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Biological Synopsis of Pumpkinseed (*Lepomis gibbosus*)

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BIOLOGICAL SYNOPSIS OF PUMPKINSEED (*Lepomis gibbosus*)

by

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This synopsis reviews biological information on the pumpkinseed in support of a risk assessment evaluating the impacts of its expansion into non-native areas of Canada. Pumpkinseed are native to eastern North America. Pumpkinseed live in small lakes, ponds, weedy bays of larger lakes, and in the quiet waters of slow-moving streams. They tolerate a wide range of environmental conditions; maximum known age is eight to ten years. Although pumpkinseed are omnivorous, their main diet is invertebrates. Some populations of pumpkinseed have adapted to feeding on benthic organisms, including snails. Larger pumpkinseed may also be piscivorous. Pumpkinseed compete with native fish communities for habitat and food, and this can have a negative impact on native species richness and/or abundance. Little research has, however, been undertaken on the species outside its native range in Canada.

RESUME

Jordan, C., Backe, N., Wright, M.C., and Tovey, C.P. 2009. Biological synopsis of pumpkinseed (*Lepomis gibbosus*). Can. Manuscr. Rep. Fish. Aquat. Sci. 2886: iv + 16 p.

Le présent synopsis examine les données biologiques sur le crapet-soleil pour appuyer une évaluation des risques portant sur les effets de l’expansion de son aire de répartition vers des régions non indigènes au Canada. Le crapet-soleil est un poisson indigène de l’est de l’Amérique du Nord. Il vit dans de petits lacs, les étangs, les baies herbeuses de grands lacs et dans les eaux tranquilles des cours d’eau à courant faible. Il tolère un large éventail de conditions environnementales et son âge maximum connu varie entre huit et dix ans. Malgré qu’il soit omnivore, le crapet-soleil se nourrit principalement d’invertébrés, et certaines populations se sont habituées à s’alimenter d’organismes benthiques, notamment d’escargots. Il se peut que le crapet-soleil de grande taille soit également piscivore. Ce poisson fait concurrence aux communautés de poissons indigènes pour l’habitat et la nourriture, et cette situation peut avoir des effets néfastes sur la richesse et/ou l’abondance d’espèces indigènes. Cependant, peu de recherches ont été réalisées sur l’espèce à l’extérieur de son aire de répartition naturelle au Canada.

INTRODUCTION

The introduction of non-native species is a serious threat to fish communities. Highly adaptable species can spread far beyond their initial point of introduction, along many pathways (Dextrase and Mandrak 2006).

Pumpkinseed sunfish *Lepomis gibbosus* Linnaeus (1758) is native to North America. Its range in Canada has expanded west to British Columbia. Invasive pumpkinseed should be considered a potential threat to freshwater biodiversity, with implications for recreational, commercial and First Nations food fisheries.

The purpose of this report is to provide background biological information that can be used to estimate the level of risk inherent in expansion of pumpkinseed range in Canada. The synopsis summarizes the biology, life history, current distribution and known impacts of the species.

1.1 NAME, CLASSIFICATION AND IDENTIFIERS

Kingdom: Animalia
Phylum: Chordata
Subphylum: Vertebrata
Class: Actinopterygii
Order: Perciformes
Suborder: Percoidei
Family: Centrarchidae
Genus: *Lepomis*
Species: *gibbosus*

Scientific name: *Lepomis gibbosus* Linnaeus (1758)
Common name (English): pumpkinseed
Common name (French): crapet-soleil

Integrated Taxonomic Information System Serial Number: 168144
Sources: Zip Code Zoo; Animal Diversity Web (all 2008).

The scientific name for pumpkinseed is derived from the Latin words *lepomis* meaning “scaled operculum cover” and *gibbosus* meaning “like a full moon;” the latter indicates a deep body shape.

1.2 DESCRIPTION

Pumpkinseed have a narrow body (Figure 1) and rarely exceed 20 cm standard length. The joined dorsal fins consist of 10 to 11 spines and 10 to 12 rays. The anal fin has three spines and 10 to 11 rays (Holtan 1998).

