



SCIENCE ADVICE FROM A RISK ASSESSMENT OF NORTHERN PIKE (*Esox lucius*) IN BRITISH COLUMBIA



Northern Pike, *Esox lucius*. Image courtesy of the New York State Department of Environmental Conservation, Albany NY.

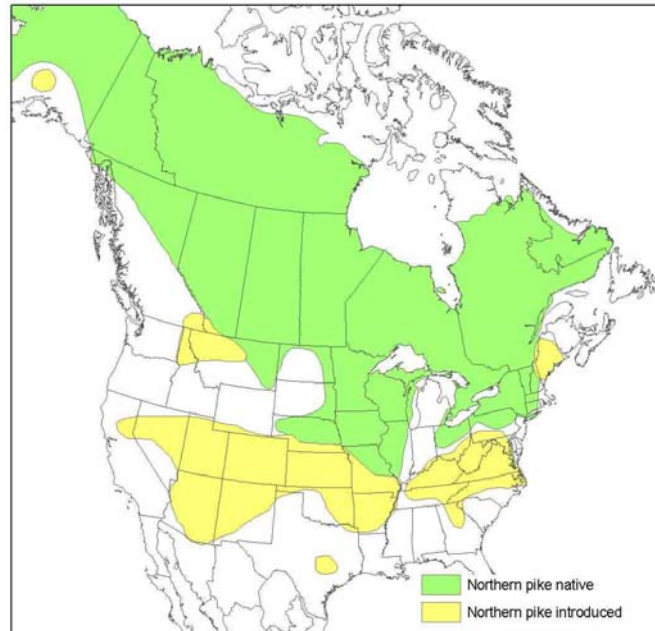


Figure 1. The North American distribution of Northern Pike (from Harvey 2009).

Context:

Northern Pike is a large cool-water species with a diverse diet of mainly fishes but also benthic invertebrates, amphibians, or mammals if opportunity arises. Northern Pike is native to the freshwaters of North America but not to southern British Columbia. This ambush predator is associated with shallow, structurally diverse habitats that are common in British Columbia's small lakes. There, it poses a very high risk to native fish species as has been demonstrated in other regions where it has been introduced. Whether Northern Pike 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 Northern Pike 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, BC. Based on discussions at the 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 (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

- Northern Pike is a large, cool-water fish found in all northern continents under a wide range of conditions. It is not native to southern British Columbia, but an introduced population has been identified there.
- Northern Pike inhabits vegetated littoral zones and where it preys on fishes.
- Northern Pike is known to have considerable impact on native fish communities in lakes where it was introduced, particularly impacting fish communities of small, shallow lakes with extensive littoral zones.
- It is a desirable fish for anglers, which has led to authorized and illegal introductions elsewhere.
- It prefers slow-moving waters, but is known to use streams to colonize downstream lakes when introduced higher in a watershed.
- The risk assessment evaluated the likelihood of arrival, survival, establishment and spread of Northern Pike in regions of British Columbia. It estimated the impact of widespread establishment of Northern Pike and combined the impact and probability estimates in a risk matrix to determine overall level of risk posed to aquatic communities in British Columbia.
- The risk of widespread establishment is considered to be high for the Columbia region and moderate for the Vancouver Island, Lower Mainland, Upper Fraser and Thompson regions.
- A very high impact with low uncertainty is expected in shallow lakes with extensive littoral zones.
- The overall level of risk was found to be high with a moderate uncertainty.
- This risk assessment was undertaken at a large scale. If risk posed to a particular waterbody is needed, a separate risk assessment, specific to that location should be undertaken.
- Fish are difficult to eliminate from a system once established. If deemed undesirable, Northern Pike should be prevented from becoming established.

