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Chapter 1

Introduction

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Walleye: what's in the name?

walleye are also called: pickerel, walleye pike, walleyed pike, yellow walleye, yellow pikeperch, pikeperch, and other names (Scott and Crossman 1973). The pike in the names walleye pike or pikeperch is obscure. There is no scientific basis for this because phylogenetically, northern pike and walleye are not close relatives. Walleye, sauger, and yellow perch are called "percids" because they are in the perch family (Percidae), whereas northern pike and muskellunge are called "esocids" because they are in the pike family (Esocidae). Pickerel is a common name for walleye in the prairie provinces of Canada, but in French-speaking Canada, the vernacular *dore'* (golden), or *doré jaune* (golden-yellow) is used. *Dore'* and *dore'jaune* are descriptive, because the background color of the walleye's body is a golden hue with brassy yellow (*jaune*) mottlings. The sauger is called "*doré noir*" (black) in French-speaking Canada.

Because of the plethora of common and colloquial names, the Committee on Names of Fishes of the American Fisheries Society has endeavored to standardize the names of fish by publishing Common and Scientific Names of Fishes from the United States and Canada (Robins 1991). The book was first published in 1948 and subsequent editions have been published in 10 year intervals. The scientific name for the walleye is *Stizostedion vitreum*, which literally means "the pungent-throated fish with glass eyes" (Carmichael et al. 1992). *Stizostedion* means pungent-throated fish in reference to the large sharp (i.e., pungent), pharyngeal teeth, and *vitreum* means glassy, in reference to the nature of the large, silvery eyes (Scott and Crossman 1973). Hereafter, in the Walleye Culture Manual, all fishes are referred by their accepted common name, but Appendix A contains a list of common and scientific names following the nomenclature published by Robins (1991).

The name walleye is clearly a reference to the smoky, white opacity of the cornea which gives the species a distinct appearance. At night, especially in the spawning season when walleye in shallow water can be spotted with a light, the eye reflects light back and gives the fish a stunning appearance. The eyeshine of walleye comes from a unique reflective layer (*tapetum lucidum*) in the retina of the eye. The *tapetum Zucidum* enhances the stimulation of more rod cells in the retina by reflecting incoming light many times. The ichthyologist, George **A.** Moore, who first described the histology of the walleye eye, said that fishes with an eye like the walleye are "pre-adapted to life in weak illumination" (Moore 1944). Field studies have demonstrated that adult walleye are crepuscular, or nocturnal, and shun bright light. Because of their visual acuity, light intensity is more important than temperature in determining feedmg and depth distribution of walleye in lakes (Ryder 1977; Kelso 1978).

The age-specific phototactic response of walleye plays an important role in the design of the cultural environment for larvae, juveniles, and food-size fish. The behavioral response of walleye to light changes with development. Larval walleye are strongly attracted to bright light; this behavior can be used to concentrate walleye fry in the catch tank that receives newly hatched fry from a battery of incubation jars or to concentrate them under a feeder (Howey et al. 1980). Larval are so strongly attracted to light that light reflected from tank surfaces will attract larvae and they will cling to the side walls of culture tanks, even in tanks that have been painted black (Bristow and Summerfelt 1994). Larvae will also be attracted to the aquablue-colored bottom of tanks that have black walls. Between 4 and 8 weeks posthatch, juvenile walleye become negatively phototactic and seek out areas with 2- to 13-lux (Bulkowski and Meade 1983). Lux is a unit of illumination equal to one lumen per square meter. Pond-raised fingerlings, 1.5 to 3.0 in (38 to 76 rnm) that are to be habituated (i.e., the process of converting fish accustomed to live food to accepting formulated feed) to formulated feed, must be cultured at low light intensity (4.2- to 15.8-lux) (Kuipers and Summerfelt 1994), or dim, in-tank lighting must be used (Siegwarth and Summerfelt 1992). Walleye are easily disturbed by shadows that often result from overhead light; and internal tank light can minimize such disturbances (Nagel 1985).

Walleye are also called a "coolwater fish", a generalization suggesting that their temperature preference falls between that of salmonids (coldwater) fishes and warmwater species such as catfishes and sunfishes. Walleye, sauger, and yellow perch and the esocids, northern pike, and muskellunge, are the five most important coolwater fishes in North America because of their recreational and commercial importance (Kendal 1978). Walleye tolerate northern climates where the water temperature is <39°F (4°C) for more than 8 months of the year, and they can tolerate temperatures up to 32°C (90°F) for short periods in the southernmost portion of their range (Collette et al. 1977).

