Sustaining American Eels: A Slippery Species for Science and Governance

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Sustaining American Eels: A Slippery Species for Science and Governance

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1. INTRODUCTION

For centuries, the American eel has been an important food source and a significant social and cultural icon for Indigenous peoples throughout eastern North America. Eel was also a staple for early settlers and the working class until the mid-20th century. It is still one of the most important commercial freshwater fisheries in Canada. However, despite its economic, social, and cultural significance, the American eel seems to have slipped through the cracks of science and management. Not only are many aspects of the eels’ life cycle still a scientific mystery, management regimes at the global, regional, and domestic level have failed to grasp the complexities of the elusive species.

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The American eel, *Anguilla rostrata* (LeSueur, 1817), belongs to the family Anguillidae, collectively referred to as freshwater eels. The 18 species in the family occur widely throughout the world.¹ The American eel is the only anguillard occurring in North American waters.²

The native range of the species encompasses more than 10,000 km of coastline from Greenland and Iceland to Venezuela, including many offshore islands.³ The Canadian distribution of American eel extends to five National Freshwater Biogeographic Zones⁴ (NFBZ) and estuaries in the provinces of Ontario, Québec, New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland and Labrador.⁵ In the United States, the species distribution range comprises the inland waters and territorial sea of all Atlantic coastal states from Maine to Florida and the Gulf of Mexico coast to the Mexican border.⁶

Eel are generally catadromous, which means they migrate to various freshwater locations as they move from their early stages of growth (as eggs, larvae [leptocephali], and glass eels) to elvers, and yellow and silver eels, respectively, as they start maturation in fresh or brackish water, before returning to the Atlantic ocean for reproduction.⁷ The American eel, as well as the European eel (*Anguilla anguilla* Linnaeus, 1758) both return to the Sargasso Sea⁸ for reproduction, frequently after juvenile growth periods as long as

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¹ Jun Aoyama, *Life History and Evolution of Migration in Catadromous Eels (Genus Anguilla)*, 2 *Aqua-Bioscience Monogr.* 1 (2009).
⁷ The catadromous lifestyle, however, is facultative as many individuals spend part of or the entire continental phase of their life cycle in brackish waters. See Section 3.1 and Françoise Daverat et al., *Phenotypic Plasticity of Habitat Use by Three Temperate Eel Species, Anguilla anguilla, A. japonica, and A. rostrata*, 308 Mar. Ecol. Prog. Ser. 231 (2006).
20 years or more.\textsuperscript{9} When silver eels return to the ocean to reproduce, they stop eating, develop expanded blue pupils designed to provide vision at lower depths, and their bodies change to deal with enormous increases in water pressure as they descend in the water column. Following reproduction, eels die.\textsuperscript{10} Recent studies have confirmed that the reproductive strategy of American eel results in panmixia; the entire species is composed of one common gene pool with no evidence of population structuring within the species.\textsuperscript{11}

Many gaps remain in the scientific knowledge of eels’ life cycle both in their continental and oceanic phase. Adult eels have never been seen in the Sargasso Sea, have never been observed mating, and have never been captured in the open ocean.\textsuperscript{12} Habitat requirements for the oceanic migration and for incubation of embryos are largely unknown, and there is also very little knowledge about specific factors that influence the production of eels in fresh water, estuarine/coastal areas, or in the oceans.

Unraveling the eels’ mysteries is not only a matter of scientific curiosity; it is a matter of pressing urgency. American eel has already been extirpated, or are close to extirpation, from part of its historical freshwater habitat;\textsuperscript{13} it has been assessed as depleted throughout its distribution in the United States;\textsuperscript{14} and it has been assessed as threatened in Canada.\textsuperscript{15} Management both in Canada and the United States is characterized by its fragmentation throughout the species’ distribution range. Efforts at coordination at the bilateral level (Canada - United States) have been unsuccessful to date, while broader regional cooperation has not been pursued.

This article addresses the slippery nature of eel science and management through four sections. Section 2 describes the socio-economic significance of American eel for First Nations\textsuperscript{16} and for commercial fishers, with particular emphasis on Canada. Section 3 summarizes the current
scientific knowledge and identifies policy-relevant knowledge gaps currently addressed by the Ocean Tracking Network (OTN) research project on American eels. Section 4 addresses the complex global and regional governance framework applicable to American eel management, as well as the fragmented Canadian and U.S. domestic management frameworks. The last section draws on this multidisciplinary groundwork to chart new directions for eel science and governance.

2. SOCIAL AND ECONOMIC IMPORTANCE OF AMERICAN EEL: UNDERSTANDINGS AND CHALLENGES

Across North America, eels have been an important source of protein for First Nations, and an important element of their traditional way of life since time immemorial. Eels have also provided important sustenance and formed the basis of a commercial fishery for the first North American settlers. However, the nature of eels’ socio-economic contribution has changed over time both for aboriginal communities and non-indigenous fishers.

2.1 Eel and First Nations: Ga’tewe’g’tieg, ga’tewe’g’tieg (We Go Hunting for Eels)17

Ga’tewe’g’tieg, ga’tewe’g’tieg. This phrase resonates back through more than 3,000 years of Mi’kmaq peoples’ continuous eel fishing.18 Indeed, the Mi’kmaq’s relationship to the American eel captured public attention during the Supreme Court of Canada’s historic Marshall decision in 1999 which upheld Mi’kmaq peoples’ 18th century treaty right to fish and sell their catch for profit.19 While the Marshall case drew public attention to Mi’kmaq fishing specifically, eels have had significance for Indigenous peoples throughout eastern North America. A recount of the historical use of eel by First Nations illustrates how eel has provided both sustenance and community to First Nations, assembling around it spiritual, political, and cultural relations.

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17 This section summarizes a detailed account of the practical, spiritual, and political significance of eel for North America First Nations contained in a longer paper contributed by Emma Feltes, on file with authors. The map included in this section was designed with the assistance of Jonathan Rotsztain, graphic designer at ALL CAPS Design.


For the Innu, eels were a consistent staple when available. Large camps would be set up along the St. Lawrence in the summer and fall due to the abundance of eels and moose (Figure 1, Point 2). By the early part of the 17th century, many southern Innu were accustomed to situate these camps around French settlements on the lower St. Lawrence. The Innu would use the tides to trap eels in weirs—low stone walls that extended from the shore. Where they could not depend on the tide, eels were speared using three-pronged harpoons.

For the Maliseet, Abanaki, and Mi’kmaq, eel had similar importance. Eels were caught by either spear or weir along the St. Lawrence River, the Restigouche River, and waterways throughout the Gaspé Peninsula, New

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20 Kenneth S. Lane, *The Montagnais Indians, 1600–1640*, 7 Kroeber Anthrop. Soc. Pap. (1952). The only exception existed in the interior Labrador Peninsula (Figure 1, Point 1), where it was taboo to eat saltwater species, including salmon, cod, eel, seal, and porpoise (Frank Gouldsmith Speck, *Naskapi: The Savage Hunters of the Labrador Peninsula* 79 (1935)).

21 Lane, *id.*, at 8.


Brunswick, Nova Scotia, and Newfoundland. For the Mi’kmaq in particular, eel and other fish were a crucial food source, making up 90 percent of their diet. This is reflected in Mi’kmaq place names, including the contemporary Eel River and Eel Ground reserves, as well as Xudjo’yan, in Sandy Point, Newfoundland (Figure 1, Point 3) which translates as “eel-spearing place.”

Eel skin was also used as rope, and to wrap sprains and other injuries. Eel oil was rubbed over the body and hair for protection against the heat, cold, and mosquitoes, and for relief from chest colds and congestion. Furthermore, there are numerous accounts of the spiritual, political, and social importance of eels for the Mi’kmaq peoples.

Eel also had a central role in the history and traditions of the Haudenosaunee First Nation. It is said that Deganawida, “The Great Peacemaker,” named the fifth Haudenosaunee longhouse clan after the eel. The Onondaga and Cayuga of the Haudenosaunee Confederacy fished eels from the streams and lakes between Lake Ontario and the Susquehanna (Figure 1, Point 6). Eels were smoked, dried, fried, roasted, or used as an ingredient in traditional corn soup, or used for tanning.
Delaware peoples would track six or seven fish species that would arrive seasonally, including eel in the fall,\textsuperscript{36} using a diversity of fishing tactics,\textsuperscript{37} that is, until the Swedish fur trade and Crown land acquisition through the late 17th century pushed them into more sedentary farming.\textsuperscript{38} Meanwhile, the Cherokee First Nation would traditionally not eat eels, which were seen as unclean,\textsuperscript{39} but they served other purposes. Ball players would rub themselves with eel skin in order to make themselves slippery,\textsuperscript{40} and women tied their hair with a tight piece of dried eel skin, which was thought to make it grow long.\textsuperscript{41}

Due to direct and indirect impacts of colonialism, Indigenous peoples’ relationship to the eel has changed. However, the magnitude and implications of this change are for the most part unknown. Catch records, challenging overall for American eel, have not been systematically kept for aboriginal sustenance and ceremonial fisheries in Canada or the United States.\textsuperscript{42} In general, there is a lack of research on the contemporary importance of the American eel for Indigenous peoples, revealing a gap between historical and contemporary anthropological documentation.

A notable exception is the research aimed at documenting the impact of the decline of the eel on the Mi’kmaq, undertaken by the Unama’ki Institute of Natural Resources (UINR), Paq’tnek Fish and Wildlife Society, Mi’kmaq Alsumk Mowimsikik Koqoey Association, and other indigenous organizations, along with Parks Canada, Mount St. Vincent University, Acadia University, and other partners.\textsuperscript{43} In this work, a multitude of factors are credited with the decline of the eel in Mi’kmaq culture. They include: the lack of physical access due to the reserve system, European settlement of fishing areas, government programmes that impede traditional fishing, changes in food preference, and environmental factors. Given the shared history of colonialism throughout Canada and the United States, one might predict that similar factors have affected other Indigenous peoples as well.

\textsuperscript{36} Marshall Joseph Becker & John Beierle, Culture Summary: Delaware (2003); William Wilmon Newcomb, The Culture and Acculturation of the Delaware Indians (1956); Zeisberger, supra note 34. See Figure 1, Point 7 representing Delaware First Nation traditional settlement.

\textsuperscript{37} Newcomb, id. at 16.

\textsuperscript{38} Id.

\textsuperscript{39} William Harlen Gilbert, The Eastern Cherokees (1978). See Figure 1, Point 8 representing the area where Cherokee First Nation settled after much migration and inter-Tribal conflict (James Mooney, Myths of the Cherokee and Sacred Formulas of the Cherokees (1982, reprint of 1891 and 1900 monographs, originally published in the 7th and 19th Annual Reports of the Bureau of American Ethnology), at 15).

\textsuperscript{40} Mooney, id. 47.

\textsuperscript{41} The Wahnenaui Manuscript: Historical Sketches of the Cherokees, Together with some of Their Customs, Traditions, and Superstitions 175 (Jack Frederick Kilpatrick ed., 1966 reprint).


\textsuperscript{43} The fruits of this work are assembled at http://www.speciesatrisk.ca/eel/AboriginalMaterials.asp (visited 17 April 2013).
As the historical literature makes clear, the impact of this change is not just material, but reverberates through cultural knowledge and political and social structures. With the eel so central to Mi’kmaq knowledge and economic activities, its decline has significant impacts on their ability to exercise self-governance, which involves the stewardship and management of such a central resource. Indeed, a UINR report notes: “Because of the longevity of the eel, changes in abundance and distribution are seen between generations. The eels we have here today may not be here for our children and grandchildren.” Such implications for resource management and long-term self-governance provide yet another reason as to why it is so important to close the gap in contemporary documentation. More research is needed, in partnership with Indigenous peoples, to determine the meaning of eel within indigenous cultures and the real impacts of the decline of the American eel, before more of this knowledge is diminished.

