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Recovery Potential Assessment for the American Eel (*Anguilla rostrata*) for eastern Canada: life history, distribution, reported landings, status indicators, and demographic parameters

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

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ABSTRACT

This report assembles biological, fisheries, and abundance indices data for the American Eel (*Anguilla rostrata*) Recovery Potential Assessment, which was held in Ottawa in June 2013. Data are compiled by four zones which are primarily or entirely in Canada (St. Lawrence Basin, Northern Gulf of St. Lawrence and Newfoundland, Southern Gulf of St. Lawrence, Scotia-Fundy) and three zones which are primarily or entirely in the United States (Atlantic Seaboard North, Atlantic Seaboard Central, Atlantic Seaboard South). American eels are born in the Sargasso Sea, migrate as leptocephali towards continental waters, metamorphose to glass eels, elvers, and yellow eels, and then return to the Sargasso Sea as silver eels to spawn and die. American eels are panmictic, meaning that they are the progeny of parents which mix randomly on the spawning ground. Stock-recruitment dynamics of the American Eel are poorly understood. It is possible that shifts in the ocean ecosystem (non-stationarity) substantially influence the number of recruits produced by a given quantity of spawners.

Eels are present but rare in Greenland and Labrador. They are widespread and often common in coastal bay and estuarine waters, and in accessible fresh waters, of the east coast of North America from Newfoundland to Florida. Eel abundance in the Caribbean Basin and the Gulf of Mexico and associated drainages is poorly known but possibly substantial. On the basis of research and fishing records and a habitat classification scheme, it is estimated that the east coast of North America between the Strait of Belle Isle and the Florida Keys contains 23,270 km^2 of brackish and salt water eel habitat. Freshwater aquatic habitat of the US Atlantic Seaboard (17,763 km^2) exceeds brackish and salt water eel habitat (14,360 km^2), but an unknown proportion of fresh water habitat is inaccessible to eels. Reported range-wide eel landings peaked in the late 1970s at ca. 3,000 t per year and have since declined to ca. 750 t per year. General Linear Modeling (GLM) indicates a severe (>99%) decline in eel recruitment to and standing stock of Lake Ontario over two or more generations (32 years), and generally declining indices elsewhere in Canada. Trends over one generation (16 years) show an improvement relative to trends over two generations. Over one generation, standing stock indices have declined in three of four zones, but neutral and rising trends are also found. US east coast abundance trends reported in a recent US assessment varied by analytic method from no temporal trend to significant downward trends.

American Eel demographic parameters from eastern North America were examined for systematic geographic variation. Elver lengths increase with latitude and distance from the spawning ground. Trends in yellow eel growth rates and size and age of silver eels showed differing trends for areas south of Cabot Strait versus those north and west of Cabot Strait. Silver eel length varied little with latitude south of Cabot Strait, but was greatest at the maximum distance from the spawning ground, in the St. Lawrence Basin. Percent male was lowest in northern areas, but otherwise sex ratios did not vary consistently with latitude. Fecundity increases with female eel size, but published size to fecundity relationships show widely varying fecundity estimates for a given eel size. Natural mortality rate of the American Eel is poorly known. Equations derived from European eel data and based on body mass, water temperature, density, and sex, appear to be the best available method to estimate natural mortality of the American Eel. Proposed recovery objectives for the American Eel in Canada are increases in abundance indices in the short term (one generation), rebuilding of abundance to levels of the mid 1980s in the medium term (three generations), and maintenance of abundance in the healthy zone of a precautionary approach framework in the long term (>50 years).

Évaluation du potentiel de rétablissement de l'anguille d'Amérique (*Anguilla rostrata*) dans l'est du Canada : cycle biologique, distribution, débarquements déclarés, indicateurs d'état, et caractéristiques démographiques

RÉSUMÉ

Le présent rapport regroupe les données sur les indices biologiques, de pêche et d'abondance pour l'évaluation du potentiel de rétablissement de l'anguille d'Amérique (*Anguilla rostrata*), qui a eu lieu à Ottawa en juin 2013. Les données ont été compilées dans quatre zones se trouvant principalement ou en totalité au Canada (bassin du Saint-Laurent, nord du golfe du Saint-Laurent et de Terre-Neuve, sud du golfe du Saint-Laurent et Scotia-Fundy) et trois zones se trouvant principalement ou en totalité aux États-Unis (côte nord de l'Atlantique, côte centrale de l'Atlantique, côte sud de l'Atlantique). Les anguilles d'Amérique naissent dans la mer des Sargasses, migrent vers les eaux continentales lorsqu'elles sont au stade de leptocéphales, se métamorphosent en civelles, en anguillettes et en anguilles jaunes, puis reviennent dans la mer des Sargasses lorsqu'elles ont atteint le stade d'anguilles argentées afin d'y frayer et d'y mourir. Les anguilles d'Amérique sont panmictiques, ce qui veut dire qu'elles descendent de parents qui s'accouplent aléatoirement dans le lieu de frai. On comprend très peu la dynamique stock-recrutement de l'anguille d'Amérique. Il est possible que des variations dans l'écosystème océanique (absence de stationnarité) influent considérablement sur le nombre de recrues produites par une quantité donnée de reproducteurs.

Les anguilles sont présentes, mais rares au Groenland et au Labrador. Elles sont toutefois répandues et souvent communes dans les baies côtières et dans les estuaires ainsi que dans les eaux douces accessibles de la côte est de l'Amérique du Nord, de Terre-Neuve-et-Labrador jusqu'en Floride. L'abondance des anguilles dans le bassin des Caraïbes et le golfe du Mexique et ses bassins versants est mal connue, mais on pense que l'abondance peut être grande. Selon les observations de recherche, des registres de pêche et un schéma de classification de l'habitat, on estime que la côte est de l'Amérique du Nord, entre le détroit de Belle Isle et les Keys de la Floride, contient 23 270 km^2 d'eau saumâtre et d'eau salée constituant un habitat pour les anguilles. La côte de l'Atlantique des États-Unis offre un plus grand habitat d'eau douce (17 763 km^2) que d'eau saumâtre et d'eau salée (14 360 km^2), mais une proportion inconnue de l'habitat d'eau douce n'est pas accessible aux anguilles. Les débarquements déclarés dans l'ensemble de l'aire de répartition de l'anguille ont connu un sommet à la fin des années 1970 à un niveau de 3 000 t par année et ont diminué depuis pour se chiffrer à 750 t par année. Un modèle linéaire général indique un important déclin (> 99 %) du recrutement des anguilles et du stock actuel du lac Ontario en l'espace de deux générations ou plus (32 ans), ainsi que des indices généralement en baisse ailleurs au Canada. Les tendances au cours d'une génération (16 ans) montrent une amélioration par rapport aux tendances sur deux générations. En l'espace d'une génération, les indices du stock actuel ont diminué dans trois des quatre zones, mais on remarque aussi des tendances stables et à la hausse. Les tendances relatives à l'abondance sur la côte est des États-Unis évaluées dans le cadre d'une évaluation américaine récente variaient selon la méthode analytique, allant d'aucune tendance temporelle à des tendances considérablement à la baisse.

Les paramètres démographiques de l'anguille d'Amérique de l'est de l'Amérique du Nord ont été examinés afin d'y déceler une variation géographique systématique. La longueur des anguillettes augmentait avec la latitude et l'éloignement du lieu de frai. Les tendances relatives au taux de croissance des anguilles jaunes et à la taille et à l'âge des anguilles argentées ont révélé des différences entre les zones au sud du détroit de Cabot et celles au nord et à l'ouest du détroit. La longueur des anguilles argentées variait peu en fonction de la latitude au sud du détroit de Cabot, mais plus les anguilles étaient loin du lieu de frai, plus elles étaient longues

dans le bassin du Saint-Laurent. Le pourcentage de mâles était à son plus faible niveau dans les zones du nord, mais sinon, le sex-ratio ne variait pas de manière significative selon la latitude. La fécondité augmente selon la taille de la femelle anguille, mais les données publiées sur la relation entre la taille et la fécondité indiquent que les estimations de la fécondité varient grandement pour les anguilles d'une taille donnée. On ne connaît pas très bien le taux de mortalité naturelle de l'anguille d'Amérique. Les équations tirées des données sur l'anguille européenne et fondées sur la masse corporelle, la température de l'eau, la densité et le sexe semblent être la meilleure méthode pour estimer la mortalité naturelle de l'anguille d'Amérique. Les objectifs de rétablissement proposés pour l'espèce au Canada sont d'accroître les indices d'abondance à court terme (une génération), de ramener l'abondance aux niveaux qui existaient au milieu des années 1980 à moyen terme (trois générations) et de maintenir l'abondance dans la zone saine du cadre de l'approche de précaution à long terme (> 50 ans).

1. INTRODUCTION

The American Eel (*Anguilla rostrata*) is the West Atlantic representative of the genus *Anguilla*, which occupies oceanic and continental waters throughout much of the world (Tesch 2003). Conservation concerns regarding the American Eel first came to the fore in the 1990s, following a precipitous decline in eel recruitment to the upper St. Lawrence River and Lake Ontario (Castonguay et al. 1994). The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Canadian component of the American Eel stock as Special Concern in 2006 (COSEWIC 2006) and Threatened in 2012 (COSEWIC 2012). In the United States, the US Fish and Wildlife Service determined that listing under the US Endangered Species Act was not warranted (US Department of the Interior 2007), but an assessment by the Atlantic States Marine Fisheries Commission declared the eel depleted in US waters (ASMFC 2012).

When COSEWIC designates an aquatic species as Threatened or Endangered, Fisheries and Oceans Canada (DFO), as the responsible jurisdiction under the Species at Risk Act (SARA), is required to undertake a number of actions. Many of these actions require scientific information on the current status of the species, population or designable unit (DU), threats to its survival and recovery, and the feasibility of its recovery. Formulation of this scientific advice has typically been developed through a Recovery Potential Assessment (RPA) that is conducted shortly after the COSEWIC assessment.

RPAs are intended to be forward-looking, examining the prospects for improved stock status under various scenarios. In the case of the American Eel, the nature of conservation problems is not fully understood. Fisheries, contaminants, turbine mortality, and blockages to freshwater habitat are among the most commonly cited conservation threats, but links between these issues and overall conservation status have not been clearly established (COSEWIC 2012; Righton and Walker 2013). Because future conservation prospects depend on the nature of factors that harm the population, the American Eel RPA must examine past and present conservation issues and status, as well as future prospects.

This paper summarizes the life history and genetic characteristics of the American Eel, compiles data on its distribution, landings, abundance indices and demographic parameters, and proposes targets for population recovery. The American Eel forms a single panmictic stock that lacks geographic variation in neutral genetic markers (Gagnaire et al. 2012). Hence conservation action is likely to be more effective if it takes the entire species (stock) into account. For this reason this paper draws data from as wide a geographic range as possible. In practice, this primarily means eastern North America between the Strait of Belle Isle and the southern tip of Florida, because data from areas to the north (Labrador, Greenland) and to the south (Gulf of Mexico, the Caribbean Basin, and associated drainages) are sparse.

This paper addresses the following RPA Terms of Reference:

- ToR 1. Evaluate present status for abundance and range and number of populations.
- ToR 2. Evaluate recent species trajectory for abundance (i.e., numbers and biomass focusing on mature individuals) and range and number of populations.
- ToR 3. Estimate, to the extent that information allows, the current or recent life-history parameters (total mortality, natural mortality, fecundity, maturity, recruitment, etc.) or reasonable surrogates; and associated uncertainties for all parameters.
- ToR 4. Estimate expected population and distribution targets for recovery, according to DFO guidelines.

To a considerable extent, the material in this paper is intended as a feedstock for analyses presented in other RPA papers, including those by Chaput et al. (2014a,b; mitigation, threats), Pratt et al. (2014, habitat), and Young and Koops (2014, modelling). Advice arising from the RPA is presented by DFO (2014).

Given the panmictic nature of the American Eel (Gagnaire et al. 2012), there is a commonality of interest between Canadian and US eel conservation. Accordingly, several of the themes addressed in this paper are also pertinent to research priorities recently identified by the Atlantic States Marine Fisheries Commission (ASMFC 2013).

2. GENERAL METHODS

2.1 GEOGRAPHIC ZONES

For the purposes of the RPA, freshwater, coastal, and continental shelf habitat of the American Eel in eastern North America is divided into seven zones (Fig. 2.1.1 and 2.1.2). These zones run from the Strait of Belle Isle to the southern tip of the Florida Keys. Zones are not defined for habitat to the north (Labrador, Greenland) because eels are rare there, and because of the scarcity of pertinent data. Zones are not defined for habitat to the south (Gulf of Mexico and the Caribbean Basin, and associated drainages) because of the scarcity of pertinent data. Eel abundance in the Gulf of Mexico and Caribbean Basin, relative to the abundance of the species as a whole, is unknown but possibly substantial. The lack of RPA zones assigned to these regions should not be taken to imply that eel populations there are unimportant.

The interior boundaries of the seven zones are the limits of the Atlantic Ocean watershed area, including watersheds which drain into the Gulf of St. Lawrence. Because the natural limit of American eels in the St. Lawrence River system is Niagara Falls, the limit of the St. Lawrence Basin zone is taken as the boundary of watersheds which drain into the St. Lawrence system below Niagara Falls. The watershed of the Great Lakes drainage above Niagara Falls was mapped to enable calculation of the watershed area of the entire St. Lawrence River/Great Lakes system. However, this area was not defined as an RPA zone because eels do not naturally occur there. On the ocean side, the seven zones are bounded by the 500 m depth contour which runs along the edge of the continental shelf.

Boundaries between zones were set by a combination of biological and management considerations (Fig. 2.1.1 and 2.1.2). The St. Lawrence Basin includes watersheds below Niagara Falls, down to the lower limit of the St. Lawrence Middle Estuary as defined by Cairns et al. (2012). This area is characterized by the large size of the female silver eels, the absence of naturally-occurring males, and a severe reduction in abundance (COSEWIC 2012). The Northern Gulf of St. Lawrence and Newfoundland zone encompasses Gulf of St. Lawrence drainages of Quebec, the Island of Newfoundland, and the islands of Saint-Pierre and Miquelon (France). There is no fishery for locally grown eels in Quebec waters of this zone, except for a small fishery in the Magdalen Islands. There is a fishery with a scattered distribution in Newfoundland. The Southern Gulf of St. Lawrence zone consists of Prince Edward Island and the Gulf of St. Lawrence drainages of New Brunswick and Nova Scotia. There is a major eel fishery in tidal waters of this zone, and a smaller scale eel fishery within limited freshwater areas. The Scotia-Fundy zone includes the Atlantic Ocean and the Bay of Fundy drainages of New Brunswick and Nova Scotia, and the drainages of Quebec and Maine that reach the Bay of Fundy via the Saint John River. The Atlantic Seaboard North zone consists of Atlantic drainages of Maine, New Hampshire, Vermont, Rhode Island, Connecticut, and New York, as well as a small area of Quebec that drains to the Atlantic via the Connecticut River. The Atlantic Seaboard Central Zone consists of drainages reaching the Atlantic Ocean in New Jersey, Pennsylvania, Delaware, Maryland, the District of Columbia, and Virginia. The Atlantic Seaboard South zone consists of drainages reaching the Atlantic Ocean in North Carolina, South Carolina, Georgia, and Florida. In recent years there have been substantial eel fisheries in the Atlantic Seaboard Central zone and smaller fisheries in the Atlantic Seaboard North and South zones.

Areas of RPA zones and watersheds and jurisdictions within these zones are given in Table 2.1.1. GIS-formatted base and marine maps for the Canadian marine portion of this paper's coverage area are posted on DFO's Library Archive as supplemental material to Cairns et al. (2012).

3. LIFE HISTORY

3.1 LIFE CYCLE

The most comprehensive review of the American Eel life cycle and biology is that of Nilo and Fortin (2001). Reviews are also provided by Facey and Van Den Avyle (1987), Aida et al. (2003), Tesch (2003), COSEWIC (2006, 2012), US Department of the Interior (2007), and ASMFC (2012).

The American Eel is a facultatively diadromous fish which reproduces in deep ocean water but grows in fresh or coastal brackish or salt (herein termed saline) water (Fig. 3.1.1). American eels begin their lives in late winter or early spring in the Sargasso Sea in the southwestern portion of the North Atlantic Ocean. The larval stage, termed leptocephalus, is laterally compressed with a nearly transparent leaf-shaped body. Aided by currents, leptocephali move towards continental rearing areas. As they cross the continental shelf, the leptocephali metamorphose to the elongated but transparent form known as glass eels. As they near land or shortly thereafter, glass eels acquire pigment and are known as elvers (Fig. 3.1.1). Elvers may settle in coastal bays and estuaries, or move into freshwater systems. Elvers gradually acquire a yellowish belly pigmentation and become yellow eels. Yellow eels may occupy salt, brackish, or fresh waters. Studies based on otolith strontium-calcium ratios indicate that yellow eels commonly shift between fresh and saline habitats (Jessop et al. 2008). Recent work has shown that neither the strontium-calcium method nor stable isotope analysis is capable of reliably detecting seasonal movements to wintering grounds (Clement et al. 2014). This suggests that fresh-saline habitat shifts may be more frequent than previously realized. Yellow eels in large river systems commonly undertake long-term upstream movements. Yellow eels that penetrate long distances into river systems are unlikely to return to saline waters during the yellow phase (see review in Lamson et al. 2006).

Eels are born asexual, and their sex determination is not yet completely understood. When yellow eels reach a length between ca. 200 and 350 mm, they become either male or female (Nilo and Fortin 2001) (see Section 7.3). Sex appears to be influenced by density, with high densities favouring males and low densities favouring females (Oliveira et al. 2001). However, transplant experiments have shown that location of capture also influences sex ratio (Verreault et al. 2009; Pratt and Threader 2011).

Yellow eels are primarily nocturnal. During the day, and during winter at temperate latitudes, eels conceal themselves in the substrate, either in self-dug burrows, or in natural cavities or other hiding places (Tomie et al. 2013). Tomie (2011) estimated that eels in the Southern Gulf of St. Lawrence spend about 74% of their yellow stage concealed in the substrate.

Upon attaining a threshold size, yellow eels begin a sexual maturation process that includes silvering of the belly and further gonad development. Male eels silver at a smaller size and younger age than females (see Section 7.2). There is also geographic variation in size at silvering. Notably, silver eels from the St. Lawrence Basin have greater mean sizes than those from other RPA zones.

Silver eels that grew in fresh water migrate downstream in late summer and in fall and head out to sea. Little is known about the departure behaviour of silver eels produced in saline water. These eels presumably simply leave their saline growth habitats and head toward open water. Béguer-Pon et al. (2012) used satellite pop-up tags to record the at-sea behaviour of silver eels that had been captured during their migration in the St. Lawrence estuary. Released eels remained in surface waters for several days. Subsequently, both normal diel vertical migration (diving during the day, surface during night) and reverse diel vertical migration (surface during the day, diving at night) were observed. No eels bearing tags successfully left the Gulf of St. Lawrence. Instead, temperature and pressure data from the satellite tags suggested ingestion by warm-gutted predators, apparently porbeagle sharks (Béguer-Pon et al. 2012). Vulnerability to predation was probably increased by drag caused by the bulky satellite tags (Methling et al. 2012). However, anecdotal reports of eels in stomachs of porbeagle sharks that were commercially fished in the eastern Gulf of St. Lawrence (Béguer-Pon et al. 2012) suggest that untagged eels are also vulnerable to shark predation. Bradford et al. (2009) used acoustic telemetry to track silver eels as they traversed the macrotidal Passamaquoddy Bay, New Brunswick. Eel movements showed no consistent relation with the tidal cycle or with depth.

Migration to the Sargasso Sea takes place over fall and winter, but there is no direct knowledge of the timing of American Eel arrival at the Sargasso Sea or reproductive behaviour while there, because no adult *Anguilla* eel has ever been observed in or near the area. Distributional studies of young eel larvae suggest that reproduction and early movements of progeny are associated with ocean fronts (See Section 4.2).

The life cycle of the American Eel and its congeners shows a number of differences from that of most other fish species (Fig. 3.1.2). Its larval stage is spent in oceanic waters of low productivity, and exhibits a prolonged period of transparency. During the glass eel, elver, yellow, and silver stages, eels have an elongate body, which contrasts with the fusiform body of most fish. During their continental lives they are primarily nocturnal, in contrast to the diurnality of most fish. ICES (2009) proposed that the main features of the eel life cycle form an adaptive suite which may contribute to the remarkable ecological success of Anguillid eels (Fig. 3.1.3). The use by leptocephali of oceanic waters of low productivity means that growth rates are slow, but predation risk may also be low because the leptocephali's transparency reduces their visibility to predators (Miller et al. 2013). The elongated body of subsequent eel stages results in low burst swimming speeds (van Ginneken et al. 2002) which decreases the ability to capture fast-swimming prey, while increasing vulnerability to predation. However, the elongated body also has advantages. At the elver stage, the elongated body facilitates creeping up wet vertical surfaces (Legault 1988), giving eels access to upstream habitat that some other freshwater or diadromous fishes may not be able to reach. During the elver, yellow, and early silver stage, eels are primarily nocturnal. This reduces predation risk, and mass-specific natural mortality in eels is much lower than mean rates for other fish species (Bevacqua et al. 2011). Nocturnality requires that the eel have a safe haven during the day. The elongated body shape facilitates burrowing (Atkinson and Taylor 1991) which provides needed refuges in muddy habitats. Finally, the elongated body permits swimming at a metabolic cost that is far lower than that of a fusiform fish of similar length (van Ginneken et al. 2005). This helps non-feeding silver eels to reach the Sargasso Sea, while still having energy reserves necessary to produce eggs or milt.

3.2 GENETIC SYSTEM

Panmixia refers to a reproductive and genetic system in which mating takes place randomly with respect to the geographic origin of reproductive animals. In a panmictic animal, there is no geographic variation in neutral genetic markers (i.e. those that have no adaptive function). The American Eel has long been suspected or considered to be panmictic (Williams et al. 1973; Avise 2003; Wirth and Bernatchez 2003). Côté et al. (2013) conducted the most comprehensive test to date of panmixia in the American Eel by examining geographic variation in neutral genetic markers. A total of 2,142 eels from 32 sampling locations were genotyped with 18 microsatellite loci. All measures of differentiation were essentially zero, and no evidence for significant spatial or temporal genetic differentiation was found. These findings strongly support the panmixia hypothesis (Côté et al. 2013).

Although the American Eel shows no geographic variation in neutral markers, there is substantial variation in phenotypic traits across the species range (Velez-Espino and Koops 2010; see also Section 7). If this variation is a simple response to local environmental conditions, then eels transplanted from one location to another should adopt the phenotypic features typical of the receiving location. However, transplantation experiments have shown that eels often retain the characteristics of their originating location after transplant. Eels transplanted by Vladykov and Liew (1982) from southwest New Brunswick to an Ontario pond showed features (rapid growth rate, an abundance of males) that were typical of source rather than receiving waters. In response to declining eel numbers in the St. Lawrence Basin, elvers from the Atlantic coast of the Maritime Provinces have been stocked at various locations in the drainage area of the St. Lawrence River and estuary (Verreault et al. 2009, 2010; Pratt and Threader 2011). Eels from these stocking campaigns have markedly different growth rates than eels which reach these waters naturally, and include a substantial portion of males, which are absent from naturally-recruited populations. The effect of geographic origin on growth has also been shown in tank-reared eels (Côté et al. 2009).

Phenotypic variation that is linked to geographic origin is paradoxical in a panmictic species. However, there is growing evidence for the occurrence of meaningful adaptive differences within marine species over relatively short geographic distances, even in the absence of neutral genetic differentiation (Hutchings et al. 2007). The essential point here is that panmixia does not preclude spatially varying selection within a single generation. Gagnaire et al. (2012) reported local genetic differences among American glass eels from different sampling sites along eastern North America. They hypothesized that these genetic differences were generated by spatially varying selection related to differing sea surface temperatures when glass eels enter continental waters. These findings contribute to an emerging interpretation that geographically-based phenotypic variations of the American Eel are due, at least in part, to selection within a generation, with the genetic effects of this selection erased at each reproductive event.

3.3 STOCK-RECRUITMENT DYNAMICS

Efforts to conserve the American Eel commonly assume that an increase in stock size during continental stages will increase the number of spawners and subsequently the number of recruits. A purely linear relationship between recruitment and spawners is not expected as there is ultimately a limit to the recruitment which can be produced when spawning stock size approaches zero and an upper limit at high spawning stock size as carrying capacity is reached. In many species, particularly pelagic spawners, when estimated recruitment is plotted against the corresponding estimated parental stock size, the pattern may appear random with low and high recruitment values seemingly as common at low and high spawning stock sizes. In such species, environmentally induced variations in density independent survival at early life stages can mask the underlying density dependent dynamic between recruitment and spawning stock.

Indeed, it is hazardous to assert that average performance is unrelated to spawning stock just because performance or recruitment is highly variable around its average (Walters and Korman 2001).

A stock and recruitment relationship should not be viewed as an average curve but rather as a family of probability distributions with means and variances that depend on the spawning stock size (Walters and Korman 2001). Two classic stock and recruitment models are the Beverton-Holt and the Ricker. In the Beverton-Holt model, recruitment increases with increasing stock size, but at a decreasing rate until an asymptote is reached. In the Ricker model, recruitment increases with increasing stock size until a peak is reached. Thereafter, recruitment decreases with increasing stock size. Because of the descending right limb of the curve, the Ricker model is termed over-compensatory.

A phenomenon which is not considered in the classic forms of the Beverton-Holt and Ricker models is depensatory survival. Depensation occurs when there is an increase in recruits per spawner as spawning stock increases, usually at low stock size, followed by the expected compensatory dynamic of the recruitment rate at larger spawning stock sizes (Hilborn and Walters 1992). A depensatory dynamic is of particular concern when populations are low, because at low stock size, the average recruitment rate may fall below replacement. The classic Beverton-Holt and Ricker models can be modified to incorporate depensatory effects at low stock sizes (Liermann and Hilborn 2001).

The exploration of stock and recruitment dynamics is fraught with potential errors and biases, including time series bias, errors in measurement, and nonstationarity (Hilborn and Walters 1992). Non-stationarity can be particularly problematic and manifests itself when there is a systematic and sustained change in some of the factors that affect reproductive fitness and recruitment. Under non-stationary conditions, environmental variables or characteristics of spawners or recruits that impact survival rates shift over time with the result that stock recruitment dynamics from the past do not apply to current or future recruitment dynamics (Hilborn and Walters 1992). At the present time, there is limited information with which to explore stock and recruitment dynamics for the American Eel. Dekker (2003) attempted to discern a stock and recruitment relationship in the European eel but did not reach a firm conclusion.

The eel life cycle consists of a series of transitions among stages. The success of these transitions can be density-dependent or density-independent, and can be succinctly summarized in a Paulik diagram, which plots the relative strength of each preceding and subsequent stage in a sequence of stock-recruitment dynamics (Fig. 3.3.1). It is plausible that density-dependent effects occur in the transition between elvers and yellow eels, because elver influx is much greater in some areas than in others (ICES 2012). However, direct tests for such a relation are lacking. Within the yellow eel stage, there is evidence that density affects migration (Feunteun et al. 2003), sex ratio (Oliveira et al. 2001; Iglesias and Lobon-Cervia 2012), and survival (Vollestad and Jonsson 1988; De Leo and Gatto 1996; Bevacqua et al. 2011). Density effects in survival in the oceanic stages are untested but appear unlikely given the vastness of the habitat. However, a depensatory effect during reproduction can be postulated. If the density of spawners in the Sargasso Sea is sufficiently low that they have difficulty finding each other, then production of recruits would fall at an increasing rate with decreasing stock size.

Highly variable production of leptocephali for given spawning stock sizes should be expected at this life stage, subject to highly variable oceanographic conditions in the spawning grounds and in the oceanography of the Atlantic. The North Atlantic Oscillation (NAO) tracks long-term changes in the ocean and atmospheric environment of the North Atlantic Ocean, from air pressure differentials between the northern and southern part of the ocean. The NAO is linked to a wide variety of biological processes (Beaugrand and Reid 2003). Proposed mechanisms by which the NAO might influence glass eel recruitment include changes in characteristics of ocean front spawning sites, changes in currents that carry leptocephali to continental rearing areas, and changes in biological productivity that affect food availability to leptocephali (Friedland et al. 2007; Bonhommeau et al. 2008a,b; Miller et al. 2009). Long-term European Eel glass eel abundance indices are negatively correlated with the NAO (Knights 2003; Friedland et al. 2007; Kettle et al. 2008; Miller et al. 2009; Durif et al. 2011). However, the NAO index has improved (i.e. decreased) since the late 1990s, but no overall improving trend in European glass eel recruitment has been noted during this period (ICES 2012).

ICES (2001) reported that the juvenile eel abundance index measured at the Moses-Saunders dam, between Ontario and New York State, and subject to a 4 year lag, was negatively correlated with the NAO. However, the correlation coefficient and significance levels were not given. de Lafontaine et al. (2009) found that the NAO explained 4% of variation in silver eel CPUE in Quebec City area traps. Confidence limits for correlations calculated from time series must be corrected for autocorrelation effects, but autocorrelation corrections were not reported in these studies.

The longest fisheries-independent American Eel abundance index is from electrofishing surveys on the Miramichi River, New Brunswick, which began in 1952. This series was compared with the winter (December to March) station-based NAO index as calculated by the US National Center for Atmospheric Research. Both series were smoothed by a five-year running mean, and the Miramichi series was de-lagged by five years to account for the mean age of juvenile eels captured by electrofishing there. The correlation coefficient between the series was -0.711 (Fig. 3.3.2). To account for autocorrelation, the degrees of freedom (df) were adjusted by the method of Pyper and Peterman (1998), as employed by Bonhommeau et al. (2008). This procedure reduced the df from 59 to 6.2, and the significance level of the correlation was $p = 0.048$. This analysis suggests a possible link between climate and oceanography that could affect recruitment of American eels to continental waters.

4. DISTRIBUTION

4.1 INTERPRETING REPORTED EEL DISTRIBUTIONS

Eel distributions are commonly described using maps that class territory either as range or non-range. In both oceanic and continental habitats, eel abundance can vary from high to rare. At the rare end of the scale, eels may occur in an area intermittently, so that most of the time eels are not present. Nevertheless, such areas may be shown as part of eel range on the basis of single or a very small number of occurrence records.

Natural and artificial barriers in rivers commonly impede upstream eel movement, but upstream migration is entirely halted only in the cases of the largest dams and waterfalls. In eastern North America, many rivers have multiple artificial and sometimes natural barriers between river mouth and headwaters. In such river basins, eels may still be able to colonize upper reaches, but only in a small fraction of the numbers which would occur in the absence of barriers. Range maps shown in this report should be interpreted as the entire area that eels are known to reach, including areas where eels are present only sporadically, or in very low densities. Where eel occurrence is rare or intermittent, the probability of detecting eel presence increases with the intensity of the search effort. Search effort can refer to searching by sampling in the field, or searching for published reports, unpublished reports, and oral, anecdotal, and traditional knowledge. Interpretation of range maps should consider the intensity of search efforts by all search methods.

4.2 DISTRIBUTION DURING SPAWNING AND DURING OCEAN MIGRATIONS

Silver eels leave continental waters in the fall to undertake an oceanic migration to their spawning grounds in the Sargasso Sea. The trajectories taken by eels during this migration are largely conjectural. Spawning occurs in the spring when eels encounter thermal fronts which extend from west to east for hundreds of km. These fronts are located in the Sargasso Sea, several hundred km south of Bermuda. These fronts are associated with the (atmospheric) subtropical convergence and separate the northern from the southern Sargasso Sea. Plancton sampling using large Isaacs Kidd midwater trawls was undertaken along oceanographic transects that extended for hundreds of km from north to south across thermal fronts (McCleave et al. 1987; Kleckner and McCleave 1988). Results showed that young leptocephali (<10 mm long) occur in and south of thermal fronts but are not found north of the fronts. Fronts along the northern edge of the warm, saline surface water mass of the southern Sargasso Sea form the northern limit of spawning by *Anguilla*. Eels presumably stop migrating and start spawning when they encounter these thermal fronts.

American and European eels spawn in a partially overlapping zone in a narrow latitudinal range in the southwestern Sargasso Sea, with the American Eel spawning site extending from 20° to 29°N and from 52° to 79°W while the European eel spawning zone extends from 20° to 30°N and from 48° to 74°W. The temporal distribution of young leptocephali indicates that spawning of the two species also overlaps in time, with American Eel spawning taking place primarily from February to April and European eel spawning taking place primarily from March to May.

Leptocephali of the two species are slowly entrained in the Gulf Stream and are eventually distributed in oceanic waters all along eastern North America. The total range occupied by these larval eels covers a broad area of the western North Atlantic Ocean (Fig. 4.2.1; Kleckner and McCleave 1985). At some point leptocephali metamorphose into glass eels that invade continental waters, sometimes using selective tidal stream transport. Even though the two *Anguilla* species co-occur in the Gulf Stream, continental separation is near perfect, and only American eels have ever been found in North America. Glass eels start invading Florida streams around January of the year following the year they were hatched as leptocephali and invade streams later during the same year the further north those streams are located. In Canada, glass eels or elvers reach river mouths in the Bay of Fundy and Atlantic coast of Nova Scotia between late April and mid-May (Jessop 1998, 2003a), the Gulf of St. Lawrence in May (Dutil et al. 2009), and Grande Rivière Blanche in the lower St. Lawrence Estuary in June and July (Côté et al. 2009).

4.3 CONTINENTAL DISTRIBUTION, NORTHERN AND OVERSEAS

The most comprehensive reviews of the distribution of the American Eel during the continental phase are provided by Nilo and Fortin (2001) and by NatureServe. NatureServe’s map (Fig. 4.3.1) shows a northern limit of the continental distribution in Greenland. The databases of the Ocean Biogeographic Information Systems and the Global Biodiversity Information Facility do not show eel records for Greenland (Fig. 4.3.2 and 4.3.3). American-European hybrid eels have been reported from Iceland (Albert et al. 2006; Als et al. 2011).

American eels, apparently escapees from aquaculture, have also been reported from Taiwanese and northern European waters (Han et al. 2002; Frankowski et al. 2009).

4.4 CONTINENTAL DISTRIBUTION IN CANADIAN AND US FRESH WATER

4.4.1 Canada

The American Eel occurs in southern Labrador up to Hamilton Inlet-Lake Melville, but the English River, 120 km further north, is considered the northern range limit based on electrofishing records (COSEWIC 2012).

American eels have been stocked in the South Saskatchewan River system in Saskatchewan, and an American Eel was later caught by an angler in the same system in Alberta (Radford 1972; Scott and Crossman 1973). The South Saskatchewan system drains into Hudson Bay. Parts of southern Alberta and Saskatchewan drain into the Missouri-Mississippi system, but NatureServe's nearest American Eel record is from South Dakota, and there is no evidence that the species has ever occurred naturally in western Canada.

Niagara Falls originally posed a complete barrier to American Eel upstream migration, but artificial waterways (Welland Canal, Trent-Severn Waterway, Erie Canal, Chicago Ship and Sanitary Canal) now provide alternate routes to the Great Lakes above Niagara Falls. Sporadic records of American Eel in the Great Lakes above Niagara Falls may be due to eel movements through these waterways, particularly the Welland Canal (Scott and Crossman 1973). Stocking of elvers in Lake Erie also contributed eels to that lake in the 1880s (Van Meter and Trautman 1970).

Verreault et al. (2004) mapped the historic distribution of the American Eel in the St. Lawrence Basin and the Quebec portion of Gulf of St. Lawrence drainages by assembling records from the period of European settlement until the 1950s, and from contemporary field work. The most upstream records of eels were identified for each tributary. It was assumed that the historic eel range extended further upstream from these sites, up to the location of the first natural obstacle on the watercourse. In Ontario, the map in Verreault et al. (2004) shows the historic eel range as occupying a broad strip, ca. 25-50 km wide, along the Ottawa and St. Lawrence rivers and the north shore of Lake Ontario (Fig. 4.4.1).

MacGregor et al. (2013) mapped the historic range of the American Eel in Ontario from historical and archeological sources and interviews with aboriginal elders and others with local knowledge. Allen (2010) and MacGregor et al. (2011) provide additional details on methods and findings. The MacGregor et al. (2013) map shows the historic Ontario eel range as the entire St. Lawrence drainage below Niagara Falls, with the exception of a small strip on the north side of the Niagara Peninsula (Fig. 4.4.2). This map shows part of the Lake Huron (Georgian Bay) drainage area, in the vicinity of Lake Nipissing, as being within the eel's historic range. Possible locations where eels might have crossed between Ottawa River and Lake Huron drainages are discussed by MacGregor et al. (2011). MacGregor et al. (2013) also mapped the Ontario range occupied by eels after 2000; this consisted of blocks along the Ottawa River and the northern and western ends of Lake Ontario, as well as Lake Ontario itself (Fig. 4.4.2). The reduction between historic and post-2000 distributions is attributed to artificial barriers to upstream migration and to the reduction in the number of recruits reaching Ontario waters.

During its continental phase the American Eel is generally associated with shallow waters, and the 10 m depth contour is commonly taken as the approximate limit of eel habitat (Verreault et al. 2004). A compilation of depth-abundance relations in American and European eels (Fig. 4.4.3) indicates that eel abundance is often strongly associated with depth, but the nature of depth-abundance relations varies markedly among sites. In some cases eel abundance increases below 20 m depth. The maximum depth of Lake Ontario is 244 m (Mills et al. 2003). Depth-abundance relations of eels in Ontario waters are poorly known, but it appears unlikely that the American Eel range includes the deeper waters of Lake Ontario.

In Quebec, Verreault et al. (2004) mapped the historic eel distribution as strips, generally between 20 and 100 km wide, running along the St. Lawrence River and the Gulf of St. Lawrence coast (Fig. 4.4.1). Current eel distribution is substantially reduced from the historic range due to artificial barriers to upstream migration (Tremblay et al. 2011).

There exist no maps of historic or current American Eel distribution in the Atlantic Provinces that are based on detailed examination of local records. Eels in New Brunswick, Nova Scotia, Prince Edward Island, and the Island of Newfoundland probably occupied all fresh waters other than those which were blocked by natural barriers.

Some of the Island of Newfoundland has a rugged topography, which leads to the presence of high and steeply inclined or vertical waterfalls (see Newfoundland waterfalls). The eel's ability to ascend barriers is linked to the height of the barrier, the steepness of the descending water, surface roughness, and the availability of access routes peripheral to the main channel (Tremblay et al. 2011). Upstream passability is size dependent, with eels under ca. 10 cm in length able to creep up wet vertical slopes to reach upstream waters (Legault 1988; Lamson et al. 2006). The American Eel's historic range in Newfoundland was probably restricted from some upstream reaches by some high and steep waterfalls. A minimum current eel range can be discerned from reported eel fishing locations (Fig. 4.4.4 and 4.4.5) (Nicholls 2011; Cairns et al. 2012). Most fishing records are close to the coast, except those between Bonavista and Notre Dame Bays. There are few fishing records in interior waters. However, the absence of fishing records does not necessarily indicate an absence of eels, because the distribution of fishing effort may be influenced by local fishing traditions, limited road access, and regulations. Insular Newfoundland contains 234 dams associated with hydroelectric development, of which 39 are 10 m high or higher (Nicholls 2011). A substantial part of central Newfoundland, and smaller areas elsewhere, lie upstream of these dams (Fig. 4.4.6). Some of these dams have salmonid fishways or bypass structures which may allow some eel passage. Hence current eel range may include some waters shown as impacted in Fig. 4.4.6.

New Brunswick contains more than 1,000 waterfalls (Guitard 2010). Examination of the photographs depicted in Waterfalls of New Brunswick (n=164) indicates that in a majority of cases the water descends at an oblique angle, typically tumbling over slopes and ledges. The historic eel range in New Brunswick probably included all fresh water except for reaches above the tallest and steepest waterfalls. Nepisiguit Falls in northeastern New Brunswick may have been a barrier to upstream eel movement, although sampling upstream of the dam that is presently located at the site of the falls has yielded a yellow eel (Walker 2012). The largest watershed in the Maritime Provinces is that of the Saint John River. This river's headwaters are in northern Maine. NatureServe's map (Fig. 4.4.7) shows all watershed units in the Saint John drainage of Maine as being within the eel's range, although the supporting text does not cite specific sources (NatureServe). If NatureServe's map is correct, it would indicate that eels were able to colonize all of the mainstem of the Saint John River within New Brunswick, despite the presence of a major falls at Grand Falls.

Commercial fishing records (Fig. 4.4.4) and electrofishing catches (Pratt et al. 2014) indicate that the American Eel is currently widely distributed in the lower Saint John River system. At the present time, a substantial portion of New Brunswick fresh waters are located upstream of artificial barriers. The largest block of habitat that is inaccessible to eels is the Saint John River above the Mactaquac Dam which was constructed in 1968 (Chaput et al. 2014b; Pratt et al. 2014). Elsewhere in New Brunswick, there are numerous smaller dams (Wells 1999; Pratt et al. 2014) and improperly installed road crossings which may block or impede eel colonization of upstream waters.

Alexander et al. (1986) surveyed fish fauna in 744 Nova Scotia lakes in 1964-1981. Fish surveys were most commonly conducted with gillnets, although other gears were also used. Natural lakes and those formed by dams were not distinguished in their data. Eels were captured in 112 of the 744 surveyed lakes (15.1%). However, the authors noted the poor catchability of eels in gillnets, and considered that eels were probably present in almost all surveyed lakes. In Nova Scotia, as in New Brunswick, most waterfalls are sloping (see these sites). The historic eel range probably included fresh waters above most, but not all, waterfalls. The present eel range in Nova Scotia is constrained by numerous artificial barriers. An inventory of water control structures in Nova Scotia contains records of 586 dams (Fielding 2011). On the Gulf of St. Lawrence coast of Nova Scotia, Breau (2013) reported that impediments to fish passage were present in 47% of 669 sites that had a stream crossing within 1 km of head of tide. Bowlby et al. (2013) enumerated blockages in the Southern Uplands region of Nova Scotia that impeded or prevented upstream migration by Atlantic Salmon. However, the method used by eels to ascend artificial and natural barriers differs from that of salmonids (Tremblay et al. 2011), so the analysis by Bowlby et al. (2013) and summarized in DFO (2103) cannot be directly applied to eels.

Prince Edward Island streams have no natural barriers to upstream eel migration because of low relief and the erodible sandstone substrate. Historic eel range probably included the entire province. There are approximately 800 dams in Prince Edward Island (MacFarlane 1999). There are no hydroelectric dams in the province. Eels are present, and often abundant, in most PEI ponds that are formed by dams (Cairns et al. 2007). Eels of all continental ages are capable of ascending dams equipped with salmonid fishways, but where the dam has a vertical water drop and no fish passage, only the elver stage is able to colonize upstream waters (Lamson et al. 2006).

4.4.1 US

The historic distribution of the American Eel in the US likely included all accessible fresh waters draining into the Atlantic Ocean and the St. Lawrence River and Lake Ontario below Niagara Falls, and a major part of US waters draining into the Gulf of Mexico (US Department of the Interior 2007). NatureServe has generated a range map for the American Eel in the US based on examination of local records. Ranges are shown by 8-digit watershed units under the hydrologic mapping scheme of the US Geological Service. Reported historic eel range includes most watershed units in the Atlantic drainage area (Fig. 4.4.7). In Gulf of Mexico drainages, reported historic range includes most watershed units in southern Alabama, Mississippi, and Louisiana. In the Mississippi drainage area, watershed units with reported eel range are scattered and often discontinuous. Watershed units with reported eel range are generally absent on the western slopes of the Appalachian region and the upper Missouri Basin. Reported historic range includes numerous reaches of the Rio Grande drainage in Texas and New Mexico.

The range of the American Eel in US fresh waters has been diminished by artificial barriers to upstream migration (US Department of the Interior 2007). NatureServes's range map shows eels to be extirpated or possibly extirpated in some watersheds in northern New York, in the Mississippi Basin, and in all watersheds in the Rio Grande drainage area (Fig. 4.4.7).

The US Fish and Wildlife Service's National Wetlands Inventory (NWI) maps and classifies wetted habitat in the US in a hierarchical scheme (Cowardin et al. 1979; Dahl et al. 2009). This report consolidates the large number of NWI habitat categories (>1,000) into Riverine Tidal, Riverine Nontidal, Lacustrine (lakes), and Palustrine (ponds, marshes and like habitat), with a further division between habitats with and without emergent plants (i.e. aquatic plants whose stalks extend above the waterline) (Table 4.4.1). Given their wide habitat tolerances (Pratt et al.

2014), eels are likely to occupy any non-emergent freshwater habitat that is accessible to them. Non-emergent fresh habitat catalogued in the NWI totaled 3,487.7 km^2 for the St. Lawrence Basin, 526.0 km^2 for Scotia-Fundy, and 17,763.4 km^2 for the Atlantic Seaboard RPA zones, for a grand total of 21,777.1 km^2. Non-emergent fresh habitat includes 1,128.5 km^2 of Riverine Tidal habitat. This habitat is likely to be fully accessible to eels. Access to substantial parts of the remaining fresh habitat (20,648.7 km^2) may be impeded or completely blocked by natural or artificial obstacles to upstream movements (Lary et al. 1998; Hitt et al. 2012). However, the NWI does not map barriers to fish passage and it does not distinguish between natural lakes and ponds, and impoundments formed by dams. No estimates are available of the surface area of waters in the eastern US that lie above dams and other obstacles.

Despite the abundance of obstacles to migration, the NatureServe map shows most watershed units in Atlantic drainages of the US as being within the eel range (Fig. 4.4.7). In some of these watershed units eels may be rare or intermittent in occurrence, due to dams which reduce upstream migration to a small fraction of what would occur if the river were free-flowing.

4.5 CONTINENTAL DISTRIBUTION IN CANADIAN AND US BRACKISH AND SALT WATER

American eels commonly occupy estuaries and protected coastal waters during their continental phase (ICES 2009). Records of commercial eel fishing can be used to indicate locations occupied by eels, because fishing would not occur if eels were not caught. Eel fishing locations, determined from logbook records and interviews with local fisheries officers, are distributed throughout much of the coastal waters of eastern Canada (Fig. 4.4.4, data from Cairns et al. 2012). The absence of fishing in some areas does not necessarily indicate the absence of eels, because the lack of eel fishing may be due to regulations or the lack of local eel fishing traditions. Eel-directed research fishing has been conducted in some areas of the Canadian east coast where there is no commercial fishery. These fisheries found eels to be common in all sampled areas. This implies that eels are present in most, or perhaps all, suitable habitat on the Canadian east coast.

To further examine the brackish and salt water distribution of the American Eel on the east coast of North America, Poirier (2013) assembled databases of 25 surveys conducted between 1959 and 2012 in waters between Labrador and Florida (Table 4.5.1; Fig. 4.5.1). Examined datasets were from 21 bottom trawl surveys, three beach seine surveys, and one longline survey. The total number of fishing sets available for analysis was 251,088. Data were assembled in a GIS database for mapping and spatial analysis (example map given in Fig. 4.5.2). Surveys in open marine waters rarely captured eels, confirming the coastal distribution of yellow American eels (Table 4.5.1, Fig. 4.5.1). Eel capture rates in the coastal zone varied widely, which may reflect, at least in part, variable gear efficiency for eel capture. Catch rates varied with depth, but the depth-catch rate pattern varied with survey location (Fig. 4.5.3 and 4.5.4). This accords with the literature compilation (Fig. 4.4.3) which similarly found wide inter-site variation in depth-abundance relations.

Cairns et al. (2012) classified Canadian east coast waters between the Strait of Belle Isle and the US border by degree of exposure to the open sea. Base maps used for this purpose classed coastal habitats with emergent vegetation (primarily salt marshes and mangrove swamps) as land. Such habitat was therefore excluded from the exposure classification scheme. Aquatic habitat was classified by approaching, on a GIS map, circles of various sizes towards inlets. Lines were drawn between the points where the circle touched the sides of the inlet, and waters inside these lines were assigned an exposure category. The classification categories were sheltered (using a 1.5 km diameter circle), semi-exposed (using a 15 km diameter circle), and exposed. The exposed category extended seaward to the 500 m contour line. This classification scheme has been extended by splitting the exposed category into exposed bay (using a 150 km diameter circle) and exposed ocean, and by expanding geographic coverage to US waters to the southern tip of the Florida Keys (Fig. 4.5.5). Areas of these habitat categories are given in Table 4.5.2.

In the brackish and salt waters of eastern Canada, 93.8% of reported commercial and recreational eel fishing locations were in the sheltered exposure category, 6.0% were in the semi-exposed category, and 0.2% were in the exposed category (Table 4.5.3). On this basis, Cairns et al. (2012) suggested that the sheltered exposure category can be considered an approximation of eel range in the brackish and salt waters of eastern Canada. Sheltered habitat in eastern Canada and the French islands of Saint-Pierre and Miquelon totals 8,909.6 km^2 (in this summation intertidal habitat is discounted by 50% because it is dewatered at low tide) (Table 4.5.2).

In the survey datasets analyzed by Poirier (2013), eels were commonly caught in sheltered waters, but they were also caught in some semi-exposed waters (Fig. 4.5.6). In particular, survey records indicated eel presence along the south side of Delaware Bay, and in tidal tributaries of Chesapeake Bay that are too broad to be classified as sheltered. Consequently, eel range in the US was judged to be sheltered waters, plus the Delaware and Chesapeake habitats noted above. Suitable saline eel habitat was thus evaluated as 14,360 km^2 in the US, for a Canada-US-Saint-Pierre and Miquelon total of 23,269.6 km^2 (Table 4.5.2).

The US Department of the Interior (2007) reported that “nearshore habitats” available to eels on the US east coast totaled 37,849 km^2. However, the cartography from which this total was derived included open marine waters, which are unlikely to be occupied by eels.

According to NatureServe, the American Eel's range includes coastal waters of states bordering the Gulf of Mexico, with the species being more common in the eastern portion of this coast. Eel landings have been reported from the Gulf of Mexico coast of Florida, Louisiana, and Texas in some years but have never exceeded 9 t (see Section 5).

For Atlantic Seaboard RPA zones within the US, fresh habitat (17,763.4 km^2, Table 4.4.1) exceeds saline habitat (14,360.0 km^2, Table 4.5.2). However some or much of the fresh habitat is not accessible or readily accessible to eels, whereas all the saline habitat is fully accessible to eels. Parallel comparisons cannot be made for the St. Lawrence Basin, Northern Gulf and Newfoundland, Southern Gulf of St. Lawrence, and Scotia-Fundy RPA zones because habitat area estimates are not available for Canadian fresh waters.

4.6 DISTRIBUTION SOUTH OF THE US

Documentation of eel distribution in waters south of the US is incomplete. Both the NatureServe and the OBIS maps show the American Eel distributed around the Gulf of Mexico and the Caribbean Basin, and along the north coast of South America (Fig. 4.3.1 and 4.3.2). However, the NatureServe map puts question marks along the South American coast. Fernandez and Vasquez (1978) described eel fisheries in Cuba. Koehn and Williams (1978) obtained samples for genetic analysis from Puerto Rico, and sex ratios have been described from Trinidad (quoted by Dolan and Power 1977). American eels have been reported 50 km inland from the coast in Mexico’s Yucatan Peninsula (Iliffe 1993, quoted by Velez-Espino and Koops 2010). Citing reports from the early 20th century, Nilo and Fortin (2001) considered that the species is absent or rare in Central America. Tesch's (2003) range map shows the American Eel to be distributed along the South American coast in the east half of Venezuela, Guyana, Suriname, and French Guyana. The same map shows no eel presence on the Central American and South American coasts from the Yucatan Peninsula to mid-Venezuela.

Landings statistics of the United Nations Food and Agricultural Organization (FAO) show landings in Cuba, the Dominican Republic, and Mexico (see Section 5). Cuban landings show a maximum of 1 t. Maximum reported landings in the Dominican Republic and Mexico are for 2011, the most recent reporting year (72 t and 140 t, respectively). These values, if correct, would imply substantial eel populations and/or exploitation in these countries.

5. LANDINGS

5.1 ST LAWRENCE BASIN AND EASTERN CANADA

Reported landings in Canada are available beginning in 1884 for Ontario, 1920 for Quebec, Newfoundland and Labrador, and 1917 for the Southern Gulf of St. Lawrence and Scotia-Fundy. Scotia-Fundy landings for 1917-1951 have not previously been compiled. Other Canadian landings have been compiled by Cairns et al. (2008).

The largest traditional eel fishery in Canada is that of the St. Lawrence Basin, and especially the silver eel fishery in the lower St. Lawrence estuary (Table 5.1.1; Fig. 5.1.1). Reported St. Lawrence Basin landings peaked at over 1,000 t in the 1930s. These include landings from the US side of Lake Ontario, whose last reported landings occurred in 1989. St. Lawrence Basin landings have declined since about 1980. The declining trend has been recently accelerated by a program that retires eel fishing licences in Quebec. Reported eel landings in Ontario have declined since about 1990, and the fishery was closed in 2004 due to conservation concerns arising from a collapse in abundance.

The only eel fishery in the Quebec portion of the Northern Gulf of St. Lawrence and Newfoundland zone is a small fishery in the Magdalen Islands (Table 5.1.1; Fig. 5.1.1). In Newfoundland, reported landings increased from a low level in the 1950s, but have been declining since about 1990. Reported landings in the Southern Gulf of St. Lawrence peaked about 1970, subsequently declined, but have held about steady since the early 2000s. With the decline in the St. Lawrence Basin fishery, the Southern Gulf of St. Lawrence now has the largest reported eel catch in Canada. Reported landings in Scotia-Fundy have declined since a peak in the mid-1990s, but there have been problems in data reporting and full landings data are not available for 2008 and 2009.

In this paper, the term "elver" is used in reference to fisheries that catch either glass eels or elvers. In Canada, 10 cm is the upper length limit for eels targeted in elver fisheries. In DFO's Maritime Region (equivalent to the Canadian portion of Scotia-Fundy), elver fisheries occur primarily on the Atlantic coast of Nova Scotia, with a smaller fishery in the Bay of Fundy area of New Brunswick. There are nine elver licences in Maritimes Region. One of these is a communal aboriginal licence. The number of individuals authorized to fish under each of the other eight licences ranges from eight to 25. One of the elver licences in Maritimes Region has an annual quota of 300 kg and the other eight have annual quotas of 900 kg. There is a single elver licence in DFO's Newfoundland and Labrador Region, which permits 16 individuals to fish elvers. Fishing is restricted to 11 locations in the western half of the south coast of Newfoundland. This fishery is subject to an annual quota of 150 kg. Elver fisheries have increased in the recent past because of high demand from the east Asian aquaculture industry, which has been described as being in a state of crisis following a severe decline in the availability of Japanese eel elvers (EASEC 2012). Reported elver landings in Scotia-Fundy were 4.42 t in 2011 and 4.19 in 2012, which are the highest reported landings in the series (Table 5.1.1d) (data for 2011 and 2012 are preliminary). The elver fishery in Newfoundland is active but its landings are unreported.

Crook and Nakamura (2013) compiled imports of "live eel fry" from Canada into China, Hong Kong, Taiwan, South Korea, and Japan, based on customs records for these countries. "Live eel fry" imports from Canada were reported to be <10 t annually in 1998-2010 and about 30 t in 2011. During the science peer review meeting of the RPA, participants who are familiar with the Scotia-Fundy elver fishery expressed the view that this fishery is well-monitored and that there are unlikely to be major illegal fisheries that are unknown to authorities. There are unconfirmed anecdotal reports of elvers harvested in the Caribbean Basin being transshipped through Toronto on the way to east Asian markets (J. Ford, DFO Maritimes Region, pers. comm.). If so, east Asian customs records might erroneously list these eels as being of Canadian provenance.

5.2 US ATLANTIC AND GULF OF MEXICO

Reported landings for the United States are available from the National Oceanic and Atmospheric Administration (NOAA) starting from 1950 (Table 5.2.1; Fig. 5.2.1). Reported landings peaked in the 1970s and early 1980s, and have since declined. Massachusetts, New York, and Atlantic and inland Florida once had important eel fisheries, but have reported minimal or nil landings in recent years. Since the early 1980s, there has been a gradual consolidation of US landings in the Atlantic Seaboard Central zone. The only state outside this zone that still reports substantial landings is North Carolina.

Reported landings from Texas, Louisiana, and the Gulf of Mexico drainage of Florida have been at most a few tons per year, with most years reporting nil landings (Table 5.2.1; Fig. 5.2.1).

The only US states that permit elver fisheries are Maine and South Carolina. Most of the fishing activity is in Maine, where high recent prices have fueled intense efforts to obtain catches (Miller and Casselman 2014). Dealer-reported elver landings in the state of Maine in the 2000s averaged roughly 2.7 t (ASMFC 2012). According to the Maine Department of Marine Resources, elver landings totaled 8.3 t in 2013. In South Carolina, annual landings were under 0.23 t in 1998-2010. Landings increased in 2011-2013 but remained under 1.13 t annually (K. Taylor, Atlantic States Marine Fisheries Commission, pers. comm.). According to Crook and Nakamura (2013), "live eel fry" imports from the US to China, Hong Kong, Taiwan, South Korea, and Japan totaled about 23 t in 2011. These authors also referred to reports of poaching and illegal trade of elvers in several US states.

5.3. LANDINGS SOUTH OF THE US

Reported landings for the Caribbean Basin and the Gulf of Mexico are available beginning in 1950 from the United Nations Food and Agricultural Organization (FAO). FAO compilations report eel landings in the Caribbean Basin and Gulf of Mexico from only three countries (other than the US) (Table 5.3.1). Reported landings from Cuba have never exceeded 1 t. Reported landings in the Dominican Republic and Mexico have been highly variable. In 2011, reported landings reached their maximum values in both countries, with the Dominican Republic reporting 72 t and Mexico reporting 140 t. Crook and Nakamura (2013) reported an expanding fishery in the Dominican Republic for elvers destined for east Asian markets, but provided no estimates of harvest quantity. FAO compilations do not report eel landings for Haiti, but a Haitian newspaper gives an account of an elver fishery in that country in 2013 (Saint-Pré 2013). This account refers to shipment of Haitian eel harvests to east Asia via Miami and Los Angeles, which suggests the possibility that east Asian customs reports such as those compiled by Crook and Nakamura (2013) might list such shipments as being of US provenance.

5.4 TOTAL LANDINGS

Overall total reported American Eel landings declined to a trough in the early 1960s (ca. 1,000 t), increased to a peak in the late 1970s (ca. 3,000 t), and have since declined to the lowest level in recent history (ca. 750 t) (Table. 5.3.1; Fig. 5.4.1).