Unique colouration helps pumpkinseed stand out from other members of the sunfish family. The breast and underside are orange to red-orange, while the back and sides

are brown to olive. On some individuals, speckles of orange, yellow, blue and emerald may be found on the sides, back and anal and caudal fins. Pumpkinseed have seven to eight irregular vertical bands on their sides. Radiating back from the snout and over the opercula are several wavy stripes. Often difficult to distinguish from bluegill *Lepomis macrochirus*, pumpkinseed can be identified by a flap on the posterior end of the operculum that is black with a crimson spot (Holtan 1998).

Pumpkinseed have pronounced sexual dimorphism. Males tend to be larger and their already prominent colours intensify during breeding (Scott and Crossman 1973). Females are paler but have more distinguished vertical bars. Juveniles of both sexes are green to olive in background colour (Scott and Crossman 1973).

Within populations, morphological differences appear to be directly related to diet (Osenberg et al. 1992; Mittelbach et al. 1999). The availability of gastropods (a primary prey item) has been correlated with the size of key jaw muscles (Mittelbach et al.1999). Larger jaw muscles allow pumpkinseed to crack shells of larger snails.

In the absence of bluegill, morphological differences are also observed between littoral and pelagic forms of pumpkinseed. Littoral pumpkinseed typically have deeper bodies, longer heads, larger molars, a more rearward placement of dorsal and pectoral fins, longer pectoral fins and more space between gill rakers (Robinson et al. 1993; Gillespie and Fox 2003). The reduction in space between the gill rakers in pelagic individuals may be advantageous for capturing small prey, such as zooplankton (Lavin and McPhail 1986; McCairns and Fox 2004).

Figure 1. Pumpkinseed *Lepomis gibbosus*. Image courtesy of the New York State Department of Environmental Conservation, Albany NY.

2.0 DISTRIBUTION

2.1 GLOBAL NATIVE DISTRIBUTION

The native range of pumpkinseed is restricted to North America (Figure 2). The species was originally found from New Brunswick down the Atlantic seaboard as far as northeastern Georgia. The species also occurred west of the Appalachian Mountains from southern Quebec to southern Ohio, west to northern Missouri, and north through eastern South Dakota to eastern Manitoba, including western Ontario (Scott and Crossman 1973).

