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THE RAPID SPREAD OF INVASIVE SMALLMOUTH BASS AND CHAIN PICKEREL AND A CHANGING NOVA SCOTIA FISHERY

JOHN L. MACMILLAN[1*], COLIN F. BUHARIWALLA[1]
KAYLEE MACLEOD[1, 2] MOLLY MACISAAC[1], LORI SWIDER[1]
ELIZABETH JONES AND ANDREW G. LOWLES[1]

[1] Inland Fisheries Division, Nova Scotia Department of Fisheries and Aquaculture, 91 Beeches Road, Pictou, NS B0K 1H0

[2] Integrated Resources Planning Division, Nova Scotia Department of Natural Resources, 136 Exhibition St, Kentville, NS B4N 4E5

John.L.MacMillan@novascotia.ca, Colin.Buhariwalla@novascotia.ca, Kaylee.MacLeod@novascotia.ca, Molly.MacIsaac@novascotia.ca, Lori.Swider@novascotia.ca, cladonia.stellaris@proton.me and Andrew.Lowles@novascotia.ca

ABSTRACT

In the 1940s, Smallmouth Bass (*Micropterus dolomieu*) and Chain Pickerel (*Esox niger*) were confirmed in 14 lakes collectively in southwest Nova Scotia. By 2025, Smallmouth Bass had been documented in 340 lakes, while Chain Pickerel had been reported in 180 lakes, representing approximately 34% of the province's lentic habitats. The initial spread of Smallmouth Bass was facilitated by government-sanctioned stocking; however, over the past 80 years, the range of both species has expanded due to natural migration and illegal introductions. The increasing popularity of Smallmouth Bass and Chain Pickerel among anglers is reflected in annual catch statistics. While the spread of these invasive species has created additional angling opportunities, their introduction has significantly disrupted the natural integrity of freshwater ecosystems, permanently altering the landscape of the sport fishery. In response to this challenge, a range of strategies and policy changes have been implemented to address the expanding threat posed by aquatic invasive species.

Keywords: brook trout, aquatic invasive species, fisheries management, rotenone

* Author to whom correspondence should be addressed: John.L.MacMillan@novascotia.ca

INTRODUCTION

The global proliferation of invasive species poses significant threats to ecosystems, resulting in extirpation and even extinction of native species (Wind 2004). Freshwater ecosystems are particularly vulnerable to invasions arising from anthropogenic introductions due to geographical isolation created by watershed boundaries, which prevent native aquatic species from dispersing into unimpacted habitat away from invasive species they are unequipped to compete with (Dextrase and Mandrak 2006). The ecological impacts of such introductions are significant, often leading to permanent shifts in aquatic ecosystems that disrupt food webs and escalate competition and predation pressures on native species, including fish, zooplankton, macroinvertebrates, amphibians, and reptiles (Jackson 1995). Once invasive species become established, they can act as source populations for further introductions and spread (Wind 2004).

Unauthorized introductions of Aquatic Invasive Species (AIS) can arise from various sources, including aquaculture escapees, transfers and releases from the aquarium trade, and introductions incentivized for recreational angling (Benson 1999, Naylor *et al.* 2001, Kerr 2014, Gertzen *et al.* 2017). Anglers are recognized as significant contributors to the spread of AIS through intentional acts, such as illegal introductions aimed at developing additional angling opportunities (Rahel 2004); careless practices, like the improper disposal of bait containing eggs and/or juveniles from non-native species; and unintentional transport on boats and boat trailers that are not properly cleaned, drained, or dried (Kerr 2014). Following the introduction, the successful establishment of invasive species is often contingent upon specific ecological factors, including native fish community composition and water quality (Kolar and Lodge 2002, Sharma *et al.* 2009).

Nova Scotia's freshwater systems are characterized by their limited size and species diversity relative to other regions in continental North America and are highly susceptible to AIS (Alexander *et al.* 1986, Davis and Brown 1996). Native fish communities in Nova Scotia are comprised of freshwater species and an array of diadromous species (Alexander *et al.* 1986) with the anadromous Brook Trout (*Salvelinus fontinalis*; BT) designated as the provincial fish. The province features over 6,700 lakes and 64 main river systems fed by many small streams (Davis and Brown 1996). These freshwater habitats are shaped by two

main geological regions: the southern uplands, characterized by the metamorphic rock and shallow soils of the southwest Nova Scotia, which support acidic surface waters with limited productivity, and the sedimentary surficial geology in northeastern Nova Scotia, including Annapolis Valley, that fosters higher freshwater productivity (Davis and Brown 1996). Additionally, surface waters in the southern regions of the province are warmer, exerting seasonal stress on cold-water salmonids like BT compared to cooler northeastern areas (MacMillan *et al.* 2005).

As piscivores, both Smallmouth Bass (*Micropterus dolomieu*; SMB) and Chain Pickerel (*Esox niger*; CP) can consume a wide array of large prey species, including fish, frogs, salamanders, turtles, snakes, mice, and young waterfowl (Mitchell *et al.* 2010, Sanderson *et al.* 2009, Whittier *et al.* 1997). Their introduction can result in competition with native piscivores and the extirpation of smaller-bodied fish species (Brown *et al.* 2009, Mitchell *et al.* 2010, Loppnow *et al.* 2013). Both SMB and CP were established in southwest Nova Scotia in the 1940s, the former through government introductions and the latter through illegal introductions (McNeill 1996, LeBlanc 2010, Mitchell *et al.* 2010).