Fish are ectothermal, which means that their body temperature is similar to that of the water. The optimal temperature for fish growth is called the standard environmental temperature (SET). The SET for coldwater fish is 50°F (19°C) for salmon and 59°F (15°C) for rainbow trout. The SET for channel catfish, a warmwater fish, is 85°F (29°C) (Piper et al. 1982). **A** SET has not been established for walleye, but the optimum temperature for walleye growth changes with life stage (fry, fingerling, or near food-size). For fingerlings, the suggested optimum range is from 71.6°F (22°C) (Smith and Koenst 1975) to 78.8°F (26°C), depending on light intensity (Hokanson and Koenst 1986). Hokansen and Koenst (1986) reported that 88.8°F (26°C) was optimal at 5 lux. Cai and Summerfelt (1992) developed an equation for estimating the optimal temperature for metabolism of juvenile walleye based on light, at 45 lux the estimated optimal temperature was 77°F (25.3°C). A ground water supply at 75 to 77°F (23.9 to 25.3°C) would be ideal; otherwise, access to heated water or use of a recycle aquaculture system is needed to maintain the optimal temperature year-around. Heating large volumes of water to a constant 77°F (25°C) would not be practical for a single pass or serial reuse system.

The coolwater habitat adaptation of walleye makes it a preferred aquaculture species for culture in climates too cool for channel catfish. Economically significant ground water sources that have ideal temperatures (75 to 77°F; 23.8 to 25°C) for walleye culture are rare, but indoor facilities with controlled environmental temperature and a recycle aquaculture system provide opportunities for walleye culture anywhere in North America (Summerfelt 1996).

Geographic range

The original range of walleye in the **U.S.** extended west from New Hampshire through the Great Lakes basin; southward on the Atlantic slope to North Carolina; and west of the Appalachians, from the Alabama River system of Georgia to the Tennessee River drainage of Alabama, and from the lower Mississippi River valley to North Dakota (Hubbs and Lagler 1949; Trautman 1957; Becker 1983). In Canada, the original range extended from the mouth of the St. Lawrence River west to include the Hudson Bay and Great Lakes drainage, the Saskatchewan River system, the Great Slave Lake and Mackenzie River (Hubbs and Lagler 1949; Trautman 1957; Scott and Crossman 1973; Becker 1983). Colby et al. (1979) report that the northern limit to the distribution of walleye in Canada can be approximated by the 55.4°F (13°C) mean July isotherm.

In the United States, the popularity of walleye as a game species has resulted in their introduction to artificial lakes within and far beyond its original range, including reservoirs throughout the Southeast, the Great Plains (eastern Colorado, Nebraska, Kansas, Oklahoma and Texas), the Colorado River, and northwest to the Columbia River.

Importance in the sport fishery of the U.S. and Canada

The abundance of walleye illustrations on the cover of sport and fishing magazines provides conspicuous evidence about the popularity of walleye to anglers. There are fishing lures and apparatus, fishing clinics, angling tournaments, and books on fishing for walleye (Sternberg 1986). Ellison and Franzin (1992) accurately described the demand for walleye angling:

> "**A** fishmg boom for walleye ... developed during the 1980s, is reminiscent of the explosion in

angling demand for largemouth bass ... during the late 1960s through the 1970s. Advances in biological knowledge of the species, improved fishing gear and techniques, angling seminars, magazine articles, and television coverage first generated and then fed an accelerating interest in walleye fishing. The growth of angling clubs and fishng tournaments and concurrent increased in the numbers of anglers who fish only for walleyes have placed great pressure on walleye resources."

Walleye are targeted **as** a sport fish in 34 states, seven provinces, and one territory (Fenton et al. 1996).

Sport fishing is an economically important recreational activity in the US. In 1991, the expenditures for sport fishing by 31 million **US** anglers ≥ 16 years old (19% of the US population in that age group) was $24 billion; $15.1 billion was spent on freshwater fishing (USDI 1993). In 1991, in freshwaters other than the Great Lakes, 9% of the 431 million angler days of fishing was for walleye and sauger, which amounted to expenditures of $1.36 billion dollars. In the Great Lakes, 40% of 2.55 million anglers fished for walleye and sauger, a greater percentage than for any other species or species group; 39% of the anglers fished for perch, 28% for salmon, 21% for black bass, and 19% for lake trout. Angler expenditures for walleye and sauger fishing in the Great Lakes was $480 million, thus the total angling value for walleye and sauger in the US in 1991 was about $2.16 billion.

