–89	485		3.3		E	20.5	3
Rivers								
Black R.	78, 92	Warm water, 6th–7th order, slope 0.01–0.7%					– 10.9	12
Chemung R.	89	Warm water, slope 0.001%					– 34.0	3, 18
Indian R.	94	Warm water, 4th–5th order, slope 0.005–0.003%					– 26.6	13
Oswegatchie R.	90	Warm water, 4th–7th order, slope 0.01–0.0.5%					– 47.0	14
St. Lawrence R.	88	"Lake St. Lawrence", very little slope.					– 14.7	15
Susquehanna R.	89–90	Warm water, slope 0.007%					56.1	3

Sources: 1) Gann 1976, 2) Gordon and Richardson 1995, 3) Cornell Warmwater Fisheries Unit (unpubl.) and Forney *et al.* 1994, 4) McKeown, 1994, 5) Gene Lane, NYSDEC Region 8, Avon NY (unpubl.), 6) Evans 1993a, 7) McBride 1991, 8) Culligan 1991, 9) Evans 1993, 10) McBride 1990, 11) McBride 1994, 12) Carlson 1993, 13) Carlson, D. M: NYSDEC Region 6, Watertown, NY (unpubl.), 14) Carlson 1992, 15) Gordon 1989, 16) Harr *et al.* 1980, 17) Forest *et al.* 1978, 18) Lane, G. 1992.

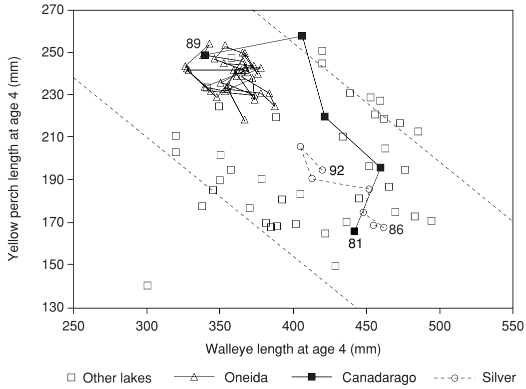

Fig. 3. The same data as in Fig. 2 but with three lakes highlighted — Oneida Lake, Canadarago Lake and Silver Lake — for which long term data series were available. The line between the data points from these three lakes represent the time course of changes in length at age 4 (1958–94 in Oneida Lake, 1986–92 in Silver Lake and 1981–89 in Canadarago Lake). The starting and ending years are marked for Silver and Canadarago Lakes.

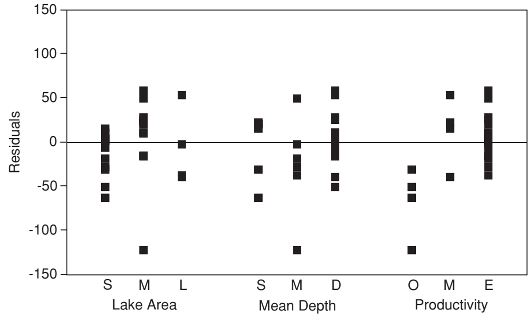

Fig. 4. Residuals from the functional regression grouped by lake type (Table 1). Lakes are classified by area as small (< 400 ha, S), medium (400–2 000 ha, M), and large (over 2 000 ha, L), by mean depth as shallow (< 5 m, S) medium (5–7 m, M) and deep (over 7 m, D), and by productivity (O – oligotrophic , M – mesotrophic and E – eutrophic).

In these lakes, walleye initially grew rapidly and perch grew slowly. Over time, walleye growth rates declined and perch growth rates increased. Length at age 4 of walleye and yellow perch in Canadarago Lake converged on the lengths observed in Oneida Lake (Fig. 3) as did walleye biomass (12–15 kg/ha in Canadarago Lake 1987). Density dependent walleye growth has been observed in several lakes elsewhere (Shuter & Koonce 1977, Colby *et al*. 1979). The changes in Silver Lake were less dramatic but followed the general trend of decreasing walleye growth rate and increasing perch growth rate. However, an expanding walleye population may not always affect perch and walleye growth rates. In Chautauqua Lake (Mooradian *et al*. 1986), growth rates of both walleye and yellow perch remained within a fairly narrow range during the expansion of the walleye population (ranges of annual averages were 371–405 mm for age-4 walleye and 168–184 mm for age 4 yellow perch for 7 years between 1979 and 1993).

Residuals from the functional regression line (calculated as the perpendicular distance from the line to each data point) were plotted for each lake category based on average values for each lake when several years were available, except for Silver and Canadarago Lakes where residuals from each year were plotted (Fig. 4). No effect of lake area or mean depth was indicated by this analysis. However, the low productivity waters in the Adirondack mountains appear to have lower growth rates for both perch and walleye than predicted by the regression. Slower growth in this region may be linked to lower productivity, but smaller size could also reflect lower temperatures and shorter growing seasons at the higher altitude and latitude, as has been shown elsewhere (Colby *et al*. 1979, Shuter & Post 1992).

