



SCIENCE ADVICE FROM A RISK ASSESSMENT OF SMALLMOUTH BASS (*Micropterus dolomieu*) IN BRITISH COLUMBIA



Smallmouth Bass (Micropterus dolomieu).
Image courtesy of the New York State
Department of Environmental Conservation,
Albany NY.

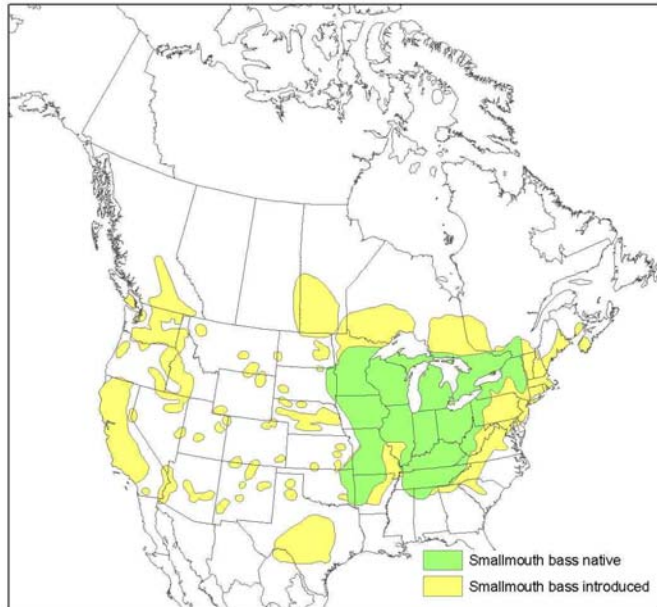


Figure 1. Native and non-native range of Smallmouth Bass from Tovey et al. (2008).

Context:

Smallmouth Bass is a moderately-sized warm water species that can alter prey and predator fish populations when introduced to a system. Smallmouth Bass is native to the freshwaters of eastern central North America but not to the majority of Canada. Historically it has been introduced to British Columbia and the states bordering it to the south through authorized stocking efforts, although recent spread has been by unauthorized means. It has had negative impacts on ecosystems where it was introduced and poses a risk to ecosystems in British Columbia.

Concerns about effects of invasive fishes on salmon populations in British Columbia were raised by fisheries managers and these concerns initiated a risk assessment of Smallmouth Bass for that province. The risk assessment was coordinated and guided by Fisheries and Oceans Canada's (DFO's) Centre of Expertise for Aquatic Risk Assessment (CEARA) and followed guidelines established by CEARA for assessing biological risk of aquatic invasive species in Canada. 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.

Scientists used habitat modelling to predict potential range and utilized existing information to assess risk posed by Smallmouth Bass to British Columbia's aquatic ecosystems. A peer review workshop, held

in Richmond, British Columbia March 4-6, 2008, evaluated the draft risk assessment according to Canadian Science Advisory Secretarial (CSAS) peer review process s guidelines. Based on discussions at this workshop the risk assessment was revised and published as a research document (Tovey et al. 2008) along with a proceedings report documenting the discussion at the meeting (DFO 2010)

SUMMARY

- Smallmouth Bass is native to the Mississippi River and and Great Lakes basins of eastern of North America and was first introduced to British Columbia in 1901 through authorized stocking to provide improved angling opportunities at a few locations. Recent changes in attitude towards introduced species and the importance native species in ecosystem functioning resulted in the need for an assessment of risk posed by Smallmouth Bass to non-invaded regions.
- A risk assessment was conducted which evaluated risk posed to large and small lakes in British Columbia by Smallmouth Bass. The assessment evaluated all stages of invasion including the probability of arrival, survival and reproduction, spread and widespread establishment. Next the assessment characterized the ecological consequences of widespread establishment then combined likelihood and consequences to determine overall risk.
- Overall risk posed to British Columbia by Smallmouth Bass was determined to be high with a moderate uncertainty. Areas predicted to be most highly impacted are the Vancouver Island, lower mainland, upper Fraser, Thompson and Columbia regions. The Arctic, central coast and north coast regions were less likely to be impacted.
- Risk is considered higher in small lakes compared to larger lakes although individual waterbodies within each region will vary in potential risk. In order to determine the risk posed to a particular waterbody, a risk assessment specific to that waterbody needs to be undertaken.
- Smallmouth Bass has specific habitat requirements that may limit establishment and spread.
- Area of highest potential impact is through predation on native minnow and other 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.

