



SCIENCE ADVICE FROM A RISK ASSESSMENT OF WALLEYE (*Sander vitreus*) IN BRITISH COLUMBIA



Walleye (*Sander vitreus*) Image courtesy of the New York State Department of Environmental Conservation, Albany NY.

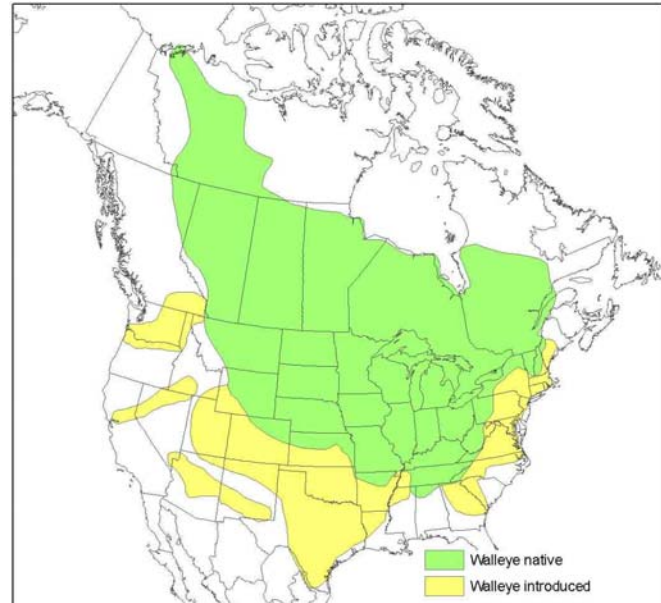


Figure 1: North American Distribution of Walleye (from Hartman 2009).

Context:

Walleye is a large member of the Percidae family that feeds on smaller fishes. It is native to the freshwaters of North America east of the Continental divide; in British Columbia it is only native in the northeast part of the province. Walleye are found in southern British Columbia in the Columbia River basin as the result of movements of individuals from introduced populations in the Roosevelt Reservoir in Washington State. In its native range Walleye populations strongly influence prey fish communities. Walleye is a significant predator of native and introduced salmonid populations as it consumes migrating and stocked juveniles. Whether Walleye 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 Walleye 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 and environmental niche modelling were the main tools used to assess the biological risk posed by Walleye 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, BC. Based on this workshop the risk assessment was revised and published as a research document (Bradford et al. 2008) along with a proceedings report that 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

- Walleye is a freshwater fish native to North America east of the Continental Divide and is only native to northeastern British Columbia.
- Walleye is a piscivorous fish that can have a great impact on prey populations in its native range.
- Walleye has very specific environmental and habitat requirements including the need for the following:
 - Large (>400 ha) mesotrophic lakes or turbid rivers or clear deep lakes;
 - Clean spawning habitats sheltered from wind or currents;
 - Greater than 900°C degree-days in summer;
 - An adequate abundance of zooplankton for larvae and forage fishes for juveniles and adults; and,
 - Spring temperatures rising above 9°C.
- Walleye migrates to spawning grounds each spring and individuals have been known to travel great distances during non-migratory time periods. This increases the potential for Walleye to move from introduced regions in Washington into southern British Columbia.
- Overall risk posed by Walleye to British Columbia's aquatic ecosystems was determined to be high with a moderate uncertainty. Areas predicted to be most highly impacted are Lower Mainland, Upper Fraser, Thompson and Columbia regions, but specific waterbodies within each region will vary in potential risk.
- Risk posed to a particular waterbody will need to be determined in a separate, specific risk assessment.
- Once introduced this species is very difficult to eliminate suggesting that proactive measures are needed if its 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

Walleye is a freshwater fish that reach a maximum age of 14-18 years. Size is dependant on growing conditions and a 10 year old fish can be 40-80 cm in length. Females are larger than males and reach maturity at 3-8 years; males mature a year earlier. Reproduction occurs in spring when water temperatures rise above 5°C after a potentially extensive migration to the spawning location. Spawning takes place in relatively shallow water along rocky shorelines of lakes or cobble river beds. The eggs are released in batches of 200-300 at a time as often as every five minutes. Spawning is completed in one night with a single female releasing 40,000-60,000 eggs. The eggs fall to the bottom and adhere to gravel or sink into crevasses as they become water hardened and lose their stickiness.