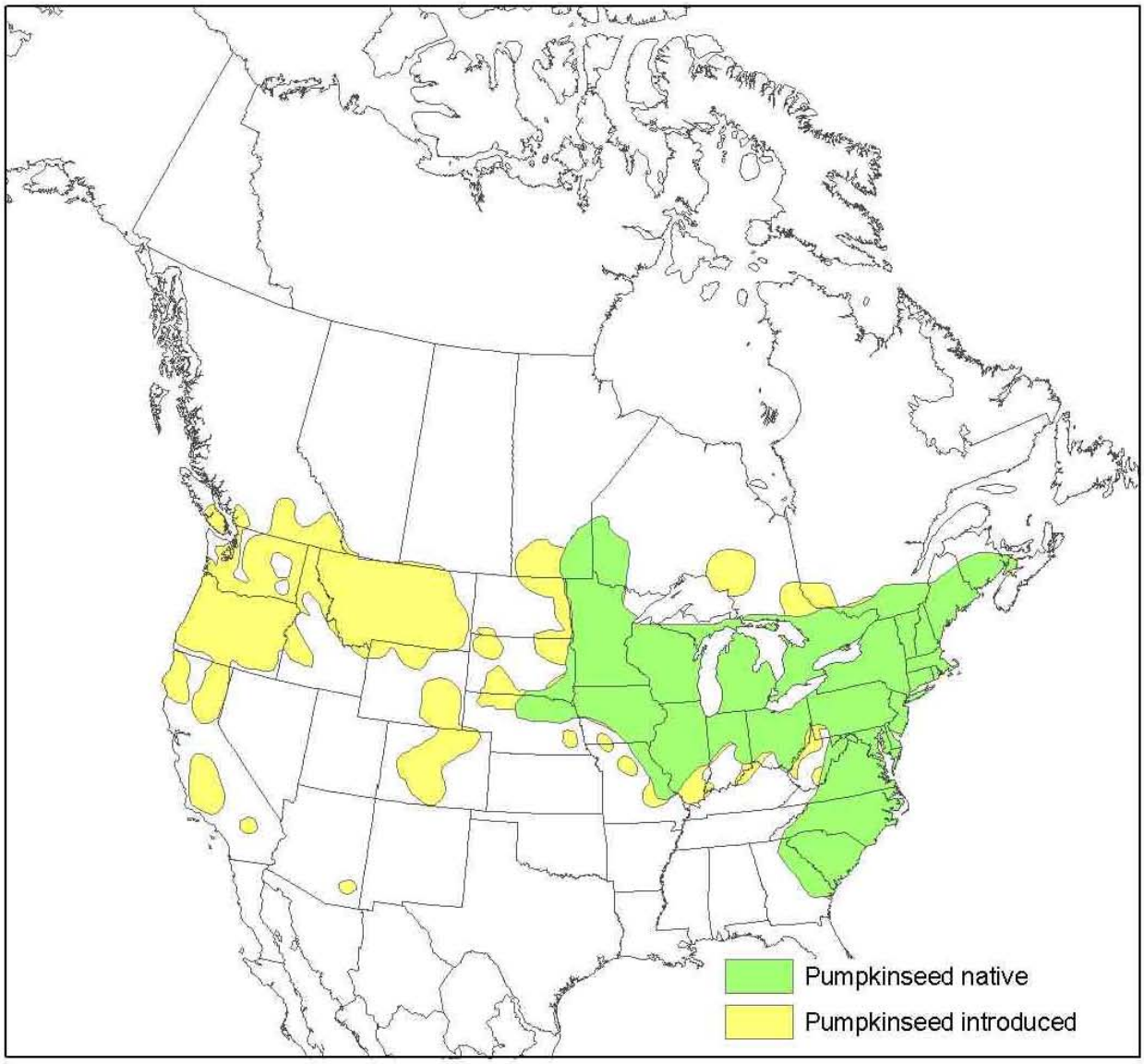

Figure 2. Pumpkinseed native and non-native distribution in North America from Bradford et al. (2008).

2.2 NON-NATIVE DISTRIBUTION

Introduction of pumpkinseed beyond its native range has occurred around the world for many years, and for many reasons. In the early 1900s, the species was introduced into European waters as a potential sport and ornamental pond fish (de Groot 1985; Copp et al. 2005). Bulgarian pumpkinseed were accidentally introduced as fry and fingerlings into the rivers of Macedonia (Economidis et al. 2000). In Spain, pumpkinseed were intentionally introduced as prey for native wild stocks that had suffered heavy predation from previously introduced pike, bass and catfish (Elvira and Almodovar 2001).

Extension of pumpkinseed range in Canada began in the early 1900s, when they were introduced into the Columbia River system (Figure 2). Since then, they have entered the Kootenay River system in British Columbia and become one of the dominant species in the lentic habitats of the Creston Valley (Ohanjanian 1988). Introductions have served different purposes in various parts of Canada, including control of other fish populations and as forage for predatory species such as largemouth bass *Micropterus salmonides* (de Magalhaes and Ratton 2005). Non-native pumpkinseed are also found in several lakes on Vancouver Island (Cassin and Silvestri 2002a, b) as well as the lower Fraser Valley (McPhail 2007).

3.0 BIOLOGY AND NATURAL HISTORY

3.1 AGE AND GROWTH

The maximum known age of pumpkinseed is eight to ten years. Young pumpkinseed grow rapidly and reach up to 5 cm in their first year (Holtan 1998). Sexual maturity and reproduction occur in the second to third years (Scott and Crossman 1973).

Several environmental parameters are known to affect the growth rate of pumpkinseed, including water quality, temperature, population density and the presence of other species (Holtan 1998). Depending on water quality, mature pumpkinseed may reach 13 to 20 cm in length and weigh 0.23 to 0.34 kg (Holtan 1998). The presence of bluegill and other fish species affects pumpkinseed growth through competition for various resources, especially during juvenile stages. Adult pumpkinseed become effective foragers despite the presence of other species (Osenberg et al.1988). Holtan (1998) describes pumpkinseed as having stunted growth in overpopulated lakes, especially in the presence of bluegill.

3.2 PHYSIOLOGICAL TOLERANCES

Pumpkinseed can tolerate a wide range of environmental conditions (Vila-Gispert et al. 2002). Their optimum temperature is 24 to 32°C, and they are believed to tolerate lower oxygen levels than do bluegill (Holtan 1998). Pumpkinseed are negatively affected when pH drops to between 5.2 and 5.3 (Sun and Harvey 1986).