2.2 Current Capture and Trade Trends

Across North America, eels were a major source of protein for early settlers. From the 17th century to the mid-20th century, eels were also a working-class staple. In the postwar period, eel consumption in North America has largely disappeared, save for some aboriginal populations and ethnic groups which have brought eel consumption traditions with them. Current eel fisheries, particularly in Atlantic Canada and the mid-Atlantic states, are dependent on European and Asian markets.

Eel consumption is still a major activity in Europe, especially in northern countries and Spain, the largest consumer of glass eels. The “rich, pure fish flavour” still appeals to the entire continent, with approximately 20 million pounds a year still being eaten. The European market prefers live eels, especially silver ones, which are typically bigger and have a higher fat content. In turn, the fat content of silver eels facilitates a preference for smoked products. Glass eels are primarily used as appetizers. The demand for, and value of, live eels make air freight an economic means of transport.

Japanese consumers prefer their local species, Anguilla japonica, but have run short of this stock (fatter, more flavourful, according to Japanese consumers). As a consequence, they now depend on imports from North

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44 Davis et al., supra note 28, at 359.
45 Denny & Paul, supra note 27, at 5.
46 Schweid, supra note 12, at 95.
47 ASMFC, Interstate Eel FMP, supra note 42, at 12.
49 Schweid, supra note 12, at 17.
50 ASMFC, Interstate Eel FMP, supra note 42, at 12.
America, typically through a commercial operation involving glass eel capture, grow-out operations in China, and processing through smoking, immersing in a sauce, and grilling for vacuum-packing and export to Japan as “kabayaki.” This operation has created a significant demand for elvers, pushing the price to records of more than US$2,000 per pound.52

Estimates of commercial catches of American eel, their values and, to a lesser extent, the number of active fishermen are difficult to obtain, largely because of the small-scale and broad geographic area of the commercial fishery and inadequate statistical collection.53 General catch trends show that the fishery remained relatively small for the first half of the 20th century. Fishing pressure increased during the 1960s and peaked in the 1970s and early 1980s in response to high prices and strong markets.54 The total North American harvest (Canada-United States) increased from an average of 1,430 tonnes annually between 1950 and 1955 to an unprecedented peak of 3,145 tonnes in 1979.55 Canadian landings reached more than 1,200 tonnes in the 1970s. Landings started to decline in the early 1990s, despite high prices and strong demand.56 The adoption of stricter regulatory measures by the different management authorities has maintained fishing effort at relatively low levels.

Current reported catches for the commercial fishery in Canada are below 500 tonnes per year,57 unevenly distributed between four fishing areas: Quebec’s St. Lawrence River and Estuary, Southern Gulf of St. Lawrence, Maritimes, and Newfoundland. The largest catches are taken in the Southern Gulf of St. Lawrence, which supports a significant yellow eel fishery mainly in New Brunswick and Prince Edward Island but also extending to Nova Scotia.58 According to a recent report, more than 500 commercial licences

51 The European Union (EU) implemented a temporary ban on eels that has been in effect since November 2010 (CFP Reform Watch, Commission Decides to Implement a Temporary Export Ban on Eels (1 November 2010), at http://cfp-reformwatch.eu/2010/11/commission-decides-to-implement-a-temporary-export-ban-on-eels/) (visited 17 April 2013). The measure was adopted as a consequence of the species being included in CITES Appendix II in July 2007, effective on 13 March 2009 (CITES, Notification to the Parties: Amendments to Appendices I and II of the Convention adopted by the Conference of the Parties at Its 14th Meeting, The Hague (Netherlands), 3–15 June 2007, No. 2007/022 (26 July 2007), at http://www.cites.org/eng/notif/2007/E022.pdf) (visited 17 April 2013). While species listed under Appendix II can be traded internationally with a permit issued by the state of export, the EU Scientific Review Group concluded that any export would have harmful effects in the conservation status of the eel and recommended the implementation of the temporary ban.

52 Personal communication with Kate Taylor, ASMFC, FMP Coordinator (October 2012).


54 ASMFC, Stock Assessment Report 2012, supra note 6, at 21.

55 COSEWIC, supra note 2, at 56.

56 Id.

57 Id. at 57.
have been issued for this region, but most of them are inactive. Additionally, three Aboriginal groups hold communal commercial eel licences. Average annual catch between 2005 and 2009 was 180 tonnes, while total catches in 2009 and 2010 were 173 and 174 tonnes, respectively.

The next most active area is the Maritimes (formerly Scotia-Fundy) Region, encompassing New Brunswick and Nova Scotia waters flowing into the Bay of Fundy and the Atlantic coast of Nova Scotia. With approximately 400 commercial licences (although many of them inactive), catch average between 1997 and 2002 was 142 tonnes, but decreased to 103 tonnes between 2004 and 2007, partly as a consequence of mandated decreases in fishing effort. Most of the 16 First Nations and two Aboriginal People Councils in the Maritimes Region hold food, social and ceremonial licences and/or communal commercial licences. Since the late 1980s, the region also supports the only elver fishery in Canada. The fishery has been limited to nine licences. The annual elver fishery catch rose from 26 kg to 4,122 kg in 1997. Recent catches for 2009, 2010, and 2011, have been 2,011 kg, 1,573 kg, and 3,530 kg, respectively.

The Quebec St. Lawrence River and Estuary fishery had, as of 2010, 55 licences and a combined annual catch average of 89.5 tonnes for yellow and silver eels for the 2005 to 2009 period. The Newfoundland and Labrador Region, which reduced licence numbers from 316 to 165 in 2004, reports a catch average of 59 tonnes for the 2005 to 2009 period. Two Aboriginal groups participate in the commercial and/or recreational eel fishery in Newfoundland: the Qalipu (Federation of Newfoundland Indians) and the Miawpukek First Nation.

Before its closure, Ontario had a significant commercial fishery for American eel. Landings in the 1970s reached a record of 228.2 tonnes,
equivalent to 20 percent of the Canadian landings. Catches declined during the 1980s and early 1990s to around 100 tonnes, and were further reduced in the following years. Between 1997 and 2003, commercial landings ranged from 11 to 41 tonnes. The fishery was ultimately closed in 2004.

Beside the commercial and aboriginal fishery, some yellow and silver eels are also caught recreationally in eastern Canada, and particularly as a winter spear fishery in the Southern Gulf of St. Lawrence and Newfoundland regions. However, information on catches and landings are not available for the recreational fishery.

3. STATUS OF SCIENTIFIC KNOWLEDGE: UNDERSTANDINGS, ADVANCES, AND CHALLENGES

3.1 Life Cycle, Habitats, Abundance, and Threats

Our present understanding of the abundance, life cycle, and preferred habitats of American eel and the most serious threats to their existence has been most recently reviewed in the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessment and status report of the American eel. Here we provide a brief summary of our understanding of eel biology, based largely on the COSEWIC report.

The American eel uses a very broad diversity of habitats. During their oceanic migrations, eels migrate across vast expanses of open ocean and, upon arrival in continental waters, exploit all salinity zones. Catadromy (most of the life cycle occurs in fresh water followed by migration to and spawning at sea) is no longer seen as obligatory for eels, but rather is a facultative life history option. In freshwater habitats, preferred habitat can be found in both lakes and rivers including all waters extending from the high-water mark down to at least 10 m depth. Growing eels (the yellow eel stage) are primarily benthic, and use substrate (rock, sand, mud), and bottom debris (woody debris, submerged vegetation) for protection and cover. Interstitial spaces comprised of rock piles and logs are important to American eel as cover, particularly during daylight hours because of their primarily nocturnal behaviour. Given the high abundance of eels often observed in tributaries, these waters seem to comprise a very important component of eel habitat.

Overwintering requirements and usage remain incompletely understood, in both fresh and saltwater habitats. Recent research, however, found that American eels commonly winter in mud bottoms in both bay and estuary

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69 Government of Canada, supra note 4, at 275.
70 COSEWIC, supra note 2, at 69; NFL EEL MANAGEMENT PLAN, supra note 67, at 15.
71 Government of Canada, supra note 4, at 277–279.
72 COSEWIC, supra note 4.
73 Id.
habitats in the southern Gulf of St. Lawrence. Eels also conceal themselves in the bottom during daytime in non-winter periods. It was estimated that American eels in eastern Canada spend about 74 percent of their entire yellow phase concealed in the substrate.

Eel densities in fresh water typically diminish with distance from the sea. In Europe, it has been reported that dispersal of eels into fresh water can be heavily influenced by density-dependent effects, that is, the higher the density, the stronger the motivation to continue to disperse upstream. Dispersal may be influenced by many factors (e.g., density-dependent effects of eels, prey and predator density and distribution, physical factors such as obstacles), including human-made obstacles. The ability of eels to overcome obstacles is size-dependent. Small eels (less than ten cm long) are able to creep up damp vertical surfaces, but larger eels are generally unable to bypass large waterfalls and dams. Connectivity among important inland habitats is thus crucial to ensure eels are able to disperse effectively and take advantage of the best growth conditions in various rearing habitats.

Habitat requirements for the oceanic migration of adults, spawning in the Sargasso Sea, and incubation of embryos are largely unknown. The northern limit of spawning by Atlantic eels (Anguilla spp.) in the Sargasso Sea is related to thermal fronts and surface water masses, with spawning taking place south of east-west thermal fronts that separate southern Sargasso Sea surface water from the mixed Subtropical Convergence Zone water to the north.

The abundance of the American eel has been in decline since the most recent peak in the 1980s. Time series data used to estimate percent change in indices of abundance from the 1950s to the 2000s (three generations of eels) are uniformly negative (from $-7.1\%$ to $-96.2\%$) in the western portion of the species’ range. Trends are mixed in the eastern portion of its range.

Indices of abundance from fishery landings series indicated a negative change. Eel abundance relative to the 1980s is very low for Lake Ontario and the St. Lawrence River according to fisheries-independent data. Between 1996 and 1997 and 2010, estimates of the total number of maturing eels declined by 65 percent in the Great Lakes and upper St. Lawrence River area, despite the reduction in mortality from commercial fisheries (see Section 4.3.2). An index of year class strength indicated a substantial decline of juvenile eels migrating

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75 Id.
76 COSEWIC, supra note 2.
79 COSEWIC, supra note 2.
80 DFO, Status and Progress, supra note 53.
upstream in a tributary of the lower St. Lawrence River between 1999 and 2005. Trends in some areas (New Brunswick) are mixed while other areas (Newfoundland, southwest Nova Scotia) indicate some declines between the 1980s and the 2000s.\textsuperscript{81}

At present, there is little understanding of specific factors that influence the production of eels in either fresh water, estuarine/coastal areas, or in the ocean. Although alterations to the marine environment (e.g., climate change and shifting salinity, temperature and current fields) may very well impact eel survival at both the larval and silver eel stages, anthropogenic factors during the continental life stages must be considered as more immediate threats.\textsuperscript{82}

In fresh waters, habitat fragmentation and turbine mortalities are significant causes of mortality. For example, the St. Lawrence River watershed in Canada contains some 8,411 dams of at least 2.5 m in height.\textsuperscript{83} Overall, these obstacles are estimated to prevent or restrict access to at least 12,140 km\textsuperscript{2} of eel fresh water habitat in the St. Lawrence River and Lake Ontario system. In addition to extensive habitat loss due to barriers, hydropower turbines are direct agents of mortality. On the main stem of the St. Lawrence River below Lake Ontario, there are two hydro complexes, the Moses-Saunders Dam completed in 1959 and the Beauharnois Dam completed in 1961. Silver eels exiting Lake Ontario are subjected to an estimated accumulated turbine mortality of 40 percent after their passage through the two generating stations. This additive turbine mortality contributes to almost 75 percent of the anthropogenic mortality during downstream migration and reduces the annual spawning escapement from the St. Lawrence River by 40 percent.\textsuperscript{84}

Finally, a handful of additional threats pose risks during the continental phase of the eel’s life cycle, including vulnerability to fisheries and the bioaccumulation of contaminants. An exotic swim bladder nematode parasite (\textit{Anguillicoloides crassus}) may be negatively affecting eels. The parasite has been found in Nova Scotia (Cape Breton Island), New Brunswick, and Lake Ontario. Supplementation of eels by stocking of wild recruits (now suspended) may also pose risks.\textsuperscript{85}

\textsuperscript{81} Id.; COSEWIC, \textit{supra} note 2, at v and 59–60.