Larval Walleye hatch in 15-30 days and begin feeding on zooplankton at 9 mm. The diet of Walleye shifts quickly to invertebrates and then to fishes by the time Walleye are 30 mm long. Juvenile and adult diets consist primarily of fishes, supplemented with insects or macro-invertebrates on occasion. Cannibalism is a significant part of feeding behaviour and may affect population structure. In its native range, Yellow Perch (*Perca flavescens*) is a favourite prey item. Walleye can consume fishes up to one half of its length and in western American reservoirs, introduced Walleye prey heavily on salmonids. Predation on migrating salmon smolts in the Columbia River is significant. Juvenile Walleye are prey for a piscivorous fishes in the native range.

Habitat

Walleye has a relatively wide range of environmental tolerances with an upper temperature range of 29-34°C and a preferred range of 20-24°C in summer. It is present in the far north and can survive long winters and short growing seasons. It tolerates low oxygen (to 2 mg·L⁻¹) but prefers levels greater than 5 mg·L⁻¹. The analyses of stocking records indicate that it prefers slightly alkaline and larger lakes. Suitable lakes are usually >400 ha, with large littoral zones. Walleye prefer shallow areas over rock and gravel shoals, and occurs at depths of 1-15 m. Its eyes are specially adapted for feeding at lower light conditions and consequently optimal

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

habitats are usually moderately turbid lakes and rivers. In British Columbia, most Walleye are caught in three types of habitat: 1) where banks were stable with cobble or gravel substrates; 2) where shoreline was uniform and water velocity at the bank was low; or, 3) where in stream cover was limited to roughness and overhead cover was provided by turbidity.

Walleye larvae are planktonic, but settle into the littoral zone by summer. Juveniles occupy shoreline habitats and adults tend to be close to shore by night and occupy offshore habitats in the day.

Behaviour and Movements

Walleye exhibits diel vertical movements associated with changing light intensities. It may come into shallow water at night to feed. In both lakes and rivers, mature Walleye move from overwintering areas to spawning areas in the early spring. There is evidence of homing behaviour with fish returning to the same spawning area year after year. Many individual Walleye marked in a spawning run were recovered within 25 km of the tagging site, while one fish traveled 139 km. After spawning, fish move both upstream and downstream. Individual fish have been known to travel a long distance (40 to >200km) during non-migration time periods.

Parasites

Walleye can be infected with a wide variety of diseases and parasites including the tapeworm *Diphyllbothrium latum* which can infect humans if uncooked flesh is consumed.

Distribution

Native distribution in Canada extends from eastern Quebec to the continental divide. It is found in the Mackenzie Basin north to the Arctic Ocean and is found as far south as Alabama and Arkansas (Figure 1). It has been introduced to the Atlantic coast states and most Pacific coast states. Range expansion is largely due to deliberate introductions and spread.

In British Columbia, Walleye is native to the lower Peace River and the Hay and Liard systems in the northeast (Figure 2). Walleye has spread through the Columbia River system following a 1960 introduction in the Roosevelt Reservoir. It is unclear whether Walleye in the Canadian portion of Columbia Basin Rivers is self-sustaining or if it uses these habitats on a seasonal basis.

