Fisheries and Oceans Canada | Pêches et Océans Canada
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Canadian Science Advisory Secretariat
Science Advisory Report 2010/082

SCIENCE ADVICE FROM A RISK ASSESSMENT OF LARGEMOUTH BASS (*Micropterus salmoides*) IN BRITISH COLUMBIA

*Largemouth Bass (*Micropterus salmoides*). Image courtesy of the New York State Department of Environmental Conservation, Albany NY*

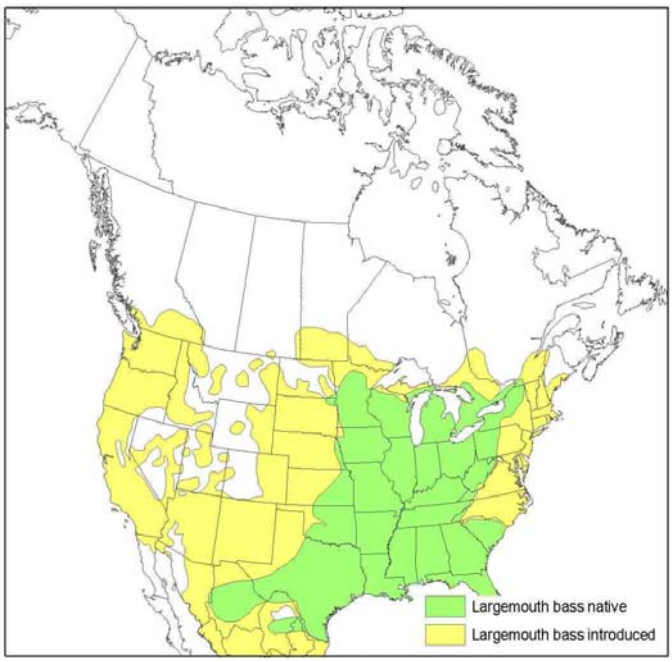


Figure 1. Native and non-native range of Largemouth Bass in North America (from Tovey et al*. 2008).*

Context:

Largemouth Bass is a moderately large warm water species with a diverse diet that consists of mainly fishes but may also include benthic invertebrates, amphibians, birds or mammals if opportunity arises. Largemouth Bass is native to the freshwaters of North America but not to British Columbia. It was introduced into British Columbia and the states bordering it to the south through authorized stocking efforts intended to increase angling opportunities, although recent spread has been by unauthorized means. This highly adaptable feeder is associated with shallow, structurally diverse habitats common in British Columbia's small lakes. There, it poses a risk to native fish species as has been demonstrated in other regions of North America where it has been introduced. Whether Largemouth Bass qualifies as an invasive species in British Columbia that warrants new management strategies depends on the extent of negative impact posed to the invaded ecosystems. For this reason a risk assessment was undertaken for Largemouth Bass in British Columbia.

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 Largemouth Bass 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 discussions at this workshop the risk assessment was revised and published as a research document (Tovey et al*. 2008) along with the proceedings report which documented the discussions at the meeting, (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

- Largemouth Bass is a voracious piscivore known to cause changes in ecosystem structure in lakes into which it has been introduced. It is responsible for local extinctions of small prey fishes and declines in minnow species' richness.
- It is occurs in both lake and river habitats and some individuals are found to move long distances, while others are territorial which may limit their spread.
- Largemouth Bass is native to eastern North America and likely first invaded British Columbia from authorized introductions in Washington State in the late 1800s. Whether Largemouth Bass qualifies as an invasive species in British Columbia that warrants new management strategies depends on the extent of negative impact posed to the invaded ecosystems.
- A risk assessment was conducted to estimate the threat posed to British Columbia's salmonid populations and aquatic ecosystems by the introduction of Largemouth Bass. The risk assessment addressed the likelihood of introduction (arrival, survival, establishment and spread) as well as the ecological consequences to the native biodiversity and ecosystem functioning, should Largemouth Bass become established. The risk assessment also assessed the threat posed by these species as vectors for diseases and parasites.
- The likelihood of survival, reproduction and spread was considered very high with very low uncertainty on Vancouver Island and the lower mainland, it was considered high with low uncertainty in the upper Fraser, Thompson and Columbia regions and was considered low with moderate uncertainty in the Arctic, central coast and north coast regions.
- The overall risk was assessed to be very high with low uncertainty in small waterbodies and moderate with moderate uncertainty in large waterbodies. The risk of genetic consequence is considered very low with low uncertainty.
- The ecological impacts caused by introduction of parasites and diseases were determined to be low with high uncertainty.
- Largemouth Bass has specific habitat requirements that may limit establishment and spread.

