# *A literature review of management approaches based on rate functions associated with yellow perch populations*

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## Introduction

This literature review is a project of the Wisconsin Department of Natural Resources (WDNR) Panfish Standing Team. In Wisconsin, "panfish" traditionally have been regulated as a broad group that includes several genera- the sunfishes (*Lepomis* spp.), the crappies (*Pomoxis* spp.), and yellow perch (*Perca flavescens*). The Panfish Standing Team is responsible for assembling and summarizing technical information to advise the WDNR Fisheries Management Board on matters of statewide panfish management policy and strategy.

The scope of this review is limited to the peer-reviewed scientific literature and several agency reports deemed relevant to the ecology and management of inland populations (excludes the Great Lakes and Mississippi River) of yellow perch in Wisconsin. This review is structured sequentially around the primary rate functions influencing fish populations – reproduction, growth, recruitment, and mortality. A description of relevant information related to each of these rate functions is presented for yellow perch. The literature included in this review does not represent an exhaustive review of all available information for the species. Instead, in the interest of focus, we limited our search to information of direct utility to Wisconsin and Upper Midwestern fishery managers.

## Distribution and Habitat

Yellow perch are widespread and common in most waters throughout Wisconsin (Figure 1). They occupy a range of waters in Wisconsin including lakes, slow moving streams, rivers and impoundments and are adaptable to a wide range of habitats. They also tend to be found in waters that are slow moving or static. Yellow perch have a high tolerance for low oxygen conditions (Herman et al. 1959).

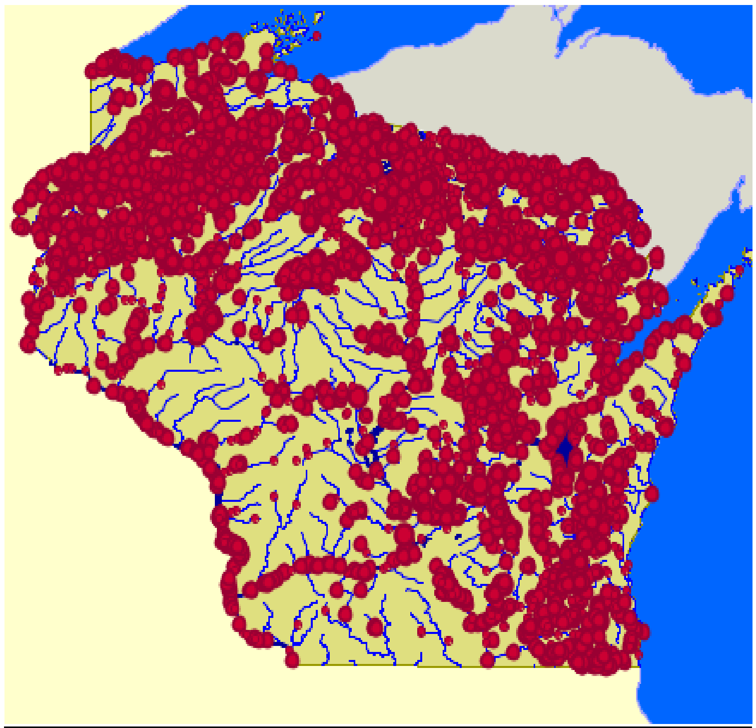

**Figure 1. Yellow perch distribution in Wisconsin (Lyons et. al 2012)**

## **<u>Recruitment</u>**

### ***Abiotic Factors Affecting Recruitment***

Water temperature is the primary determinant of the commencement of spawning. Spawning generally occurs shortly after ice-out, at water temperatures of 7.2-11.1° C (45-52° F). In addition, winter temperatures can have an effect on the development of yellow perch eggs. Hokanson (1977) suggests that a maximum winter temperature of 10ºC is required for gonad development. Generally, yellow perch move from deep water to shallow water spawning areas in spring. Yellow perch are random spawners with females depositing their eggs on a variety of substrates in depths ranging from 0.5 – 8.0 meters. Substrates include sand, gravel, rubble, submerged vegetation or brush, often in sheltered areas. The egg strand can range from 0.61 to 2.1 meters in length. Hatching time of eggs is quite variable but can range from 5-10 days (Becker 1983).

***Biotic Factors Affecting Recruitment***

Recruitment is a function of predation, available food resources, adult population size, and environmental factors (Forney 1971, Post et al. 1997, Rose et al. 1999, Sanderson et al. 1999, Hrabik 2001). Yellow perch are an important prey species for many predators such as largemouth bass *(Micropterus salmoides)*, walleye *(Sander vitreus)*, and northern pike *(Esox lucius)* (Seaburg and Moyle 1964). An introduction of a top predator or a large year class of predators can lower recruitment of yellow perch. Anderson and Schupp (1986) reported that northern pike stocked in Horseshoe Lake, Minnesota had a detrimental effect on the size structure and recruitment of yellow perch. Rose et al. (1999) noted that recruitment of yellow perch was reduced in Oneida Lake, NY when strong year classes of walleye were produced.