Interactions with other fish species could affect the relationship between walleye and perch growth rates. In northern centrarchid-dominated lakes, growth and abundance of percids may be affected by the degree northern pike (*Esox lucius*) control bluegill (*Lepomis macrochirus*) and white sucker (*Catastomus commersoni*), (Colby *et al*. 1987, Hayes 1992). The lakes and reservoirs that we examined have varied fish communities, including black bass (*Micropterus* sp.), esocids, various centrarchid species and in some cases abundant alewife (*Alosa pseudoharengus*), golden shiners (*Notemigonus crysoleucas*), white perch (*Morone americana*) and gizzard shad (*Dorosoma cepedianum*). The presence of these species does not seem to affect the relationships between walleye and perch length at age. For example residuals from two waters with abundant alewife populations (Conesus Lake and Ashokan Reservoir) were + 10 and – 40 (Table 1). This does not necessarily mean that the other species are not affecting the total biomass and growth of walleye and yellow perch. Perch growth may be slow due to both inter and intra-specific competition. As long as the competitor is also a good forage fish for walleye (which is not always the case, see Rudstam *et al.* 1993 or Hambright 1994), we may find a negative correlation between walleye and perch growth rates, even if perch is a minor component of the forage fish biomass.

We believe our analysis is useful for two reason. First, the negative correlation between growth rates of walleye and yellow perch in the waters investigated indicates the importance of predator-prey interactions in determining growth of the two species in New York State. With the exception of one of the oligotrophic lakes, there were no lakes in which both species grew fast or both grew slow. Lake Erie had faster perch growth than expected from observed walleye growth rates, possibly because the walleye samples were composed of both local fish and fish migrating from the western basin to the eastern basin of the lake. Shorter growing season and colder temperatures further north likely limits growth rates of these species. However, within New York State, which is in the central region of their distribution, biotic interactions are at least as important as abiotic factors for determining size at age of walleye and yellow perch. This is similar to the observations of a negative correlation between proportional stock densities (an index of size) of bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*) in ponds (Anderson 1978).

Secondly, our results have implications for percid management. Managing one species will likely affect the other. In the case of Silver and Canadarago Lakes, the management strategy was to establish a large walleye populations to provide better walleye fishing and a smaller population of faster growing yellow perch. Anglers generally prefer a few large yellow perch to many small ones. This strategy was successful (Fig. 3), although the increased perch growth rates was accompanied by decreased walleye growth rates. If this decline average size of walleye is deemed too large, reductions in walleye populations may be the next step in management of these lakes.

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References

Anderson, R. O. 1978: New approaches to recreational fishery management. — In: Novinger, G. D. & Dillard, J. G. (eds.), New approaches to the management of small impoundments. North Central Division of the American Fisheries Society Bethesda, Maryland. Special Publ. 5: 73–78.

Carlson, D. M. 1992: A fisheries management survey of the middle Oswegatchie River. — NY Dept. Environm. Conserv. Report, Albany, NY.

— 1993: 1992–93 Black River fisheries survey: Carthage to Lyons Falls. — NY Dept. Environm. Conserv. Report, Albany, NY.

Colby, P. J., McNichol, R. E. & Ryder, R. A. 1979: Synopsis of biological data on the walleye, Stizostedion v. vitreum (Mitchill 1818). — FAO Fisheries Synopsis 119.

Colby, P. J., Ryan, P. A., Schupp, D. H. & Serns, S. L. 1987: Interactions in north-temperate lake fish communities. — Can. J. Fish. Aquat. Sci. 44: 104–128.

Collette, B. B. & Banarescu, P. 1977: Systematics and zoogeography of the fishes of the family Percidae. — J. Fish. Res. Board Can. 34: 1450–1463.

Culligan, W. J. 1991: 1991 Annual report Lake Erie Unit to the Lake Erie Committee and The Great Lakes Fishery Commission. — NY Dept. Environm. Conserv. Report, Albany, NY.

Evans, J. T. 1993: Silver Lake fisheries survey 1992. — New York State Department of Environmental Conservation Report, Albany, NY.

— 1993a: Cuba Lake fisheries survey 1991–1992. — NY Dept. Environm. Conserv. Report, Albany, NY.

Forest, H. S., Wade, J. Q. & Maxwell, T. F. 1978: The limnology of Conesus Lake. — In: Bloomfield, J. A. (ed.), Lakes of New York State, volume I: 122–225. Academic Press, NY.

Forney, J. L. 1976: Year-class formation in the walleye (Stizostedion vitreum vitreum) population of Oneida Lake, New York, 1966–73. — J. Fish. Res. Board Can. 33: 783–792.

— 1977: Evidence for interspecific and intraspecific competition as factors regulating walleye (Stizostedion vitreum vitreum) biomass in Oneida Lake, New York. — J. Fish. Res. Board Can. 34: 1812–1820.

— 1980: Evolution of a management strategy for the walleye in Oneida Lake, New York. — NY Fish and Game J. 27: 105–141.