Travel by US citizens for sport fishing in the Canadian provinces of Ontario, Manitoba, and Saskatchewan is nearly synonymous with fishing for walleye. Scott and Crossman (1973), authors of the respected "Freshwater Fishes of Canada," state, "The walleye is probably the most economically valuable species in Canada's inland waters." In 1990, walleye represented 16.3% of the total freshwater fishes captured by anglers in Canada (Fenton et al. 1996).

Commercial fisheries for walleye in the U.S. and Canada

walleye were once a substantial part of the commercial fisheries of the Great Lakes, but especially Lake Erie (Hubbs and Lagler 1949). However, data on commercial harvest of walleye is difficult to obtain. The last year of record for commercial harvest data from the Great Lakes and the Mississippi River was in the 1977 issue of Fishery Statistics of the **US** (NOAA 1984), which was the last year of issue for that government publication. The annual report of the Fisheries of the United States, a different statistical report on **US** fisheries, does not provide data on commercial harvest from the Great Lakes or the Mississippi River.

Available data indicate a sharp decline in commercial harvest of walleye, Walleye harvest by Canadian and US commercial fishers from Lake Erie declined from 24 million lbs (10.8 million kg) in 1956 to 1.03 million lbs (0.47 million **kg),** in 1977; 89% of the total was by

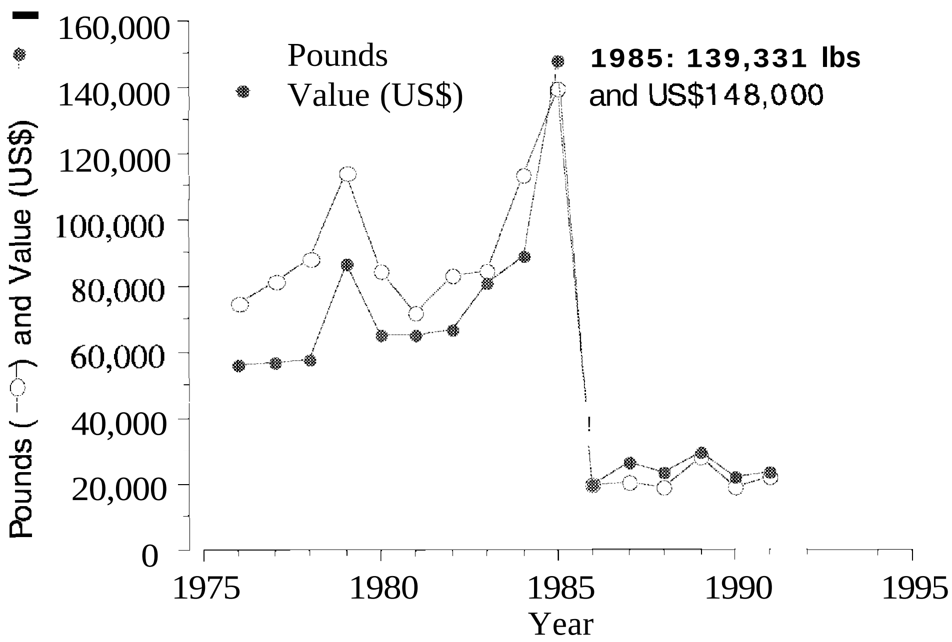

Figure 1. Commercial harvest of walleye from the Great Lakes and Mississippi River from 1976-1991 (data from O'Rourke and Edon 1995).

Canadians (NOAA 1984) In 1977, catch in Lake of the Woods was slightly more than the Great Lakes — 1.1 million lbs (0.50 million kg); 79.5% of the harvest was by Canadians. In 1977, landings of walleye on the Mississippi River was 580,000 lbs (263,088 kg) by Minnesota and Wisconsin fishers (both states reported the same harvest), which was greater than the 334,000 lbs (151,502 kg) harvest on the US side of the Great Lakes in the same year.