Yellow perch need sufficient forage in their first summer to survive the winter and recruit to the adult population (Hrabik 2001, Rudstam et al. 2004). Rose et al. (1999) reported an increase in yellow perch recruitment as mayfly production increased in Oneida Lake, NY. Accordingly, competition for limited food resources can detrimentally affect yellow perch recruitment (Siefert 1972). For example, introduced rainbow smelt (*Osmerus mordax)* in Wisconsin lakes have been shown to outcompete yellow perch since smelt eat the same food but hatch earlier and grow faster (Hrabik et al. 2001).

***Managing Recruitment***

Top predators can play a large role in the population dynamics of yellow perch. In systems with a large year class of juvenile yellow perch, predation can be used as tool to manage recruitment to the adult population. Rudstam et al. (2004) reported that walleye were significant cause of mortality on juvenile yellow perch in Oneida Lake, NY. In some lakes, age-0 yellow perch make up the majority of prey in walleye diet and can have a profound affect on recruitment. Guy and Willis (1991) reported that largemouth bass affected recruitment of yellow perch in South Dakota lakes. Managers can provide quality fishing opportunities for yellow perch by promulgating regulations that manipulate predator prey interactions. More liberal bag limits and reduced length limits on predators will reduce mortality on juvenile yellow perch which can increase recruitment into the adult population.

In systems with overabundant slow growing perch populations the opposite management technique can be used to limit recruitment. In lakes containing both largemouth bass and yellow perch, largemouth bass can prey on juvenile yellow perch which in turn can increase mortality and limit recruitment (Guy and Willis 1991). This strategy could be used to produce a quality yellow perch fishery with high proportional stock density (PSD). Fisheries managers could limit exploitation on predators, in turn reducing yellow perch recruitment, increasing growth and improving size structure. This strategy has been used before to manage bluegill fisheries in many small reservoirs.

It is difficult to manage competition due to underlying circumstances and interactions such as prey year class strength, predator stock size, and environmental conditions. However, competition for food resources between age 0 fish can affect mortality and limit recruitment of yellow perch into the adult populations. In one case, abundant cohorts of prey species like gizzard shad can buffer predation on age-0 yellow perch (Fitzgerald 2006, Forney 1980, Mills and Forney 1988) yet in other cases other prey species such as the exotic rainbow smelt can outcompete yellow perch (Hrabik et al. 2001). Manipulating predator stocks through regulations appears to be the best way to manage competition, yet success will heavily depend on the species of prey and predators involved as yellow perch are often preferred prey in Wisconsin lakes.

A study conducted by Hanchin et al. (2003) tried to increase yellow perch recruitment by construction of conifer tree reef. Results from the study indicated reefs contributed 14-37% of yellow perch production. Authors felt that construction of several smaller reefs may provide more benefit than just a single large reef. Increasing complex littoral woody habitat, may provide increased spawning substrates for yellow perch in many Wisconsin lakes.

**<u>Growth</u>**

Yellow perch growth appears to be strongly correlated with predator size structure. Anderson and Weithman (1978) found that when yellow perch PSDs were less than 10, gamefish were low in number. They suggest a balanced yellow perch population should have PSD ranges of 30-50. Guy and Willis (1991) found that largemouth bass density influenced yellow perch growth and size structure in small South Dakota impoundments, presumably through alleviating density-dependent limitations on growth. Specifically, high densities of largemouth bass were correlated with faster growth and high PSD scores. In a more recent study conducted by Paukert and Willis (2002) growth was found not to be density dependent for yellow perch however, largemouth bass predation of yellow perch was found to be the most significant factor in determining yellow perch size structure. Finally, Pierce et al. (2006) found that walleye stocking and increased predation on yellow perch reduced their numbers and improved growth rates. When stocking was discontinued yellow perch numbers rebounded and growth rates decreased.

Population abundance may influence yellow perch growth depending on size and age. Schneider (1971) and Clady (1977a) found that yellow perch growth was largely independent of density up to age 2, but thereafter, was inversely related to density. Similarly, Weber and Les (1982) found that relative abundance of young of year yellow perch in Lake Winnebago was not a factor in growth. Clady (1977a) suggested that density dependent effects on age 2+ yellow perch may be attributable to shifts in feeding behavior and also interactions of several cohorts (as a unit) at one time.