6. ABUNDANCE INDICES

6.1 ST. LAWRENCE BASIN AND EASTERN CANADA

6.1.1 Indices

This section updates the DFO (2010) compilation of eel abundance indices from Canada and from US St. Lawrence waters. Ladder, trawl, and electrofishing series reflect eel recruitment to the St. Lawrence River above the Moses-Saunders dam and eel standing stocks in Lake Ontario (Table 6.1.1; Fig. 6.1.1). Series from western Quebec reflect upstream eel movements at the Beauharnois Dam on the St. Lawrence River and at the Chambly Dam on the Richelieu River (Table 6.1.2; Fig. 6.1.1). Abundance series for the St. Lawrence Basin include those in the St. Lawrence estuary, where silver eels exiting the St. Lawrence system are captured in commercial and in one research trap in the Quebec City area and further downstream (Table 6.1.2; Fig. 6.1.1). Series in the Quebec portion of the Northern Gulf of St. Lawrence and Newfoundland are short and generally discontinuous (Table 6.1.3; Fig. 6.1.2). Newfoundland datasets cover both Gulf of St. Lawrence and Atlantic drainages (Table 6.1.4, Fig. 6.1.2). In the Southern Gulf of St. Lawrence, series are derived from commercial CPUE, electrofishing, and elver traps (Table 6.1.5; Fig. 6.1.3). The electrofishing series from the Miramichi River in eastern New Brunswick is the longest fisheries-independent abundance series available for the American Eel (Table 6.1.5c).

Scotia-Fundy data include the East River Chester and East River Sheet Harbour elver series (Table 6.1.6; Fig. 6.1.4). Three electrofishing datasets from Atlantic and Bay of Fundy drainages are reported in this paper (Table 6.1.6; Fig. 6.1.4). Previous eel abundance series compilations (Cairns et al. 2008; DFO 2010) included an electrofishing index from the LaHave River on Nova Scotia's South Shore. In 1996, a hydroelectric dam was constructed at Morgans Falls, on the river's mainstem. An elver fishway was constructed at Morgans Falls ca. 1997, and existed until ca. 2006-2007. During this period, water flow regimes in the fishway varied interannually and in some years water may not have been supplied to the fishway. In addition, the fishway's substrate was changed during the period of operation. These changes may have caused variation in the ability of elvers and small yellow eels to ascend Morgans Falls and colonize upstream waters during the index period (1996-2012). Because of these potential biases, the LaHave electrofishing series is not included in this report.

6.1.2 Trend analyses

6.1.2.1 Data inputs

Temporal trends were analysed for a subset of the eel abundance indicators in the four RPA zones that are largely or wholly in Canada (St. Lawrence Basin, Northern Gulf of St. Lawrence and Newfoundland, Southern Gulf of St. Lawrence, Scotia-Fundy; Fig. 2.1.1). Analyses were conducted for time intervals corresponding roughly to one generation (16 years), two generations (32 years) or over the time series of data. The indicators were grouped by life stage type, habitat type, and RPA zone (Table 6.1.7). The life stage types considered were:

1) recruitment, as elvers into a river or as upstream migrants at the yellow eel stage,

2) standing stock of eels at the yellow eel stage or for combined yellow and silver eels, and
3) spawner abundance at the silver eel stage.

A distinction is made between fishery dependent and fishery independent indicators. The majority of indicators are from freshwater habitats; there were only two indicators of abundance from estuary / marine areas and these were fishery dependent indicators (Table 6.1.7).

A total of eight composite indices and one single index were developed from the subset of 21 abundance indicators (Table 6.1.7).

There are three indices of recruitment to freshwater for two RPA zones (Table 6.1.7). There are two indices of elver recruitment in the Scotia-Fundy area but only one contemporary index (East River Chester). In the St. Lawrence Basin, there is a single index of recruiting yellow eels into the upper St. Lawrence River and Lake Ontario at the Moses-Saunders eel ladders, and one composite index of recruiting yellow eels into the mid St. Lawrence Basin (at Beauharnois, and at Chambly on the Richelieu River). For the Moses Saunders index, the total count of eels ascending the two ladders (Moses, operated in 2006-2012, and Saunders, operated in 1975-2012) was used. For the Moses-Saunders index, the 1974 observation is excluded because the period of monitoring was incomplete. There is no count for 1996. The Beauharnois West ladder counts beginning in 1998 were considered the most consistently monitored index of the series. For Chambly, the time series beginning in 1999 was used because eel counts in 1998 may have been biased by an exceptional passage of eels that had accumulated below the dam prior to the ladder's installation in 1998.

Indices of standing stock are available for the four RPA zones with the majority from freshwater (Table 6.1.7). For the St. Lawrence Basin, two indices of standing stock are available from surveys in Lake Ontario. For the Main Duck Island electrofishing index, only wild eels are considered, the eels captured in 2010 to 2012 were assessed as having originated from the stocking program (J. Casselman, pers. comm.). The three indices for Newfoundland, in the Northern Gulf and Newfoundland zone, are from counts at counting fences which are focused on monitoring Atlantic salmon stocks (Table 6.1.7). The counting fences cover a wide geographic range in Newfoundland. The indices for the southern Gulf include two fishery independent indices from freshwater from electrofishing surveys in the Miramichi and Restigouche rivers; these surveys were designed primarily for monitoring juvenile Atlantic Salmon and have varied in number of sites sampled over time. In the analysis for Miramichi, the data point for 1991 was excluded as only three sites were sampled that year; otherwise sampling occurred at about 15 to over seventy sites annually. The other standing stock indices for the southern Gulf are commercial catch rate indices from the commercial fyke net fisheries of PEI and Gulf Nova Scotia, beginning in 1996 and 1997, respectively (Table 6.1.7). Finally, indices of standing stock for the Scotia-Fundy zone are from electrofishing surveys in three rivers, two in New Brunswick Bay of Fundy (Nashwaak, Big Salmon) and one from the Atlantic coast of Nova Scotia (St. Marys rivers) (Table 6.1.7). As with the southern Gulf of St. Lawrence electrofishing series, these surveys were designed to monitor the abundance of juvenile Atlantic Salmon.

Silver eel abundance indices are available from the St. Lawrence estuary portion of the St. Lawrence Basin region. The indices include one fishery independent index (St. Nicolas trapnet) and three fishery dependent indices and were previously analysed by de Lafontaine et al. (2010). The fishery dependent indices were available to 2005 whereas the St. Nicolas trapnet data are available to 2009 (Table 6.1.7).

6.1.2.2. Analysis

A composite index was derived when several indicators were available for a combination of life stage, habitat, and RPA zone. Of interest in these analyses is the annual composite index of abundance over the available indicators so the indices were analyzed using year and site as factors, without interaction. A Generalized Linear Model (GLM) was used to analyze the data. As all the indices are catches, counts, or densities and therefore non-negative, we assumed a Poisson distribution and the log link function (Zuur et al. 2009). All the indices examined indicated overdispersion (variance increased with the mean) and the standard errors were corrected for this using a quasi-GLM model (Zuur et al. 2009). The GLM analyses were done in R. Predicted values for the main effect "year" were obtained using the R package "Effects."

Some of the abundance indices were provided as densities or catch rates and are standardized to units of area (m^2) or effort (seconds or hours). As Poisson data should be integer values, the indices were re-scaled using an appropriate multiplier to integer values (for example, the electrofishing density data from the Southern Gulf of St. Lawrence were presented as eels per 100 m^2 to two decimal places and these data were rescaled to integers by multiplying the individual indices by 100 (i.e. eels per ha). The re-scaling has no effect on the fitting and estimation of the trends. In two cases (the St. Lawrence River recruitment indices and the St. Lawrence Basin (Lake Ontario) standing stock indices), the scales and units of the indices were very dissimilar and for illustrative purposes, the scale units were removed by dividing the annual values by the mean value of the indices for a defined period: the 1999 to 2011 time period for the St. Lawrence recruitment indices and the 1990 to 2000 time period for the standing stock indices of Lake Ontario. Again, this rescaling has no consequence on the trend analysis results.

The annual percent change over the entire time period of the indicator series as well as the percent change for the most recent 16 and 32 years were calculated using an exponential model of the form:

$N_y \sim \text{Lognormal}(\log.\mu_y, \sigma^2)$

$\log.\mu_y = \text{alpha} + Z * (y-1)$ for y = 1 to Y, Y = 17, 33 or length of available time series.

Note that alpha is the intercept or log of the estimated abundance in year 1 of the time series.

The percent change was calculated as:

$\%change_t = \exp(Z*t) - 1,$ for t = 1, 16, 32 years.

The instantaneous change was estimated using the mean of the annual predicted values from the GLM analyses and the posterior distribution of Z was derived using Monte Carlo Markov Chain using Gibbs sampling, in OpenBUGS (Spiegelhalter et al. 2010). The median and the 90% Bayesian Credibility Interval (BCI) of the posterior distributions are reported for Z. If the 90% BCI range includes 0, then the change over the time period is not considered statistically significant.

6.1.2.3. Recruitment indices

The two elver recruitment indices cover the period 1990 to 2012 with a gap in 2003-2007 (Table 6.1.6a; Fig. 6.1.5). The two indices were simultaneously collected during a short period, 1996 to 1999. The recruitment indices were higher in East River Chester, the contemporary index, compared to East River Sheet Harbour, and ranged from a low of 450,000 in 1999 to a high of just under 2 million in 2008 and 2012 (Fig. 6.1.5). The percent change over the recent 16 years is estimated at +83% (-30% to +384% BCI range) and is not statistically significant (Table 6.1.8 and 6.1.9). Over the time period available, there is an increasing but statistically non-significant ($p = 0.09$) temporal trend.

The recruitment index to Lake Ontario, derived from the counts of eels at the Moses-Saunders dam ladders, peaked in 1983 at over 1.3 million eels and declined to the lowest value of the time series at just over 900 animals in 2001 (Table 6.1.8; Fig. 6.1.6). There is a statistically significant decline of 13.7% annually in the eel counts over the 38 years of the time series (-17% to -11% BCI range) (Table 6.1.9). For the most recent 32 years, the index has declined by 99% (-99.8% to -95.0% BCI range) (Table 6.1.9). There has been an improvement in the counts of eels during the recent 16 years, rising from low values of a few thousand eels in the late 1990s to over 50,000 eels in both 2011 and 2012 (Fig. 5.6.1.6). The increased trend in abundance translates to a statistically significant percent change over that time period of 4000% (Table 6.1.9).

The recruitment indices at the two eel ladders in the middle St. Lawrence region (Beauharnois on the St. Lawrence River, Chambly on the Richelieu River) begin in 1998 (Fig. 6.1.7; Table 6.1.2a). Counts of eels at the Beauharnois Dam eel ladder have increased over the time series whereas counts at the Chambly eel ladder in the Richelieu River have been highly variable with a slight increase from 1999 to 2011 (Fig. 6.1.7). The composite index for these two series shows a significant positive trend, increasing by 18.4% annually, and has increased by 799% (+212% to +2,531% BCI range) over the recent 13 years (Table 6.1.8 and 6.1.9).

6.1.2.4. Standing stock indices

Indices of standing stock of eels in freshwater habitat are available from the four geographic areas. Indices of standing stock in estuary/marine habitat are only available from the southern Gulf of St. Lawrence (Table 6.1.7).

For the St. Lawrence Basin, standing stock indices are available for Lake Ontario (Table 6.1.1c and 6.1.1d). The adjusted composite index for Lake Ontario was at a maximum value in 1972 and 1975 and declined to the lowest values of the time series in 2010 and 2011 (Table 6.1.8; Fig. 6.1.8). There has been a slight upturn in the index in 2012, which may be partly attributable to the stocking program that occurred in 2006 to 2010 but may also be related to the increased recruitment to Lake Ontario as indicated by the increased counts of eels at the Moses-Saunders eel ladder particularly since 2008 (Fig. 6.1.6). The composite index shows a statistically significant decline in the annual percent change over the time series of 24.7% (-29.9% to -19.0% BCI range). The composite index has declined by 100% over the most recent 16 and 32 years (Table 6.1.8; Fig. 6.1.8).

The composite index of standing stock for the northern Gulf and Newfoundland area is derived from counts of eels at three salmonid counting facilities and begins in 1971 for one facility and 1986 and 1993 for the other two facilities (Table 6.1.4a; Fig. 6.1.9). More eels have been enumerated at the Western Arm Brook site on the northern peninsula of Newfoundland than at the other two sites (Fig. 6.1.9). The composite index shows a non-statistically significant decline of -2.2% annually over the time series 1971 to 2011 (-4.6% to 0.3% BCI range; probability of no decline = 0.07) (Table 6.1.8 and 6.1.9). The composite index over the recent 16 years has declined by 63% (-84% to -17% BCI range) whereas over the most recent 32 years, a non-statistically significant ($p = 0.23$) decline of 41% was noted (-81% to +90% BCI range) (Table 6.1.9).

The standing stock index for the southern Gulf of St. Lawrence for freshwater habitat was derived from estimates of densities of eels in electrofishing surveys of the Miramichi River and the Restigouche River (Table 6.1.5c; Fig. 6.1.10). There is no statistically significant ($p = 0.34$) change in the composite index over the entire 61 year time series (-0.2% annual rate of change, -1.1 to +0.7% BCI range) (Table 6.1.8 and 6.1.9). Over the recent 16 year time period, there is no trend in the composite index (median = +31%, -54% to +266% BCI range) but in the recent

32 years, there has been a statistically significant increase of 151% in the composite index (20% to 428% BCI range) (Table 6.1.9).

The standing stock index for the Atlantic coast of Nova Scotia and Bay of Fundy was derived from electrofishing surveys in three rivers covering the period 1985 to 2009 (Table 6.1.6b; Fig. 6.1.11). The composite index shows a statistically significant annual rate of decline of 3.0% over the 1985 to 2012 time period (-3.2% to -2.9% BCI range) (Table 6.1.8 and 6.1.9). Over the most recent 16 years, the composite index has declined by 39% (-42% to -36% BCI range) (Table 6.1.9).

A composite index for standing stock in estuarine/marine habitat was derived from logbook data of the commercial fyke net fisheries in PEI and Gulf Nova Scotia, beginning in 1996 (Table 6.1.5a; Fig. 6.1.12). Over the time period of available data (17 years), the composite index increased by 8% annually (+6% to +10% BCI range) and over the most recent 16 years, the composite index has increased by 246% (154% to 366% BCI range) (Table 6.1.8 and 6.1.9; Fig. 6.1.12).

6.1.2.5. Silver eel indices

Indices of silver eel abundance are available for the St. Lawrence Basin area, and were derived from catches at trapnets in the St. Lawrence River; one is a fishery independent index and three are fishery dependent indices (Table 6.1.2c; Fig. 6.1.13). The composite index shows a statistically significant decline of 1.9% annually (-2.6% to -1.1% BCI range) over the time series from 1971 to 2012 (Table 6.1.8 and 6.1.9; Fig. 6.1.13). Over the recent 16 years, there is a statistically non-significant decline of 20% (-52% to +32% BCI range) (Table 6.1.9). This contrasts with estimates of silver eel escapement from the St. Lawrence Basin of 488,000 and 397,000 animals in 1996 and 1997 respectively and corresponding estimates of 155,000 and 160,000 animals in 2010 and 2011 (Table 6.1.2b), respectively, a change in abundance of -64% over that time period. Over the recent 32 year time period, the composite index has declined by 41% (-58% to -16% BCI range) (Table 6.1.9).

6.1.2.6. Uncertainties and analysis considerations

A GLM model was used to develop annual values of composite indices. The GLM model provides the structure with which to estimate this annual value over the entire time series, as if each index had been monitored in all years. Each index within a composite was given equal weight and the annual predicted value therefore represents the average (on the log scale) of the annual predicted values for each index. In several cases, the trends of individual indices within the composites differed and these differences are averaged out within the composite index. For the indices with units of catch rates or densities, only the average values over sites sampled were provided. Ideally, the individual samples within each site and year would have been analysed, including the units of the sample (effort, area of site sampled) and this is something that should be considered in the future. Additionally, the trends in the composite indices were analysed using the mean of the predicted values. It would have been preferable to analyse the trends taking into account the uncertainty in the annual predicted values; the expectation is that when uncertainty is included, the trend analysis would have resulted in greater uncertainty.

The indices included are considered to be representative and proportional to the life history stage and the RPA zone. As such, the trend in the indices is considered to be representative of the trend of the life stage in the RPA zone. It is assumed that the sampling methods for each index have been consistent through their respective time series. If this is not the case, the assumption of representativeness would be violated. Several of the freshwater indices of standing stock were derived from monitoring programs focused on species other than eels (electrofishing surveys in the Maritime Provinces, fence counts in Newfoundland). There are so few directed programs to monitor eels, if this was a criterion for considering whether an index would be used, then there would be very few useable indicators within a very narrow geographic distribution in eastern Canada.

No attempt has been made to develop an overall composite index for eastern Canada. Such an index could only be developed for the standing stock life stage in freshwater as this is the only lifestage and habitat type represented across the four geographic areas. We did not propose any assumptions on relative weight of the areas to the composite index for eastern Canada and giving equal weight to each area was not considered reasonable. If equal weight is given to each area, this equates to a simple average of four indices.

6.1.2.7. Conclusions

The updated analysis of trends of indicators confirms the conclusions of COSEWIC (2012) that there has been a general decline in abundance of American Eel in Canada over the past two (32 years) or more generations with very strong declines of greater than 99% in the indices of recruitment to and standing stock in Lake Ontario (Table 6.1.9). Declines in abundance have been noted in the standing stock indices of Newfoundland (although not statistically significant) and in the silver eel indices from the St. Lawrence Basin. The only region showing an increasing trend in standing stock over the past 32 years is the southern Gulf of St. Lawrence freshwater standing stock indices (Table 6.1.9).

On the shorter time scale of the most recent 16 years or approximately one generation, there has been a relative improvement in the status of the indices (Table 6.1.9 and 6.1.10). Proportionally more indices show no temporal trend or an increasing temporal trend for the most recent 16 years; nevertheless standing stock indices have declined for three of the four geographic areas (Table 6.1.9 and 6.1.10). Increasing trends in recruitment were noted in the St. Lawrence Basin and strong increases were noted in the recruitment indices to the upper St. Lawrence / Lake Ontario and in the indices of standing stock in estuarine/marine areas of the southern Gulf of St. Lawrence (Table 6.1.10). Declines in standing stock indices were noted for Lake Ontario, Newfoundland and the Atlantic coast of Nova Scotia / Bay of Fundy areas (Table 6.1.10). Variations in abundance with no statistically significant trends were observed in the elver recruitment index, the southern Gulf of St. Lawrence freshwater standing stock index and the silver eel abundance index from the St. Lawrence Basin (Table 6.1.10).

6.2 US ATLANTIC

ASMFC (2012) provided a comprehensive compilation of US eel abundance series, which are reproduced in this report as Tables 6.2.1 and 6.2.2 and Figures 6.2.1 and 6.2.2. The ASMFC (2012) interpretation of abundance trends varied with analytic method. ASMFC (2012) used GLM to combine individual yellow eel abundance series into composite series for 44 years, 30 years, and 20 years (Table 6.2.3; Fig. 6.2.3). ASMFC (2012, p. 82) stated that there is no overall trend in the longest of these series. ASMFC (2012) reported that, after an initial decline in 1985-1989, the 30 year time series showed little variability or trend. The 20 year series was reported to show limited variability and a slightly increasing trend. In contrast to these findings, ASMFC (2012, p. 101) stated "The data evaluated in this assessment provide evidence of declining or, at least, neutral abundance of American Eel in the U.S in recent decades. All three trend analysis methods (Mann-Kendall, Manly, and ARIMA) detected significant downward trends in numerous indices over the time period examined."

Poirier (2013) calculated mean annual abundance indicators from 25 trawl, beach seine, and longline surveys on the east coast of North America. In some of these series, eel captures were too rare to allow trend interpretation. Table 6.2.4 and Figure 6.2.4 present abundance series from six surveys on the east coast of the US. This analysis presents data from the Virginia

Institute of Marine Science (VIMS) Chesapeake Bay trawl series separately for the Rappahannock, York, and James estuaries, and also for the Virginia-Chesapeake region as a whole. Data are presented as mean eels per set and as the percent of sets that caught eels. For the VIMS series, only the percent of sets that caught eels is reported, because the dataset supplied to Poirier (2013) provided data on presence/absence only. Abundance trends in these series varied among surveys (Fig. 6.2.4.). The VIMS series showed declining percent of sets catching eels in the three estuaries, and for the survey as a whole. This follows the same trend shown in the analysis of Fenske et al. (2011), who had access to the full VIMS dataset. In contrast to the VIMS series, commercial CPUE indices in Rappahannock, York and James estuaries, and in the estuary of the nearby Potomac River, do not show declining trends (Fig. 6.2.5). It is possible that these series may be biased by the non-recording of data when catches are zero, a practice that is common among eel fishers in the area (L. Lee, North Carolina Division of Marine Fisheries, pers. comm.). Since zero catches are more frequent when abundance is low, non-reporting of zero catches would produce a CPUE trend line that declines less steeply than would the trend line of the true CPUE.

Data analysed by ASMFC (2012) did not include the VIMS trawl series because of unexplained anomalies in the files that they received. Inclusion of the VIMS series would have added a declining signal to the composite analyses conducted by ASMFC (2012).

7. DEMOGRAPHIC PARAMETERS

7.1 GEOGRAPHIC INPUTS

Velez-Espino and Koops (2010) argued that American Eel demographic parameters vary in geographic clines, and that parameters for particular places or regions could be predicted with reasonable reliability from clinal relations. This section examines American Eel demographic parameters, and seeks to identify geographically-based predictors of these parameters.

Among the chief potential geographic predictors are latitude, distance from the spawning ground, and water temperature. These are provided for each RPA zone in Table 7.1.1. Following the method of Jessop (2010), distance from the spawning ground is calculated from a starting point at 25.08ºN, 68.08ºW, to the continental shelf off central Florida, then along the continental shelf, and finally directly shoreward. It should be noted that effective distance between spawning and rearing areas may differ between larval and silver eels. Larval eel movements are largely controlled by ocean currents, whereas silver eels are active swimmers and may take a more direct route from rearing to spawning waters. Mean annual water temperatures are taken from literature values for the St. Lawrence Basin, the Northern Gulf of St. Lawrence and Newfoundland, and the Southern Gulf of St. Lawrence (see footnote in Table 7.1.1). Mean annual temperatures for other zones are from a National Oceanic and Atmospheric Administration online tool which expands the map shown in Figure 7.1.1.

7.2 SIZES, AGES, AND GROWTH

Mean elver lengths (mm) as compiled by Jessop (2010) increase with both latitude (Length = 31.672 + 0.670 * Lat; $r^2 = 0.667$; $p < 0.0001$; $n = 32$) and distance from the spawning ground (km) (Length = 50.155 + 0.00329 * Distance; $r^2 = 0.609$; $p < 0.0001$; $n = 32$) (Fig. 7.2.1).

A length-at-age scatterplot for eels sampled from fresh and saline waters of the Southern Gulf of St. Lawrence (Fig. 7.2.2) illustrates several typical features of eel length at age:

1) within each salinity zone, there is wide inter-individual variability in eel length at age,
2) eels in saline water generally show greater length at age than those in fresh water, and

3) the cloud of points for eels in fresh water forms an asymptote in the right-hand limb of the graph.

The asymptote of length-at-age in fresh-sampled eels should not be interpreted as evidence that growth of individual eels follows an asymptotic curve. Because eel maturation and departure for the spawning ground is linked to size rather than age, slow-growing eels remain longer in continental waters and are vulnerable to sampling at greater ages, while rapidly growing eels leave the system at younger ages and are thereafter unavailable for sampling. Hence the asymptotic right arm of the freshwater length-at-age plot represents the growth trajectories of slower-growing eels which mature at older ages.

Literature values of silver eel sizes and growth rates, drawn largely from the compilations of Cairns et al. (2009), Jessop (2010), and ASMFC (2012), are presented in Table 7.2.1. Jessop (2010) identified a discontinuity in the geographic variation of eel growth parameters at Cabot Strait, with the relations for points in the St. Lawrence system and Newfoundland having different slopes than those from the Atlantic coast south of Cabot Strait. The present study confirms this discontinuity. In general, length of silver eels that were sampled south of Cabot Strait varied little with latitude and distance from the spawning ground (Table 7.2.2; Fig. 7.2.3 and 7.2.4). Female silver eel length was greatest beyond Cabot Strait at the maximum distance from the spawning ground, which is the St. Lawrence Basin. Female silver age south of Cabot Strait significantly increased with latitude and distance for eels sampled in fresh waters but not in saline waters. Female growth rates south of Cabot Strait decreased significantly with latitude and distance from the spawning ground in fresh waters, but showed no significant trend in saline waters.

Table 7.2.3 compiles literature coefficients of length-weight equations, in the allometric form (Weight = a * Length^b).

7.3 SEX RATIOS AND FECUNDITY

Sex in anguillid eels is not genetically predetermined. Eels are born sexually undifferentiated, and differentiation typically starts between lengths of 200 and 350 mm (see review in Nilo and Fortin 2001). Eels can be identified as females if they exceed the maximum size of silver males in the local area. Some eels under the size of silver males can be sexed by macroscopic examination of gonads, but histological preparations are required to reliably sex eels whose gonads are at an early stage of development.

Eel density and sex determination appear to be linked, with higher proportions of males associated with high densities. The finding, from Maine and Nova Scotia, that eels from lake habitat are mostly female and eels from river habitat are mostly male is consistent with this notion (Oliveira et al. 2001), because lakes have greater surface area than rivers, leading to lower densities for a given recruitment. In two English rivers, the decline of European Eel abundance was accompanied by a shift from male dominance to female dominance (Bark et al. 2009). However, density does not fully predict eel sex ratios, and the exact nature of the sex determination process remains unclear (Davey and Jellyman 2005).

Table 7.3.1 presents reported percent of males in American eels sampled from 65 locations. In this table, the percentage male is based only on eels for which the sex was successfully identified. In the St. Lawrence Basin, males are common among eels that had been transplanted as elvers from the Atlantic coast of the Maritime provinces (Verreault et al. 2009; Pratt and Threader 2011), but identified males are absent or extremely rare among naturally recruited eels. Mean reported percent males is 4.6% in the Northern Gulf of St. Lawrence and Newfoundland and 1.5% in the Southern Gulf of St. Lawrence. In Scotia-Fundy and the three Atlantic Seaboard zones, reported percent male varies widely among sites, and RPA zone means range from 10.1% to 33.7%. Other than the low values at the most northerly sites, percent male in samples shows no consistent trend with latitude (Fig. 7.3.1). Reported mean percent male is similar between fresh (18.7%) and saline (19.4%) sampling sites (Mann-Whitney non-parametric U = 333.5, p = 0.357).

Measuring and understanding sex ratios in the American Eel is challenging because sex ratios are likely to vary with life stage, and because of the difficulty in obtaining unbiased samples for sexing. An initial sex ratio can be defined as the ratio, just prior to sexual differentiation, of the number of eels destined to become females relative to the number of eels destined to become males. During sexual differentiation, it becomes possible to determine sex and to calculate sex ratio. However, eels destined to become female may start differentiation at a smaller minimum length (166 mm) than eels destined to become males (209 mm) (Nilo and Fortin 2001). A sample of eels within the length range over which differentiation occurs will contain males, females, and undifferentiated individuals. Because of the later start of differentiation in males, the proportion of males in such a sample will be lower than the proportion of eels, just prior to differentiation, that are destined to become males. One can postulate a sex ratio at the end of the differentiation period, as indicated by the length at which all eels are sexually differentiated. However, such a ratio would be difficult to measure in practice, because any sample of eels contains a mixture of lengths, making it difficult to locate and sample eels just at the point when they have attained a given length threshold.

Sex ratio may also be measured during the yellow stage. Female eels have a longer yellow stage than male eels, and therefore remain in the pool of yellow eels available to be sampled for longer than male eels. This will increase representation of female eels, relative to male eels, in a sample of yellow eels used to calculate sex ratio. Finally, sex ratio can be measured at the silver stage, usually by capturing migrating eels that are descending rivers. Female silver eels are on average older than male silver eels, and are therefore subject to natural (and fishing) mortality for a longer period. This will increase representation of male eels, relative to female eels, in a sample of silver eels used to calculate sex ratio.

At any stage, reliable measurements of sex ratio depend on obtaining unbiased samples in the field. During the yellow and silver phases, male eels are typically smaller than female eels, so sampling gear must be capable of capturing eels in an unbiased manner over a broad range of sizes.

The process of acquiring yellow eels for sex ratio measurement must also consider the possibility of size-linked habitat selection. In Southern Gulf of St. Lawrence bays, estuaries, and freshwater ponds, American eels caught in fyke nets and visually observed in nighttime glass bottom boat surveys have broadly similar length-frequency distributions, with few recorded lengths under about 300-350 mm (Cairns et al. 2007; Hallett 2013; Hallett et al. unpubl. data). In both cases, the rarity of small eels does not appear to be an artifact of method. In glass bottom boat observations, objects much smaller than the smallest observed eels can be readily seen from the vessel (J. Hallett and D. Cairns, pers. obs.). The rarity of small eels in fyke net captures does not appear to be due to gear bias, because fitting these nets with fine-mesh liners does not increase captures of small eels (D. Cairns, unpubl. data). These findings suggest that small eels, under ca. 300-350 mm in length, are rare in the habitats covered by fyke net sampling and glass bottom boat surveys in the Southern Gulf of St. Lawrence. ICES (2009) reported that small European eels were commonly captured in Sweden in dredge samples in very shallow vegetated habitat, and suggested that small eels may exhibit fine-scale habitat selection that differs from that of larger eels. Pratt et al. (2014) also reported evidence for size-based habitat selection in fresh waters. Since male eels have a smaller maximum size than female eels, sampling in habitats where small eels are poorly represented will lead to underrepresentation of males in samples used to calculate sex ratio. Overall, the dependence of American Eel sex ratios on life history stage, and the risk of sampling bias, means that reported sex ratios should be viewed with caution.

Fecundity-length and fecundity-weight relations have been calculated for two sites in the St. Lawrence Basin, two sites in the Northern Gulf of St. Lawrence and Newfoundland, and one site each in the Southern Gulf of St. Lawrence, Atlantic Seaboard North, and Atlantic Seaboard Central (Table 7.3.2). Fecundities for a given eel length calculated from length-fecundity equations varied substantially with the equation used (Fig. 7.3.2). Within the St. Lawrence River and northern and southern Gulf, mean fecundity of sampled eels ranged from 6.5 million eggs for eels with a mean length of 693 mm (Long Pond, PEI), to 14.5 million eggs for eels with a mean length of 1,001 mm (Iroquois Dam, St. Lawrence River) (Tremblay 2009).

7.4 NATURAL AND FISHING MORTALITY

Natural mortality is poorly understood in anguillid eels, and much of what is known or surmised is based on studies of the European Eel (see review by ICES 2012). In common with other fish, body size and temperature are considered to be major influences of eel natural mortality, with mortality declining at increasing size and cooler temperatures. Generalized methods are available for estimating fish natural mortality from body weight (Peterson and Wroblewski 1984; McGurk 1986; Lorenzen 1996), maximum expected age (Hoenig 1983; Jensen 1996), and von Bertalanffy growth parameters (Roff 1984; Jensen 1996). However, anguillid eels show differences from typical patterns of teleost life cycle and ecology, which reduces confidence that these generalized methods will give valid results for anguillid eels. ICES (2012) compared mortalities during continental life of European eels calculated by these methods. Cumulative continental mortality varied greatly with method of calculation (range 1-99%), which suggests that some or many of these methods give unrealistic results when applied to eels.

Several methods are available for estimating eel natural mortality from empirical data. The catch-curve method (Ricker 1975) is based on the decreasing strength of cohorts with age. Application of this technique to eels raises a number of problems. Eels commonly move upstream with age, or shift between salinity zones (Feunteun et al. 2003; Lambert et al. 2006). These movements may alter age structure of the sampled population and bias mortality estimates that are produced by catch curve analysis. In particular, there is no ready way to distinguish the decrease in cohort strength due to natural mortality during the yellow phase from that due to departure as silver eels to the spawning grounds. Spawning emigration can be viewed as a form of mortality, because eels die after they spawn. However, in practical terms, population modeling requires estimates specific to the yellow phase, in contrast to post-spawning mortality, which is 100%. Because catch curve estimates encompass the net effects of emigration/immigration as well as natural mortality, they are more properly referred to as "loss rates." Catch curve mortality estimates may also be affected by variation in recruitment, in the form of random fluctuations or temporal trends.

ICES (2001) proposed a method to estimate loss rates of eels from length frequency distributions, with the aid of a population model which was used to convert length structure into age structure. This approach suffers from the same limitations of the catch curve method, with additional uncertainty arising from the conversion of length structure to age structure.

Cumulative natural mortality during the continental phase can be estimated by measuring the number of glass eels/elvers entering a freshwater system and the number of silver eels from the same cohort that later leave the system. In practice, accurate mortality estimates by this method are difficult to achieve, because it requires multiple years of total movement counts and because in many systems at least some eels enter fresh waters at the yellow rather than the elver stage (Vollestad and Jonsson 1988). In addition, eels are notoriously adept at averting capture at counting barriers, making it difficult to achieve certainty that counts are complete.

Natural mortality can also be estimated from tagging studies. Immigration/emigration complicates analysis of such data sets, but advanced capture-mark-recapture analysis techniques are capable of disentangling the various effects to yield valid mortality estimates (Imbert et al. 2010).

Table 7.4.1 presents estimates of natural mortality and loss rates for the American Eel. Instantaneous loss rates (per year), calculated from catch curves for the tidal Hudson River Estuary, were 0.135 in the freshwater portion and 0.145 in the brackish water portion (Morrison and Secor 2003; Cairns et al. 2009). Fenske et al. (2011) calculated a loss rate of 0.24 per year from the same Hudson Estuary data, and used this estimate in a population model of eels in the Potomac River. Loss rates in Prince Edward Island, estimated by modeled length frequency distributions, were 0.25 per year in freshwater ponds and 0.28 per year in unfished bays and estuaries (ICES 2001). ASMFC (2012) evaluated American Eel natural mortality as 0.15 to 0.25 per year, based on an integration of various methods. They also proposed use of Lorenzen's (1996) equation which estimates natural mortality as an allometric function of mass. They felt that the unaltered Lorenzen (1996) equation would overestimate mortality for eels, but indicated that there was little objective basis for determining an appropriate adjustment factor for the equation.

Bevacqua et al. (2011) developed equations to estimate sex-specific natural mortality for European eels based on body mass, annual mean water temperature, and stock density (expressed as low, medium, and high). ICES (2012) considered this to be the most complete method available, and it has become widely used in European Eel population modelling.

The Bevacqua et al. (2011) equation for instantaneous natural mortality is:

$M = e^{q}\, e^{(-E/(k * T))} w^{b}$, where

> e = the mathematical constant 2. 718281828
> q = a constant specific to sex and density with
> q_{male} = 48.5, 49.3, and 49.7 for low, medium, and high density, respectively
> qf_{emale} = 49.9, 50.4, and 50.8 for low, medium, and high density, respectively
> E = a constant specific to sex with
> E_{male} = 1.22 and E_{female} = 1.24
> $k = 8.62 \times 10^{-5}$
> T = mean annual water temperature in degrees Kelvin (0ºK = – 273.15 ºC)
> w = body weight in g, and
> b = -0.46.

Figure 7.4.1 plots natural mortality against age for male and female eels for the seven RPA zones, based on temperatures from Table 7.1.1, elver lengths from Table 7.5.1, growth rates from Table 7.2.2, length-weight relations from Table 7.2.3, and the Bevacqua et al. (2011) equation. Densities are assumed to be medium. Estimated natural mortality declines steeply with age, and varies widely among RPA zones. For females aged 8, estimated natural mortality varied tenfold, with the lowest M in the coldest zone (Northern Gulf of St. Lawrence, mean annual temperature 4.9ºC, M = 0.025) and the highest in the warmest zone (Atlantic Seaboard South, mean annual temperature 20.8ºC, M = 0.25). Chaput and Cairns (2011) used the Bevacqua et al. (2011) equation to estimate natural mortality for eels in the Miramichi River, New Brunswick. Estimates of M were 0.04 for 100 g males, 0.05 for 100 g females, and 0.02 for 500 and 1,000 g males and females. These values are lower than those given by other methods for eels and they are also lower than natural mortality estimates for other fish species of similar size (Bevacqua et al. 2011). Low natural mortality may be reasonable considering the nocturnal behavior of eels during the growth phase. Eels spend a high proportion of their total time during the yellow phase concealed in the substrate (estimated at 74% in the Southern Gulf of St. Lawrence, Tomie 2011), where predation mortality is likely to be low.

Natural mortality during the first year of the eel's continental life is particularly poorly known. Jessop (2000) estimated instantaneous elver mortality in a Nova Scotia river by two methods. Although both methods were subject to substantial uncertainty, they yielded similar results (instantaneous mortality of 0.0612 and 0.0675 per day, Jessop 2000). It is possible that survival of arriving juvenile eels varies geographically due to density-dependent effects. Elvers are caught in commercial quantities at numerous locations on the Atlantic coasts of New Brunswick and Nova Scotia, and also in Newfoundland (Cairns et al. 2012). In contrast, repeated efforts to capture elvers for commercial and monitoring purposes in the Southern Gulf of St. Lawrence have yielded low, and often nil, captures (Dutil et al. 2009). These authors attributed low abundance of elvers in the Gulf of St. Lawrence to cold temperatures during the migration period and to the long and indirect route from the spawning ground into the Gulf. However, despite the apparently low influx of elvers to the Southern Gulf of St. Lawrence, yellow eels are common in this zone and support major fisheries (Hallett 2013, see also landings data in Section 5). This finding could be explained by high density-dependent mortality in areas outside the Gulf of St. Lawrence which are heavily seeded by arriving glass eels/elvers. If this is the case, mortality in the first year of continental life will be lower in the Gulf of St. Lawrence than on the Atlantic coast. However, data are unavailable to test this hypothesis.

American and European eels have broadly similar ecologies and life cycles, and ecological traits reported in one species are commonly generalized to the other species. However, differences between the North American and European species must be considered in any application of the Bevacqua et al. (2011) model to the American Eel. Cairns et al. (2009) compared anguillid eel growth rates between fresh and saline growth habitats. To minimize temperature effects, comparisons were restricted to sites where data were available from fresh and saline habitats in the same watercourse. Analysis was further restricted to growth data in which the salinity of the rearing habitat had been determined by otolith Sr/Ca ratios. On average, eels in northeastern North America that were reared in brackish or salt (saline) water had growth rates 2.07 times greater than those reared in fresh water. No suitable data for analysis were available for American eels south of the Hudson River. For other eel species, including the European Eel, ratios of growth in saline to fresh waters were typically about 1.15. With their slower growth rates, eels in fresh water take longer to reach the size at which maturation takes place. Hence if annual mortality is similar across salinity zones, eels occupying fresh water will have a higher cumulative mortality and a lower lifetime fitness than those in saline water. However, the depressing effect of slow freshwater growth on fitness could be neutralized if natural mortality is lower in fresh water.

In the Hudson Estuary, estimated loss rates are similar between fresh (0.135) and saline (0.145) reaches (Table 7.4.1; Cairns et al. 2009). In addition, estimated loss rates are similar between freshwater ponds (0.25) and saline bays and estuaries (0.28) of PEI (Table 7.4.1; ICES 2001). These findings are consistent with the notion that natural mortality does not vary with habitat salinity. However, it must be emphasized that there are major limitations in the methods used in these comparisons, so that any conclusions are tenuous.

Bevacqua et al. (2011) based their analysis on data from seven study sites, including five freshwater sites, one brackish-salt lagoon, and one hypersaline lagoon. Their analysis did not measure the effect of habitat salinity on natural mortality estimates. In any case, growth superiority of European eels in saline waters is small (saline:fresh ratio: 1.14; Cairns et al.

2009), so it appears unlikely that there would be a saline:fresh differential in natural mortality that would compensate in any major way for slower growth in fresh water.

With no evidence for a salinity-based difference in annual natural mortality in the American Eel, and some slight evidence against it, it would appear appropriate to ignore habitat salinity when annual natural mortality estimates are generated for use in population models. It must be borne in mind that this approach will produce lower spawner-per-recruit ratios and lower lifetime fitness values in fresh-reared than in saline-reared eels.

Table 7.4.2 compiles literature values of American Eel fishing mortalities and exploitation rates. Exploitation rates, estimated by mark and recapture of outmigrating silver eels in the St. Lawrence estuary were 19% in 1996, 24% in 1997, 10.5% in 2010, and 7.8% in 2011. In the Southern Gulf of St. Lawrence, exploitation rates were estimated as the quotients of reported landings and biomass estimated from glass-bottom boat surveys. Exploitation rates were estimated as 29.7% in New Brunswick, 6.7% in Nova Scotia, and 5.3% in Prince Edward Island. In the Atlantic Seaboard, reported fishing mortalities range from 0.105 to 1.19 (exploitation rates 10% to 69.6%).

7.5 PARAMETERS FOR POPULATION MODELLING

The elver length to latitude relation is recommended for modelling, because it has a higher r^2 than the relation with distance from the spawning ground (Fig. 7.2.1). Calculated elver lengths for each zone are given in Table 7.5.1. Silver eel lengths and ages and growth rates that are recommended for modelling are presented in Table 7.5.2. Regression equations are recommended if the regression is significant ($P<0.05$). If relations with latitude and with distance from the spawning ground are both significant, the relation with the stronger r^2 is recommended. If neither relation is significant, then mean values from the literature compilation are recommended. Length-weight relations based on the greatest sample size are recommended for modelling (Table 7.2.3).

Because percent males shows no consistent trend with respect to latitude, the mean percent male value for each zone is recommended for modelling (Table 7.3.1). However, the choice of these values must be considered preliminary, because sex ratios are likely to vary with the life stage sampled, and literature reports of sex ratio are derived from samples obtained from a variety of life stages (see Section 7.3). Recommended fecundity relations are those which were obtained from collections within, or close to, the RPA zone (Table 7.5.1). Where two relations had the same proximity to the RPA zone, the one with the higher r^2 was selected.

Because the Bevacqua et al. (2011) equation embraces the main factors likely to influence eel mortality (body weight, temperature, density, sex), and because fully satisfactory empirical measures of American Eel natural mortality are unavailable, this equation seems the best available option for estimating natural mortalities for American Eel population modelling.

Standard deviations and coefficients of variation of elver size, length at age, female silver length, female silver age, and fecundity are presented in Table 7.5.3 as an aid to incorporating variability of these parameters in models.

8. RECOVERY TARGETS

Recovery objectives are defined for both abundance and distribution. Recovery of American Eel could be considered complete once all the regions achieve the recovery objective. Because of the long life of the American Eel in Canada, a period of three generations is considered to equal about 50 years (average of 22 years mean age from freshwater stocks and 9 years mean age from estuarine stocks; COSEWIC 2012). Short term objectives are those expected within one generation (16 years), medium term objectives within three generations (50 years), and long term goals greater than three generations.

Distribution objectives discussed and agreed to at the RPA peer review meeting are:

Short term (one generation, ~ 16 years)	Medium term (three generations, ~ 50 years)	Long term (> 50 years)
Maintain current distribution of eels within its current range and increase distribution leading to increased escapement of eels in productive areas where access to recruitment to a surface area equivalent to what has been a lost over the past generation	Increase distribution of eels in areas where access to recruitment to productive areas equivalent to what has been lost over the past three generations	Re-establish recruitment of the species and escapement of eels through the majority of the suitable and productive historic habitat across the Canadian range to support abundance targets

Recovery objectives for abundance defined during the peer review meeting are:

Short term (one generation, ~ 16 years)	Medium term (three generations, ~ 50 years)	Long term (> 50 years)
Arrest the decline in abundance indices (recruitment, standing stock and production of spawners), where these have occurred and demonstrate increases in these indices within one generation, and outside the critical zone where these reference levels have been established.	Rebuild overall abundance of American Eel in regions and overall in Canada to the levels of the mid-1980s as measured by the key available abundance indices.	Maintain abundance in the healthy zone of the Precautionary Approach framework.

The proposed medium-term abundance recovery objective is to restore abundance of American eels to levels of the mid-1980s (DFO 2010). The mid-1980s period is interpreted in this document as the period from 1981 to 1989.

Only a limited number of indices extend back to the 1980s. The mean and range of the indices for that time period are shown in Table 8.1. The value of the indices for the most recent five-year period available and the status of the index relative to the recovery objectives are also shown in Table 8.1.

The index of the standing stock in freshwater habitat of the Southern Gulf of St. Lawrence is the only index for which the recent five-year average abundance exceeds the value of the recovery objective (Table 8.1). The recent five-year silver eel index from the St. Lawrence Basin is at about two-thirds the value of the recovery objective, whereas standing stock indices in Newfoundland and the Atlantic coast of Nova Scotia/Bay of Fundy are at about at 32% and 47%, respectively of the recovery objective level. The recent five-year status relative to recovery is the poorest for the Lake Ontario recruitment and standing stock indices (Table 8.1).

The short term objective is to arrest the decline and demonstrate an increase in the indicators over one generation. In all areas and life stages, except for the standing stock indicators of the Southern Gulf of St. Lawrence, declines in abundance during the previous 25 to 32 years were noted (Table 8.2). The short term objective is therefore relevant to consider in the context of recovery. The abundance values corresponding to the medium term recovery objectives by life stage and geographic when available are also shown below (Tables 8.1 and 8.2).

The status of the indicators for the recent 16-year time period relative to the short term and medium term recovery objectives are summarized in Table 8.3. The short term objectives of arresting a decline and increasing the indices have been met (✓) for the recruitment indices of the St. Lawrence Basin and for the Scotia-Fundy RPA zones. The short term objective has also been met for the standing stock indicator of the Southern Gulf of St. Lawrence. Progress is still required (☒) to achieve the short term objectives for the other life stage and geographic area indicators. For the medium term objective, only the standing stock indicator for the Southern Gulf of St. Lawrence has met the objective (Table 8.3).

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TABLES

Table 2.1.1. Areas, including both land and fresh water, of North American watersheds that drain into the Atlantic Ocean between the Strait of Belle Isle and the Florida Keys.

See Figure 2.1.1 for a map of zones and watersheds. Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Region	Area (km²)	Including Great Lakes above Niagara Falls (percent of total)	Excluding Great Lakes above Niagara Falls (percent of total)
Great Lakes above Niagara Falls			
Ontario	277,182	11.31	15.69
US	406,696	16.60	23.02
St. Lawrence Basin			
Ontario - Lake Ontario and St. Lawrence River drainage			
Lake Ontario and St. Lawrence River waters	10,433	0.43	0.59
Land and inland waters	31,372	1.28	1.78
Ontario - Ottawa River drainage	50,199	2.05	2.84
Quebec -Ottawa River drainage	95,348	3.89	5.40
Quebec - St. Lawrence River drainage	203,764	8.31	11.53
New York - Lake Ontario and St. Lawrence River drainage			
Lake Ontario and St. Lawrence River waters	9,169	0.37	0.52
Land and inland waters	54,605	2.23	3.09
Pennsylvania	248	0.01	0.01
Vermont	13,496	0.55	0.76
Northern Gulf of St. Lawrence and Newfoundland			
New Brunswick - Northern Gulf of St. Lawrence drainage	23	0.00	0.00
Quebec - Northern Gulf of St. Lawrence drainage	273,472	11.16	15.48
Labrador - Northern Gulf of St. Lawrence drainage	29,036	1.18	1.64
Newfoundland - Northern Gulf of St. Lawrence drainage	23,834	0.97	1.35
Newfoundland - Atlantic drainage	86,767	3.54	4.91
St. Pierre and Miquelon, France	220	0.01	0.01
Southern Gulf of St. Lawrence			
New Brunswick - Southern Gulf of St. Lawrence drainage	33,247	1.36	1.88
Nova Scotia - Southern Gulf of St. Lawrence drainage	9,469	0.39	0.54
Prince Edward Island	5,691	0.23	0.32
Scotia-Fundy			
Maine - Scotia-Fundy drainage	18,813	0.77	1.06
Quebec - Scotia-Fundy drainage	7,196	0.29	0.41
New Brunswick - Scotia-Fundy drainage	39,199	1.60	2.22
Nova Scotia - Scotia-Fundy drainage	45,637	1.86	2.58
Atlantic Seaboard North			
Quebec - Atlantic Seaboard North drainage	295	0.01	0.02
Maine - Atlantic Seaboard North drainage	65,097	2.66	3.68
New Hampshire	23,951	0.98	1.36
Vermont - Atlantic Seaboard North drainage	11,355	0.46	0.64
Massachusetts	20,908	0.85	1.18
Rhode Island	2,784	0.11	0.16
Connecticut	12,829	0.52	0.73
New York - Atlantic Seaboard North drainage	37,304	1.52	2.11
Atlantic Seaboard Central			
New York - Atlantic Seaboard Central drainage	22,472	0.92	1.27
New Jersey	19,478	0.79	1.10
Pennsylvania - Atlantic Seaboard Central drainage	75,210	3.07	4.26
Delaware	5,089	0.21	0.29
Maryland - Atlantic Seaboard Central drainage	24,475	1.00	1.39
District of Columbia	177	0.01	0.01
Virginia - Atlantic Seaboard Central drainage	58,938	2.41	3.34
West Virginia - Atlantic Seaboard Central drainage	9,251	0.38	0.52

Table 2.1.1 (continued).

Region	Area (km²)	Including Great Lakes above Niagara Falls (percent of total)	Excluding Great Lakes above Niagara Falls (percent of total)
Atlantic Seaboard South			
Virginia - Atlantic Seaboard South drainage	26,089	1.06	1.48
North Carolina - Atlantic Seaboard South drainage	111,813	4.56	6.33
South Carolina	79,878	3.26	4.52
Georgia - Atlantic Seaboard South drainage	78,814	3.22	4.46
Florida - Atlantic Seaboard South drainage	39,284	1.60	2.22
Sums			
Great Lakes above Niagara Falls + St. Lawrence Basin	1,152,511	47.03	65.23
Great Lakes above Niagara Falls	683,878	27.91	38.71
St. Lawrence Basin	468,633	19.12	26.53
Northern Gulf of St. Lawrence and Newfoundland	413,351	16.87	23.40
Southern Gulf of St. Lawrence	48,406	1.98	2.74
Scotia-Fundy	110,846	4.52	6.27
Atlantic Seaboard North	174,521	7.12	9.88
Atlantic Seaboard Central	215,090	8.78	12.17
Atlantic Seaboard South	335,878	13.71	19.01
Total without Great Lakes above Niagara Falls	1,766,726	72.09	100.00
Total with Great Lakes above Niagara Falls	2,450,604	100.00	na

Table 4.4.1. Areas (km^2) of aquatic habitat in those parts of the US that drain into the Atlantic Ocean or the St. Lawrence system below Niagara Falls, by RPA zone, as compiled from US Fish and Wildlife Service National Wetlands Inventory (NWI) shapefiles.

Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

				Saline	Riverine tidal		Riverine non-tidal		Lacustrine		Palustrine		Total fresh			Percent of state area		
RPA zone and state	Total area (km^2)	Area within RPA zone	% covered by NWI	intertidal emergent	Non-emergent	Emergent	Non-emergent	Emergent	Non-emergent	Emergent	Non-emergent	Emergent	Non-emergent	Emergent	Total	Non-emergent	Emergent	Total
St. Lawrence Basin (SL)																		
Vermont[1]	24,850.5	13,496.2	100.0	na	na	na	39.3	na	874.7	0.1	38.0	717.8	951.9	717.9	1,669.9	7.1	5.3	12.4
New York																		
As reported	na	na	na	na	na	na	325.0	0.1	1,443.7	2.5	123.5	3,235.7	na	na	na	na	na	na
Adjusted[2]	125,479.8	54,604.9	70.4	na	na	na	461.4	0.2	1,898.5	3.2	175.3	4,593.5	2,535.2	4,596.9	7,132.1	4.6	8.4	13.1
Pennsylvania	117,176.3	248.2	100.0	na	na	na	na	na	na	na	0.5	0.8	0.5	0.8	1.4	0.2	0.3	0.5
Scotia-Fundy (SF)																		
Maine	83,910.0	18,813.2	100.0	na	na	na	96.3	na	391.1	na	38.7	1,633.4	526.0	1,633.4	2,159.5	2.8	8.7	11.5
Atlantic Seaboard North (ASN)																		
Maine	83,910.0	65,096.7	100.0	91.6	35.9	0.3	259.8	0.1	3,399.8	1.0	192.0	6,223.4	3,887.5	6,316.4	10,203.9	6.0	9.7	15.7
New Hampshire	23,951.0	23,951.0	100.0	23.7	0.1	na	86.4	Na	676.5	0.5	106.9	1,023.3	870.0	1,047.5	1,917.5	3.6	4.4	8.0
Vermont	24,850.5	11,354.6	100.0	na	na	na	25.5	na	64.4	na	21.1	213.1	111.0	213.1	324.1	1.0	1.9	2.9
Massachusetts																		
As reported	na	na	na	185.7	3.8	na	109.8	na	509.2	2.4	114.9	1,763.1	na	na	na	na	na	na
Adjusted[3]	20,907.6	20,907.6	98.8	187.9	3.9	0.0	111.1	0.0	515.2	2.4	116.2	1,783.9	746.4	1,974.2	2,720.6	3.6	9.4	13.0
Rhode Island	2,783.7	2,783.7	100.0	15.2	0.1	na	4.2	na	78.8	0.0	19.5	236.3	102.7	251.5	354.2	3.7	9.0	12.7
Connecticut	12,829.1	12,829.1	100.0	49.3	30.1	0.6	29.8	na	152.9	0.7	138.3	598.1	351.1	648.8	999.9	2.7	5.1	7.8
New York																		
As reported	na	na	na	115.8	104.5	0.0	58.9	0.0	444.6	0.3	146.6	1,226.1	na	na	na	na	na	na
Adjusted[4]	125,479.8	37,303.6	72.7	115.8	104.5	0.0	81.0	0.0	611.3	0.4	201.5	1,685.8	998.3	1,802.0	2,800.4	2.7	4.8	7.5
Atlantic Seaboard Central (ASC)																		
New York																		
As reported	na	na	na	na	na	na	67.2	0.5	139.9	0.1	74.7	532.8	na	na	na	na	na	na
Adjusted	125,479.8	22,471.9	93.0	na	na	na	72.3	0.6	150.4	0.1	80.3	572.7	303.0	573.3	876.3	1.3	2.6	3.9
New Jersey	19,477.7	19,477.7	100.0	816.2	63.0	2.7	55.0	0.2	208.5	0.1	107.6	2,794.1	434.2	3,613.2	4,047.4	2.2	18.6	20.8
Pennsylvania	117,176.3	75,210.0	100.0	na	41.4	0.6	432.1	2.1	383.1	0.9	177.5	880.5	1,034.1	884.1	1,918.2	1.4	1.2	2.6
Delaware	5,089.3	5,089.3	100.0	296.5	9.8	na	2.2	na	18.2	0.0	27.2	704.5	57.3	1,001.0	1,058.3	1.1	19.7	20.8
Maryland	25,554.8	24,474.9	100.0	907.5	69.9	6.4	83.8	0.0	70.0	2.2	69.9	1,724.8	293.7	2,640.9	2,934.6	1.2	10.8	12.0
District of Columbia	176.9	176.9	100.0	na	16.5	0.1	0.1	na	1.3	0.1	0.1	0.8	18.0	1.1	19.1	10.2	0.6	10.8
Virginia	103,682.9	58,937.7	100.0	763.397	342.4	3.1	152.6	0.0	247.7	0.4	227.5	2,629.4	970.2	3,396.3	4,366.6	1.6	5.8	7.4
West Virginia	62,705.7	9,251.3	100.0	na	na	na	27.2	0.0	10.6	na	12.5	21.6	50.3	21.7	72.0	0.5	0.2	0.8
Atlantic Seaboard South (ASS)																		
Virginia	103,682.9	26,089.0	100.0	0.0	na	na	40.2	na	297.6	0.4	95.3	1,476.0	433.1	1,476.4	1,909.5	1.7	5.7	7.3
North Carolina	127,954.8	111,812.9	100.0	934.6	86.9	na	293.7	na	1,161.2	5.0	457.8	14,849.4	1,999.5	15,789.0	17,788.5	1.8	14.1	15.9
South Carolina	79,877.5	79,877.5	100.0	1,328.3	115.4	0.0	147.7	na	1,476.3	0.1	300.3	11,310.2	2,039.7	12,638.6	14,678.3	2.6	15.8	18.4
Georgia	152,150.1	78,814.4	100.0	1,448.2	38.9	na	144.3	na	608.1	0.0	460.8	11,285.1	1,252.1	12,733.3	13,985.4	1.6	16.2	17.7
Florida Atlantic	146,330.7	39,284.3	100.0	701.0	169.7	na	154.6	na	1,444.3	na	345.3	7,624.8	2,113.9	8,325.8	10,439.8	5.4	21.2	26.6
Summations by state																		
Maine	83,910.0	83,909.9	100.0	91.6	35.9	0.3	356.1	0.1	3,790.9	1.0	230.6	7,856.8	4,413.5	7,949.9	12,363.4	5.3	9.5	14.7
New Hampshire	23,951.0	23,951.0	100.0	23.7	0.1	0.0	86.4	0.0	676.5	0.5	106.9	1,023.3	870.0	1,047.5	1,917.5	3.6	4.4	8.0
Vermont	24,850.5	24,850.8	100.0	0.0	0.0	0.0	64.8	0.0	939.1	0.1	59.0	930.9	1,062.9	931.0	1,993.9	4.3	3.7	8.0
Massachusetts	20,907.6	20,907.6	100.0	187.9	3.9	0.0	111.1	0.0	515.2	2.4	116.2	1,783.9	746.4	1,974.2	2,720.6	3.6	9.4	13.0
Rhode Island	2,783.7	2,783.7	99.0	15.2	0.1	0.0	4.2	0.0	78.8	0.0	19.5	236.3	102.7	251.5	354.2	3.7	9.0	12.7
Connecticut	12,829.1	12,829.1	100.0	49.3	30.1	0.6	29.8	0.0	152.9	0.7	138.3	598.1	351.1	648.8	999.9	2.7	5.1	7.8
New York	125,479.8	114,380.5	100.0	115.8	104.5	0.0	614.7	0.8	2,660.2	3.7	457.1	6,852.0	3,836.5	6,972.3	10,808.8	3.4	6.1	9.4
New Jersey	19,477.7	19,477.7	100.0	816.2	63.0	2.7	55.0	0.2	208.5	0.1	107.6	2,794.1	434.2	3,613.2	4,047.4	2.2	18.6	20.8
Pennsylvania	117,176.3	75,458.2	100.0	0.0	41.4	0.6	432.1	2.1	383.1	0.9	178.1	881.3	1,034.7	884.9	1,919.6	1.4	1.2	2.5

RPA zone and state	Total area (km²)	Area within RPA zone	% covered by NWI	Saline intertidal emer-gent	Riverine tidal		Riverine non-tidal		Lacustrine		Palustrine		Total fresh			Percent of state area		
					Non-emer-gent	Emer-gent	Non-emer-gent	Emer-gent	Non-emer-gent	Emer-gent	Non-emer-gent	Emer-gent	Non-emer-gent	Emer-gent	Total	Non-emer-gent	Emer-gent	Total
Delaware	5,089.3	5,089.3	100.0	296.5	9.8	0.0	2.2	0.0	18.2	0.0	27.2	704.5	57.3	1,001.0	1,058.3	1.1	19.7	20.8
Maryland	25,554.8	24,474.9	100.0	907.5	69.9	6.4	83.8	0.0	70.0	2.2	69.9	1,724.8	293.7	2,640.9	2,934.6	1.2	10.8	12.0
District of Columbia	176.9	176.9	100.0	0.0	16.5	0.1	0.1	0.0	1.3	0.1	0.1	0.8	18.0	1.1	19.1	10.2	0.6	10.8
Virginia	103,682.9	85,026.6	100.0	763.4	342.4	3.1	192.8	0.0	545.3	0.8	322.8	4,105.4	1,403.4	4,872.7	6,276.1	1.7	5.7	7.4
West Virginia	62,705.7	9,251.3	100.0	0.0	0.0	0.0	27.2	0.0	10.6	0.0	12.5	21.6	50.3	21.7	72.0	0.5	0.2	0.8
North Carolina	127,954.8	111,812.9	100.0	934.6	86.9	0.0	293.7	0.0	1,161.2	5.0	457.8	14,849.4	1,999.5	15,789.0	17,788.5	1.8	14.1	15.9
South Carolina	79,877.5	79,877.5	100.0	1,328.3	115.4	0.0	147.7	0.0	1,476.3	0.1	300.3	11,310.2	2,039.7	12,638.6	14,678.3	2.6	15.8	18.4
Georgia	152,150.1	78,814.4	100.0	1,448.2	38.9	0.0	144.3	0.0	608.1	0.0	460.8	11,285.1	1,252.1	12,733.3	13,985.4	1.6	16.2	17.7
Florida	146,330.7	39,284.3	100.0	701.0	169.7	0.0	154.6	0.0	1,444.3	0.0	345.3	7,624.8	2,113.9	8,325.8	10,439.8	5.4	21.2	26.6
Summations by RPA zone																		
St.Lawrence Basin (SL)		68,349.3		0.0	0.0	0.0	500.7	0.2	2,773.2	3.4	213.8	5,312.1	3,487.7	5,315.6	8,803.3	5.1	7.8	12.9
Scotia-Fundy (SF)		18,813.2		0.0	0.0	0.0	96.3	0.0	391.1	0.0	38.7	1,633.4	526.0	1,633.4	2,159.5	2.8	8.7	11.5
AtlanticSeaboard North (ASN)		174,226.4		483.5	174.6	1.0	597.8	0.1	5,499.0	5.1	795.6	11,763.9	7,067.0	12,253.6	19,320.5	4.1	7.0	11.1
AtlanticSeaboard Central (ASC)		192,617.8		2,783.6	543.1	12.9	753.1	2.4	939.4	3.6	622.5	8,755.8	2,858.1	11,558.3	14,416.3	1.5	6.0	7.5
AtlanticSeaboard South (ASS)		335,878.1		4,412.1	410.8	0.0	780.5	0.0	4,987.5	5.5	1,659.5	46,545.5	7,838.3	50,963.1	58,801.5	2.3	15.2	17.5
AtlanticSeaboard Total		702,722.3		7,679.2	1,128.5	13.9	2,131.5	2.4	11,425.9	14.3	3,077.6	67,065.1	17,763.4	74,774.9	92,538.3	2.5	10.6	13.2
Grand total		789,885		7,679	1,129	14	2,728	3	14,590	18	3,330	74,011	21,777	81,724	103,501	3	10	13

[1] In Vermont, lacustrine non-emergent habitat includes 653.0 km^2 in Lake Champlain and 221.7 km^2 outside Lake Champlain.
[2] The NWI does not cover some parts of New York State. Adjusted habitat areas are calculated as (Habitat area reported by NWI)*100/(Percent of zone that is covered by NWI). Lacustrine areas of Lake Champlain are not subject to this adjustment. Lacustrine non-emergent habitat includes 359.8 km^2 in Lake Champlain and 1,538.7 km^2 outside Lake Champlain. Lacustrine emergent habitat includes 0.6 km^2 in Lake Champlain and 2.6 km^2 outside Lake Champlain. Lake Ontario is not included in lacustrine habitat areas.
[3] The NWI does not cover all parts of Massachusetts. Adjusted habitat areas were calculated as (Habitat area reported by NWI)*100/(Percent of zone that is covered by NWI).
[4] The NWI does not cover all parts of New York State. Adjusted habitat areas were calculated as (Habitat area reported by NWI)*100/(Percent of zone that is covered by NWI). Saline and riverine tidal habitats were not subject to this adjustment because the NWI covered all areas of NY with tidal waters.