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

Northern Pike is a large cool water species that can reach 1 m in length. It may live for as long as 30 years although only 40% of populations have individuals older than 7 years. Average-sized pike, in Canada's small commercial fishery, are 0.9-2.3 kg and females are generally larger than males. The largest pike taken in Canada was 19 kg. Age at maturity is variable and can range from 3-5 years for females and a year earlier for males. Reproduction occurs in spring (mid-May) when water has warmed to 8-12°C. Northern Pike leaves the lake and migrates up tributaries to vegetated areas in flooded marshes or shallow pools where spawning occurs. Females produce 15,000-60,000 eggs per individual. Fertilized eggs sink to the bottom and adhere to vegetation where they remain, unguarded, until hatching in 5-30 days (temperature dependant). Newly hatched larvae stick themselves to vegetation using an adhesive gland on their head and remain in place for 10-15 days as the yolk is absorbed. After this initial period, larvae feed on zooplankton for 7-10 days before switching to a diet of fishes. Adults are a visual ambush predator whose diet consists of fishes, but also includes invertebrates, birds, mammals and amphibians. The ideal prey size is one third to one half the pike's body length. Soft-bodied fishes are preferred to those with spines.

Physiological Tolerances

Northern Pike tolerates a wide range of environmental conditions, which makes it relatively easy to introduce outside its native range. Northern Pike prefers waters 19-21°C with an upper lethal temperature limit of 29°C. It can tolerate temperatures as low as 0.1°C. It has varying responses to dissolved oxygen and survives in concentrations as low as 0.3 mg l⁻¹. Northern Pike will move when O₂ levels fall below 4 mg l⁻¹ and ceases feeding at levels below 2 mg l⁻¹. Northern Pike

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

tolerates a wide range of alkalinity and, although is primarily a freshwater species, it is occasionally found in coastal waters (up to 10‰), supporting the possibility of Northern Pike entering new freshwater habitat through coastal movements.

Habitat

Northern Pike prefers shallow, moderately productive waters in beds of aquatic macrophytes or other cover. Although it is occasionally found in rivers, they prefer slow moving water.

Behaviour and Movements

Northern Pike is most active at dawn and dusk, although, during winter they become more active during the day. Northern Pike is relatively sedentary apart from its spawning migration, but does move to deeper waters in summer when water temperatures rise.

Parasites

Many parasites and diseases are known in Northern Pike, likely due to its wide distribution, diverse diet, and the number of studies on Northern Pike. While many parasites are generalists, some are specific to Northern Pike. One cestode (*Triænophorus crassus*) infects Northern Pike as a primary host, but uses salmonids as an intermediate host. It is known to render salmonid flesh unmarketable. Northern Pike is also susceptible to viral hemorrhagic septicemia, an emerging disease spreading through the Great Lakes and affecting a number of fish species.

Risk Posed to Watersheds of British Columbia

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

Probabilities of widespread establishment were combined with the estimated ecological consequences in a risk matrix and the overall risk posed by Northern Pike was found to be intermediate to high with moderate uncertainty, depending on the region being assessed (Table 2).

Overall genetic risk posed by Northern Pike is considered low to intermediate with a moderate uncertainty (Table 3).

Overall risk posed to aquatic ecosystems of British Columbia by pathogens or fellow travelers that may be associated with Northern Pike introductions was found to be intermediate with high uncertainty (Table 4).

Table 1. The probability (Rank) of arrival, survival and reproduction, spread, and widespread establishment once arrived (WEOA) of Northern Pike including Uncertainty (Unc) (from Bradford et al. 2008).

	Vancouver Island (VI)		Lower Mainland (LM)		Upper Fraser (UF)		Thompson (TH)		Columbia (CO)		Central & N Coast (CC & NC)	
Element	Rank	Unc	Rank	Unc	Rank	Unc	Rank	Unc	Rank	Unc	Rank	Unc
Arrival	L	L	L	L	M	M	L	M	M*	M	L	M
Surv. & Reprod.	M	M	M	M	M	M	M	M	M	M	M	M
Spread	M	M	M	M	H	M	H	M	H	M	L	H
WEOA	M	M	M	M	M	M	M	M	H	M	L	H

Notes: Northern Pike are native to the Arctic region of BC and are also native to a few watersheds in the north coast region but these are ignored in the table. For arrival, the Columbia ranking applies to the Okanogan basin.

Table 2. Matrix for overall ecological risk by region (from Bradford et al. 2008).