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 any non-indigenous species being introduced.

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

Largemouth Bass is a moderately large fish native to the freshwaters of North America. It is the largest member of the centrarchid family and is typically 203-380 mm in length, with a maximum weight of ~2 kg. It lives 13-15 years in Ontario. Growth rates and body size at age vary throughout its range (Figure 1). In Canada, females reach sexual maturity by 4-5 years and males at 3-4 years. Spawning starts in late spring and continues into early summer with a peak in mid-June. Males begin nest selection and construction once water temperatures reach 15°C. Nests are usually found in debris, gravel, sand and soft mud near bulrushes, reeds, and water lilies. Nests are made in shallow water, often >1 m deep, and spread 2 m apart due to the aggressive nature of males. Spawning occurs near dawn or dusk and eggs are released in batches. The number of eggs released increases with female size and ranges from 2,000 to over 94,000. Eggs hatch in 3-5 days and are guarded by the male. Larvae remain in the nest until the yolk is absorbed (~10 days) and then disperse daily to feed upon amphipods, insect larvae and zooplankton. For 3-4 weeks they reform into a larval 'brood swarm' at night with continued protection by the male. As Largemouth Bass grow, diet shifts from insect larvae and small zooplankton, to larger insect pupae and nymphs, to larger invertebrates, and finally, to fishes and other larger macroinvertebrates (including crayfishes). The proportion of fishes in the diet increases with size. Largemouth Bass is an ambush predator known for its voracious appetite. Using weeds for concealment it preys upon a variety of fishes and the selected prey species change with size of the individual and prey availability. Young Largemouth Bass are preyed upon by other fishes that share their habitat as well as various birds. Adults are not usually preyed upon because of their size, swimming ability and spines.

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

Habitat

Largemouth Bass is found in all water types including creeks, estuaries, lakes, large, slow-moving rivers; ponds, reservoirs; and swamps. It prefers warm, shallow lakes and bays with considerable shallow littoral zones, extensive vegetation, and, in northern latitudes enough area to provide over wintering habitat. It is found in areas of soft substrate and dense beds of vegetation. In British Columbia, it occurs primarily in shallow, warmwater lakes and rarely succeeds in oligotrophic lakes.

Behavior and Movements

Largemouth Bass is active in the warmer seasons; once water temperature fall below ~10°C, it moves to deeper waters and activity level decreases. In spring, it returns to shallow waters and resumes regular feeding activities prior to spawning. It is characterized as semi-mobile with some individuals having a small home range (<5 km) while others are transient (>25% moved 5-10 km). It feeds in shallow water at night, and, during the day, cruises above aquatic plants or rests near overhanging structures. Adults are solitary while juveniles will school in summer.

Parasites

Over 103 parasites have been identified in Largemouth Bass. The most important of these are Black-Spot and Yellow Grub, which deteriorate the quality of the fish and make it less palatable to humans, and Bass Tapeworm, which can cause sterility or seriously affect reproduction of infected fish. None of these are harmful to humans.

An invasive parasitic copepod (*Neoergasilus japonicus*), native to eastern Asia, was found in Largemouth Bass 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.