The spread of SMB outside their native range in Ontario is anticipated to lead to the extirpation of leuciscid populations and a loss of aquatic biodiversity, culminating in the homogenization of aquatic fauna (Jackson and Mandrak 2002). Native species may exhibit avoidance behaviour in response to introduced SMB, potentially increasing their predation risk and depleting energy reserves during foraging activities (Schlosser 1987). Native salmonids, including BT, are particularly vulnerable to the impacts of introduced SMB through direct predation on juvenile life stages and changes in food web dynamics (Vander Zanden *et al.* 1999, Harvey and Karieva 2005, Fritts and Pearsons 2006, Sharma *et al.* 2009a).

Similarly, the introduction of CP has been shown to result in detrimental impacts to species richness and diversity (Whittier *et al.* 1997). In Nova Scotia, the introduction of CP has adversely affected native fish populations. Mitchell *et al.* (2010) compared lakes with and without CP and found those with CP showed diminished species richness and diversity, truncated size distributions, and simplified food webs. Risk assessments of closely related Northern Pike (*Esox lucius)* have similarly demonstrated catastrophic effects on native fish communities post-introduction (DFO 2010).

Both SMB and CP thrive in lentic habitats, deep pools and slow-flowing sections of river systems (Chaput and Caissie 2010). Established populations of these two invasive species are prevalent in southwest Nova Scotia. Water temperature is a key factor influencing the distribution of SMB and other freshwater fish species (Armour 1993). Juvenile SMB, particularly those under 50 mm, struggle to survive the winter in New Brunswick lakes due to the cold climate (Curry *et al.* 2005). However, the presence of SMB and CP in northeastern Nova Scotia suggests that the cooler conditions do not inherently impede the establishment of these populations, and projected warming trends could further expand habitat suitability for these AIS (Shuter *et al.* 2002).

Despite limited research on the impact of invasive species on BT in Nova Scotia, lake survey datasets can offer valuable insights. Peterson and Martin-Robichaud (1989) note the absence of BT in lakes inhabited by SMB and CP, both in Nova Scotia and New Brunswick. Similarly, risk evaluations of SMB in Nova Scotia and New Brunswick have ranked the potential impact of SMB on lake habitats as high, and on riverine habitats as moderate, concluding that SMB can become dominant within the aquatic food webs of both habitat types (Chaput and Caissie 2010).

Anecdotal evidence from Nova Scotian anglers indicates a decline in trout catches following SMB introductions, a trend corroborated by existing literature and documented in other regions (Oliver *et al.* 1991, Whittier and Kincaid 1999, Brown *et al.* 2009). Recent shifts in species distribution, coupled with increasing popularity among anglers, have enabled SMB to carve out a substantial presence within Nova Scotia's sport fishery. These changes reflect the species' adaptability and in combination with evolving angler preferences highlight the importance of adaptable resource management strategies that meet the needs of current sport fishing trends in the province.

The growth of SMB and CP fisheries in Nova Scotia from the 1940s to the 1990s resulted in the establishment of popular recreational fishing opportunities, subsequently prompting SMB angler groups to advocate for greater fishing access and protective regulatory initiatives. Consequently, management strategies evolved to promote these fisheries, including policies that support competitive sport fishing events, regulations that increased opportunities, such as extended seasons and night fishing, and conservation measures such as spawning season restrictions to reduce fish harvest.

However, in response to the continued proliferation of AIS throughout the province, management strategies have more recently shifted towards a stricter regulatory approach aimed at curtailing the spread and mitigating the rate of introductions. Typically, public awareness campaigns and legislative measures are the first step in this regard, as eradicating established invasive fish populations is both costly and complex (Rahel 2004). Management measures to control the spread of invasive species often occur decades after their initial introduction, which frequently necessitates a review of policies initially intended to protect and promote these species (Rahel 2004).

REVIEW

This review summarizes the expansion of SMB and CP distribution since their first introduction to Nova Scotia, incorporating historical datasets that describe the spread of these AIS within the province. We also summarize angler catch data for native BT and AIS from the 1980s onwards, identifying major trends within the federal Survey of Recreational Fishing in Canada and the provincial Nova Scotia Angler Licence Stub Program. Finally, we examine fisheries management strategies employed for AIS from the 1990s onwards, creating a timeline of recreational fishing regulations related to these two species, with emphasis on more recent approaches to control their spread and mitigate ecological impacts.

Evaluating AIS Distribution

Reports on the distribution of invasive SMB and CP in Nova Scotia are frequently submitted by anglers and the public to the Nova Scotia Department of Fisheries and Aquaculture (NSDFA). These reports require confirmation from NSDFA staff or other knowledgeable individuals (e.g. community groups or other government partners). Confirmation surveys employing angling, electrofishing, and eDNA are also conducted to verify the presence of invasive species in new waterbodies. Once reports are deemed accurate, they are added to a provincially maintained list of waterbodies impacted by AIS.

To quantify the spread of invasive SMB and CP across primary and secondary watersheds in Nova Scotia, we calculated the surface area of lentic habitat impacted by AIS across the province. It is important to note that the date of detection does not necessarily reflect

the introduction date, but rather the 'confirmation' date, as species confirmation often occurs several years post-introduction. Additionally, all totals are conservative estimates based on available data. For example, remote systems that are connected to impacted waterbodies may be inaccessible, but in the absence of barriers, can be assumed to host AIS. For the analysis of AIS distribution data, the number of confirmed AIS waterbodies was summarized by decade. They exclude riverine habitat, given the nature of the dataset and challenges associated with quantifying total suitable lotic habitat. We evaluated the number of primary and secondary watersheds occupied by AIS, the percentage of lentic ecosystem surface area affected, and the number of lakes impacted by SMB and CP using the provincial AIS detection database, the Nova Scotia Hydrographic Network, and the Nova Scotia Topographic Database (UTM/NAD83 projection). This analysis also utilized provincial watershed mapping information captured using QGIS software. The total percentage of lake habitat occupied by SMB and CP was calculated based on a total lake surface area of 225,495 hectares within Nova Scotia, as described by Alexander *et al.* (1986).