Boisclair and Rasmussen (1996) showed that total fish community density could significantly affect yellow perch growth. However, a more recent study conducted by Purchase et al. (2005) found that total fish density had no significant affect on yellow perch early growth rate or size.

Yellow perch serve as an important prey item for a variety of predator species. Seaburg and Moyle (1964) found that in a Minnesota lake, 70-85% of the food in largemouth bass stomachs was yellow perch, whereas sunfishes and bullheads *(Ameiurus* spp.) constituted only 15-30%. Guy and Willis (1991) suggested that yellow perch are probably more suitable prey item for bass due to body shape (i.e. yellow perch are more fusiform and easier to eat than centrarchids).

Isermann et al. (2007) suggest that yellow perch size and sex selective fishing mortality on growth should strongly be considered when evaluating length limits.

Appropriate yellow perch habitat may influence growth. Sass et al. (2006) studied the ecosystem impacts of removing coarse woody debris from the littoral area. In their studies yellow perch growth remained unchanged, however, abundance declined to very low levels. Purchase et al. (2005) found that yellow perch early growth and maximum size was positively related to lake surface area.

Young of year yellow perch feed on zooplankton and as they grow larger will switch to benthic invertebrates (Becker 1983). In Nebish Lake, Wisconsin, cladocerans and copepods made up a significant part of yellow perch diet throughout most of the year (Serns and Hoff 1984). In this study, dipterans were major food items for most yellow perch during May-July. Consumption of fish in this study was found to be very low (compared to aquatic insects) but was the highest during the month of July. Cannibalism at various life stages is also readily apparent in yellow perch populations (Thorpe 1977).

The amount and type of forage available for juvenile and adult yellow perch may be a likely factor that can influence growth. Hrabik et al. (2001) found that diet overlap and competition between age-0 yellow perch and exotic rainbow smelt may reduce the likelihood of strong year classes of yellow perch when large year classes of rainbow smelt occur. Serns and Hoff (1984) investigated the relationship of yellow perch and smallmouth bass diet overlap, specifically focusing on zooplankton. They found limited diet overlap and suggested yellow perch and smallmouth bass were compatible for introduction or restoration purposes in northern Wisconsin lakes.

***Growth Management***

Yellow perch diet is strongly dependent on forage consisting of zooplankton. Fertilization in pond culture is a common technique to improve zooplankton production and prey availability in a pond environment, however, it is probably not an appropriate management option on natural inland lakes due to deleterious affects to water quality and habitat.

Stocking of predators, including walleye, largemouth bass, muskellunge *(Esox masquinongy)*, and northern pike, to increase predator numbers and predation on abundant slow growing yellow perch may be useful management tool. Minimum length limits to protect predatory fish may also have useful application to reduce overabundant, slow growing yellow perch populations.

Stocking of yellow perch has been found to be detrimental in small impoundments due to their tendency to overpopulate. Guy and Willis (1991) suggest that if yellow perch are introduced to small impoundments that largemouth bass harvest be controlled to prevent yellow perch from degrading into a high-density, low-size-structure fishery.

Yellow perch have been found to be more tolerant of low dissolved oxygen levels and may be able to survive winterkill conditions better than other panfish species (Herman et al. 1959). Stocking of yellow perch into lakes that suffer partial or infrequent winter kill may be a useful tool for restoration purposes.

Population density is a major determinant of yellow perch growth. In some instances, predator stocking rates may be inadequate to control overabundant slow growing yellow perch. In addition, excessive recreational harvest of predator species may contribute to imbalanced yellow perch populations. Bauer et al. (2004) utilized fyke nets to manually remove yellow perch from a small lake in Michigan. After one year of removals yellow perch proportional stock density and relative weight were significantly higher than premanipulation years. Manual removal of yellow perch may be a useful tool to increase yellow perch growth in small inland lakes and impoundments.

## **Mortality**

### ***Abiotic Factors Affecting Mortality***

There are many physical and natural factors that influence mortality in fishes. In the early stages of embryo development water conditions, water temperature, and even solar radiation can affect egg development and survival. Williamson et al. (1997) observed that water clarity in lakes affected the survival of yellow perch eggs. In lakes with low dissolved organic carbon (DOC) solar radiation had a significant effect on mortality of yellow perch eggs. Moreover, egg mortality was higher in the shallow portion of the lakes (< 0.4 m) with low DOC than in areas deeper than 1 m.