\textsuperscript{82} COSEWIC, \textit{id}.


\textsuperscript{85} The efforts to reverse the declining status of American eel in the upper parts of the St. Lawrence River were supported through a restocking programme. Over seven million individuals were stocked in the upper Richelieu River in 2005 and in the upper St. Lawrence River and Lake Ontario in 2006. The stocking programme was discontinued following findings of swimbladder parasites in eels stocked in
3.2 Knowledge Gaps and the OTN Eel Research Project

The multidisciplinary OTN eel research project is addressing some of the main unknowns of American eel life cycle, some of which have clear policy relevance. One set of questions at the forefront of its research agenda is the dynamics, through space and time, of adult eels as they move to their breeding grounds. On the North American east coast, the diverse paths eels take back to the Sargasso Sea and the behavioural mechanisms responsible for such a feat remain among the great mysteries in animal biology. Advances in this area will inform management measures to protect migration paths, and will provide insight into the open-ocean habitat requirements of spawning eels. Investigation of such issues may require cross-boundary scientific cooperation to get a fuller picture of migration dynamics.

Another key area of the OTN research is the identification of different migratory pathways experienced during the continental phase, research that is being supported by eel otolith analyses. A variety of migratory patterns have been described.\(^8^6\) Eels may spend their entire lives in estuaries, or they may move through a variety of different bodies of water. Generally speaking, anguillid eels found at higher latitudes exhibit a greater probability of remaining in the lower reaches of watersheds in brackish water. The upper St. Lawrence-Great Lakes population component exhibit true catadromy with little evidence of an estuarine phase in the life cycle. Although eels are genuinely panmictic, there appears to be strong selection on specific alleles that may explain life-history differences among continental population components, although the differences can also be partly phenotypic.\(^8^7\)

Using a combination of acoustic pingers and moored hydrophones, the OTN team has demonstrated that yellow eels have very restricted movements within the St. Lawrence River and estuary, but a small proportion migrate to the brackish section of the estuary over several years. Downstream migration of silver eels occurs at night during the ebbing tide and picks up speed as the year advances. Eels exhibit stop and go behaviour, with some eels suspending movement for weeks in different freshwater parts of the river before resuming their migration. A moored array of hydrophones at Cabot Strait recorded out migrating eels in December, but also indicated a very low survival of eels migrating out of the Gulf of St. Lawrence (overall detection rate of less than four percent of released eels). One possible cause of this is predation. The

\(^{8^6}\) Daverat et al., supra note 7.

\(^{8^7}\) C. Côté et al., Differential Effects of Origin and Salinity Rearing Conditions on Growth of Glass Eels of the American Eel, Anguilla rostrata: Implications for Stocking Programmes, 74 J. Fish Biol. 1934 (2009); Côté et al., supra note 11. The genetics of the American eel is the primary research area of Professor Louis Bernatchez, in the Biology Department at Laval University, who leads a research effort funded through a separate NSERC strategic grant.
tracking of large silver eels in the Gulf of St. Lawrence using satellite tags that record depth and temperature before being released from tagged eels on a predetermined date revealed an unexpectedly high predation rate from porbeagle sharks. This raises the possibility that migrating eels may represent a reliable, predictable food resource for porbeagle sharks.

The development of coupled physical-biological models of the eel migration is another way of exploring the variety of behaviours that could be adopted by eels under specific conditions of oceanic circulation and temperature. These models are designed to provide researchers with plausible migration scenarios that may then be tested using direct observations of migratory behaviour. To obtain this detailed tracking data from the North Atlantic Ocean, while attempting to avoid the high predation in the Gulf, the OTN research team conducted satellite tagging of eels in Nova Scotia. The team aims to record the oceanic movements of eels to the Sargasso Sea and, in combination with physical-biological models, to describe the mechanisms employed by eels to complete their spectacular migrations.

4. CURRENT MANAGEMENT

Three images best describe the management framework for American eel: a slippery global governance framework, limited bilateral cooperation, and a fragmented domestic framework.

4.1 Slippery Global Governance Framework

Getting a grip on the international legal normative framework applicable to the American eel is not easy as multiple conventions and soft law documents are relevant. Key agreements include the UN Convention on the Law of the Sea (LOSC), the Convention on Biological Diversity (CBD), and potentially the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). While a plethora of non-legally binding documents, such as Agenda 21 and the Rio Declaration on Environment and Development,

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89 The models are developed in collaboration with professors Keith Thompson and Jinyu Shen, Dalhousie University.
provide guidance for principled coastal and ocean governance, the Food and Agriculture Organization of the United Nations (FAO) has been the main purveyor of fisheries-specific guidance through its Code of Conduct for Responsible Fisheries and numerous technical guidelines.


The provisions of LOSC are both directly and tangentially applicable to the American eel. Article 67 of the Convention specifically sets out state responsibilities for managing catadromous species like eels. A coastal state in whose waters catadromous species spend the greater part of their life cycle has management responsibility and must ensure the ingress and egress of migrating fish. Harvesting is prohibited on the high seas and any fishery within exclusive economic zones (EEZs) would be subject to other fisheries conservation obligations for the EEZ set out in the Convention. Where catadromous fish migrate through the EEZ of another state, whether as juvenile or maturing fish, the coastal state and the other state concerned are required to manage such fish by agreement. Such agreement must ensure the species’ rational management, which is not defined.

Various other LOSC provisions may tangentially apply to eel management. For example, all states are required to protect and preserve the marine environment. States are obligated to minimize to the fullest extent possible the release of toxic substances and to take measures necessary to protect rare or fragile ecosystems as well as the habitat of depleted, threatened, or endangered species and other forms of marine life. States also have a general obligation to cooperate with each other in the conservation and management of living resources in areas of the high seas.
Arguably a gap exists within LOSC relating to American eel, which is considered a single, panmictic breeding population. Article 67 merely requires management cooperation between the coastal state where the catadromous species spends the greater part of its life cycle and the state through which the species migrates in the EEZ. Drafters of the Convention did not seem to have in mind the possible need for broader cooperation for a panmictic catadromous species found from the southern tip of Greenland to the northeast coast of South America and into inland areas of the Mississippi and Great Lakes drainages.

4.1.2 Convention on Biological Diversity

The CBD calls upon its parties to undertake a long list of measures to promote the conservation and sustainable use of biodiversity, with many being relevant to American eels. For example, parties are required to establish a system of protected areas, promote the protection of ecosystems and natural habitats, and encourage the recovery of threatened species through the development and implementation of management plans or strategies. Preserving traditional practices and lifestyles of indigenous and local communities relating to biological diversity is urged. Parties have a general duty to cooperate in conserving biological diversity in areas beyond national jurisdiction and on other matters of mutual interest.

Numerous decisions and guidelines have been adopted by CBD parties over the years having relevance to coastal and marine environmental protection, with two decisions standing out for potential relevance to American eel management. Decision VII/11, adopted in 2004, sets out implementation guidelines for the ecosystem approach. The guidelines emphasize the need to pay attention to spatial and temporal scales of ecosystems where river basins or large marine areas may require new environmental mechanisms to engage stakeholders across administrative borders and a redesigning of assessment and monitoring efforts.

106 Id.
107 CBD, supra note 91, at Art. 8(a).
108 Id. at Art. 8(f).
109 Id. at Art. 8(j).
110 Id. at Art. 5.
112 The decision adds implementation guidelines and annotations to the 12 ecosystem approach principles first adopted in May 2000 at COP 5 through Decision V/6 on the Ecosystem Approach.
Decision X/2, adopted in October 2010 and establishing a Strategic Plan for Biodiversity 2011–2020, sets out 20 biodiversity targets,\textsuperscript{114} with three particularly relevant to eel management. Target 6 urges that by 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species.

Target 11 calls for at least 17 percent of terrestrial and inland water areas, and 10 percent of coastal and marine areas, to be included in ecologically representative and well-connected systems of protected areas by 2020. Target 12 urges by 2020 the prevention of extinction of human-threatened species and the improvement and sustainment of their conservation status, particularly those most in decline.

The Executive Secretary of the CBD has helped convene a series of regional workshops to facilitate the identification of ecologically or biologically significant marine areas (EBSAs) through the application of scientific criteria. A Wider Caribbean and Western Mid-Atlantic Regional Workshop was held in Brazil, 30 April–5 May 2012.\textsuperscript{115} Participants identified the Sargasso Sea as an EBSA and noted its importance as a spawning ground for both American and European eels. Such recognition should substantially support an initiative by the Sargasso Sea Alliance, a consortium of the Bermuda government, leading conservation and marine science organizations, and individuals, to discuss and develop appropriate management and protection measures for the Sargasso high sea areas.\textsuperscript{116}

4.1.3 Convention on International Trade in Endangered Species

Through trade control levers CITES seeks to prevent endangered and threatened species from going extinct. Commercial trade is not allowed for species listed under Appendix I, is restricted for species listed under Appendix II, and is subject to special permits for species listed under Appendix III.\textsuperscript{117}

\begin{footnotesize}
\begin{itemize}
  \item Decision X/2, The Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets (2010).
  \item CBD, Report of the Wider Caribbean and Western Mid-Atlantic Regional Workshop to Facilitate the Description of Ecologically or Biologically Significant Marine Areas, UNEP/CBD/SBSTTA/16/INF/7 (2012).
  \item Regarding the case for protection, see Laffoley et al., supra note 8.
  \item For species listed on Appendix I no commercial trade is allowed and any allowable trade, for example for scientific purposes, would be subject to strict import and export permit requirements (CITES, supra note 92, at Art. III). Trade in Appendix II listed species would be restricted and require an export permit from the state of export with the permit verifying the export is not considered detrimental to the species’ survival (\textit{id.} at Art. IV).
\end{itemize}
\end{footnotesize}
While the European eel was added to CITES Appendix II in 2007, a similar listing has not occurred for the American eel. The United States undertook public consultations regarding a possible proposal to the March 2013 16th Conference of the Parties to CITES for listing the American eel on Appendix II. However, the United States subsequently decided not to proceed with the listing request.

4.1.4 FAO Code of Conduct and Technical Guidelines

The Code of Conduct for Responsible Fisheries, adopted by the FAO Conference in October 1995, suggests principles and standards applicable to the conservation of all fisheries and thus is also applicable to American eel fisheries. States are urged to take measures to conserve biodiversity of aquatic habitats and ecosystems, to protect endangered species, and to allow depleted stocks to be restored. States are encouraged to integrate fisheries interests into coastal area management processes. A precautionary approach to fisheries management is expressly called for. Bilateral and regional cooperation in scientific research is urged given the transboundary nature of many aquatic ecosystems.