Largemouth Bass is susceptible to Largemouth Bass Virus (LMBV); the only known fatal condition in Largemouth Bass. LMBV causes lesions on the swim bladder and is difficult to diagnose as there are no external lesions. LMBV is responsible for several large fish kills and although other fish species are carriers, it does not appear to affect those species. Mode of infection is through the water or by eating infected prey items.

Risk Posed to Watersheds of British Columbia

The probability of each stage of invasion (arrival, survival and reproduction, spread and widespread establishment once arrived) was estimated for the major regions of British Columbia and the results are presented in Table 1.

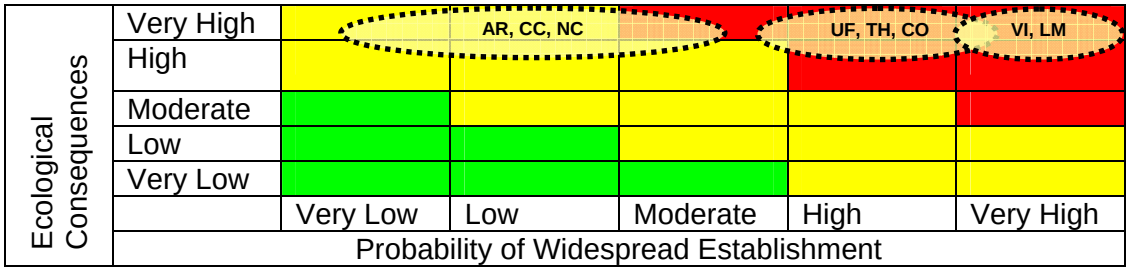
Table 1. The probability of arrival, survival and reproduction, spread, and widespread establishment once arrived (WEOA) of the Largemouth Bass in the eight regions of British Columbia with the associated uncertainties (Unc). 'A' indicates that the bass has already arrived in the region (from Tovey et 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	A	A	H	L	A	A	A	A	VL	H	L	M	L	M
Survival & Repro	H	L	VH	VL	M	H	H	M	M	M	VL	M	L	H	L	H
Spread	VH	L	VH	VL	H	L	H	L	H	VL	L	H	L	M	L	M
WEOA	VH	L	VH	VL	H	H	H	M	H	M	L	H	L	H	L	H

The ecological consequences of the establishment of Largemouth Bass were determined to be different in waterbodies of different sizes. In small lakes, the ecological consequences were determined to be very high with low uncertainty and in large lakes the ecological consequences were determined to be moderate with high uncertainty.

A risk matrix was used to determine overall risk to small waterbodies by combining the likelihood of widespread establishment with ecological consequences (Table 2). The risk was determined to be moderate with high uncertainty for small waterbodies in the Arctic, central and north coast regions, and high with moderate uncertainty in Thompson, Columbia and upper Fraser regions. Overall risk was estimated to be high with low uncertainty in small waterbodies in the Vancouver Island and Lower Mainland regions.

Table 2: Matrix for determining overall ecological risk for small waterbodies, where green indicates low risk, yellow indicates moderate risk, and red represents the conditions for a high risk designation. The size of the ellipse represents the amount of uncertainty (from Tovey et al*. 2008).*



The risk matrix combining ecological consequence with probability of establishment for large waterbodies is shown in Table 3. Overall risk is considered to be moderate with high uncertainty in the Arctic, central and north coast regions; and high with high uncertainty in the other regions. The actual impact will depend on the individual waterbody invaded and the population density that is reached in that system. Table 4 is the matrix used to determine overall genetic risk to existing populations.

Table 3: Matrix for determining overall ecological risk for large waterbodies, where green indicates low risk, yellow indicates moderate risk, and red represents the conditions for a high risk designation. The size of the ellipse represents the amount of uncertainty (from Tovey et al*. 2008).*

Ecological Consequences						
	Very High					
	High		AR, CC, NC		UF, TH, CO	VI, LM
	Moderate					
	Low					
	Very Low					
		Very Low	Low	Moderate	High	Very High
		Probability of Widespread Establishment				

Table 4: Matrix for determining overall genetic risk, where green indicates low risk, yellow indicates moderate risk, and red represents the conditions for a high risk designation. The size of the ellipse represents the amount of uncertainty (from Tovey et al*. 2008).*

Genetic Consequences						
	Very High					
	High					
	Moderate					
	Low					
	Very Low		AR, CC, NC		UF, TH, CO	VI, LM
		Very Low	Low	Moderate	High	Very High
		Probability of Widespread Establishment				

Considerations Regarding Arrival

- Largemouth Bass is present in five regions in southern British Columbia and may spread by natural dispersal from these areas (Figure 2).