At one time, exploitation of walleye from Lakes Erie and Ontario was so intense that the blue pike, a subspecies of the walleye, was harvested to extinction (Zarbock 1977); but environmental changes to the deep water habitat of the blue pike was also a contributing factor. In the 1970s, walleye were considered the most exploited percid species in North American commercial and recreational fisheries (Kendall 1978). In Canada, the number of walleye caught declined from 25 million in 1986 to 20 million in 1990 (Fenton et al. 1996). Although a commercial fishery for walleye still exists on the Canadian side of the Great Lakes, especially on the north shore of Lake Erie, except for tribal fisheries, there is no licensed commercial harvest of walleye from the **US** portion of lakes Erie, Huron, Superior, and Michigan. Commercial harvest of walleye in the US has been eliminated in favor of the economically more valuable use of walleye stocks as resources for sport fishing.

In 1994, the Michigan Department of Natural Resources Fisheries Division reported harvest of walleye from the Great Lakes by the Inter-Tribal Fisheries and Assessment Program was regulated by COTFMA (Bay Mills, Soo Tribe, and Grand Travers) and the Great Lakes Indian Fish and Wildlife Commission (Bad River, Keweenan Bay, and Red Cliff Bands of Lake Superior Chippewa Indians) (CFN 1995). In 1994, the tribal harvest of walleye from Michigan waters of the Great Lakes was 9,216 lbs (4,180 kg) valued at $12,626 ($1.37/lb, $3.00/kg). Data of tribal harvest elsewhere (Minnesota, Wisconsin, New York) were not found, but even collectively, tribal harvest in the Great Lakes and other freshwaters of the US is trivial compared with Canada.

Commercial harvest of walleye in North America is largely from Canada, but even there, the total harvest of walleye has been declining; between 1973 and 1978, commercial harvest of walleye in the Province of Manitoba was only 65% of the average annual harvest between 1945 and 1954 (Sifa and Ayles 1981). Commercially harvested walleye pass through several marketing channels, but the larger portion are exported to the **US** under the aegis of the Freshwater Fish Marketing Corporation (FFMC), a "schedule III crown corporation" established in 1969 by the Freshwater Fish Marketing Act (documents supplied Dan Topolinski, FFMC, personal communication):

> "The corporation has the exclusive right to market and trade in fish in interprovincial and export trade and shall exercise that right, either by itself or by its agents with the objective of: marketing fish in an orderly manner; increasing returns to fishers; and promoting international markets for and increasing interprovincial and export trade in fish."

The mandate of the FFMC is to achieve the greatest possible economic returns to the commercial fishers. It accomplishes this mandate by marketing fish in an orderly manner, and by serving as a single-desk agent for promoting markets and export of fish, which happen to be mainly to the US because that is where they obtain the best price. The income of the FFMC has averaged between CN$40-50 million (US$29.5-36.8 million) for 1990-1994. The FFMC affects the livelihoods of about 3,000 commercial fishers, of whom 70% are Aboriginal. They fish on about 400 lakes in western Ontario, the three prairie provinces of Alberta, Saskatchewan, Manitoba, and the Northwest Territories. Commercial fishers in eastern Ontario operate independent of the FFMC through a greater diversity of smaller marketing channels. FFMC consolidates the processing and marketing of fish by collecting fish at about 90 landing points from which fish are transported fresh to a centralized processing facility located in Winnipeg, Manitoba. Packing stations are located in Hay River, in the North West Territory, and La Ronge, Saskatchewan. FFMC maximizes returns to fishers located in small, isolated communities.

The harvest of walleye by the FFMC between 1990 and 1994 ranged from 6.7-10.9 million lbs (3.0-4.9 million kg), but the annual landings shows a somewhat downward trend (Table 1). In 1992, the year for which landings and values data were available by province and territories, 47.0% of the walleye and 96.4% of the sauger were harvested in Manitoba, and 44.5% were harvested in Ontario; 44.9% of monetary value of

Table 1. Landings (round weight, in millions of pounds) of walleye and sauger processed by the Freshwater Fish Marketing Corporation of Canada[1].