Table 4.5.1. Eel catches in 25 research surveys on the east coast of North America.

See Poirier (2013) for data sources. Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Survey	Total eels caught	Total number of sets	Eels caught per set				Sets that caught eels	
			Mean	SD	Min	Max	Number	Percent
NL_T	0	41,636	0.0000	0.0000	0	0	0	0.0000
NGSL_T	6	11,223	0.0005	0.0481	0	5	2	0.0178
SLE_T	10	187	0.0535	0.2256	0	1	10	5.3476
EGSL_LL	0	5,236	0.0000	0.0000	0	0	0	0.0000
SGSL_T	1	5,880	0.0002	0.0130	0	1	1	0.0170
SGSL_BS	524	6,423	0.0816	3.1776	0	252	168	2.6156
NS_T	0	2,573	0.0000	0.0000	0	0	0	0.0000
SS_T	9	13,792	0.0007	0.0390	0	3	5	0.0363
NEF_T	55	32,159	0.0017	0.1149	0	16	24	0.0746
MENH_T	5	2,068	0.0024	0.0491	0	1	5	0.2418
MA_T	18	6,348	0.0028	0.0753	0	4	13	0.2048
NEAMAP_T	25	1,519	0.0165	0.2978	0	8	9	0.5925
RI_T	16	5,274	0.0030	0.0645	0	3	14	0.2655
LIS_T	10	5,966	0.0017	0.0448	0	2	9	0.1509
LI_BS	499	4,234	0.1179	1.1710	0	34	162	3.8262
PB_T	22	7,811	0.0028	0.0576	0	2	20	0.2560
LIA_T	9	543	0.0166	0.1540	0	2	7	1.2891
HE_BS	4,158	12,820	0.3243	1.1009	0	40	2,185	17.0437
NJA_T	39	4,427	0.0088	0.1581	0	8	27	0.6099
NJDB_T	39	1,549	0.0252	0.1798	0	2	33	2.1304
DEDB_T	6,385	8,059	0.7923	3.8211	0	118	1,508	18.7120
VIMS_T,1968-1978	NA	7,309		NA			1,228	16.8012
VIMS_T,1979-2011	NA	28,533		NA			3,378	11.8389
VIMS_T,1968-2011	NA	35,842		NA			4,606	12.8508
NC_T	1,484	24,545	0.0605	0.4130	0	28	1,235	5.0316
SEAMAP_T	0	6,754	0.0000	0.0000	0	0	0	0.0000
GA_T	3	4,220	0.0007	0.0267	0	1	3	0.0711
Total	13,317	251,088	0.0619	0.9987	0	252	10,046	4.0010

Table 4.5.2. Areas (km^2) of aquatic habitat on the east coast of North America between the Strait of Belle Isle and the Florida Keys, by exposure category and tidal zone.

Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

	Sheltered			Semi-exposed			Exposed-Bay			Exposed-Ocean			Total			Yellow
Zone	Inter-tidal	Sub-tidal	Total[1]	Inter-tidal	Sub-tidal	Total[1]	Inter-tidal	Sub-tidal	Total[1]	Inter-tidal	Sub-tidal	Total[1]	Inter-tidal	Sub-tidal	Total	eel habitat[2]
St. Lawrence Basin (SL)																
Quebec	30.6	304.1	319.4	226.4	2,124.7	2,237.9	22.5	169.0	180.3	0	0	0.0	279.6	2,597.8	2,737.6	319.4
Northern Gulf of St. Lawrence and Newfoundland (NG)																
Quebec	374.1	1,219.2	1,406.3	293.6	2,033.7	2,180.5	385.8	136,117.1	136,310.0	0	0	0.0	1,053.6	139,370.0	139,896.8	1,406.3
Newfoundland, Gulf drainage	38.5	252.8	272.0	17.9	1,253.7	1,262.7	15.5	34,739.6	34,747.4	0	0	0.0	71.9	36,246.1	36,282.1	272.0
Newfoundland, Atlantic drainage	78.9	3,325.6	3,365.1	11.5	8,648.7	8,654.4	3.0	27,911.3	27,912.8	5.3	414,973.0	414,975.6	98.6	454,858.7	454,908.0	3,365.1
Saint-Pierre and Miquelon	5.4	16.4	19.1	1.1	129.9	130.4	1.8	1,769.0	1,769.9	0.0	7,658.2	7,658.2	8.3	9,573.5	9,577.7	19.1
Southern Gulf of St. Lawrence (SG)																
New Brunswick	85.4	374.3	417.0	64.0	751.4	783.4	48.4	12,932.1	12,956.3	0	0	0.0	197.8	14,057.8	14,156.7	417.0
Nova Scotia	75.1	138.0	175.5	26.2	381.5	394.6	16.4	14,140.8	14,149.0	0	0	0.0	117.7	14,660.3	14,719.1	175.5
Prince Edward Island	194.7	372.5	469.9	61.5	378.6	409.3	89.4	21,570.2	21,614.8	0	0	0.0	345.6	22,321.3	22,494.1	469.9
Scotia-Fundy (SF)																
New Brunswick	80.8	573.3	613.8	86.0	876.7	919.7	14.6	6,211.2	6,218.5	0	1,243.8	1,243.8	181.4	8,905.0	8,995.7	613.8
Nova Scotia	419.1	1,642.0	1,851.5	466.3	5,433.8	5,666.9	1.4	6,067.7	6,068.4	29.9	194,409.5	194,424.5	916.7	207,553.1	208,011.4	1,851.5
Atlantic Seaboard North (ASN)																
Maine	438.5	1,312.0	1,531.3	40.8	2,150.3	2,170.6	2.1	511.1	512.2	16.1	36,816.7	36,824.7	497.5	40,790.1	41,038.8	1,531.3
New Hampshire	8.9	37.1	41.6	0	0	0.0	0	0	0.0	2.5	359.6	360.9	11.5	396.7	402.4	41.6
Massachusetts	68.8	390.8	425.1	39.0	1,357.8	1,377.3	21.9	5,385.2	5,396.1	5.7	87,422.0	87,424.9	135.3	94,555.7	94,623.4	425.1
Rhode Island	10.0	334.1	339.1	1.0	195.4	195.9	0.6	1,480.7	1,481.0	0	4,654.0	4,654.0	11.6	6,664.1	6,669.9	339.1
Connecticut	14.4	117.2	124.4	5.4	1,371.0	1,373.8	0	0	0.0	0	0	0.0	19.9	1,488.2	1,498.1	124.4
New York	14.0	1,065.4	1,072.4	4.7	2,106.2	2,108.6	5.4	1,352.2	1,354.8	2.7	22,093.6	22,094.9	26.8	26,617.3	26,630.7	1,072.4
Atlantic Seaboard Central (ASC)l																
New Jersey Atlantic	6.66	605.80	609.1	2.41	161.82	163.0	1.21	907.02	907.6	6.24	27,461.67	27,464.8	16.5	29,136.3	29,144.6	609.1
New Jersey Delaware Bay																
<2.5 km of land	2.22	47.94	49.1	2.17	110.69	111.8	0	168.5	168.5	0	0	0.0	4.40	324.9	329.3	49.1
>2.5 km of land	0	0	0.0	0	43.3	43.3	0	617.3	617.3	0	0	0.0	0	660.6	660.6	0.0
New Jersey Total	8.9	653.7	658.2	4.6	315.8	318.1	1.2	1,692.8	1,693.4	6.2	27,461.7	27,464.8	20.9	30,124.0	30,134.5	658.2
Pennsylvania	0.2	2.6	2.7	0	0	0.0	0	0	0.0	0	0	0.0	0.2	2.6	2.7	2.7
Delaware Atlantic	0.2	89.4	89.5	0	0	0.0	0.8	287.0	287.5	0.1	1,626.7	1,626.7	1.1	2,003.1	2,003.7	89.5
Delaware Bay																
<2.5 km of land	1.5	103.9	104.7	0.4	146.8	146.9	1.2	141.1	141.7	0	0	0.0	3.1	391.8	393.3	251.6
>2.5 km of land	0	0	0.0	0	29.3	29.3	0	591.1	591.1	0	0	0.0	0	620.4	620.4	0.0
Delaware Total	1.7	193.3	194.2	0.4	176.0	176.2	2.0	1,019.3	1,020.3	0.1	1,626.7	1,626.7	4.2	3,015.3	3,017.4	341.1
Maryland Atlantic	2.7	278.3	279.6	0	0	0.0	0	0	0.0	1.3	9,338.6	9,339.2	4.0	9,616.8	9,618.8	279.6
Chesapeake Bay Proper	0.0	0.0	0.0	5.5	1,947.1	1,949.8	0.6	944.7	945.0	0	0	0.0	6.1	2,891.8	2,894.8	0.0
Chesapeake Bay Tribs	53.7	997.1	1,024.0	20.1	2,016.3	2,026.4	0.0	0	0.0	0	0	0.0	73.9	3,013.5	3,050.4	3,050.4
Maryland Total	56.5	1,275.4	1,303.6	25.6	3,963.4	3,976.2	0.6	944.7	945.0	1.3	9,338.6	9,339.2	83.9	15,522.1	15,564.0	3,330.0
Virginia Atlantic	338.4	326.4	495.6	19.8	39.8	49.7	1.9	378.8	379.7	3.4	15,102.7	15,104.4	363.4	15,847.8	16,029.5	495.6
Chesapeake Bay Proper	0	0	0.0	12.1	387.1	393.1	16.8	3,071.9	3,080.3	0	0	0.0	28.9	3,459.0	3,473.5	0.0
Chesapeake Bay Tribs	66.8	958.0	991.4	9.5	646.8	651.6	0.2	17.5	17.6	0	0	0.0	76.5	1,622.4	1,660.6	1,660.6
Virginia Total	405.2	1,284.5	1,487.1	41.4	1,073.8	1,094.4	18.9	3,468.2	3,477.7	3.4	15,102.7	15,104.4	468.8	20,929.2	21,163.6	2,156.2
Atlantic Seaboard South (ASS)																
North Carolina	61.6	1,417.3	1,448.1	79.9	6,880.0	6,919.9	0	0	0.0	16.4	54,377.7	54,385.9	157.9	62,675.0	62,753.9	1,448.1
South Carolina	72.2	730.3	766.4	10.2	330.6	335.7	0	0	0.0	17.1	40,233.6	40,242.2	99.5	41,294.5	41,344.2	766.4
Georgia	16.9	455.7	464.2	2.8	199.0	200.4	0	0	0.0	10.8	18,476.7	18,482.1	30.4	19,131.4	19,146.7	464.2
Florida Atlantic	41.4	1,616.7	1,659.2	14.7	426.6	433.9	0	0	0.0	61.1	59,062.9	59,093.4	117.1	61,106.2	61,186.6	1,659.2
Summations																
St. Lawrence Basin (SL)	30.6	304.1	319.4	226.4	2,124.7	2,237.9	22.5	169.0	180.3	0.0	0.0	0.0	279.6	2,597.8	2,737.6	319.4
Northern Gulf and Newfoundland (NG)	497.0	4,814.0	5,062.5	324.1	12,066.0	12,228.1	406.1	200,537.1	200,740.1	5.3	422,631.2	422,633.9	1,232.4	640,048.3	640,664.5	5,062.5

Zone	Sheltered			Semi-exposed			Exposed-Bay			Exposed-Ocean			Total			Yellow eel habitat[2]
	Inter-tidal	Sub-tidal	Total[1]	Inter-tidal	Sub-tidal	Total[1]	Inter-tidal	Sub-tidal	Total[1]	Inter-tidal	Sub-tidal	Total[1]	Inter-tidal	Sub-tidal	Total	
Southern Gulf of St. Lawrence (SG)	355.2	884.8	1,062.4	151.7	1,511.5	1,587.3	154.2	48,643.1	48,720.2	0.0	0.0	0.0	661.1	51,039.4	51,369.9	1,062.4
Scotia-Fundy (SF)	499.9	2,215.3	2,465.3	552.3	6,310.5	6,586.7	16.0	12,279.0	12,287.0	29.9	195,653.3	195,668.2	1,098.1	216,458.1	217,007.1	2,465.3
Atlantic Seaboard North (ASN)	554.6	3,256.5	3,533.8	90.9	7,180.7	7,226.1	30.0	8,729.2	8,744.1	27.1	151,345.9	151,359.4	702.5	170,512.2	170,863.4	3,533.8
Atlantic Seaboard Central (ASC)	472.4	3,409.6	3,645.8	71.9	5,529.0	5,564.9	22.8	7,125.0	7,136.4	11.0	53,529.6	53,535.1	578.1	69,593.2	69,882.2	6,488.3
Atlantic Seaboard South (ASS)	192.0	4,220.1	4,316.1	107.5	7,836.1	7,889.9	0.0	0.0	0.0	105.4	172,150.9	172,203.5	404.9	184,207.1	184,409.6	4,337.9
Canada and SPM	1,382.7	8,218.2	8,909.6	1,254.5	22,012.6	22,639.9	598.8	261,628.1	261,927.5	35.1	618,284.5	618,302.1	3,271.2	910,143.6	911,779.1	8,909.6
US	1,219.0	10,886.2	11,495.7	270.3	20,545.8	20,680.9	52.8	15,854.2	15,880.6	143.4	377,026.3	377,098.0	1,685.5	424,312.4	425,155.2	14,360.0
Total	2,601.7	19,104.4	20,405.3	1,524.8	42,558.4	43,320.8	651.5	277,482.3	277,808.1	178.6	995,310.8	995,400.1	4,956.7	1,334,456.0	1,336,934.3	23,269.6

[1] Total areas are calculated as (Intertidal area/2)+(Subtidal area)

[2] For Delaware, yellow eel habitat is considered to be the total of sheltered and semi-exposed habitat in Delaware Bay <2.5 km from land, and sheltered habitat in the Atlantic and in Delaware Bay >2.5 km from land. For Maryland and Virginia, yellow eel habitat is considered to be the total of all habitat in Chesapeake Bay Tribs, and the total of sheltered habitat in the Atlantic and Chesapeake Bay Proper districts. For other provinces and states, yellow eel habitat is considered to be the total of sheltered habitat.

Table 4.5.3. Number of fishing locations, including commercial and recreational fisheries, for yellow and silver American eels in eastern Canada and St. Pierre and Miquelon, by geographic sector and exposure category.

Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

	Brackish and salt waters								Fresh waters		All waters
	Sheltered		Semi-exposed		Exposed		Total				
Area	Number	%[1]	Number	%[1]	Number	%[1]	Number	%[2]	Number	%[2]	Number
St. Lawrence Estuary	4	17.4	19	82.6	0	0.0	23	100.0	0	0.0	23
Gulf of St. Lawrence	2,763	94.8	150	5.1	2	0.1	2,915	99.3	21	0.7	2,936
St. Lawrence Estuary and Gulf	2,767	94.2	169	5.8	2	0.1	2,938	99.3	21	0.7	2,959
Quebec-Gulf	62	100.0	0	0.0	0	0.0	62	100.0	0	0.0	62
Quebec-total	66	77.6	19	22.4	0	0.0	85	100.0	0	0.0	85
New Brunswick-Gulf	935	86.3	148	13.7	0	0.0	1,083	98.9	12	1.1	1,095
Nova Scotia-Gulf	194	99.5	1	0.5	0	0.0	195	97.0	6	3.0	201
Prince Edward Island	1,559	99.9	0	0.0	2	0.1	1,561	99.9	1	0.1	1,562
Maritime Provinces-Gulf	2,688	94.7	149	5.2	2	0.1	2,839	99.3	19	0.7	2,858
Newfoundland-Gulf	13	92.9	1	7.1	0	0.0	14	87.5	2	12.5	16
Newfoundland-Atlantic	52	86.7	4	6.7	4	6.7	60	85.7	10	14.3	70
Newfoundland-total	65	87.8	5	6.8	4	5.4	74	86.0	12	14.0	86
Nova Scotia - Atlantic-Fundy	86	88.7	11	11.3	0	0.0	97	74.6	33	25.4	130
Scotia-Fundy	92	88.5	12	11.5	0	0.0	104	68.9	47	31.1	151
Nova Scotia-total	280	95.9	12	4.1	0	0.0	292	88.2	39	11.8	331
New Brunswick-total	941	86.3	149	13.7	0	0.0	1,090	97.7	26	2.3	1,116
Atlantic-Fundy	144	87.8	16	9.8	4	2.4	164	74.2	57	25.8	221
Gulf of St. Lawrence and Atlantic-Fundy	2,907	94.4	166	5.4	6	0.2	3,079	97.5	78	2.5	3,157
Canada	2,911	93.8	185	6.0	6	0.2	3,102	97.5	78	2.5	3,180

[1] Percent of locations in brackish and salt waters
[2] Percent of locations in all waters

Table 5.1.1a. Landings (t) of American eels from 1884 to 1916 from Lake Ontario, the only jurisdiction for which landings are reported.

Acronym SL refers to the RPA zone. Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	SL Ontario 1	SL New York State Lake Ontario 2
1884	2.5	na
1885	4.0	27.7
1886	8.8	na
1887	6.5	na
1888	4.2	na
1889	6.2	na
1890	8.5	116.6
1891	9.3	na
1892	19.8	na
1893	30.8	na
1894	35.4	na
1895	26.6	na
1896	32.6	na
1897	14.3	29.9
1898	18.9	na
1899	15.8	56.2
1900	18.3	na
1901	30.4	na
1902	29.6	na
1903	16.6	33.6
1904	20.7	na
1905	8.8	na
1906	8.3	na
1907	9.3	na
1908	10.2	20.0
1909	29.7	na
1910	47.6	na
1911	62.9	na
1912	102.2	na
1913	86.8	36.7
1914	136.0	4.1
1915	99.7	0.5
1916	64.8	1.8

1 Data as compiled by Cairns et al. (2008)
2 Data for 1884-1997 are from Baldwin et al. (1979).

Table 5.1.1b. Landings (t) of American eels from 1917 to 1953 from jurisdictions for which landings are reported.

"na" means data are not available. Canada Total includes landings from New York Lake Ontario. Acronyms SL, NG, SG, and SF refer to RPA zones. Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	SL Ontario [1]	SL New York Lake Ontario [2]	SL Quebec yellow [1]	SL Quebec silver [1]	NG Newfoundland Gulf drainage [3]	NG Newfoundland Atlantic drainage [3]	SG New Brunswick [1]	SG Nova Scotia [1]	SG Prince Edward Island [1]	SF large eel New Brunswick [4]	SF large eel Nova Scotia [4]	Canada Total
1917	57.2	na	na	na	na	na	51.0	12.6	0.0	33.6	12.6	0.0
1918	61.9	na	na	na	na	na	61.8	13.1	0.0	14.5	1.4	0.0
1919	75.9	na	na	na	na	na	75.1	6.3	0.0	16.1	0.5	0.0
1920	41.7	na	8.1	266.5	0.0	0.0	24.2	10.7	0.0	31.4	2.7	386.6
1921	50.9	na	9.8	300.3	0.0	0.0	40.7	14.8	0.0	28.3	5.6	466.7
1922	66.6	na	24.1	426.4	0.0	0.0	14.0	7.5	0.0	15.4	0.0	575.3
1923	56.2	na	55.2	500.0	0.0	0.0	10.2	0.7	0.0	22.3	0.0	664.2
1924	54.3	na	79.9	456.8	0.0	0.0	10.0	7.5	0.0	29.5	3.6	660.3
1925	68.8	na	45.2	486.9	0.0	0.0	18.4	4.3	0.0	27.1	2.7	653.5
1926	52.2	na	51.6	900.3	0.0	0.0	5.4	5.7	0.0	32.7	1.4	1049.3
1927	48.7	na	48.9	550.0	0.0	0.0	1.4	3.5	0.0	21.8	5.7	680.0
1928	41.0	na	68.3	913.5	0.0	0.0	16.3	6.6	0.0	64.9	17.2	1127.8
1929	33.6	27.2	46.6	474.1	0.0	0.0	5.2	4.5	0.0	59.2	5.9	656.3
1930	43.8	2.3	66.5	511.0	0.0	0.0	11.8	15.2	0.0	30.2	3.6	684.4
1931	32.8	20.4	76.1	692.8	0.0	0.0	18.8	11.9	0.0	35.0	2.5	890.2
1932	22.5	20.0	88.1	754.8	0.0	0.0	9.1	13.8	0.0	31.3	2.5	942.0
1933	28.7	18.1	96.6	991.2	0.0	0.0	11.0	16.7	0.0	38.0	2.3	1202.6
1934	22.4	29.5	102.8	905.5	0.0	0.0	11.3	5.8	0.0	42.1	2.5	1121.9
1935	27.0	20.9	100.9	906.9	0.0	0.0	7.6	5.2	0.0	34.6	2.3	1105.5
1936	23.9	20.0	96.6	872.4	0.0	0.0	4.4	4.1	0.0	21.5	3.5	1046.3
1937	29.9	4.5	56.6	768.0	0.0	0.0	5.7	4.2	0.0	34.8	5.3	909.1
1938	19.2	20.0	59.1	777.6	0.0	0.0	9.4	9.7	0.0	31.6	30.0	956.5
1939	10.3	16.8	38.1	729.7	0.0	0.0	11.0	8.7	0.0	43.7	19.5	877.7
1940	14.6	14.5	21.3	377.2	0.0	0.0	4.8	10.6	0.0	36.8	16.6	496.4
1941	7.4	na	16.7	115.1	0.0	0.0	3.6	3.4	0.0	38.3	16.1	200.6
1942	7.1	8.2	27.4	440.9	0.0	0.0	12.5	4.8	0.0	39.2	16.3	556.3
1943	15.7	10.0	50.7	584.5	0.0	0.0	14.1	5.0	0.0	38.0	11.6	729.6
1944	18.1	5.4	20.5	272.1	0.0	0.0	13.9	6.9	0.0	37.7	9.5	384.1
1945	19.7	8.6	39.2	345.7	0.0	0.0	14.5	10.7	0.0	35.5	8.9	482.8
1946	15.7	11.3	23.4	297.6	0.0	0.0	29.1	16.7	0.0	25.6	11.3	430.8
1947	15.1	11.3	22.2	299.5	0.0	0.0	31.8	13.6	0.9	22.2	3.2	419.8
1948	18.0	7.7	11.8	210.3	0.0	0.0	29.0	8.7	10.0	20.9	10.0	326.3
1949	20.9	9.1	9.3	175.0	0.0	0.0	29.4	37.6	3.6	53.5	20.0	358.4
1950	13.0	0.5	10.0	288.8	0.0	0.0	22.2	23.6	2.3	24.5	20.4	405.3
1951	21.6	10.9	11.6	338.8	0.0	0.0	15.5	20.9	3.6	30.8	3.2	456.9
1952	29.4	8.2	12.9	378.1	0.0	0.0	15.8	11.9	5.0	30.8	8.6	500.7
1953	25.8	0.9	12.5	390.1	0.0	0.0	13.1	7.7	6.3	35.0	21.0	512.4

[1] Data as compiled by Cairns et al. (2008)
[2] Data for 1917-1953 are from Baldwin et al. (1979)
[3] Data are for the Island of Newfoundland only. Data for 1920-1951 are from Eales (1968). Data for 1952-1953 are from the Newfoundland and Labrador Statistics Agency's Historical Statistics of Newfoundland and Labrador Vol. 1 (http://www.stats.gov.nl.ca/publications/Historical/PDF/SectionK.pdf).
[4] Data from 1917 to 1951 are from Fisheries Statistics of Canada. Data for 1952-1953 are from Jessop (1996).

Table 5.1.1c. Landings (t) of American eels from 1954 to 1989 from jurisdictions for which landings are reported.

"na" means data are not available. Canada Total includes landings from New York Lake Ontario. Acronyms SL, NG, SG, and SF refer to RPA zones. Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	SL Ontario [1]	SL New York Lake Ontario [2]	SL Quebec yellow [1]	SL Quebec silver [1]	NG Newfoundland Gulf drainage [3]	NG Newfoundland Atlantic drainage [3]	SG New Brunswick [1]	SG Nova Scotia [1]	SG Prince Edward Island [1]	SF large eel New Brunswick [4]	SF large eel Nova Scotia [4]	Canada Total
1954	35.4	4.1	14.5	337.6	0.0	0.0	33.1	6.4	3.7	46.8	9.5	491.1
1955	30.8	4.5	18.9	381.5	0.0	1.8	48.6	10.5	9.1	54.1	39.6	599.5
1956	18.8	4.5	14.2	380.0	0.0	0.0	10.5	14.6	4.6	42.8	2.4	492.4
1957	45.0	10.0	15.0	545.5	0.0	0.0	8.6	10.1	12.3	13.7	5.0	665.1
1958	53.5	12.7	22.6	454.4	0.0	0.0	14.5	14.1	18.7	33.9	6.6	631.1
1959	55.8	9.5	20.5	367.7	0.0	0.0	23.6	11.4	26.4	19.6	0.0	534.5
1960	50.0	12.7	20.3	441.8	0.0	0.0	30.9	23.6	31.9	17.9	0.0	629.1
1961	59.1	13.6	22.7	358.8	0.3	0.0	57.4	27.8	17.7	20.9	7.4	585.7
1962	49.2	10.9	29.1	354.2	0.0	23.5	81.9	26.4	13.1	16.8	8.2	613.3
1963	76.9	8.6	28.7	439.6	0.0	37.0	53.7	23.6	15.9	31.4	13.1	728.5
1964	111.5	15.0	30.2	417.0	1.0	12.0	56.4	18.8	34.2	20.5	9.2	725.7
1965	85.6	11.3	29.9	517.9	0.0	3.3	62.6	16.3	48.6	13.7	5.3	794.5
1966	64.9	15.9	28.5	459.4	0.0	0.0	99.2	15.0	32.8	18.2	19.7	753.6
1967	61.5	15.4	27.3	408.2	0.0	0.0	108.0	52.3	61.8	9.1	4.1	747.8
1968	78.4	33.6	30.2	467.5	0.0	0.0	150.6	28.3	130.7	15.3	12.3	947.0
1969	76.7	17.2	27.6	485.1	0.0	0.0	214.2	38.1	194.5	19.4	60.4	1133.2
1970	66.1	22.7	9.8	303.9	0.0	0.0	294.7	45.4	239.9	12.3	54.3	1049.1
1971	76.2	17.2	5.8	307.4	43.0	1.0	319.4	52.1	351.4	35.8	63.5	1272.8
1972	123.1	11.3	30.2	278.6	79.0	0.0	272.8	50.3	272.8	11.2	34.1	1163.4
1973	85.4	18.1	22.3	278.5	27.0	4.0	220.4	28.0	157.2	11.1	27.1	879.2
1974	100.7	23.1	28.4	360.2	21.0	0.0	156.2	28.3	101.2	8.6	20.9	848.6
1975	167.6	13.6	27.0	497.8	7.4	0.5	120.8	28.6	103.5	13.9	51.9	1032.7
1976	155.2	16.3	34.1	383.8	6.7	4.6	118.7	18.0	94.1	9.5	78.2	919.3
1977	187.9	na	24.2	482.7	7.7	11.6	110.1	5.9	97.6	9.0	99.9	1036.6
1978	230.5	19.1	28.8	496.6	14.5	1.2	81.6	12.3	113.6	52.8	44.8	1095.8
1979	223.3	18.1	28.2	477.2	19.7	3.7	102.4	12.6	111.0	20.8	120.3	1137.3
1980	165.3	29.9	25.2	570.2	70.5	12.2	150.4	9.5	120.1	41.8	24.8	1220.0
1981	108.8	43.1	30.9	569.1	31.2	10.4	191.2	7.5	220.0	20.1	35.5	1267.8
1982	29.3	35.8	24.6	356.6	21.1	15.6	159.2	11.3	167.6	14.5	3.3	838.9
1983	76.2	0.5	24.6	327.2	19.3	8.7	97.4	9.6	150.5	19.5	0.2	733.6
1984	123.4	0.5	30.8	380.9	1.9	12.1	122.4	8.9	164.6	8.0	2.8	856.2
1985	104.8	cl	0.0	389.5	11.2	9.5	202.4	5.1	139.4	6.3	74.4	942.6
1986	117.0	cl	27.4	412.9	15.3	11.2	230.2	15.6	226.0	5.7	54.5	1115.8
1987	103.7	cl	20.7	398.5	6.7	23.9	171.6	13.2	149.9	15.0	48.6	951.8
1988	106.1	cl	19.9	404.2	3.0	57.9	233.5	24.7	124.7	14.3	134.9	1123.3
1989	122.5	0.5	27.8	402.3	41.9	41.5	209.0	30.2	69.5	6.0	116.4	1067.5

[1] Data as compiled by Cairns et al. (2008)

[2] Data for 1954-1977 are from Baldwin et al. (1979). Data for 1978 and later are from Lary and Busch (1997). The New York Lake Ontario fishery was closed in 1983, 1984, and 1989, but small harvests were reported for those years.

[3] Data are for the Island of Newfoundland only. Data for 1954 are from the Newfoundland and Labrador Statistics Agency's Historical Statistics of Newfoundland and Labrador Vol. 1. Data for 1955-1961 are from Fisheries Statistics of Canada. Data for 1961-1989 are from Knight (1997).

[4] Data from 1954-1974 are from Jessop (1996). . Data for 1975-1989 are from DFO Maritimes Region files.

Table 5.1.1d. Landings (t) of American eels from 1990 to 2012 from jurisdictions for which landings are reported.

"na" means data are not available. "cl" means the fisheries were closed. Canada Total includes landings from New York Lake Ontario, Saint-Pierre et Miquelon (SPM) and elver landings from Scotia-Fundy. Acronyms SL, NG, SG, and SF refer to RPA zones. Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	SL Ontario [1]	SL New York Lake Ontario [2]	SL Quebec yellow [1,3]	SL Quebec silver [1,3]	NG Magdalene Islands	NG Newfound-land Gulf drainage [4]	NG Newfound-land Atlantic drainage [4]	NG SPM [5]	SG New Bruns-wick [1]	SG Nova Scotia [1]	SG Prince Edward Island [1]	SF large eel New Bruns-wick [6]	SF large eel Nova Scotia [6]	SF Elver [6]	Canada Total
1990	120.0	cl	33.8	439.9	na	70.1	76.8	na	149.3	20.8	123.8	4.8	90.7	0.17	1130.1
1991	117.9	cl	30.5	364.1	na	77.7	56.2	0.0	130.2	34.8	126.6	39.2	87.5	0.07	1064.8
1992	124.0	cl	24.7	297.6	na	51.5	38.5	0.0	119.6	56.0	54.0	61.7	59.0	0.23	886.8
1993	105.8	cl	21.0	309.0	na	60.8	55.1	0.0	88.3	89.2	74.0	71.4	115.9	0.71	991.2
1994	83.0	cl	20.9	261.5	na	53.1	57.9	0.0	68.1	42.3	45.8	99.5	131.0	1.57	864.7
1995	62.7	cl	23.0	255.4	na	42.1	43.3	0.0	60.2	16.3	34.6	116.0	113.7	3.24	770.5
1996	57.2	cl	30.0	214.3	na	37.5	56.9	0.0	48.7	11.4	36.0	69.8	101.7	2.86	666.4
1997	41.1	cl	26.9	174.7	na	27.0	44.7	1.8	36.4	17.2	31.3	60.5	110.2	4.13	575.8
1998	19.4	cl	23.4	204.8	na	23.9	49.0	0.0	49.2	15.0	23.6	73.3	87.7	2.05	571.3
1999	19.0	cl	19.9	157.9	na	14.7	40.2	0.0	47.2	9.0	35.3	75.6	119.1	0.48	538.4
2000	27.5	cl	37.4	154.8	na	21.5	48.3	0.0	76.4	6.9	63.5	90.0	69.0	0.68	595.9
2001	26.4	cl	34.6	139.2	na	9.9	26.8	0.0	92.2	3.4	41.2	68.5	64.3	1.84	508.3
2002	11.1	cl	34.9	132.9	na	33.6	31.9	0.0	129.0	4.2	86.4	52.3	63.3	2.40	582.0
2003	13.2	cl	31.2	106.3	na	43.0	32.9	0.0	139.6	9.1	71.3	35.0	59.0	1.85	542.5
2004	0.1	cl	37.8	103.2	na	35.1	29.0	0.0	123.1	4.4	69.0	57.7	55.8	1.51	516.7
2005	cl	cl	20.8	98.0	na	38.7	32.4	0.0	102.3	7.0	81.5	46.2	45.9	3.04	475.8
2006	cl	cl	10.0	98.8	na	44.8	35.2	0.0	100.5	9.9	87.4	64.7	48.7	2.46	502.6
2007	cl	cl	6.6	81.4	4.0	32.8	33.2	0.0	115.5	9.3	94.4	28.1	20.6	2.03	428.0
2008	cl	cl	3.0	72.6	na	25.9	19.5	0.0	99.2	11.2	44.4	na	na	3.59	275.9
2009	cl	cl	2.8	54.9	na	22.9	19.5	0.0	111.4	1.1	56.6	na	na	1.42	269.1
2010	cl	cl	3.0	51.3	na	37.4	14.7	0.0	93.9	20.4	70.5	5.6	15.4	1.26	313.5
2011	cl	cl	2.6	53.0	na	29.9	21.9	na	110.6	8.9	100.1	4.7	7.8	4.42	343.9
2012	cl	cl	na	na	na	37.7	26.2	na	152.8	8.0	127.3	na	na	4.19	na

[1] Data compiled by Cairns et al. (2008)
[2] Data for 1990 and later are from Lary and Busch (1997).
[3] Data for 2006-2009 are from COSEWIC (2012). Data for 2010 are from ICES (2011). Data for 2011 are from G. Verreault, Quebec MNR.
[4] Data are for the Island of Newfoundland only. 0.1 t were reported landed in Labrador in 1993 (Cairns et al. 2008). Data for 1990-1995 are from Knight (1997). Data for 1996-2010 are from DFO Newfoundland and Labrador Region files.
[5] Saint-Pierre and Miquelon data from Gilly (2010)
[6] Data 1990-2012 are from DFO Maritimes Region files.

Table 5.2.1. Landings (t) of American eels on the Atlantic Seaboard and US states of the Gulf of Mexico, 1950-2011.

Landings are from NOAA National Marine Fisheries Service. No landings reported from Pennsylvania, Alabama and Mississippi. Acronyms ASN, ASC, and ASS refer to RPA zones. The acronym GoM refers to the Gulf of Mexico. Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	ASN Maine	ASN New Hampshire	ASN Massachusetts	ASN Rhode Island	ASN Connecticut	ASN New York	ASC New Jersey	ASC Delaware	ASC Maryland	ASC Virginia	ASS North Carolina	ASs South Carolina	ASC Georgia	ASS Florida – East coast	ASS Florida - Inland	GoM Florida – West coast	GoM Louisiana	GoM Texas	US Total
1950	17.2	0.0	7.9	15.1	6.8	123.7	34.6	15.4	422.8	227.5	79.2	0.0	0.0	4.4	0.0	0.6	0.0	0.0	955.2
1951	24.0	0.0	11.2	15.2	5.8	170.6	19.5	2.4	370.1	192.4	14.8	0.0	0.0	7.2	0.0	0.3	0.0	0.0	833.5
1952	19.1	0.0	11.9	6.9	8.3	78.3	22.4	15.5	381.6	167.1	17.5	0.0	0.0	5.5	0.0	0.0	0.0	0.0	734.1
1953	18.5	0.0	11.3	14.8	11.4	66.1	23.4	18.8	302.2	145.0	23.8	0.0	0.8	3.1	0.0	1.3	0.0	0.0	640.5
1954	5.2	0.0	9.8	6.9	11.4	85.4	30.8	16.4	165.7	190.5	16.8	0.0	0.8	2.0	0.0	3.9	0.0	0.0	545.6
1955	14.8	2.7	10.2	8.5	5.9	117.4	42.2	4.9	203.0	193.0	20.5	0.0	0.0	2.6	0.0	2.3	0.0	0.0	628.0
1956	13.3	2.3	7.0	9.4	8.5	111.4	26.7	6.8	211.6	203.3	51.3	0.0	0.2	2.3	0.0	2.4	0.0	0.0	656.5
1957	8.9	4.1	4.5	4.8	11.4	102.6	34.7	17.4	192.6	155.7	28.6	0.0	3.0	3.5	0.0	0.2	0.0	0.0	572.0
1958	9.7	3.4	8.3	9.4	9.4	135.0	28.3	11.7	182.2	190.3	39.4	0.0	0.1	3.0	0.0	0.2	0.0	0.0	630.4
1959	7.6	2.3	6.0	11.7	7.4	117.3	28.1	12.0	126.5	238.6	45.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	603.1
1960	13.8	2.7	16.2	19.6	8.5	116.3	18.8	2.9	88.5	87.2	29.9	0.0	0.4	0.0	0.0	0.0	0.0	0.0	404.8
1961	14.5	2.3	8.9	20.4	6.0	110.5	13.8	2.5	72.3	102.0	25.7	0.0	0.7	0.0	0.0	0.0	0.0	0.0	379.6
1962	16.1	2.9	7.3	15.0	8.1	58.7	10.1	4.3	51.8	96.3	19.6	0.0	0.1	0.0	0.0	0.0	0.0	0.0	290.3
1963	16.9	2.3	11.0	16.3	6.9	91.7	10.8	5.4	60.3	199.9	17.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	439.5
1964	10.4	2.3	8.0	14.2	8.2	78.8	35.7	5.4	84.4	142.3	24.0	0.0	2.5	55.4	0.0	0.0	0.0	0.0	471.6
1965	23.6	2.3	9.4	8.5	5.3	120.3	41.5	15.4	88.4	336.6	18.1	0.0	2.1	31.8	0.0	5.7	0.0	0.0	709.0
1966	22.1	3.2	11.2	11.3	3.9	77.2	65.2	14.5	100.8	212.7	24.7	18.7	0.4	13.8	0.0	0.0	0.0	0.0	579.7
1967	22.1	3.2	18.1	14.3	6.4	66.8	80.2	14.7	124.3	313.3	10.5	34.6	1.9	12.3	0.0	1.8	0.0	0.0	724.5
1968	29.7	16.4	20.5	17.6	19.1	65.7	53.0	16.0	120.2	321.9	11.1	55.2	0.7	21.6	0.0	0.4	0.0	0.0	769.1
1969	17.2	2.1	22.2	21.0	7.9	78.6	112.5	20.0	141.9	345.6	8.0	42.6	0.0	26.9	0.0	2.5	0.0	0.0	849.0
1970	17.1	2.5	25.6	16.6	22.5	62.7	95.0	26.4	131.0	546.5	7.0	10.0	2.4	13.6	0.0	0.0	0.0	0.0	978.9
1971	24.7	3.2	34.7	17.6	19.9	73.8	104.6	45.2	106.2	554.7	75.8	25.6	3.0	17.4	0.0	2.4	0.0	0.0	1,108.8
1972	31.8	2.4	25.1	10.3	21.7	67.5	118.9	20.4	104.3	222.9	35.1	19.1	4.8	27.7	0.0	0.0	0.0	0.0	712.0
1973	34.5	2.5	17.9	8.0	12.1	51.6	104.7	27.4	81.8	115.5	60.6	31.9	5.1	37.1	0.0	0.0	0.0	0.0	590.7
1974	36.1	2.4	79.9	9.7	5.1	43.2	98.1	30.6	65.9	659.1	205.0	6.8	3.5	142.2	0.0	0.0	0.0	0.0	1,387.6
1975	70.2	2.5	226.3	10.0	19.1	46.1	100.5	29.2	93.0	586.9	107.7	13.5	4.3	297.7	0.0	0.0	0.0	0.0	1,607.0
1976	86.6	2.8	138.2	8.9	16.1	55.2	92.3	36.7	74.9	257.2	231.3	7.9	2.0	105.9	0.0	0.3	0.0	0.0	1,116.3
1977	79.7	2.5	143.2	10.6	7.5	42.8	56.9	43.5	82.6	162.7	117.2	6.2	1.1	196.5	0.0	0.0	0.0	0.0	953.0
1978	60.6	2.0	150.4	11.9	11.5	48.2	53.9	85.3	93.5	527.7	315.5	11.4	1.6	241.7	0.0	0.0	0.0	0.0	1,615.2
1979	50.4	1.9	135.8	10.2	12.3	44.0	52.8	85.3	121.7	544.6	433.0	4.5	3.9	144.7	147.4	0.0	0.0	0.0	1,792.5
1980	47.9	2.7	114.7	10.0	10.9	209.0	38.1	60.3	146.2	193.2	435.5	0.0	45.1	51.7	90.7	2.9	0.0	0.0	1,458.9
1981	25.0	3.0	97.0	8.2	10.0	154.9	53.1	90.4	330.0	342.1	197.8	0.0	5.8	51.6	0.0	0.5	0.0	0.0	1,369.4
1982	20.5	3.2	60.1	4.9	8.8	83.2	109.9	61.9	38.3	323.9	215.7	0.0	16.6	30.4	24.5	0.0	3.5	0.0	1,005.4
1983	5.4	1.7	27.7	4.8	0.9	26.4	136.0	47.7	41.7	313.3	183.3	0.0	0.0	0.1	40.4	0.9	9.0	0.0	839.3

Year	ASN Maine	ASN New Hamp-shire	ASN Mass-achu-setts	ASN Rhode Island	ASN Con-necti-cut	ASN New York	ASC New Jersey	ASC Dela-ware	ASC Mary-land	ASC Virginia	ASS North Carolina	ASs South Carol-ina	ASC Geor-gia	ASS Florida – East coast	ASS Florida - Inland	GoM Florida – West coast	GoM Loui-siana	GoM Texas	US Total
1984	0.0	1.3	14.9	2.8	3.4	48.2	242.0	56.4	49.7	356.7	320.4	0.0	0.0	0.0	17.7	0.7	2.7	0.1	1,117.0
1985	10.9	1.0	11.6	3.9	2.1	54.1	153.0	60.3	39.0	359.0	101.7	0.0	0.0	0.0	18.1	1.2	0.0	0.0	815.9
1986	7.6	0.4	11.5	1.2	5.2	63.8	133.5	59.1	50.6	333.6	153.5	0.0	0.0	1.7	174.6	4.2	0.0	0.0	1000.5
1987	0.0	0.2	11.2	0.5	11.2	28.8	86.8	43.3	56.3	338.5	58.0	0.0	0.0	0.0	83.0	0.0	0.0	0.0	717.8
1988	0.0	0.1	11.7	1.8	19.1	14.6	87.0	42.6	63.5	299.4	26.0	0.0	0.7	0.4	0.0	5.5	1.1	0.0	573.5
1989	12.7	0.0	13.6	0.9	9.6	20.2	87.9	52.5	149.2	237.2	69.2	0.0	2.5	0.1	87.5	3.5	0.4	0.0	747.0
1990	30.0	0.0	12.6	0.0	6.0	18.9	61.1	117.5	125.0	193.1	25.6	0.0	0.0	0.5	103.4	1.6	0.0	0.0	695.3
1991	8.3	0.0	10.6	0.0	4.4	20.2	98.4	116.2	176.0	219.1	5.5	0.0	0.7	0.2	90.7	2.8	0.0	0.0	753.1
1992	8.0	0.1	16.2	0.0	6.3	26.8	84.8	31.7	122.0	280.4	8.0	0.0	0.0	0.4	74.4	0.5	0.0	0.0	659.6
1993	6.6	0.6	12.6	0.0	4.5	19.3	88.2	59.9	180.4	274.3	14.8	0.0	0.0	0.8	49.4	0.6	0.0	0.0	712.0
1994	24.1	0.0	0.0	0.0	0.0	6.9	76.2	97.5	237.3	193.9	43.5	0.0	0.0	0.5	25.4	0.1	0.0	0.0	705.4
1995	23.7	0.0	0.0	0.0	5.8	0.2	66.1	73.1	180.4	144.2	78.8	0.0	0.2	0.0	21.8	0.0	0.0	0.0	594.3
1996	4.6	0.0	0.0	0.0	8.3	0.4	105.1	0.0	0.0	276.3	64.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	458.9
1997	21.1	0.0	0.1	0.0	0.0	0.0	52.9	0.0	187.3	94.4	58.4	0.0	0.0	0.0	12.2	0.0	0.0	0.0	426.4
1998	15.9	0.2	0.0	0.0	2.5	0.2	42.8	59.6	212.1	86.5	41.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	461.1
1999	21.0	0.0	0.2	0.0	4.7	0.0	40.9	58.5	189.6	98.3	45.3	0.0	0.0	0.0	0.0	0.0	0.2	0.0	458.7
2000	0.0	0.0	0.0	0.0	0.0	0.5	20.6	54.1	181.3	68.5	57.7	0.0	0.0	0.0	8.0	0.0	0.0	0.0	390.7
2001	10.3	0.1	0.0	0.0	0.8	0.0	26.2	54.7	188.7	61.9	48.6	0.0	0.0	0.0	2.7	0.0	0.0	0.0	394.0
2002	10.3	0.0	0.0	10.5	0.0	0.1	29.3	41.0	132.6	46.8	27.2	0.0	0.0	0.0	3.4	0.0	0.0	0.0	301.2
2003	6.9	0.0	0.7	0.0	0.0	0.2	45.7	70.5	198.2	56.6	78.0	0.0	0.0	0.0	3.8	0.0	0.0	0.0	460.6
2004	16.4	0.0	0.9	9.0	0.6	1.4	54.7	64.3	62.4	64.1	58.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	332.3
2005	10.3	0.0	2.3	0.0	0.2	4.1	67.2	50.1	207.2	32.5	22.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	396.3
2006	0.0	0.0	0.4	0.0	1.6	1.8	72.1	54.6	155.3	37.1	15.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	338.1
2007	3.9	0.0	0.1	0.0	0.4	2.0	74.5	59.5	144.5	32.3	17.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	334.4
2008	3.8	0.0	0.0	4.0	2.7	1.0	63.7	36.3	197.5	36.7	10.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	356.5
2009	2.4	0.0	0.0	0.0	0.3	2.6	55.1	27.0	176.1	51.7	29.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	344.9
2010	2.6	0.0	0.0	1.8	0.1	3.5	48.9	31.1	205.8	36.2	55.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	385.4
2011	4.3	0.1	0.2	0.9	0.0	16.1	58.5	41.1	331.9	49.2	27.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	530.2

Table 5.3.1. Reported landings (t) of American eels by RPA zone for Canada and the Atlantic seaboard of the US as well as landings from other jurisdictions (US, Caribbean, and the Gulf of Mexico) not included in the RPA zones.