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. manusc.¹). Completed risk assessments should be used by ecosystem managers 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

The Smallmouth Bass is a moderate-sized fish in the Centrarchidae family. The largest individuals are typically less than 50 cm, and weigh less than 2 kg. Females reach sexual maturity at ~6 years of age and males mature at ~5 years. Maximum age in Canada is thought to be 15 years. The breeding season begins in late spring when the water temperatures reach ~13°C and continues through early summer until water is ~20°C. Males create a saucer shaped spawning nest approximately 500 mm in diameter and 50-100 mm deep containing a cluster of large stones in the centre, found at water depths of 0.6-1.8 m. Nests are located in quiet water over firm sand, mud or gravel or rocky bottoms of lakes or rivers and are located close to cover such as large rocks, stumps or logs. Smallmouth Bass is territorial and will return to the same nest site in subsequent years. Females produce 2,000-20,000 sticky eggs that are released in batches, sometimes in more than one nest. Males exhibit a large degree of parental care and will aggressively guard eggs and larvae for up to one month.

Larvae grow quickly reaching 40-100 mm in the first year. When temperatures drop below 7-10°C, Smallmouth Bass enter a winter starvation period during which feeding stops and fish survival on stored energy. A critical size at the end of the first growing season is required for young-of-the-year to survive this winter starvation period. The critical size required is dependant on the length of winter. In spring, when temperatures rise above 8.5°C, Smallmouth Bass resumes feeding activities.

Larval Smallmouth Bass feed on copepods, waterfleas and other small zooplankton. As size increases, diet shifts to aquatic insects and crayfish. Once over 50 mm in length, fishes become important in the diet. Adults are known as voracious littoral zone predators and eat mostly fishes, insects and crayfish. The choice of prey is influenced by fish length, age and prey availability.

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

Habitat

Smallmouth Bass prefers clean, clear, mesotrophic lakes > 40 ha with an average depth >9 m. It is often associated with the littoral drop-off and seeks structures such as logs, pier posts or rocky outcroppings. It also inhabits wide cool and clear streams and rivers (>10.5 m) of mid-order, with a moderate current, and over 50% pool habitat. Abundant shade and cover, substrates of gravel and larger materials and deep pools are also important.

To support overwintering populations, a lake needs to be at least 3-15 m deep and provide crevasses, hollow logs, ledges or rock fissures in which Smallmouth Bass can hide.

Physiological Tolerances

Water temperature is one of the most important factors that influence range and distribution, migration spawning date, nest guarding behaviour, success of incubation, growth rate, periods of growth and winter responses. The optimal temperature range for adults is 21-27°C and optimum range for spawning is 12.8-21°C. It can survive extreme winter conditions but does not feed at < 10°C.

High water discharge during the winter and during nesting periods adversely influence riverine populations. River gradients of 0.75-4.7 m·km⁻¹ are the conditions in which riverine populations are found. High sediment and turbidity are not well tolerated.

Smallmouth Bass prefers a specific pH zone of 7.9-8.1 and tolerates 5.7-9.0. It is highly sensitive to elevated aluminum concentrations at low pH. Optimal dissolved oxygen varies by life stage: normal activities require >6 mg·L⁻¹, spawning requires >7 mg·L⁻¹ and embryonic and larval development requires >6.5 mg·L⁻¹.

Behavior and Movements

Smallmouth Bass feeds at any time, but is most active in the early morning and evening. It seeks protection from light at all life stages and takes refuge under banks or in deep waters. It moves to deeper waters in winter and into warmer, shallower bays in spring. It has a home range that can be as small as a pool in the river environment, and is generally less than 3 km in a lake environment. Some populations have been described as migratory and while others are sedentary. One riverine population is known to move 70 km downstream for winter and back for spring spawning while some males were found to build nests within 130 m of where they nested the previous years. Another study found a population to be 69% migratory and 31% sedentary. Although Smallmouth Bass is capable of quick acceleration, it is assumed to be poor at ascending barriers.