3.3 REPRODUCTION

Spawning usually takes place in late spring to early summer, at temperatures between 15 and 25°C (McPhail 2007) and may continue into August when water temperatures reach 27.8°C (Scott and Crossman 1973).

Before reproduction, males construct small, circular nests on sand or gravel in water less than 1 m deep (McPhail 2007). Colonies can contain up to 15 nests. Males use their caudal fins to sweep out a shallow, saucer-shaped depression 10 to 38 cm in diameter (Holtan 1998). Submerged aquatic vegetation is often found surrounding the perimeter of the nests (Scott and Crossman 1973). Nesting areas may be shared with other species (Klarr et al. 2004).

Once the nest is built, males vigorously defend them before spawning. Females wait in deeper water until the nests are constructed, then move towards them in schools. Males swim out from the nests to attract females. The female releases between 1 500 and 7 000 eggs in an irregular pattern (Holtan 1998). Males may spawn more than once, with the same or different partners (Breder and Rosen 1966). Females may spawn in more than one nest; occasionally, multiple females will spawn simultaneously in the same nest (Holtan 1998).

Parental care is provided exclusively by the male (Rios-Cardenas and Webster 2005), who stays close to the nest following fertilization in order to chase away predators (Robinson et al. 1993; Holtan 1998). Eggs hatch three to five days after fertilization, depending on water temperature. One nest can produce from 1 500 to 15 000 fry; the average is 8 000 (Holtan 1998). The male fans the nest to keep it clean and well-oxygenated until the larvae are able to feed on their own. This usually occurs around 10 to 11 days after hatching, when the young move into shallower water and away from the nest (Scott & Crossman 1973; Rios-Cardenas 2005). Males then begin cleaning the nest for a second spawn (Scott & Crossman 1973).

On occasion, pumpkinseed build nests in bluegill colonies. Where this occurs, crossbreeding of bluegill and pumpkinseed is fairly common (Holtan 1998). Pumpkinseed are also known to hybridize with other sunfish such as warmouth *Lepomis gulosus*, redbreast *Lepomis auritus*, green *Lepomis cyanellus*, orangespotted *Lepomis humilis* and longear *Lepomis megalotis* (Scott and Crossman 1973).

3.4 FEEDING AND DIET

3.4.1 Prey items

Pumpkinseed are omnivorous (Copp et al. 2004) and demonstrate trophic and/or resource polymorphism. For example, individuals in the pelagic zone appear to be specialized for foraging on zooplankton, while those that live in shallow littoral habitat feed primarily on macro-invertebrates (Robinson et al. 1993; Gillespie and Fox 2003; McCairns and Fox 2004).

Although pumpkinseed feed on the most frequent and abundant prey available, their main diet is invertebrates, mostly dipteran larvae (Hambright and Hall 1992; Johnson and Dropkin 1993; Godinho et al*.*1997; White 2002). In a study of three shallow western Washington lakes, approximately 98.8% of the pumpkinseed diet was invertebrates, while the other 1.2% consisted of aquatic plants and detritus (Bonar et al*.* 2004).

During early juvenile development, pumpkinseed occupy the same space and consume roughly the same diet as bluegill (McCairns and Fox 2004). Depending on body length, a prey shift may occur, from zooplankton to molluscs (snails) and crustaceans (White 2002; Rezsu and Specziar 2006). Initially, juvenile pumpkinseed feed on planktonic crustaceans such as *Leptodora kindtii*, shifting to benthic or epiphytic macro-invertebrates like *Limnomysis benedemi*, *Dikerogammarus sp*., *Corophiu*m *curvispinum* and various chironomidae; later, they may consume fish (Rezsu and Specziar 2006).

In open water, stable zooplankton populations support pumpkinseed (Robinson et al. 1993). Hambright and Hall (1992) found that the rate of feeding and zooplankton size were correlated with the size of the pumpkinseed. Periphyton is also an important component of the pumpkinseed diet (Prince and Maughan 1978). With age, pumpkinseed become increasingly predatory, and their diets may consist of small fishes and amphibians (Scott and Crossman 1973; Holtan 1998). Pumpkinseed have also been known to consume fish eggs and aquatic plant debris (Garcia-Berthou and Moreno-Amich 2000; Copp et al*.* 2004).