The FAO has adopted over 20 guidelines to further flesh out the Code of Conduct with those on the ecosystem approach and the precautionary approach being particularly important. Guidelines on the Ecosystem Approach to Fisheries (EAF), issued in 2003, highlight the need to reconsider institutional arrangements for fisheries management in light of broad ecosystem boundaries and call for the formulation of EAF management plans that describe critical habitats and establish management measures to reduce adverse environmental impacts. Guidelines on the Precautionary Approach to Capture Fisheries and Species Introductions, published in 1996, suggest a...
suite of possible precautionary measures for various types of fisheries including new or developing fisheries, over-utilized or fully utilized fisheries, and traditional or artisanal fisheries. Setting of precautionary target and limit reference points for fisheries is generally encouraged.

4.2 Limited Bilateral Cooperation

Despite the long-standing tradition of informal and formal coordination and cooperation for fisheries scientific research and management between Canada and the United States, formal and targeted cooperation in addressing American eel issues has been limited with three main avenues evident. First, the Great Lakes Fishery Commission, established pursuant to a 1954 agreement and tasked with facilitating scientific research, suggesting fisheries management measures, and controlling sea lamprey populations, has been a forum for sharing information and fostering research on the American eel. A bi-national American Eel Task Group, created in 2006, aimed to assist recovery of eels in the St. Lawrence River and Lake Ontario and was reportedly working on a memorandum of understanding to that effect. However, this initiative has been put on hold partly due to the differing listing processes of Ontario and Fisheries and Oceans Canada (DFO) under their respective species at risk legislation. The Task Group is presently inactive.

Second, the Gulf of Maine Council on the Marine Environment, established in 1989 by the premiers of New Brunswick and Nova Scotia and the governors of Massachusetts, Maine, and New Hampshire, has raised public awareness on the plight of American eels and has included restoration of

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130 Id. at 13–16.
131 Id. at 10.
135 Personal communication with John M. Dettmers, Senior Fisheries Biologist, Great Lakes Fishery Commission (27 February 2013).
coastal and ocean habitats as one of its goals. Under the Council’s 2007–2012 Action Plan, 49 new habitat restoration projects were funded with an estimated 145 miles of streams opened to fish passage. The Action Plan 2012–2017 pledges continuation of providing Gulf of Maine habitat restoration grants and technical assistance for restoring coastal ecosystems.

Third, the Canada-U.S. Transboundary Resources Steering Committee, established in 1995 as an informal arrangement to facilitate federal coordination of scientific research and fisheries management in the Gulf of Maine region, has at least placed American eel on the “radar screen.” While the bilateral arrangement has primarily focused on developing scientific advice and allocating quotas for three shared cod, haddock, and yellowtail flounder stocks on Georges Bank, a Species at Risk Working Group has developed a Canada-U.S. transboundary species at risk matrix that tracks the listing and recovery efforts for marine species at risk in the two countries. American eel is listed on the matrix, but since neither country has proceeded with formal listing under the species at risk legislation (see Section 4.3), no cooperative recovery discussions have occurred to date.

4.3 Fragmented Domestic Framework

4.3.1 United States American Eel Management Framework

American eel are managed via a multi-level government framework in the United States. The most active participants in this framework are the states themselves. American eel are harvested in every state on the Atlantic coast, and each state has established its own management infrastructure. The states also coordinate efforts via an interstate commission, the Atlantic States Marine Fisheries Commission (ASMFC). Finally, the federal government through the Fish and Wildlife Service (FWS) and National Oceanic and Atmospheric Administration (NOAA) has, to date, some involvement in the regulation of the American eel fishery, but its role may become much greater if a pending Endangered Species Act listing of the American eel as “endangered” is approved.

139 Id. at 4.
140 For a detailed overview, see Emily J. Pudden & David L. VanderZwaag, Canada-United States Bilateral Fisheries Management in the Gulf of Maine: Struggling towards Sustainability under the Radar Screen, in Russell & VanderZwaag, supra note 125, at 177, 180–190.
141 Id. at 182–185.
142 Id. at 188.
143 Copy of matrix is on file with the authors.
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U.S. Interstate Management Efforts: The Atlantic States Marine Fisheries Commission

The ASMFC, one of three interstate marine fisheries commissions in the United States, coordinates the management and conservation of the transboundary coastal fisheries144 in the 15 Atlantic coast states from Maine to Florida within the states’ territorial seas and inland waters.145 Coordination is achieved through the Commission’s Interstate Fisheries Management Program (ISFMP).146 Each state has one vote in any Commission meeting.147

The ISFMP, in coordination with member states and research teams, develops interstate fishery management plans (FMPs) providing a comprehensive species-specific management document that identifies goals for the species, the species’ current status, ecological challenges affecting the species, and management actions needed to support the species goals.148 Following the Commission’s adoption of an FMP, all state agencies must promulgate regulations implementing the FMP within their state.149 The state regulations can be more restrictive than those set out in the FMP, but they cannot be less restrictive.150 The Atlantic Coastal Fisheries Cooperative Management Act of 1993 provided the ASMFC with authority to ensure member state compliance with FMPs.151 If the Commission determines a state is not compliant, it must notify the U.S. Secretary of Commerce, who has the authority to declare a moratorium on fishing in the non-compliant state’s fishery.152

In order to balance the conservation of the American eel with sustaining its commercial, recreational, scientific, and educational uses, the ASMFC approved the first FMP for American eel in 1999.153 The eel was declining in abundance, but at that time there was little understanding of the eel’s status as a species, the ecological impacts on the population, or the management solutions needed to restore the eel.154 The 1999 FMP required states to collect
eel harvest data, conduct an annual abundance survey, maintain or tighten existing commercial fishery regulations, implement recreational limits of fifty eel per person bait possession, and set a six-inch minimum size for all eel harvested.\textsuperscript{155} Maine and South Carolina are the only exceptions to the six-inch minimum size limit because both states have glass eel fisheries.\textsuperscript{156} The FMP was amended in 2006, establishing additional reporting and control measures.\textsuperscript{157}

In addition to creating and implementing FMPs, the Commission undertakes peer-reviewed stock assessments to understand the health of the American eel population. The first stock assessment, completed in 2006, was “inconclusive” regarding the status of the American eel stock.\textsuperscript{158} Additionally, the Commission requested in 2004 that the FWS and the National Marine Fisheries Service (NOAA Fisheries) conduct an American eel status review.\textsuperscript{159} That report, released in 2007, concluded that the eel population had been extirpated from some portions of its historical freshwater habitat over the past 100 years . . . [and the species abundance has declined] likely as a result of harvest or turbine mortality, or a combination of factors.\textsuperscript{160}

FWS also concluded that, at that time, listing the American eel as either “endangered” or “threatened” was not warranted.\textsuperscript{161}

In response to stock assessment reports in 2005 and 2006, and considering that the yellow eel population declined in the prior two decades and that the stock was “at or near low levels,”\textsuperscript{162} the Commission’s American Eel Management Board (the Board) introduced a second addendum to the eel FMP.\textsuperscript{163} The 2008 FMP Addendum increased emphasis on improving upstream and downstream passage of silver eel, allowing more silver eel to reach the Sargasso Sea to spawn.\textsuperscript{164} It stopped short, however, of imposing commercial

\textsuperscript{155} Id. at v.


\textsuperscript{157} The 2006 FMP Addendum gave states two options. Option 1 required states to create commercial fishing permits with mandatory reporting of eel catch and effort. Option 2 required states to attach mandatory purchase-reporting requirements to dealer permits and implement a commercial permit and reporting programme (ASMFC, ADDENDUM I TO THE INTERSTATE FISHERY MANAGEMENT PLAN FOR AMERICAN EEL 8 (2006), at http://www.asmfc.org/speciesDocuments/eel/fmps/addendumI.pdf [hereinafter Addendum I]) (visited 23 November 2013).

\textsuperscript{158} Addendum II, supra note 156, at 2.

\textsuperscript{159} Id. at 3.

\textsuperscript{160} Id. (quoting 50 C.F.R. § 17 (2012)).

\textsuperscript{161} Id. at 3.

\textsuperscript{162} Id.

\textsuperscript{163} Id.

\textsuperscript{164} Id.

\textsuperscript{155} Id. at v.


\textsuperscript{157} The 2006 FMP Addendum gave states two options. Option 1 required states to create commercial fishing permits with mandatory reporting of eel catch and effort. Option 2 required states to attach mandatory purchase-reporting requirements to dealer permits and implement a commercial permit and reporting programme (ASMFC, ADDENDUM I TO THE INTERSTATE FISHERY MANAGEMENT PLAN FOR AMERICAN EEL 8 (2006), at http://www.asmfc.org/speciesDocuments/eel/fmps/addendumI.pdf [hereinafter Addendum I]) (visited 23 November 2013).

\textsuperscript{158} Addendum II, supra note 156, at 2.

\textsuperscript{159} Id. at 3.

\textsuperscript{160} Id. (quoting 50 C.F.R. § 17 (2012)).

\textsuperscript{161} Id. at 3.

\textsuperscript{162} Id.

\textsuperscript{163} Id.

\textsuperscript{164} Id.
fishery management measures until another stock assessment was completed, citing evidence that imposing “further restrictions on the American eel harvest would significantly impact fishermen.”

The American Eel Stock Assessment Committee finalized another stock assessment in May 2012, concluding that the American eel stock is “depleted.” The Commission is currently considering a draft FMP Addendum III in response to the “depleted” stock assessment. The draft addendum considers a number of management options for the commercial and recreational eel fishery, including closure of glass eel fisheries, gear reductions, dealer requirements (residency, reporting, licensing), increased monitoring across life stages, and habitat recommendations.

**Additional State Controls**

All Atlantic coast states allow commercial harvesting of the American eel, but vary in how they manage those fisheries. All states have to comply with FMP requirements at a minimum, but can implement additional management options such as shutting down the fishery, capping licences, and setting permit and gear fees.

Glass eel and elver fisheries are prohibited in every Atlantic coast state except Maine and South Carolina. South Carolina’s glass eel fishery is minimal, as only ten permits are available for in-state and out-of-state residents. Maine has a sizeable glass eel and elver fishery, however. As the fishery grew, the state passed laws restricting the number of licences by establishing a lottery system and, more recently, by capping the elver fishery licences, allowing only those with an elver licence each of the prior three years to apply for a renewal. Poaching of glass eels and elvers is considered to be a “serious problem” in many states, but enforcement is low due to the fact that the fishery is very mobile and usually executed at night.

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165 Id. at 5.
166 ASMFC, STOCK ASSESSMENT REPORT 2012, supra note 6, at 4.
168 ASMFC, DRAFT ADDENDUM III TO THE FISHERY MANAGEMENT PLAN FOR AMERICAN EEL FOR PUBLIC COMMENT (March 2013), at http://www.asmfc.org/ (follow “Managed Species” hyperlink; then follow “American eel” hyperlink) [hereinafter ASMFC, Draft Addendum III] (visited 17 April 2013).
169 ASMFC, STOCK ASSESSMENT REPORT 2012, supra note 6, at 20.
170 Id.
171 ME. REV. STAT. ANN. tit. 12, § 6505-A (amended 2011). Despite this measure, catches have increased significantly. According to preliminary data, glass eel harvest for 2012 reached more than 20,000 pounds, more than double the harvest of 2011 and four times the average annual harvest between 2007 and 2011 (ASMFC, Draft Addendum III, supra note 168, at 14).
172 ASMFC, STOCK ASSESSMENT REPORT 2012, supra note 6, at 20.
The yellow/silver American eel is commercially harvested much more widely on the Atlantic coast. States manage the eel using a variety of regulatory tools ranging from licensing requirements to size restrictions.173

The minimum standards set out in the American eel FMP, supplemented by the patchwork of state regulations, have historically been the sole source of management of the eel population. However, declining catches and the recognition that the stock is officially “depleted” have exposed the fishery to greater oversight from the federal government.