History of AIS Introductions

In response to rising concerns over degrading habitat suitability for native salmonids in southwestern Nova Scotia, the provincial government introduced SMB to Bunker Lake, Yarmouth County, in 1942 with the intention of enhancing angling opportunities for alternative species. This lake, in addition to nine others, was seeded through government-sanctioned SMB stocking, although only six of these lakes produced self-sustaining populations by 1953 (McNeill 1995). In contrast, the introduction of CP to Nova Scotia was unauthorized, with illegal introductions to three lakes in the southwestern region, which were first detected in 1945 (Catt 1949). The Spectacle Lake system in Digby County was the first system where CP was officially confirmed in Nova Scotia (Gilhen 1974).

By 1960, the distribution of SMB and CP had expanded to 14 and seven waterbodies, respectively. Throughout the 1960s and 1970s, clusters of SMB-inhabited waterbodies emerged near the city of Halifax along the eastern shore of the province and in Kings County. In 1971, government-sanctioned stocking of SMB in Spectacle Lake, Digby County, resulted in the establishment of a self-sustaining population alongside already established CP (McNeill 1995). From 1967 to 1984, five lakes within a hydroelectric development system known as the

Gaspereau-Black River Complex were stocked to further enhance angling opportunities (McNeill 1995). Murphy Lake, Kings County, was the final lake in the system to be stocked, with releases recorded in 1984. This event concluded all historical government-sanctioned SMB stocking in the province (McNeill 1995, LeBlanc 2010).

By 2000, the total number of lakes across the province with SMB and CP had expanded to 132 and 84, respectively, including the first confirmation of their presence in northern mainland Nova Scotia. From 2000 to 2019, impacted lakes increased to 295 and 165, respectively. Recent expansion into un-colonized northeastern mainland watersheds occurred in 2019 with SMB in Piper Lake, St. Mary's River system and again in 2020 with Dobsons Lake, Cole Harbour River system. However, successful eradication of SMB from Piper and Dobsons Lakes was achieved using Noxfish Fish Toxicant II (5% rotenone) in 2020 and 2022, respectively (Fig 1). These two systems remain free of SMB and CP at present.

By 2025, a total of 441 lakes and approximately 45.8% of the secondary watersheds in the province were inhabited by either SMB, CP or both. Lakes with confirmed AIS account for approximately 6.6% of the total 6674 lakes in the province (Alexander *et al*. 1986). However, the lakes where AIS are introduced, and therefore those with confirmed AIS presence, are often larger lakes. Of the total lentic habitat in the province, 75,703 hectares are occupied by AIS, representing 34% of the province's total lentic surface area (Table 1). Of this, lakes with SMB only (n=261) account for 3.9%, lakes with CP only (n=101) account for 1.5%, and lakes with both SMB and CP (n=79) account for 1.2%.

Table 1 Breakdown of lake count and total lake surface area of CP and SMB occupied lakes in Nova Scotia by decade from 1942-2025.

Decade	CP Lake Count	SMB Lake Count	CP and SMB Lake Count	Surface Area of CP Lakes (ha)	Surface Area of SMB Lakes (ha)	% of Lentic Habitat with SMB and/or CP	% of Total Lakes with SMB and/or CP
1940's	7	7	0	423	427	0.4%	0.2%
1950's	7	14	0	423	1019	0.6%	0.3%
1960's	17	30	1	835	6962	3.4%	0.7%
1970's	29	51	6	1754	9004	4.6%	1.3%
1980's	32	75	6	1896	14726	7.2%	1.7%
1990's	74	144	23	9376	25576	12.8%	3.6%
2000's	104	227	45	14715	45470	21.6%	5.6%
2010's	152	308	73	38408	52413	31.6%	8.0%
2025	180	340	79	41568	55352	33.6%	9.0%