Variations in water temperature during spawning and egg deposition can have a significant effect on egg and embryo survival. Hansen et al. (1998) reported that fluctuations in water temperatures after egg fertilization increased mortality of eggs in percids in Escanaba Lake, WI. Other authors have made similar observations: fluctuations in water temperature affected embryo development during incubation (Hokanson 1977), altered or interrupted spawning of adults due to temperature fluctuations (Koonce et al. 1977), and increased mortality in fertilized eggs during embryo development (Koenst and Smith 1976).

Fishing pressure can be a significant source of mortality of yellow perch at various times throughout the year. However, exploitation rates from sport fishing are reported infrequently due to the expense of a creel survey (Clady 1977b, Kempinger et al. 1975). Mortality rates of yellow perch have been found to be higher during winter because of exploitation during the ice fishing season. Clady (1977b) reported an annual exploitation rate of 4.4% for yellow perch in Oneida Lake, NY. Boe (1984) reported that exploitation in Okoboji Lakes, IA was 22%. Kempinger et al. (1975) reported that annual exploitation of yellow perch in Escanaba Lake, WI ranged from 2% to 34%. However, exploitation rates are generally less than 30% (Boe 1984) but may exceed 60% on some bodies of water (Radomski 2003). Recent studies show that panfish fishermen are motivated to catch quality perch that are larger in size (Petering et al. 1995). Isermann et al. (2005) reported that ice fisherman would rather catch five yellow perch between 254-300 mm than 10 yellow perch 203 mm and less in size

***Biotic Factors Affecting Mortality***

There are many biotic factors that can affect mortality of percids including but not limited to disease, parasites, predation, exploitation, and competition. Epizootic outbreaks can have a direct effect on the mortality of yellow perch and in some lakes parasites can be a significant source of mortality (Szalai 1991). Lake Mendota, WI experienced a die off of yellow perch during the summer 1939 caused by a myxosporidian outbreak which produced sores and lesions and ultimately caused death of those fish that were infected with the parasite (Bardach 1951). In addition, fish that are infected with parasites often mature at a slower rate making them more susceptible to predation (Szalai 1991).

Generally, speaking top predators can affect the size structure of prey populations by influencing mortality of various life stages (Rice et al. 1993); yellow perch mortality and size structure are influenced by various predator species (as discussed in the growth section). Additionally, cormorants *(Phalacrocorax auritus)* can be efficient predators on fish especially in systems where cormorants have no natural predators. Rudstam et al. (2004) reported that high mortality of juvenile perch in Oneida Lake, NY was the result of an increased cormorant population which ultimately led to the decline yellow perch. It is also well documented that walleye can be a significant source of mortality on juvenile yellow perch (Lyons and Magnuson 1987, Forney 1980, Nielsen 1980).

Competition for food can affect mortality of yellow perch during their first year of life. Over-winter starvation can be a significant source of mortality of young-of-year (YOY) yellow perch (Letcher et al. 1996). Fitzgerald (2006) reported that over-winter survival of YOY perch is dependent upon the growth obtained before entering winter months

Mortality Management

Yellow perch often spawn on weedy and woody habitat in water depths less than 2 m. Woody habitat is often a limiting factor in systems due to anthropogenic disturbances. The survival of yellow perch eggs is greater in lakes with a high level of DOC than in lakes with a lower level of DOC (Williamson et al. 1997). One way to increase survival of eggs is to improve spawning habitat. If habitat improvements are needed in low DOC lakes structures should be placed in water depths greater than 1 m, if feasible, to minimize any effects of solar radiation on survival of eggs and embryos.

Little can be done to manage disease outbreaks and many of the worst diseases such as viral hemorrhagic septicemia and spring viremia of carp virus were introduced to Wisconsin waters. Our best tool in preventing the spread and introduction of water born diseases through the transfer of water from one body of water to another is public education and outreach.

Several authors have reported how yellow perch growth and size structure improved after introducing top predators. Pierce et al. (2006) reported the walleye stocked in Lake Thirteen, MN reduced intraspecific competition between yellow perch and improved the size structure of the population. Liao et al. (2004) reported that walleye had a positive effect on the growth and size structure of yellow perch in Sprit Lake, IA. Anderson and Schupp (1986) reported that the stocking of northern pike in Horseshoe Lake, MN reduced recruitment of yellow perch into the adult population and improved the quality of the fishery. However, top down management may not always have the desired effect on target fish populations. Careful consideration should be given to habitat conditions within an individual system before stocking a specific top predator. Otherwise, the desired changes in stock quality may not be realized. If managers select the top down model to improve yellow perch growth and size structure, specific regulations often need to be promulgated to protect top predators from over exploitation, or the desired effect to the target population may not be realized. However, managers should monitor the impacts of predation on yellow perch juvenile survival closely so as not to reduce recruitment to unacceptable levels.

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