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

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

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

Table 4. Matrix for determining overall risk for fellow travelers. The solid ellipse is for ecological impacts; the dashed ellipse is for genetic effects (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

- Northern Pike is native to the Arctic drainage and part of the North Coast Drainage (Figure 1).
- Northern Pike has been recently observed in southeastern British Columbia in Ha Ha Lake (Figure 2).

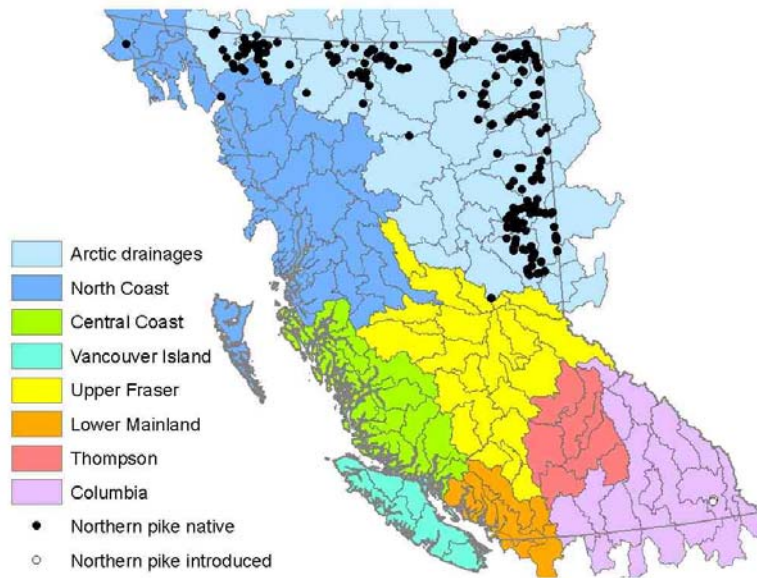


Figure 2. Observations of Northern Pike in British Columbia (from Bradford et al. 2008).

Considerations Regarding Survival and Establishment

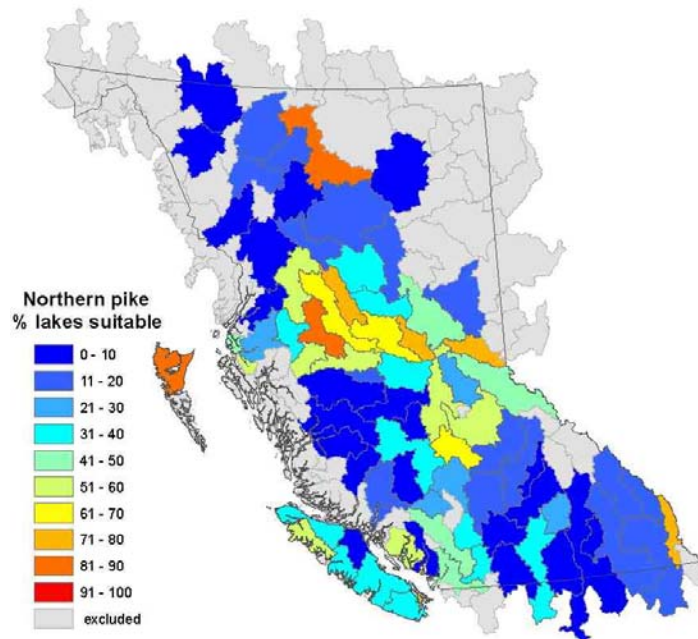


Figure 3. Results of the habitat suitability model for Northern Pike. For each watershed, the proportion of lakes predicted to be suitable for pike is indicated by the colour. Watersheds with less than 5 lakes with data are excluded. (from Bradford et al. 2008).

- Northern Pike is one of the most widely distributed fish species in circumpolar regions of North America and Eurasia.
- Northern Pike requires specific suitable environmental conditions including appropriate littoral regions with suitable habitat for spawning and feeding.