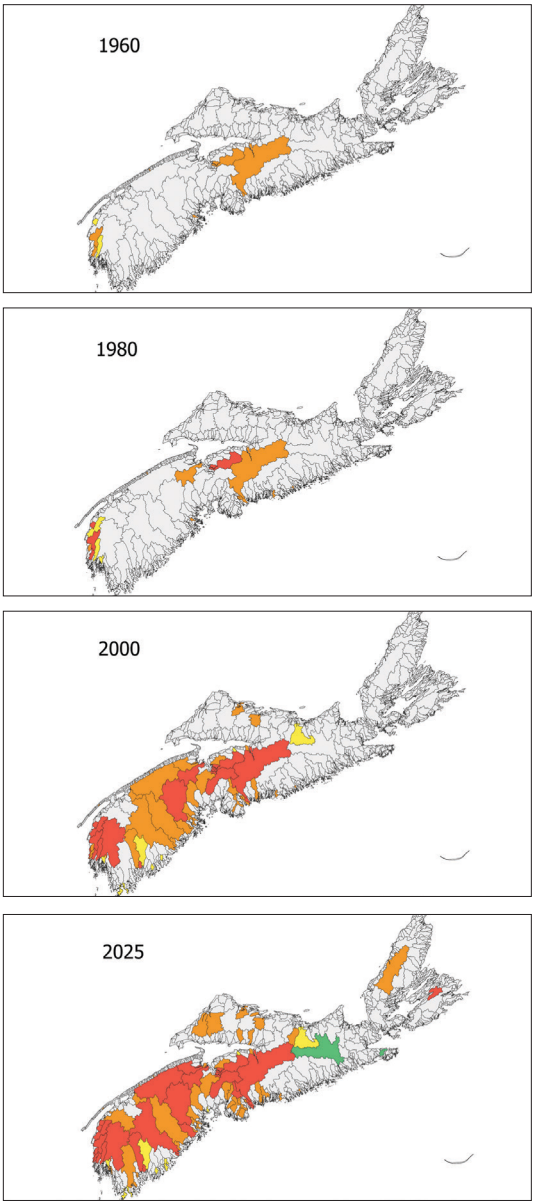


Fig 1 **Changes in distribution of CP and SMB across secondary watersheds from 1960 to 2025. Orange represents SMB presence, yellow represents CP presence, red represents presence of both SMB and CP, and green represents the watersheds of the two lakes (Piper Lake, St. Mary's River and Dobsons Lake, Cole Harbour River) where eradication efforts (rotenone) have taken place.**

Monitoring changes in species distribution has been significantly enhanced through the adoption of eDNA assessments (Baillie *et al.* 2019, Loeza-Quintana *et al.* 2019). These tools facilitate the rapid detection of invasive species and have proven effective in global contexts, including monitoring problematic species such as Asian Carp and Round Goby (Jerde *et al.* 2013, Nevers *et al.* 2018). In Nova Scotia, eDNA surveys have been employed to track the distribution of SMB and CP in key areas such as Kejimkujik National Park (Loeza-Quintana *et al.* 2021) and NSDFA initiatives in St Mary's River (Piper Lake) and Cole Harbour River (Dobsons Lake). Department of Fisheries and Oceans Canada's AIS program has adopted widespread provincial eDNA monitoring through community partnerships with Nova Scotia Invasive Species Council, Atlantic Salmon Federation, Nova Scotia Salmon Association, and Margaree Salmon Association, among others. These groups share novel observations of SMB and CP detected through their work. The increasing popularity of eDNA within the province complements traditional sampling methods for AIS surveillance and allows managers to more accurately track the distribution of SMB and CP.

Angler Catch

Trends in annual angler catch data serve as an index for assessing the health of fisheries and as a means of understanding angler preferences. Catch data for this study were collected from two primary sources: 1) the Survey of Recreational Fishing in Canada (SRFC), and 2) the Nova Scotia Angler Licence Stub Program (ALSP). The SRFC, conducted every five years, gathered data from a randomized sub-sample of licensed anglers. This comprehensive survey provides critical insights into recreational harvests, fishing activities, and economic statistics reported by anglers across Canada. For our analysis, we utilized Nova Scotia provincial catch data from the SRFC covering the years 1980 to 2015 (see DFO 1988-2019 for survey methodology). The SRFC was discontinued following the 2015 survey.

The Nova Scotia ALSP, initiated in 1966, is associated with the purchase of a recreational fishing licence and collects individual angler catch data across various species. A pre-addressed and postage-paid stub is attached to each fishing licence sold within the province. Online licence holders (available from 2020 onwards) also receive a link for their digital report card. Each angler is required to report annual effort (days fished) and catch by species in the respective counties they fished.

Catch data are subsequently submitted to the NSDFA. These data are used to estimate the total annual catch by extrapolating the proportion of angler-submitted licence stubs to the total number of licences sold each year. Reliability of these estimates may be compromised by varying/low return rates and the sample's non-random nature. Despite these limitations, catch trends reflect changes in angler preferences, fishing opportunities, and the health of the fishery. To account for variations in fishing effort, we standardized the total catch data from the ALSP dataset by converting it to annual catch per angler (CPA) for BT, SMB, and CP.

The CPA from SRFC and the ALSP indicate decreasing BT catches over time with concurrent increases in SMB and CP catches (Fig 2). The change in CPA for BT and SMB is greater in 2015 relative to other survey years for the SRFC, while the ALSP remains more consistent for BT across time and increases for SMB in 2015. Over the 35-year period, licence sales decreased from a high of over 82,000 to a low of almost 50,000 (Table 2). While reporting catch data is mandatory, response rates for the ALSP range from 3.4 to 7.3 %, which presents a challenge for managers trying to get an accurate representation of changes in the fishery through time.

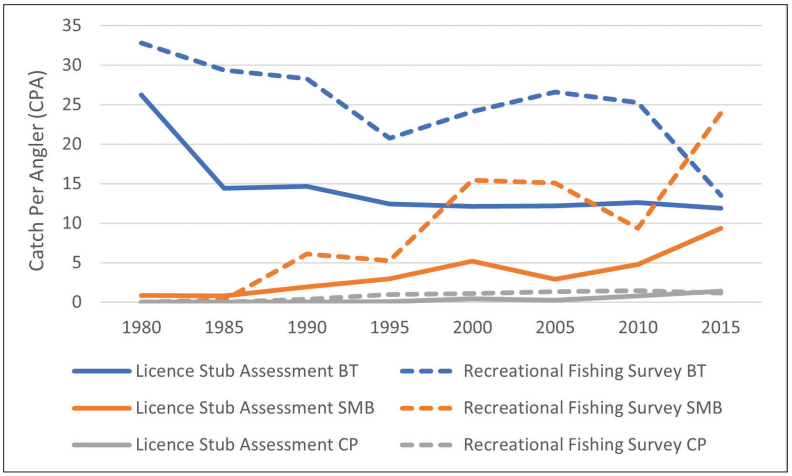


Fig 2 **Catch Per Angler (CPA) for SMB, CP and BT from the Nova Scotia Angler Licence Stub Program and the National Sportfishing survey data for 1980-2015, Nova Scotia.**