Diseases and Parasites

In its native range, Smallmouth Bass is thought to be controlled, in part, by a degree of parasitic infection. In the east, Smallmouth Bass is found with between 24-30 different parasites that affect individuals to varying degrees. Populations of Smallmouth Bass studied in the west had relatively few parasites. There were only four parasite species found on 80% of Smallmouth Bass studied in Christina Lake, British Columbia. Major parasites found in British Columbia are *Proteocephalus* sp., *Rhabdochona* sp., *Ergasilus caeruleus*, and an unnamed cestode. Bass in the Okanagan system are rumored to be full of worms and are inedible. The bass tapeworm

(*Proteocephalus ambloplites*) is considered a problem for trout and salmon management. This worm's first host is cyclopoid copepods, an important food item for Rainbow Trout, Cutthroat Trout, and Coho Salmon. The bass tapeworm attacks reproductive organs and can cause sterility. The *Proteocephalus* species currently found in British Columbia is not *ambloplites* and it is thought that it can be prevented by obtaining certified bass stocks if authorized introductions continue.

Distribution

Smallmouth Bass is native to central North America where its native range encompasses all the Great Lakes with the exception of northern Lake Superior and continues south to Oklahoma and Arkansas (Figure 1). It has been introduced throughout the rest of North America largely through authorized means.

Potential vectors of spread

Smallmouth Bass is found in five regions of British Columbia and can spread by natural means through connecting waterways. Adults are not generally migratory, although migratory behaviour has been seen in some populations. Upstream movements have been observed in cases where conditions permitted. Downstream spread may be the result of drift of larvae or small juveniles from an upstream source population. The main expansion of range in North America was through deliberate human introductions. Although authorized introductions have ceased, unauthorized releases are still likely.

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 (Table 1). Given widespread establishment of Smallmouth Bass, ecological consequences were expected to differ based on the size of waterbody invaded. In small waterbodies impact is predicted to be very high with very low uncertainty and in large waterbodies impact is expected to be high with moderate uncertainty. Predicted genetic consequences were considered to be very low with a low uncertainty. The probability of widespread establishment and the resulting ecological consequences were combined in a risk matrix to determine the overall risk posed by Smallmouth Bass to the regions of British Columbia. Table 2 is the overall risk matrix for small waterbodies which indicates a high risk to all regions in British Columbia. Table 3 is the overall risk matrix for larger waterbodies, indicating a moderate to high risk posed depending on the region involved. The risk of pathogens, parasites and fellow travelers was considered to be moderate to low risk overall (Table 4).

Table 1. The probability of arrival, survival and reproduction, spread, and widespread establishment once arrived (WEOA) of the Smallmouth 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).

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

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).

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

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 (Tovey et al. 2008).

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

Table 4. Matrix for determining overall risk of fellow travelers of Smallmouth Bass. Green indicates low risk, yellow indicates moderate risk, and red represents the conditions for a high risk designation. The solid ellipse represents the ecological and genetic consequences of establishment (from Tovey et al. 2008).

Ecological or Genetic Consequences	Very High						
	High						
	Moderate						
	Low						
	Very Low						
		Very Low	Low	Moderate	High	Very High	
Probability of Widespread Establishment							

Considerations Regarding Arrival

- Smallmouth Bass is confirmed to be in 60 waterbodies in British Columbia, mainly in the Lower Mainland and on Vancouver Island (Figure 2).



Figure 2. Distribution of known (confirmed) occurrences of Smallmouth Bass in British Columbia (Tovey et al. 2008).

Consideration Regarding Survival and Establishment

- A habitat suitability model was used to determine areas in which Smallmouth Bass was expected to survive. The model used five variables for each of the lakes in British Columbia: surface area, maximum depth, and September, October and November air temperature. Other variables were rejected based on initial assessment. The model was validated with independent data set of Smallmouth Bass occurrences in British Columbia. Based this model the probability of survival and reproduction is considered to be high for the Columbia, Vancouver Island, Thompson and Upper Fraser regions and very high for the Lower Mainland region (Figure 3).
- The required critical size for young-of-the-year to survive winter depends on the length of the winter starvation period. Smallmouth Bass living in good summer growing conditions are not likely to be limited by cold winter temperatures.
- Low winter oxygen levels may limit survival.
- Smallmouth Bass feeds on a wide range of prey and shows adaptability to various feeding environments.
- Parental care increases the probability of becoming established although specific conditions are required for reproduction to occur. These conditions are not considered in the habitat suitability model and may have a modifying effect.

