Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences
Pacific Region
Canadian Science Advisory Secretariat
Science Advisory Report 2010/084

SCIENCE ADVICE FROM A RISK ASSESSMENT OF PUMPKINSEED (*Lepomis gibbosus*) IN BRITISH COLUMBIA

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

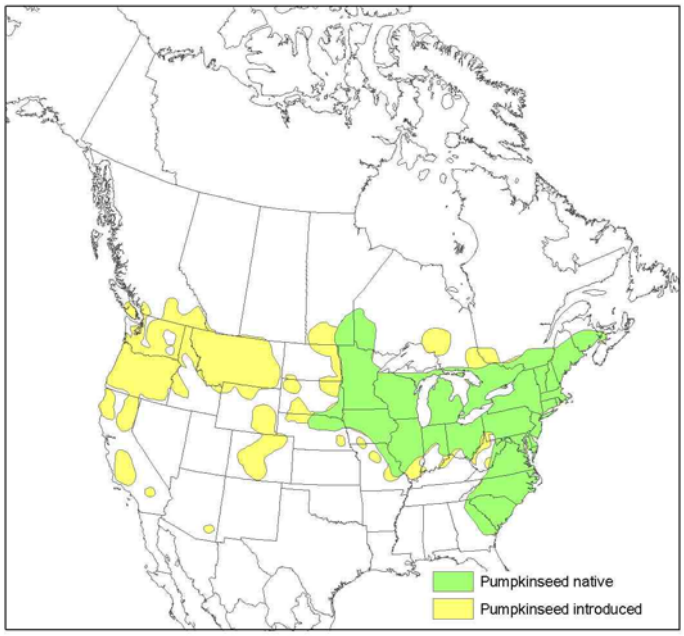


Figure 1. Native and non-native distribution of Pumpkinseed in North America (from Jordan et al*. 2009).*

Context:

Pumpkinseed is a small, warm-water species with an omnivourous diet that consists of mainly invertebrates but can include zooplankton or fishes. Pumpkinseed is native to the freshwaters of eastern North America and not to British Columbia. It has been introduced into British Columbia by natural dispersal through the Columbia River system from the states bordering it to the south or by unauthorized means. This adaptable feeder can successfully spread and colonize new areas and has become known as the most successfully introduced species of fish in Europe. There, as in British Columbia, it poses a risk to native fish species and for this reason a risk assessment was undertaken.

Fisheries and Oceans Canada's (DFO's) Centre of Expertise for Aquatic Risk Assessment (CEARA) provided guidelines to assess the biological risk of aquatic invasive species in Canada. A risk assessment provides science-based guidance to resource managers for the development and implementation of management options. Literature review was the main tool used to assess the biological risk posed by Pumpkinseed to aquatic ecosystems in British Columbia. A draft risk assessment was peer reviewed by internal and external experts, as required by the Canadian Science Advisory Secretariat (CSAS), at a national workshop held March 4-6, 2008 in Richmond, British Columbia. Based on discussion at this workshop the risk assessment was revised and published as a research document (Bradford et al*. 2008) along with the proceedings report which documented the discussions (DFO 2010). This risk assessment was conducted at a relatively broad scale and is not intended to provide detailed information or advice for specific waterbodies or on impacts to individual*

populations, but to summarize information at a larger scale. Risk posed to a particular waterbody will need to be determined in a specific risk assessment.

SUMMARY

- Pumpkinseed is a small centrarchid, native to North America (Figure 1.), which is often kept as an aquarium fish due to its attractive colouration.
- Pumpkinseed is considered to be a nuisance species when introduced to a new region as it generates little angler interest other than as a forage fish for more highly prized piscivores.
- Pumpkinseed competes with native fish communities for habitat and food. Introduced Pumpkinseed is considered a factor in the decline of 7 out of 41 endangered fish species in Canada.
- Pumpkinseed has a high level of life history plasticity and is able to adjust its age and size at maturity as well as its diet to suit the conditions of a particular waterbody.
- Once established, factors such as later maturation and larger size at maturity allow it to be successful in a competitive environment.
- Parental care of eggs and larvae increase the chances of establishment, although, specific requirements of reproductive behaviour mean that certain environmental conditions are required for nesting to occur. A lack of suitable nest building habitat or suitable prey for larvae would decrease the chance of establishment.
- The ecological impacts, caused by the introduction of parasites and diseases associated with Pumpkinseed, were determined to be moderate with high uncertainty.
- Overall, the risk posed by Pumpkinseed ranges from moderate to high with moderate uncertainty in small waterbodies and low to high with moderate uncertainty in large waterbodies depending on the region of British Columbia considered.
- Pumpkinseed poses the lowest overall risk to the Arctic region and the highest risk to the Lower Mainland and Columbia River regions.
- Risk posed to a particular waterbody will need to be determined in a separate, specific risk assessment if required.
- Once introduced Pumpkinseed is difficult to eliminate. A proactive approach is necessary should spread be deemed undesirable.