"na" means data are not available. "N" is the FAO code for "negligible," meaning that landings are between 0 t and 0.5 t. In data summations, cells marked "N" are given a value of 0.25 t. Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

	RPA zones							Jurisdictions not included in the RPA zones								
Year	SL St. Lawrence Basin	NG Northern Gulf of St. Lawrence and Nfld	SG Southern Gulf of St. Lawrence	SF Scotia-Fundy	ASN Atlantic Seaboard North	ASC Atlantic Seaboard Central	ASS Atlantic Seaboard South	US	Cuba, inland waters[1,2]	Dominican Republic, inland waters[1,2]	Mexico Inland waters[1,2]	Mexico Marine waters[1,2]	Mexico Total[1,2]	Non-US Total[1,2]	Caribbean and Gulf of Mexico Total	Grand total
1920	317.6	0.0	34.9	34.1	na	na	na	na	na	na	na	na	na	na	na	na
1921	377.3	0.0	55.5	33.9	na	na	na	na	na	na	na	na	na	na	na	na
1922	538.4	0.0	21.5	15.4	na	na	na	na	na	na	na	na	na	na	na	na
1923	630.9	0.0	10.9	22.3	na	na	na	na	na	na	na	na	na	na	na	na
1924	609.7	0.0	17.5	33.1	na	na	na	na	na	na	na	na	na	na	na	na
1925	600.9	0.0	22.7	29.8	na	na	na	na	na	na	na	na	na	na	na	na
1926	1,004.1	0.0	11.1	34.1	na	na	na	na	na	na	na	na	na	na	na	na
1927	647.6	0.0	4.9	27.4	na	na	na	na	na	na	na	na	na	na	na	na
1928	1,022.8	0.0	22.9	82.1	na	na	na	na	na	na	na	na	na	na	na	na
1929	581.5	0.0	9.7	65.1	na	na	na	na	na	na	na	na	na	na	na	na
1930	623.6	0.0	27.0	33.8	na	na	na	na	na	na	na	na	na	na	na	na
1931	822.1	0.0	30.7	37.5	na	na	na	na	na	na	na	na	na	na	na	na
1932	885.3	0.0	22.9	33.8	na	na	na	na	na	na	na	na	na	na	na	na
1933	1,134.7	0.0	27.7	40.2	na	na	na	na	na	na	na	na	na	na	na	na
1934	1,060.2	0.0	17.1	44.6	na	na	na	na	na	na	na	na	na	na	na	na
1935	1,055.8	0.0	12.8	36.9	na	na	na	na	na	na	na	na	na	na	na	na
1936	1,012.7	0.0	8.5	25.0	na	na	na	na	na	na	na	na	na	na	na	na
1937	859.1	0.0	9.9	40.1	na	na	na	na	na	na	na	na	na	na	na	na
1938	875.8	0.0	19.1	61.6	na	na	na	na	na	na	na	na	na	na	na	na
1939	794.8	0.0	19.7	63.2	na	na	na	na	na	na	na	na	na	na	na	na
1940	427.6	0.0	15.4	53.4	na	na	na	na	na	na	na	na	na	na	na	na
1941	139.2	0.0	7.0	54.4	na	na	na	na	na	na	na	na	na	na	na	na
1942	483.6	0.0	17.3	55.4	na	na	na	na	na	na	na	na	na	na	na	na
1943	660.9	0.0	19.1	49.5	na	na	na	na	na	na	na	na	na	na	na	na
1944	316.0	0.0	20.8	47.3	na	na	na	na	na	na	na	na	na	na	na	na
1945	413.2	0.0	25.2	44.4	na	na	na	na	na	na	na	na	na	na	na	na
1946	348.0	0.0	45.8	37.0	na	na	na	na	na	na	na	na	na	na	na	na
1947	348.1	0.0	46.3	25.4	na	na	na	na	na	na	na	na	na	na	na	na
1948	247.8	0.0	47.7	30.9	na	na	na	na	na	na	na	na	na	na	na	na
1949	214.3	0.0	70.6	73.5	na	na	na	na	na	na	na	na	na	na	na	na
1950	312.3	0.0	48.1	44.9	170.7	700.3	83.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1,360.5
1951	382.8	0.0	40.0	34.0	226.8	584.4	22.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1,290.4
1952	428.6	0.0	32.7	39.4	124.5	586.6	23.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,234.8

	RPA zones							Jurisdictions not included in the RPA zones								
Year	SL St. Law-rence Basin	NG Northern Gulf of St. Law-rence and Nfld	SG Southern Gulf of St. Lawrence	SF Scotia-Fundy	ASN Atlantic Seaboard North	ASC Atlantic Seaboard Central	ASS Atlantic Seaboard South	US	Cuba, inland waters[1,2]	Domin-ican Re-public, inland waters[1,2]	Mexico Inland waters[1,2]	Mexico Marine waters[1,2]	Mexico Total[1,2]	Non-US Tota[1,2]	Carib-bean and Gulf of Mexico Total	Grand total
1953	429.3	0.0	27.1	56.0	122.1	489.4	27.7	1.3	0.0	0.0	0.0	0.0	0.0	0.0	1.3	1,152.9
1954	391.6	0.0	43.2	56.3	118.7	403.4	19.6	3.9	0.0	0.0	0.0	0.0	0.0	0.0	3.9	1,036.7
1955	435.8	1.8	68.2	93.7	159.5	443.1	23.1	2.3	0.0	0.0	0.0	0.0	0.0	0.0	2.3	1,227.5
1956	417.5	0.0	29.7	45.2	151.9	448.4	53.8	2.4	0.0	0.0	0.0	0.0	0.0	0.0	2.4	1,148.9
1957	615.4	0.0	31.0	18.7	136.3	400.4	35.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1,237.1
1958	543.3	0.0	47.3	40.5	175.2	412.5	42.5	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	1,261.5
1959	453.5	0.0	61.4	19.6	152.3	405.2	45.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,137.6
1960	524.8	0.0	86.4	17.9	177.1	197.4	30.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,033.9
1961	454.2	0.3	102.9	28.3	162.6	190.6	26.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	965.3
1962	443.4	23.5	121.4	25.0	108.1	162.5	19.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	903.6
1963	553.8	37.0	93.2	44.5	145.1	276.4	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,168.0
1964	573.6	13.0	109.4	29.7	121.9	267.8	81.9	0.0	0.0	0.0	N	0.0	0.3	0.3	0.3	1,197.5
1965	644.7	3.3	127.5	19.0	169.4	481.9	52.0	5.7	0.0	0.0	N	0.0	0.3	0.3	6.0	1,503.8
1966	568.7	0.0	147.0	37.9	128.9	393.2	57.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,333.3
1967	512.5	0.0	222.1	13.2	130.9	532.5	59.3	1.8	0.0	0.0	N	0.0	0.3	0.3	2.1	1,472.5
1968	609.8	0.0	309.6	27.6	169.0	511.1	88.6	0.4	0.0	0.0	N	0.0	0.3	0.3	0.7	1,716.3
1969	606.6	0.0	446.8	79.8	149.0	620.0	77.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	2.5	1,982.2
1970	402.5	0.0	580.0	66.6	147.0	798.9	33.0	0.0	0.0	0.0	N	0.0	0.3	0.3	0.3	2,028.2
1971	406.7	44.0	722.9	99.3	173.9	810.7	121.8	2.4	0.0	0.0	N	0.0	0.3	0.3	2.7	2,381.9
1972	443.2	79.0	595.9	45.3	158.8	466.5	86.7	0.0	0.0	0.0	N	0.0	0.3	0.3	0.3	1,875.6
1973	404.4	31.0	405.6	38.2	126.6	329.4	134.7	0.0	0.0	0.0	N	0.0	0.3	0.3	0.3	1,470.1
1974	512.4	21.0	285.7	29.5	176.4	853.7	357.5	0.0	0.0	0.0	N	0.0	0.3	0.3	0.3	2,236.5
1975	706.1	7.9	252.9	65.8	374.2	809.6	423.2	0.0	0.0	0.0	1.0	0.0	1.0	1.0	1.0	2,640.7
1976	589.4	11.3	230.8	87.7	307.8	461.1	347.1	0.3	0.0	0.0	7.0	0.0	7.0	7.0	7.3	2,042.6
1977	694.8	19.3	213.6	109.0	286.3	345.7	321.0	0.0	0.0	0.0	7.0	0.0	7.0	7.0	7.0	1,996.6
1978	775.0	15.7	207.5	97.6	284.6	760.4	570.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,711.0
1979	746.8	23.4	226.0	141.2	254.6	804.4	733.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,929.8
1980	790.7	82.7	280.0	66.6	395.2	437.8	623.0	2.9	0.0	0.0	0.0	0.0	0.0	0.0	2.9	2,678.9
1981	751.9	41.6	418.7	55.6	298.1	815.6	255.2	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2,637.2
1982	446.3	36.7	338.1	17.8	180.7	534.0	287.2	3.5	N	0.0	0.0	0.0	0.0	0.3	3.8	1,844.6
1983	428.4	28.0	257.5	19.7	66.9	538.7	223.8	9.9	N	0.0	0.0	0.0	0.0	0.3	10.2	1,573.1
1984	535.6	14.0	295.9	10.8	70.6	704.8	338.1	3.5	N	0.0	0.0	0.0	0.0	0.3	3.8	1,973.5
1985	494.3	20.7	346.9	80.7	83.6	611.3	119.8	1.2	N	0.0	0.0	0.0	0.0	0.3	1.5	1,758.7
1986	557.4	26.5	471.8	60.1	89.7	576.8	329.8	4.2	N	0.0	0.0	0.0	0.0	0.3	4.5	2,116.5
1987	522.8	30.6	334.7	63.6	51.9	524.9	141.0	0.0	N	0.0	0.0	0.0	0.0	0.3	0.3	1,669.8
1988	530.3	60.9	382.9	149.2	47.3	492.5	27.1	6.6	N	1.0	0.0	0.0	0.0	1.3	7.9	1,698.0
1989	553.0	83.4	308.7	122.4	57.0	526.8	159.3	3.9	1.0	1.0	0.0	0.0	0.0	2.0	5.9	1,816.5
1990	593.7	146.9	293.9	95.6	67.5	496.7	129.5	1.6	N	N	0.0	0.0	0.0	0.5	2.1	1,825.9
1991	512.5	133.9	291.6	126.8	43.5	609.7	97.1	2.8	N	N	0.0	0.0	0.0	0.5	3.3	1,818.4

Year	RPA zones							Jurisdictions not included in the RPA zones								Grand total
	SL St. Lawrence Basin	NG Northern Gulf of St. Lawrence and Nfld	SG Southern Gulf of St. Lawrence	SF Scotia-Fundy	ASN Atlantic Seaboard North	ASC Atlantic Seaboard Central	ASS Atlantic Seaboard South	US	Cuba, inland waters[1,2]	Dominican Republic, inland waters[1,2]	Mexico Inland waters[1,2]	Mexico Marine waters[1,2]	Mexico Total[1,2]	Non-US Tota[1,2]	Caribbean and Gulf of Mexico Total	
1992	446.3	90.0	229.6	120.9	57.4	518.9	82.8	0.5	N	N	0.0	0.0	0.0	0.5	1.0	1,546.9
1993	435.8	115.9	251.5	188.0	43.6	602.8	65.0	0.6	0.0	N	0.0	0.0	0.0	0.3	0.9	1,703.5
1994	365.5	111.0	156.2	232.1	31.0	604.9	69.4	0.1	1.0	49.0	0.0	0.0	0.0	50.0	50.1	1,620.1
1995	341.1	85.4	111.0	232.9	29.7	463.8	100.8	0.0	0.0	44.0	0.0	43.0	43.0	87.0	87.0	1,451.8
1996	301.5	94.4	96.1	174.4	13.3	381.4	64.2	0.0	0.0	0.0	0.0	35.0	35.0	35.0	35.0	1,160.3
1997	242.7	73.5	84.9	174.8	21.2	334.6	70.6	0.0	0.0	0.0	0.0	19.0	19.0	19.0	19.0	1,021.2
1998	247.5	72.9	87.8	163.1	18.8	401.0	41.3	0.0	0.0	1.0	0.0	9.0	9.0	10.0	10.0	1,042.4
1999	196.8	54.9	91.5	195.2	25.9	387.3	45.3	0.2	0.0	2.0	0.0	2.0	2.0	4.0	4.2	1,001.1
2000	219.7	69.8	146.7	159.7	0.5	324.5	65.7	0.0	0.0	7.0	0.0	1.0	1.0	8.0	8.0	994.6
2001	200.2	36.7	136.8	134.6	11.2	331.5	51.3	0.0	0.0	1.0	0.0	N	0.3	1.3	1.3	903.5
2002	178.9	65.5	219.6	118.0	20.9	249.7	30.6	0.0	0.0	37.0	0.0	1.0	1.0	38.0	38.0	921.2
2003	150.8	75.9	219.9	95.9	7.8	371.0	81.8	0.0	0.0	23.0	0.0	N	0.3	23.3	23.3	1,026.3
2004	141.1	64.1	196.5	115.0	28.3	245.5	58.5	0.0	0.0	9.0	0.0	2.0	2.0	11.0	11.0	860.0
2005	118.8	71.1	190.8	95.1	16.9	357.0	22.4	0.0	0.0	14.0	0.0	0.0	0.0	14.0	14.0	886.1
2006	108.9	80.0	197.9	115.9	3.8	319.1	15.2	0.0	0.0	24.0	0.0	0.0	0.0	24.0	24.0	864.7
2007	88.0	70.0	219.3	50.7	6.4	310.8	17.2	0.0	0.0	2.0	0.0	0.0	0.0	2.0	2.0	764.4
2008	75.6	45.5	154.8	0.0	11.5	334.2	10.8	0.0	0.0	17.0	0.0	0.0	0.0	17.0	17.0	649.4
2009	57.7	42.4	169.1	0.0	5.3	309.9	29.7	0.0	0.0	9.0	0.0	0.0	0.0	9.0	9.0	623.0
2010	54.3	52.2	184.7	22.3	8.0	322.0	55.4	0.0	0.0	10.0	0.0	0.0	0.0	10.0	10.0	708.9
2011	55.6	na	219.6	16.9	21.6	480.7	27.9	0.0	0.0	72.0	0.0	140.0	140.0	212.0	212.0	na
2012	na	na	266.2	31.4	na	na	na	na	na	na	na	na	na	na	na	na

[1] Data are from FAO statistics listings of "American eels, *Anguilla rostrata*". FAO has no reported landings in the Americas for "River eels nei, *Anguilla* spp.". FAO reports nil landings of American eels in the following countries and territories: Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Bonaire, Brazil, British Virgin Islands, Cayman Islands, Colombia, Costa Rica, Curaçao, El Salvador, French Guiana, Greenland, Guadeloupe, Guatemala, Haiti, Honduras, Iceland, Jamaica, Martinique, Montserrat, Netherlands Antilles, Nicaragua, Panama, Puerto Rico, Saint Barthélemy, Saint Kitts and Nevis, Saint Lucia, Saint Vincent/Grenadines, Saint-Martin, Suriname, Trinidad and Tobago, Turks and Caicos, US Virgin Islands, and Venezuela.

[2] N is the FAO code for "negligible," meaning that landings are between 0 t and 0.5 t. In data summations, cells marked N are given a value of 0.25 t.

Table 6.1.1a. Abundance indices and mean length of American eels at the eel ladders of the Moses-Saunders Dam.

Means are arithmetic unless otherwise indicated. For the Moses eel ladder counts, “na” means not operating. For the mean lengths, “na” means not available. Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Moses eel ladder counts (US)	Saunders ladder annual passage (Canada)[1]	Sum of Moses and Saunders ladder indices	Mean length (mm) of eels ascending the Saunders ladder
1974	na	130,000	130,000	na
1975	na	936,128	936,128	347.0
1976	na	659,478	659,478	347.9
1977	na	966,800	966,800	367.8
1978	na	794,600	794,600	318.9
1979	na	869,135	869,135	na
1980	na	253,758	253,758	373.5
1981	na	748,724	748,724	362.7
1982	na	1,013,848	1,013,848	374.6
1983	na	1,313,570	1,313,570	367.0
1984	na	647,480	647,480	382.4
1985	na	935,320	935,320	404.3
1986	na	230,570	230,570	406.1
1987	na	465,364	465,364	409.8
1988	na	213,187	213,187	404.0
1989	na	258,622	258,622	458.2
1990	na	121,907	121,907	429.8
1991	na	40,241	40,241	433.6
1992	na	11,534	11,534	na
1993	na	8,289	8,289	414.3
1994	na	163,518	163,518	492.8
1995	na	35,076	35,076	na
1996	na	20,587	20,587	na
1997	na	6,117	6,117	470.9
1998	na	3,432	3,432	471.6
1999	na	1,860	1,860	457.9
2000	na	2,895	2,895	457.1
2001	na	944	944	454.7
2002	na	2,663	2,663	469.2
2003	na	2,876	2,876	479.3
2004	na	11,325	11,325	456.0
2005	na	14,891	14,891	413.6
2006	8,184	8,960	17,144	383.7
2007	11,344	2,860	14,204	386.6
2008	25,932	6,398	32,330	367.4
2009	18,415	1,799	20,214	325.2
2010	38,173	961	39,134	365.7
2011	39,576	11,624	51,200	363.2
2012	25,256	25,913	51,169	na

[1] Data for 1974-1995 are from Casselman et al. (1997). Data for 1997-2006 are from the Lake Ontario Management Unit, Ontario Ministry of Natural Resources. In 1974, counts were conducted from Aug 12 (Casselman et al. 1997) to Sep 11 (Eckersley 1982). Since this is after the period of peak migration, the value for 1974 is likely downwardly biased. Data are unavailable for 1996. The value shown for 1996 is the mean of values for the previous and subsequent years.

Table 6.1.1b. Abundance indices (mean counts per day of effort) based on tailwater surveys of mortalities at the Moses-Saunders Dam, 2000 to 2011.

"na" means not available. Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	NYPA 1	OPG 2 Method 1	OPG 2 Method 2
2000	14.8	na	na
2001	17.8	na	na
2002	13.8	5.1	na
2003	11.7	3.4	na
2004	11.1	2.5	na
2005	10.1	1.4	na
2006	7.6	1.8	na
2007	6.0	na	4.8
2008	1.4	na	2.7
2009	1.2	na	2.7
2010	1.8	na	2.7
2011	1.1	na	1.6

[1] NYPA is New York Power Authority. Data are from Riveredge Associates (2012).
[2] OPG is Ontario Power Generation. For OPG, sampling methodology and survey route were changed in 2007 to include a greater portion of the immediate tailwater. Hence data prior to and after 2007 are not directly comparable.

Table 6.1.1c. Abundance indices (arithmetic mean and geometric mean eels per trawl) from the trawl survey in Bay of Quinte, 1972 to 2012.

Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Arithmetic mean (eels per trawl) [1]	Geometric mean (eels per trawl) [1]
1972	8.563	1.8732
1973	5.700	1.6199
1974	3.800	0.9966
1975	8.000	1.5430
1976	3.526	1.2864
1977	3.200	1.0642
1978	0.950	0.4165
1979	2.050	0.7673
1980	0.533	0.2518
1981	2.000	1.5299
1982	2.500	1.8845
1983	0.667	0.5572
1984	0.500	0.3299
1985	2.375	0.7783
1986	3.333	0.8654
1987	3.500	1.5522
1988	0.583	0.2990
1989	0.583	0.9522
1990	0.583	0.3561
1991	0.889	0.4541
1992	1.250	0.5846
1993	0.775	0.4336
1994	2.450	1.1568
1995	0.150	0.0905
1996	0.700	0.3558
1997	0.151	0.0849
1998	0.179	0.1225
1999	0.146	0.0740
2000	0.100	0.0532
2001	0.023	0.0058
2002	0.050	0.0125
2003	0.000	0.0000
2004	0.000	0.0000
2005	0.000	0.0000
2006	0.000	0.0000
2007	0.000	0.0000
2008	0.000	0.0000
2009	0.000	0.0000
2010	0.000	0.0000
2011	0.000	0.0000
2012	0.025	0.0292

[1] Based on 2 to 40 trawls per year in June-September 1972-1988 and 1990-2012 at 5 sites (Trenton, Belleville, Big Bay, Deseronto, Hay Bay). Of these, only Big Bay and Hay Bay were sampled in all of these years. Data are unavailable for 1989 and the value shown for 1989 is the mean of the values for the preceding and subsequent years. Trawls were 6 min long, with a swept area of approximately 0.2453 ha. The origin of eels caught in 2012 (i.e. wild or stocked) was not determined.

Table 6.1.1d. Abundance indices (eels per hour of electrofishing during nighttime) of American eels by wild and stocked categories based on electrofishing surveys in Lake Ontario Main Duck Island and St. Lawrence River Mallory Town Landing, 1984 to 2012.

Data are from Casselman and Marcogliese (Appendix I, 2013). Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Lake Ontario Main Duck Island Wild	Lake Ontario Main Duck Island Stocked	St. Lawrence River Mallory Town Landing Wild	St. Lawrence River MalloryTown Landing Stocked
1984	51.300	0.000	na	na
1985	42.900	0.000	na	na
1986	na	na	na	na
1987	na	na	na	na
1988	na	na	na	na
1989	40.300	0.000	na	na
1990	na	na	na	na
1991	na	na	na	na
1992	na	na	na	na
1993	19.000	0.000	na	na
1994	27.600	0.000	22.250	0.000
1995	11.300	0.000	na	na
1996	7.100	0.000	14.300	0.000
1997	7.300	0.000	na	na
1998	12.900	0.000	11.030	0.000
1999	21.600	0.000	14.220	0.000
2000	9.370	0.000	7.380	0.000
2001	6.820	0.000	4.730	0.000
2002	3.360	0.000	2.910	0.000
2003	0.650	0.000	2.180	0.000
2004	0.520	0.000	2.010	0.000
2005	1.230	0.000	2.097	0.000
2006	0.492	0.000	0.699	0.000
2007	0.208	0.000	0.279	0.000
2008	0.148	0.000	0.000	0.000
2009	0.192	0.000	0.184	0.783
2010[1]	0.000	0.321	0.914	7.923
2011	0.000	0.536	0.000	11.596
2012	0.000	0.483	0.000	20.932

[1] In Mallory Town Landing in 2010, reported catch rates were 0.656 for wild eels, 5.684 for stocked eels, and 2.497 for eels of unknown status. In this table the eels of unknown status are assigned to the wild and stocked categories, proportionate to the catch rates of each identified category.

Table 6.1.2a. Abundance indices of American eels in the Quebec portion of the St. Lawrence Basin: counts of small eels at the ladders at the Richelieu River Chambly Dam and at the Beauharnois Dam on the St. Lawrence River, 1994 to 2011.

Data are from Cairns et al. (2008) with updates from G. Verreault, Québec MRN. Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Richelieu River Chambly Dam ladder count	Beauharnois West ladder count [2]	Beauharnois East ladder count [2]
1994	na	24,721	15,134
1995	na	17,072	na
1996	na	na	na
1997	10,863 [1]	na	na
1998	9,875	5,441	na
1999	3,685	10,692	na
2000	239	6,881	na
2001	357	13,099	na
2002	240	10,503	32,608
2003	3,336	32,684	26,885
2004	727	42,635	15,951
2005	2,177	51,694	2,932
2006	434	50,389	28,127
2007	1,340	52,969	1
2008	239	87,942	811
2009	3,685	61,321	12
2010	6,476	79,312	7
2011	1,066	65,633	2

[1] In 1997, most counted eels were released downstream from the dam to test the efficiency of the eel passage facility.
[2] Ascending eels were counted in traps at the west site in 1994-1995 and 1998-2001, and at the east site in 1994 and 2002-2003. Permanent eel ladders with counting facilities were installed at the west site in 2002 and at the east site in 2004. Eels were counted at the east ladder on only 10 days in 2005. The estimated total extrapolated from the 10 days of counts is 2,932. A substantial portion of eels in 1994-1998 (West) and 1994 (East) were released below the dam for tagging studies.

Table 6.1.2b. Abundance indices of American eels in the Quebec portion of the St. Lawrence Basin: estimates of total silver eel migrants (number of eels in 1996, 1997, 2010, and 2011) and catch per unit of effort (kg of eels per m of leader) of silver eels in commercial trapnets of the St. Lawrence River 1996 to 2012.

Data are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	St. Lawrence estuary silver eel migrants (number) [1]	Lower St. Lawrence estuary CPUE (kg of eels per m of net) [2]
1996	488,000	3.07
1997	397,000	2.87
1998	na	3.99
1999	na	3.40
2000	na	3.47
2001	na	3.48
2002	na	4.11
2003	na	3.63
2004	na	3.79
2005	na	4.03
2006	na	3.64
2007	na	3.15
2008	na	3.33
2009	na	4.12
2010	155,395	4.99
2011	159,700	3.72
2012	na	3.52

[1] from Caron et al. (2003), ICES (2011), and G. Verreault, Québec MRN. Estimates by capture-mark-recapture of outmigrating silver eels.
[2] from G. Verreault, Québec MRN.

Table 6.1.2c. Abundance indices of American eels in the Quebec portion of the St. Lawrence Basin: silver eel counts in Quebec City area estuary traps, 1994 to 1946, 1964 to 2012.

Data[1] are available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Carrière	Anse Douville	Anse Gingras	Saint-Nicolas (Aquarium du Québec)	Pont	North Shore	Anse Verte	Saint-Rom-uald[2]	Landry	Saint-David	Lévis
1944	na	na	na	na	na	na	na	846	568	na	na
1945	na	na	na	na	na	na	na	908	721	na	na
1946	na	na	na	na	na	na	na	638	835	na	na
1964	na	na	na	na	1,031	na	na	na	na	na	na
1965	na	na	690	na	1,208	na	na	na	na	6,761	na
1966	na	na	401	na	662	224	na	na	na	na	na
1967	na	na	984	na	822	na	na	na	na	na	na
1968	na	na	851	193	751	na	48	na	na	na	na
1969	na	na	959	na	728	na	na	na	na	na	na
1970	na	na	na	na	na	na	na	na	na	na	na
1971	na	na	na	414	na	na	na	na	na	na	na
1972	na	na	na	297	na	na	na	na	na	na	na
1973	na	na	na	225	na	na	na	1,138	na	na	na
1974	na	na	na	209	na	na	na	1,916	na	na	na
1975	na	na	na	232	na	na	na	3,020	na	na	na
1976	na	na	na	194	na	na	na	1,964	na	na	na
1977	na	1,711	na	328	na	na	na	2,379	na	na	na
1978	na	na	na	449	na	na	na	4,232	na	na	na
1979	na	2,338	na	273	na	na	na	4,314	na	na	na
1980	na	1,226	na	187	na	na	na	2,294	na	na	na
1981	na	816	na	176	na	na	na	1,471	na	na	na
1982	na	1,082	na	199	na	na	na	2,864	na	na	na
1983	na	1,661	na	234	na	na	na	2,675	na	na	na
1984	na	na	na	166	na	na	na	2,944	na	na	na
1985	293	743	na	200	na	na	na	2,686	na	na	na
1986	369	720	na	176	na	na	na	2,356	na	na	na
1987	394	911	na	166	na	na	na	2,474	na	na	na
1988	na	1,196	na	207	na	na	na	2,109	na	na	1,040
1989	na	482	na	83	na	na	na	796	na	na	423
1990	na	819	na	160	na	na	na	1,359	na	na	787
1991	na	600	na	169	na	na	na	891	na	na	945
1992	na	708	na	177	na	na	na	1,566	na	na	1,369
1993	na	986	na	188	na	na	na	1,276	na	na	702
1994	na	971	na	200	na	na	na	1,683	na	na	1,291
1995	na	814	na	208	na	na	na	1,860	na	na	1,196
1996	na	341	na	127	na	na	na	1,622	na	na	894
1997	na	528	na	138	na	na	na	1,571	na	na	1,221
1998	na	536	na	205	na	na	na	1,962	na	na	1,175
1999	na	na	na	381	na	na	na	2,146	na	na	1,822
2000	na	na	na	190	na	na	na	1,872	na	na	998
2001	na	na	na	350	na	na	na	na	na	na	na
2002	na	491	na	239	na	na	na	1,524	na	na	639
2003	na	282	na	257	na	na	na	1,168	na	na	651
2004	na	364	na	200	na	na	na	878	na	na	200
2005	na	410	na	223	na	na	na	975	na	na	399
2006	na	na	na	218	na	na	na	na	na	na	na
2007	na	na	na	125	na	na	na	na	na	na	na
2008	na	na	na	142	na	na	na	na	na	na	na
2009	na	na	na	145	na	na	na	na	na	na	na
2010	na	na	na	174	na	na	na	na	na	na	na
2011	na	na	na	153	na	na	na	na	na	na	na
2012		na	na	183	na	na	na	na	na	na	na

[1] Data for 1944-2009 from Y de Lafontaine, Environment Canada, as reported in Cairns et al. (2008), de Lafontaine et al. (2009, 2010), and COSEWIC (2012). For 2010-2012, data from G. Verreault, Quebec MRN.

[2] The trap was set up differently in 1944-1946 than in 1973-2005; hence data for the two periods are not comparable

Table 6.1.3a. Abundance indices of American eels in the Quebec portion of the Northern Gulf of St. Lawrence and Newfoundland RPA zone: elver index from the Saint-Jean River estuary 2009 to 2012.

Data are from Dionne et al. (2013) and available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Elver index (trap C1, number per trap-day)
2009	2.99
2010	0.83
2011	0.10
2012	3.81

Table 6.1.3b. Abundance indices of American eels in the Quebec portion of the Northern Gulf of St. Lawrence and Newfoundland RPA zone: small eel counts and estimates from the Petite Trinité River, 1982-1985, 1993-1996, and 1999-2001.

Data compiled by Cairns et al. (2008) and available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Visual counts of eels creeping up rocks [1]	Capture-mark-recapture estimate [2]
1982	4,027	na
1983	3,643	na
1984	732	na
1985	581	na
1993	1,178	na
1994	488	na
1995	3,440	na
1996	3,550	na
1999	na	13,912
2000	na	19,829
2001	na	17,534

[1] Counts of eels > 15 cm in length and aged 1-2 years old
[2] Estimates of eels > 12 cm in length and aged 1-2 years old

Table 6.1.3c. Abundance indices of American eels in the Quebec portion of the Northern Gulf of St. Lawrence and Newfoundland RPA zone: indices from the River Sud-Ouest including yellow eel counts ascending a rock face, yellow eel counts at a fishway trap at falls, and index of year-class strength, 1994 to 2012.

Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Visual count of eels ascending a rock face [1]	Count at fishway trap at falls [1]	Year-class strength index [2]
1994	16,617	na	na
1995	na	na	0.737
1996	2,280	na	1.310
1997	na	na	1.045
1998	na	na	1.020
1999	na	407	1.344
2000	na	285	1.114
2001	na	435	1.109
2002	na	na	0.908
2003	na	570	0.874
2004	na	407	0.713
2005	na	2,279	0.564
2006	na	2,171	na
2007	na	195	na
2008	na	642	na
2009	na	169	na
2010	na	2,406	na
2011	na	685	na
2012	na	784	na

[1] Sud-ouest, rock face, falls: from G. Verreault, as compiled by Cairns et al. (2008). Mean length of eels ascending the rock face is 22.8 cm with an age range of 2-10 years. Eels from the fishway trap at the falls had a mean length 24.6 cm and an age range of 2-10 years.
[2] Sud-ouest, year class strength index: from G. Verreault and Verreault and Tardif (2009)

Table 6.1.3d. Abundance indices of American eels in the Quebec portion of the Northern Gulf of St. Lawrence and Newfoundland RPA zone: indices from the Rivière Sud-Ouest include silver eel counts at a counting fence with monitoring gaps during the season and full season fence counts in 1996 to 2004, and counts of migrant silver eels from the Petite Rivière Trinité 1999 to 2001.

Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Rivière Sud-Ouest [1] Fish fence count (with gaps during the season)	Rivière Sud-Ouest [1] Fish fence count (full season fence count)	Petite Rivière Trinité [2] counts
1996	214	na	na
1997	na	na	na
1998	na	na	na
1999	na	315	2,309
2000	34	na	3,019
2001	na	108	2,855
2002	na	68	na
2003	na	60	na

[1] Sud-ouest fish fence: from G. Verreault, as compiled by Cairns et al. (2008)
[2] Petite Trinité: as compiled by Cairns et al. (2008)

Table 6.1.4a. Abundance indices of American eels in the Newfoundland portion of the Northern Gulf of St. Lawrence and Newfoundland RPA zone: counts of eels at three counting fences in Newfoundland, 1971 to 2011.

Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Western Arm Brook (Gulf of St.Lawrence drainage)	Campbellton River (Atlantic drainage)	Conne River (Atlantic drainage)
1971	86	na	na
1972	197	na	na
1973	97	na	na
1974	574	na	na
1975	96	na	na
1976	29	na	na
1977	118	na	na
1978	69	na	na
1979	1	na	na
1980	135	na	na
1981	401	na	na
1982	319	na	na
1983	168	na	na
1984	227	na	na
1985	332	na	na
1986	40	na	5
1987	77	na	16
1988	10	na	27
1989	10	na	45
1990	1	na	13
1991	32	na	24
1992	511	na	30
1993	87	18	52
1994	54	40	50
1995	64	31	99
1996	95	2	68
1997	73	91	27
1998	177	73	24
1999	73	3	17
2000	87	85	48
2001	42	86	21
2002	110	25	16
2003	39	20	14
2004	23	40	7
2005	10	10	0
2006	52	4	58
2007	63	3	48
2008	46	na	76
2009	28	na	na
2010	27	na	na
2011	83	na	na

Table 6.1.4b. Abundance indices of American eels in the Newfoundland portion of the Northern Gulf of St. Lawrence and Newfoundland RPA zone: indices expressed as mean catch of eels per station from electrofishing surveys in Highlands River and Northeast Brook (Trepassey), 1980 to 1999, 2012.

Data compiled by Cairns et al. (2008) and available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Highlands River (Gulf of St. Lawrence drainage)	Northeast Brook (Trepassey) (Atlantic drainage)
1980	21.8	na
1981	9.2	na
1982	na	na
1983	na	na
1984	na	8.0
1985	na	6.0
1986	na	3.3
1987	na	5.0
1988	na	4.5
1989	na	5.5
1990	na	6.3
1991	na	2.5
1992	na	4.8
1993	4.5	2.8
1994	2.0	1.0
1995	2.3	2.5
1996	1.7	1.3
1997	0.3	na
1998	0.8	na
1999	0.5	na
2012	na	9.0

Table 6.1.5a. Abundance indices of American eels in the Southern Gulf of St. Lawrence RPA zone: catch per unit of effort indices from commercial fisheries in the southern Gulf of St. Lawrence, 1996 to 2012.

Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Gulf Nova Scotia commercial fyke nets (kg/gear-day)	Gulf Nova Scotia commercial winter spearing (kg/spear-hour)	Prince Edward Island commercial fyke nets (kg/gear-day)
1996	na	na	0.29
1997	1.73	2.33	0.26
1998	0.93	3.30	0.47
1999	na	na	0.85
2000	1.23	1.81	0.84
2001	1.34	1.10	0.59
2002	1.74	3.18	0.71
2003	1.31	2.91	0.80
2004	2.43	3.41	1.06
2005	2.26	3.73	0.95
2006	2.33	4.76	0.82
2007	2.95	5.64	1.36
2008	2.66	6.00	1.44
2009	2.61	3.01	1.01
2010	2.90	4.69	1.19
2011	3.80	4.48	1.32
2012	2.31	4.48	1.52

Table 6.1.5b. Abundance indices of American eels in the Southern Gulf of St. Lawrence RPA zone: elver indices from monitoring facilities in Prince Edward Island, 2005 to 2012.

Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	McCallums Pond (PEI) ramp trap June-August (elvers/gear-day)	Cass Pond (PEI) habitat trap June-August (elvers/gear-haul)
2005	1.78	2.57
2006	0.48	0.60
2007	0.30	0.97
2008	0.72	1.24
2009	0.07	0.52
2010	0.04	0.69
2011	0.19	0.15
2012	0.05	0.89

Table 6.1.5c. Abundance indices of American eels in the Southern Gulf of St. Lawrence RPA zone: indices of abundance from electrofishing surveys in two rivers of New Brunswick, 1952 to 2012.

Data compiled by Cairns et al. (2008) and available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	Restigouche River, (NB) electrofishing (eels/100 m^2)	Miramichi River (NB) electrofishing (eels/100 m^2)
1952	na	0.56
1953	na	1.13
1954	na	0.30
1955	na	0.57
1956	na	0.40
1957	na	0.25
1958	na	0.28
1959	na	2.00
1960	na	0.87
1961	na	0.34
1962	na	0.14
1963	na	0.44
1964	na	1.17
1965	na	0.87
1966	na	1.07
1967	na	1.02
1968	na	1.42
1969	na	0.62
1970	na	0.31
1971	na	1.90
1972	0.43	1.46
1973	0.50	1.25
1974	0.35	1.57
1975	1.01	1.23
1976	0.23	1.06
1977	0.37	1.24
1978	0.28	0.65
1979	0.10	0.16
1980	0.48	0.15
1981	0.09	0.37
1982	0.09	0.89
1983	0.51	0.94
1984	na	0.47
1985	0.32	0.18
1986	0.48	0.15
1987	0.29	0.18
1988	0.76	0.27
1989	0.60	0.07
1990	0.36	0.25
1991	0.21	0.00
1992	0.06	0.16
1993	0.00	0.64
1994	0.31	0.21
1995	0.00	0.07
1996	0.00	0.67
1997	0.00	0.32
1998	0.22	0.51
1999	0.43	0.87
2000	0.46	0.59
2001	2.05	1.36
2002	2.45	0.57
2003	0.40	0.55
2004	0.86	0.79
2005	1.08	0.98
2006	1.41	0.68
2007	0.67	1.46
2008	0.43	0.43
2009	0.39	0.77
2010	0.69	0.75
2011	0.09	0.12
2012	0.56	1.25

Table 6.1.6a. Abundance indices of American eels in the Scotia-Fundy RPA zone: elver run estimates to two rivers of Nova Scotia, 1988 to 2012.

Recent East River Chester numbers are based on preliminary analysis and are subject to revision. Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	East River Chester elver run estimates (number of fish)	East River Sheet Harbour elver run estimates (number of fish)
1990	na	218,300
1991	na	376,000
1992	na	219,200
1993	na	134,100
1994	na	309,900
1995	na	101,500
1996	1,217,825	336,500
1997	1,605,627	467,400
1998	515,241	109,200
1999	450,418	134,600
2000	791,553	na
2001	600,196	na
2002	1,686,592	na
2003	na	na
2004	na	na
2005	na	na
2006	na	na
2007	na	na
2008	1,920,294	na
2009	1,140,461	na
2010	617,849	na
2011	1,873,502	na
2012	1,922,463	na

Table 6.1.6b. Abundance indices of American eels in the Scotia-Fundy RPA zone: indices of abundance (eels per 100 m²) from the first pass of electrofishing surveys in two rivers of New Brunswick and one river in Nova Scotia, 1985 to 1986, 1991 to 2012.

Data compiled by Cairns et al. (2008) and available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	St. Marys River (NS) (open sites)	Big Salmon River (NB) (barrier sites)	Nashwaak River (NB) (open sites)
1985	6.89	na	na
1986	6.48	na	na
1991	na	na	3.10
1992	na	na	0.73
1993	na	na	1.18
1994	na	na	0.46
1995	6.61	na	0.62
1996	3.51	0.33	1.39
1997	5.04	4.38	1.04
1998	8.45	na	1.22
1999	5.42	3.16	0.70
2000	1.66	2.97	1.37
2001	1.68	0.62	1.50
2002	1.40	1.90	1.36
2003	1.83	1.43	0.52
2004	0.47	1.26	2.05
2005	1.41	1.48	1.47
2006	1.11	1.37	0.85
2007	1.90	1.00	1.43
2008	0.80	0.87	1.27
2009	1.03	1.41	1.09
2010	1.59	na	1.08
2011	1.45	na	0.62
2012	0.94	na	1.73

Table 6.1.7. Summary of the characteristics of the indices used to assess trends in abundance of American Eel in Canada by life stage, habitat type, and RPA zone.

Acronyms for RPA zones are: SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland, SG = Southern Gulf of St. Lawrence, and SF = Scotia-Fundy.

Life stage type	Habitat type	RPA zone	Index type	Index name	Available time period	Analysis type
Recruitment (elver)	Freshwater	SF	Independent	East River Sheet Harbour	1990-1999	Composite
				East River Chester	1996-2002, 2008-2012	
Recruitment (yellow)	Freshwater	SL	Independent	Moses-Saunders eel ladder counts	1974-2012	Single
				Beauharnois West count	1998-2011	Composite
				Chambly – Richelieu River	1999-2011	
Standing stock (yellow)	Freshwater	SL	Independent	Bay of Quinte trawl survey	1972-2012	Composite
				Main Duck Island electrofishing	1984-2012	
Standing stock (yellow and silver)	Freshwater	NG	Independent	Western Arm Brook fence counts	1971-2011	Composite
				Conne fence counts	1986-2008	
				Campbellton fence counts	1993-2007	
Standing stock (yellow)	Freshwater	SG	Independent	Miramichi electrofishing	1952-1990, 1992-2012	Composite
				Restigouche electrofishing	1972 to 2012	
Standing stock (yellow)	Estuary / marine	SG	Fishery-dependent	Gulf NS fyke net commercial CPUE	1997-1998, 2000-2012	Composite
				PEI fyke net commercial CPUE	1996-2012	
Standing stock (yellow)	Freshwater	SF	Independent	St. Mary's electrofishing	1985-1986, 1995-2009	Composite
				Nashwaak electrofishing	1991-2009	
				Big Salmon electrofishing	1996-1997, 1999-2009	
Spawner abundance (silver eel)	Freshwater	SL	Independent	Saint-Nicolas trapnet	1971-2009	Composite
			Fishery-dependent	Levis	1988-2000, 2002-2005	
				Anse-Douville	1977, 1979-1983, 1985-1998, 2002-2005	
				Saint-Romuald	1973-2000, 2002-2005	

Table 6.1.8. Individual and composite American Eel indices used in the trend analysis.

Column headers show RPA zone acronym, specific index and type, and index units. Details of treatment of data are in text. Acronyms for RPA zones are: SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland, SG = Southern Gulf of St. Lawrence, and SF = Scotia-Fundy.

Year	SL Lake Ontario Composite adjusted index 1,2	SL Moses-Saunders index	SL Composite adjusted ladder count index 2,3	SL Quebec City area traps composite index 2	NG Composite index from Newfoundland fence counts 2	SG Composite electrofishing index 2	SG Composite commercial CPUE index 2	SF Composite electrofishing index 2	SF Composite elver index 2
1952	na	na	na	na	na	0.50	na	na	na
1953	na	na	na	na	na	1.02	na	na	na
1954	na	na	na	na	na	0.27	na	na	na
1955	na	na	na	na	na	0.51	na	na	na
1956	na	na	na	na	na	0.36	na	na	na
1957	na	na	na	na	na	0.22	na	na	na
1958	na	na	na	na	na	0.25	na	na	na
1959	na	na	na	na	na	1.80	na	na	na
1960	na	na	na	na	na	0.78	na	na	na
1961	na	na	na	na	na	0.31	na	na	na
1962	na	na	na	na	na	0.13	na	na	na
1963	na	na	na	na	na	0.40	na	na	na
1964	na	na	na	na	na	1.05	na	na	na
1965	na	na	na	na	na	0.78	na	na	na
1966	na	na	na	na	na	0.96	na	na	na
1967	na	na	na	na	na	0.92	na	na	na
1968	na	na	na	na	na	1.28	na	na	na
1969	na	na	na	na	na	0.56	na	na	na
1970	na	na	na	na	na	0.28	na	na	na
1971	na	na	na	1,412	59	1.71	na	na	na
1972	13,407	na	na	1,013	135	0.96	na	na	na
1973	8,925	na	na	445	67	0.89	na	na	na
1974	5,949	130,000	na	693	394	0.98	na	na	na
1975	12,525	936,128	na	1,061	66	1.14	na	na	na
1976	5,521	659,478	na	704	20	0.66	na	na	na
1977	5,010	966,800	na	1,014	81	0.82	na	na	na
1978	1,487	794,600	na	1,527	47	0.47	na	na	na
1979	3,209	869,135	na	1,590	1	0.13	na	na	na
1980	834	253,758	na	851	93	0.32	na	na	na
1981	3,132	748,724	na	566	275	0.23	na	na	na
1982	3,914	1,013,848	na	952	219	0.50	na	na	na
1983	1,044	1,313,570	na	1,049	115	0.74	na	na	na
1984	2,053	647,480	na	1,014	156	0.42	na	na	na
1985	2,992	935,320	na	833	228	0.25	na	2.89	na
1986	4,089	230,570	na	747	21	0.32	na	2.80	na
1987	4,332	465,364	na	815	44	0.24	na	na	na
1988	1,784	213,187	na	751	18	0.52	na	na	na
1989	2,260	258,622	na	294	26	0.34	na	na	na

Year	SL Lake Ontario Composite adjusted index 1,2	SL Moses-Saunders index	SL Composite adjusted ladder count index 2,3	SL Quebec City area traps composite index 2	NG Composite index from Newfoundland fence counts 2	SG Composite electrofishing index 2	SG Composite commercial CPUE index 2	SF Composite electrofishing index 2	SF Composite elver index 2
1990	1,691	121,907	na	515	7	0.31	na	na	440,819
1991	1,413	40,241	na	430	27	0.25	na	na	759,267
1992	1,795	11,534	na	630	257	0.11	na	2.33	442,637
1993	1,018	8,289	na	520	56	0.33	na	2.26	270,792
1994	2,396	163,518	na	683	51	0.26	na	2.19	625,790
1995	317	35,076	na	672	69	0.04	na	2.13	204,962
1996	809	na	na	492	59	0.34	0.43	2.06	678,345
1997	255	6,117	na	570	68	0.16	0.89	2.00	904,719
1998	386	3,432	125	639	98	0.37	0.63	1.94	271,212
1999	533	1,860	1,121	911	33	0.66	1.25	1.88	255,316
2000	258	2,895	144	641	79	0.53	0.93	1.83	440,698
2001	151	944	247	1,194	53	1.74	0.87	1.77	334,160
2002	103	2,663	186	477	54	1.54	1.10	1.72	939,012
2003	13	2,876	1,279	389	26	0.48	0.95	1.67	440,819
2004	10	11,325	687	271	25	0.84	1.57	1.62	na
2005	24	14,891	1,184	331	7	1.05	1.44	1.57	na
2006	10	17,144	697	744	41	1.06	1.41	1.52	na
2007	4	14,204	972	426	41	1.08	1.94	1.47	1,069,126
2008	3	32,330	1,075	484	58	0.44	1.84	1.43	634,953
2009	4	20,214	1,703	495	19	0.59	1.63	1.39	343,988
2010	0	39,134	2,665	na	19	0.73	1.84	1.34	1,043,074
2011	0	51,200	1,043	na	57	0.11	2.30	1.30	1,070,333
2012	18	51,169	na	na	na	0.92	1.72	1.26	1,069,126

1 Individual annual indices are adjusted by dividing the annual index by the index specific mean of the 1990 to 2000 period prior to analysis with GLM to derive the composite index.
2 Annual mean value for the composite index from the GLM model.
3 Annual counts are adjusted by dividing the annual counts at each index by the site specific mean count of the 1999 to 2011 period.

Table 6.1.9. Summary (median, 90% Bayesian Credibility Interval, number of years) of the percent change in indices of recruitment, of standing stock, and of silver eel production by habitat type from the four RPA zones of eastern Canada.

Acronyms for RPA zones are: SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland, SG = Southern Gulf of St. Lawrence, and SF = Scotia-Fundy. "na" means data are not available for analysis.

Life stage type	Habitat type	RPA zone	Index type, description (number of individual indicators) and series	Change in abundance (median; 90% B.C.I.; years)		
				Annual over available data series	Over recent 16 years	Over recent 32 years
Recruitment	Freshwater	SF	Composite Elver counts (2) 1990 to 2012	+3.1% -0.7% to +6.9% 23 years	+83% -30% to +384%	na
		SL	Single Moses-Saunders eel ladder index 1975 to 2012	-13.7% -17% to -11% 38 years	4,000% 1,368% to 10,800%	-99% -99.8% to -95.0%
			Composite Eel ladder counts (2) 1998 to 2011	+18.4% +9.2% to +28.6% 14 years	+799% +212% to 2,531% (13 years)	na
Standing stock	Freshwater	SL	Composite Lake Ontario survey indices (2) 1972 to 2012	-24.7% -29.9% to -19.0% 41 years	-100% -100% to -99.6%	-100% -100% to -99.9%
		NG	Composite Fence counts (3) 1971 to 2011	-2.2% -4.6% to +0.3% 41 years	-63% -84% to -17%	-41% -81% to +90%
		SG	Composite Electrofishing (2) 1952 to 2012	-0.2% -1.1% to +0.7% 61 years	+31% -54% to +266%	+151% +20% to +428%
		SF	Composite Electrofishing (3) 1985 to 2009	-3.0% -3.2% to -2.9% 28 years	-39% -42% to -36%	na
	Estuary / marine	SG	Composite Commercial CPUE (2) 1996 to 2012	+8% +6% to +10% 17 years	+246% +154% to +366%	na
Spawner production	Freshwater	SL	Composite Trapnet catches (4) 1971 to 2012	-1.9% -2.6% to -1.1% 42 years	-20% -52% to +32%	-41% -58% to -16%

Table 6.1.10. Summary of trends in the abundance indices of American Eel for three time periods by life stage, habitat type and RPA zone.

Acronyms for RPA zones are : SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland, SG = Southern Gulf of St. Lawrence, and SF = Scotia-Fundy. ↑ represents a statistically significant ($p < 0.05$) increase in abundance, ⇔ represents no change in abundance, and ↓ represents a statistically significant decline in abundance. "na" means data are not available for analysis.

Life stage type	Habitat type	RPA zone	Index type and specifics	Recent 16 years	Recent 25 to 32 years	> 32 years
Recruitment	Freshwater	SF	Elver counts	⇔	na	na
		SL	Moses-Saunders ladder counts	↑	↓	↓
			Eel ladder counts (Quebec)	↑	na	na
Standing stock	Freshwater	SL	Lake Ontario survey indices	↓	↓	↓
		NG	Fence counts	↓	⇔	⇔
		SG	Electrofishing	⇔	↑	⇔
		SF	Electrofishing	↓	↓	na
	Estuary / marine	SG	Commercial CPUE	↑	na	na
Spawner production	Freshwater	SL	Trapnet catches	⇔	↓	↓
Percentage of all indices			↓	33%	67%	60%
			⇔	33%	17%	40%
			↑	33%	17%	0%
Number of indices				9	7	6

Table 6.2.1. American Eel young-of-the-year abundance indices on the Atlantic Seaboard of the United States.

Column header gives RPA zone acronym (ASN, ASC, ASS), index specific location, state, and analysis method (GLM refers to General Linear Models). Data from ASMFC (2012). Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	ASN West Harbor Pond ME (GLM)	ASN Lamprey R. NH (GLM)	ASN Jones R. MA (GLM)	ASN Gilbert Stuart Dam RI (GLM)	ASN Carman's R. NY (GLM)	ASC Patcong Creek NJ (GLM)	ASC Millsboro Dam DE (GLM)	ASC Turville Creek MD (non-GLM)	ASC Clark's Millpond Potomac system (GLM)	ASC Gardy's Millpond Potomac system (GLM)	ASC Bracken's Pond VA (non-GLM)	ASC Kamp's Millpond VA (GLM)	ASC Wormley Creek VA (GLM)	ASS Goose Creek SC (GLM)	ASS Altamaha Canal GA (GLM)	ASS Guana R. Dam FL (non-GLM)
2000	na	na	na	356.3	43.27	55.65	4454	5423	0.3342	28.50	1038	15.39	na	16.18	na	na
2001	3861	5.284	542.7	27.53	7.591	300.4	11736	6162	0.1764	23.25	480.3	135.5	907.6	245.9	9.840	102.0
2002	1187	18.31	93.02	678.7	344.6	2182	3344	647.5	2.685	4.489	127.8	474.5	481.4	143.9	1.271	24.226
2003	523.5	1.711	902.4	3.385	6.338	57.05	8180	3489	0.5285	1.982	981.4	61.21	207.5	105.3	1.391	47.879
2004	88.28	3.532	117.9	6.587	25.18	63.42	5092	3422	3.523	0.9643	347.8	8.483	797.4	4.489	1.548	7.844
2005	3719	1.845	808.6	48.20	16.04	712.2	5307	1263	4.897	2.776	741.2	91.04	378.0	101.0	1.188	150.2
2006	138.5	42.85	491.6	20.77	7.316	3502	6812	1377	1.445	1.035	519.8	7.501	877.5	36.87	3.111	8.548
2007	104.6	0.8824	449.4	44.61	11.29	317.9	12904	7362	1.791	4.474	865.9	3.932	1430	80.01	1.313	12.364
2008	1894	0.9975	219.0	10.07	14.70	290.9	1166	3171	0.6465	7.242	21.18	17.26	125.4	141.2	1.692	15.862
2009	1406	2.408	263.7	35.74	23.54	356.4	846.3	4260	0.6057	6.284	1.643	4.608	113.4	56.85	0.7232	18.469
2010	1845	4.966	39.24	16.49	6.044	na	6539	8636	3.280	1.938	411.5	66.19	2575	34.81	0.8776	30.583

Table 6.2.2a. American Eel abundance indices on the east coast of the United States: indices from the Atlantic Seaboard North (ASN).

Column header gives RPA zone acronym (ASN), index specific location, state, gear type, life stage (YOY refers to young of the year), and analysis method (GLM refers to General Linear Models). Data from ASMFC (2012). Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	ASN Farmill R. CT e-fishing elver & yellow non-GLM	ASN Long Is. Sound NY seine yellow GLM	ASN Long R. NY epibenthic sled & Tucker trawl YOY GLM	ASN Hudson R. NY seine (NYDEC Alosine Survey) elver & yellow GLM	ASN Long R. NY epibenthic sled & Tucker trawl yearling & older GLM	ASN Hudson R. NY seine (NYDEC Striped Bass Survey) elver & yellow GLM
1974	na	na	0.1967	na	1.387	na
1975	na	na	0.07988	na	1.628	na
1976	na	na	0.08428	na	1.111	na
1977	na	na	0.03278	na	0.6033	na
1978	na	na	0.1064	na	0.3819	na
1979	na	na	0.2473	na	0.3502	na
1980	na	na	0.06838	1.128	0.4964	0.4010
1981	na	na	0.002349	1.175	0.6672	1.144
1982	na	na	na	0.6196	0.5934	1.280
1983	na	na	na	0.6652	0.7986	1.396
1984	na	0.3670	0.0009607	0.2869	1.243	1.357
1985	na	0.6905	na	0.5780	0.7023	0.7197
1986	na	0.1769	na	0.9898	0.6177	0.4336
1987	na	0.07191	na	0.7037	0.8425	0.7291
1988	na	0.06696	0.0054591	0.4904	0.3224	0.9902
1989	na	0.09318	0.03685	0.3565	0.3708	0.6328
1990	na	0.01017	na	0.3155	0.5378	0.6728
1991	na	0.008061	0.05928	0.2671	0.3988	0.6464
1992	na	0.01681	0.05873	0.3407	0.1819	0.5169
1993	na	0.02405	0.2183	0.2366	0.1827	0.2275
1994	na	0.01140	0.08636	0.2341	0.2575	0.3847
1995	na	2.22045E-16	0.04560	0.2596	0.2564	0.3457
1996	na	2.22045E-16	0.04505	0.3443	0.4029	0.2714
1997	na	2.22045E-16	0.02625	0.07388	0.1334	0.6125
1998	na	0.01080	0.03869	0.3675	0.08569	0.3167
1999	na	2.22045E-16	0.01600	0.4939	0.08122	0.4229
2000	na	0.01305	0.03652	0.4230	0.06703	0.2365
2001	257	0.006263335	0.05948	0.3501	0.1671	0.2104
2002	179	0.007513224	0.02767	0.7821	0.03244	0.2218
2003	151	0.01735	0.03200	0.2739	0.1069	0.3181
2004	272	0.02374	0.01329	0.4844	0.1261	0.3885
2005	225	0.01754	0.05574	0.1662	0.07680	0.1423
2006	227	2.22045E-16	0.01435	0.2562	0.08767	0.1411
2007	241	0.01220	0.02469	0.4054	0.1650	0.1403
2008	340	2.22045E-16	0.009261	0.4038	0.09222	0.2321
2009	283	0.007873087	0.009939	0.1966	0.1914	0.3847
2010	337	2.22045E-16	na	na	na	na

Table 6.2.2b. American Eel abundance indices on the east coast of the United States: indices from the Atlantic Seaboard Central (ASC).

Column header gives RPA zone acronym (ASC), index specific location, state, gear type, life stage (YOY refers to young of the year), and analysis method (GLM refers to General Linear Models). Data from ASMFC (2012). Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	ASC Little Egg Inlet NJ icthyoplankton net YOY GLM	ASC Delaware R. NJ seine (NJDFW Striped Bass Survey) yellow GLM	ASC Delaware R. DE trawl, (Delaware Trawl Survey) elver & yellow GLM	ASC Delaware R. DE trawl (PSEG Trawl Survey) elver & yellow GLM	ASC Delaware R. PA e-fishing elver GLM
1970	na	na	na	0.4371	na
1971	na	na	na	0.6412	na
1972	na	na	na	0.4873	na
1973	na	na	na	0.2682	na
1974	na	na	na	0.2121	na
1975	na	na	na	0.2759	na
1976	na	na	na	0.3284	na
1977	na	na	na	0.2081	na
1978	na	na	na	0.1894	na
1979	na	na	na	1.250	na
1980	na	7.736E-14	na	0.4803	na
1981	na	0.09006	na	2.140	na
1982	na	1.014	1.503	na	na
1983	na	0.5312	0.6004	na	na
1984	na	2.592E-14	0.4508	5.236	na
1985	na	0.1739	0.3181	8.024	na
1986	na	0.3495	0.4856	2.485	na
1987	na	1.730E-14	0.3696	2.385	na
1988	na	0.09332	0.3788	2.649E-11	na
1989	na	0.06687	0.3684	0.2766	na
1990	na	0.04558	0.2400	0.7092	na
1991	na	0.02572	0.3591	0.2749	na
1992	1.425	0.08658	1.009	0.4841	na
1993	1.774	0.03152	0.6975	0.5031	na
1994	2.318	0.1263	0.1656	na	na
1995	2.302	0.05586	0.7182	0.5491	na
1996	1.545	0.08807	0.5626	0.08149	na
1997	1.365	0.08184	0.6261	1.039	na
1998	1.759	0.04447	0.6495	0.9195	na
1999	1.095	0.05042	0.9857	0.8867	23.41
2000	0.8454	0.07388	0.2314	0.4902	8.637
2001	1.366	0.05797	0.7933	0.6922	30.63
2002	1.216	0.07578	0.6135	0.6249	23.00
2003	1.029	0.05307	0.4186	1.384	17.96
2004	0.8056	0.3258	1.301	0.9618	25.06
2005	1.615	0.1322	0.9067	3.125	17.09
2006	1.682	0.1306	0.5421	1.171	23.31
2007	1.807	0.09674	0.6153	0.6042	26.29
2008	1.819	0.08133	0.3597	0.6444	23.08
2009	0.9957	0.1670	0.7423	1.364	32.36
2010	0.3315	na	0.4687	0.5468	17.51

Table 6.2.2c. American Eel abundance indices on the east coast of the United States: indices from the Atlantic Seaboard Central (ASC).

Column header gives RPA zone acronym (ASC), index specific location, state, gear type, life stage (YOY refers to young of the year), and analysis method (GLM refers to General Linear Models). Data from ASMFC (2012). Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	ASC Chesapeake Bay MD seine (MDDNR Striped Bass Survey) yellow GLM	ASC North Anna R. VA e-fishing elver & yellow GLM	ASC Lower Chesapeake Bay & tribs VA seine (VIMS Juvenile Striped Bass Survey) (short series) yellow GLM	ASC Lower Chesapeake Bay & tribs VA seine (VIMS Juvenile Striped Bass Survey) (long series) yellow GLM
1966	1.967	na	na	na
1967	0.1322	na	na	0.1838
1968	0.2018	na	na	0.2467
1969	0.1088	na	na	0.1439
1970	0.5030	na	na	0.1206
1971	0.5208	na	na	0.1899
1972	2.220E-16	na	na	0.1171
1973	0.09672	na	na	2.992E-15
1974	0.2415	na	na	na
1975	0.9291	na	na	na
1976	0.3803	na	na	na
1977	0.5272	na	na	na
1978	0.6511	na	na	na
1979	0.6196	na	na	na
1980	0.2850	na	na	0.08007
1981	0.4069	na	na	0.1085
1982	0.2546	na	na	0.07009
1983	2.583E-16	na	na	3.019E-15
1984	0.3127	na	na	0.06670
1985	0.3370	na	na	0.02564
1986	0.1948	na	na	0.02764
1987	0.1658	na	na	0.02564
1988	0.5054	na	na	0.04341
1989	0.1218	na	0.09889	2.992E-15
1990	0.05286	6.724	0.04410	2.992E-15
1991	2.220E-16	6.147	0.05116	2.992E-15
1992	0.06043	6.942	0.07347	2.992E-15
1993	0.06320	3.344	0.08943	0.02187
1994	0.05449	3.824	0.1137	2.992E-15
1995	0.07653	5.256	0.08222	0.04301
1996	0.05832	9.337	0.2087	0.06024
1997	0.5880	7.304	0.2874	0.06209
1998	0.3660	5.743	0.03540	0.04198
1999	0.5394	7.452	0.1081	0.02187
2000	0.3633	7.569	0.1666	0.08611
2001	0.1982	11.55	0.2349	0.06024
2002	0.2111	6.281	0.08937	0.04063
2003	0.8944	na	0.02994	3.018E-15
2004	0.3948	18.46	0.09123	0.04198
2005	0.9001	10.95	0.06750	0.08923
2006	0.05459	11.59	0.09787	2.992E-15
2007	0.06610	10.65	0.06649	0.02133
2008	0.5945	23.76	0.07342	0.06942
2009	0.2559	33.60	0.08880	0.1259
2010	0.2366	na	0.03173	0.04198

Table 6.2.2d. American Eel abundance indices on the east coast of the United States: indices from the Atlantic Seaboard South (ASS).

Column header gives RPA zone acronym (ASS), index specific location, state, gear type, life stage (YOY refers to young of the year), and analysis method (GLM refers to General Linear Models). Data from ASMFC (2012). Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	ASS Beauford Inlet NC icthyoplankton net YOY GLM	ASS Pamlico Sound, shallow water NC trawl elver & yellow GLM	ASS State waters SC e-fishing elver & yellow GLM
1987	0.6433	na	na
1988	1.020	na	na
1989	0.8422	0.1461	na
1990	0.6241	0.5614	na
1991	0.2597	0.3065	na
1992	1.132	0.3485	na
1993	0.6101	0.1988	na
1994	1.542	0.3151	na
1995	1.543	0.1917	na
1996	0.6090	0.3628	na
1997	0.3301	0.1137	na
1998	1.095	0.1130	na
1999	0.1698	0.3637	na
2000	0.2797	0.03511	na
2001	0.4087	0.1305	1.060
2002	0.9585	0.1854	0.8041
2003	0.4056	0.1063	1.268
2004	na	0.2794	0.9731
2005	na	0.1686	0.9465
2006	na	0.1116	0.8521
2007	na	0.09250	0.7035
2008	na	0.1432	0.6666
2009	na	0.04220	0.8032
2010	na	0.1607	0.6918

Table 6.2.3. Combined American Eel abundance indices on the Atlantic Seaboard of the United States, as analyzed by General Linear Models.

Column header gives distribution of states, gear type, and life stage (YOY refers to young of the year). Data from ASMFC (2012). Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

Year	ME to FL various gears YOY	NY to NC 3 series various gears YOY	DE to VA 3 series various gears elver & yellow	NY to NC 7 series various gears elver & yellow	NY to SC 12 series various gears elver & yellow
1967	na	na	0.8052	na	na
1968	na	na	0.8868	na	na
1969	na	na	0.7670	na	na
1970	na	na	0.8302	na	na
1971	na	na	0.9239	na	na
1972	na	na	0.6686	na	na
1973	na	na	0.6081	na	na
1974	na	na	0.5874	na	na
1975	na	na	0.8514	na	na
1976	na	na	0.6904	na	na
1977	na	na	0.6896	na	na
1978	na	na	0.7203	na	na
1979	na	na	1.1320	na	na
1980	na	na	0.7594	na	na
1981	na	na	1.1265	1.1526	na
1982	na	na	0.8036	1.1666	na
1983	na	na	0.6124	1.0469	na
1984	na	na	1.3737	1.1855	na
1985	na	na	1.5437	1.2150	na
1986	na	na	1.0241	1.0506	na
1987	na	1.1369	0.9969	0.9972	na
1988	na	1.2938	0.6446	0.7902	na
1989	na	1.2535	0.6188	0.7325	na
1990	na	1.1102	0.6896	0.7809	na
1991	na	0.9610	0.5750	0.6955	1.0473
1992	na	1.3002	0.6468	0.7114	1.1410
1993	na	1.3558	0.6613	0.6626	0.9878
1994	na	1.7003	0.6449	0.7305	1.0098
1995	na	1.4936	0.6855	0.7052	1.0574
1996	na	1.2064	0.5630	0.6714	1.1007
1997	na	1.0272	0.9739	0.8037	1.1888
1998	na	1.3682	0.8679	0.7606	1.0936
1999	na	0.9161	0.9036	0.8033	1.2384
2000	4.8929	0.8972	0.7891	0.7279	1.0457
2001	7.6249	1.1018	0.7705	0.7222	1.1672
2002	7.2614	1.1744	0.7514	0.7386	1.0986
2003	3.2055	1.0134	1.0882	0.8307	1.1874
2004	2.0459	0.9548	0.8861	0.8474	1.3954
2005	5.9953	1.2143	1.4316	0.8939	1.3133
2006	3.7995	1.1737	0.7688	0.6989	1.1074
2007	3.6692	1.1960	0.6838	0.6884	1.0853
2008	2.4811	1.2399	0.8876	0.7688	1.2184
2009	2.0894	1.0387	0.9530	0.8181	1.3247
2010	4.1280	na	0.7430	0.7204	1.0429

Table 6.2.4. American Eel abundance series from beach seine and trawl surveys on the east coast of the United States (Poirier 2013).