**United States Management Role and Pending Endangered Species Act Listing**

Although the federal government does not have day-to-day management responsibilities for the American eel,174 the FWS is a non-voting member of the Commission and provides research and input on habitat improvement, dam relicensing projects, improved access such as eel passage projects, and conservation programmes.175 Additionally, representatives from FWS and NOAA Fisheries are on the Commission’s Eel Technical Committee.176 Finally, FWS also provides much-needed funding for species conservation and stock assessment modelling.

The other manner in which the federal government can get involved in the management of the American eel is via an Endangered Species Act (ESA) listing.177 The ESA was enacted to “provide a means whereby the ecosystems

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173 In Maine, the sizeable yellow/silver eel pot fishery is managed using licensing requirements, minimum size limits, gear or mesh size restrictions, and trip level reporting. New Hampshire, Massachusetts, Rhode Island, and Connecticut all require commercial licences and trip level reporting. The New York yellow/silver eel fishery takes place mainly in Lake Ontario, the Hudson River, the upper Delaware River, and on the coast. Fishing in the Hudson River is subject to minimum and maximum size restrictions to limit exposure to PCBs, and fishing in the freshwater portions of the river and its tributaries has been prohibited since 1976 because of PCB exposure risk. Harvesting on the St. Lawrence River is limited to bait only. New Jersey imposes commercial licensing regulations and minimum mesh and size limits. Delaware requires catch reporting and a minimum size limit. The Maryland and Virginia yellow/silver eel pot fisheries are primarily located in the Chesapeake Bay, and are subject to licensing, reporting, and mesh size requirements. North Carolina has a small coastal yellow/silver eel pot fishery that is subject to licensing, reporting, and mesh size and bait limit rules. South Carolina issues licences and permits, requires reporting, and imposes various gear restrictions on its coastal eel fishery. Georgia does not have a specific eel licence but does require catch reporting. Finally, the yellow/silver eel fishery in Florida is subject to permit and mesh size requirements. For a thorough description of each of the Atlantic states’ regulatory requirements, see ASMFC, STOCK ASSESSMENT REPORT 2012, id. at 20.

174 The American eel is considered a United States Fish and Wildlife Service [hereinafter USFWS] trust resource, however, and is managed by the USFWS on federally owned lands.

175 See ASMFC Compact, supra note 147, at 4.

176 See ASMFC, PROCEEDINGS OF THE ATLANTIC STATES MARINE FISHERIES COMMISSION AMERICAN EEL MANAGEMENT BOARD iv (1 May 2012), at http://www.asmfc.org (follow “Managed Species” hyperlink; then follow “American Eel” hyperlink; then follow “Meetings & Minutes Summaries”) (visited 23 November 2012).

upon which endangered species and threatened species depend may be con-
served, to provide a program for the conservation of such endangered species
and threatened species.”178 In the last ten years, FWS has been petitioned twice
for an ESA listing of the American eel. The first petition in 2004 resulted in a
2007 final determination from FWS that an ESA listing was “not warranted”
at that time.179 The political climate has changed since 2007 due to the new
presidential administration, and in 2010, the Council for Endangered Species
Act Reliability (CESAR), a non-profit organization, petitioned FWS for ESA
listing of the American eel.180 With respect to regulatory activity, CESAR
specifically noted that the ASMFC, the “only regulatory authority currently
exercised[,] . . . has done little over the past decade” to address the decline
of the species.181 Based on the decline of the American eel and the lack of
adequate regulatory management, CESAR urged FWS to list the American
eel as “threatened.”182

In September 2011, FWS issued a 90-day finding (more than a year after
the date it received the petition) that ESA listing may be warranted, stating
that the CESAR petition included enough information to conduct a status
review.183 The results of the status review must be published within 12 months
of receiving a petition.184 As of August 2012, FWS had still not published
the status review of the American eel. Concerned by the lack of regulatory
action regarding its petition, CESAR filed a complaint against FWS seeking
a declaratory judgment stating that FWS’ failure to comply with the ESA
statutory status review time frame constituted a violation of the ESA, and

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178 Id.
179 12-Month Finding on a Petition To [sic] List the American Eel as Threatened or Endangered, 72 Fed.
Reg. 22, 4967 (2 Feb 2007). Despite finding habitat decline, USFWS found that the “highly resilient”
eel was still “widely distributed over the majority of its historical range” (id. at 4995). Furthermore,
there was no evidence that parasites or contaminants were causing population-level effects, and there
was no indication of mortality due to turbines, non-native species, or predation (id. at 4996).
180 See COUNCIL FOR ENDANGERED SPECIES ACT RELIABILITY, PETITION TO LIST THE AMERICAN EEL
(ANGUILLA ROSTRATA) AS A THREATENED SPECIES UNDER THE ENDANGERED SPECIES ACT (2010), at
2012). The CESAR petition cited a steep decline in the eel population since the 1980s and held a
number of factors responsible: dam operations that have contributed to an 84 percent loss of American
stream habitat, overutilization by commercial fishing, a swimbladder parasite, inadequacy of existing
regulatory mechanisms, climate change, stream acidification, turbine injury, and mercury and PCB
contamination (id. at 1–2).
181 Id.
182 Id. at 1.
183 90-Day Finding on a Petition To [sic] List the American Eel as Threatened, 76 Fed. Reg. 189, 60431
(September 29, 2011). Listing a species under the ESA following the receipt of a petition is a multi-step
regulatory process. First, USFWS must determine whether the petition presents “substantial informa-
tion” such that granting the petition may be justified, and issues an opinion in the form of a 90-day
finding (16 U.S.C.A. § 1533 (2011)). If USFWS determines “the petition presents substantial scientific
or commercial information indicating that the petitioned action may be warranted[,]” the ESA requires
the Secretary of Commerce to “promptly” initiate a status review of the species (id.).
sought an injunction to compel the Secretary of the Interior to make certain a
date by which FWS would complete the status review. At the time of writing,
the date of completion for the status review had not been set.

Once completed, the status review may make one of three different
determinations with respect to CESAR’s petition. First, the Secretary could
find that the petitioned action is “not warranted.” Second, the Secretary
could find that the petitioned action is warranted, and will “promptly publish”
a proposed regulation implementing the listing. If the American eel is listed
under the ESA, FWS would lead the management of the eel in coordination
with other federal agencies and states, and would authorize take permits,
if appropriate, to private landowners and researchers. Finally, the Secretary
could find that the petitioned action is “warranted but precluded,” that is, data
support the need to list the American eel, but the listing is precluded by other
pending ESA proposals of higher priority.

4.3.2 Canadian Eel Management Framework

The catadromous nature of the species and its wide natural distribution
in eastern Canada result in a fragmented domestic governance framework.
Freshwater fisheries in Canada are subject to a complex patchwork of juris-
diction between the federal, provincial, and territorial governments developed
and evolving since the first Fisheries Act in 1868. As a consequence of the

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185 Complaint at 2–3, Center for Environmental Science Accuracy and Reliability (f/k/a Council for
187 Id.
192 Under the Constitution Act, 1867, 30 & 31 Vict. Ch. 3 (U.K.), reprinted in R.S.C. 1985, app. II,
no. 5, the federal Parliament was assigned responsibility for sea coast and inland fisheries (§91.12),
while provinces were assigned responsibility for matters of property and civil rights (§92.13) and
the management of public lands (§92.5). During the initial years of Confederation, it was interpreted that
the federal government had exclusive authority for the management of all fisheries in Canada. However,
in later years the provinces disputed this interpretation (L.S. PARSONS, MANAGEMENT OF MARINE FISHERIES
IN CANADA 19 (1993)). Several judicial decisions clarified the authorities of the two levels of government
pertaining to fisheries (id.). Over time, a complex system of delegation of federal administrative authority
to the provinces and territories has evolved on the basis of constitutional provisions, judicial decisions,
and federal-provincial negotiations (id. at 19–23). Currently, freshwater fisheries administration is
delegated to the province in Quebec and Ontario. In the Maritime Provinces, delegation has taken place
for trout enhancement only. In Newfoundland, the federal government retains full management authority
for all fisheries in accord with the 1949 Terms of Union (see id.; DFO, FRESHWATER INITIATIVE: DISCUSSION
(visited 22 November 2012). The regulation of fish processing plants falls under the provincial power
over property and civil rights, outside federal jurisdiction.
different constitutional and administrative arrangements, three jurisdictions have authority to manage American eel: the federal Minister of Fisheries and Oceans (including three DFO administrative regions: Gulf, Maritimes, and Newfoundland and Labrador), the province of Ontario, and the province of Québec. The federal government has a lead role for the protection of fish habitat under the Fisheries Act. Additionally, a greater role of the federal government is also undertaken with respect to freshwater and marine species at risk, although each province has also enacted laws and regulations for the protection of endangered species potentially applicable to freshwater species.

Concerns about the status of American eel in all provinces in the 1990s and early 2000s stressed the need for an on-going inter-jurisdictional forum for the discussion and coordination of eel conservation activities. For this purpose, DFO and the provinces of Quebec and Ontario established the Canadian Eel Working Group (CEWG) and the Canadian Eel Science Working Group (CESWoG), which met for the first time in 2003. The work of these two committees led to the development of a federal-provincial Canadian-wide American eel management plan released in draft form in April 2007. The long-term goal of the draft management plan was to rebuild overall abundance of American eel in Canada to its level in the mid-1980s, while the short-term goal is to reduce eel mortality from all sources by 50 percent relative to the 1997 to 2002 average.

The Management Plan has yet to receive formal approval. However, the short-term goal of the draft management plan has been adopted

as a management objective by the different competent authorities, achieving some level of informal coordination across jurisdictions. The efforts appear to be insufficient: the last assessment on the progress on achieving management goals reveal that the short-term objective has generally not been met.  

Several reasons explain this result, including the high cost of some management measures, the lack of technological solutions for some issues (e.g., reduction in turbine mortality), and the lack of means to assess target reductions.

A further complexity in the Canadian legal landscape for eel management—and a complexity that was not addressed in the eel draft management plan—is the “special position of aboriginal peoples [in the fishery, as] recognized in Canadian constitutional provisions, in land claim settlements, in treaties, and at international law.” A series of judgments in the 1970s and 1980s secured state recognition of an Aboriginal right to harvest resources for subsistence and ceremonial purposes. In 1999, the landmark Marshall decision (a case that stemmed from alleged violations of federal laws and regulations in the fishing and selling of eel by members of a Mi’kmaq band) further recognized a treaty right to participate in the commercial fishery to sustain a “moderate livelihood,” subject to reasonable and justified limitations for conservation and management purposes. The Supreme Court has also asserted the federal, provincial, and territorial governments’ legal duty to consult and, where appropriate, accommodate when the Crown contemplates conduct that might adversely impact potential or established Aboriginal or treaty rights.