BACKGROUND

Aquatic invasive species (AIS) are non-indigenous species that have an impact on the ecosystems in which they are introduced. These impacts include severe reductions or extirpations of native species, reductions in the abundance or productivity of sport, commercial or culturally important species and habitat alterations. While recent intercontinental introductions have attracted much attention, movements of fish species within the continent have a long history. These introductions have expanded the range of many species and contributed to a trend of homogenization of fish fauna in both the United States and Canada. Beginning in the mid-1800s fishes were transported west to satisfy demands by settlers for fishes that they had become familiar with in the east. Additionally, water development projects in the west created reservoirs that were stocked to provide fishing opportunities. Only in the past 20 years has a more conservative approach to introductions been taken including the outright opposition to the introduction of any non-indigenous species.

The Canadian Action Plan to Address the Threat of Aquatic Invasive Species, was approved by the Canadian Council of Fisheries and Aquaculture Ministers in 2004 (CCFAM 2004), and outlines a national approach for managing AIS. One of the strategies developed to address threats posed by potential and existing AIS is risk assessment. Fisheries and Ocean Canada's (DFO's) Centre of Expertise for Aquatic Risk Assessment (CEARA) was created to develop a standardized approach for assessing risk posed by potential AIS. CEARA has developed draft guidelines for a biological risk assessment that include the evaluation of all stages of introduction (arrival, survival, establishment and spread) and the impacts made to the invaded ecosystem should the evaluated AIS become widely established (Mandrak et al., National Detailed Level Risk Assessment Guidelines: Assessing the Biological Risk of Aquatic Invasive Species. Unpubl. manuscr.[1]). Completed risk assessments should be used by ecosystem mangers to identify potential AIS, focus on species that pose the highest risk, and to develop management strategies that will result in prevention of the greatest harm.

RISK ASSESSMENT

Biology

Pumpkinseed (*Leponis gibbosus*) is a small, attractive centrarchid of 13-20 cm in length and 0.23 – 0.34 kg in weight at maturity. Age and size at maturity depends on environmental conditions but is usually reached in 2 years. Pumpkinseed lives for 7-9 years. The breeding season lasts all spring and summer when water temperatures are between 15 and 25°C. The male creates a shallow nest, 100-400 mm in diameter, on sand or gravel in shallow areas (<1m depth) with aquatic vegetation. A colony of up to 15 nests is created and can cause significant habitat alteration. Females move into the area to release from 600 to 12,000 eggs in batches and sometimes into more than one male's nest. The sticky, demersal eggs are 1 mm in diameter and are guarded and fanned by the male. Eggs hatch in 3-5 days, depending on water temperature. Males guard the fry for about a week, returning them to the nest in their mouths if they attempt to stray. Fry leave the nest for open water for a period of time before returning to the littoral zone.

Pumpkinseed is omnivorous and an opportunistic feeder. Prey selection varies with age, prey availability, habitat, season and presence of other fish species. There are two morphological forms of Pumpkinseed; one, with wide short gill rakers that feed mainly on benthic macro invertebrates and, a second, with longer gill rakers, better adapted to feed on planktonic prey. Fry feed on zooplankton but Pumpkinseed becomes more piscivorous as it grows larger.

In its native range, juvenile Pumpkinseed is eaten by many predatory fishes, including, larger Pumpkinseed. It is an important prey item in the Western Grebe's (*Aechmophorus occidentalis*) diet in southern British Columbia.

[1] June 3-5, 2008 national advisory meeting on National Guidelines for Assessing the Biological Risk of Aquatic Invasive Species.

Habitat

Pumpkinseed is usually found in quiet, slower moving streams, ponds, small lakes, and the weedy shallow bays of large lakes. It prefers clear water and areas of submerged vegetation or brush.