Column header gives location, state, gear, and the survey abbreviation of Poirier (2013). % set = percentage of sets with eels. Mean = mean number of eels per set. "na" = data are not available. Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

	Long Island NY beach seine LI_BSa		Hudson Estuary NY beach seine HE_BS		Delaware Bay NJ trawl NJDB_T		Delaware Bay & River DE (Juvenile Finfish Trawl Survey) DEDB_T		Rappa-hannock R. VA trawl VIMS_T	York R. VA trawl VIMS_T	James R. VA trawl VIMS_T	Chesapeake Bay & tribs (all) VA trawl VIMS_T	Coastal sounds NC trawl NC_T	
Year	% sets	Mean	% sets	Mean	% sets	Mean	% sets	Mean	% sets	% sets	% sets	% sets	% sets	Mean
1973	na	na	na	na	na	na	na	na	na	na	na	na	4.720	0.055
1974	na	na	na	na	na	na	na	na	na	na	na	na	1.944	0.021
1975	na	na	na	na	na	na	na	na	na	na	na	na	2.888	0.029
1976	na	na	na	na	na	na	na	na	na	na	na	na	4.933	0.049
1977	na	na	na	na	na	na	na	na	na	na	na	na	3.010	0.030
1978	na	na	na	na	na	na	0.000	0.000	na	na	na	na	8.952	0.148
1979	na	na	na	na	na	na	0.000	0.000	20.472	22.845	29.167	21.591	8.091	0.175
1980	na	na	10.849	0.274	na	na	15.301	0.601	23.596	44.366	33.043	29.712	6.034	0.129
1981	na	na	24.752	0.525	na	na	25.000	2.696	30.769	39.310	34.513	33.668	7.717	0.077
1982	na	na	27.053	0.609	na	na	23.651	1.295	32.407	50.000	26.623	32.323	4.822	0.048
1983	na	na	18.482	0.462	na	na	18.565	0.992	31.395	40.132	33.871	36.220	3.828	0.038
1984	18.056	0.778	16.721	0.472	na	na	23.770	0.750	49.206	57.500	45.641	49.624	4.696	0.048
1985	15.000	0.300	26.667	0.556	na	na	11.712	0.261	32.308	44.660	33.028	37.543	3.360	0.034
1986	13.534	0.541	27.527	0.581	na	na	10.417	0.333	35.849	31.132	35.088	34.049	3.013	0.030
1987	6.522	0.304	21.393	0.575	na	na	7.018	0.149	27.273	32.653	33.721	31.250	3.475	0.036
1988	13.714	0.560	21.622	0.570	na	na	7.627	0.314	9.901	23.148	21.053	6.826	5.432	0.055
1989	10.563	0.246	19.874	0.387	na	na	12.551	0.381	18.400	16.535	28.302	10.048	5.613	0.056
1990	3.361	0.059	19.822	0.394	na	na	12.563	0.226	22.689	24.800	26.852	10.545	10.791	0.113
1991	1.709	0.026	13.717	0.305	0.000	0.000	15.185	0.415	20.000	17.829	13.761	8.073	6.015	0.063
1992	2.778	0.037	20.215	0.333	0.000	0.000	21.300	0.957	12.000	13.600	25.225	7.864	9.337	0.101
1993	3.333	0.033	12.397	0.196	0.000	0.000	20.939	0.531	11.811	12.403	22.523	7.629	5.199	0.052
1994	3.788	0.076	15.258	0.245	1.429	0.014	19.355	0.774	19.200	13.953	21.622	9.302	7.143	0.075
1995	0.000	0.000	15.296	0.245	4.545	0.061	20.357	0.707	20.213	15.238	31.250	9.804	3.198	0.032
1996	3.125	0.094	18.066	0.270	0.000	0.000	28.674	0.946	22.179	18.725	32.895	15.431	6.720	0.081
1997	0.000	0.000	11.111	0.224	1.299	0.013	24.643	2.121	25.660	17.803	27.547	15.410	3.380	0.037
1998	2.174	0.022	17.684	0.265	0.000	0.000	19.713	1.022	20.313	16.858	26.792	13.471	4.498	0.045
1999	0.840	0.008	17.156	0.343	0.000	0.000	23.929	1.536	12.879	12.121	25.455	10.210	7.358	0.084
2000	2.597	0.032	14.017	0.215	0.000	0.000	15.356	0.487	18.113	10.646	18.613	9.304	2.524	0.025
2001	1.081	0.011	12.615	0.216	0.000	0.000	18.638	0.978	11.255	14.159	19.214	9.140	5.199	0.052
2002	1.667	0.033	20.920	0.382	3.896	0.052	20.000	0.586	7.955	11.494	18.939	9.450	4.294	0.043
2003	2.857	0.143	15.745	0.232	3.896	0.052	21.168	0.580	14.015	7.308	17.045	8.480	5.460	0.055
2004	3.109	0.031	19.068	0.318	2.597	0.026	25.275	1.824	13.258	7.280	12.121	7.026	4.932	0.049
2005	1.724	0.029	8.316	0.120	7.792	0.104	29.304	1.000	7.576	4.580	11.610	5.285	5.094	0.054
2006	0.541	0.005	10.064	0.150	6.494	0.078	22.711	0.571	3.774	3.462	8.678	3.521	4.938	0.049
2007	0.472	0.009	12.527	0.221	5.195	0.052	20.147	0.575	5.682	7.576	6.415	4.330	3.015	0.030
2008	0.000	0.000	15.400	0.240	0.000	0.000	18.681	0.447	12.500	10.728	10.227	7.353	3.571	0.036
2009	0.490	0.005	15.011	0.192	na	na	23.810	0.612	10.227	9.615	10.985	6.781	3.097	0.031
2010	1.026	0.010	na	na	na	na	na	na	11.742	12.692	6.792	5.954	4.348	0.043
2011	0.943	0.009	na	na	na	na	na	na	na	na	na	na	na	na

Table 7.1.1. Latitudes, distance from the spawning ground, and mean annual water temperatures, by RPA zone.

	Latitude (ºN) [1]			Distance from the spawning ground (km) [1]			Mean annual water temperature (°C) [2]		
RPA zone	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
St. Lawrence Basin (SL)	45.35	46.80	43.90	5,380	5,100	5,660	9.6	8.6	14.1
Northern Gulf and Newfoundland (NG)	49.05	46.60	51.50	4,410	3,860	4,960	4.9	1.5	10.0
Southern Gulf (SG)	46.85	45.60	48.10	4,325	4,000	4,650	8.9	6.8	9.9
Scotia-Fundy (SF)	45.20	43.40	47.00	3,550	3,100	4,000	7.0	7.0	7.0
Atlantic Seaboard North (ASN)	42.85	40.50	45.20	2,700	2,200	3,200	10.0	12.0	8.0
Atlantic Seaboard Central (ASC)	38.55	36.60	40.50	2,050	1,900	2,200	13.5	15.0	12.0
Atlantic Seaboard South (ASS)	30.40	24.20	36.60	1,665	1,430	1,900	20.8	26.5	15.0

[1] For the St. Lawrence Basin, the min. latitude and the min. distance is at Quebec City and the max. latitude and the max. distance is eastern Lake Ontario. For other zones, latitude and distance are measured along the zone's salt-water coastline.

[2] For the St. Lawrence Basin, the mean annual temperature is from the Atwater water intake station in Montreal (Hudon et al. 2010). The eastern Lake Ontario mean annual temperature is taken as the St. Lawrence River mean annual temperature at Cornwall (Hudon et al. 2003). The Quebec City mean annual temperature is taken as the value for Montreal, minus the differential between water intake temperatures in Montreal and Sainte-Foy, Quebec (1ºC; de Lafontaine et al. 2009). For the Northern Gulf of St. Lawrence and Newfoundland and the Southern Gulf, temperatures are from the modelled bottom temperatures in 2.5 x 2.5 km cells which contain at least 75% sheltered habitat (Dutil et al. 2012). Temperatures in all other zones are from NOAA (Fig. 7.2.1).

Table 7.2.1. Mean length and age of silver eels, and eel growth rate by sex and salinity of growth habitat for sampling sites within RPA zones for eastern North America.

Also shown are the geographic position (latitude and longitude) and distance to the spawning ground of each sampling site. "na" means data are not available. Data available in spreadsheet format from the senior author (david.cairns@dfo-mpo.gc.ca).

RPA zone [1]	Province or state	Site	Sex	Phase [2]	Salinity of growth habitat	Let	Long	Distance from spawning ground (km) [3]	Silver eel mean length (mm)	Silver eel mean age (yr)	Growth rate (mm/yr)	Reference
SL	QC	Kamouraska, St. Lawrence River	F	Silver	Fresh	47.45	70.05	4,990	837	20.1	41.6	Tremblay 2009
SL	QC	Upper St. Lawrence River	F	Silver	Fresh	45.42	73.66	5,520	915	19.7	43.2	Casselman 2003
SL	QC	Upper St. Lawrence River	F	Silver	Fresh	44.82	75.30	5,520	1,001	20.9	47.9	Tremblay 2009
SL	ON	Lake Ontario	F	Yellow	Fresh	43.77	76.68	5,690	na	na	54.9	Hurley 1972
NG-Gulf	NL	Castors River	F	Silver	Fresh	50.92	56.95	4,560	664	19.7	30.5	Jessop et al. 2009
NG-Gulf	NL	River of Ponds	F	Silver	Fresh	50.50	57.35	4,510	599	na	na	Gallant 2011
NG-Gulf	QC	Petite Rivière de la Trinité	F	Silver	Fresh	49.53	67.23	4,700	675	19.3	31.7	Fournier & Caron 2005, Tremblay 2009
NG-Gulf	QC	Rivière Saint-Jean Gaspé Peninsula	F	Silver	Fresh	48.77	64.43	4,480	520	11.4	40.0	I. Thibault & G. Verreault, pers. comm.
NG-Gulf	QC	Rivière du Sud-Ouest	F	Silver	Fresh	48.36	68.76	4,840	1,016	21.4	44.4	Tremblay 2009, G. Verreault, pers. comm.
NG-Atlantic	NL	Hollyrood Bay	F	Silver	Fresh	46.78	53.63	3,880	722	12.9	51.0	Bouillon & Haedrich 1985
NG-Atlantic	NL	Dog Bay	F	Silver	Fresh	49.42	54.57	4,320	778	13.0	54.9	Bouillon & Haedrich 1985
NG-Atlantic	NL	Topsail Pond	F	Silver	Fresh	47.53	52.98	4,100	694	12.3	51.2	Gray & Andrews 1971
NG-Atlantic	NL	Salmonier River	F	Silver	Fresh	47.30	53.25	3,950	820	na	na	Gallant 2011
NG-Atlantic	NL	Chance Cove River	F	Silver	Fresh	46.76	53.01	3,880	507	na	na	Gallant 2011
SG	PEI	Long & Campbells Ponds	F	Silver	Fresh	46.41	63.06	4,370	708	18.3	35.3	Cairns et al. 2007, Tremblay 2009
SG	PEI	McCallums, Cass, & Marshalls Ponds	F	Yellow	Fresh	46.40	63.17	4,378	na	na	45.2	Lamson et al.2009
SG	PEI	Whitlocks Pond	F	Yellow	Fresh	46.35	62.53	4,375	na	na	39.9	Cairnsetal.2004
SG	NS	Margaree River	F	Silver	Fresh	46.19	61.16	4,280	645	21.9	26.5	Cairns et al. 2007
SF	NS	East River Chester	F	Silver	Fresh	44.58	64.17	3,300	442	17.1	22.7	Jessop et al. 2004
SF	NS	LaHave River	F	Silver	Fresh	44.36	64.35	3,250	610	19.4	28.3	Jessop 1987
SF	NS	Medway River	F	Silver	Fresh	44.13	64.63	3,225	555	19.2	25.7	Jessop 1987
ASN	ME	Four Maine rivers	F	Yellow	Fresh	44.50	68.50	3,200	na	na	31.9	Oliveira&McCleave2002
ASN	RI	Annaquatucket River	F	Silver	Fresh	41.55	71.44	2,490	510	12.8	35.3	Oliveira 1999
ASC	VA	Shenandoah River	F	Silver	Fresh	38.92	78.19	2,400	872	12.6	64.7	Goodwin & Angermeier 2003

RPA zone[1]	Province or state	Site	Sex	Phase[2]	Salinity of growth habitat	Let	Long	Distance from spawning ground (km)[3]	Silver eel mean length (mm)	Silver eel mean age (yr)	Growth rate (mm/yr)	Reference
ASC	DE	Indian River	F	Silver	Fresh	38.59	75.29	2,150	608	11.0	50.0	Barber 2004
ASS	SC	Cooper River	F	Adv.yel.	Fresh	33.20	79.99	1,580	629	7.7	75.0	Harrell & Loyacano 1982, Hansen & Eversole 1984
SG	PEI	Brackley & Covehead Bays	F	Adv.yel.	Saline	46.42	63.17	4,376	na	7.5	98.2	Lamson e tal.2009
SG	PEI	BoughtonEstuary	F	Yellow	Saline	46.29	62.51	4,370	na	na	101.0	Cairns et al.2004
SF	NS	EastR.,Chester	F	Silver	Saline	44.58	64.17	3,300	499	na	27.7	Jessop et al.2004
ASC	DE	Delaware Bay	F	Yellow	Saline	39.00	75.30	2,200	na	na	83.0	Barber 2004
ASC	VA	Rappahannock R.	F	Yellow	Saline	37.82	76.75	2,065	516	8.8	52.4	Owens & Geer 2003
ASC	VA	York R.	F	Yellow	Saline	37.47	76.77	2,030	517	8.3	55.4	Owens & Geer 2003
ASC	VA	James R.	F	Yellow	Saline	37.25	76.70	2,030	518	7.4	62.4	Owens & Geer 2003
ASS	SC	Charleston Harbor	F	Adv. yel.	Saline	32.79	79.92	1,590	550	5.8	85.9	Michener & Eversole 1983
ASS	GA	Savannah Estuary	F	Silver	Saline	32.04	80.91	1,580	584	8.6	61.9	Facey & Helfman 1985
NG-Gulf	QC	Petite R. de la Trinité	M	Silver	Fresh	49.42	67.14	4,700	376	13.0	24.0	Fournier & Caron 2005
NG-Gulf	QC	St. Jean R., Gaspé Pen	M	Silver	Fresh	48.77	64.43	4,480	350	10.4	27.5	I. Thibault pers. comm.
SG	PEI	Long & Campbells Ponds	M	Silver	Fresh	46.41	63.06	4,370	339	5.2	53.1	Cairns et al. 2007
SF	NS	East R., Chester	M	Silver	Fresh	44.58	64.17	3,300	351	15.4	19.2	Jessop et al. 2004
SF	NS	Medway R.	M	Silver	Fresh	44.13	64.63	3,225	392	12.7	26.1	Jessop 1987
ASN	ME	Four Maine rivers	M	Yellow	Fresh	44.50	68.50	3,200	na	na	28.9	Oliveira & McCleave 2002
ASN	RI	Annaquatucket R.	M	Silver	Fresh	41.55	71.44	2,490	337	10.9	25.6	Oliveira 1999
ASC	DE	Indian R.	M	Silver	Fresh	38.59	75.29	2,150	352	6.4	46.0	Barber 2004
ASS	GA	McKinneys Pond	M	Silver	Fresh	32.79	82.27	1,880	329	4.8	57.4	Facey & Helfman 1985
SF	NS	East R., Chester	M	Silver	Saline	44.58	64.17	3,300	358	na	21.8	Jessop et al. 2004
ASS	GA	Savannah Estuary	M	Silver	Saline	32.04	80.91	1,580	328	5.3	52.1	Facey & Helfman 1985

[1] RPA zones are: SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland (-Gulf means Gulf of St. Lawrence drainage, -Atlantic means Atlantic drainage), SG = Southern Gulf of St. Lawrence, SF = Scotia-Fundy, ASN = Atlantic Seaboard North, ASC = Atlantic Seaboard Central, and ASS = Atlantic Seaboard South.
[2] Advanced yellow eels are considered to have the same length and age as silver eels
[3] Distance from the spawning ground, along a route from the Sargasso Sea to the continental shelf of Florida, and thence along the coast to the study site (Jessop 2010).

Table 7.2.2. Means and regression statistics for length (mm), age (yr) of silver eels, and growth rate (mm/yr), against latitude and distance of growth habitat from the spawning ground.

Means and regressions are based on data in Table 7.2.1. Parameters with superscript a and in the cell with borders are those proposed for use in population modelling [1].

							Regression against latitude				Regression against distance from the spawning ground (km)			
Region [2]	Sex	Salinity of growth habitat	Dependent variable	Mean	SD	N	a	b	r^2	p-value	a	b	r^2	p-value
St Law & Nfld	F	Fresh	Length	740.1	155.2	15	2,340.989	-33.5310	0.086	0.151	-117.541	0.1890	0.359	0.011
S of Cabot Strait	F	Fresh	Length	603.7	135.4	7	1,198.039	-14.5809	0.043	0.311	817.254	-0.0813	0.000	0.381
All	F	Saline	Length	530.7	31.0	6	754.036	-6.0388	0.709	0.022	608.362	-0.0370	0.459	0.084
St Law & Nfld	F	All	Length	740.1	155.2	15	2,340.989	-33.5314	0.086	0.151	-117.541[a]	0.1895[a]	0.359	0.011
S of Cabot Strait	F	All	Length	570.0[a]	104.9	13	763.431	-4.9574	0.216	0.478	639.307	-0.0291	0.000	0.540
St Law & Nfld	F	Fresh	Age	17.6	4.0	12	42.673	-0.5270	0.000	0.447	-3.799	0.0046	0.298	0.039
S of Cabot Strait	F	Fresh	Age	14.3	4.4	7	-26.422	0.9980	0.866	0.001	-3.042	0.0066	0.948	0.000
All	F	Saline	Age	7.7	1.1	6	6.966	0.0203	0.000	0.858	7.741	0.0000	0.000	0.990
St Law & Nfld	F	All	Age	16.8	4.7	13	26.811	-0.2106	0.000	0.796	-7.714[a]	0.0053[a]	0.255	0.045
S of Cabot Strait	F	All	Age	11.6	4.7	12	-25.552	0.9623	0.802	0.000	-4.683[a]	0.0070[a]	0.911	0.000
St Law & Nfld	F	Fresh	growth rate	42.5	8.8	15	114.924	-1.5330	0.045	0.220	29.388	0.0028	0.000	0.533
S of Cabot Strait	F	Fresh	Growth rate	41.7	19.4	8	227.926	-4.5169	0.888	0.000	116.225	-0.0276	0.803	0.002
All	F	Saline	Growth rate	69.8	24.0	9	33.598	0.9204	0.000	0.594	47.525	0.0085	0.035	0.293
St Law & Nfld	F	All	Growth rate	49.3[a]	20.7	17	195.866	-3.1122	0.014	0.286	68.513	-0.0042	0.000	0.690
S of Cabot Strait	F	All	Growth rate	50.8	21.4	15	212.083	-4.0945	0.713	0.000	118.893[a]	-0.0281[a]	0.740	0.000
St Law & Nfld	M	Fresh	Length	355.0	19.0	3	-138.874	10.2463	0.459	0.348	-155.325	0.1130	0.997	0.025
S of Cabot Strait	M	Fresh	Length	352.1	24.4	5	220.553	3.2622	0.227	0.237	282.852	0.0266	0.305	0.196
All	M	Saline	Length	342.9	21.1	2	251.860	2.3764	na	na	300.626	0.0173	na	na
St Law & Nfld	M	All	Length	355.0	19.0	3	-138.874	10.2463	0.459	0.348	-155.325[a]	0.1130[a]	0.997	0.025
S of Cabot Strait	M	All	Length	349.5[a]	22.1	7	233.640	2.9141	0.418	0.069	291.717	0.0226	0.451	0.059
St Law & Nfld	M	Fresh	Age	9.5	4.0	3	-110.357	2.4873	0.968	0.081	-89.599	0.0220	0.724	0.242
S of Cabot Strait	M	Fresh	Age	10.0	4.4	5	-24.311	0.8517	0.838	0.019	-7.345	0.0067	0.899	0.009
All	M	Saline	Age	5.3	NA	1	na	na	na	na	na	na	na	na
St Law & Nfld	M	All	Age	9.5[a]	4.0	3	-110.357	2.4873	0.968	0.081	-89.599	0.0220	0.724	0.242
S of Cabot Strait	M	All	Age	9.2	4.4	6	-19.789	0.7455	0.842	0.006	-5.217[a]	0.0059[a]	0.892	0.003
St Law & Nfld	M	Fresh	Growth rate	34.9	15.9	3	516.487	-9.9920	0.981	0.061	386.789	-0.0779	0.356	0.384
S of Cabot Strait	M	Fresh	Growth rate	33.9	14.6	6	155.526	-2.9655	0.863	0.005	90.194	-0.0208	0.712	0.022
All	M	Saline	Growth rate	37.0	21.4	2	129.517	-2.4163	na	na	0.000	1.0000	na	na
St Law & Nfld	M	All	Growth rate	34.9[a]	15.9	3	516.487	-9.9920	0.981	0.061	386.789	-0.0779	0.356	0.384
S of Cabot Strait	M	All	Growth rate	34.6	14.9	8	141.368[a]	-2.6454[a]	0.881	0.000	85.253	-0.0192	0.802	0.002

[1] Parameters proposed for use in population modeling are chosen as follows. Regression equations are used if P values are <0.05. If both regression equations have P<0.05, the equation with the highest r^2 is chosen. If neither regression equation has P<0.05, then the mean value for the zone from Table 7.2.1 is chosen.

[2] St Law & Nfld refers to the St. Lawrence Basin and the Northern Gulf of St. Lawrence and Newfoundland, and the Southern Gulf of St. Lawrence RPA zones. S of Cabot Strait refers to Scotia-Fundy, Atlantic Seaboard-North, Atlantic Seaboard-Central, and Atlantic Seaboard-South RPA zones.

Table 7.2.3. Weight-length relationships for American eels from selected locations by RPA zones.

Equations have the form Weight = a $Length^b$, where weight is in g and length is in mm. Weights predicted by the equations are presented for eels of 200, 500, and 800 mm total length. Regression coefficients with the highest sample size are proposed for use in population modelling, and are shown with superscript a and in the cells with borders.*

RPA Zone [1]	Location of sampling or growth	Prov. / state of growth area	Salinity of growth area	N	a	b	Predicted weight (g) Length 200 mm	Length 500 mm	Length 800 mm	References
SL-US	Lake Champlain	VT	Fresh	426	9.3325 E-07	3.1700	18	336	1,489	Facey and LaBar (1981)
SL-Canada	Lake Ontario and upper St. Lawrence River, 1964-2008	ON,NY	Fresh	37,784	2.0770 E-08[a]	3.7008[a]	7	202	1,151	Ontario-MNR, via X. Zhu
SL	St. Lawrence Estuary	QC,ON,NH,VT, NY	Fresh	3,841	4.4610 E-06	3.0100	38	593	2,442	Larouche et al. (1974)
NG-Gulf drainage	Western Newfoundland	NL	Mixed	117	1.7800 E-07	3.3500	9	196	946	B. Jessop pers. comm.; Jessop et al. (2009)
NG-Gulf drainage	Western Newfoundland	NL	Saline	77	5.0120 E-08	3.5500	7	191	1,014	Brennan (1976)
NGAtlantic drainage	Topsail Pond, Avalon Pen.	NL	Fresh	145	1.1566 E-07	3.4395	9	222	1,118	Gray and Andrews (1971); Nilo and Fortin (2001)
NG-Atlantic drainage	Stoney River, Avalon Pen.	NL	Fresh	645	1.7037 E-06[a]	3.0103[a]	14	227	934	K. Clarke, unpubl.
SG	Southern Gulf of St. Lawrence	NB,NS,PE	Mixed	7,001	5.1286 E-07[a]	3.1970[a]	12	218	980	D. Cairns unpubl.
SF	East River Chester (elvers only)	NS	na	244	4.3833 E-07[a]	3.1084[a]	na	na	na	Jessop (2003b)
SF	Southwest Nova Scotia Rivers	NS	Fresh	832	8.8716 E-07[a]	3.1170[a]	13	229	993	D. Cairns, using data from Jessop (1987)
ASN	Maine rivers	ME	Fresh	3,116	9.8400 E-07[a]	3.0900[a]	13	215	919	Oliveira and McCleave (2000)
ASN	Hudson Estuary	NY	Mixed	543	6.3096 E-07	3.2000	15	273	1,230	Morrison and Secor (2003)
ASC	Delaware commercial fishery	DE	Saline	328	6.5000 E-07[a]	3.1800[a]	13	249	1,109	Clark (2009)
ASC	York River, Chesapeake Bay	VA	Saline	255	8.0300 E-07	3.1474	14	251	1,101	Owens and Geer (2003)
ASS	Charleston Harbour	SC	Saline	484	1.9249 E-06[a]	3.0067[a]	16	251	1,031	Michener (1980)
ASS	Fridaycap Creek	GA	Saline	218	5.0847 E-07	3.2315	14	268	1,223	Helfman et al. (1984)

[1] SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland (-Gulf means Gulf of St. Lawrence drainage, -Atlantic means Atlantic drainage), SG = Southern Gulf of St. Lawrence, SF = Scotia-Fundy, ASN = Atlantic Seaboard North, ASC = Atlantic Seaboard Central, and ASS = Atlantic Seaboard South

Table 7.3.1. Percentage of males among sexed eels in North America, by sampling locations within RPA zones and salinity of growth habitat.

Acronyms for RPA zones are : SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland (-Gulf means Gulf of St. Lawrence drainage, -Atlantic means Atlantic drainage), SG = Southern Gulf of St. Lawrence, SF = Scotia-Fundy, ASN = Atlantic Seaboard North, ASC = Atlantic Seaboard Central, and ASS = Atlantic Seaboard South.

RPA zone	Prov./ State	Location	Salinity	Lat. (ºN)	% male[1]	Reference
SL	QC	St. Lawrence Estuary	Fresh	47.6	0.0	Desjardins et al. (1983)
SL	QC	Kamouraska, St. Lawrence Estuary	Fresh	47.6	0.0	Couillard et al. (1997)
SL	QC	St. Lawrence Estuary	Fresh	47.0	0.0	Larouche et al. (1974)
SL-US	VT	Lake Champlain	Fresh	44.7	0.0	Facey and LaBar (1981)
SL-Canada	ON	Lake Ontario	Fresh	44.0	0.0	Hurley (1972)
NG-Gulf drainage	NL	Castors River	Fresh	50.9	5.0	Jessop et al. (2009)
NG-Gulf drainage	NL	River of Ponds	Fresh	50.5	0.0	Gallant (2011)
NG-Gulf drainage	QC	Matamek R	Fresh	50.3	0.0	Dolan and Power (1977)
NG-Gulf drainage	QC	Matamek R	Saline	50.3	4.8	Dolan and Power (1977)
NG-Gulf drainage	NL	St. Georges River	Fresh	48.5	16.1	Gallant (2011)
NG-Gulf drainage	NL	Flat Bay Brook	Saline	48.4	33.3	Gallant (2011)
NG-Gulf drainage	NL	Muddy Hole	Saline	48.1	0.0	Jessop et al. (2009)
NG-Atlantic drainage	NL	Salmon River	Fresh	51.1	0.0	Gray and Andrews (1970)
NG-Atlantic drainage	NL	Dog Bay	Fresh	49.5	0.0	Bouillon and Haedrich (1985)
NG-Atlantic drainage	NL	Burnt Berry Brook	Fresh	49.4	1.8	Gray and Andrews (1970)
NG-Atlantic drainage	NL	Campbellton R	Fresh	49.3	0.0	Gallant (2011)
NG-Atlantic drainage	NL	Arran Cove	Saline	47.8	0.0	Gallant (2011)
NG-Atlantic drainage	NL	Topsail Pond	Fresh	47.5	0.0	Gray and Andrews (1970)
NG-Atlantic drainage	NL	Topsail Barachois	Saline	47.5	0.0	Gray and Andrews (1970)
NG-Atlantic drainage	NL	Indian Pond	Saline	47.4	0.0	Gray and Andrews (1970)
NG-Atlantic drainage	NL	Southern Nfld rivers	Fresh	47.4	5.4	Vladykov (1966)
NG-Atlantic drainage	NL	Salmonier R	Fresh	47.3	0.0	Gallant (2011)
NG-Atlantic drainage	NL	Chance Cove R	Fresh	46.8	0.0	Gallant (2011)
NG-Atlantic drainage	NL	Holyrood Bay	Fresh	46.7	0.0	Bouillon and Haedrich (1985)
SG	NB	Miramichi River	Fresh	47.0	0.0	Cairns et al. (2008)
SG	PE	Long & Campbells Ponds	Fresh	46.4	2.9	Cairns et al. (2007)
SF	NB	Meduxnekeag R, Saint John R system, above Mactaquac Dam	Fresh	46.2	0.0	Ingraham (1999)
SF	NB	Saint John R, base of Mactaquac Dam	Fresh	46.0	1.2	Ingraham (1999)
SF	NB	French and Indian Lakes, Saint John R system	Fresh	45.9	17.2	Ingraham (1999)
SF	NB	Oromocto R, Saint John R system	Fresh	45.8	45.1	Ingraham (1999)
SF	NB	Crecy Lake	Fresh	45.5	20.1	Vladykov (1968)
SF	NB	Dennis Stream	Fresh	45.2	32.5	Peterson et al. (1996)
SF	NS	LaHave R	Fresh	44.4	0.0	Jessop (1987)
SF	NS	Medway R	Fresh	44.1	2.5	Jessop (1987)
SF	NS	Eel Brook	Fresh	43.9	0.0	Jessop (1987)
ASN	ME	East Machias R	Fresh	44.7	52.0	Oliveira et al. (2001)
ASN	ME	Chandler R	Fresh	44.6	98.0	Oliveira et al. (2001)
ASN	ME	Pleasant R	Fresh	44.5	77.0	Oliveira et al. (2001)
ASN	ME	Medomak R.	Fresh	44.0	76.0	Oliveira et al. (2001)
ASN	ME	Sheepscot R	Fresh	44.0	49.0	Oliveira et al. (2001)
ASN	NY	Hudson Estuary	Fresh	42.5	0.0	Morrison and Secor (2003), ASMFC (2012)
ASN	RI	Annaquatucket R	Fresh	41.6	89.5	Krueger and Oliveira (1997)
ASN	RI	Annaquatucket R	Fresh	41.5	75.0	Servidio (1986)
ASN	RI	Rivers	Fresh	41.5	88.2	Winn et al. (1975)
ASN	RI	Rivers	Saline	41.5	54.7	Winn et al. (1975)

RPA zone	Prov./ State	Location	Salinity	Lat. (ºN)	% male[1]	Reference
ASN	RI	Point Judith Pond	Saline	41.4	10.6	Bieder (1971)
ASC	MD	Chesapeake Bay, estuaries	Fresh	39.0	0.0	Foster and Brody (1982) in Helfman et al. (1987)
ASC	MD	Chesapeake Bay estuaries	Saline	38.4	43.7	Weeder and Hammond (2009)
ASC	VA	Shenandoah R	Fresh	38.9	0.0	Goodwin and Angermeier (2003)
ASC	VA	Potomac R tributaries	Fresh	38.9	29.0	Goodwin and Angermeier (2003)
ASC	DE	Indian R tributaries	Fresh	38.6	77.6	Barber (2004)
ASC	VA	James R Estuary	Saline	37.2	0.0	Hedgepeth (1983)
ASS	GA	Savannah R	Fresh	33.3	15.0	Helfman et al. (1987)
ASS	SC	Pinnopolis Dam, Cooper R system	Fresh	33.2	1.6	Harrell and Loyacano (1982)
ASS	SC	Cooper R Estuary	Saline	33.2	4.2	Hansen and Eversole (1984)
ASS	SC	Wadboo Creek, Cooper R system	Fresh	33.2	1.3	Harrell and Loyacano (1982)
ASS	SC	Charleston Harbor	Saline	32.8	6.6	Michener (1980)
ASS	GA	Ogeechee R pond	Fresh	32.8	4.0	Helfman et al. (1987)
ASS	GA	Savannah R Estuary	Saline	32.1	58.0	Helfman et al. (1987)
ASS	GA	Ogeechee R	Fresh	32.1	26.0	Helfman et al. (1987)
ASS	GA	Ogeechee R Estuary	Saline	31.9	25.0	Helfman et al. (1987)
ASS	GA	Altamaha R	Fresh	31.6	6.0	Helfman et al. (1987)
ASS	GA	Altamaha R Estuary	Saline	31.4	36.0	Helfman et al. (1987)
ASS	GA	Satilla R	Fresh	31.2	0.0	Helfman et al. (1987)
ASS	GA	Satilla R Estuary	Saline	31.0	33.0	Helfman et al. (1987)
Mean value by RPA zone[2]						
SL					0.0%	
NG					4.5%	
SG					1.5%	
SF					10.1%	
ASN					44.7%	
ASC					29.1%	
ASS					13.0%	
All fresh[3]					18.7%	
All saline[3]					19.4%	
All					18.8%	

[1] Calculated as 100 * number of males/number of eels whose sex was successfully determined
[2] Zonal means are means of means of drainage category for NG or of provinces or states for all other RPA zones.
[3] Mean percent male does not differ significantly between salinity categories (Mann-Whitney U test = 333.5, p =0 .357)

Table 7.3.2. Regression statistics for associations between American Eel fecundity at length and fecundity at weight.

*Regression equations have the form fecundity (number of eggs) = a*Length(cm)^b or a*Weight(g)^b. Acronyms for RPA zones are : SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland (-Gulf means Gulf of St. Lawrence drainage, -Atlantic means Atlantic drainage), SG = Southern Gulf of St. Lawrence, SF = Scotia-Fundy, ASN = Atlantic Seaboard North, ASC = Atlantic Seaboard Central, and ASS = Atlantic Seaboard South.*

					Salinity	Mean	Fecundity (millions)			Regression against length (cm)			Regression against weight (g)			
RPA zone	Sampling location	Lat. (ºN)	Long. (ºW)	Prov./state of growth area	of growth area	length of sample (mm)	Mean	SD	N	a	b	r^2	a	b	r^2	Reference
SL	Iroquois Dam, St. Lawrence River	44.82	75.30	ON,NY	Fresh	1,001	14.5	2.3	30	341,193	0.812	0.103	2,355,049	0.234	0.086	Tremblay (2009)
SL	Kamouraska, St. Lawrence River	47.45	70.05	QC,ON,NH, VT,NY	Fresh	837	12.2	3.2	30	17,824	1.467	0.195	390,841	0.483	0.204	Tremblay (2009)
NG	R. du Sud-ouest	48.37	68.72	QC	Fresh	1,043	13.3	3.2	30	308	2.293	0.405	35,237	0.762	0.425	Tremblay (2009)
NG	R. du Sud-ouest	48.37	68.72	QC	Fresh	1,021	na	na	25	0.016	4.377	0.935	450.817	1.288	0.929	Verreault (2002)
NG	Petite R. de la Trinité	49.53	61.23	QC	Fresh	679	6.9	3.1	30	453	2.270	0.805	67,764	0.719	0.792	Tremblay (2009)
SG	Long Pond, Dalvay	46.42	63.08	PEI	Fresh	693	6.5	1.5	30	3,673	1.761	0.289	147,231	0.592	0.280	Tremblay (2009)
ASN	Maine rivers, mostly the Penobscot and Sheepscot systems	44.50	69.00	ME	Fresh	577 [1]	na	na	63	18.20	2.964	0.900	14,608	0.915	0.920	Barbin and McCleave (1997)
ASC	Cape Charles, VA	37.07	76.03	Probably VA, MD, WV	Probably mixed	633	na	na	21	0.281	3.744	0.782	1,698	1.116	0.921	Wenner and Musick (1974)

[1] Median length

Table 7.4.1. Estimates of American Eel natural mortality rates from literature by RPA zone and location.

Acronyms for RPA zones are : SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland, SG = Southern Gulf of St. Lawrence, SF = Scotia-Fundy, ASN = Atlantic Seaboard North, ASC = Atlantic Seaboard Central, and ASS = Atlantic Seaboard South.

RPA zone	Prov./ state	Location	Value or formula[1]	Method	Comments	Sources
SL	ON/QC	St. Lawrence River, Lake Ontario	M = 0.167 per year	Not defined	From elver to silver stage	Greig et al. (2006)
NG	QC	Petite R. de la Trinité	S = 2.0% or 2.1%	Counts of entering elvers and exiting silver eels	Entry to and exit from the system were not measured in all years, which reduces the reliability of the estimate.	ICES (2001)
SG	PEI	Unfished brackish and salt waters	L = 0.28 per year	Life history model using length-frequency data		ICES (2001)
SG	PEI	Unfished freshwater ponds	L = 0.25 per year	Life history model using	length-frequency data	ICES (2001)
SF	NS	Fresh water, South Shore	M=0.0612 to 0.0675 per day	Trap counts, mark-recapture	Jessop (2000) considered that mark-induced mortality may have influenced these results.	Jessop (2000)
ASN	NY	Unfished fresh waters, Hudson Estuary	L = 0.135 per year	Catch curve analysis, with	ages grouped in 3 yr bins	Morrison and Secor (2003); Cairns et al. (2009)
ASN	NY	Unfished brackish waters, Hudson Estuary	L = 0.145 per year	Catch curve analysis, with	ages grouped in 3 yr bins	Morrison and Secor (2003); Cairns et al. (2009)
ASC	MD/ VA	Exploited brackish waters, Potomac River	L = 0.24 per year	Catch curve analysis on Hudson Estuary eels, rescaled to population declines in Chesapeake Bay and the St. Lawrence River	This estimate was generated for use on Potomac River eels	Fenske et al. (2011); using data from Morrison and Secor (2003)
Atlantic Seaboard All	All states	Eastern US	M = 0.15 to 0.25 per year	Integration of various methods		ASMFC (2012)
Atlantic Seaboard All	All states	Eastern US	$M = y*3.00*Mass^{-0.288}$	Regression model	ASMFC (2012) says there is little basis for estimating y. As a starting point, it used y=0.164.	Equation of Lorenzen (1996), as modified by ASMFC (2012).

[1] S = survival rate between river entry as elvers and river exit as silvers
L = instantaneous loss rate, which includes natural mortality, emigration, and immigration
M = instantaneous natural mortality rate
y = an adjustment term used in the Lorenzen (1996) equation

Table 7.4.2. Estimates of American Eel fishing mortality rates and exploitation rates by RPA zone and location.

Acronyms for RPA zones are : SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland, SG = Southern Gulf of St. Lawrence, SF = Scotia-Fundy, ASN = Atlantic Seaboard North, ASC = Atlantic Seaboard Central, and ASS = Atlantic Seaboard South.

RPA zone	Prov./ state	Location	Stage	Value [1]	Method	Comments	Sources
SL	QC	St. Lawrence estuary, 1996	Silver	ER=19%	Mark-recapture of outmigrating silver eels	Silver eels migrating through the St. Lawrence estuary have been subject to other fisheries earlier in their lives, which are not reflected in this exploitation rate	Caron et al. 2003
SL	QC	St. Lawrence estuary, 1997	Silver	ER=24%	Mark-recapture of outmigrating silver eels	See comment for St. Lawrence 1996 above	Caron et al. 2003
SL	QC	St. Lawrence estuary, 2010	Silver	ER=10.5%	Mark-recapture of outmigrating silver eels	See comment for St. Lawrence 1996 above	ICES 2011
SG	NB	Bays and estuaries	Mostly yellow	F=0.23/yr	Exploitation rate is estimated to be 29.7%, from (mean fishery landings)/(biomass estimated from glass bottom boat surveys). This was converted to F by assuming that 29.7% of eels between 530 mm (the min legal size) and 699 mm (the silver size) are harvested each year, that eels are in the legally fishable size range during 2 years, and that natural mortality is nil.	The glass bottom boat method underestimates total biomass, which will tend to upwardly bias estimates of F.	Exploitation rate from Hallett 2013. Time and lengths available to the fishery from Lamson et al. 2009.
SG	NS	Bays and estuaries	Mostly yellow	F=0.046/yr	Methods as in Southern Gulf-NB above. Exploitation rate is estimated to be 6.7%.	Comment as in Southern Gulf-NB above.	Sources as in Gulf-NB above.
SG	PEI	Bays and estuaries	Mostly yellow	F=0.0355	Methods as in Southern Gulf-NB above. Exploitation rate is estimated to be 5.3%.	Comment as in Southern Gulf-NB above.	Sources as in Gulf-NB above.
SG	NB/NS/ PEI	Bays and estuaries	Mostly yellow	F=0.0625	Methods as in Southern Gulf-NB above. Exploitation rate is estimated to be 9.0%.	Comment as in Southern Gulf-NB above.	Sources as in Gulf-NB above.
SF	NS	East River Chester, 1996	Elver	F=0.350/yr	Estimated from exploitation rate which was calculated as fishery catch/(fishery catch+trap catch), with the trap being located 40-100 m upstream from the fishery.	na	Jessop 2000
SF	NS	East River Chester, 1997	Elver	F=0.375/yr	Methods as in East River Chester 1996 above	na	Jessop 2000
SF	NS	East River Chester, 1998	Elver	F=0.728/yr	Methods as in East River Chester 1996 above	na	Jessop 2000
ASC	DE	Tidal waters	Mostly yellow	F=0.34	Thompson-Bell model	na	Clark 2009
ASC	MD	Chesapeake Bay	Mostly yellow	F=0.37 to 1.19	Thompson-Bell model	na	Weeder and Uphoff 2009
ASC	MD	na	na	F=0.43	Not reported	na	ASMFC 2012, quoting J. Weeder, pers. comm.
ASC	MD/VA	Potomac River	Mostly yellow	ER= ~10% to ~60%	Age and sex-structured assessment model	na	Fenske et al. 2011
Atlantic Seaboard All	All US	na	na	ER=22.1%	Depletion-Based Stock Reduction Analysis model, based on a single-stanza natural mortality model	na	ASMFC 2012

[1] F = instantaneous fishing mortality rate; ER = exploitation rate

Table 7.5.1. Summaries of elver length, elver length-weight regression coefficients, adult eel percent males, and fecundity, by RPA zone.

Acronyms for RPA zones are : SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland, SG = Southern Gulf of St. Lawrence, SF = Scotia-Fundy, ASN = Atlantic Seaboard North, ASC = Atlantic Seaboard Central, and ASS = Atlantic Seaboard South.

RPA zone	Elver length (mm)[1]	Elver length-weight Regression coefficients[2] a	b	Percent males[3]	Fecundity[4] Regression coefficients a	b	Female silver eel length[4]	Fecundity[4]
SL	63.0	0.00000002077	3.7008	0.0	17,824	1.467	90	13,155,712
NG	64.5	0.00000170373	3.0103	4.5	453	2.270	72	7,402,395
SG	63.1	0.00000051286	3.1970	1.5	3,673	1.761	70	6,550,316
SF	62.0	0.00000088716	3.1170	10.1	3,673	1.761	57	4,540,200
ASN	60.4	0.00000098400	3.0900	44.7	18.201	2.964	57	2,916,282
ASC	57.5	0.00000065000	3.1800	29.1	0.281	3.744	57	1,054,269
ASS	52.0	0.00000192486	3.0067	13.0	0.281	3.744	57	1,054,269
All zones, elvers	na	0.00000043833	3.1084	na	na	na	na	na

[1] Based on the formula 31.672 + 0.670 * Latitude (Fig. 7.2.1). In the St. Lawrence Basin, elvers are considered to recruit at Quebec City, so elver lengths are calculated from the latitude of Quebec City (Table 7.1.1). Elsewhere the formula uses the RPA zone's mean latitude.

[2] From Table 7.2.3. Equations have the form Weight = a * $Length^b$, where measurements are in mm and g, respectively.

[3] From Table 7.3.1.

[4] Regression coefficients are from Table 7.3.2, chosen on the basis of geographical proximity and highest r^2. Female silver eel lengths are from Table 7.2.2.

Table 7.5.2. Predicted silver eel length (mm), silver eel age (years), and growth rate (mm / year) for female and male American eels, by RPA zone, based on latitudes and distances from the spawning ground in Table 7.1.1 and parameters proposed for population modelling in Table 7.2.2.

"na" means data not appropriate. Acronyms for RPA zones are : SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland, SG = Southern Gulf of St. Lawrence, SF = Scotia-Fundy, ASN = Atlantic Seaboard North, ASC = Atlantic Seaboard Central, and ASS = Atlantic Seaboard South.

		Silver eel length (mm)				Silver eel age (yr)				Growth rate (mm / yr)			
		Regression coefficients				Regression coefficients				Regression coefficients			
Sex	RPA zone	a	b	Length	Method 1	a	b	Age	Method [1]	a	b	Growth rate	Method [1]
Female	SL	-117.541	0.1895	902	R-DSG	-7.71379	0.0053	20.9	R-DSG	na	na	49.3	Mean
	NG	-117.541	0.1895	718	R-DSG	-7.71379	0.0053	15.7	R-DSG	na	na	49.3	Mean
	SG	-117.541	0.1895	702	R-DSG	-7.71379	0.0053	15.3	R-DSG	na	na	49.3	Mean
	SF	na	na	570	Mean	-4.68272	0.0070	20.3	R-DSG	118.8932	-0.0281	19.3	R-DSG
	ASN	na	na	570	Mean	-4.68272	0.0070	14.3	R-DSG	118.8932	-0.0281	43.1	R-DSG
	ASC	na	na	570	Mean	-4.68272	0.0070	9.7	R-DSG	118.8932	-0.0281	61.4	R-DSG
	ASS	na	na	570	Mean	-4.68272	0.0070	7.0	R-DSG	118.8932	-0.0281	72.2	R-DSG
Male	SL	-155.32468	0.11299	453	R-DSG	na	na	9.5	Mean	na	na	34.9	Mean
	NG	-155.32468	0.11299	343	R-DSG	na	na	9.5	Mean	na	na	34.9	Mean
	SG	-155.32468	0.11299	333	R-DSG	na	na	9.5	Mean	na	na	34.9	Mean
	SF	na	na	349	Mean	-5.21668	0.0059	15.8	R-DSG	141.3685	-2.6454	21.8	R-Lat
	ASN	na	na	349	Mean	-5.21668	0.0059	10.8	R-DSG	141.3685	-2.6454	28.0	R-Lat
	ASC	na	na	349	Mean	-5.21668	0.0059	6.9	R-DSG	141.3685	-2.6454	39.4	R-Lat
	ASS	na	na	349	Mean	-5.21668	0.0059	4.7	R-DSG	141.3685	-2.6454	60.9	R-Lat

[1] R-DSG refers to regression against mean distance from the spawning grounds; R-Lat refers to regression against mean latitude; Mean refers to mean of values from Table 7.2.2.

Table 7.5.3. Variability in biological characteristics (length and weight) of American Eel elvers, female silver eel length and age, length at age of American eels from freshwater and saline habitats of the southern Gulf of St. Lawrence, and estimated fecundity by location of sampling.

Parameter	Sampling location	Mean	SD	CV	N	Source
Elver length (mm)	East River, Chester, NS	63.95	3.0820	0.048	360	Jessop 2001
Elver weight (g)	East River, Chester, NS	0.1763	0.0335	0.190	360	Jessop 2001
Female silver length (mm)	Long and Campbells Ponds, PEI	697	52	0.075	282	Cairns et al. 2007
Female silver length (mm)	Margaree River, NS	642	49	0.076	319	Cairns et al. 2007
Female silver length (mm)	Long and Campbells Ponds, Margaree R	668	57	0.086	601	Cairns unpubl.
Female silver age (yr)	Long and Campbells Ponds, PEI	18	4	0.200	82	Cairns et al. 2007
Female silver age (yr)	Margaree River, NS	22	3	0.134	71	Cairns et al. 2007
Length (mm) at age 2, fresh water	Southern Gulf of St. Lawrence	218	41.8	0.192	28	D. Cairns unpubl.
Length (mm) at age 3, fresh water	Southern Gulf of St. Lawrence	250	48.1	0.192	60	D. Cairns unpubl.
Length (mm) at age 4, fresh water	Southern Gulf of St. Lawrence	291	43.5	0.149	91	D. Cairns unpubl.
Length (mm) at age 5, fresh water	Southern Gulf of St. Lawrence	332	73.4	0.221	99	D. Cairns unpubl.
Length (mm) at age 6, fresh water	Southern Gulf of St. Lawrence	378	93.1	0.246	102	D. Cairns unpubl.
Length (mm) at age 7, fresh water	Southern Gulf of St. Lawrence	425	108.4	0.255	74	D. Cairns unpubl.
Length (mm) at age 8 fresh water	Southern Gulf of St. Lawrence	481	126.1	0.262	38	D. Cairns unpubl.
Length (mm) at age 2, saline water	Southern Gulf of St. Lawrence	358	32.4	0.090	19	D. Cairns unpubl.
Length (mm) at age 3, saline water	Southern Gulf of St. Lawrence	424	40.6	0.096	131	D. Cairns unpubl.
Length (mm) at age 4, saline water	Southern Gulf of St. Lawrence	496	85.6	0.173	140	D. Cairns unpubl.
Length (mm) at age 5, saline water	Southern Gulf of St. Lawrence	541	97.3	0.180	226	D. Cairns unpubl.
Length (mm) at age 6, saline water	Southern Gulf of St. Lawrence	567	107.4	0.189	229	D. Cairns unpubl.
Length (mm) at age 7, saline water	Southern Gulf of St. Lawrence	577	115.5	0.200	167	D. Cairns unpubl.
Length (mm) at age 8, saline water	Southern Gulf of St. Lawrence	562	103.9	0.185	66	D. Cairns unpubl.
Length (mm) at age 2, all salinities	Southern Gulf of St. Lawrence	275	79	0.288	47	D. Cairns unpubl.
Length (mm) at age 3, all salinities	Southern Gulf of St. Lawrence	369	92	0.248	191	D. Cairns unpubl.
Length (mm) at age 4, all salinities	Southern Gulf of St. Lawrence	415	124	0.298	231	D. Cairns unpubl.
Length (mm) at age 5, all salinities	Southern Gulf of St. Lawrence	477	132	0.277	325	D. Cairns unpubl.
Length (mm) at age 6, all salinities	Southern Gulf of St. Lawrence	509	135	0.265	331	D. Cairns unpubl.
Length (mm) at age 7, all salinities	Southern Gulf of St. Lawrence	530	133	0.251	241	D. Cairns unpubl.
Length (mm) at age 8, all salinities	Southern Gulf of St. Lawrence	532	119	0.223	104	D. Cairns unpubl.
Fecundity (millions)	Kamouraska, St. Lawrence River, QC	12.2	3.2	0.262	30	Tremblay 2009
Fecundity (millions)	R. du Sudouest, QC	13.3	3.2	0.241	30	Tremblay 2009
Fecundity (millions)	Petite R. de la Trinité, QC	6.9	3.1	0.449	30	Tremblay 2009
Fecundity (millions)	Long Pond, Dalvay, PEI	6.5	1.5	0.231	30	Tremblay 2009

Table 8.1. Values of the indices corresponding to the abundance recovery objectives for American Eel and the value of the indices for the most recent five-year period for which data are available.

The recovery objective values shown are the mean and range of the values of the indices for the period 1981 to 1989. For the index of the standing stock from the St. Lawrence Basin, the relative index is the composite of the annual value for each index divided by the average value for the 1990 to 2000 time period. For the Lake Ontario survey indices, the index is the composite index of the annual value for each index divided by the average value for the 1990 to 2000 time period. Acronyms for RPA zones are : SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland, SG = Southern Gulf of St. Lawrence, and SF = Scotia-Fundy.

Life stage	Habitat	RPA zone	Indices	Units of the indices	Recovery objective value	Recent five years	Recent 5-year mean as a % of recovery objective mean
					Mean (range)	Mean (range)	
Recruitment	Freshwater	SF	Elver counts	Counts	na	832,295 (343,988 to 1,070,333)	na
		SL	Moses-Saunders ladder counts	Counts	647,400 (213,200 to 1,313,600)	38,800 (20,200 to 51,200)	6.0%
			Eel ladder counts (Quebec)	Relative index	na	1,491 (972 to 2,665)	na
Standing stock	Freshwater	SL	Lake Ontario survey indices	Relative index	2,844 (1,044 to 4,332)	5.0 (0.0 to 18.0)	0.2%
		NG	Fence counts	Counts	122 (18 to 225)	39 (19 to 58)	31.6%
		SG	Electrofishing	Eels per 100 m²	0.40 (0.23 to 0.74)	0.56 (0.11 to 0.92)	140.5%
		SF	Electrofishing	Eels per 100 m²	2.8 (2.80 to 2.89)	1.3 (1.3 to 1.4)	47.2%
	Estuary / marine	SG	Commercial CPUE	Catch rate (kg net day^{-1})	na	1.86 (1.63 to 2.30)	na
Spawner production	Freshwater	SL	Trapnet catches	Catches (number)	756 (285 to 1016)	526 (469 to 604)	69.7%

Table 8.2. Trends in abundance of the life stage indicators, values of the indices corresponding to the abundance recovery objectives for American Eel, and the long term recovery objective values for abundance by RPA zone.

Acronyms for RPA zones are : SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland, SG = Southern Gulf of St. Lawrence, and SF = Scotia-Fundy.

RPA zone	Change in abundance in recent 25 to 32 years	Medium term recovery objective values	Long term recovery objective values
SL	Recruitment 99% decline (32 years)	Recruitment (Moses- Saunders eel ladder count): 647,400 (213,200 to 1,313,600)	Not defined
	Standing stock > 99% decline (32 years)	Standing stock (Lake Ontario relative survey composite index): 2,844 (1,044 to 4,332)	Not defined
	Silver eel 41% decline (32 years)	Silver eel (composite index of catch in number in estuarine trapnets): 756 (285 to 1016)	Not defined
NG	Standing stock 41% decline (not statistically significant) (32 years)	Standing stock (composite index of count at fences) 122 (18 to 225)	Not defined
SG	Standing stock 151% increase (32 years)	Standing stock (composite index of eels per 100 m²) 0.40 (0.23 to 0.74)	Not defined
SF	Standing stock 58% decline (28 years)	Standing stock (composite index of eels per 100 m²) 2.8 (2.80 to 2.89)	Not defined

Table 8.3. Present (recent 16 years) status of the life stage indicators by RPA zone relative to the short term and medium term recovery objectives for abundance.

A check mark (✓) indicates that the recovery objective has been met whereas an x mark (☒) indicates that the objective has not been met. Acronyms for RPA zones are : SL = St. Lawrence Basin, NG = Northern Gulf of St. Lawrence and Newfoundland, SG = Southern Gulf of St. Lawrence, and SF = Scotia-Fundy.

RPA zone	Short term (arrest decline in one generation)	Medium term (rebuild abundance in 3 generations)
SL	Recruitment: 4000% and 800% increase ✓	Recruitment: 6.0% of objective ☒
	Standing stock: 99% decline ☒	Standing stock: 0.2% of objective ☒
	Silver eel: 33% decline ☒ (not statistically significant)	Silver eel: 69.7% of objective ☒
NG	Standing stock: 63% decline ☒	Standing stock: 31.6% of objective ☒
SG	Standing stock: No change or increasing ✓	Standing stock: 140.5% of objective ✓
SF	Recruitment: No change ✓	Recruitment: na
	Standing stock: 39% decline ☒	Standing stock: 47.2% of objective ☒

FIGURES

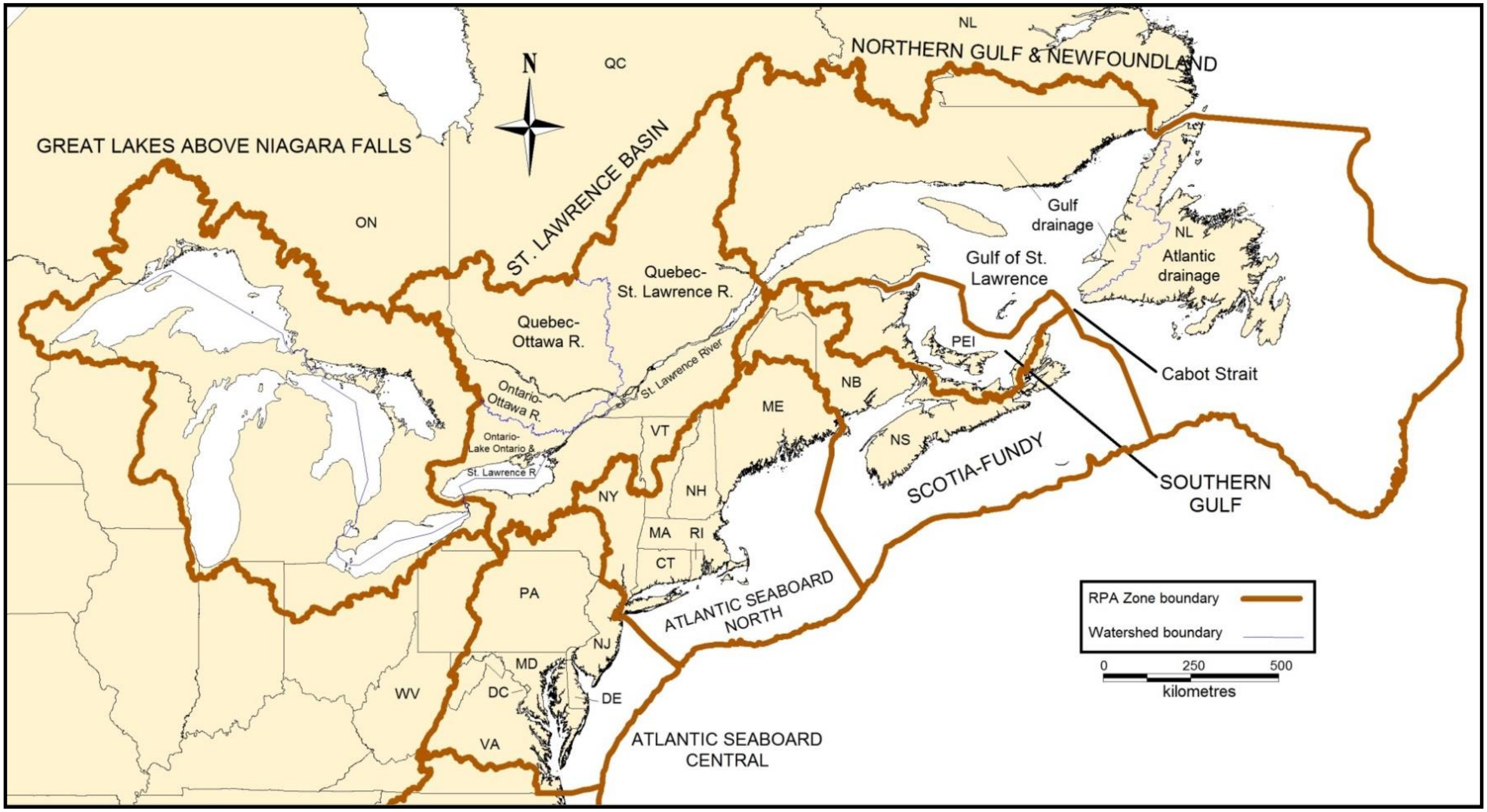

Figure 2.1.1. Boundaries used to define RPA zones for the northern zones of eastern Canada and the Atlantic Seaboard Central zone used in the American Eel Recovery Potential Assessment.
The Great Lakes above Niagara Falls is not an RPA zone, but is mapped to facilitate measurement of its area.