Table 2 **Licence sale statistics, total catch and catch per angler (CPA) of Brook Trout, Smallmouth Bass, and Chain Pickerel from the Nova Scotia Angler Licence Stub Program and the National Sportfishing survey 1980-2015, Nova Scotia.**

	1980	1985	1990	1995	2000	2005	2010	2015
Licence Stub Assessment								
Licence sales (stubs)	82,449	78,095	68,276	62,481	64,217	50,050	65,206	57,841
Stubs returned %	3.4	7.3	7.1	7.2	5.4	3.0	4.7	3.5
Brook Trout	2,164,109	1,126,229	1,000,948	775,945	776,850	609,504	823,909	686,410
Smallmouth Bass	71,907	64,334	133,320	185,726	333,317	145,847	311,041	541,376
Chain Pickerel	na	na	na	4,411	26,187	11,188	51,110	81,373
Brook Trout CPA	26.2	14.4	14.7	12.4	12.1	12.2	12.6	11.9
Smallmouth CPA	0.87	0.82	2.0	3.0	5.2	2.9	4.8	9.4
Chain Pickerel CPA	na	na	na	0.07	0.41	0.22	0.78	1.41
Survey of Recreational Fishing in Canada								
Brook Trout	2,712,503	2,295,695	2,035,523	1,324,900	1,560,416	1,351,559	1,621,807	777,123
Smallmouth Bass	na	18,007	439,073	337,061	998,487	766,977	598,869	1,378,344
Chain Pickerel	na	1,092	26,388	63,892	68,879	67,450	94,769	65,031
Brook Trout CPA	32.8	29.4	28.3	20.8	24.1	26.6	25.3	13.5
Smallmouth CPA	na	0.23	6.1	5.3	15.5	15.1	9.3	23.9
Chain Pickerel CPA	na	0.01	0.37	1.0	1.1	1.3	1.5	1.1

Fisheries Management

SMB Regulation Changes

Changes to SMB angling regulations over the past 25 years (2000 to 2025) are summarized in Table 3. Between 2000 and 2001, growing interest in improving the SMB fishery within the angling community garnered support for the use of special regulations on specific waterbodies, to protect larger individuals and thin out high-density, slow-growing populations. Special SMB Management Areas (SBMAs) were created on targeted lakes, and fisheries were classified into categories such as high-harvest fisheries (HHF) and trophy fisheries (TF) (NSDFA 2001). HHFs encouraged exploitation with a large daily bag limit of ten fish, while TFs incorporated various measures to reduce harvest, such as reduced bag limits of three fish and size regulations aimed at safeguarding larger fish. Notably, the season in SBMAs was extended from Oct 31-Dec 31. Province-wide SMB spawning season (SS) specific regulations were also introduced in 2001, which included mandatory release and bait restrictions during spawning times in late spring, except in HHFs. SS bait restrictions remained in place until 2008 (NSDFA 2008). Additionally, in 2001, night fishing opportunities for SMB were introduced in select waterbodies near Halifax.

By 2010, angler's concerns about AIS were being strongly expressed in the Recreation Fishing Survey data. For the first time since the initial survey in 1975, control of AIS was rated as the number one concern for anglers. However, according to the 2010 survey data, 98% of SMB and 94% of CP caught were still being released back into their habitats (NSDFA 2012b). This highlights the complexity of fisheries management and of developing strategies that promote or mandate retention of these AIS within the angling community. In 2011, NSDFA further differentiated their management approaches between the NE and SW regions of the province. In the SW region, SMB continued to be managed as sportfish with regulations remaining largely unaffected. In the NE region, they were managed as an invasive species, and SMB seasons were closed (with some exceptions) to further discourage illegal introductions. Where SMB angling was still permitted, the bag limit increased to 25 in most lakes to encourage removals (NSDFA 2011). In November 2012, the Live Fish Possession Regulations created under the Fisheries and Coastal Resources Act came into effect and then were first included in the Anglers Handbook

Table 3 **Summary of angling regulations related to Smallmouth Bass (SMB) in Nova Scotia from 2000-2025. The table is divided into the two managment regions of the province; the southwest (SW) region and the northeast (NE) region. Regulations have differed between the two regions since prior to 2000. Special Bass Management Areas (SBMA), including High Harvest Fisheries (HHF) and Trophy Fisheries (TF) are referenced throughout, as are specific SMB spawning season (SS) regulations. Season and bag limit changes are bolded for added clarity on when changes occurred.**