Behaviour and Movements

Adults can be found in pairs or smaller loose aggregations, while juveniles, 3-14 mm, form fairly large schools. Juveniles undertake a diurnal migration staying in benthic areas by day and moving toward the surface at night.

Feeding generally peaks at dusk and dawn and is low during the day. Feeding was seen to decrease at temperatures below 15 °C.

Parasites

Pumpkinseed host parasites of many types and over 104 species have been noted. Black-spot is frequently found on Pumpkinseed and is the resting stage of a trematode whose final host is the belted kingfisher (*Megaceryle alcyon*).

An invasive parasitic copepod (*Neoergasilus japonicus*), native to eastern Asia, was found in Pumpkinseed and three other fish species in Lake Huron, in 1994. By 2001, it was found in an additional seven fish species. This parasite can swim well, is found on a variety of hosts and is able to move from one host to another easily. It has spread quickly across Europe and North America and poses a risk to British Columbia's fishes.

As parasites are often introduced by exotic fish hosts associated with aquaculture, the United States Department of Agriculture's Animal Plant Health Inspection Services (USDA-APHIS) has issued a federal order to prohibit interstate transport of numerous non-native species including Pumpkinseed.

Risk Posed to Watersheds of British Columbia

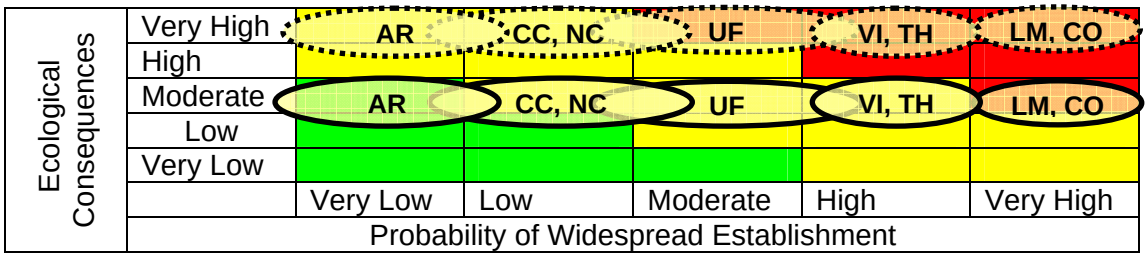
The probability of arrival, survival, establishment and reproduction, spread and widespread establishment once arrived were evaluated for eight regions of British Columbia. Results are presented in Table 1.

A risk matrix was used to combine the probability of widespread establishment with the predicted impact to determine overall risk. As the impact is predicted to differ depending on the size of the waterbody, small and large waterbodies are represented separately in the resulting risk matrix (Table 2). Overall, the risk posed by Pumpkinseed ranges from moderate to high in small waterbodies with moderate uncertainty and low to high in large waterbodies with moderate uncertainty. Pumpkinseed poses the lowest overall risk to the Arctic region and the highest risk to the Lower Mainland and Columbia River regions.

Table 1. The probability of arrival, survival and reproduction, spread, and widespread establishment once arrived (WEOA) of the Pumpkinseed for the eight regions of British Columbia with the associated uncertainties (Unc). 'A' indicates that the Pumpkinseed has already arrived in the region (from Bradford et al*. 2008).*

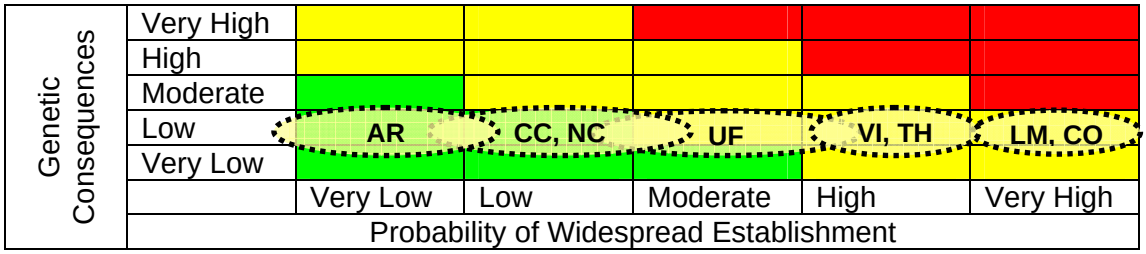
	Vancouver Island (VI)		Lower Mainland (LM)		Upper Fraser (UF)		Thompson (TH)		Columbia (CO)		Arctic Drainage (AR)		Central Coast (CC)		North Coast (NC)	
Element	Prob	Unc	Prob	Unc	Prob	Unc	Prob	Unc	Prob	Unc	Prob	Unc	Prob	Unc	Prob	Unc
Arrival	A		A		M	H	A		A		VL	H	L	H	L	H
Survival & Repro	H	L	VH	L	L	H	H	M	M	M	VL	M	L	L	L	H
Spread	H	VL	VH	VL	M	L	H	L	VH	VL	L	H	L	M	L	M
WEOA	H	L	VH	L	M	H	H	M	VH	M	VL	H	L	M	L	H