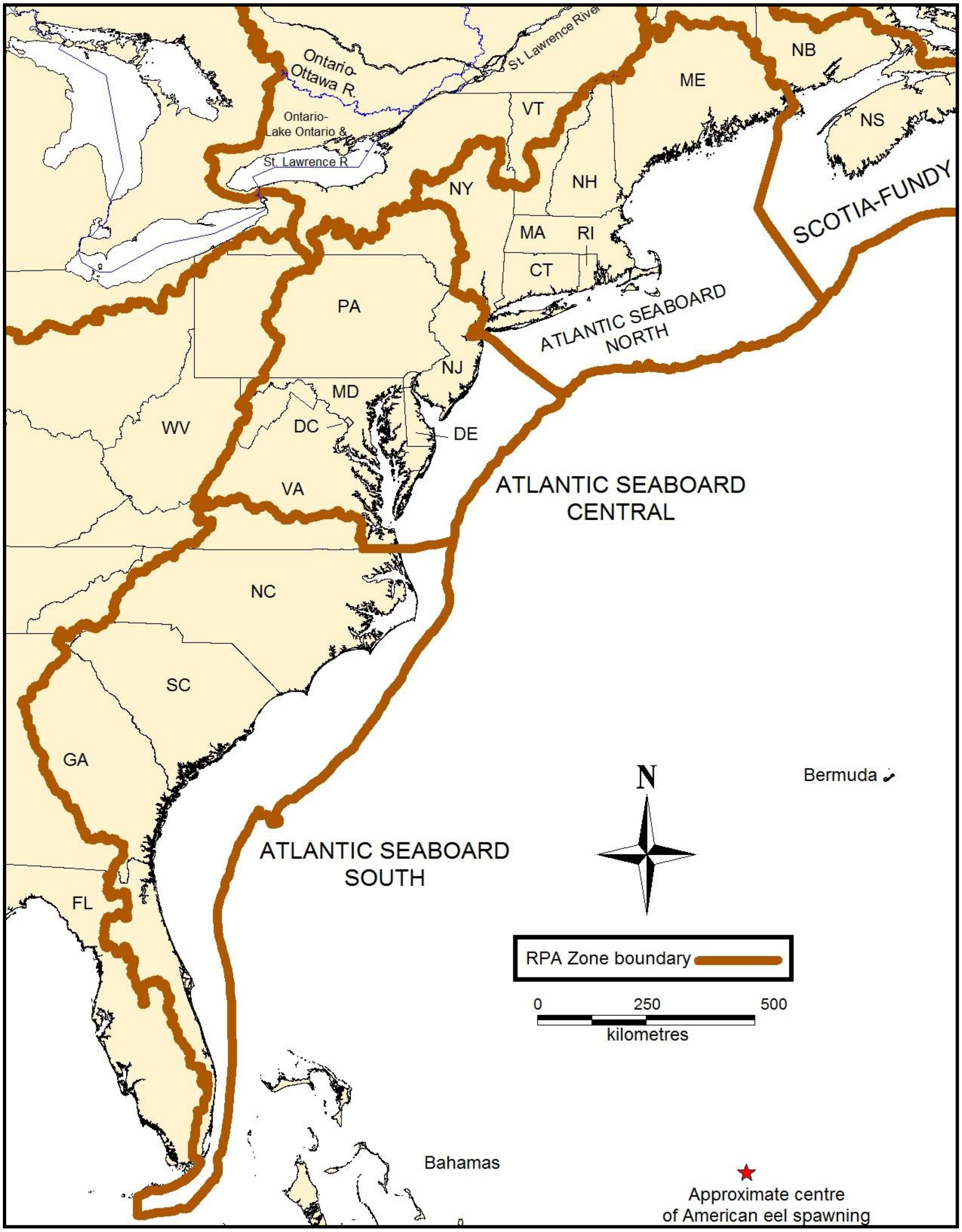

Figure 2.1.2. Boundaries of the Atlantic Seaboard North (ASN), Central (ASC), and South (ASS) Recovery Potential Assessment zones.
The approximate centre of American Eel spawning (25ºN, 68ºW) is from McCleave 1993.

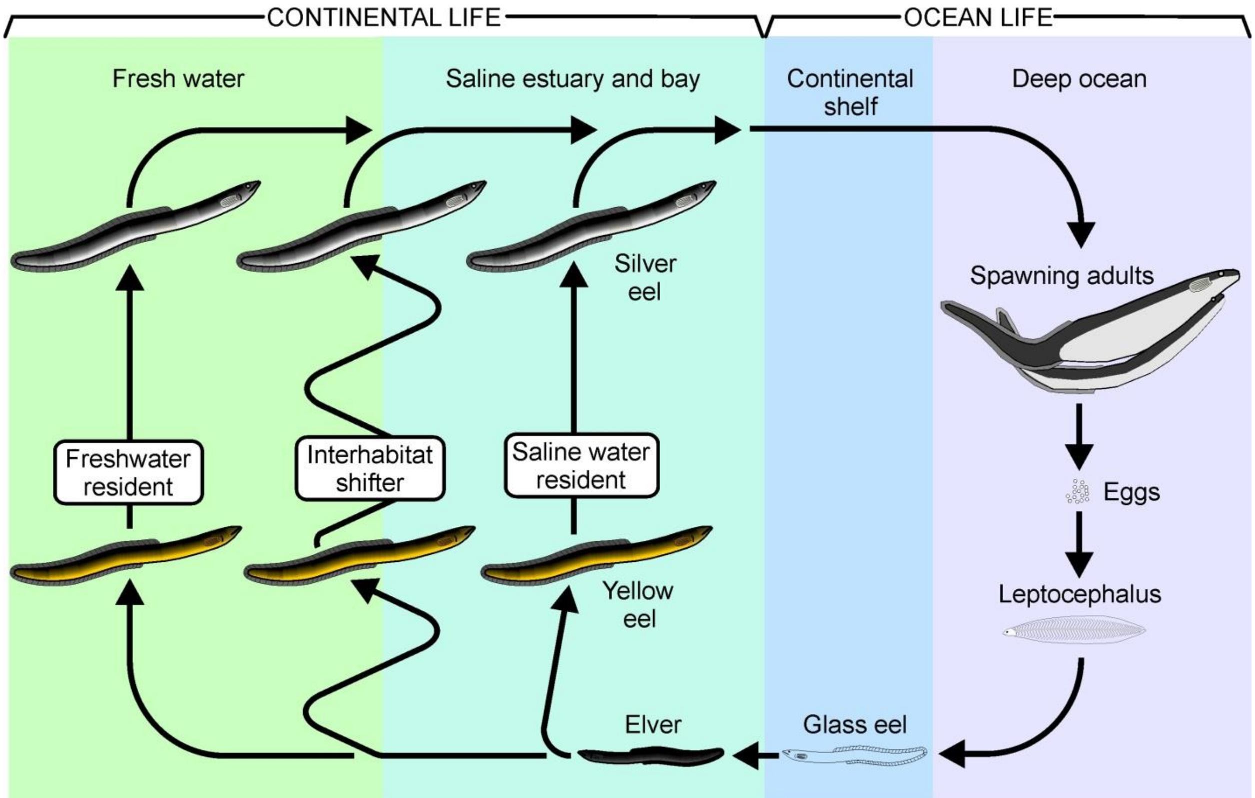

Figure 3.1.1. Schematic diagram of the American Eel life cycle, showing alternative life history patterns during continental life.

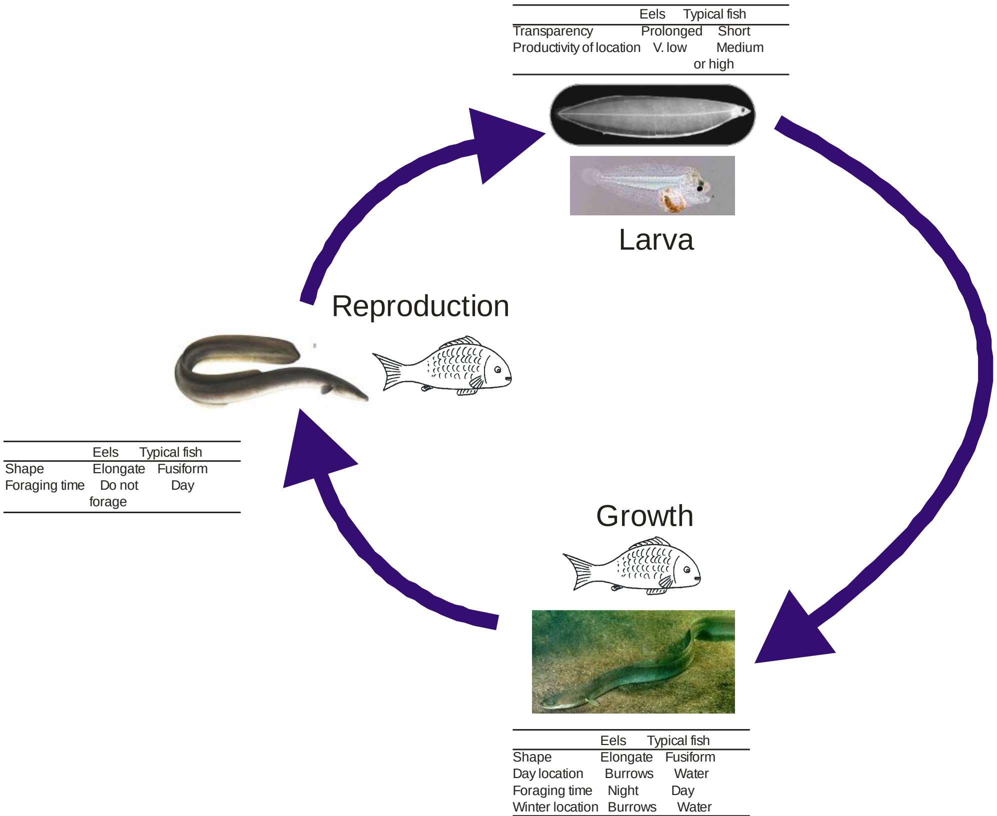

Figure. 3.1.2. Life cycle of anguillid eels, compared to that of typical fish. Modified from ICES (2009).

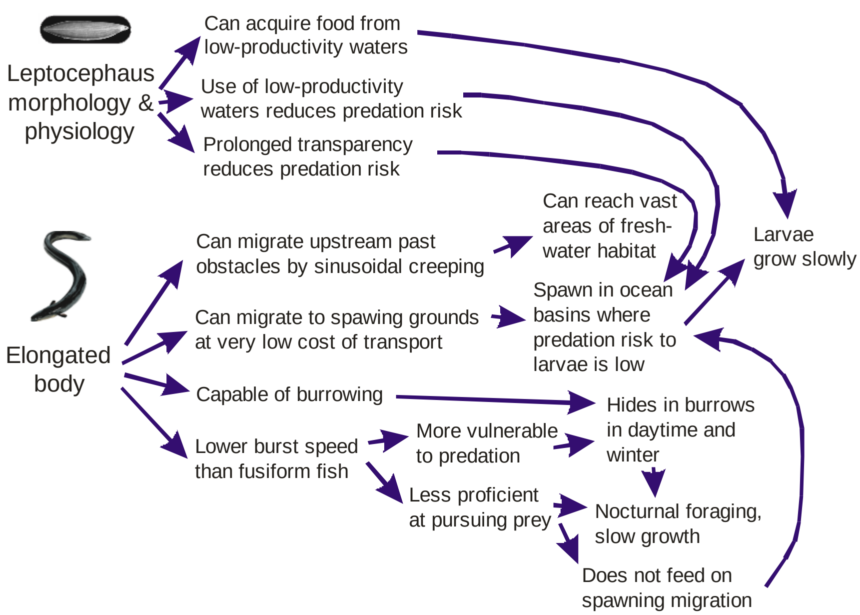

Figure 3.1.3. Some adaptive traits of the American Eel, behaviours they enable, and their ecological consequences (modified from ICES 2009).

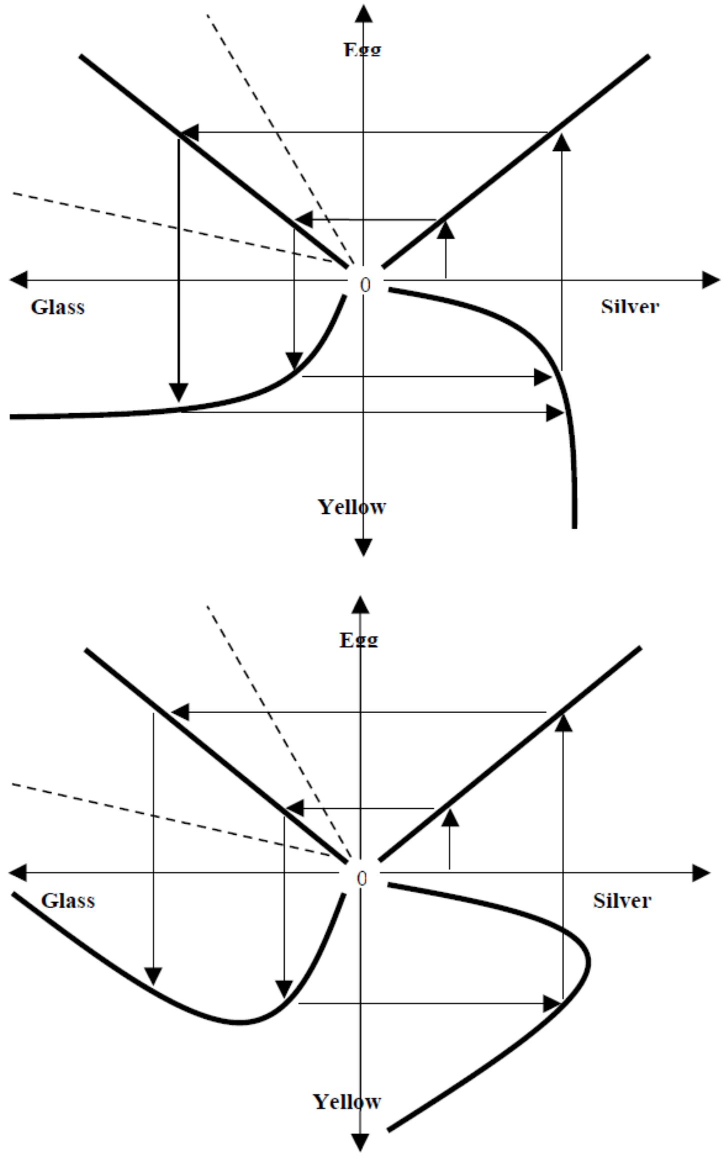

Figure 3.3.1. Paulik diagrams illustrating transitions between American Eel life stages. Trajectories proceed in a counter-clockwise direction. The lower right quadrants illustrate transition patterns between yellow eels and reproducing silver eels under an asymptotic (Beverton-Holt) model (upper panel) and an over-compensatory (Ricker) model (lower panel). Figure from ICES (2001).

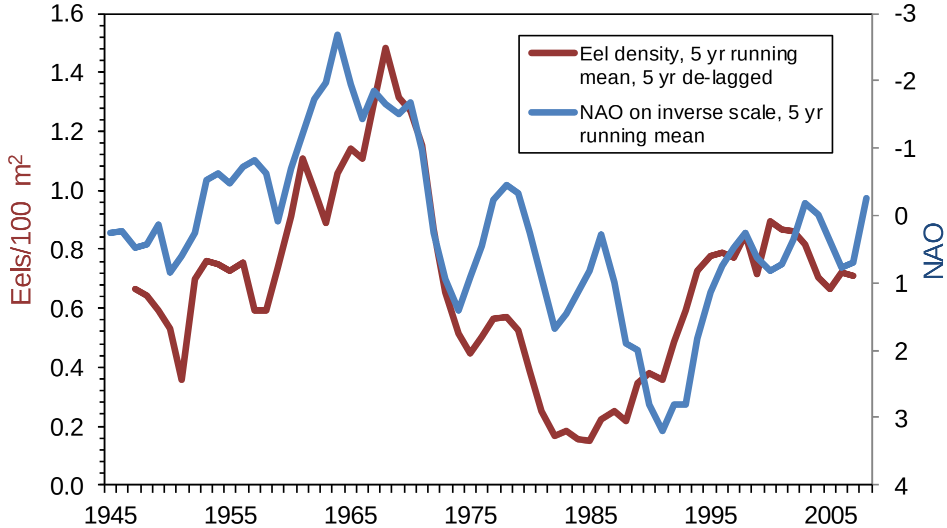

Figure 3.3.2. Relation between 5 year running means of eel density estimated from Miramichi electrofishing surveys, and the station-based winter (December to March) North Atlantic Oscillation index. The Miramichi series was de-lagged by five years to account for the mean continental age of juvenile eels in electrofishing captures.

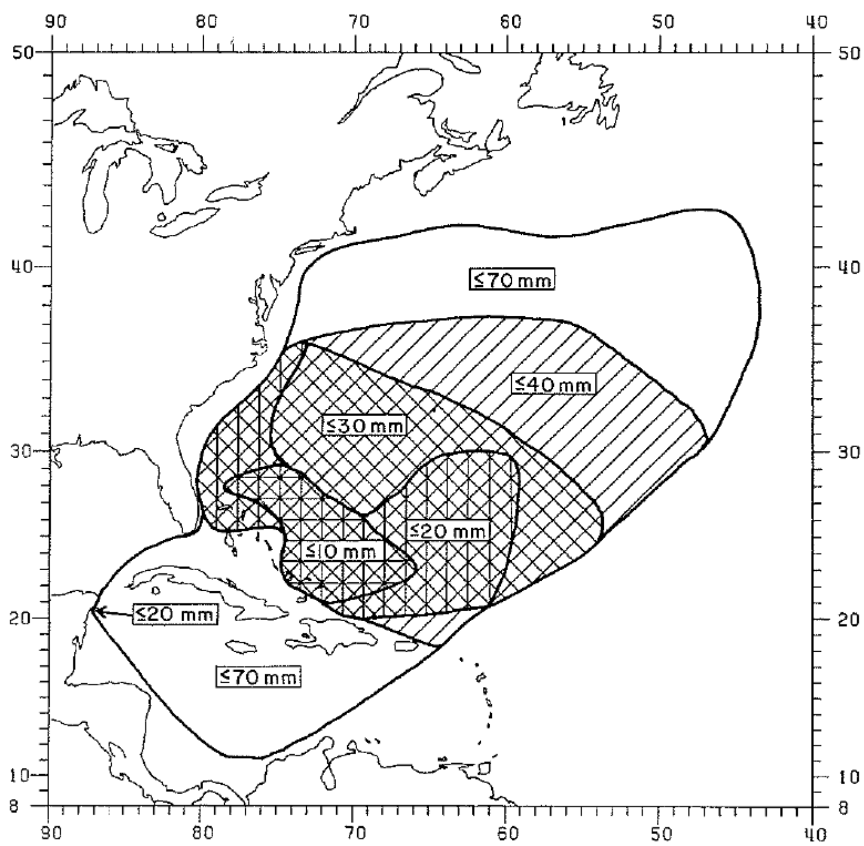

Figure 4.2.1. Distribution of larval American eels in the Atlantic Ocean, by size category (from Kleckner and McCleave 1985).

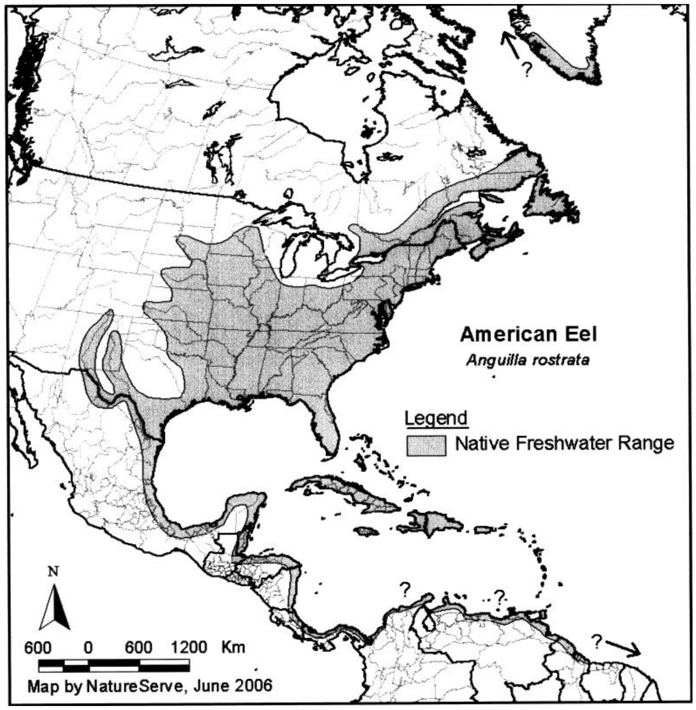

Figure 4.3.1. NatureServe's map of the continental range of the American Eel (source: US Department of the Interior 2007).

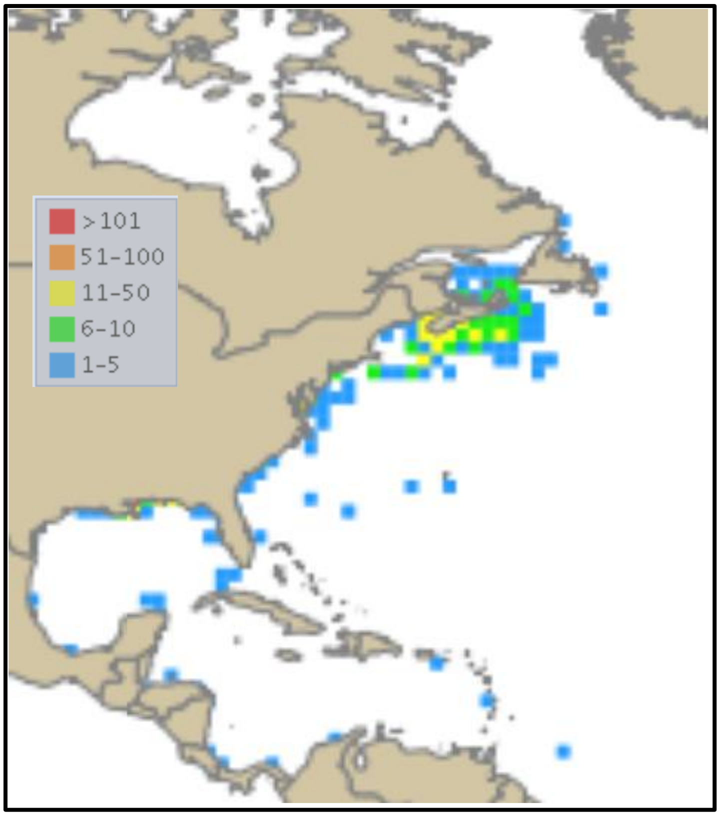

Figure 4.3.2. Location of American Eel records in the [Ocean Biogeographic Information System](#) database.

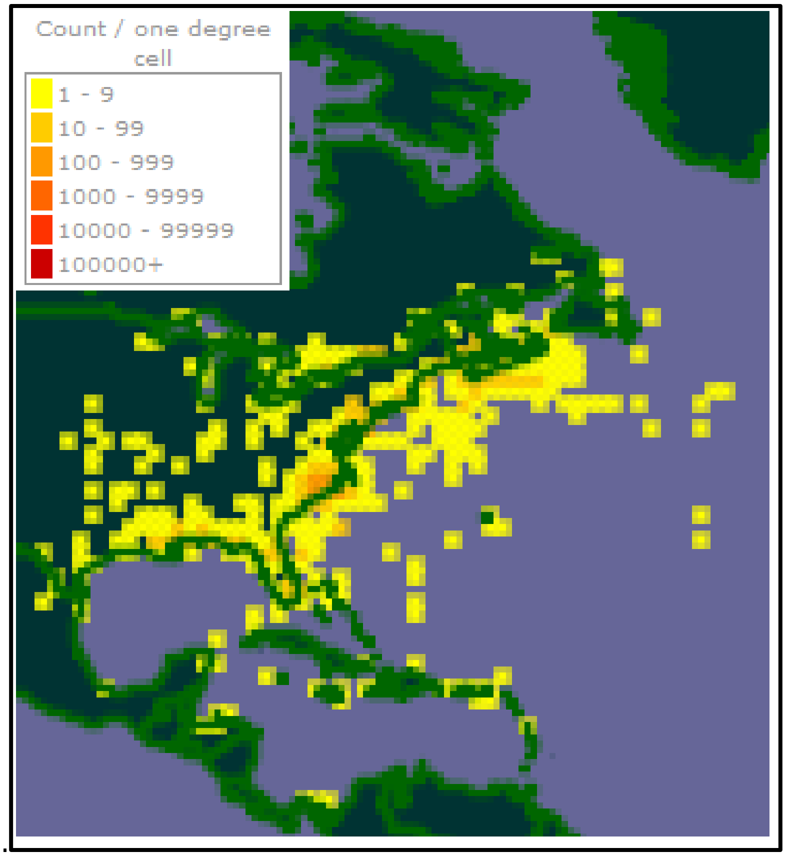

Figure 4.3.3. Location of American Eel records in the Global Biodiversity Information Facility database.

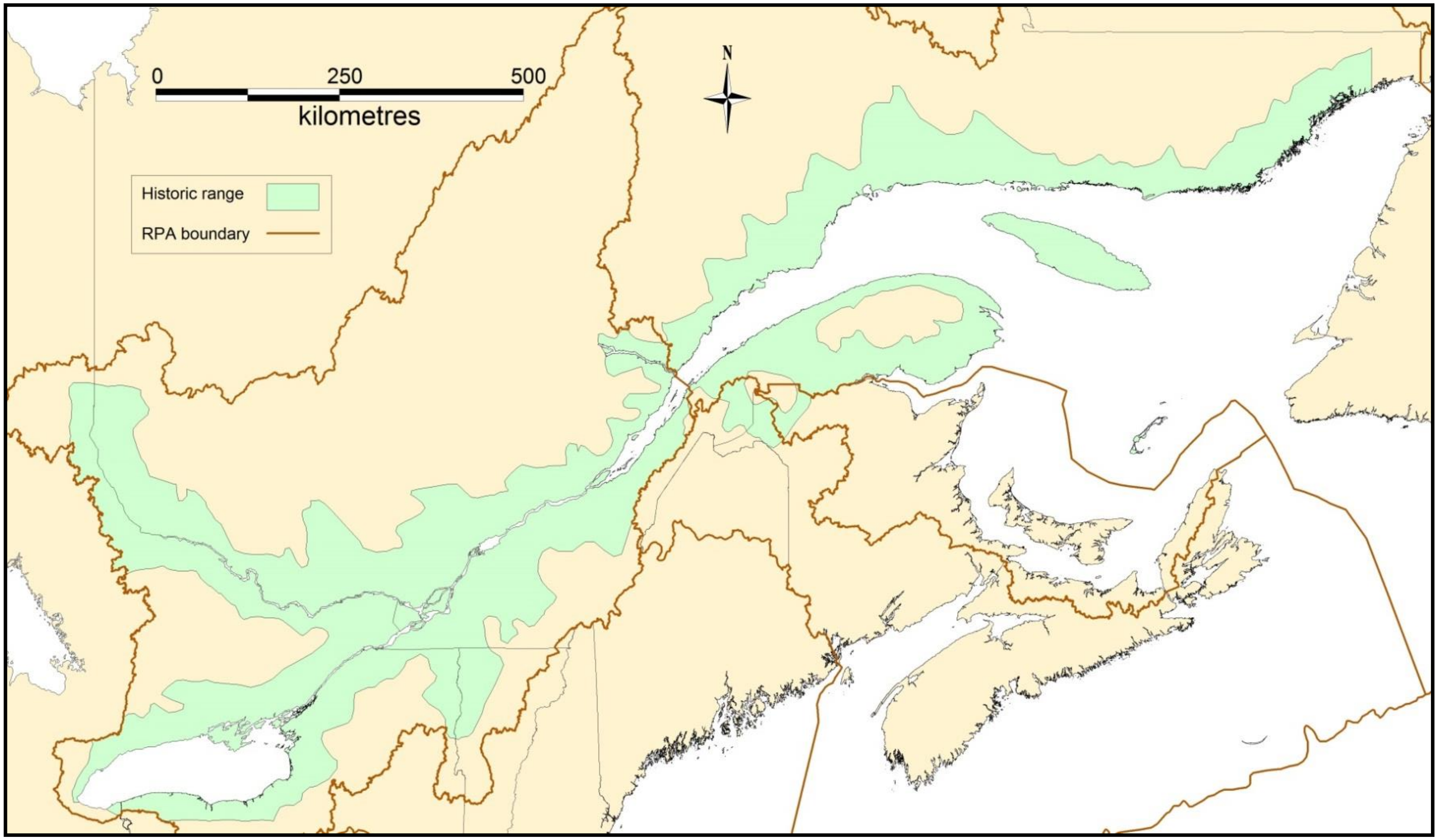

Figure 4.4.1. The historic range of the American Eel in St. Lawrence River drainages of Ontario, Quebec, New York, and Vermont, and the Gulf of St. Lawrence drainages of Quebec, according to Verreault et al. (2004).

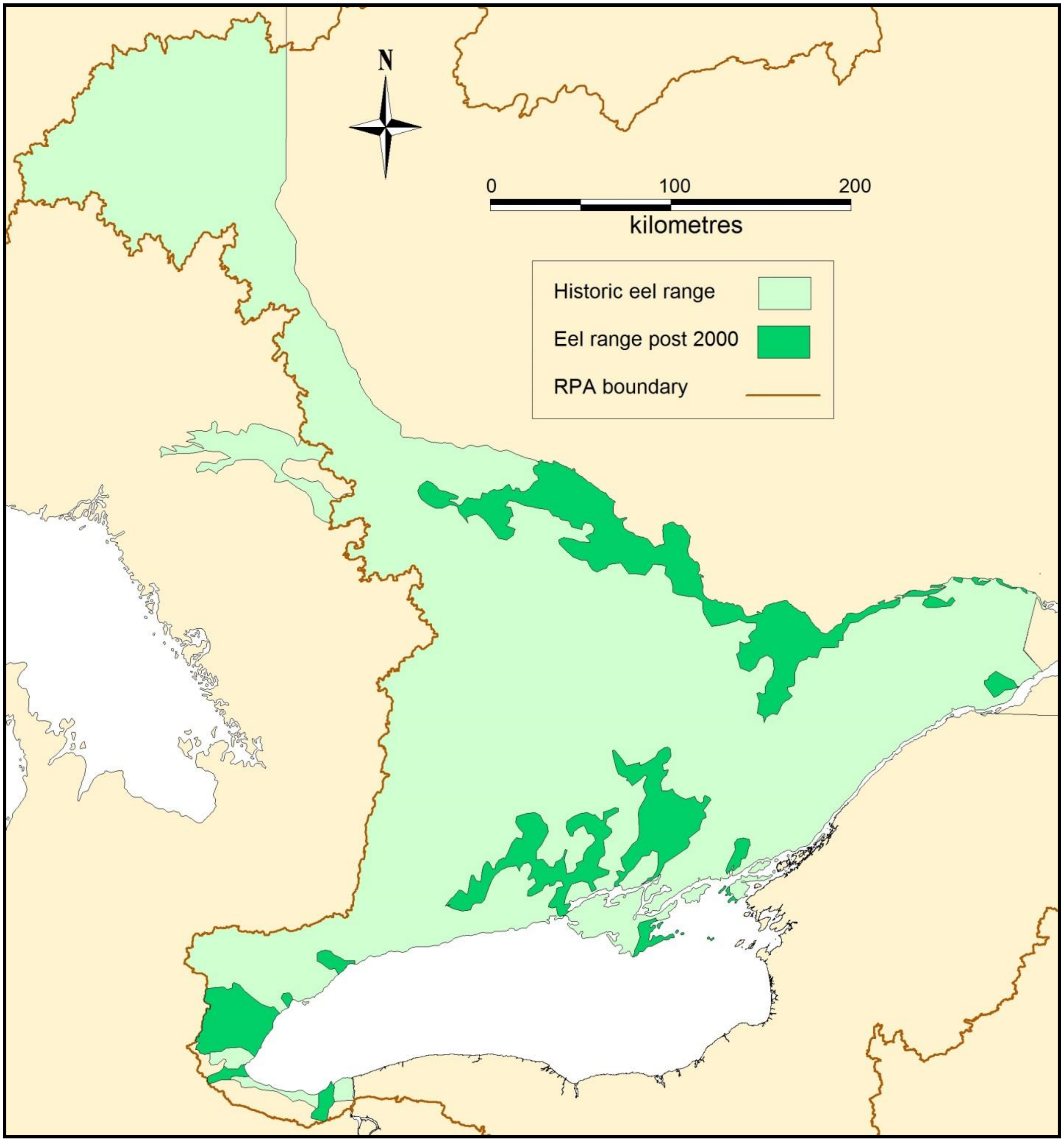

Figure 4.4.2. The historic and post-2000 range of the American Eel in Ontario, according to MacGregor et al. (2013).

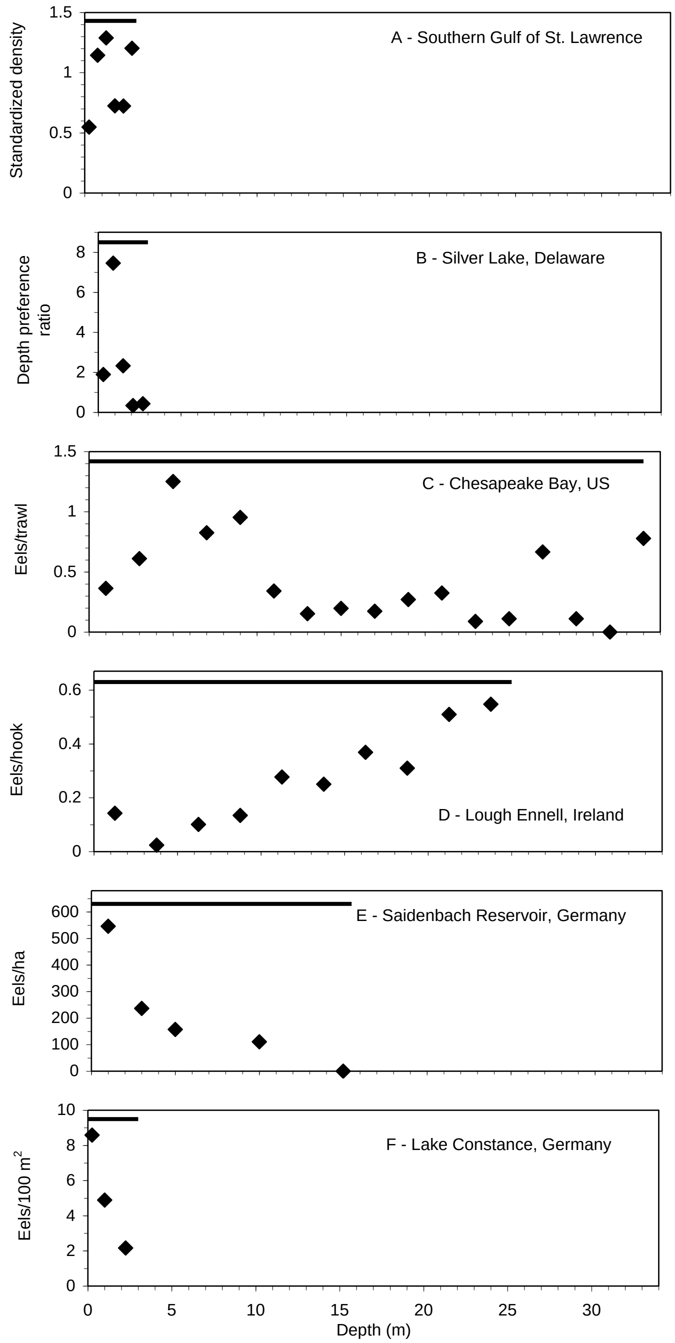

Figure 4.4.3. Abundance indicators of American and European eels vs. depth summarized in Cairns et al. (2012).
Horizontal lines indicate the range of depths covered in each study. A - densities from glass bottom boat surveys in the Southern Gulf of St. Lawrence (Hallett 2013). Densities are standardized by dividing densities within depth ranges by mean densities in all depth ranges. B - ratio of observed to expected counts from radio-tracking in Silver Lake, Delaware (Thomas 2006). C - eels per trawl in Chesapeake Bay, US (Geer 2003). D - eels per longline hook in Lough Ennell, Ireland (Yokouchi et al. 2009). E - densities from diving surveys, Saidenbach Reservoir, Germany (Schulze et al. 2004). F - mean densities across habitat types from electrofishing and trammel nets, Lake Constance, Germany (Fischer and Eckmann 1997).

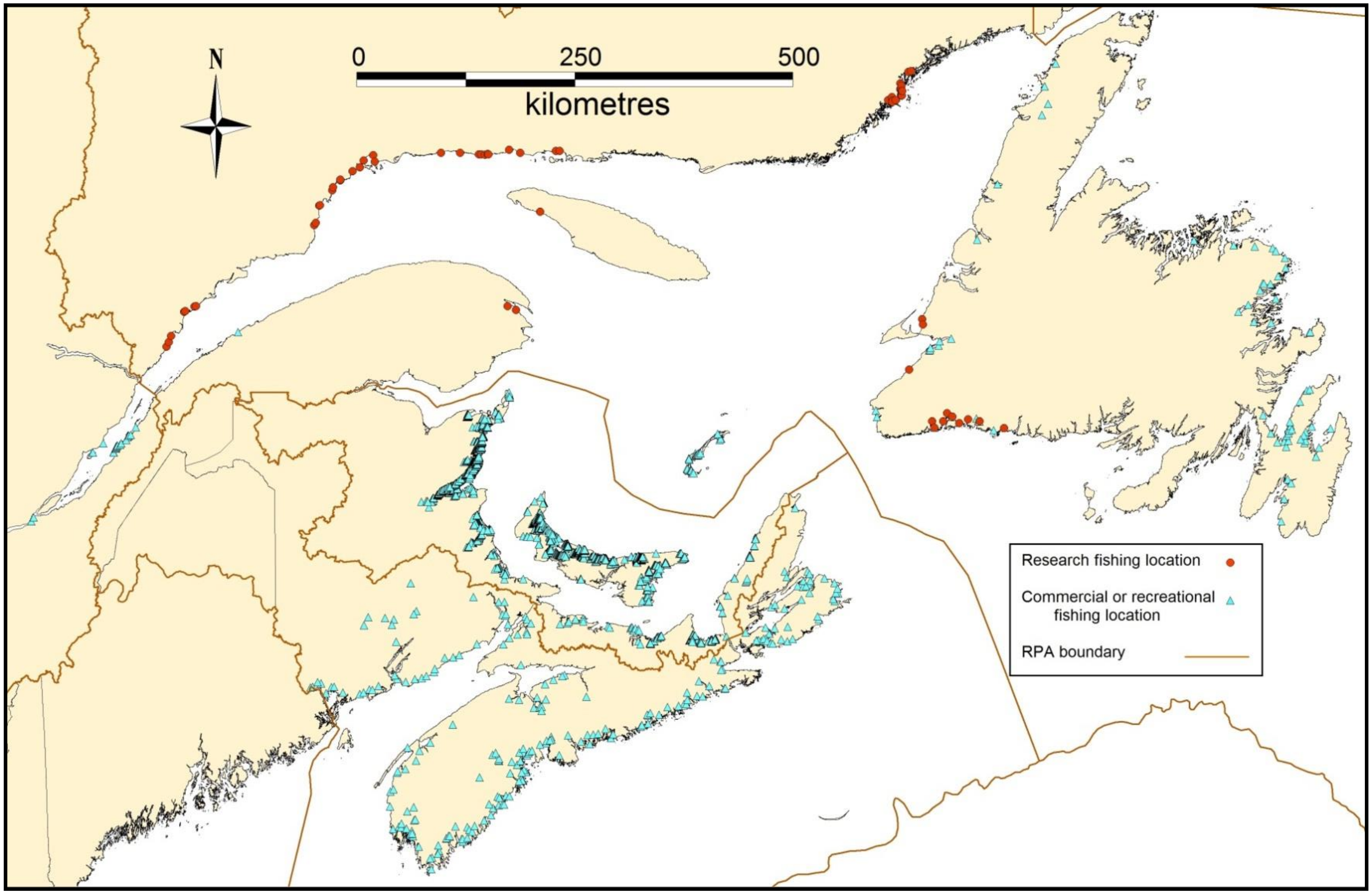

Figure 4.4.4. Locations of research, commercial, and recreational eel fishing sites in eastern Quebec and the Atlantic Provinces. Data from Cairns et al. (2012).

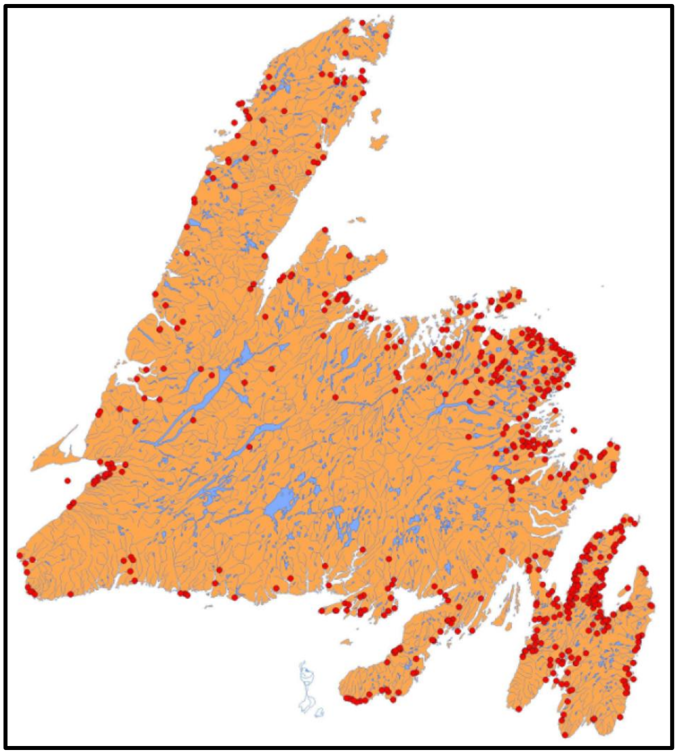

Figure 4.4.5. Reported locations of eel fishing in insular Newfoundland, 1990-2005 (from Nicholls 2011).

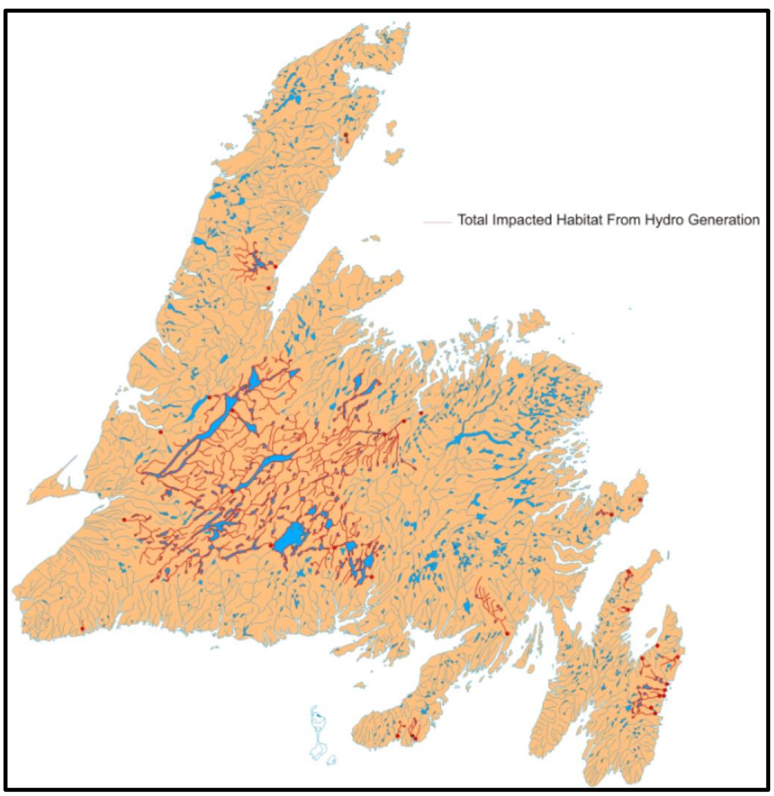

Figure 4.4.6. Habitat in insular Newfoundland to which eel access is partially or completely restricted by hydroelectric dams (from Nicholls 2011).

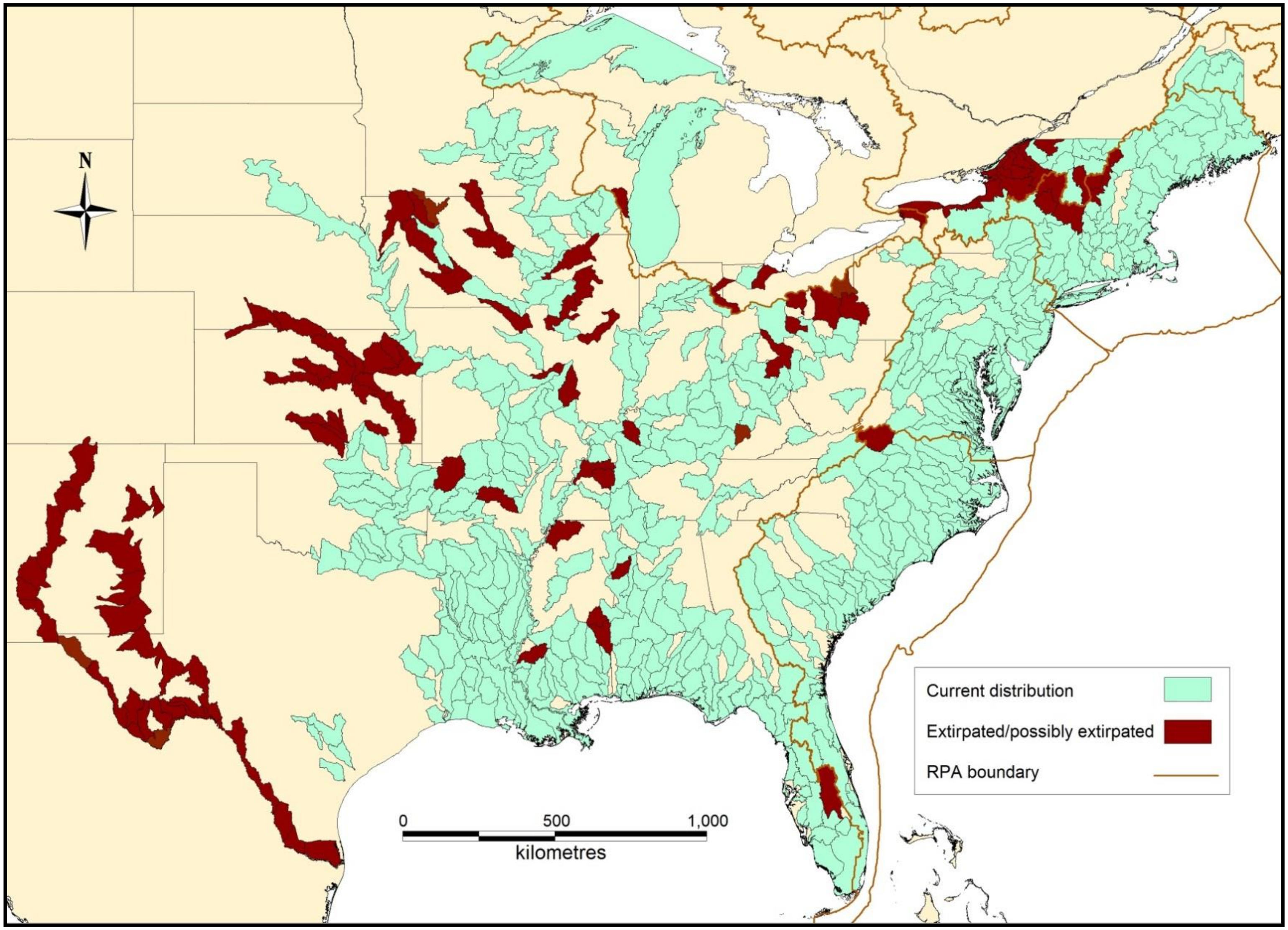

Figure 4.4.7. The range of the American Eel in the United States by watershed units, according to [NatureServe](). The GIS shapefile was downloaded from www.natureserve.org/getData/fishMaps.jsp and the current and extirpated designations are from www.natureserve.org/explorer/servlet/NatureServe?searchSciOrCommonName=anguilla+rostrata&x=6&y=6.

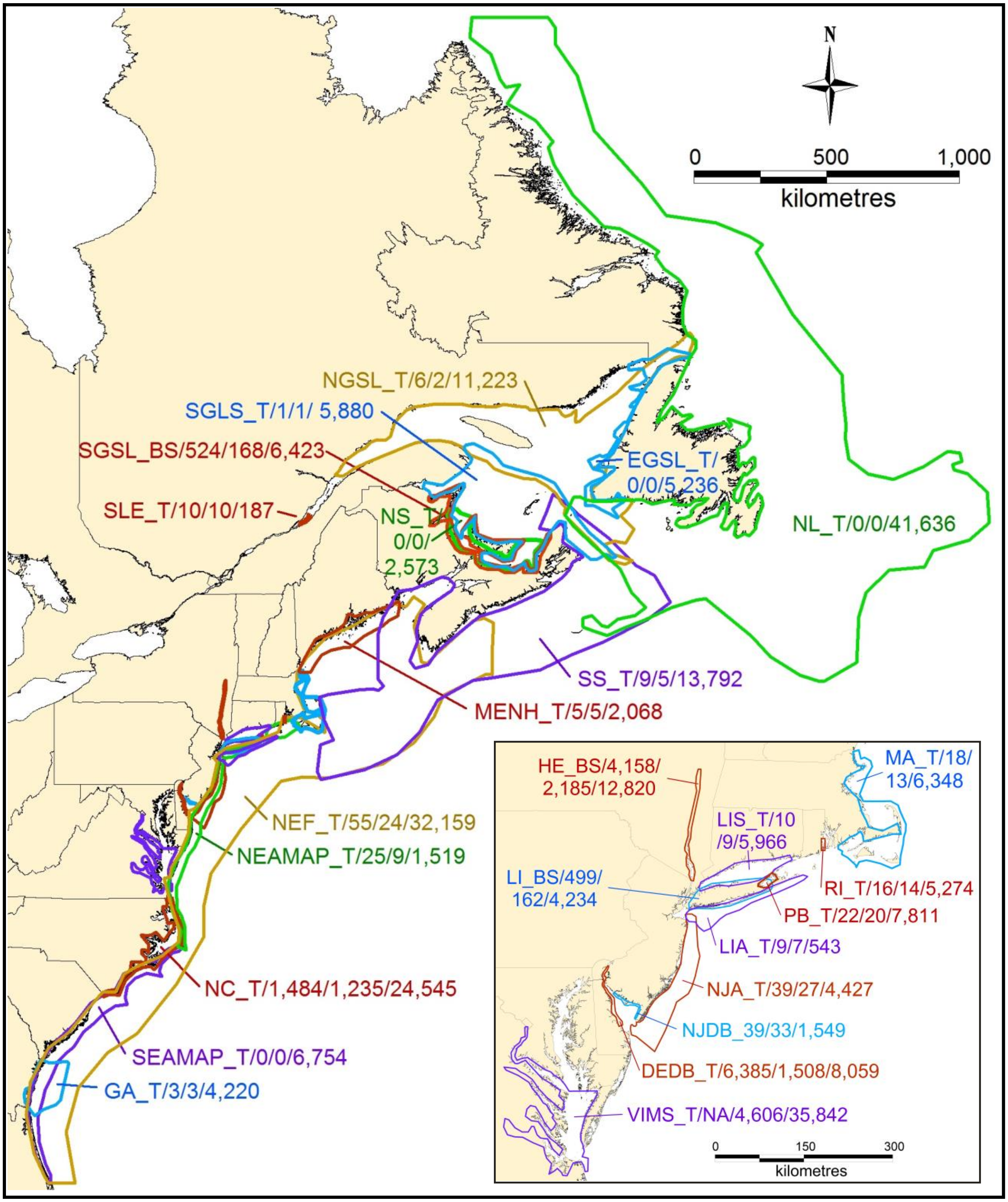

Figure. 4.5.1. Locations of research surveys on the east coast of North America as compiled by Poirier (2013).
The survey abbreviation, the number of eels caught, the number of sets which caught eels, and the total number of sets are given for each survey. The inset map shows survey locations in the central US east coast. The number of eels caught is unavailable for the VIMS_T survey.

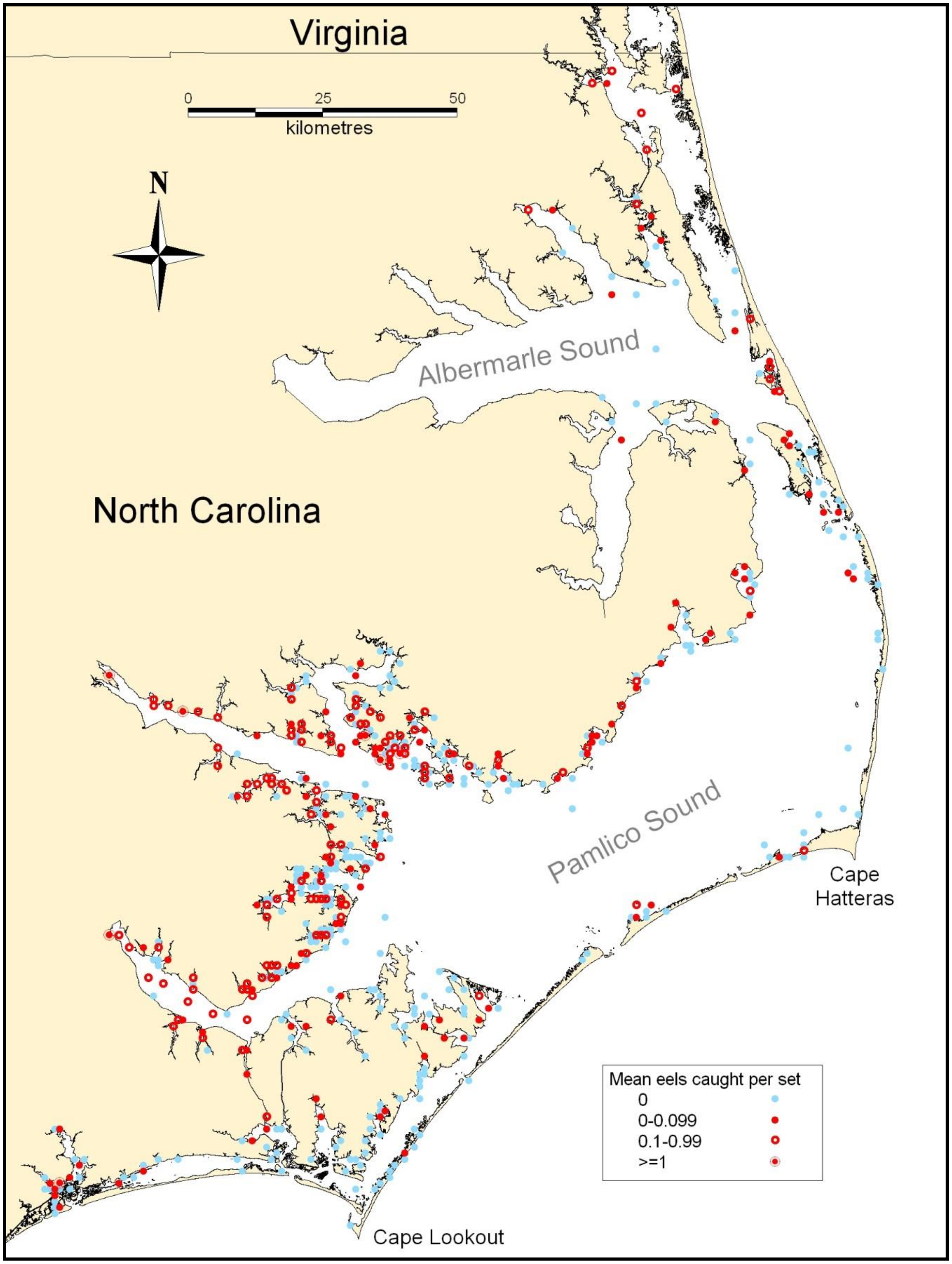

Figure 4.5.2. Distribution of sets, and number of American eels caught per set, in the North Carolina Trawl Survey (NC_T), based on 24,545 sets during 1973 to 2010.
Each symbol represents multiple sets within a rectangle measuring 0.01° latitude x 0.01° longitude. From Poirier (2013).