Year(s)	SW Region Season (Bag limit)	NE Region Season (Bag limit)	SBMAs & SSs Season (Bag limit)	Description of regulation change(s) and additional notes
2000	Apr 15-Oct 31 (5)	Apr 15-Sep 30 (5)	N/A	
2001	**Apr 1**-Oct 31 (5)	**Apr 1**-Sep 30 (5)	**HHF: Apr 1-Dec 31 (10)** **TF: Apr 1-Dec 31 (3)** **SS: Apr 21-Jun 10 (0)**	SBMA established. HHF - bag limit 10 with two over 25 cm, TF - bag limit 3 with one over 40 cm, all between 30-40 cm released. SS - zero retention, no natural bait permitted in all waters except in HHFs. Night fishing for SMB permitted on several waterbodies.
2003, 2004	Apr 1-Oct 31 (5)	Apr 1-Sep 30 (5) **Extended season lakes:** **Apr 1-Oct 31 (5)**	HHF: Apr 1-**Oct 31**/ Dec 31 (10) TF: Apr 1-Dec 31 (3) SS: **Apr 17-Jun 6** (0)	One new HHF lake established in Cape Breton, Inverness Co. (Apr 1-Oct 31). Five SMB new lakes in Pictou Co., Cumberland & Colchester Co.'s with extended seasons (Oct 31). Increased SMB angling opportunities established.
2008	Apr 1-Oct 31 (5)	Apr 1-Sep 30 (5) Extended season lakes: Apr 1-Oct 31 (5)	HHF: Apr 1-Oct 31/ Dec 31 (10) TF: Apr 1-Dec 31 (3) SS: **Apr 1-Jun 15 or Jun 30** (0)	Province-wide natural bait prohibition during SS removed. HHF - max length changed to 30cm. TF - all fish over 35 cm to be released. A number of new lakes added to the HHF and TF lists. SS dates were earlier in SW regions.

Table 3 cont'd.

Year(s)	SW Region **Season** **(Bag limit)**	NE Region **Season** **(Bag limit)**	SBMAs & SSs **Season** **(Bag limit)**	**Description of regulation change(s) and additional notes**
2011	Apr 1-Oct 31 (5, **25 Hants Co.)**	**Closed all year.** **Some exceptions:** **Apr 1-Oct 31 (25)**	TF: Apr 1-Dec 31 (3) SS: Apr 1-Jun 15 or Jun 30 (0)	HHF regulations removed. No open season in NE region except for select lakes where the bag limit was increased to 25. Three more TF locations established in Queens and Colchester Co.'s.
2013	Apr 1-Oct 31 (5, 25 Hants Co.)	Closed all year. Some exceptions: Apr 1-Oct 31 (25)	TF: Apr 1-Dec 31 (3) SS **(within SBMAs only):** **May 1-Jun 15** (0)	SS restrictions dropped outside SBMAs. Live Fish Possession Regulations created under the Fisheries and Coastal Resources Act came into effect late 2012 (Nov), and first included in the Anglers Handbook in 2013.
2014, 2015	Apr 1-Oct 31 (5, 25 Hants Co.)	Closed all year. Some exceptions: Apr 1-Oct 31 (25)	TF: Apr 1-Dec 31 (3) SS (SBMAs): **May 1- Jun 15** (0)	Four new SMBA lakes established in SW region. Middle River, Pictou added to lake exceptions open for SMB.
2017, 2018	Apr 1-Oct 31 (5, 25 Hants Co.) **Extended season lakes:** **Apr 1-Dec 31 (3)**	Closed all year. Some exceptions: Apr 1-Oct 31 (25)	Apr 1-Dec 31 (3) SS (SBMAs): May 1-Jun 15 (0)	Dropped the term 'Trophy Fisheries' within SBMAs (2017). Extended seasons (Apr 1-Dec 31) designated for eight new lakes in SW region (2018).
2019	Apr 1-Oct 31 (5, 25 Hants Co.) Extended season lakes: Apr 1-Dec 31 (3)	Closed all year. Some exceptions: Apr 1-Oct 31 (25)	Apr 1-Dec 31 (3) SS (SBMAs): May 1- Jun 15 (0)	Piper Lake (Pictou Co.) closed to all angling for all species due to detection of SMB, the first confirmation in this watershed.

2020	Apr 1-Oct 31 (5, 25 Hants Co.) Extended season lakes: Apr 1-Dec 31 (3)	Closed all year. Some exceptions: Apr 1-**Sep 30** (25)	Apr 1-Dec 31 (3) SS (SBMAs): May 1-Jun 15 (0)	The provincial SMB managment boundary was adjusted slightly and decribed in detail for the first time in Anglers Handbook. Exception lakes in NE region season changed to align with trout season (Apr 1-Sep 30). All lakes with extended CP season also open to SMB in NE region. Covid19 pandemic delayed season opening and tournaments not permitted.
2021	Apr 1-Oct 31 (5, 25 Hants Co.) Extended season lakes: Apr 1-Dec 31 (3)	Closed all year. Some exceptions: Apr 1-Sep 30 (25)	Apr 1-Dec 31 (3) SS (SBMAs): May 1-Jun 15 (0)	Dobsons Lake (Guysborough Co.) closed to all angling for all species due to detection of SMB, the first confirmation in this watershed.
2025	Apr 1-Oct 31 (5, 25 Hants Co.) Extended season lakes: Apr 1-Dec 31 (3)	**Open season coincides with trout (Mandatory retention)**	Apr 1-Dec 31 (3) SS (SBMAs): May 1-Jun 15 (0)	Mandatory retention of SMB in the NE region and in all waters of the West Branch LaHave River. SMB angling reopening in NE region, open season coincides with trout season.

in 2013. These aimed to enhance legal ramifications for individuals found with live fish and dissuade illegal introductions.

In 2020, the boundary line between the two SMB management areas was adjusted slightly and described in detail in the Anglers Handbook for the first time (Hwy 102 from the junction of Hwy 104, 118, 107 and 328). In the NE region the season was changed to better align with the trout season (Apr 1-Sep 30), and all lakes with extended CP seasons were also open to SMB. In 2025, mandatory retention was enacted in the NE region with SMB angling permitted during trout season. A map showing the NE and SW AIS management regions was included in the 2025 Handbook for the first time (Fig 3, NSDFA 2025).