Table 2. Matrix for determining overall risk by region. The dotted ellipses are for the ecological consequences estimate for small waterbodies and the solid ellipses are for large rivers and lakes (from Bradford et al*. 2008).*



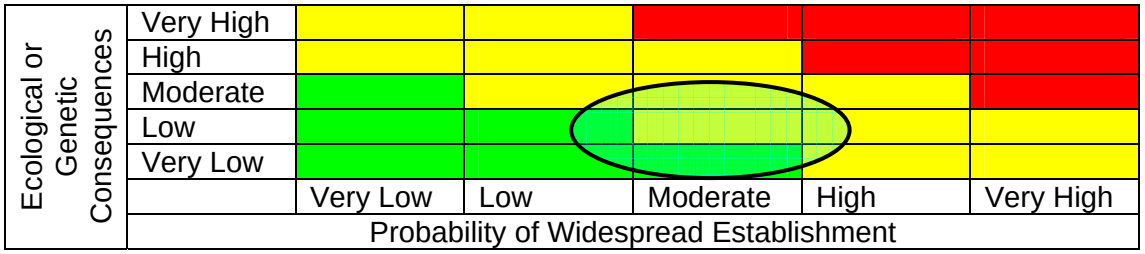
Genetic risk posed by Pumpkinseed in British Columbia was determined to be low to moderate overall with moderate uncertainty (Table 3).

Table 3. Matrix for determining genetic risk, by region (from Bradford et al*. 2008).*



Risk posed by fellow travelers of Pumpkinseed to British Columbia's aquatic ecosystems was determined to be moderate with high uncertainty (Table 4).

Table 4. Matrix for determining overall risk of pathogens, parasites, and/or fellow travelers of pumpkinseed. The ellipse represents both the ecological and genetic impacts (from Bradford et al*. 2008).*



Considerations Regarding Arrival

- Pumpkinseed in British Columbia likely originated in the Columbia River system, from Washington and Idaho, and spread to other parts of southern British Columbia from there. Confirmed locations of Pumpkinseed in British Columbia are shown in Figure 2.
- Its scattered distribution suggests human intervention as a significant vector, either as contamination in Smallmouth Bass (*Micropterus dolomieu*) stocking efforts, or, as a deliberate introduction as prey fish for larger piscivores.
- Pumpkinseed is kept in aquariums. The practice of illegally releasing a fish into nearby lakes or streams when it outgrows its tank is, unfortunately, a common one.
- The probability of arrival into areas where they are not currently present was assessed on the strength of human vectors. Areas in close proximity to established Pumpkinseed populations and with high human populations or extensive human use have an increased chance of Pumpkinseed arriving.

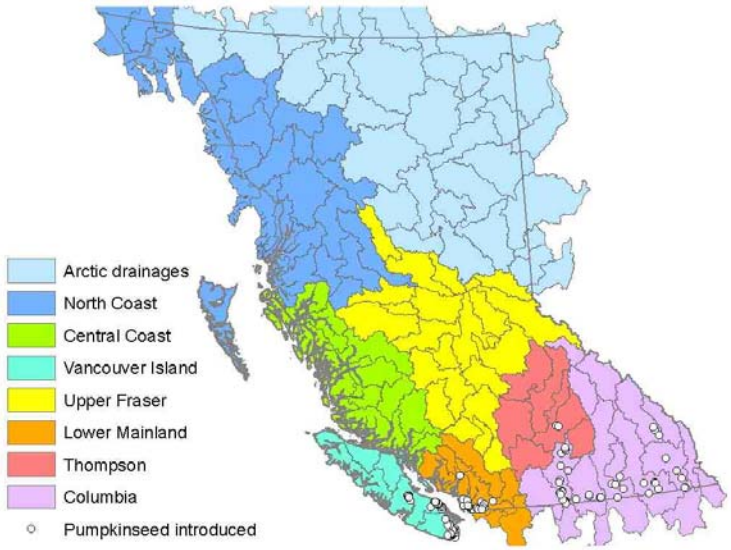


Figure 2. Distribution of known (confirmed) occurrences of Pumpkinseed in British Columbia (from Bradford et al*. 2008).*