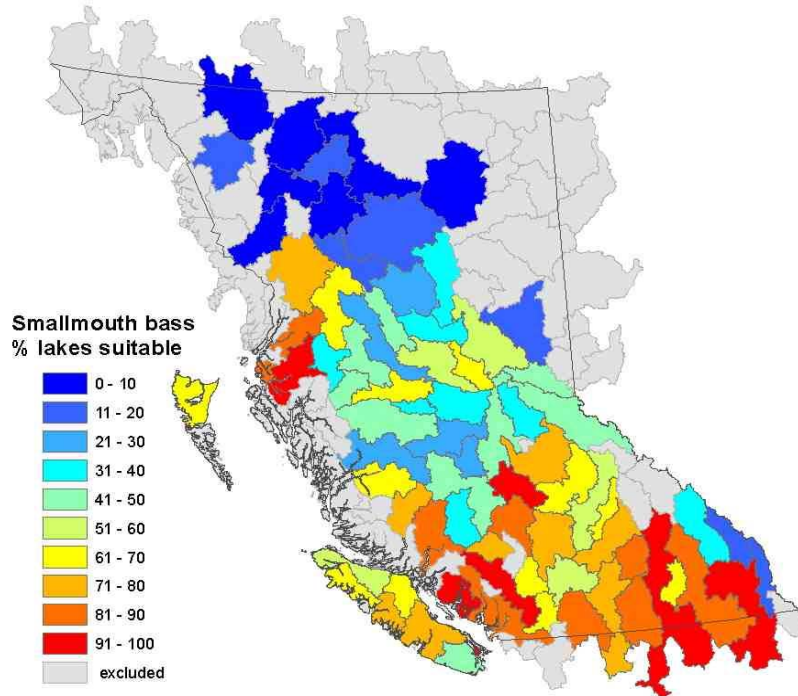


Figure 3. The potential distribution of Smallmouth Bass in British Columbia based on the results of a Habitat Suitability Model that indicates the proportion of lakes in a region that would sustain a population ($n=1882$ lakes). Watersheds with ≥ 5 lakes with data are included (Tovey et al. 2008).

Considerations Regarding Spread

- Smallmouth Bass is considered a prized game fish for many anglers. This increases the likelihood of unauthorized introduction but has a high uncertainty.
- The probability of an unauthorized introduction increases with increased human population density in or number of visitors to an area.
- The probabilities of unauthorized introduction and of natural dispersal increases with proximity to an established population.
- Smallmouth Bass habitat includes both rivers and basins which allows fish to spread easily through a watershed with the correct environmental conditions. It may be blocked from upstream movement by waterfalls or dams without passage facilities.
- Smallmouth Bass is considered territorial which may limit movements.

Considerations Regarding Ecological Impacts

- Smallmouth Bass competes with other species for common food resources.
- Its main impact is expected to be predation on smaller fishes and it may become the main component of the food web, particularly in systems with low biological and physical complexity. Introductions are known to cause shifts in forage fish assemblage, diversity, and abundance.
- Smallmouth Bass is known to prey on juvenile salmonids that are especially vulnerable during smolt migration.
- Impact is greater in lakes with less complexity (and prey refuge) including lakes with highly developed shorelines or where woody debris and aquatic vegetation are removed.
- Smallmouth Bass can alter the suite of predators as well as prey fishes, reducing populations, and, reducing trophic position indicating overall food web changes.

- Impact is expected to be greater in small lakes where Smallmouth Bass occupies a large proportion of the lake and smaller in large lakes where Smallmouth Bass occupies only shallow bays and its populations are expected to be lower.
- Based on the large amount of literature regarding impacts of Smallmouth Bass on small, warm, waterbodies, there is a very low degree of uncertainty associated with the rating. In larger waterbodies the degree of uncertainty is considered to be moderate because the proportion of preferred habitat is less than in small lakes and the bass are likely to be concentrated in bays. Local impacts could be high in these cases, however.

Considerations Regarding Genetic Impacts

- There are no fishes native to British Columbia known to hybridize with Smallmouth Bass.