3.4.2 Feeding behaviour

Pumpkinseed feeding generally peaks at dusk and dawn and is low during the day (Collins and Hinch 1993; Johnson and Dropkin 1993; McPhail 2007). Pumpkinseed forage at different times throughout the day, possibly optimizing the diversity of prey available (Godinho et al. 1997). Some foraging occurs at night, usually in the water column. Changes in weather patterns may affect foraging, so day to day variances in foraging pattern may be observed (Collins and Hinch 1993). Seasonal differences in foraging activities may be related to changes in abundance and activity of prey, temperature-specific foraging rates and reproductive activities (Collins and Hinch 1993). Reductions in foraging during reproduction were observed in June and July (Thorp et al*.* 1989; Collins and Hinch 1993). Kieffer and Colgan (1993) concluded that habitat structures influenced the ability of pumpkinseed to become more efficient foragers.

In addition to feeding in the pelagic zone, pumpkinseed have adapted to feeding on benthic organisms (Johnson and Dropkin 1993; Keiffer and Colgan 1993; Holtan 1998; White 2002). Capture of benthic organisms involves suction feeding using an externally generated flow field (Parsons and Robinson 2006).

Pumpkinseed foraging decreases during winter, particularly when water temperatures drop below 15ºC (Collins and Hinch 1993; Rios-Cardenas and Webster 2005). Pumpkinseed adapt by shrinking their stomachs and secreting mucus until water temperature increases (Rios-Cardenas and Webster 2005). Growth and consumption increase with water temperature, particularly during breeding season in the spring

(Rios-Cardenas 2005). During the parental care period, male pumpkinseed weight decreases as foraging is limited to the shallow waters surrounding their nests (Thorp et al. 1989; Rios-Cardenas and Webster 2005). Increased male mortality has been observed during these periods (Rios-Cardenas and Webster 2005).

3.5 HABITAT REQUIREMENTS

Pumpkinseed typically live in small lakes, ponds, weedy bays of larger lakes, and in the quiet waters of slow-moving streams. They prefer clear water with an abundance of submerged vegetation, but can sometimes be found on rocky shoals (Scott & Crossman 1973; Robinson et al. 1993).

3.6 INTERSPECIFIC INTERACTIONS

Pumpkinseed are prey to various species throughout their life cycle (Marcus and Brown 2003). In southeastern B.C., western grebe *Aechmophorus occidentalis* are known to forage on pumpkinseed and perch in the Creston Valley (Forbes and Sealy 1990). These species appear to play a major role in the grebe's reproductive success. The maximum size of pumpkinseed consumed by young grebes ranges from 13 to 15 cm (Forbes and Sealy 1990).

Pumpkinseed eggs, fry and juveniles are common prey for largemouth bass (Ohanjanian 1988; Ardent and Wilson 1999). Predation ceases at around 7.0 cm. Other species preying on small pumpkinseed include smallmouth bass *Micropterus dolomieu*, yellow perch *Perca flavescens*, walleye *Sander vitreus*, muskellunge *Esox masquinongy*, northern pike *Esox lucius* and other sunfish (Scott and Crossman 1973; Holton 1998). In northern Europe, pike-perch *Stizostedion lucioperca* and northern pike *E. lucius* consume pumpkinseed (Copp et al. 2004).

3.7 BEHAVIOUR AND MOVEMENTS

Vila-Gispert and Moreno-Amich (1998) described a vertical migration pattern in which pumpkinseed larvae are more abundant in benthic areas of lake or stream by day, and migrate toward the surface at night. There was no mention of this behaviour continuing into adult stages.

Young pumpkinseed (total length 3.5 to 14 mm) form fairly large schools in both littoral and limnetic zones (Vila-Gispert and Moreno-Amich 1998; Holtan 1998). The adults rarely school, and are instead found in pairs or loose aggregations of three to four individuals. Adults usually stay close to the shoreline in submerged vegetation (Ohanjanian 1988; Vila-Gispert and Moreno-Amich 1998).

3.8 DISEASES AND PARASITES

Pumpkinseed host parasites from many different groups, including protozoans, trematodes, cestodes, nematodes, acanthocephala, leeches, mollusks, crustaceans and one linguatulan (Scott and Crossman 1973).