	Landings, weight in millions of pounds (lb) or kilograms (kg)		
Fiscal year	Walleye lb (kg)	Sauger lb (kg)	Totals lb (kg)
1990	10.9 (4.9)	5.9 (2.7)	16.8 (7.6)
1991	8.7 (4.0)	4.8 (2.2)	13.5 (6.1)
1992	9.6 (4.4)	5.5 (2.4)	15.1 (6.8)
1993	8.5 (3.8)	4.1 (1.9)	12.6 (5.7)
1994	6.7 (3.0)	3.2 (1.4)	9.9 (4.5)

[1] Data are from FFMC, Winnipeg, Canada.

walleye was from Manitoba and 47.1% from Ontario. In 1992, the only year from which I obtained data on walleye, the average price per pound in the round was CN$1.63 (US$1.20, $2.60/kg).

Stocking for sport fishery enhancement

Because of inadequate recruitment, annual stockings are frequently used to maintain walleye populations; such programs have been underway for more than 90 years. In 1906, the US Bureau of Fisheries, the forerunner of the US Fish and Wildlife Service, stocked 368.2 million "pike perch" (formerly, a common colloquial name for walleye), which was 19.1% of the total number of eggs, fry, fingerlings, and adult fishes that were stocked in that year (Bureau of Fisheries 1906). The national fish hatchery system grew substantially after 1906 to a peak in the late 1950s. Although the number of federal hatcheries has declined since the 1960s, in 1991, 65. 8 million walleye, 3.8 million sauger, and 0.4 million saugeye (walleye x sauger hybrids) were distributed by federal hatcheries, and walleye fry stocking, was 31.6% of the 221.19 million fish distributed that year (FWS 1992).

In 1983 and 1984, state, federal and provincial fisheries management agencies in North America stocked more than one billion walleye fry and fingerlings (Conover 1986). Between 1986 and 1991, thirty-two state, federal, and provincial agencies reported stocking walleye and 29 agencies operated fingerling stoclung programs; each agency produced an average of 32.5 million fingerlings at a total cost of US$19 million (Fenton et al. 1996), which seems to be a very minor cost relative to the economic value of walleye in the recreational fisheries of the **US** and Canada. For example, $19 million was only 0.9% of the $2.16 billion of the economic value of walleye fishmg in the US in 1991.

Walleye raised by Indian tribes and private producers arc also used for stocking inland lakes although few statistics on production by the private sector are available. In a survey of the North Central Region conducted in 1991, forty-seven of 286 contacts (16.4%) responding to the survey indicated that they were raising walleye (Hushak 1993). The value of walleye was 8.0% (US$1.1 million) of US$13.9 million in total gross sales for respondents to the survey. In Minnesota, however, commercial (fish farmers) producers are the major sources of walleye that are purchased by lake associations and angler clubs for private lakes, and sales are also made to county and municipal governments. In 1992, over 600,000 walleye fingerlings valued at $328,000 ($0.54 per fish) were sold by private growers in Minnesota (MDA 1993).

Numerically, fry made up 98% of walleye stockings in the **US** and Canada (Conover 1986). However, the relative survival of stocked fingerlings is 16 to 60 times greater than that of fry (Heidmger et al. 1987). Large numbers of fingerlings can be raised to 1.5-2.5 inches (35-50 mm) by traditional pond-culture methods (Beyerle 1979; **Fox** 1989; Summerfelt et al. 1993). The focus of research by government agencies is increasingly directed to training pond-raised fingerlings to formulated feeds in intensive culture to meet the demand from recreational fisheries management for a larger (100-150 mm) fingerling (Cheshire and Steele 1972; Nagel 1974, 1976; Beyerle 1975; Nickum 1986).

Ellison and Franzin (1992) reviewed ten studies of maintenance stochng evaluations that were reported in a 1990 symposium. The overall finding was that success of various stochng practice remains largely unpredictable. In these studies, 32% of 34 fry stockings, 32% of the 22 small fingerling stockings, and 50% of the 40 reports on stocking large fingerlings were considered successful to some degree.

Aquacultural potential of walleye

walleye has been recognized by the National Aquaculture Development Plan (Joint Subcommittee on Aquaculture **1983)** as a species with substantial aquaculture potential. Potential, in this case, refers to its favorable attributes such as its high esteem as a sport and food fish throughout their natural distribution and the existence of past and present commercial markets for a full range of walleye life stages—from fertilized eggs to food-size fish.