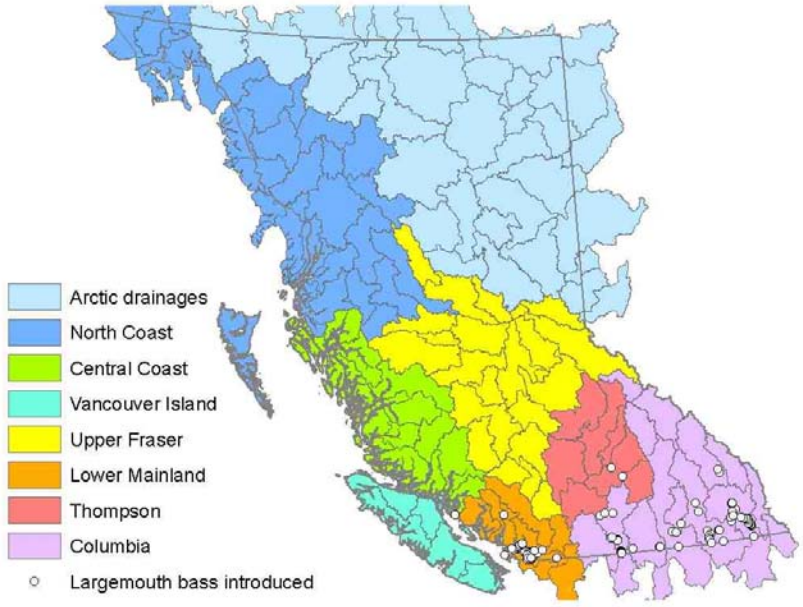


Figure 2. Distribution of known (confirmed) occurrences of Largemouth Bass in British Columbia. Note that one of the points in the Thompson Region is a misidentification. (from Tovey et al*. 2008)*

- Largemouth Bass currently found in lakes and ponds of British Columbia first arrived through natural dispersal from Idaho and Washington and were further spread by introductions.
- Largemouth Bass is present in 85% of Washington's warmwater lowland lakes with public access and in 84% of the same type of lake in Oregon.

Considerations Regarding Survival and Establishment

- Areas with >1750 degree-days were considered most suitable for Largemouth Bass and regions >1500 and <1750 were considered less suitable. The Atlas of Canada growing degree day map is reproduced in Figure 3.
- Largemouth Bass is able to feed on a wide range of prey and shows adaptability to various feeding environments.
- Largemouth Bass prefers shallow, warm-water lakes and has a reduced ability to survive in large oligotrophic lakes.
- Largemouth Bass is tolerant of high temperatures and slight turbidity.
- Largemouth Bass is sensitive to low oxygen and is found to avoid levels of 1.5 mg O_2 per litre or less.
- Parental care by male Largemouth Bass increases the likelihood of establishment; however specific conditions are required for spawning and, if not met, would decrease the likelihood of establishment.
- Factors considered more important to recruitment than competition or predation include availability of food for newly rising fry, nest desertion, parasite sterility, temperature at spawning time, and wave action.

Figure 3. The Atlas of Canada Growing Degree Days map. The regions with >1750 DD (■) were considered to have lakes most suitable for Largemouth Bass.

- Juveniles are piscivorous at a small size and young age, which contribute to success as an invader. Largemouth Bass has a high growth rate that increases the chance of establishment.
- Largemouth Bass is susceptible to winter kill, which may exclude it from northern interior regions.