CP Regulation Changes

Regulation changes for CP angling since 2000 have been less complex as they have been managed as an invasive species consistently across both the NE and SW regions of the province. CP angling has always been permitted during any sportfish open season (salmon, trout, SMB). There was no set bag limit until 2002, when a province-wide limit of 25 was introduced. From 2002 until 2018 CP angling opportunities continued to expand and increase through the addition of extended seasons, 'open all year' CP lakes, and winter CP angling opportunities. In 2018, the provincial bag limit was increased dramatically to 100 fish per day. Finally, in 2025 mandatory retention of CP was enacted province-wide (NSDFA 2025).

Tournament Trends

The increased distribution of SMB in western Nova Scotia, combined with a growing popularity for this sportfish among anglers, led to the establishment of competitive SMB sport fishing tournaments in 1982. These provincially sanctioned tournaments were concentrated among central and western lakes where SMB had been introduced and popular fisheries for them already existed. By 2025, many of the lakes where tournaments were historically hosted continue to sport annual events by recognized, long-standing fishing organizations. The main target species for these events has consistently been SMB, however, some groups also target CP as many lakes that are popular for SMB tournament angling have both species.

SMB tournament fishing is permitted only in areas they are managed as a sportfish, west of the established Highway 102 boundary. Tournament organizers must apply for permits issued by the province

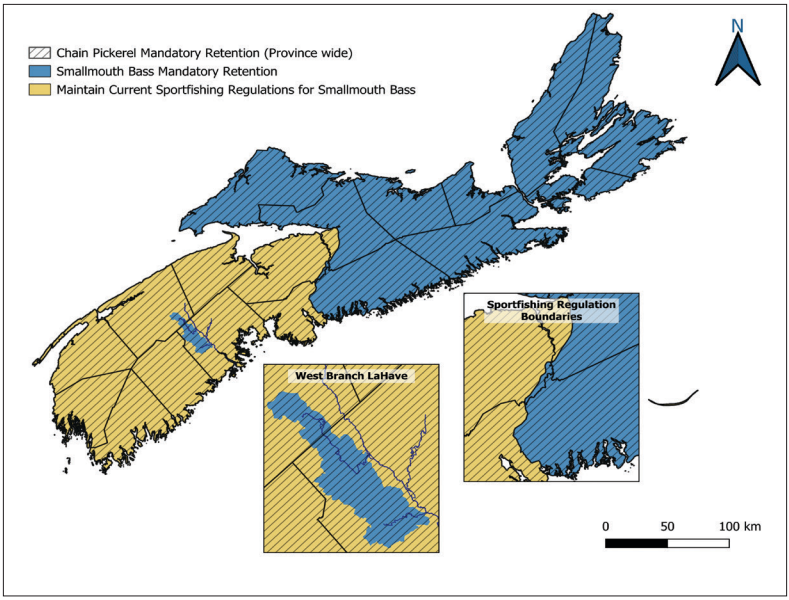


Fig 3 **AIS management boundaries established in Nova Scotia in 2025, illustrating mandatory retention zone for SMB (NE region and West Branch LaHave River) and CP (province-wide).**

to host sport fishing events and, subsequently, report summarized data from all events post-season as a condition of future permits – a policy that 1) allows the province to track tournament numbers and locations to maintain working datasets, and 2) keeps organizations accountable for data collection. In "Weigh-In" style tournaments, rules allow for a maximum of five fish to be captured and weighed at designated weigh-in stations before being released back into the lake. This tournament style has remained the most common amongst fishing organizations. "Catch-Photo-Release" (CPR) style tournaments do not weigh fish, opting instead for recorded lengths and photo evidence as proof of catch. The first CPR tournament was held in 2014 by an organization that continues to host multiple CPR tournaments annually present-day. This event style has grown in popularity in recent years, likely due to evolving trends in SMB fishing ethics (preference for immediate fish release versus holding in a livewell) and the increased access it affords anglers in remote/novel fishing sites (possible to use smaller watercrafts when a livewell is not required).

The majority of tournaments occur between early May to late September. Data reported to NSDFA between 2002 and 2025, shows a mean annual tournament number of 48.9 (± 5, SD), excluding 2020, which saw only four events due to COVID-19 pandemic restrictions. Outside of 2020, tournament numbers per year have ranged from 42 to 58 since 2002, illustrating a consistent popularity for SMB sport fishing over time. It should be noted that tournaments are limited by scheduling constraints as there are only so many weekends and accessible lakes of suitable size available for hosting events during the open season.

Despite changes in management strategies and increased public awareness of AIS, the consistency in annually recurring SMB tournaments indicates a continued interest in fishing for SMB among certain anglers. Over time, trends regarding tournament timing and target species have appeared in direct response to SBM regulation changes in the SW region. By 2013, there were growing concerns being voiced by tournament anglers regarding fishing SMB during their spawning season. These concerns contributed to NSDFA's decision to maintain spawning season restrictions within SBMA's (zero retention, May 1-Jun 15), while dropping it outside SBMA's. Our records indicate a voluntary decrease in the number of tournaments hosted within spawning season from 2013 onward. Mandatory retention of CP has recently resulted in many SMB organizations that have historically included CP as a secondary target species in their events to omit it entirely for the 2026 season. This is likely due to the logistical challenges of retaining all CP caught during day-long tournaments, as well as a preference and culture of catch and release fishing amongst some tournament anglers and organizations. Overall, it is evident through tournament data that Nova Scotia's popular SMB sport fishery has evolved and changed over time alongside NSDFA's management strategies for SMB.