- An ecological niche model based on climatic and lake chemistry variables was created for lakes in British Columbia and was found to perform in an intermediate manner (21 of 37 lakes with Northern Pike were correctly predicted). This is likely due to the fact that lakes with native Northern Pike populations have little environmental data available to create the model. The model predicted that Northern Pike would be able to persist in a low percentage of lakes in British Columbia with the highest predictions for the Upper Fraser, North Coast and Lower Mainland regions (Figure 3).
- This model was based on generalized lake data and does not consider specific habitat requirements of Northern Pike (spawning and larval habitat).
- Northern Pike is unlikely to establish in glacial lakes or lakes or reservoirs without extensive littoral zones and macrophytes beds.

Considerations Regarding Spread

- Although largely sedentary, Northern Pike expands its range when conditions permit.
- One study concluded that 100% of lakes downstream of source populations became colonized with Northern Pike.
- An upstream colonization potential model predicted that upstream migration would be restricted by the presence of high-gradient barrier reaches.
- The identification of only one illegally introduced population in southern British Columbia suggests that there may be little interest in introducing Northern Pike or that Northern Pike is difficult to translocate. Recent successful introductions in the southern United States and Pacific Northwest highlight the significance of the risk.

Considerations Regarding Ecological Impacts

- Although it competes with other species for common resources, the primary impact on native ecosystems is expected to be a result of predation.
- Species most vulnerable to Northern Pike are those with small adult body size and a lack of spiny rays.
- In its native range, Northern Pike strongly influence prey fish communities; in Alberta, cyprinids are generally absent from lakes containing Northern Pike.
- Cascading trophic effects are another known impact. Increases in zooplankton and invertebrates numbers are seen following reductions in planktivorous fish populations due to predation by Northern Pike.
- In Idaho, salmonids were found in the stomachs of Northern Pike and were taken in preference to sticklebacks or introduced centrachids. In Alaska, Northern Pike were found to concentrate at lake outlets to prey on migrating salmon smolts.
- Northern Pike management plans, created to minimize its negative impacts, are in place in several American states.
- The risk is greatest in shallow, small lakes where all soft-bodied fishes are potential prey. In larger lakes, fishes inhabiting the vegetated littoral zone will be affected.
- It is unclear if introduced Northern Pike will lead to dramatic alterations in aquatic communities of larger ecosystems.

Considerations Regarding Genetic Impacts

- The potential for Northern Pike introductions from southern British Columbia to interbreed with native populations in the Mackenzie, Yukon or other northern river basins is unlikely. Thus the risk of genetic impact by introduced Northern Pike is estimated to be low.
- Northern Pike is unlikely to hybridize with any other native fishes in British Columbia.

Considerations Regarding Fellow Travelers

- As the primary means of introduction are illegal introduction and natural spread, fellow travelers of Northern Pike are likely to be introduced with the fish and are expected to survive under the same conditions.
- If Northern Pike is introduced for illegal stocking purposes, it is most likely to come from within British Columbia and carry parasites already present there.

Sources of Uncertainty

The key uncertainties in this risk assessment are associated with the likelihood of spread and impact of fellow travelers.

- Northern Pike has been identified in only one location in southern British Columbia. This could mean that there is less interest in illegally stocking Northern Pike, or, that it is a difficult species to establish in a system with a low number of propagules. There have been successful illegal introductions in California, Nevada, Arizona and the Pacific Northwest suggesting that it can be done. It is extremely difficult to predict the extent of illegal introductions. Natural spread, once a population is established, is much more certain, especially downstream of the initial site.
- It is very difficult to predict the type or number of fellow travelers that would be present on illegally introduced Northern Pike.

CONCLUSIONS

Although native to North America, Northern Pike has been introduced extensively beyond its native range. It is found around the globe in a wide range of environmental conditions. It prefers cool water and is thought to be prevented from southern expansion by temperature limitations. Northern Pike is a desirable fish for angling, which has led to legal and illegal introductions. Northern Pike is top predator known to have had considerable impact on native fish communities, especially soft-bodied fishes, in lakes where it was introduced. The Northern Pike is known to have devastating effects on native fishes in lakes with extensive vegetated littoral zones. There is considerable uncertainty regarding the risk presented by parasites and fellow travelers of Northern Pike. Overall, Northern Pike received a high risk rating with moderate uncertainty, especially for small lakes in southern British Columbia.

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 Northern Pike 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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