The types of animals used in aquaculture are related to biological traits that make the animal adaptable to the crowded environment of the pond, cage, tank, or raceways where they are to be raised. Biological characteristics of fish that are important for a decision on their suitability for aquaculture include: (1) desirable reproductive traits; (2) lack of cannibalism; (3) suitable growth rate; (4) acceptance of artificial food; (5) tolerance of crowding and other hatchery conditions; (6) disease resistance; and (7) palatability (Summerfelt 1982). These issues are addressed throughout this culture manual. Although an itemized analysis at these points would not be justified, in summary, walleye are a highly fecund fish, i.e., it is easy to strip gametes and fertilize them; fry are easily incubated in conventional hatchery containers; the time needed to hatch eggs can be regulated within a range of 10 to 40 days; they can be spawned out of season; they do have cannibalistic tendencies, but this varies with stocks, and it seems to be reduced by domestication, and it is not a problem when fish are adequately fed; fingerlings can be raised at high densities in fertilized ponds to 2 in (50 mm); both fry and fingerlings can be habituated to formulated feed, and although fry feeds are special, walleye can be grown out to food size on a variety of fish feeds; walleye are tolerant of crowding and hatchery conditions, providmg the light intensity is correct; walleye are surprisingly tolerant of poor water quality; walleye are not more prone to diseases than other fish; and their flesh quality and palatability is excellent. Thus, the biological characteristics of walleye are desirable for aquaculture; however, cultural condtions must consider the importance of their light sensitive eye and phototactic response. Offspring of wild stocks are skittish, but they do well at low light or with in-tank lighting, and domesticated stocks and the interspecific hybrids are quite docile and they show hybrid vigor.

An economic assessment of the aquaculture potential for walleye is more dfficult, but walleye has been a valuable commercial species for over 150 years. In 1990 and 1991, two surveys of retail, wholesale, and other firms that comprise the traditional marketing channel for fish and seafood products within the North Central Region (Hushak et al. 1992; Hushak 1993) indicated that fishes with the most marketing potential in the region were walleye, yellow perch, bluegill, and largemouth bass. The most significant species (or species groups) in the 1991 survey, measured by gross sales at the farm level, were salmonids ($6.18 million), catfish ($2.58 million), baitfish ($1.89 million), walleye ($1.11 million) and largemouth bass ($0.65 million) (Hushak 1993).

Walleye are already a cultured species, albeit a small industry geared to the production of eggs, fry, and pond-raised fingerlings for stochng. Priced per pound, however, sales for stoclung bring excellent returns if the markets can be found. For a time, the incentive of excellent market prices resulted in a rapid expansion of commercial production of fry and fingerlings. Newly hatched fry often sold for 1- to 1.5-cents, and 1.5- to 4-in (35- to 100 mm) fingerlings sold for $0.25-0.75 each. For example, one commercial source lists 2-in (50.8 mm) walleye (available in July) at $0.45 each, or $0.35 each per 1,000, and another source lists 5- to 8- in (127-203 mm) walleye (available September-November) at $0.90-1.35 each. Commercial pond production has been particularly marked in Minnesota and to a lesser extent elsewhere. Excellent prices for fry and fingerlings have bolstered commercial walleye production of small fish to the point where there is intense competition for regional markets.

Walleye has favorable name recognition in restaurants. Although mainly sold in smaller, local, upscale, white-table-cloth restaurants, it is on the menu of some national franchise chains such as Red Lobster®. Given the favorable name recognition for walleye by the public, and a limited commercial supply, skin-on walleye fillets sell for more than cultured catfish, salmon, or trout. Since February 1987, I have recorded retail prices of skin-on walleye fillets at local retail outlets, the prices ranged from a low of $4.98 (September 21, 1991) to $10.95 (October 15, 1995), with a mean of $6.97. In that interval, the price of walleye fillets were 118% of the price of cultured salmon fillets (mean was $6.46). Retail prices of this magnitude have been a strong stimulus to the private sector for the production of food-size fish (1.25-1.5 lbs, 567-681 g). In 1994 walleye sold for US$1.37/lb ($3.00/kg) in tribal sales, and CN$1.63 (US$1.20) by FFMC. These prices are substantially greater than the $0.77-0.79/lb ($1.70-1.74/kg) farm price for channel catfish in 1995 (ERS 1996).

Hushak (1993) stated that "While North Central growers want to raise high-valued species such as yellow perch, walleye, and hybrid striped bass, the technology is not fully developed.''Thus, Hushak suggests that cultural technology is the constraint. The purpose of the research program of the North Central Regional Aquaculture Center (NCRAC) has been to overcome critical constraints, but substantial research efforts have been underway by state and federal natural resource agencies as well. Is the information base for cultural technology of walleye sufficient to commence commercial production of food-size walleye?