**Fisheries Management**

Eel fishing effort is unevenly distributed in its Canadian range, with some areas subject to intensive fisheries while others are totally unexploited. The stage targeted by fisheries (glass eel, elver, yellow eel, and silver eel) also varies geographically. Currently, the eel fishery concentrates in four areas:

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197 DFO, Status and Progress, supra note 53.


200 Marshall decision, supra note 19.


202 Government of Canada, supra note 4, at 279.

203 Id.
St. Lawrence River and estuary in Québec, the southern Gulf of St. Lawrence, the Maritimes, and Newfoundland.\textsuperscript{204} Ontario closed the commercial fishery in 2004 and the recreational fishery in 2005.\textsuperscript{205}

The Quebec eel fishery in the St. Lawrence River and estuary takes place in four main fishing areas (Montreal archipelago, Lake Saint Pierre, St. Lawrence freshwater estuary, and St. Lawrence marine estuary),\textsuperscript{206} with the main fishing areas being Lake Saint Pierre and the brackish estuary. The fishery targets mainly silver eels.\textsuperscript{207} The commercial fishery is regulated through licences, fishing seasons, gear restrictions, and minimum size.\textsuperscript{208} Recreational fisheries for American eel in Quebec waters are managed through fishing licences and closed seasons established for each of the 29 defined recreational fishing zones in Québec.\textsuperscript{209} Between 2002 and 2009, Quebec implemented a buy-back programme on commercial fishing licences that considerably reduced the fishing effort.\textsuperscript{210} As of 2010, 55 licences were still in effect for the Quebec silver and yellow eel fishery.\textsuperscript{211} This measure, together with a decline of eel abundance from Lake Ontario, explains a 53 percent reduction in reported catches in the 2005–2009 period, compared to the 1997–2002 average considered in the draft management plan.\textsuperscript{212}

The tidal waters of the southern Gulf of St. Lawrence support a significant yellow eel fishery, mainly in New Brunswick and Prince Edward
Island but also extending to Nova Scotia. In this region, fishing licences, closed areas, fishing seasons, minimum size, and gear restrictions are the management tools used to regulate both the commercial and recreational eel fisheries. Additionally, daily catch limits have been established for the eel recreational fishery. Despite American eel fisheries in this fishing area being under the responsibility of only one federal agency (DFO, Gulf Region), DFO has adopted the practice of establishing province-specific management measures. Although generally there has been an effort to harmonize these management measures, provincial regulations differ in some aspects for both commercial and recreational fisheries.

Management measures, and particularly closed seasons, closed fishing areas, and minimum size, have been increasingly restrictive. However, they have not been sufficient to reduce fishing mortality as required in the draft management plans.

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213 The inland and tidal waters of New Brunswick (NB) and Nova Scotia (NS) that contribute to the fishery are those that flow in the Northumberland Strait or the Gulf of St. Lawrence. Hereinafter they are referred to as Gulf NB and Gulf NS. Other waters of these provinces also contribute to the Maritimes fishery, which are subject to different management regimes.

214 The current eel regulations for the commercial fishery in the Gulf Region are included in the Maritime Provinces Fishery Regulation, S.O.R./93-55, Part V and in Variation orders 2007-010, 2012-021, 2012-083, and 2013-005 issued by DFO’s Regional Director for the Gulf Region. The regulations contain different management measures depending on the province, the nature of the waters (inland or tidal), and the gears used (pots, traps, or spears). The commercial eel fishery in inland waters is closed in Gulf NB and Prince Edward Island (PEI). Gulf NS allows an inland eel fishery with eel pots and/or traps between 1 September and 24 October. Gulf NB and PEI also have closed the tidal eel fishery with spears, while Gulf NS allows a commercial spear fishery in tidal waters from 15 January to 30 April. The three provinces authorize a commercial eel fishery with eel pots and/or traps in tidal waters for one or two seasons during the year, although PEI has closed some tidal waters to commercial fisheries and NS has closed some tidal waters for eel trap and pot fisheries. Minimum size for all commercial fisheries is 53 cm.

215 The eel regulations for the recreational fishery in the Gulf Region are included in the Maritime Provinces Fishery Regulation, S.O.R./93-55, Part V and in Variation orders 2010-04, 2009-119, 2006-110 and 2002-003 issued by DFO’s Regional Director for the Gulf Region. As in the case of commercial fisheries, the management regimes vary according to the province, the nature of the waters (inland or tidal), and the gears used (pots, traps, or spears). Recreational eel fisheries in inland waters are closed in PEI, restricted to pots and to some inland waters of NB, and restricted to pots and traps in NS. The season for the inland recreational fishery with pots in NB extends from 1 January to 29 December, and a minimum size requirement of 20 cm is in place. In inland waters of NS, a recreational fishery with traps and pots can take place between 1 September and 24 October, with a minimum size requirement of 53 cm. In tidal waters, both NB and PEI allow a recreational fishery with spears only and during one or two seasons during the year. The minimum size in PEI is 25 cm, while in NB it is 53 cm except for the winter season. NS allows a recreational fishery in tidal waters with traps and pots between 1 September and 24 October, with the exception of the East River of Pictou. A recreational fishery with spears is allowed to take place in tidal waters between 15 January and 15 March. The minimum size is 53 cm for all recreational fisheries in Gulf NS.

216 The daily catch limit in Gulf NB and Gulf NS is ten eels (Maritime Provinces Fishery Regulation, S.O.R./93-55), while in PEI the daily limit is six eels (variation order 2002-003 by the DFO Regional Director for the Gulf Region). A requirement to retain all eels was imposed on the winter recreational spear fishery to prevent high-grading, that is, the practice of discarding dead, injured, or small eels in order to make room to catch larger eels within the daily bag limit.
management plan. Reported landings in the Gulf Region in 2004–2008 showed an increase of 46.2 percent with respect to the 1997–2002 reference level, largely due to an increased abundance in that region.\textsuperscript{217}

The Maritimes Region, encompassing New Brunswick (Bay of Fundy) and Nova Scotia (Bay of Fundy and Atlantic coast), supports a commercial fishery for yellow and silver eels with approximately 400 commercial licences, although many are reportedly inactive.\textsuperscript{218} The fishery is regulated through fishing seasons, gear restrictions, and minimum size measures.\textsuperscript{219}

Since the late 1980s this area supports the only elver fishery in Canada,\textsuperscript{220} with nine elver fishery licences. Eight elver licences allow the holder to catch 900 kg, while one allows a 270 kg catch.\textsuperscript{221} As a matter of policy, elver licences are not issued for rivers with established large eel fisheries.\textsuperscript{222} Each river is also subject to a catch limit of 300 kg.\textsuperscript{223} Although the adopted management measures have allowed a 27 percent reduction in the reported landings of larger eels to 2007, compared to the 1997–2002 average, this decrease is insufficient to comply with the objectives stated in the draft management plan. Additionally, there are concerns of incomplete reporting for the 2004–2007 period.\textsuperscript{224}

The eel fishery in the province of Newfoundland and Labrador is restricted to the island of Newfoundland. The commercial fishery consists of an inland and coastal eel pot fishery and a fyke net fishery targeting silver and yellow eel, which is distributed throughout the province but concentrated in the southwest and northeast coasts.\textsuperscript{225} The recreational fishery consists mostly of winter harvesting (spearing) through the ice.\textsuperscript{226} The province regulates the

\textsuperscript{217} DFO, Status and Progress, supra note 53, at 17.
\textsuperscript{218} Government of Canada, supra note 4, at 280. The number of commercial eel licences was frozen in May 1993, while the number of recreational eel licences has been frozen at current levels since February 1997 (DFO, Status and Progress, supra note 53, at 13).
\textsuperscript{219} Maritime Provinces Fishery Regulations, S.O.R.93-55, Part IV, subject to any variation orders that may be issued. Minimum size is 35 cm since 2005, with the exception of southwestern New Brunswick (including the Saint John River) where a 30 cm minimum size has been in force since 1998 (DFO, Status and Progress, supra note 53, at 13). Since May 2005, there is a mandatory requirement for escape mechanisms (1 inch by 1/2 inch openings) in fishing gears (\textit{id.}).
\textsuperscript{220} Exploratory licences for glass eels have been issued for the Miramichi River in the southern Gulf of St. Lawrence and for Newfoundland, but no commercial elver fishery developed (DFO, Eel IFMP - NB, supra note 196 at 30; DFO, Eel IFMP - NFL, supra note 196, at 7 and 10–11).
\textsuperscript{221} Government of Canada, supra note 4, at 280; and personal communication with Greg Stevens, Senior Advisor, Fisheries and Aquaculture Management, Fisheries and Oceans Canada (11 April 2013). Licence holders were authorized to catch an additional 100 kg for restocking purposes, but restocking activities are now suspended.
\textsuperscript{222} DFO, Scotia-Fundy Elver IFMP, supra note 196, ¶1.2 and 4.2.5.
\textsuperscript{223} Id.
\textsuperscript{224} DFO, Status and Progress, supra note 53, at 17–18.
\textsuperscript{225} DFO, Eel IFMP - NFL, supra note 196, at 2.
\textsuperscript{226} Government of Canada, supra note 4, at 280; NFL EEL MANAGEMENT PLAN, supra note 67, at 15.
fishery through commercial and recreational licences,\textsuperscript{227} eel fishing seasons,\textsuperscript{228} gear restrictions,\textsuperscript{229} and minimum length requirements.\textsuperscript{230} The licences identify the freshwater bodies where the activity can take place,\textsuperscript{231} as well as a maximum gear amount for each commercial licence holder. No new commercial licences have been issued since 1998,\textsuperscript{232} and no new recreational licences have been issued since 1999.\textsuperscript{233} Additionally, the number of licences was practically halved in 2004.\textsuperscript{234} Although landings decreased by 47 percent with respect to the 1997–2002 average, practically achieving the objectives of the draft management plan, this reduction is attributed to market conditions rather than the implementation of these more restrictive management measures.\textsuperscript{235}

\textit{Fish Habitat Protection}

American eel faces serious anthropogenic threats in the form of destruction and disruption of habitat, particularly freshwater habitat. Dams, and particularly turbines, are considered one of the most important current threats to eel survival.\textsuperscript{236} Legislation and administrative practices aim to address these threats through the prevention of further habitat degradation, and through recovery of habitat.