In Norway, two non-native flatworm parasites were found on the gill filaments of pumpkinseed (Sterud and Jorgensen 2006). In North America, two parasitic anchor worm species, *Lernaea cruciata* and *L*. *cyprinecea,* were found on pumpkinseed in Lake Huron, Michigan (Hudson and Bowen 2002). A parasitic copepod native to eastern Asia, *Neoergasilus japonicus,* was found on the dorsal, anal and caudal fins of the same population.

Copepod parasites are often introduced by exotic fish hosts associated with fish culture (Hudson and Bowen 2002). Some actions have been taken to minimize the transfer of such parasites. The United States Department of Agriculture's Animal Plant Health Inspection Service (USDA-APHIS) recently issued a federal order to prohibit interstate transport of numerous non-native species (including pumpkinseed) from eight states surrounding the Great lakes region: Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin. This also included importation of pumpkinseed from Ontario and Quebec. This order was issued in order to prevent the spread of viral hemorrhagic septicemia (VHS), of which copepods are a carrier, into potential aquaculture facilities for pumpkinseed and other non-native species (Egrie, G., Holland, J., and Merrill, P., USDA APHIS Veterinary Services, National Center for Animal Health Program, 2006 personal communication).

4.0 USE BY HUMANS

4.1 RECREATIONAL FISHING

Particularly active in the summer, pumpkinseed will bite any lure and do not fight much (Holtan 1998, White 2002). These habits make them easy to catch for young fishers, as does their location along the shoreline in shallow water. Pumpkinseed also have excellent flavour, are low in fat and high in protein (White 2002). Despite these positives, they are often viewed as a pest fish by most adults (Holtan 1998).

There have been no management plans developed in Canada for recreational angling on sunfish (Ministry of Natural Resources Ontario 2006). However, anglers in most provinces of Canada must acquire a provincial freshwater fishing license for any non-tidal fish. In B.C., a fishing license is not required because pumpkinseed is not listed as a freshwater game fish (Twaddle, P. Ministry of Environment, April 2007 personal communication). In Ontario, the recreational fishery for pumpkinseed is open year-round in most areas. However, a closure during spawning periods has been recommended, as well as catch-limits, to place a value on the resource, prevent commercialization and avoid overexploitation (Ministry of Natural Resources Ontario 2006).

4.2 COMMERCIAL FISHING

In Canada, pumpkinseed are commercially harvested on the St. Lawrence River, whose population peaked in 1989 before gradually declining over the next eight years (Mathers 1999). The commercial catch in this area increased in 1999 but has yet to return to the numbers observed from 1987 to 1991 (Mathers 1999). To date, there are no records of

commercial pumpkinseed fisheries west of Manitoba (Watkinson, D. DFO, Freshwater Institute, April 2007 personal communication).

There are U.S. commercial fisheries for pumpkinseed in the Great Lakes including Lake St. Clair (Baldwin et al. 2007). In the waters of New York State, the annual reported catch of sunfish (pumpkinseed and bluegill) between 1991 and 2001 was 9.7 tonnes (LaPan 2004). Data on the commercial catch of pumpkinseed from the Great Lakes and Lake St. Clair are available for 1867 to 2000.

4.3 AQUACULTURE

There are six producers of sunfish in the United States, mostly in Texas and Wisconsin (Morris, J.E. Iowa State University, jemorris@iastate.edu, April 2007, pers. comm.). Sunfish are commonly cultured in ponds, with occasional use of cages and recirculation tanks (Morris and Mischke 2003). The market for cultured sunfish is for stocking sport fish ponds and lakes, with some baitfish production and scientific research. There is currently potential as a food fish in Illinois, where over half of the sport fish caught is *Lepomis* or *Pomoxis* (Morris and Mischke 2003). Pumpkinseed is not known to be one of the cultivated sunfish species in the United States or Canada; bluegill and its hybrids are currently the main species being cultivated.

5.0 IMPACTS ASSOCIATED WITH INTRODUCTIONS

Pumpkinseed are not known to feed directly on aquatic flora (Fox, M.G. Trent University, mfox@trentu.ca, April 2007, pers. comm.). Mature males do remove aquatic macrophytes in the nesting area, but these macrophytes normally grow back quickly following the breeding season.