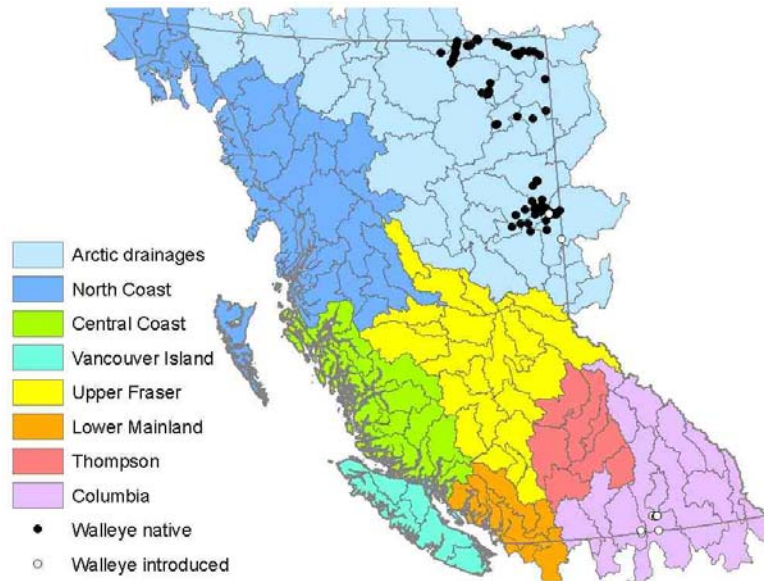


Figure 2. The known distribution of Walleye in British Columbia (from Bradford et al. 2008).

Potential Distribution

Environmental niche modeling based on terrestrial environmental characteristics was determined to be the best predictor of current distribution of Walleye in British Columbia. Results are given in Figure 3. The model predicted the highest mean suitability for the Thompson River followed by the Upper Fraser, the Arctic and Columbia areas. The lowest level of environmental suitability was predicted for Vancouver Island and the Central Coast.

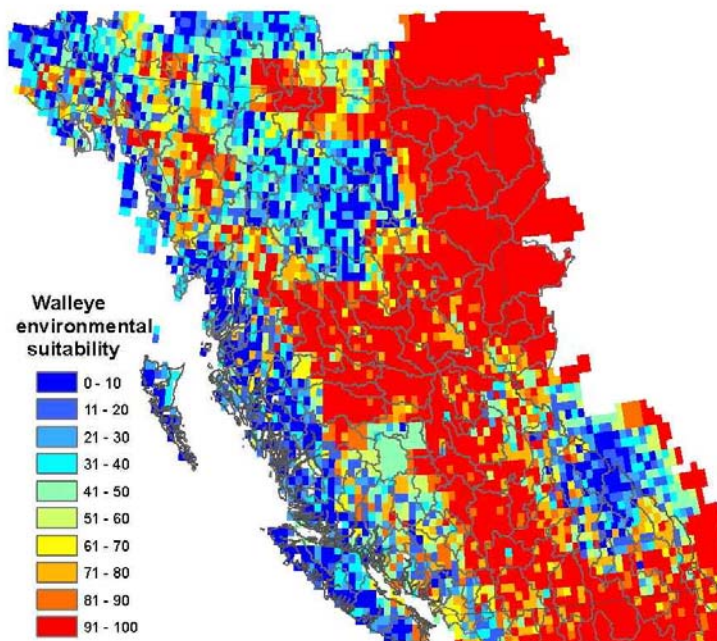


Figure 3. Predictions of environmental suitability for Walleye in British Columbia. Areas with higher scores have environmental conditions more suitable for Walleye populations (from Bradford et al. 2008).

Risk Posed to Watersheds of British Columbia

Probabilities of each stage of invasion; arrival, survival, establishment, spread; and widespread establishment, were assessed for the main regions of British Columbia. Next, ecological consequences of widespread establishment were predicted and the results are combined in a matrix to determine overall ecological risk (Table 1). Genetic consequences were also predicted and combined with the probability of widespread establishment to determine overall genetic risk (Table 2). Lastly, the genetic and ecological consequences of fellow travelers (parasites, pathogens etc.) were estimated and combined with probability of widespread establishment for each of the regions (Table 3).

Overall, Walleye is predicted to have a moderate to high impact on British Columbia's freshwater ecosystems. Fellow travelers are predicted to have a moderate impact. The actual impact will depend on the individual waterbody invaded and the population density that is reached in that waterbody.

Table 1. Matrix for determining overall ecological risk of Walleye (from Bradford et al. 2008).

Ecological consequences	Very High					
	High		CC,NC	VI,AR	LM,UF,TH,CO	
	Medium					
	Low					
	Very Low					
		Very Low	Low	Moderate	High	Very High
Probability of widespread establishment						

*AR-Arctic Region, CC- Central Coast, CO-Columbia River, FR-Fraser River, LM-Lower Mainland, NC – North Coast, TH-Thompson River, VI-Vancouver Island.