\textsuperscript{227} Newfoundland and Labrador Fishery Regulations, S.O.R./78-443, § 34.
\textsuperscript{228} Fishing for eels in inland waters with pots is allowed between 1 July and 31 October, and in coastal waters between 1 June and 31 October. Fishing with fyke nets in inland waters is authorized only between early August (two days before the “black moon” in August) and 31 October; and in coastal waters between 1 June and 31 October (DFO, Eel IFMP - NFL, supra note 196, at 10). The fishing seasons were reduced by one month in 1998. A winter spear fishery is also allowed between 1 November and 31 March (Newfoundland and Labrador Fishery Regulations, S.O.R./78-443, § 34). The fyke net fishery closes when scheduled salmon rivers are closed to angling due to low water levels and high water temperatures, a situation that occurred in 2012 (DFO, Eel IFMP - NFL, supra note 196, at 12).
\textsuperscript{229} A three-year gear reduction programme was initiated in 1997 to ensure that all fishers comply with the regional standard for maximum gear amounts. At the end of the three-year reduction programme, all eel fishers were limited to a maximum of 75 eel pot (25 pots in inland waters and 50 pots in coastal waters) and 15 fyke nets (DFO, Eel IFMP - NFL, supra note 196, at 9–10). Salmonid bycatch exclusion devices were made mandatory for fyke nets in 1999 (id. at 11). At least one-third of the width of all rivers and streams must be left open at all times (id. at 10). The use of bait is not permitted in eel fyke nets (id.).
\textsuperscript{230} The minimum retention size for eels is currently 30 cm. This minimum size was increased in 2005 from 20 cm.
\textsuperscript{231} Fishers can only harvest from rivers that have been traditionally fished and identified in their licences (DFO, Status and Progress, supra note 53, at 13).
\textsuperscript{232} Id.; DFO, Eel IFMP - NFL, supra note 196, at 9.
\textsuperscript{233} DFO, Eel IFMP - NFL, supra note 196, at 9.
\textsuperscript{234} DFO, Status and Progress, supra note 53, at 13.
\textsuperscript{235} Id. at 18.
\textsuperscript{236} Turbine passage is a major cause of mortality for seaward migrants of rivers in which eel are able to ascend past hydro dams. Turbine mortality in the two dams on the St. Lawrence River main stem can reach 26 percent at a single dam and cumulates at least 40 percent for silver eel migrating from Lake Ontario to the estuary (see Section 3.1). Cumulative mortalities have been estimated for the Ottawa and its tributary, the Mississippi. Survival of eel ascending this system is estimated to be as low as 2.8 percent due to turbine mortality alone (Government of Canada, supra note 4, at 284).
The Canadian legislative and regulatory framework offers a number of provisions to protect fish habitat. The main provisions in this respect are the Fisheries Act\(^237\) Sections 20 and 35, the implementation of which is guided by several policies and operational guidelines.\(^238\) Section 20 requires the owner or occupier of a river or stream obstruction to construct and maintain fish passage if the Minister determines it to be necessary for the public interest.\(^239\) Section 35, in turn, prohibits any work, undertaking, or activity that results in the harmful alteration or disruption, or the destruction, of fish habitat, unless prior authorization from the Minister is obtained.\(^240\) DFO’s policy in implementing these two provisions is to address fish passage requirements of new works and undertakings under Section 35 of the Fisheries Act, while Section 20(1) is reserved for resolving issues involving existing obstructions.\(^241\) Despite the seemingly strong fish habitat protection provisions provided under the Fisheries Act, they have shown severe limitations to effectively protect fish habitat.\(^242\) Furthermore, recently enacted legislation further weakens the fish habitat provisions.\(^243\)

DFO and other organizations have led some noteworthy initiatives to address habitat loss and direct mortality of American eel caused by dams and

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\(^{237}\) Fisheries Act, RSC, 1985, c F-14.

\(^{238}\) These include DFO, **POLICY FOR THE MANAGEMENT OF FISH HABITAT** (1986) and DFO, **PRACTITIONERS GUIDE TO FISH PASSAGE FOR DFO HABITAT MANAGEMENT STAFF, VERSION 1.1** (2007) [hereinafter DFO, **PRACTITIONERS GUIDE**].

\(^{239}\) Fisheries Act, **supra** note 237, § 20.1.

\(^{240}\) *Id.*, § 35.1 and §35.2 b). In implementing §35 according to existing fish habitat policies, the construction of adequate fish passage may be considered: a) a condition to determine that the work, undertaking or activity does not cause harmful alteration, disruption, or destruction (HADD) to the fish habitat and thus the issuing of a letter of advice; or b) a mitigation measure considered in the decision to issue a HADD permit. Other situations in which works and undertakings may proceed are described in § 35.2 a), c), and d).

\(^{241}\) See DFO, **PRACTITIONERS GUIDE**, **supra** note 238. In the case of existing obstructions, with §20(1) being a discretionary power, DFO’s policy is to solve problems proactively and cooperatively working with the owners of obstructions (*Id.* at 6).

\(^{242}\) DFO’s implementation of §35 to works and undertakings has been criticized and its effectiveness questioned. See *COMMISSIONER ON ENVIRONMENT AND SUSTAINABLE DEVELOPMENT, REPORT OF THE COMMISSIONER ON ENVIRONMENT AND SUSTAINABLE DEVELOPMENT TO THE HOUSE OF COMMONS: PROTECTING FISH HABITAT* (2009)). This is particularly the case for American eel, which traditionally has not been considered a priority species for research on dam passages and the implementation of s. 35 and s. 20 of the Fisheries Act (see, for example, CHIF and DFO, **MOVING FORWARD WITH THE RESEARCH AGENDA: UNDERSTANDING IMPACTS OF HYDRO ON FISH AND FISH HABITAT IN FRESHWATER. JOINT RESEARCH PLAN FOR PUBLIC AND PRIVATE ORGANIZATIONS IN CANADA** (December 2007) at 11, at http://www.dfo-mpo.gc.ca/science/coe-cde/chif-eng.pdf (visited 17 April 2013)).

\(^{243}\) As a result of an amendment passed into law on June 2012 and taking effect on a future date, s 35(1) of the Fisheries Act will prohibit any work, undertaking, or activity that results in serious harm to fish that are part of a commercial, recreational, or aboriginal fishery, or to fish that support such a fishery. It limits the current scope of the fish habitat protection provision by: a) limiting protection to habitat of fish that are part of a commercial, recreational, or aboriginal fishery; and b) limiting protection to cases of permanent alteration or destruction of habitat (Jobs, Growth and Long-term Prosperity Act, S.C. 2012, c. 19).
other barriers. For example, DFO implemented a study focused on the identification of barriers, estimation of habitat loss, and prioritization of barriers that need to be reopened in Ontario, Québec, and the Maritime Provinces.244 Similarly, Ontario Power Generation has undertaken a trap and transfer pilot study since 2008 in the vicinity of the two largest hydropower dams in the St. Lawrence River to evaluate the impact on silver eel survival and escapement, and is showing promising results.245 Fish-friendly turbines are being developed, but their implementation in existing facilities is not cost-effective.246

Although these initiatives are positive steps, they still have to translate into effective and decisive action for the recovery of lost or disrupted eel habitat. A recent assessment concluded that there has not been any demonstrated progress in reducing mortality of eels during passage through turbines in medium and large hydroelectric generating stations.247 As is discussed below, critical habitat identification under the Species at Risk Act248 (SARA) would significantly improve the prospects for habitat protection. However, this legal tool is not yet available for American eel.

**Species at Risk Act and Provincial Legislation on Endangered Species**

Considering the dramatic declines of American eel, in particular in Lake Ontario and the upper St. Lawrence River, COSEWIC assessed the species in 2006, concluding that it was a species of special concern. The independent assessment by COSEWIC triggers for the federal government the obligation to consider the listing of the species under SARA as a species of special concern, a listing that in turn results in the obligation to manage the species to prevent it from becoming endangered or threatened.249 The listing of American eel underwent an extended consultation process, but no decision has been made to date.250

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244 Government of Canada, *supra* note 4, at 284.
245 First results show that 67.1 percent of large yellow/silver eels are completing their migration to the Middle Estuary within two years after being transferred and show similar energy content and sexual development as non-transferred silver eel (*id.*).
246 *Id.*
249 *Id.* at §§ 6, 65–72.
In 2012, COSEWIC re-assessed the species and concluded that eel in Canada should be considered a single designatable unit with a threatened status. A listing decision based on the COSEWIC re-assessment is not expected before 2014. If listed, the species would benefit from stronger protection measures for its individuals, residences, and critical habitat and a formal and on-going recovery planning process.

Some provinces have also adopted measures under the provincial legislation to protect vulnerable species. Ontario listed the species as endangered under the Ontario Endangered Species Act on 30 June 2008, while habitat protection under the general habitat provisions will be triggered on 30 June 2013 unless a habitat regulation is developed before that date. A recovery strategy has been drafted but is still pending adoption. In Newfoundland and Labrador, eel has also been listed according to the provincial Endangered Species Act as a vulnerable species, and a management plan has been adopted pursuant to Section 13(1) of the Act. Since the provincial government does not have direct management responsibilities for American eel, the purpose of the management plan is to contribute to management by identifying knowledge gaps, facilitating directed studies within the province, and sharing information with other management agencies. In Quebec, the species is considered as likely to be designated as threatened or vulnerable under Section 9 of the Act Respecting Threatened or Vulnerable Species. None

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251 COSEWIC, supra note 2.
252 SARA prohibits the killing, harm, harass, capture, or taking of an individual listed as an extirpated, endangered, or threatened species (§ 32), and damage or destruction of the residence of one or more listed individuals (§ 33). It contains provisions for the protection of identified critical habitat of listed species (§§ 56–64) and environmental assessment for impacts of federal related projects to species at risk (§ 79). It further provides substantial enforcement measures (§§ 85–119) and encouragement of financial support for recovery activities (§ 11). For more information on the protection mechanisms of SARA, see Kate Smallwood, A Guide to Canada’s Species at Risk Act (2003); VanderZwaag & Hutchings, supra note 250. For a critical review of the federal government’s implementation of SARA, see Royal Society of Canada Expert Panel, Sustaining Canada’s Marine Biodiversity: Responding to the Challenges Posed by Climate Change, Fisheries, and Aquaculture 201, 207 (2012).
253 SARA, supra note 248, §§ 37–55.
256 Ontario Endangered Species Act, supra note 254, § 10(1), (3).
257 Rob MacGregor et al., Draft Recovery Strategy for the American Eel (Anguilla Rostrata) in Ontario (2010).
259 Newfoundland and Labrador Regulation 57/02, Endangered Species List Regulations under the Endangered Species Act (O.C . 2002-274), amended by Newfoundland and Labrador Regulations 157/04, 17/06, 116/07, 9/08, 114/09, and 68/10, Schedule C.
260 NFL Eel Management Plan, supra note 67.
261 Ministerial Order Concerning the Establishment of a List of Threatened or Vulnerable Vascular Plant Species which Are Likely to Be so Designated and a List of Threatened or Vulnerable Wildlife Species Which Are Likely to Be so Designated, RRQ, c E-12.01, r 4 (Que).
262 Act Respecting Endangered or Vulnerable Species, R.S.Q., c. E-12.01 (Que).
of the Maritime Provinces have listed American eel under their provincial endangered species legislation.263

5. FUTURE DIRECTIONS FOR AMERICAN EEL SCIENCE AND MANAGEMENT

The previous sections portray a challenging road for American eel conservation and sustainable use. The current situation is marked by a strong market demand for eels, particularly elvers, many gaps in knowledge both in natural and social sciences, and an incomplete management regime that has as yet had limited success in halting the eels’ decline. A renewed commitment and a more decisive, integrated, and proactive action are required to address the multiple challenges ahead. Possible avenues to improve scientific knowledge and to forge stronger management arrangements for the elusive eel are discussed next.

5.1 Directions for Natural Science

The oceanic migration of American eel leptocephalus larvae from their deep-sea spawning site in the southwestern Sargasso Sea to the continental shelf is still pretty much a black box, as is the migration of glass eels across the shelf to estuaries and rivers and during the first year of continental life. The same can be said for the oceanic migration of maturing eels from rivers and estuaries to the continental shelf and the deep Atlantic Ocean. Although the larval and maturing eel migrations are of equal importance, the OTN will focus on the latter by attempting to elucidate the spatial and temporal dynamics of the oceanic migrations of adult eels as they move to their spawning grounds in the Sargasso Sea. On the North American east coast, the diverse paths adult eels take back to the Sargasso Sea are unknown but such knowledge may provide guidance for management measures to protect migration pathways. Further investigation of such issues will require cross-boundary scientific cooperation to get a fuller picture of migration dynamics.

Studies of the oceanic component of the adult migration by deploying satellite pop-up tags and developing coupled biological-physical models in the Gulf of St. Lawrence and the North Atlantic Ocean are needed to explore the feasibility, in terms of arrival times and energy expenditures, of different migration scenarios. These modelling efforts should be pursued.