There is only limited literature describing the impacts of pumpkinseed on fauna. Some negative impacts on fauna by other fish species have been observed in Europe (Copp et al. 2004). Introduced pumpkinseed are considered a factor in the decline of 7 out of 41 endangered fish species in Canada (Dextrase and Mandrak 2006).

5.1 IMPACTS ON ZOOPLANKTON

Middelbach (1988) suggested that fishes in lentic systems have three kinds of impact on invertebrates: the size structure of benthic invertebrates; benthic invertebrate species richness; and total density. Hambright and Hall (1992) described pumpkinseed as particulate feeders who, when found with other planktivorous fishes in high densities, can shift to smaller zooplankton (Mittlebach 1988). *Daphnia*, one of the primary food sources for pumpkinseed, can move into areas where thermal stratification and low light levels make them less available to pumpkinseed (Hartleb and Haney 1998).

The presence of pumpkinseed is known to affect benthic micro- and macroinvertebrates, depending on life stage (Thorp 1988; Elkin and Baker 2000). Benthic invertebrate diversity and density is likely to be reduced significantly as a result

of reproductive behaviour and nest building; this effect is also detectable the following year (Thorp 1988).

Adult pumpkinseed can use gastropods as their primary food resource (Osenberg and Mittelbach 1989). A reduction of snail abundance has been observed due to predation by pumpkinseed. However, some snails have adapted to predation through a change in shell shape (Osenberg et al. 1992, DeWitt 1998). Osenberg et al. (1992) described reduced abundance of molluscs in lakes in the Iberian Peninsula (Southwest Europe), as a result of predation by introduced pumpkinseed. In contrast, Lodge et al. (1998) concluded that strong predation by pumpkinseed on snails in north Wisconsin lakes resulted in no effects on abundance or the number of species; an extensive vegetated littoral zone may have provided refuge for snails.

5.2 IMPACTS ON FISH

Pumpkinseed compete with native fish communities for habitat and food. Pumpkinseed also cause decreased species richness through predation (Copp et al. 2004). In Westwood Lake, Vancouver Island, low trout numbers were attributed to the presence of pumpkinseed (Cassin and Silvestri 2002 b). Pumpkinseed have also played a prominent role in the extirpation of a number of scientifically important stickleback species in other Vancouver Island lakes (McPhail 2007).

The foraging strategy of pumpkinseed is often described as opportunistic. Adults can be piscivorous (Cassin and Silvesti 2002 a,b) and have the potential to affect salmonid stocks through consumption of their eggs and fry. Declerck et al. (2002) describe a moderate overlap in diet between pumpkinseed, topmouth gudgeon *Pseudorasbor*a *parva* and brown bullhead *Ameiurus nebulosus*; these species all rely on chironomid larvae, but differential consumption of chironomid size classes seems to allow niche differentiation.

Niche overlaps are difficult to interpret because species shift niches based on competition for resources. However, Fisher Huckins et al. (1999) propose a competition theory wherein introduction of a species with more efficient foraging abilities can cause expansion of the native species' diet.

In European waters, pumpkinseed are thought to cause decreased richness of native freshwater fishes (Lever 1996, Copp et al. 2005). Intentional introduction of pumpkinseed resulted in impacts on native species such as European perch *Perca fluviatilis,* including their eggs and larvae (Lever 1996; Garcia-Berthou and Moreno-Amich 2000; Klarr et al. 2004). Predation on fish eggs is likely to have strong effects on fish populations. In Spanish river systems, introduced adult pumpkinseed and adult brown trout *Salmo trutta* compete for the same resources and prey on smaller pumpkinseed (Klarr et al. 2004).

5.3 IMPACT SUMMARY

Many aquatic ecosystems where pumpkinseed have been introduced have shown direct and indirect impacts related to habitat disruption and competition for resources (Dextrase and Mandrak 2006). The ability of pumpkinseed to compete in aquatic ecosystems can have severe negative implications for native species (Wynne 1995). Effects on benthic invertebrate density have been described during the reproductive season, and pumpkinseed can also reduce snail density.

Introduced pumpkinseed have been implicated in the extirpation of stickleback species, a decline in salmonids from a Vancouver Island lake, as well as reducing native fish species richness in several European locations.

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