Considerations Regarding Fellow Travelers

- As the primary vectors of spread are natural dispersal and unauthorized introduction; fellow travelers that exist with Smallmouth Bass will be introduced as well.
- Any parasite of Smallmouth Bass is likely to survive in conditions satisfactory for the fish.
- If a parasite were introduced to a waterbody currently containing Smallmouth Bass; the likelihood of spread would be very high due to high densities of Smallmouth Bass and the high degree of parental care.
- There are a large number of parasites known to be carried by Smallmouth Bass in its native range although information on the ability of those parasites to infect native species of British Columbia is unknown at the time. The probability of establishment of fellow travelers is considered moderate with high uncertainty.
- Ecological impact of parasites carried by Smallmouth Bass is considered to be low with a very high uncertainty based on the low number of parasites discovered on Smallmouth Bass in British Columbia and a lack of literature on the topic to guide the assessment.

Sources of Uncertainty

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

- Spread is by unauthorized introduction and subsequent natural spread. Unauthorized introductions are very difficult to assess.
- Ecological impacts are less certain in larger lakes and limited to the littoral zone. Impacts are potentially very high in areas where populations of Smallmouth Bass reach high numbers, but this will vary with the proportion of the lake that is littoral habitat.
- It is not known what fellow travelers may be introduced with Smallmouth Bass or what impacts they will have on the ecosystem once arrived.

CONCLUSIONS

- Overall risk posed to British Columbia by Smallmouth Bass is considered to be high with a moderate uncertainty. Areas predicted to be most highly impacted are the Vancouver Island, lower mainland, upper Fraser, Thompson and Columbia regions. The Arctic, central coast and north coast regions are less likely to be impacted.
- Risk is considered to be higher in small lakes compared to large lakes, although individual waterbodies within each region will vary in potential risk. In order to assess the risk to a particular waterbody, a risk assessment specific to that waterbody needs to be undertaken.

- Smallmouth Bass has specific requirements that may limit establishment and spread.
- Area of highest potential impact is 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 Smallmouth Bass 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>.

Brown, T.G., Runciman, B., Pollard, S., Grant, A.D.A., and Bradford, M.J. 2009. Biological synopsis of Smallmouth Bass (*Micropterus dolomieu*). Can. Manuscr. Rep. Fish. Aquat. Sci. 2887: v + 50 p.

CCFAM (Canadian Council of Fisheries and Aquaculture Ministers) 2004. A Canadian Action Plan to Address the Threat of Aquatic Invasive Species. <http://www.dfo-mpo.gc.ca/science/enviro/ais-eae/index-eng.htm> (accessed May, 2010)

DFO. 2010. Proceedings of the National Workshop on Six Invasive Fishes Risk Assessment in British Columbia; 4-6 March 2008. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2009/040.

Tovey, C.P., Bradford, M.J., and Herborg, L-M. 2008. Biological Risk Assessment for Smallmouth Bass (*Micropterus dolomieu*) and Largemouth Bass (*Micropterus salmoides*) in British Columbia. Can. Sci. Adv. Sec. Res. Doc. 2008/075.

FOR MORE INFORMATION

Contact: Becky Cudmore
Centre of Expertise for Aquatic Risk Assessment
867 Lakeshore Rd.
Burlington ON L7R 4A6 Canada
Tel: (905) 336-4474
Fax: (905) 336-6435
E-Mail: becky.cudmore@dfo-mpo.gc.ca

Contact: Michael Bradford
Fisheries and Oceans Canada, and Cooperative Resource Management
Institute, Simon Fraser University,
Burnaby, BC, V5A 1S6
Tel: (604) 666-7912
Fax: (604) 666-1995
E-Mail: mike.bradford@dfo-mpo.gc.ca

This report is available from the:

Centre for Science Advice (CSA)
Pacific Region
Fisheries and Oceans Canada
3190 Hammond Bay Road,
Nanaimo, British Columbia V9T 6N7

Telephone: (250) 756-7208
Fax: (250) 756-7209
E-Mail: Janice.Mattu@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas

ISSN 1919-5079 (Print)
ISSN 1919-5087 (Online)
© Her Majesty the Queen in Right of Canada, 2011

La version française est disponible à l'adresse ci-dessus.

**CORRECT CITATION FOR THIS PUBLICATION**

DFO. 2011. Science Advice from a Risk Assessment of Smallmouth Bass (*Micropterus dolomieu*) In British Columbia. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/085.