Experience with raising walleye to food-size has been largely limited to a few researchers who started by habituating pond-raised fingerlings to formulated feed. In 1989 a large scale effort to raise walleye to food size was started by Aquaculture Inc., Rolla, Missouri (NCRAC Journal 1990). Unfortunately, that project may have been ahead of the rapid rate of technological progress and it is no longer growing walleye. The goal of the Walleye Culture Manual is to help fill the technology gap so that culture of all stages of walleye will be more effective and so that walleye can be raised economically to food size in the future.

Although NCRAC research program on walleye has been diverse—pond culture, reproductive biology, larviculture—the goal has always been to develop technology for the production of walleye as a food fish. Eventually, the end use of walleye by commercial aquaculture will change from the culture of fry and fingerlings for stocking progeny to the production of fish for the food fish market.

Research needs

T h e biology of walleye has been reviewed by Scott and Crossman (1973), Collette et al. (1977), Kendall (1978), Colby et al. (1979), Becker (1983), Craig (1987), and others. These references are invaluable resources for basic information on the biological attributes of walleye important to their culture. The status of walleye culture has been reviewed by Nickum (1978, 1986). A culture manual on walleye was available by the U.S. Bureau of Fisheries in 1900 (Comm. Fish. 1900). Richard and Hynes (1986) prepared a pond culture manual based on their experiences at the White Lake Fish Culture Station. Most cultural practices for walleye have developed from trial-and-error rather than from experimental design. The potential for development of a substantial walleye food-fish culture seems to be realistic, but for commercial walleye aquaculture to be profitable, many aspects of the production process need further study in order to shorten the time required to take a fish from egg to harvest size and to improve economic efficiency of all aspects of their culture. More field trials are needed to generate reliable economic data on alternative production systems. The case studies and chapters in this manual demonstrate many traditional technologies. Some need refinement, but critical constraints remain for raising a walleye from a pond-cultured summer fingerling to a food-size fish in an economically efficient food-fish culture system. To obtain the level of economic efficiency required to be competitive in the food-fish market, commercial producers need access to domesticated broodstock, includmg both walleye and sauger lines that are needed to produce high performance interspecific hybrids, and research to extend out-of-season spawning to all months; feeding strategies and low-stress cultural systems that will improve feed efficiency and reduce disease; identification of important fish pathogens and stress factors that affect their occurrence; and development of vaccines and FDA-approved therapeutics to control disease problems. Although substantial, these research needs should be kept in perspective. Very few scientist-years have been given to walleye aquaculture, especially when compared with that devoted to poultry, swine and cattle production, or even that for trout and catfish culture. Great strides have been made by investigators in the North Central Region since inception of the USDA regional aquaculture center program: the problem with noninflation of the gas bladder has been resolved, walleye are spawned out of season, pond culture strategies have been evaluated, and technology transfer developed. Researchers have spoken to state and regional conferences on their research findings, workshops have been offered on special topics, and this manual developed to provide a comprehensive information source for walleye culture.

Summary

walleye is an important sport fish in the **US,** with a value based on angler expenditures of $2.2 billion in 1991. Historically, walleye have been an important commercial species; now however, except for small tribal fisheries, commercial harvest in the **US** is prohibited. From 1990-95, Canadian harvest of walleye in Ontario, the prairie provinces, and NWT ranged from 6.7 to 10.9million lbs (3.0 to 4.9 million kg) annually, and a substantial **part** of that harvest was marketed in the **US.** In 1992, fishers in Canada received CN$1.64 (US$1.20) per pound (US$2.60/kg) netted from remote natural lakes. The larger part of **US** aquaculture is by public agencies who culture fry and fingerlings for stocking purposes. Nearly all commercial aquaculture is marketed for sport fish enhancement. However, high retail prices *($6.97)* for walleye and an interest in development of new species for the market have spurred interest in production of food-size walleye. Technological constraints have been cited as reasons for walleye culture to lag. Thus, NCRAC sponsored research, production of the Walleye Culture Manual, and workshops are several steps being taken to help fill the technology gap so that culture of all stages of walleye will be more effective and so that walleye can be raised economically to food size in the near future.

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