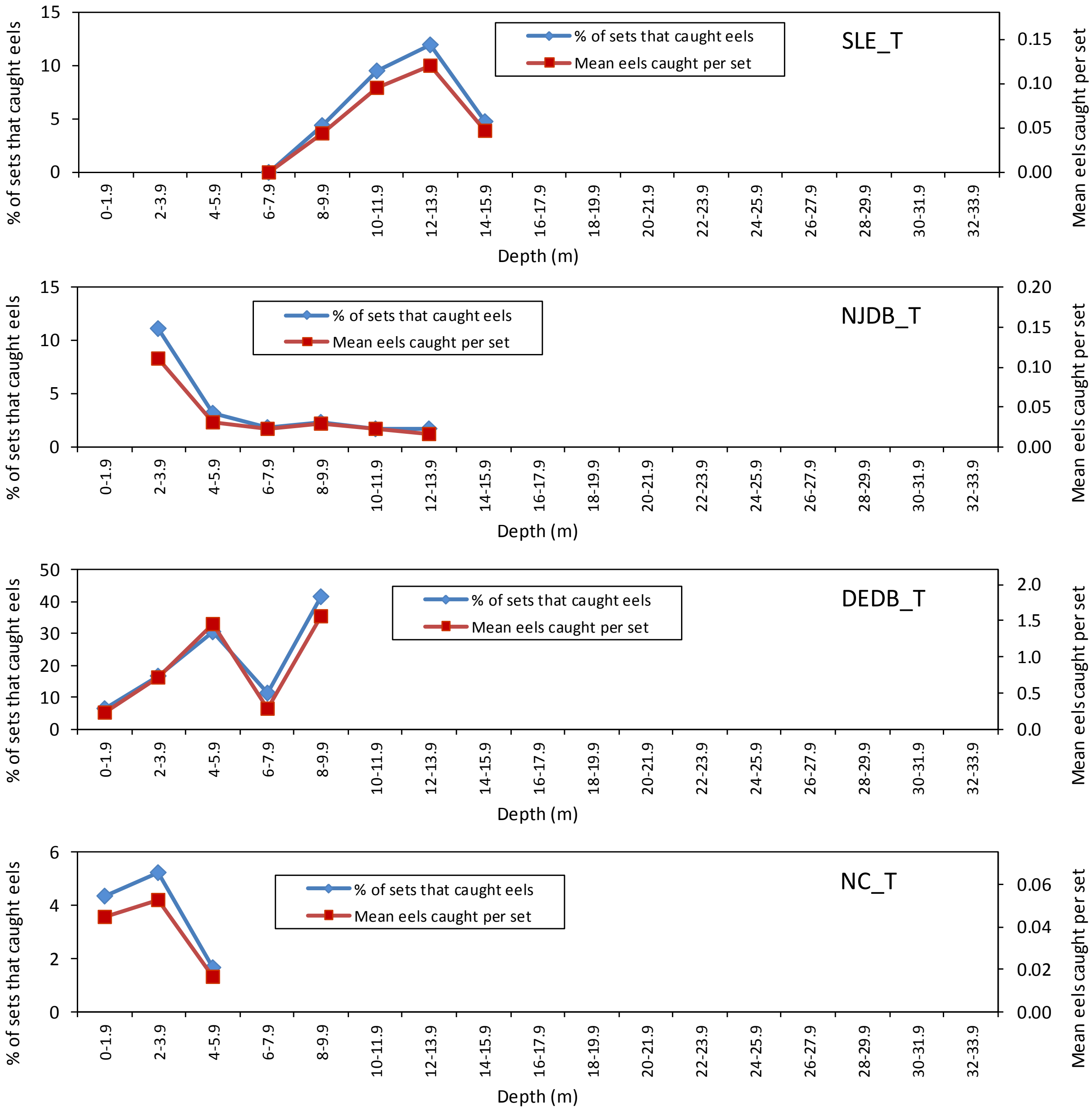

Figure 4.5.3. Percent of sets that caught eels and mean eels caught per set, by 2 m depth bins, in the SLE_T, NJDB_T, DEDB_T, and NC_T surveys.
Data from Poirier (2013).

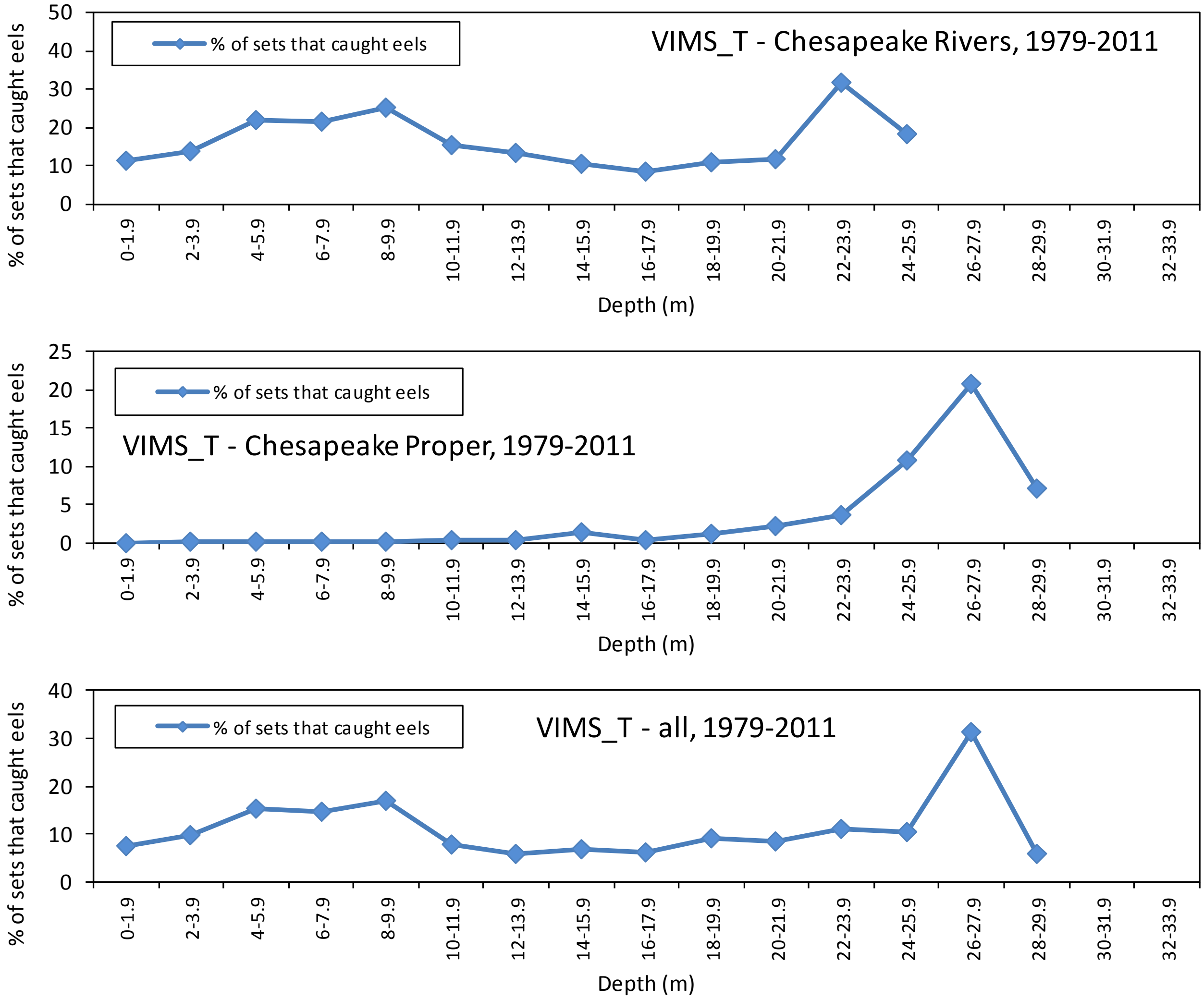

Figure 4.5.4. Percent of sets that caught eels, by 2 m depth bins, in river estuaries on the west side of Chesapeake Bay, in Chesapeake Bay Proper, and in the full VIMS_T dataset.
Data from Poirier (2013).

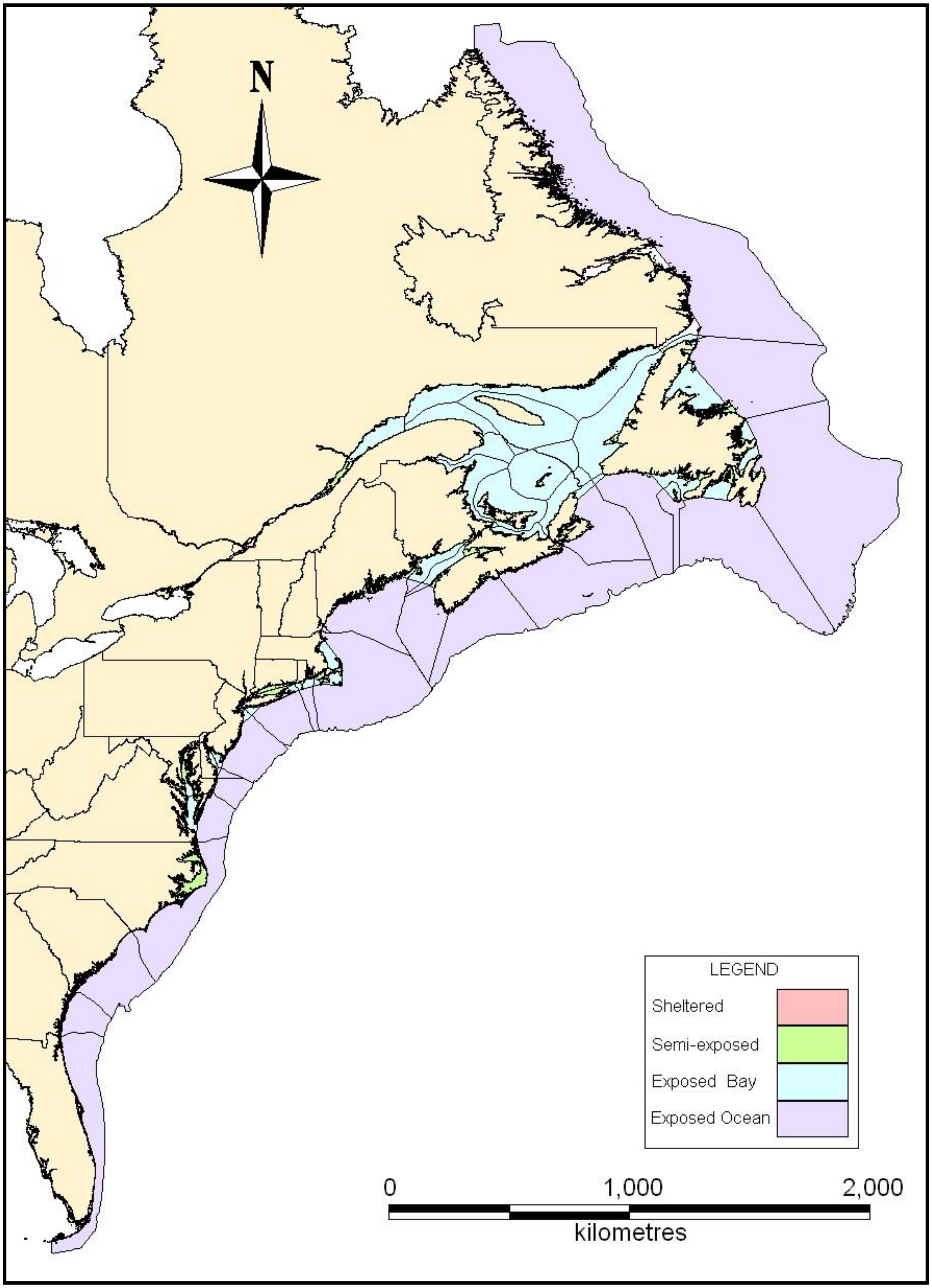

Figure 4.5.5. Exposure zone classification (sheltered, semi-exposed, exposed bay, exposed ocean) of waters of the east coast of North America.

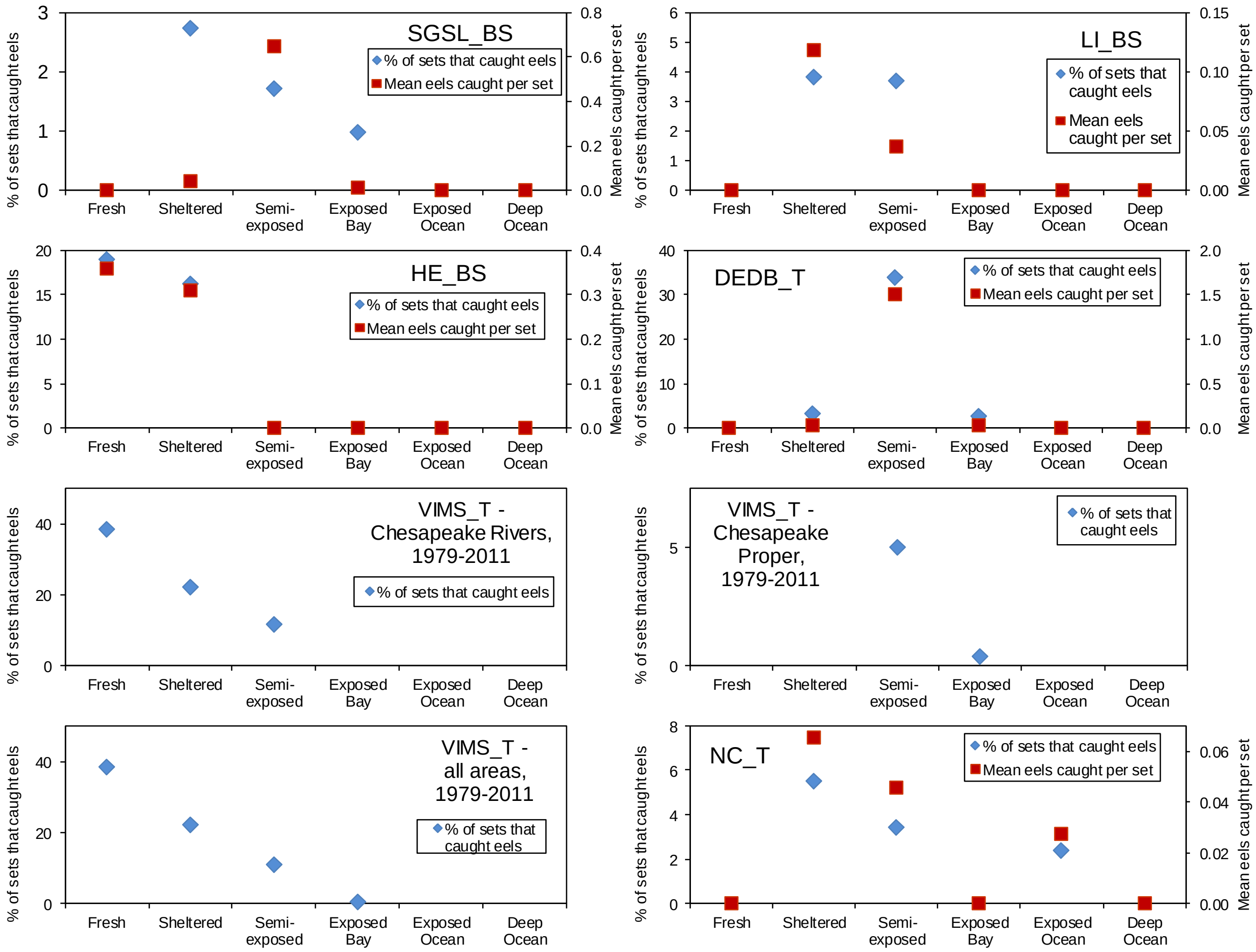

Figure 4.5.6. Percent of sets that caught eels and mean eels caught per set by exposure zone in the SGSL_BS, LI_BS, HE_BS, DEDB_T, VIMS_T, and NC_T surveys.
Data from Poirier (2013).

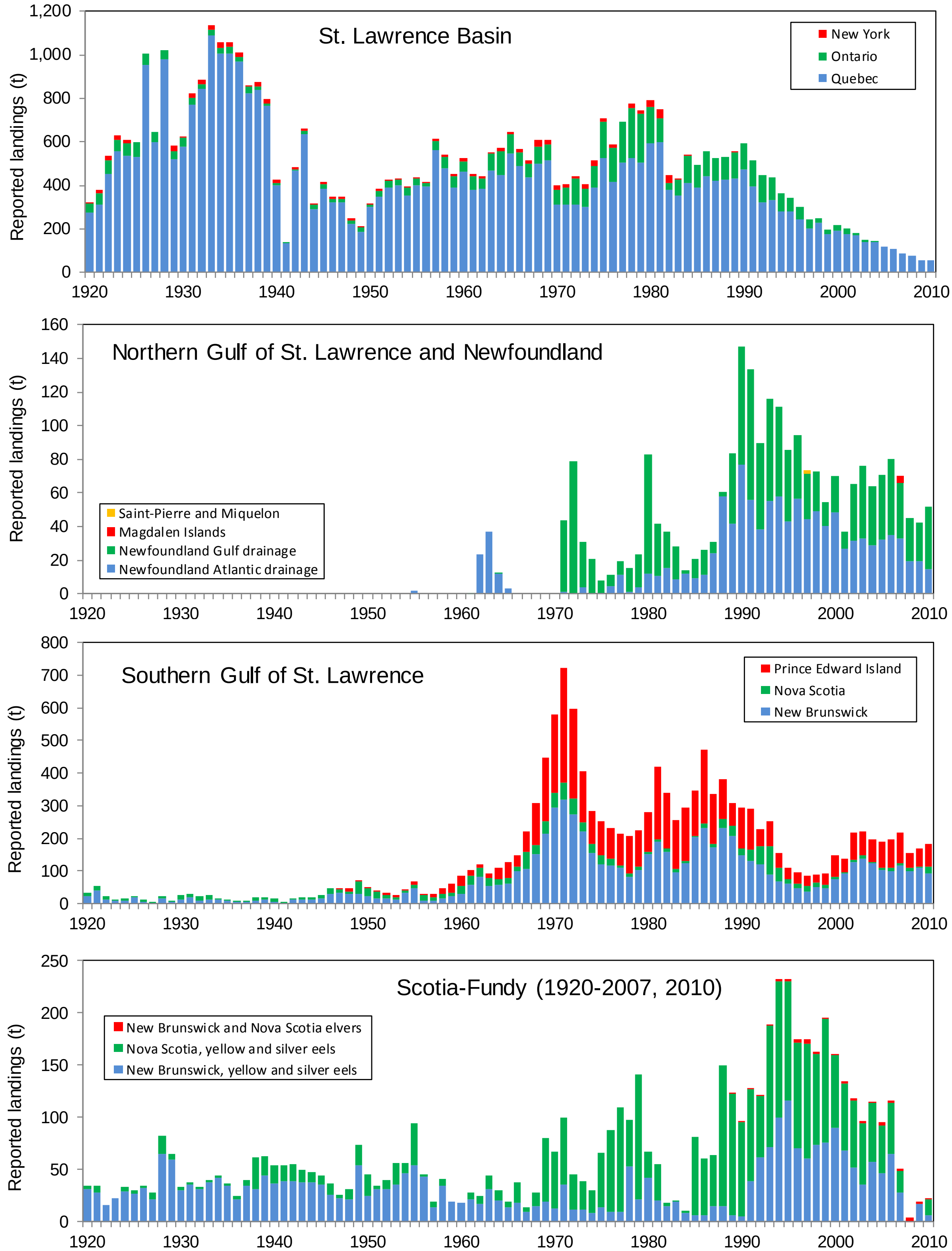

Figure 5.1.1. Reported landings (t) of American Eel in the St. Lawrence Basin, Northern Gulf of St. Lawrence and Newfoundland, Southern Gulf of St. Lawrence, and Scotia-Fundy RPA zones, 1920 to 2010.

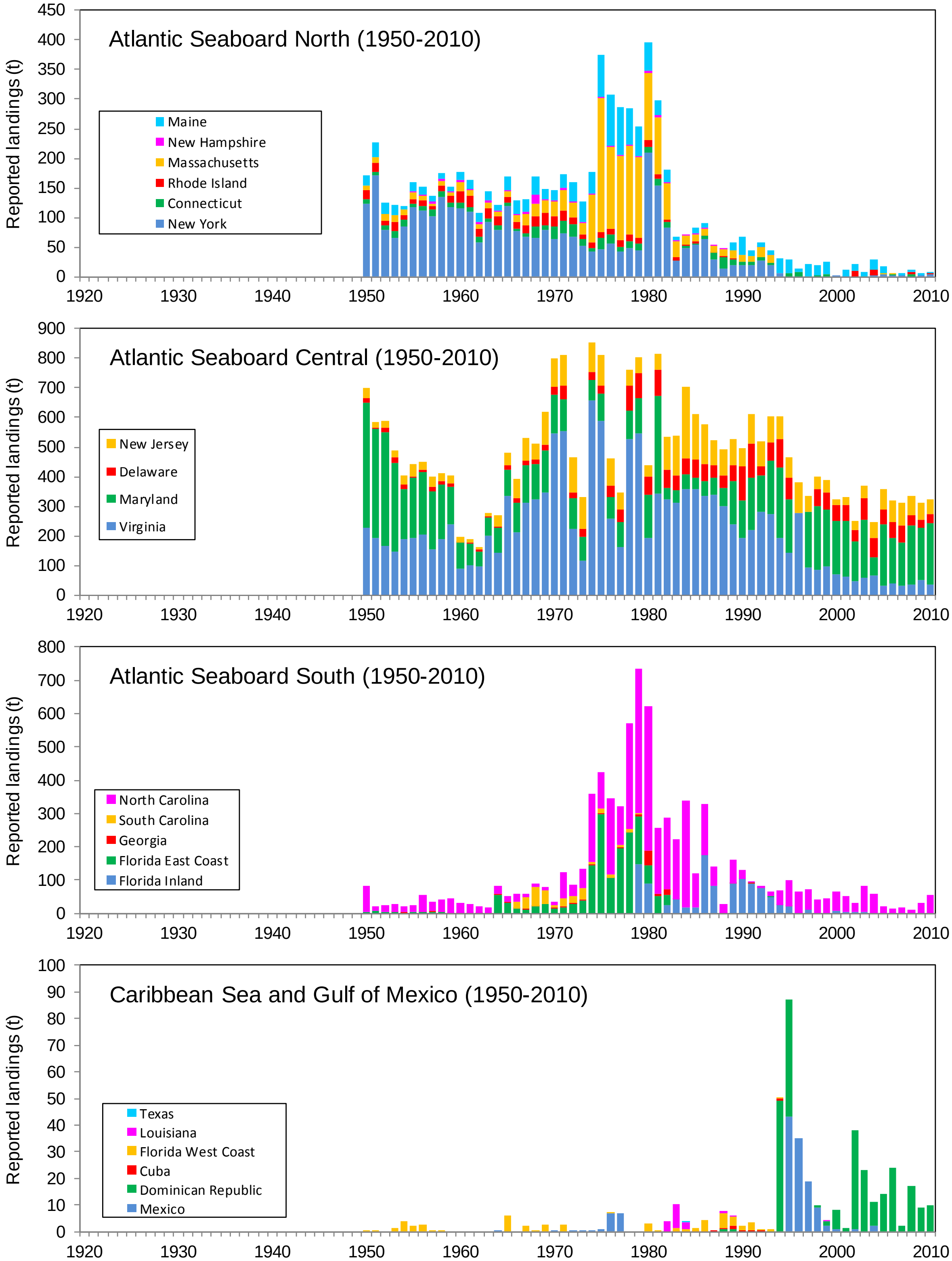

Figure 5.2.1. Reported landings (t) of American Eel in the US Atlantic Seaboard North, Central and South RPA zones as well as in the Caribbean Sea and the Gulf of Mexico, 1950 to 2010.

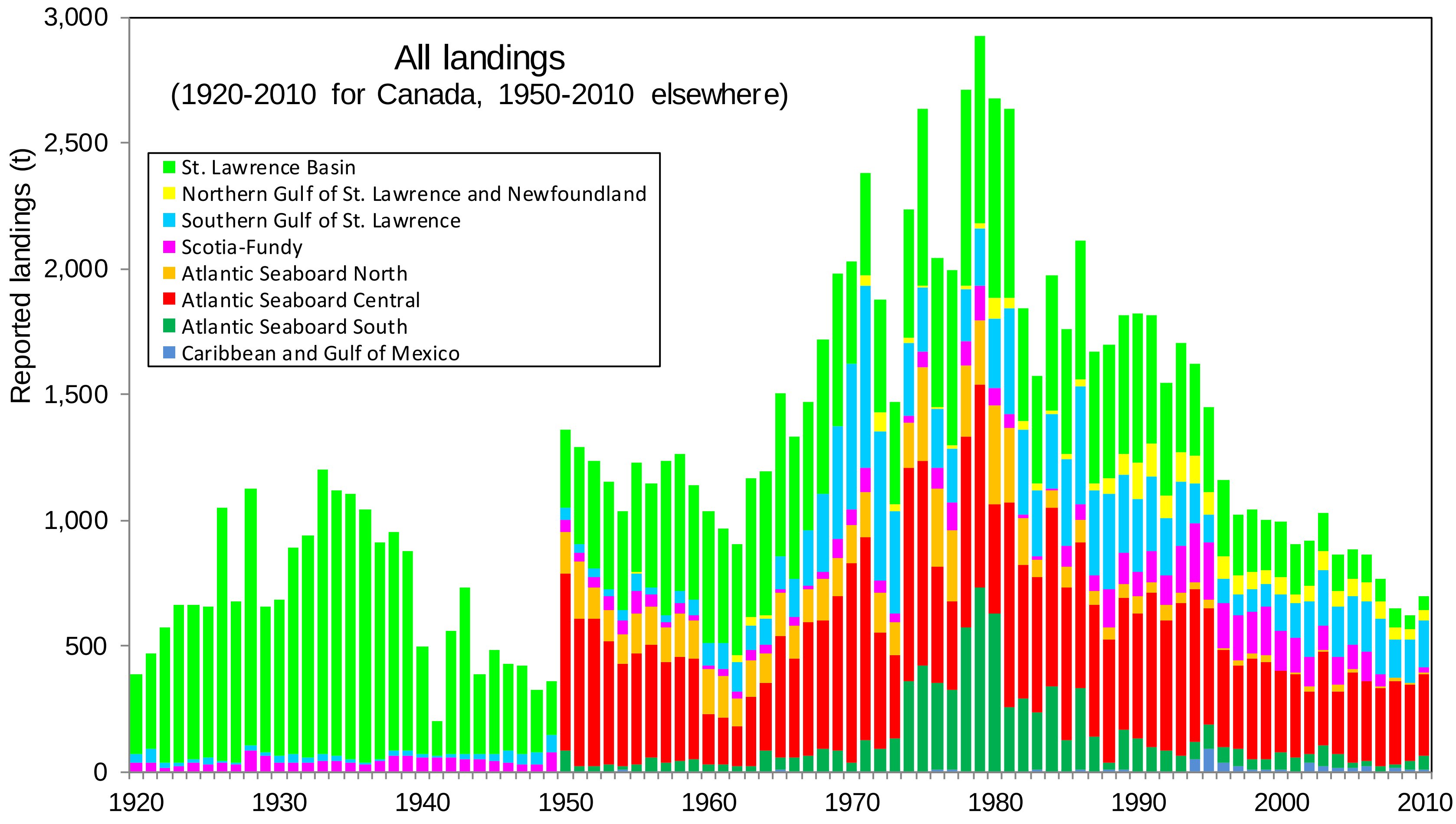

Figure 5.4.1. Reported landings (t) of American Eel in all areas, 1920 to 2010 for Canada, 1950 to 2010 elsewhere.

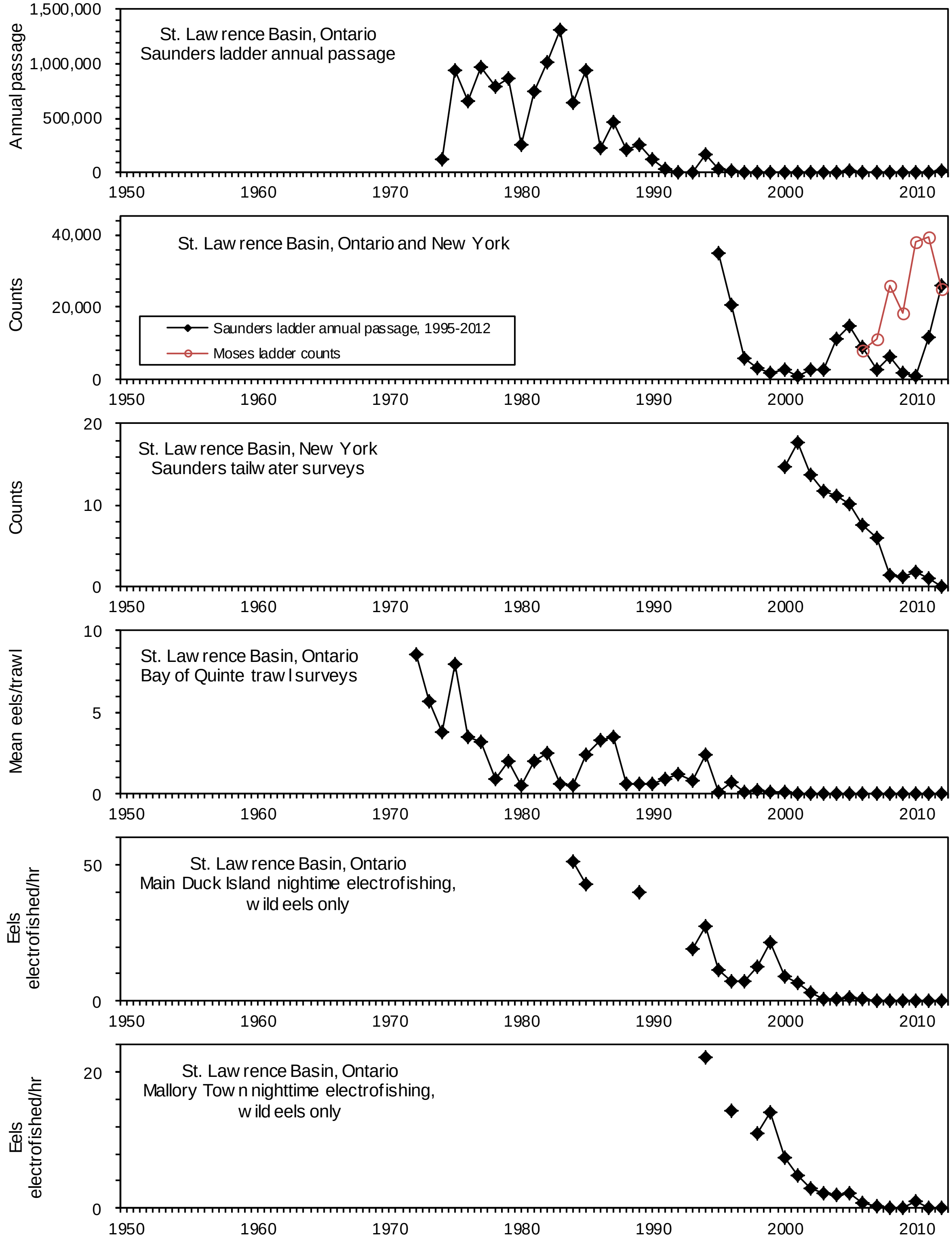

Figure 6.1.1. American Eel abundance indicators in the St. Lawrence Basin RPA zone.

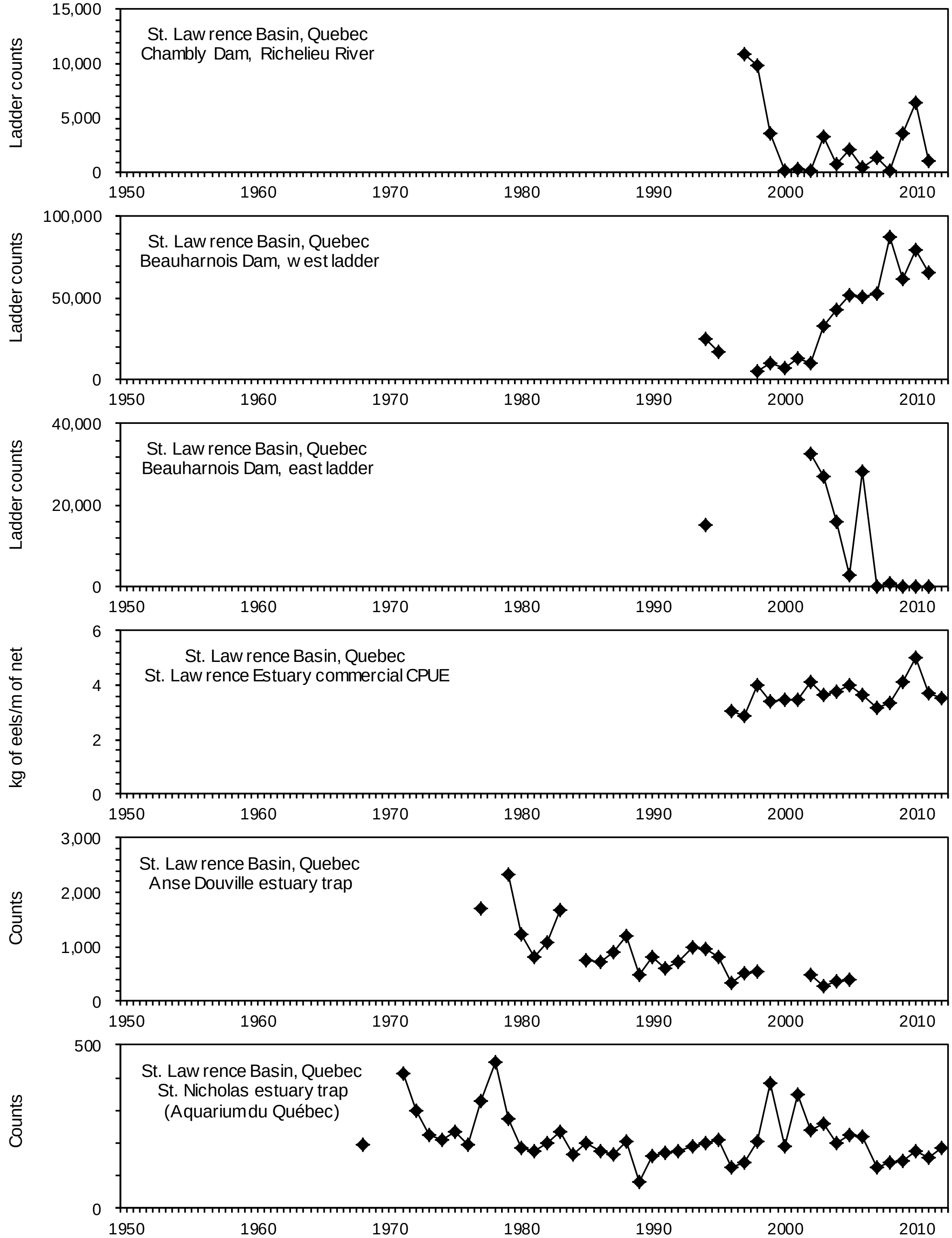

Figure 6.1.1 (continued).

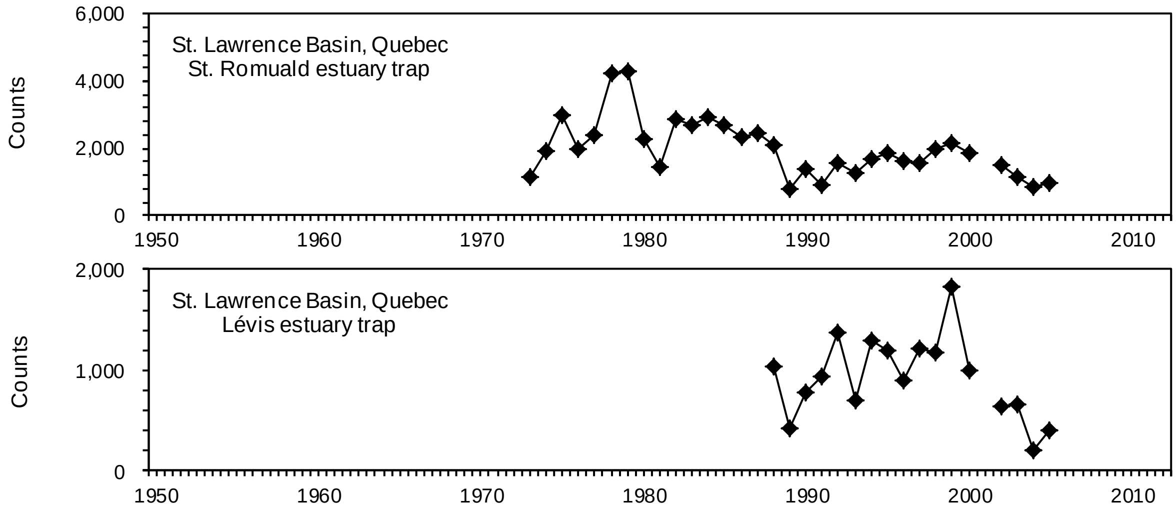

Figure 6.1.1 (continued).

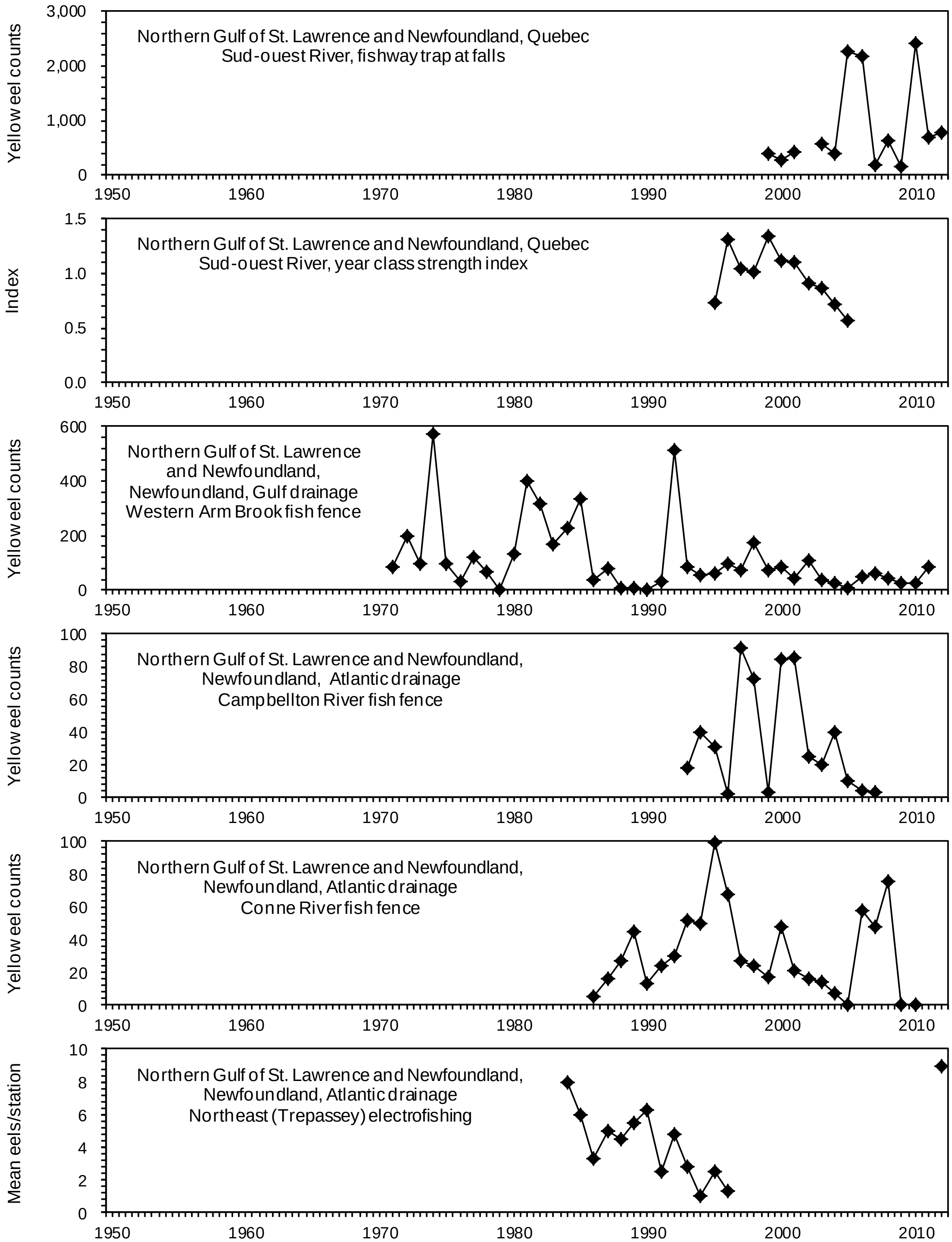

Figure 6.1.2. American Eel abundance indicators in the Northern Gulf of St. Lawrence and Newfoundland RPA zone.

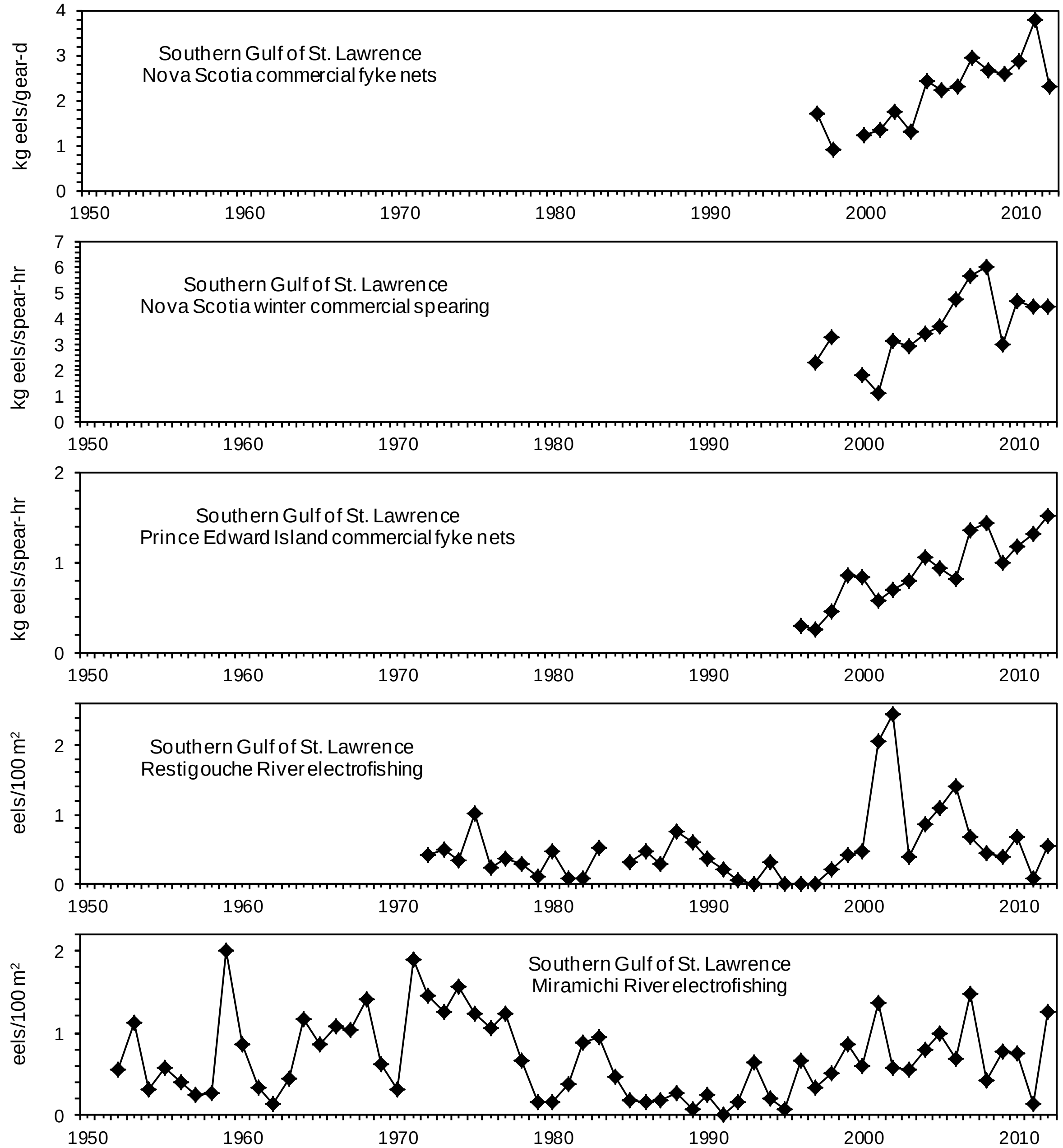

Figure 6.1.3. American Eel abundance indicators in the Southern Gulf of St. Lawrence RPA zone.

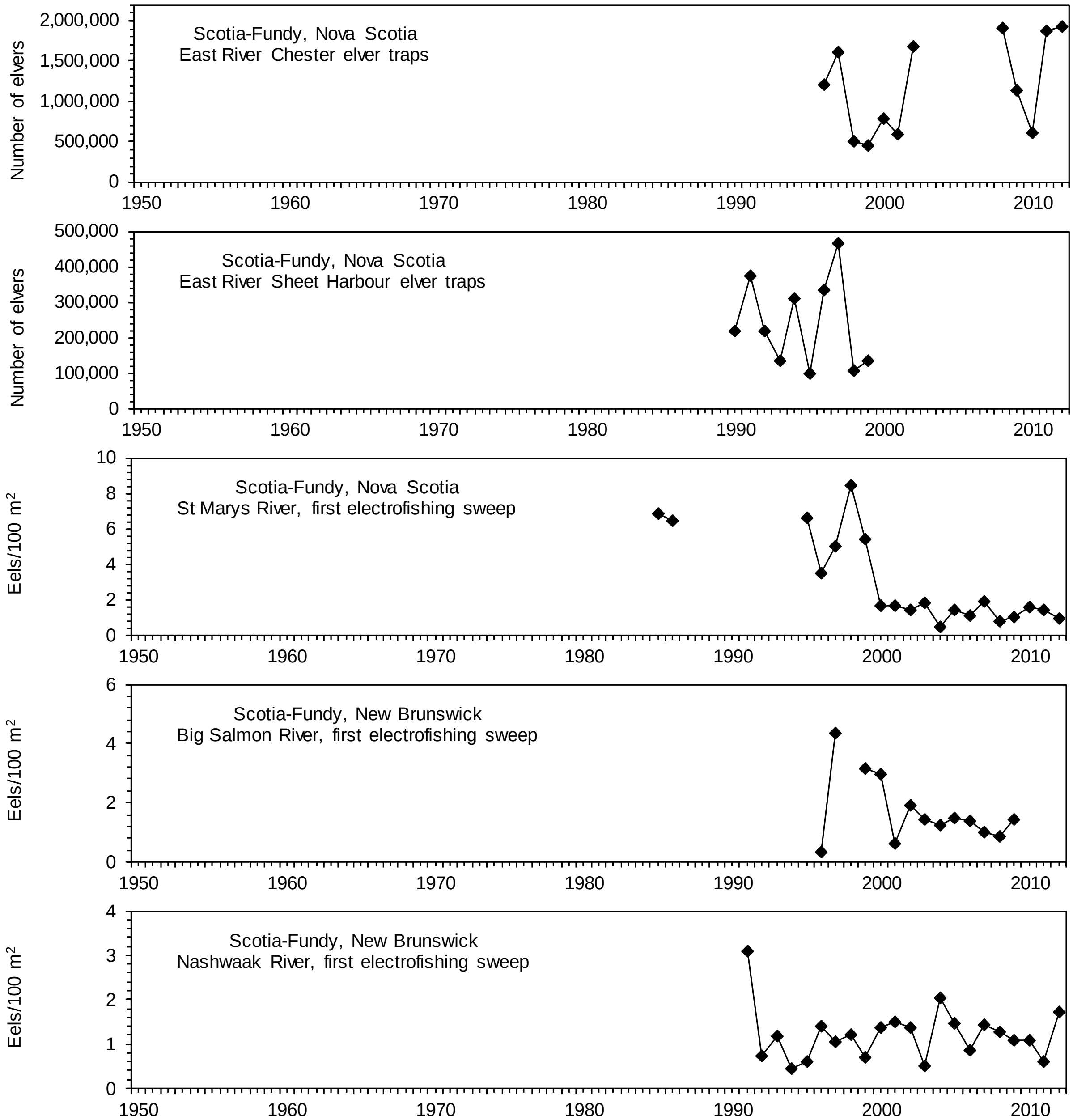

Figure 6.1.4. American Eel abundance indicators in the Scotia-Fundy RPA zone.

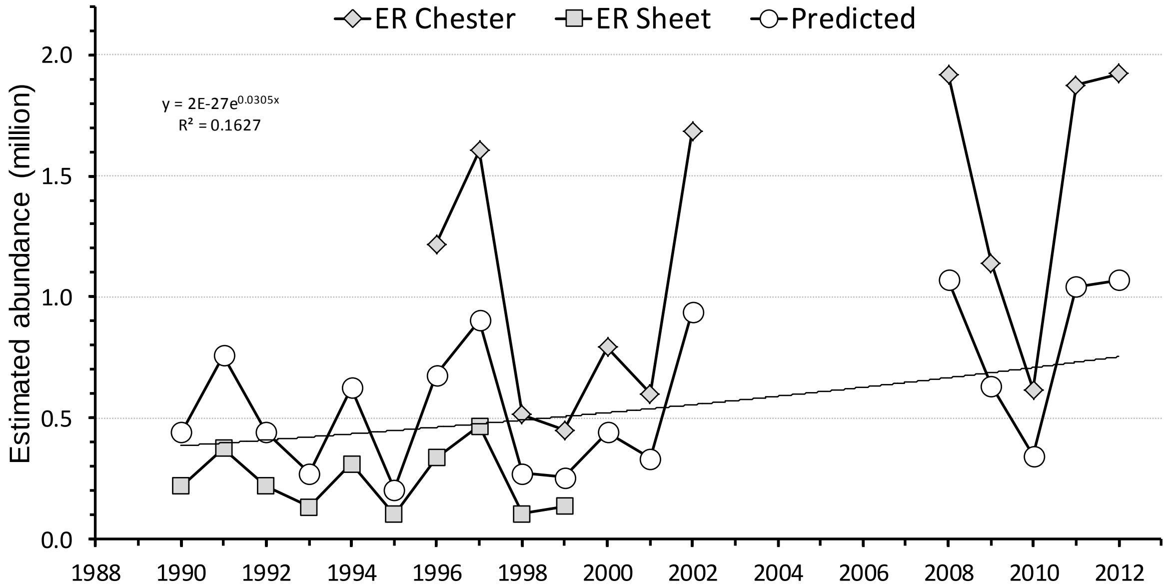

Figure 6.1.5. Trend analysis for the elver recruitment index for the Scotia-Fundy RPA zone, 1990 to 2012. Data are unavailable from either of the two monitored rivers for 2003-2007. The predicted value represents the adjusted annual mean value for the composite index. Recent data are preliminary and are subject to revision.

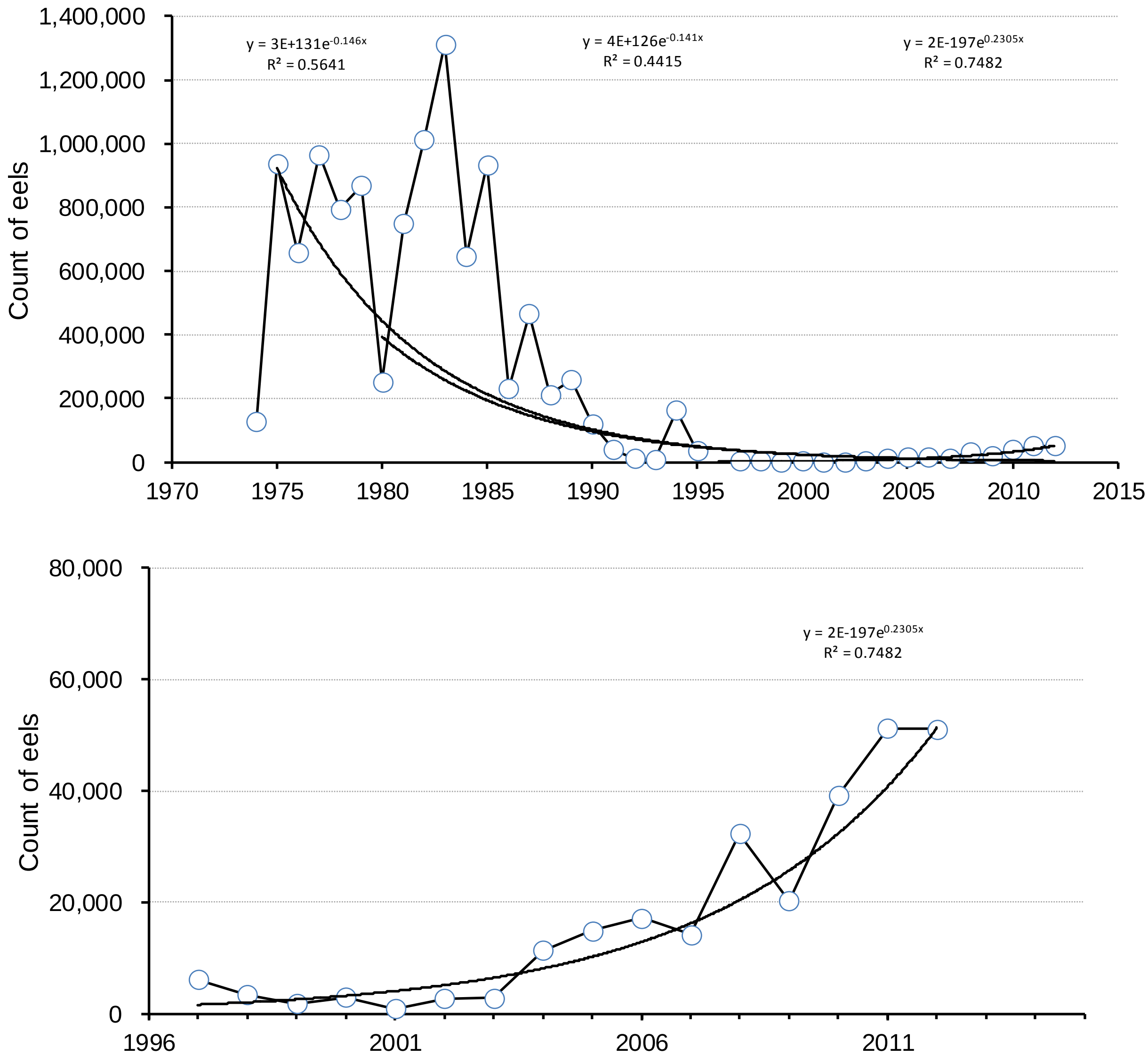

Figure 6.1.6. Trend analysis of the Lake Ontario recruitment index for counts at the Moses and Saunders eel ladders, 1974 to 2012.
The upper panel shows the full series and the lower panel shows data for 1997-2012. The trend analysis excludes the 1974 value and there are no data for 1996.

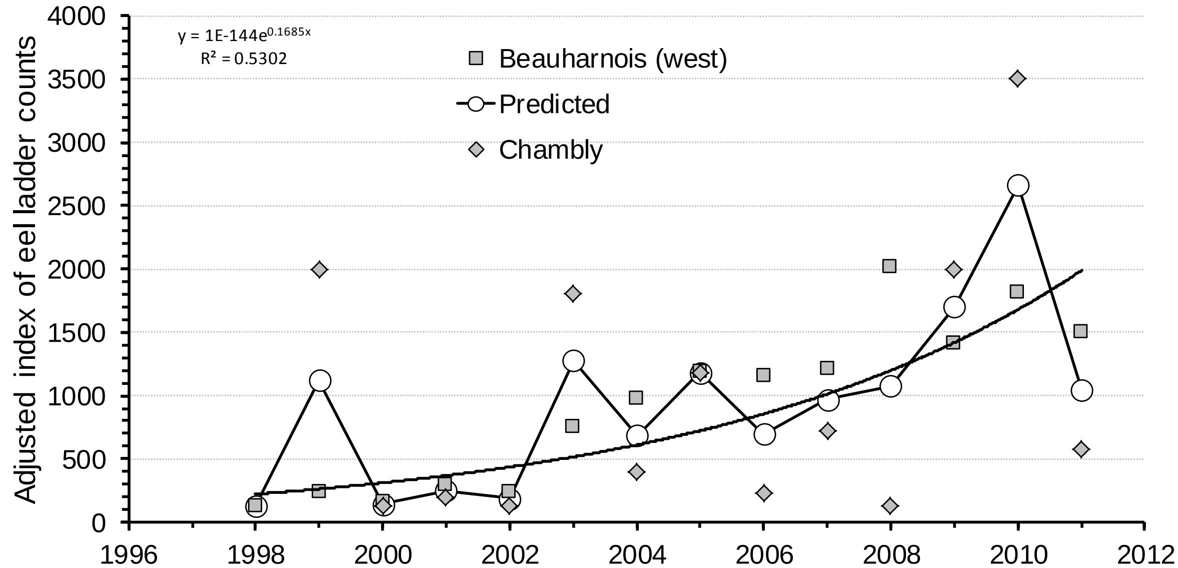

Figure 6.1.7. St. Lawrence Basin yellow eel recruitment indices at two eel ladders, 1998 to 2011. The adjusted index refers to the annual indices divided by the index specific mean of the 1999 to 2011 time period. The predicted value represents the adjusted annual mean value for the composite index.

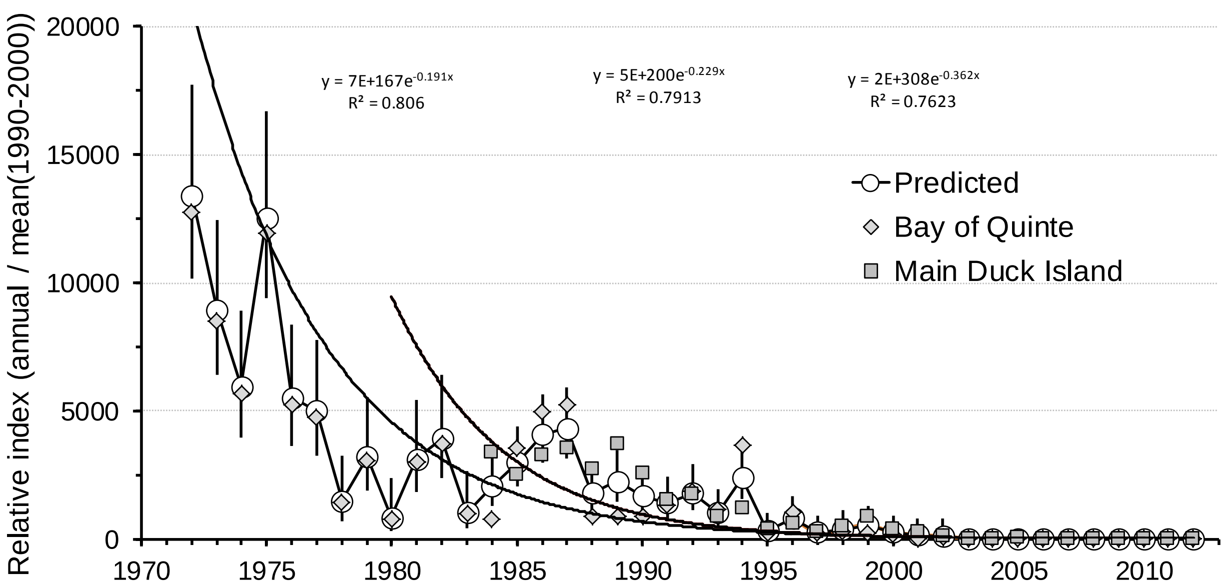

Figure 6.1.8. The St. Lawrence Basin (Lake Ontario) standing stock indices, 1972 to 2012. The relative index refers to the annual indices divided by the index specific mean of the 1990 to 2000 time period. The predicted values represent the adjusted annual mean value for the composite index. The error bars in the figure define the 90% confidence interval ranges of the predicted value for the year effect.