Habitat Modification

In addition to regulatory efforts, active stream habitat restoration initiatives spearheaded by non-governmental organizations (NGOs) have made notable progress. The Nova Scotia Salmon Association's Adopt-A-Stream program provides funding and guidance to NGOs to focus on rehabilitating degraded habitats and enhancing connectivity across watersheds. Although these efforts can enhance connectivity for native species, they may also inadvertently facilitate the spread of invasive

species (Rahel 2007). Therefore, it is crucial to maintain physical barriers that inhibit the migration of AIS (Carpenter and Terrell 2005). Recent recognition of the role that connectivity enhancement plays in facilitating AIS spread has become a pivotal consideration in decision-making processes concerning barrier removals within the Adopt-A-Stream Program (CARP 2020). Provincial and federal agencies, NGOs, and community groups have recently begun collaborating to integrate AIS considerations more effectively into the regulatory frameworks for restoration and fish passage initiatives.

To combat the spread of AIS while protecting native habitats, various physical barriers have been constructed and trialed, including innovative designs like barrier falls intended to limit upstream migration (Novinger and Rahel 2003, Thompson and Rahel 1998). For example, in 2019, barriers were established in Kejimkujik National Park, Nova Scotia, to prevent the colonization of CP in upstream lakes (Parks Canada 2022). Although barriers at Kejimkujik did not achieve the intended exclusion, the project showcased a novel design approach and a rapid installation timeline that offered important lessons for future barrier development. Exclusion barriers are typically temporary, and their success is enhanced when the goal is to limit upstream movement rather than downstream movement (Rahel 2013). Additional measures implemented by NSDFA include earthen berms with water control structures and fish exclusion screens, and specially designed temporary barrier nets aimed at containing SMB populations in conjunction with mechanical removal efforts.

Chemical Control Methods

Chemical control methods, particularly the use of piscicides like rotenone and Antimycin A, have proven to be effective strategies for the eradication of invasive species (Halfyard 2010, Rytwinski *et al.* 2019). Rotenone has been employed in a limited number of management initiatives in the Maritimes over the past century. One of the first documented rotenone applications in Canada occurred in 1936 in Second River, a tributary of the River Philip, Nova Scotia, to reduce the wild salmonid population above the historic Cobequid Fish Hatchery in an effort to reduce risk of disease (McGonigle and Smith 1938). In New Brunswick, rotenone was used successfully in Despres Lake to eradicate CP (Connel *et al.* 2002) and unsuccessfully in the Miramichi River for SMB (Ward 2020). Rotenone had not been used in Nova

Scotia since 1952 (Hayes and Livingstone 1955), however, given the additional spread of AIS into un-impacted areas in recent years, a more aggressive approach to AIS management was adopted by NSDFA, including the use of rotenone to prevent the spread into the eastern region of the province (Fig 1).

Upon detection of SMB in Piper Lake, St, Mary's River in 2019 and subsequently in Dobsons Lake, Cole Harbour River in 2020, a rapid response was initiated involving containment, angling and eDNA surveys in surrounding systems, to evaluate the scope of the problem and target removals using nets and electrofishing. In Piper Lake, de-watering to induce winter kill was also attempted but was not effective in eradicating SMB. Both Piper and Dobsons lakes are headwater lakes, and the decision to pursue chemical eradication using rotenone was made to protect the freshwater ecology and native sport-fisheries in downstream waters and to prevent these lakes from becoming sources for future illegal introductions. Treatments were carried out in accordance with Finlayson *et al.* (2018) using Noxfish® Fish Toxicant II (5% rotenone) in Piper Lake in October 2020 and Dobsons Lake in September 2022.

Post-treatment surveys and subsequent annual electrofishing assessments confirmed the successful eradication of SMB in both lakes (NSDFA unpublished data). Repopulation of native fish communities within the treated lakes was achieved through natural migration following the removal of temporary containment barriers. Surveys suggest that the eradication efforts were effective in both lakes, and indicate fish, invertebrates, and zooplankton (McCallum Environmental Ltd. 2021, 2023, NSDFA unpublished data) can recolonize vacant habitats within one to two years in Nova Scotia. This finding is consistent with observations in the literature (Kiser *et al.* 1963, Peterson *et al.* 2011, Pham *et al.* 2017, Sandodden *et al.* 2022).

CONCLUSIONS

Invasive SMB and CP have broad-ranging impacts on native aquatic species in Nova Scotia, contributing to declining BT populations and increasing annual catch rates for AIS. In recent years, many anglers have underscored the critical importance of controlling AIS to enhance Nova Scotia's sport fishery (NSDFA 2012a). However, the notable expansion of SMB and CP populations is primarily attributed

to illegal introductions and subsequent natural migration through interconnected aquatic systems. The freshwater systems in Nova Scotia lack natural resistance to the establishment of invasive species such as SMB and CP, resulting in increased spread into new habitats and likely broader ecological impacts. To tackle the numerous challenges posed by these AIS, resource allocation by managers necessitated a shift from traditional departmental focus on native sportfish to robust policy implementation and collaborative initiatives targeting AIS. In recent years, a series of strategies aimed at combating illegal introductions while preserving native fish populations and restoring ecological balance have been implemented (Loppnow *et al.* 2013). These proactive strategies have included improved monitoring, enforcement of stricter regulations, containment measures, targeted eradication efforts, mandatory retention regulations, and increased public awareness efforts (Rahel 2004).

By addressing connectivity and employing various control mechanisms designed to limit the spread of invasive fish, these strategic initiatives could significantly contribute to the protection and preservation of native aquatic habitats. Continuous monitoring, assessment, and adaptation is critical to ensuring the long-term sustainability of native fisheries and maintaining ecological integrity within the province's freshwater ecosystems.

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