Considerations Regarding Spread

- Largemouth Bass is able to live in lakes as well as rivers so connectivity of waterbodies in a region affects spread.
- Territorial behavior may limit spread although some individuals have been observed to move large distances.
- Spread within the western United States was likely by natural dispersal through the Columbia River system.
- Largemouth Bass is considered a good game fish and may be spread through illegal introductions by 'bucket biologists' for the addition of angling opportunities.
- The number of anglers that inhabit or visit a waterbody, its proximity to an area with established populations and its connectivity with other waterbodies, all increase the chance of spread to that waterbody.

Considerations Regarding Ecological Impacts

- Largemouth Bass is a voracious, mainly piscivorous, littoral predator estimated to need 4 kg of food to produce 1 kg of fish.
- Vast evidence of local extinctions of small prey fishes (especially cyprinids) exists for lakes where Largemouth Bass occur.
- In a study of small, temperate lakes dominated by piscivorous species; native minnow richness is reduced compared to lakes without piscivores. Minnow richness also varies with the number of predators present.
- Lakes with *Micropterus* species are likely to have great reductions in native species richness. However, minnow species declined with increased human activity, even in the absence of predators. The destruction of littoral habitat, including the removal of submerged logs and aquatic vegetation, is suggested as the cause. Therefore, lakes with both introduced predators and altered habitat would likely experience a larger impact from Largemouth Bass.
- After an initial rise with increased habitat complexity, predatory success of Largemouth Bass decreases as habitat complexity continues to increase. The expected impact of Largemouth Bass is likely to be greatest in lakes with moderate human impact.
- In shallow lakes of western Washington State, a study of Largemouth Bass diet showed it was responsible for 98% of the predation on Coho Salmon. Extent of impact depends on the size of the lake the coho run passes through and the number of Largemouth Bass present in that lake.
- There is evidence that introduced Largemouth Bass initiates top-down effects on the plankton of a lake. Effects include a decrease in planktivore numbers, an increase in overall zooplankton biomass and shift in composition from smaller zooplankton (rotifers and copepods) to larger species (cladocerans) as well as a decrease in phytoplankton biomass.

Considerations Regarding Ecological Impacts

- The Largemouth Bass is not known to hybridize with any species native to British Columbia

Considerations Regarding Fellow Travelers

- The primary vector of spread is by natural dispersal, so any parasites associated with individual fish will be transported with those fish and are expected to survive in the same conditions as the fish.
- There are hundreds of parasites known to infect Largemouth Bass, but only four have been discovered on Largemouth Bass in British Columbia.
- Whether parasites carried by Largemouth Bass are able to infect native fishes in British Columbia is unknown as there is no literature on disease outbreaks in British Columbia.

Sources of Uncertainty

The key uncertainties of this risk assessment are associated with the probability of widespread arrival in several regions, with the ecological impacts on large lakes and with fellow travelers.

- Spread is by unauthorized introduction and subsequent natural spread. This vector is very difficult to assess.
- Ecological impacts are well known in small lakes but the impacts on larger lakes will be limited to the littoral zone. Impacts could be quite extreme in areas where populations of Largemouth Bass build to high numbers, but this is dependant on the individual lake.
- It is not known what fellow travelers may be introduced with Largemouth Bass or what impacts they will have on the ecosystem once arrived.

CONCLUSIONS

- Overall risk posed to British Columbia by Largemouth Bass is high with a moderate uncertainty. Areas predicted to be most highly impacted are Vancouver Island, lower mainland, upper Frasier, Thompson and Columbia regions. The Arctic, central coast and north coast regions are less likely to be impacted. Individual waterbodies within each region will vary in potential risk.
- Largemouth Bass has specific requirements that may limit establishment and spread.
- The highest probability of ecological impact from the introduction of Largemouth Bass is through predation on native minnow or soft rayed species.
- It is very difficult to eliminate a species from a system once established. Proactive measures are needed if spread is deemed undesirable.

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 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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