Forney, J. L., Rudstam, L. G., Green, D. M. & Stang, D. L. 1994: Percid sampling manual. — New York State Department of Environmental Conservation, Albany, NY.

Gammon, J. R. & Hasler, A. D. 1965: Predation by introduced muskellunge on perch and bass. — Wisc. Acad. Sci. Arts Letters 54: 249–272.

Gann, M. C. 1976: 1976 fisheries survey Ashokan Reservoir. — NY Dept. Environm. Conserv. Report, Albany, NY.

Green, D. M. 1986: Post-stocking survival of walleye fingerlings in Canadarago Lake, New York. — In: Stroud, R. H. (ed.), Fish culture in fisheries management. Proceedings of a Symposium on the Role of Fish Culture in Fisheries Management: 381–389. American Fisheries Society, Bethesda, Maryland.

Gordon, W. H. 1989: Lake St. Lawrence warmwater fish stock assessment 1988. — Great Lakes Fishery Commission, St. Lawrence River Subcommittee Report.

Gordon, W. H. & Richardson, D. M. 1995: Upper Raquette River impoundments: assessment and management of coolwater fish stocks 1990–94.— NY Dept. Environm. Conserv. Report, Albany, NY.

Hambright, K. D. 1994: Morphological constraints in the piscivore-planktivore interaction – implications for the trophic cascade hypothesis. — Limnol. Oceanogr. 39: 897–912.

Harr, T. E., Fuhs, G. W., Green, D. M., Hetling, L. J., Smith, S. B. & Allen, S. P. 1980: Limnology of Canadarago Lake. — In: Bloomfield, J. A. (ed.), Ecology of the Lakes of East-Central New York, Lakes of New York State, Vol. III: 130–264. Academic Press, New York.

Hayes, D. B., Taylor, W. W. & Schneider, J. C. 1992: Response of yellow perch and the benthic invertebrate community to a reduction in the abundance of white suckers. — Trans. Am. Fish. Soc. 121: 36–53.

Kempinger, J. J. & Carline, R. F. 1977: Dynamics of walleye (Stizostedion vitreum vitreum) population in Escanaba Lake, Wisconsin, 1955–72. — J. Fish. Res. Board Can. 34: 1800–1811.

Lane, G. 1992: A summer (1989/1991) fisheries survey of the Chemung River. — NY Dept. Environm. Conserv. Report, Albany, NY.

McBride, N. D. 1990: Snyders Lake fisheries management. — NY Dept. Environm. Conserv. Report, Albany, NY.

— 1991: Dyken Pond fisheries management. — NY Dept. Environm. Conserv. Report, Albany, NY.

— 1994: Tomhannock Reservoir fisheries management. — NY Dept. Environm. Conserv. Report, Albany, NY.

McKeown, P. E. 1994: Status of the fish stocks in Chautauqua Lake, 1993. — NY Dept. Environm. Conserv. Report, Albany, NY.

Mills, E. L., Forney, J. L., Clady, M. D. & Schaffner, W. R. 1978: Oneida Lake. — In: Bloomfield, J. A. (ed.), Lakes of New York State, Vol. II: Ecology of the Lakes of Western New York: 367–446. Academic Press, NY.

Mills, E. L. & Forney, J. L. 1988: Trophic dynamics and development of freshwater pelagic food webs. — In: Carpenter, S. R. (ed.), Complex interactions in lake communities: 11–30. Springer-Verlag, NY.

Mooradian, S., Forney, J. L. & Staggs, M. 1986: Response of muskellunge to establishment of walleye in Chautauqua Lake, New York. — Am. Fish. Soc. Spec. Publ. 15: 168–175.

Post, J. R. & Rudstam, L. G. 1992: Fisheries management and the interactive dynamics of walleye and perch populations. — In: Kitchell, J. F. (ed.), Food web management: a case study of Lake Mendota: 381–406. Springer Verlag, NY.

Ricker, W. E. 1973: Linear regressions in fishery research. — J. Fish. Board Can. 30: 409–434.

Rudstam, L. G., Lathrop, R. C. & Carpenter, S. R. 1993: The rise and fall of a dominant planktivore: direct and indirect effects on zooplankton. — Ecology 74: 303–319.

Shuter, B. J. & Koonce, J. F. 1977: A dynamic model of the western Lake Erie walleye (Stizostedion vitreum vitreum) population. — J. Fish. Res. Board Can. 34: 1972–1982.

Shuter, B. J. & Post, J. R. 1990: Climate, population viability and zoogeography of temperate fishes. — Trans. Am. Fish. Soc. 119: 314–336.

Tarby, M. L. 1974: Characteristics of yellow perch cannibalism in Oneida Lake and the relation to first year survival. — Trans. Am. Fish. Soc. 103: 462–471.

VanDeValk, A. J., Rudstam, L. G. & Forney, J. L. 1994: Walleye stock assessment and population projections for Oneida Lake, 1994–97. — New York State Department of Environmental Conservation Report, Albany, NY.