Considerations Regarding Survival and Establishment

- Based on distribution in Canada, areas with >1750˚C degree-days were considered favourable climate for Pumpkinseed (Figure 3). Much of southern British Columbia meets this condition with the exception of areas of higher elevation.
- Pumpkinseed has a high level of life history plasticity and is able to adjust the time of and size at maturity as well as its diet to suit the conditions, thereby increasing the chances of survival.
- Once established in an environment, later maturation and larger size at maturity allows Pumpkinseed to be successful in a competitive environment.
- Parental care of eggs and larvae increase the chances of establishment, although, the requirements of Pumpkinseed's reproductive behaviour means specific environmental conditions are required. A lack of suitable nest building habitat, or lack of suitable prey for larvae, would decrease the chance of establishment. These habitat factors were not considered in the climate-based assessment of suitable area.

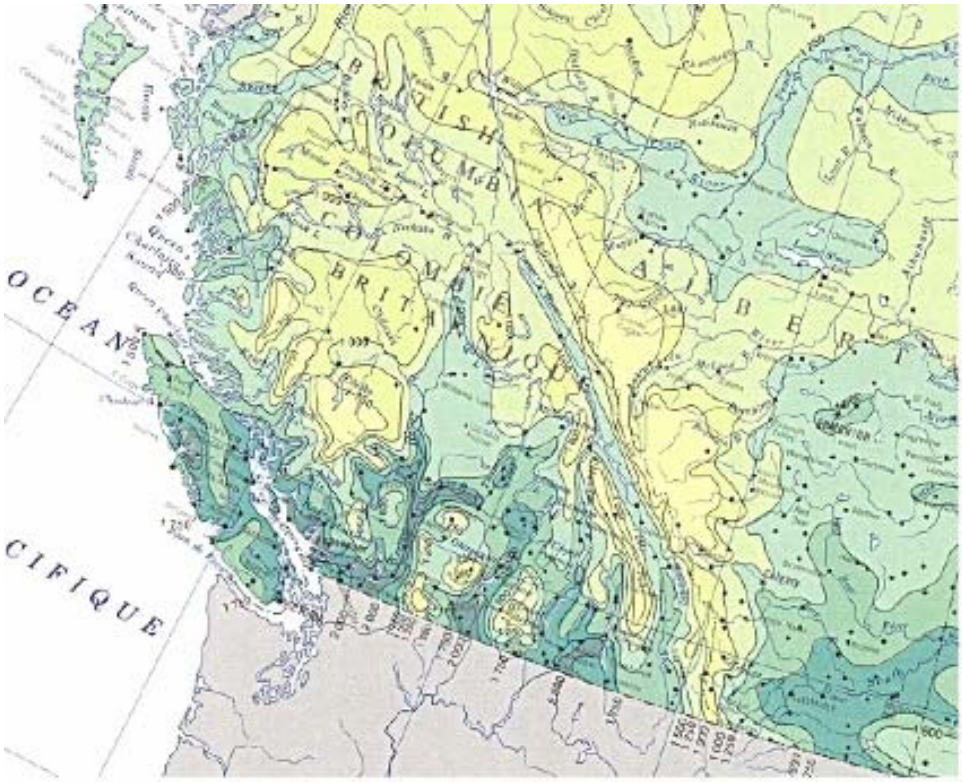


Figure 3. The Atlas of Canada Growing Degree-Days map. The best habitat for Pumpkinseed was considered to have >1750 DD. Some lakes may be suitable at 1750-1500 DD; areas with <1500 DD were considered unsuitable. Reproduced with permission of Natural Resources Canada.

Considerations Regarding Spread

- Based on climate considerations, the northern limit in the interior appears to be the southern Caribou Plateau and coastal areas predicted to be suitable may not have sufficient summer warmth for egg and larval development.
- Pumpkinseed successfully spreads and colonizes new areas once introduced and is the most successfully introduced species in Europe.
- Preference for slow moving waters reduces the chance of spread without human intervention.
- High territoriality limits spread, although, larvae are less territorial and may disperse through areas that do not contain littoral habitat.