Migratory pathways can be simulated based on physical models of the oceanographic field and tracking particles that are governed by different responses to temperature and salinity, and possess different degrees of directional bias expressed through varying rates of swimming speed and compass orientation. Modelled migratory trajectories may then serve to predict migratory mechanisms and pathways that must be evaluated by empirical observations in situ. A new generation of pop-up tags employing geomagnetism for geolocation may provide the in situ empirical observations necessary to test the validity of model-based hypotheses of migratory performance.

Another important future direction for eel research relates to population genetics and eel life histories. There is an apparent paradox between important regional variability in life history traits during the juvenile (yellow) eel stage in continental waters on the one hand, and evidence for a single panmictic population on the other. Recently, researchers have found local genetic differences generated by spatially varying selection among American glass eels from different sampling sites in eastern Canada characterized by different sea-surface temperatures when they enter continental waters.264 Latitudinal differences in juvenile growth rate after adjustment for growing season temperatures that may have genetic origins have also been reported.265 This research avenue should be pursued.

Another issue that deserves attention is the marine prey-predator relationships of eel. Satellite tagging of eels has revealed an unexpectedly high rate of predation by warm-gutted predators on American eels in the lower estuary of the St. Lawrence River and Gulf of St. Lawrence (see Section 3.2). The predator was identified as the porbeagle shark. As the pupping grounds of female porbeagle sharks apparently are located in the Sargasso Sea,266 it seems plausible that eels and sharks form a strong predator-prey relationship with sharks tracking the migration of eels south to their respective reproductive sites. Given the high levels of predation documented and the diminishing out migration of silver eels from the Great-Lakes-Upper St. Lawrence area, this predation may represent a major source of mortality, contributing to significant reductions in an already reduced eel spawner biomass. Complicating this issue further, porbeagle shark are themselves under consideration for protection,267 raising the possibility of legislative and management conflicts among jurisdictions and species vying for protected status. Future research

264 Côté et al., supra note 11.
266 S.E. Campana, W. Joyce, & M. Fowler, Subtropical Pupping Ground for a Cold-water Shark, 67 CAN. J. FISH. AQUAT. SCI. 769 (2010).
267 Porbeagle shark has been assessed as endangered in its Canadian range of distribution (COSEWIC, COSEWIC ASSESSMENT AND STATUS REPORT ON THE PORBEAGLE SHARK LAMNA NASUS IN CANADA (2004)) but the Governor General in Council, on the recommendation of the Minister of the Environment, decided not to add the species to Schedule I of the Species at Risk Act (Order Giving Notice of
should aim to test the hypothesis that porbeagle sharks are major predators of American eels during their migration in the Gulf of St. Lawrence and in the Atlantic Ocean. The use of a new generation of miniature satellite tags and chat tag technology\textsuperscript{268} will provide information on predation rates of tagged eels by predators such as porbeagle sharks.

Finally, we know next to nothing about the biology of American eels distributed south of their Sargasso Sea spawning grounds. Although American eels have been captured in the fresh waters of the Caribbean Islands and South America, we know nothing of their abundance, demographic structure, or their migration routes at the leptocephalus stage or at the adult silver eel stage. The importance of this segment of the panmictic eel population to the overall abundance of the species and its overall population dynamic is unknown and merits attention in the future.

5.2 Social Science Directions

The complex relationships among eel, aboriginal traditional uses in North America, and commercial exploitation to provision foreign markets constitute a valuable case study to analyse theories of knowledge\textsuperscript{269} with actor-network theory standing out as a particularly useful approach. The actor-network theory emphasizes the need to track and understand the complex array of actors and actions at multiple levels that influence scientific, technological, and social discourses.\textsuperscript{270} A further idea is that non-humans can be understood as agents, or actors, in networks and thus, the relationship between humans and non-humans should be a particular priority for sociological research.\textsuperscript{271}

\textsuperscript{268} Satellite tags mounted on predators act as hydrophones to record acoustic pingers mounted on prey species.

\textsuperscript{269} For a review of various sociological theories, see Richard Lempert, The Inevitability of Theory, 98 CAL. L. REV. 877 (2010).

\textsuperscript{270} See, for example, Bruno Latour, Networks, Societies, Spheres: Reflections of an Actor-Network Theorist, 5 INT’L J. COMM. 796 (2011); Reza Dibadj, Postmodernism, Representation, Law, 29 U. HAW. L. REV. 377 (2007).

\textsuperscript{271} Bruno Latour, Politics of Nature: How to Bring the Sciences into Democracy (2004); Mrill Ingram, Keeping Up with the E. Coli: Considering Human-Nonhuman Relationships in Natural Resources Policy, 50 NAT. RES. J. 371 (2010).
The actor-network perspective may be particularly valuable for the examination of American eel in two significant ways. First, the elusive character of the creature itself, along with the difficulty of creating any sense of scientific certainty about the basic facts of the eels’ life cycle, recommends an approach to knowledge which emphasizes its social origins. Such an approach, mindful of the incomplete knowledge on eel as network agent, would advocate for a stronger emphasis on a precautionary approach in relevant management regimes.

Second, the close connections to the species of Aboriginal populations over the long history in North America suggest an actor-network formulation in which eels are extended a ceremonial equality. The industrial era provides a more exploitative view of eels, but contrasting aboriginal perspectives raise questions about actual, and preferred, relationships. Further research on Indigenous peoples’ historical and contemporary relationship to eel has the potential to provide valuable insights into these questions. There is a particular need for research on customary and/or ecological knowledge and use, as well as their cultural connections. Furthermore, strengthening the understanding of the aboriginal relationship with eels may significantly contribute to a management regime that fulfils federal fiduciary responsibilities towards Aboriginal and treaty rights, as required under the Canadian Constitution Act\textsuperscript{272} and called for under international instruments.\textsuperscript{273}

5.3 Management Directions

Envisioning future directions for American eel management remains difficult in light of the many current governance uncertainties and realities. Although the effective implementation of coordinated domestic management measures in Canada and the United States under existing legal frameworks would go a long way to address the threats to the species, that scenario has so far remained elusive. As discussed in Section 4, neither Canada nor the United States has been able to finalize a consistent and substantive management plan for American eel that covers the range of eels’ distribution under their jurisdiction. Key known threats, and particularly habitat fragmentation and turbine mortalities, have not been adequately addressed. Stronger protective nets under species


\textsuperscript{273} For example, under Article 25 of the United Nations Declaration on the Rights of Indigenous Peoples (U.N. Res. 61/295, 13 September 2007), Indigenous peoples have “the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources and to uphold their responsibilities to future generations in this regard.” Under Article 26, Indigenous peoples “have the right to the lands, territories and resources which they have traditionally owned, occupied or otherwise used or acquired.” Indigenous peoples “have the right to the conservation and protection of the environment and the productive capacity of their lands or territories and resources” and the “right to determine and develop priorities and strategies for the development or use of their lands or territories and other resources” (Arts. 28 and 32).
at risk legislation would trigger various recovery responsibilities, but neither Canada nor the United States has yet decided to list American eel.

Domestic management measures alone would in any case be insufficient to adequately address the governance challenges of the species. Recent scientific research confirming panmixia makes broader cooperation among range coastal states a necessary element of any governance framework. Some steps in that direction have already been taken by Canada and the United States, but cooperation attempts have not been finalized and are reportedly on hold for the time being. Various management suggestions offered by academics and practitioners to establish a regional conservation organization, possibly along the lines of the North American Salmon Conservation Organization, have not been followed.

Garnering political will to address new management initiatives for American eel may be problematic in light of the relatively low public profile to date of this catadromous species. No political structure like the European Union exists for fostering broad regional cooperation to conserve American eels in the North Atlantic. Nevertheless, at least three possible ways forward stand out.

First, Canada and the United States might take seriously the mandate emanating from Article 67 of the LOSC, namely, a requirement to enter into a bilateral agreement where a catadromous species migrates across EEZs. The two countries could take a more proactive and precautionary approach to American eel conservation by negotiating at least a bilateral framework agreement to enhance scientific cooperation and to pledge development of further measures to conserve the American eel. Considering the high demand for glass eel and the potential impacts of this fishing practice on the sustainability of the species, discussion of common and precautionary approaches for the regulation of elver fisheries might be a priority.

Second, the on-going initiative of the Sargasso Sea Alliance to establish the Sargasso Sea as a marine protected area might be built upon to spawn broader inter-regional cooperation in studying and protecting the American eel. Through the evolving process of developing new management arrangements for the Sargasso Sea, development of a conservation strategy, memorandum of understanding, or other agreement might be considered to address the broader ecosystem linkages raised by the American eel. The identification of the Sargasso Sea as ecologically or biologically significant marine

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274 See, for example, MacGregor et al., supra note 194, at 20. The ASMFC, STOCK ASSESSMENT REPORT 2012, supra note 6, at 18–19, endorsed a similar approach by stating that “[i]deally, there would be an ‘International Northwest Atlantic Eel Council.’”

275 Through Council Regulation (EC) No. 1100/2007, the European Union has required Members States to prepare eel management plans setting target levels of escapement and considering restocking measures.

276 See text accompanying supra note 99. Adult eels from Canada may traverse the U.S. EEZ en route to the Sargasso Sea while juveniles may transit via ocean currents on their route into Canadian waters.

277 See text accompanying supra notes 115 and 116.
area under the CBD represents an important endorsement to the initiative. However, Canada has yet to join in the international efforts to protect this Atlantic ecosystem.279

Third, the cooperative path offered by the Convention on the Conservation Migratory Species of Wild Animals might be followed. The Convention encourages the forging of new agreements among range states of migratory species. A framework memorandum of understanding for the conservation and wise use of American eels might at least be considered involving all states contributing to the apparent common spawning population. While neither Canada nor the United States is party to the CMS,280 the Convention does allow states to join subsidiary agreements even without having party status.281 A broader agreement under the CMS umbrella with broad participation of coastal states in the range of American eel distribution may also facilitate the necessary cooperation and sharing of scientific information required to assess all components of the panmictic species and develop coordinated management objectives. Scientific and management cooperation between North America and Europe may also be a fruitful avenue to pursue considering the close biological proximity of the American eel and the European eel (Anguilla anguilla), including partially overlapping spawning sites.

As the mysteries of eel unravel, management needs and challenges come to the forefront. In addressing them, the continuing calls from the international community for strengthening precautionary and ecosystem approaches to coastal and ocean management continue to offer aspirational goals.282

278 From 2–4 December 2012 the Sargasso Sea Alliance convened a technical preparatory meeting to discuss a draft political declaration, the Hamilton Declaration, which is expected to be formalized at an inter-ministerial meeting in 2014. States bordering the Sargasso Sea and range states of key species will likely pledge to further cooperate in conservation efforts and commit to establish a Sargasso Sea Commission in Bermuda (Hamilton Declaration Negotiations Initiated, SARGASSO SEA ALLIANCE NEWSLETTER (December 2012), at http://archive.constantcontact.com/fs169/1109154724045/archive/1111908328655.html; and personal communication with David Freestone, Executive Director, Sargasso Sea Alliance (15 April 2013)).

279 Canada did not attend the technical preparatory meeting held in December 2012 (id.).


281 For example, while the United States is not a party, it is a participant in three MOUs (marine turtles in the Indian Ocean and Southeast Asia, Pacific Island cetaceans and sharks)(id.). American eel, of course, would need to be listed under Appendix I or II of the CMS (CMS, Arts. III, IV).