Table 2. Matrix for determining overall genetic risk for Walleye (from Bradford et al. 2008).

Genetic consequences	Very High					
	High					
	Medium					
	Low					
	Very Low					
		Very Low	Low	Moderate	High	Very High
Probability of widespread establishment						

Table 3. Matrix for determining overall risk for fellow travelers of Walleye. The solid ellipse represents ecological risks and the dashed ellipse is for genetic risks (from Bradford et al. 2008).

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

Considerations Regarding Arrival

- Walleye is native to a portion of the Arctic region and has been found in the Columbia Drainage basin.
- Walleye is found in watersheds adjacent to British Columbia and in portions of British Columbian watersheds that are outside of British Columbia proper.
- Requests have been made to stock Walleye in order to control populations of Yellow Perch.
- Walleye is considered a desirable sport fish and may be introduced illegally by bucket biologists.

Considerations Regarding Survival and Establishment

- Walleye does not colonize as readily as Yellow Perch and only 35% of North American stocking attempts were considered successful. In many cases agencies are forced to stock lakes annually because natural reproduction does not occur.
- Factors considered essential for Walleye establishment are the following:
 - Large (>400 ha) mesotrophic lakes or turbid rivers or clear deep lakes;
 - Clean spawning habitats sheltered from wind or currents;
 - Greater than 900°C degree-days in summer;
 - An adequate abundance of zooplankton for larvae and forage fishes for juveniles and adults; and,
 - Spring temperatures rising above 9°C.

Considerations Regarding Spread

- Walleye can migrate great distances and this enhances its ability to spread from an initial point of introduction.
- Most Walleye have limited movements during non-spawning periods although there are often a few individuals that move long distances (40 to >200km).
- Spread is constrained by the presence of suitable connecting waters, particularly large rivers with slow moving currents and cover in the form of turbidity or depth.
- They may be blocked from upstream movements by waterfalls or dams without passage facilities.
- There is a limited suitable habitat in mountainous headwaters.
- Deliberate illegal human introductions are likely to be unsuccessful due to insufficient numbers stocked.

Considerations Regarding Ecological Impacts

- Walleye competes with other species for common food resources.
- Its main impact is expected to be the result of predation. In its native range, Walleye populations strongly influence prey fish communities.
- Walleye is a significant predator of native and introduced salmonid populations as it consumes migrating and stocked juveniles.
- Based on modeling results for the lower Columbia River, Walleye is estimated to be responsible for only a small loss in productivity of salmon populations and less important than native predators.
- Impacts will be greatest in waterbodies where Walleye is able to establish and form significant populations.

Considerations Regarding Genetic Impacts

- Yellow perch is the only other native member of the Percidae found in British Columbia. Eggs of Walleye crossed with Yellow Perch do not hatch so the possibility of genetic impact is very low with low uncertainty.

Considerations Regarding Fellow Travelers

- Introductions will likely result from natural movements of fish in established populations or illegal introductions that are unlikely to be screened or treated for disease. Any parasites or pathogens present are likely to accompany their host and survive in conditions acceptable to the host.

Sources of Uncertainty

There are key uncertainties regarding arrival and impacts of potential fellow travelers of Walleye.

- The main vectors of spread are natural movement and illegal introduction. These vectors are difficult to accurately estimate, especially illegal introduction.
- Fellow travelers of Walleye are expected to survive in conditions that are suitable for Walleye. It is unknown which fellow travelers will be introduced and what their impacts will be on British Columbia ecosystems, especially, for exotic parasites, newly introduced to North America.

CONCLUSIONS

- Overall risk posed to British Columbia by Walleye was determined to be high with a moderate uncertainty. Areas predicted to be most highly impacted are Lower Mainland, Upper Fraser, Thompson and Columbia regions, but specific waterbodies within each region will vary in potential risk.
- Walleye has specific requirements of waterbodies that may limit establishment and spread.
- Area of highest potential impact is through predation on native species.
- Once introduced this species is very difficult to eliminate suggesting that proactive measures are needed if its 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 Walleye 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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