Considerations Regarding Ecological Impacts

- Introduced Pumpkinseed is considered a factor in the decline of 7 out of 41 endangered fish species in Canada.
- Pumpkinseed competes with native fish communities for habitat and food. It is thought to play a prominent role in the extirpation of scientifically important stickleback species (*Gasterosteus* spp.) in Vancouver Island lakes.
- Pumpkinseed is responsible for the reduction of native fish species richness when it was introduced to Europe although some coexistence is possible as European Pumpkinseed feed mainly on chironomids and amphipods rather than molluscs as they do in North America.

- Pumpkinseed prefers the same habitat as juvenile Coho Salmon (*Oncorhynchus kisutch*) though it has not been found to have a direct effect on Coho. It was not found to consume them directly, and the growth rates of Coho juveniles in areas with Pumpkinseed were greater than growth rates in neighbouring areas without Pumpkinseed.
- Pumpkinseed has been known to reduce snail (*Physa* spp.) abundance when introduced. *Physa* spp. adapt to predation with a change in shell morphometry to match predator feeding style and that results in a reduction in predation rate. In lakes where *Physa* spp. have adapted to avoid crayfish predation, the adapted shape can render them more susceptible to predation by introduced Pumpkinseed.
- Reductions in snail density caused by Pumpkinseed introductions can affect the biomass and composition of epiphytic algae. Increased epiphytic algal growth on macrophytes reduces the available light and nutrients to those macrophytes causing a decline in their growth.
- Macrophytes removed by Pumpkinseed during nest making grow back quickly following the breeding season but nest excavation results in a reduction in benthic invertebrate diversity and density that is still detectable the year following the nesting behaviour.
- Zooplankton behaviour and life history are known to change in response to Pumpkinseed introduction. *Daphnia pulex* moved into areas of low light and thermal stratification to avoid predation while *Daphnia longispina* increase the production of offspring resulting in higher fitness in the presence of Pumpkinseed. Fish presence has also been observed to induce earlier first reproduction, smaller size at maturity and smaller offspring in zooplankton.
- Most studies show that impacts of Pumpkinseed occur through competitive interactions and have indirect effects on different trophic levels. Observations suggest that the impact is greatest in small warm lakes and other small lakes where Pumpkinseed make up the largest proportion of the fish population.

Considerations Regarding Genetic Impacts

- There are no fishes native to British Columbia that are known to hybridize with Pumpkinseed.

Considerations Regarding Fellow Travelers

- With the primary means of introduction being illegal introductions, fellow travelers and parasites of Pumpkinseed are likely to be introduced with the fish and also likely to survive in the same conditions as the fish.
- If Pumpkinseed is introduced for illegal stocking purposes, it is most likely to come from within British Columbia and carry parasites already present there. If Pumpkinseed is introduced as a result of release of aquarium fish, it could be from outside British Columbia and introduce a novel parasite.

Sources of Uncertainty

There are key uncertainties associated with ecological consequences in large waterbodies and the probability of widespread establishment in Upper Fraser and Central and North Coast regions.

- Impacts of Pumpkinseed are mainly through changes to the foodweb and as such are difficult to predict, especially in large lakes where impacts are restricted to the shallow, littoral areas inhabited by Pumpkinseed.

- Spread is more uncertain in the Upper Fraser, Central, and, North Coast regions because of lower connectivity within watersheds, low human population density and usage and little past history of spread.

CONCLUSIONS

Pumpkinseed is considered to be a nuisance species because of the lack of angler interest and the high risk of negative impact on aquatic communities. Impacts on the aquatic community are mainly indirect but can be very high. Pumpkinseed poses a higher risk to smaller waterbodies than to larger ones. It poses a higher risk in southern British Columbia where the climate is suitable and in waterbodies where suitable littoral habitat is available for nesting. This risk assessment was conducted at a broad scale. If risk to an individual waterbody is necessary it will have to be determined in a separate risk assessment.

OTHER CONSIDERATIONS

This risk assessment was conducted using the time frame for ecological consequences of ten years. This time frame may not be sufficient for dispersal, natural or otherwise, to allow Pumpkinseed populations to achieve widespread establishment as several generations are likely needed for a population to become established and an ecological impact become noticeable to scientific observers.

SOURCES OF INFORMATION

This Science Advisory Report is from the Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, regional advisory meeting of March 4-6, 2008 on Risk assessment of spiny-rayed fishes (six species). Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm.

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