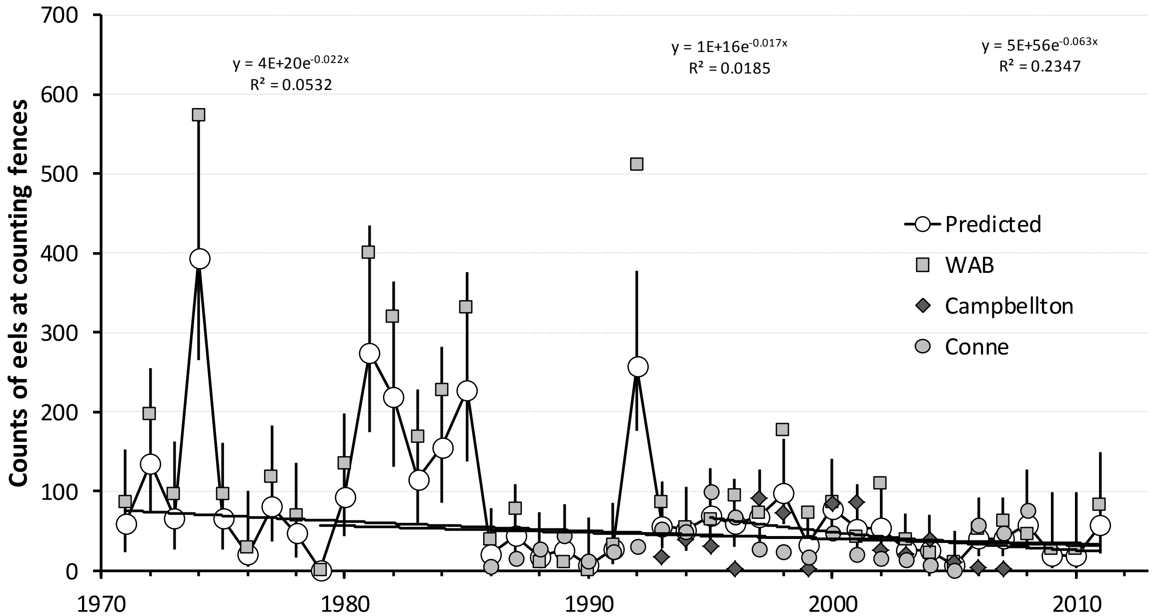

Figure 6.1.9. The northern Gulf and Newfoundland RPA zone standing stock indices, 1971 to 2011. The predicted values represent the mean of the composite index from the GLM model. The error bars in the figure define the 90% confidence interval ranges of the predicted value for the year effect.

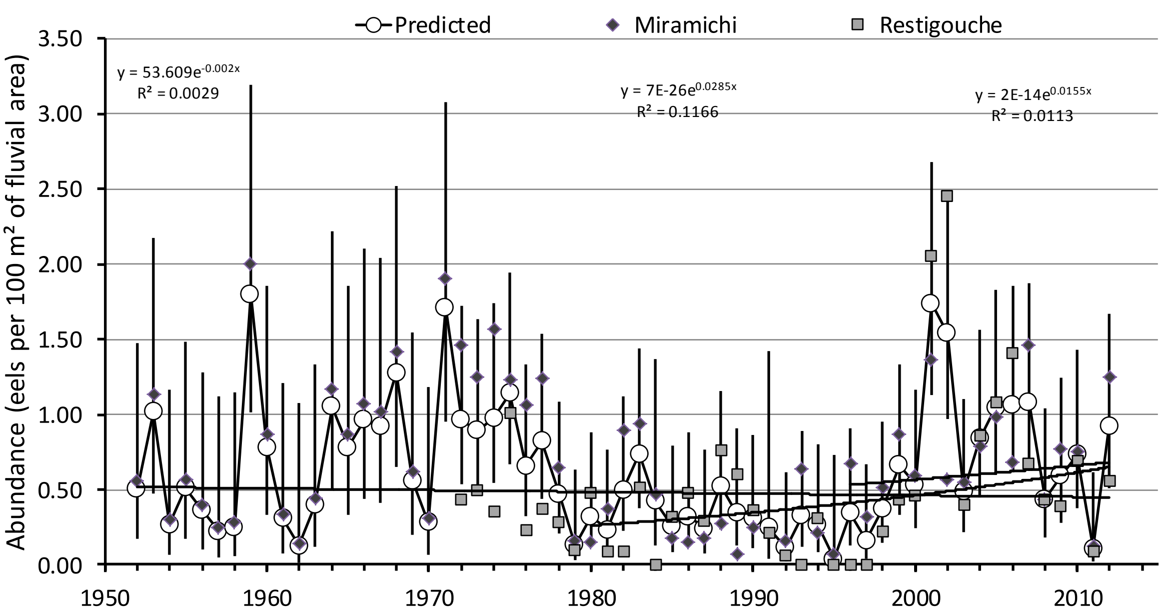

Figure 6.1.10. The southern Gulf of St. Lawrence RPA zone standing stock indices for freshwater habitat, 1952 to 2012.
The predicted values represent the mean of the composite index from the GLM model. The error bars in the figure define the 90% confidence interval ranges of the predicted value for the year effect.

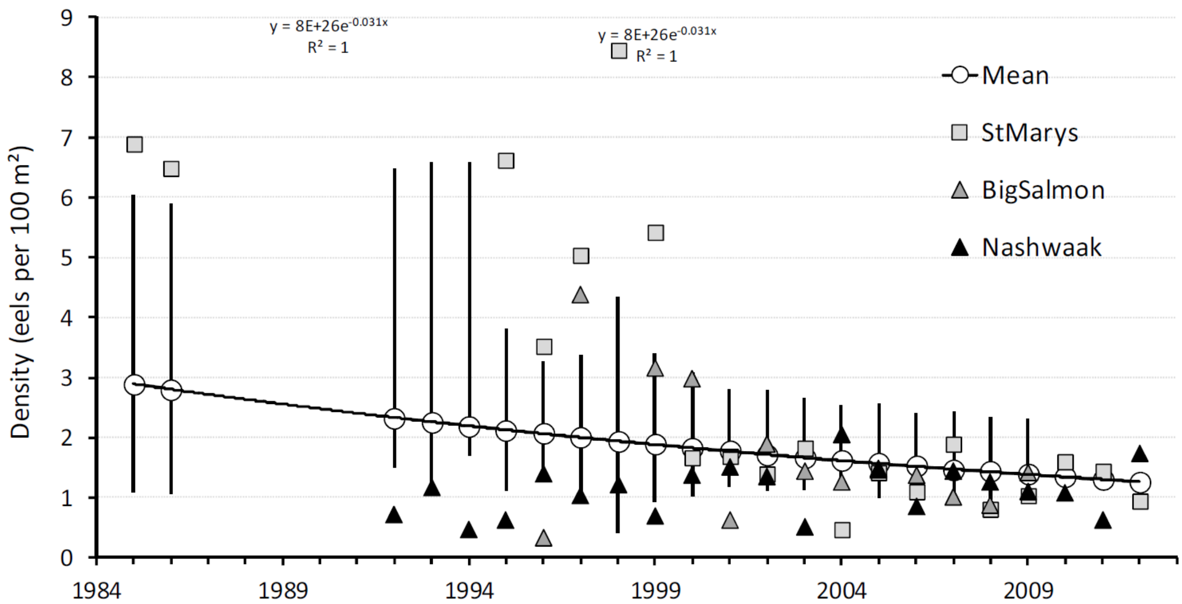

Figure 6.1.11. The Scotia Fundy RPA zone standing stock indices for freshwater habitat, 1985 to 2012, excluding 1987 to 1990.
The predicted values represent the mean of the composite index from the GLM model. The error bars in the figure define the 90% confidence interval ranges of the predicted value for the year effect.

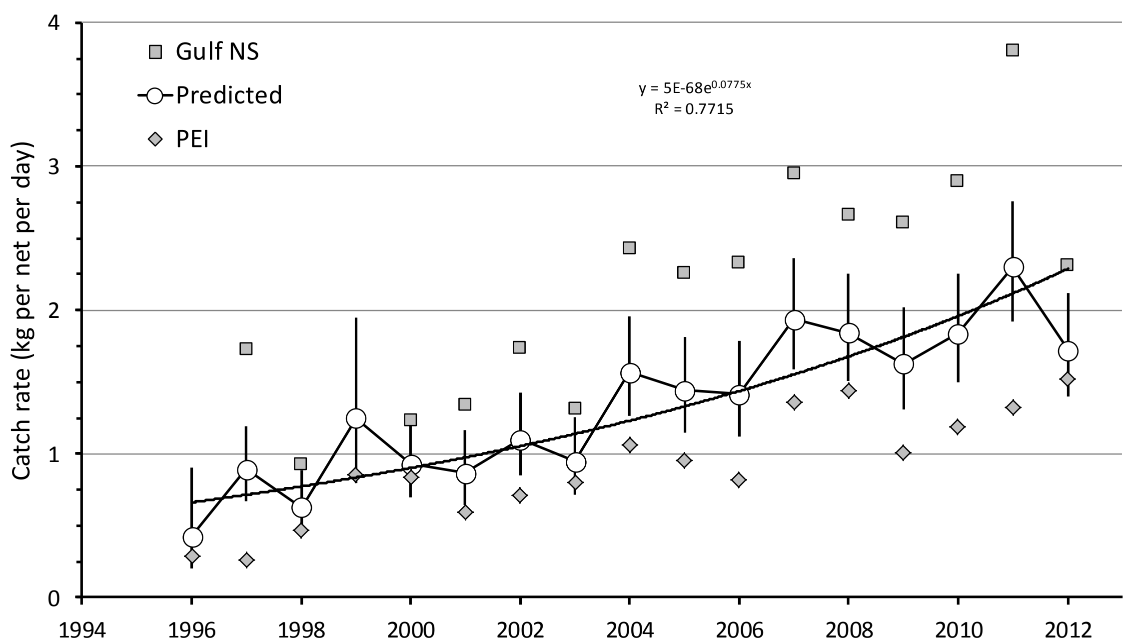

Figure 6.1.12. The southern Gulf of St. Lawrence RPA zone standing stock indices for estuarine/marine habitat, 1996 to 2012.
The predicted values represent the mean of the composite index from the GLM model. The error bars in the figure define the 90% confidence interval ranges of the predicted value for the year effect.

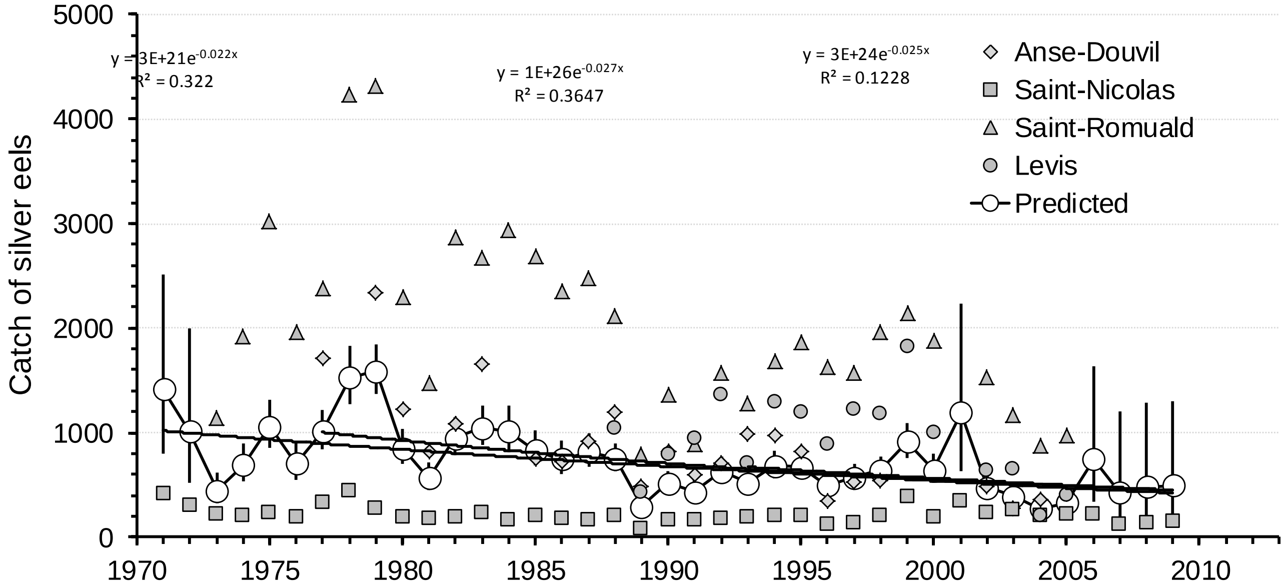

Figure 6.1.13. The silver eel indices from the St. Lawrence Basin RPA zone for the period 1971 to 2009. The predicted values represent the mean of the composite index from the GLM model. The error bars in the figure define the 90% confidence interval ranges of the predicted value for the year effect.

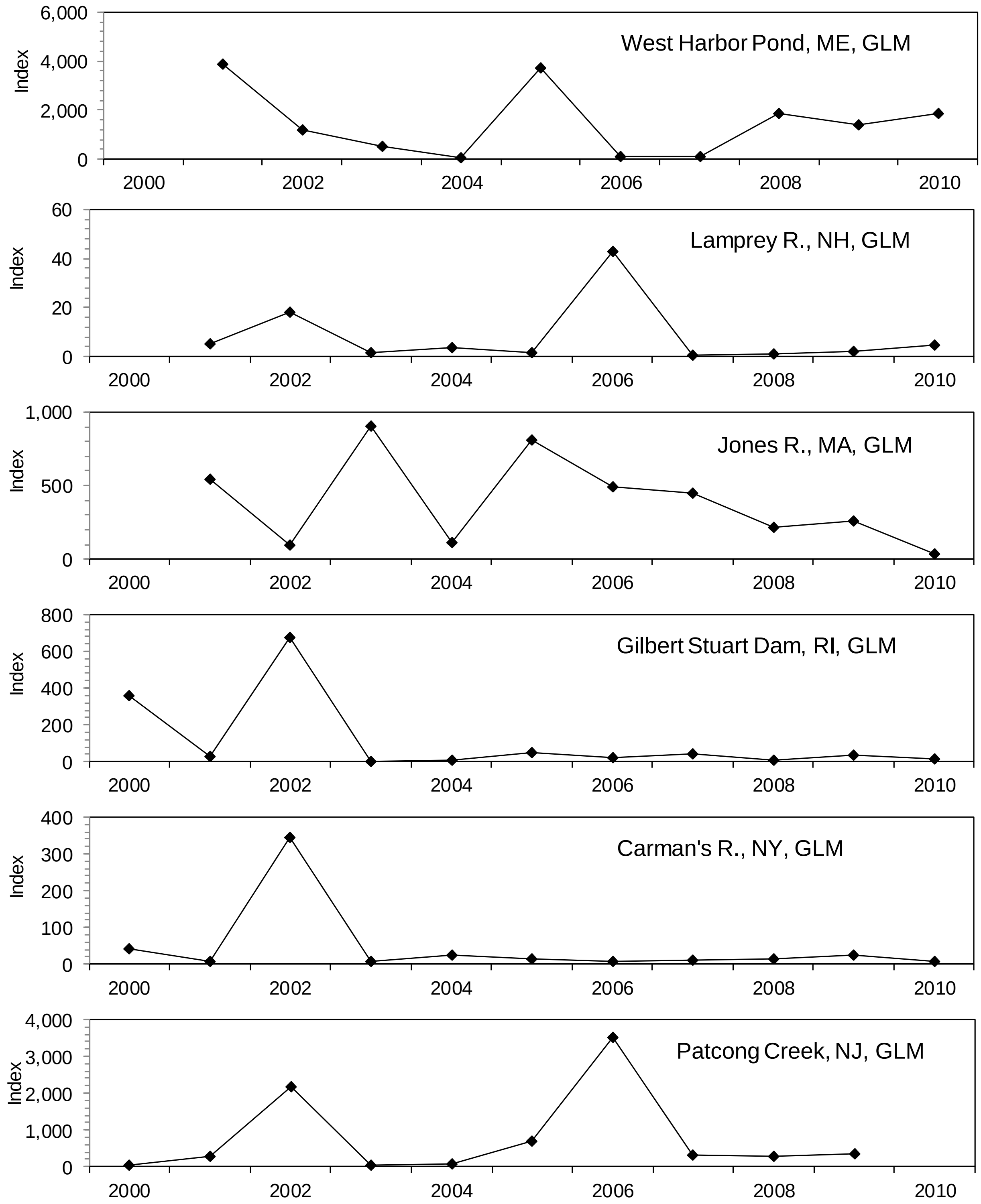

Figure 6.2.1. American Eel young-of-the year abundance indices on the Atlantic Seaboard of the United States.
The title in each panel gives location, state, and analysis method. Data from ASMFC (2012).

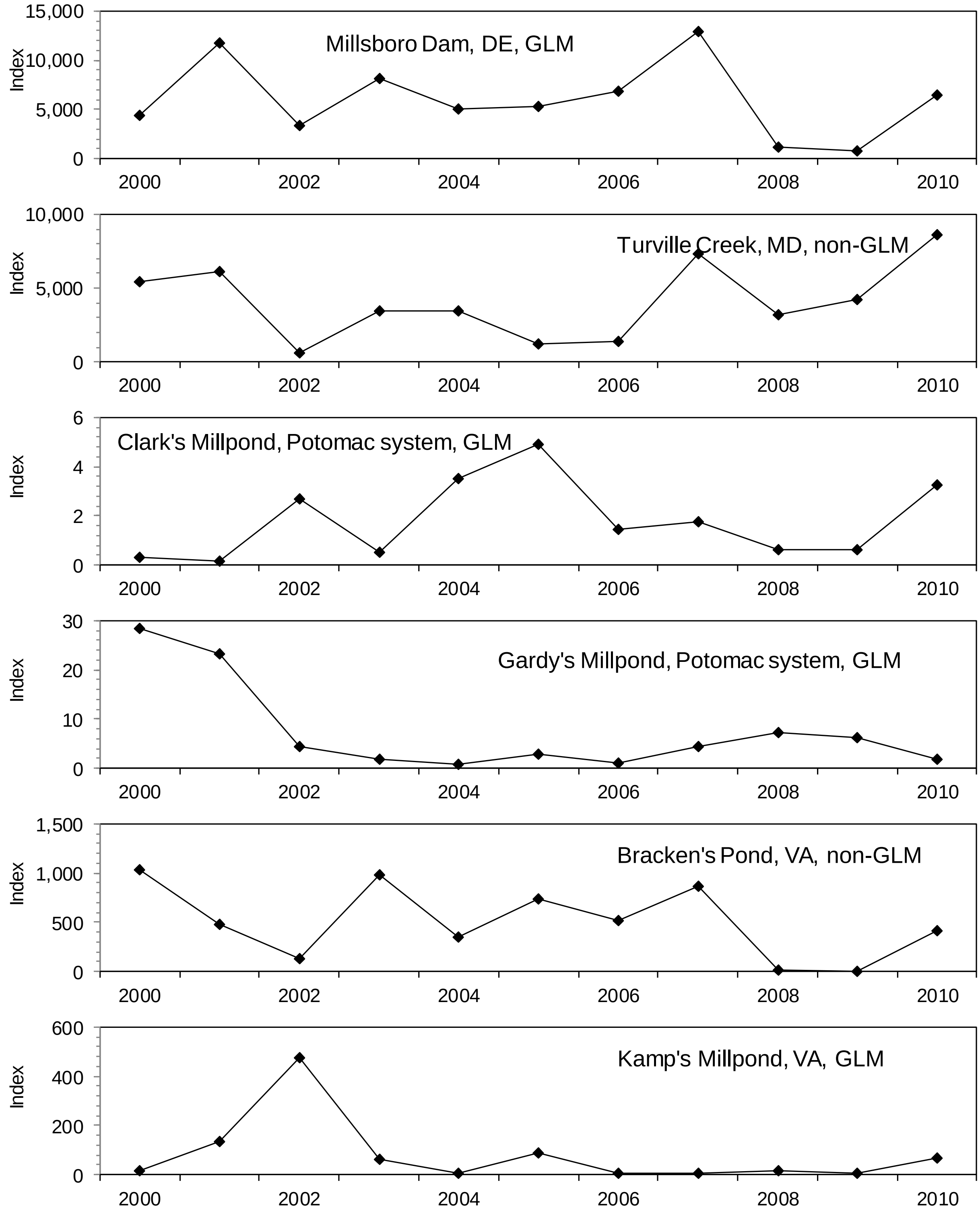

Figure 6.2.1 (continued).

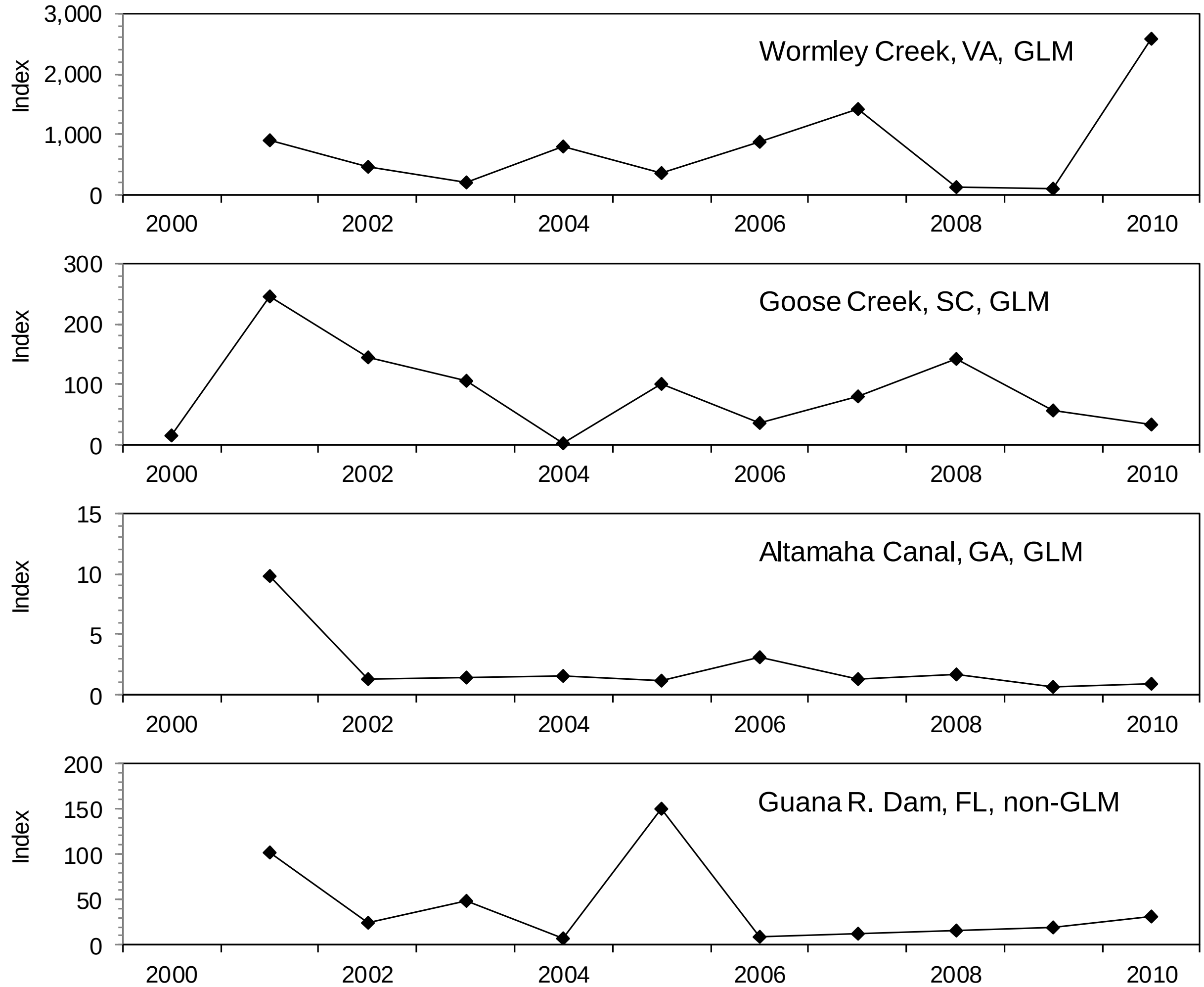

Figure 6.2.1 (continued).

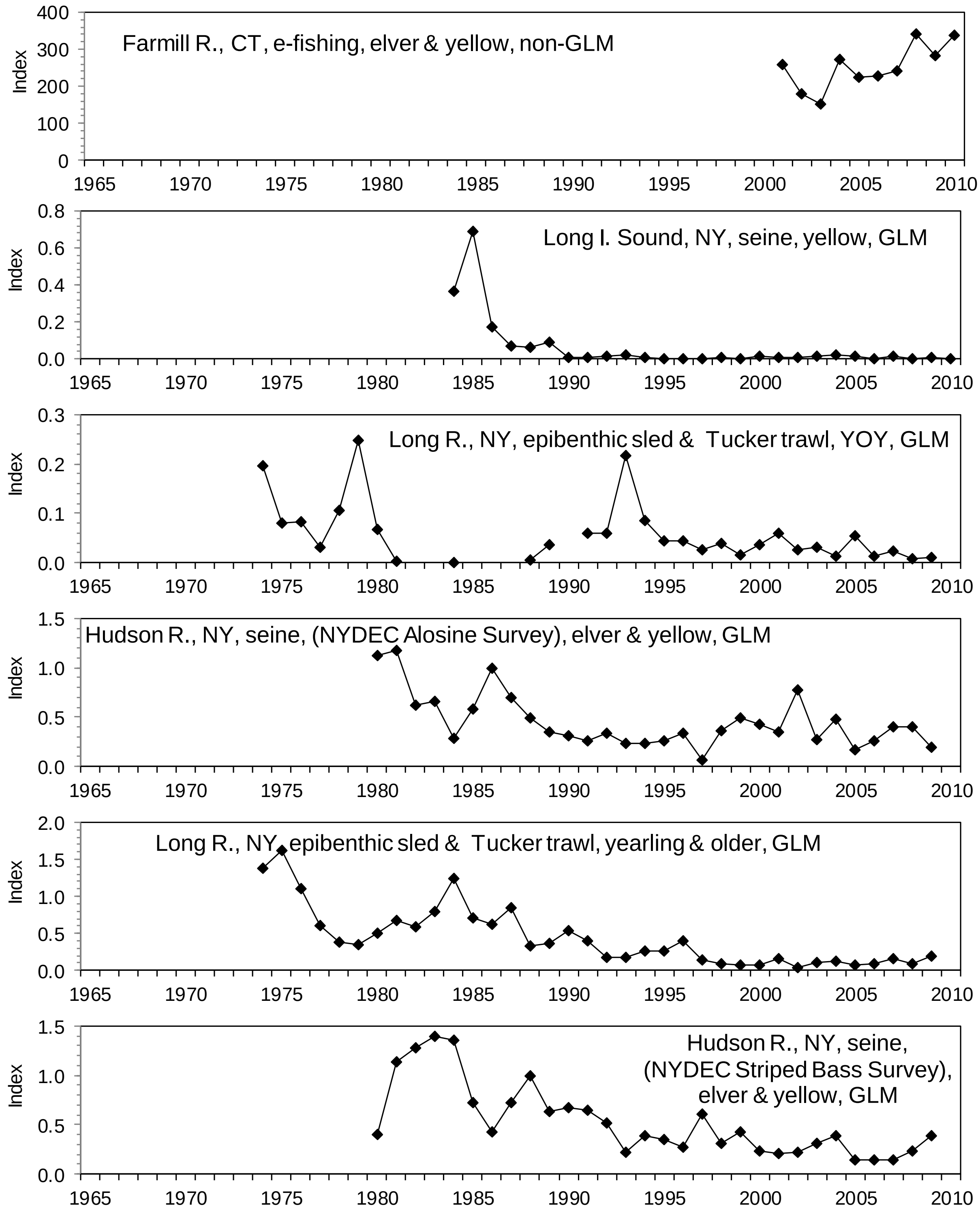

Figure 6.2.2. American Eel abundance indices on the Atlantic Seaboard of the United States. Panel titles give location, state, gear, life stage, and analysis method. YOY - young of the year; GLM - General Linear Models. Data from ASMFC (2012).

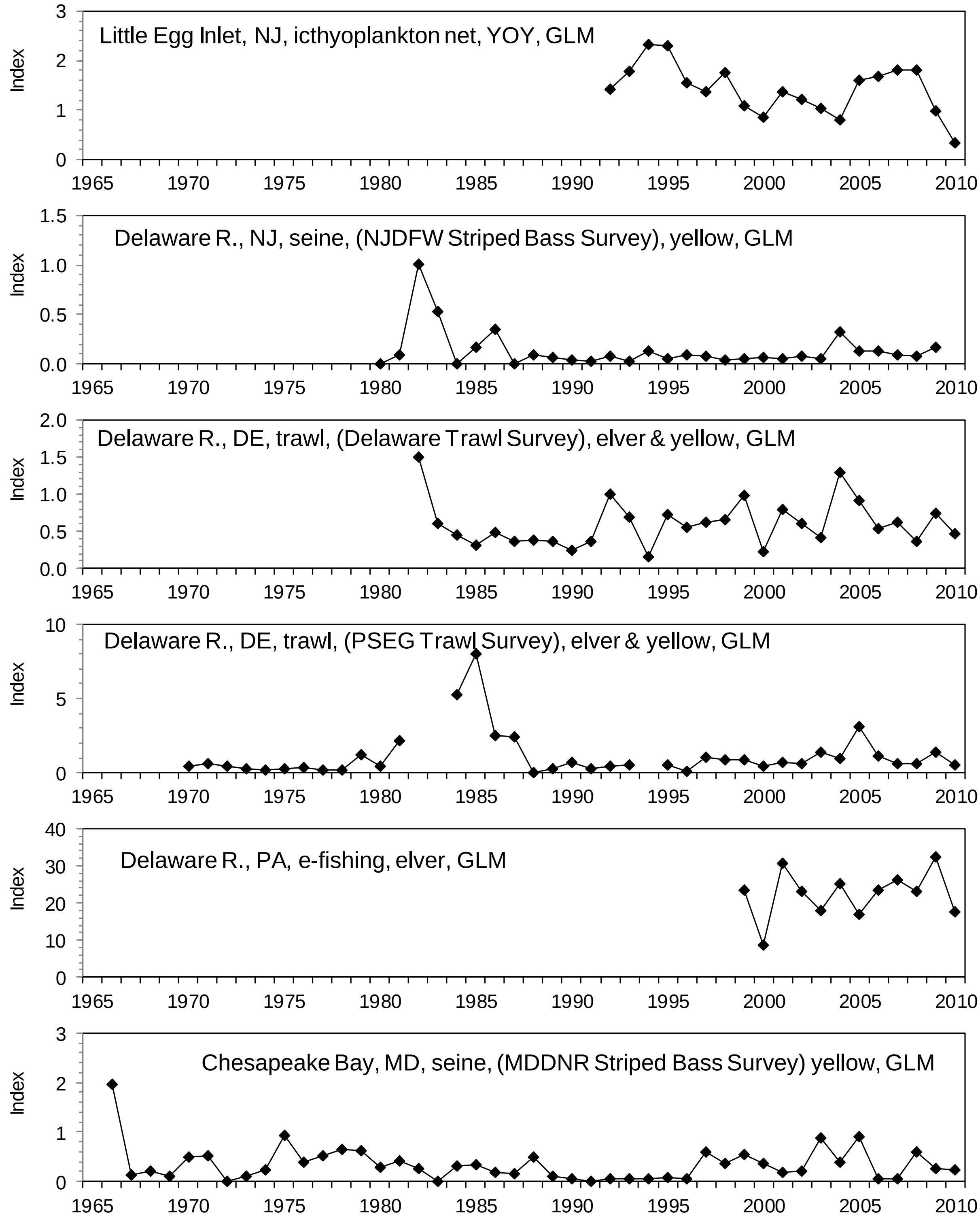

Figure 6.2.2 (continued).

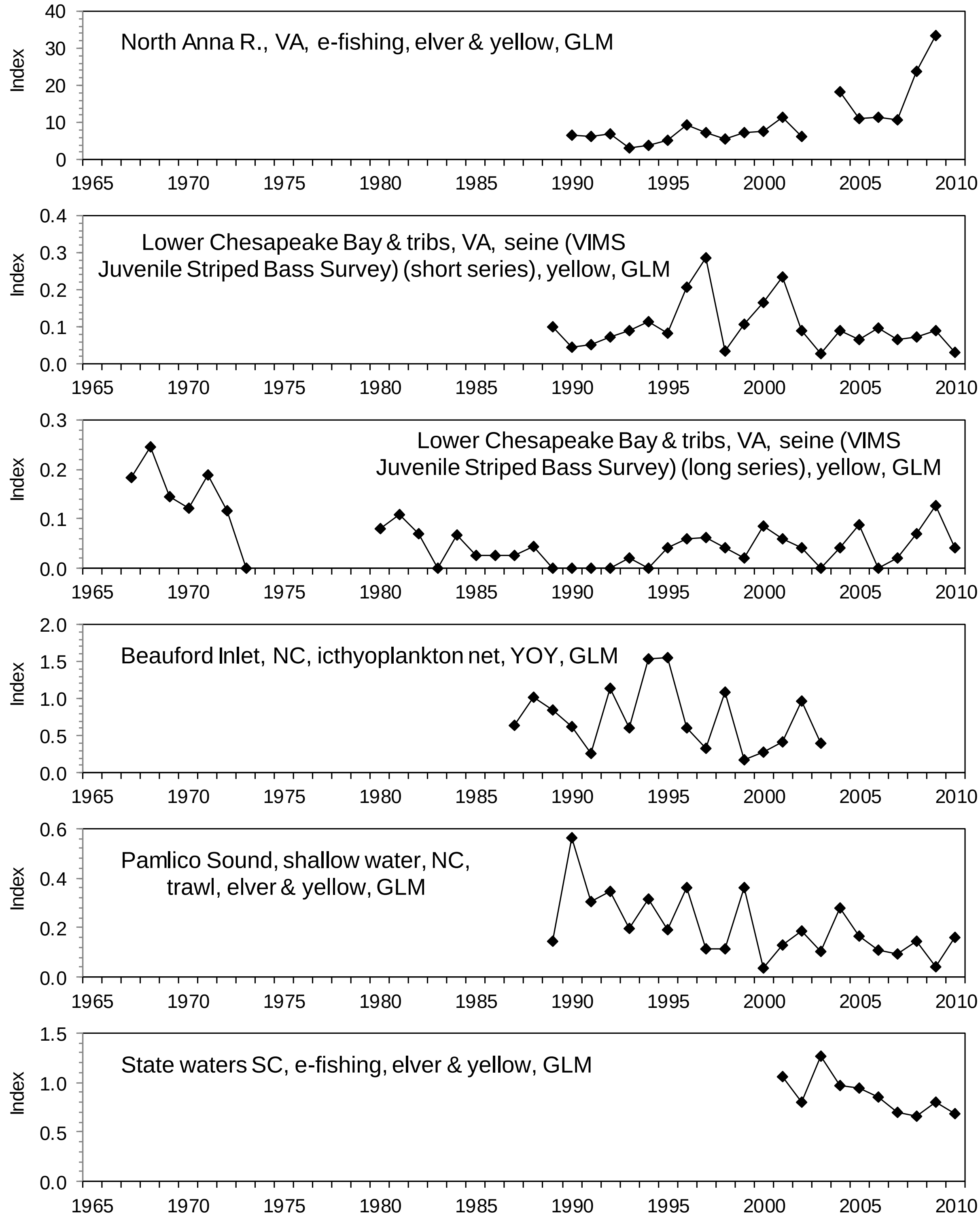

Figure 6.2.2 (continued).

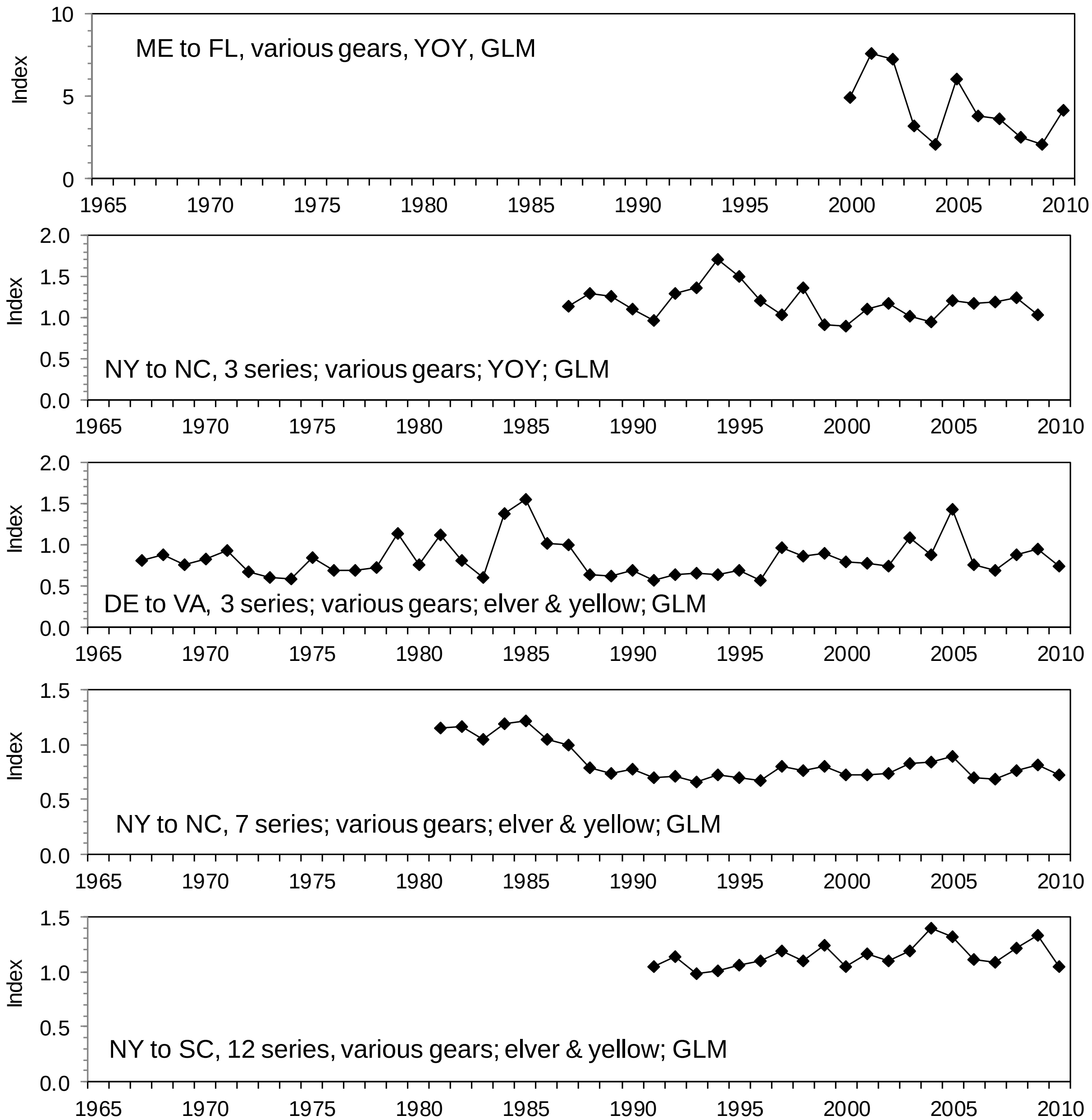

Figure 6.2.3. Combined American Eel abundance indices on the Atlantic Seaboard of the United States. Panel titles give location, gear, life stage, and analysis method. YOY - young of the year; GLM - General Linear Models. Data from ASMFC (2012).

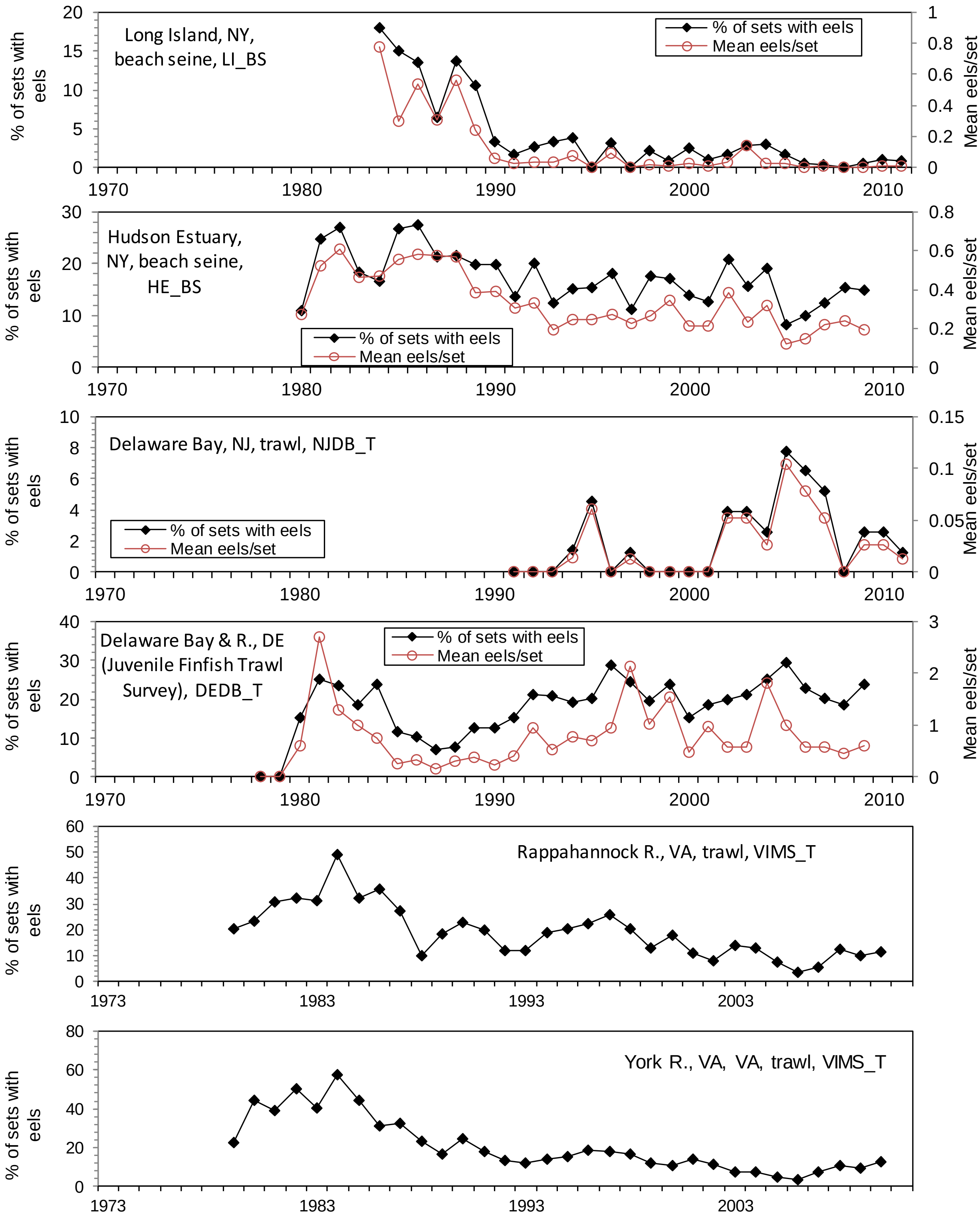

Figure 6.2.4. American Eel abundance series from beach seine and trawl surveys on the Atlantic Seaboard of the United States as compiled by Poirier (2013).
Panel titles give location, state, gear, and abbreviation used in Poirier (2013).

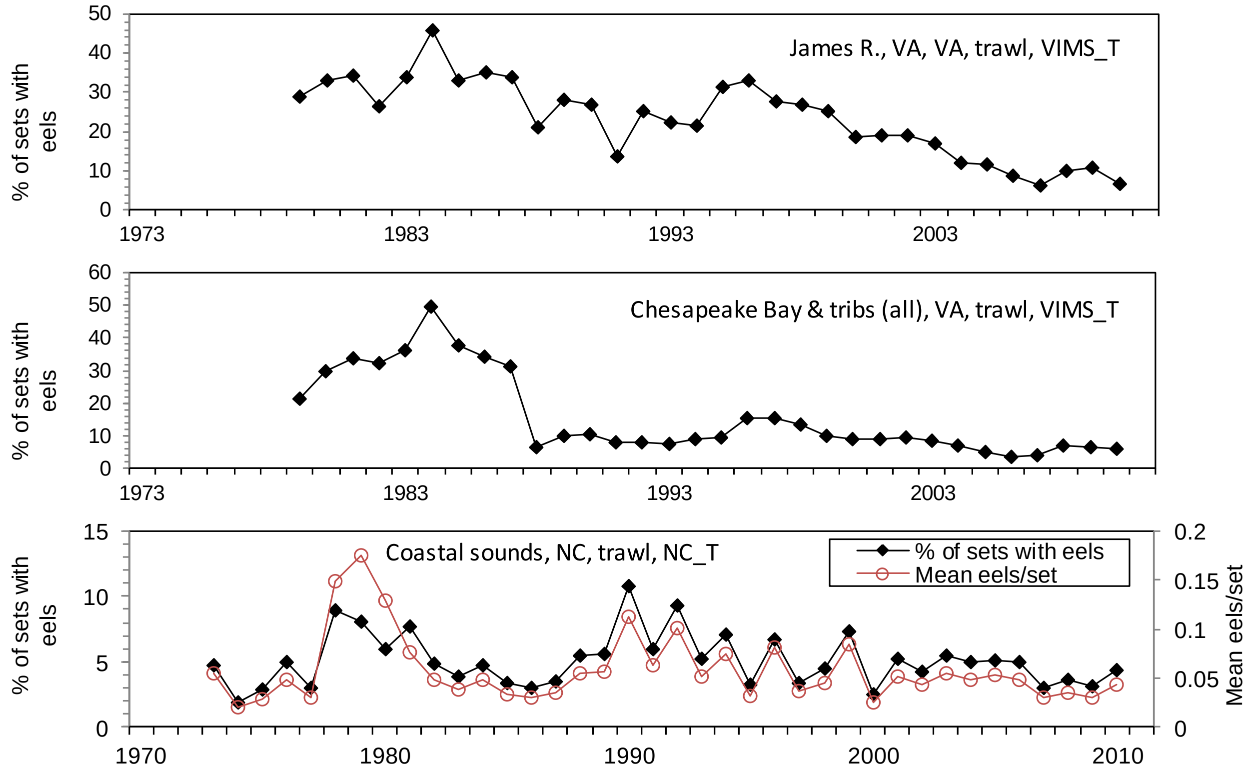

Figure 6.2.4 (continued).

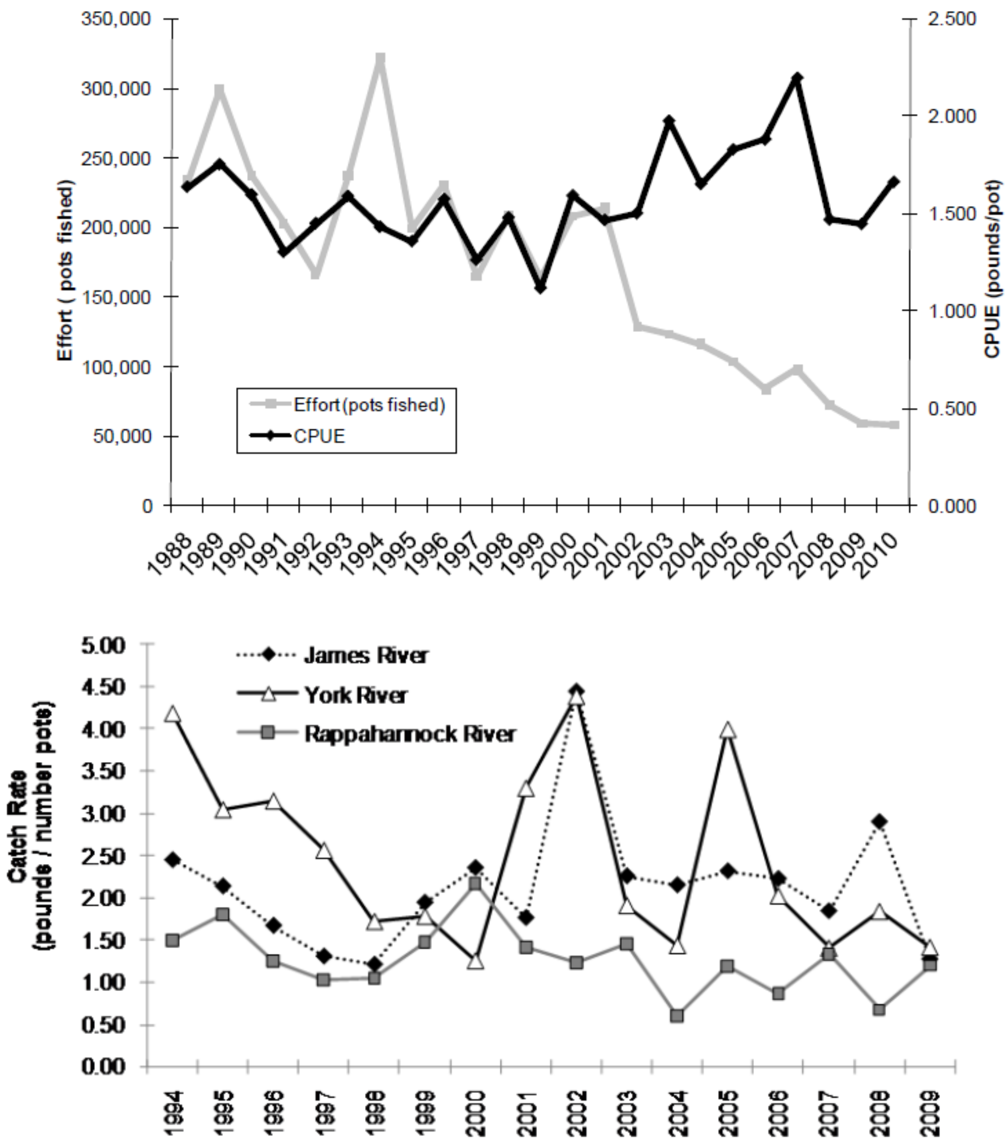

Figure 6.2.5. Catch per unit effort from commercial eel pot fisheries in the Potomac (upper panel), and the James, York, and Rappahannock river estuaries (lower panel), Chesapeake Bay, Virginia (from ASMFC 2012).

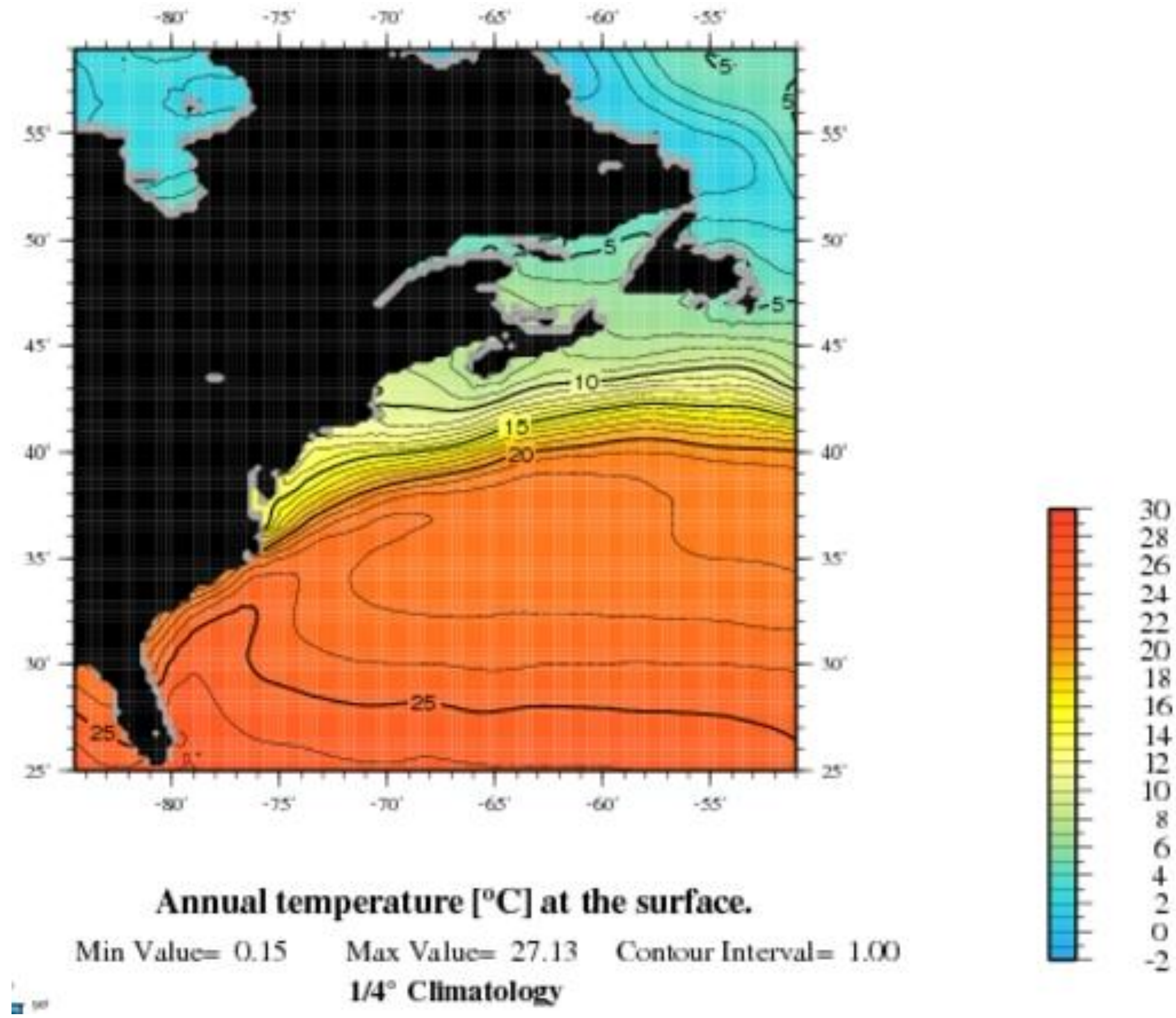

Figure 7.1.1. Annual mean sea surface temperatures summarized from the [National Oceanographic Data Centre of NOAA](). Temperatures are plotted for 1/4° cells.

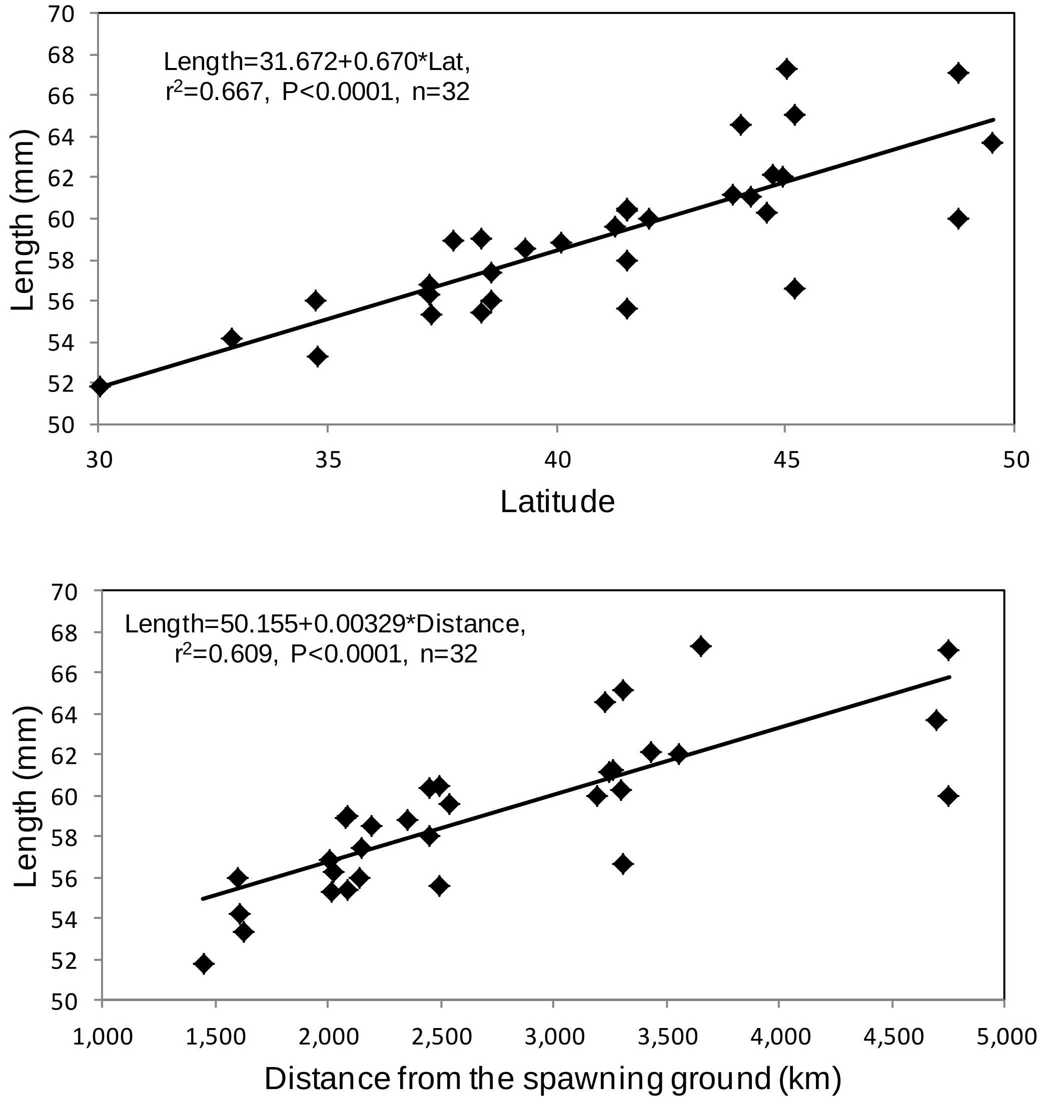

Figure 7.2.1. Scatterplots of American Eel mean elver lengths versus latitude (upper panel) and distance from the spawning ground (lower panel).
Data from Jessop (2010; Table 2) using corrected lengths where available.

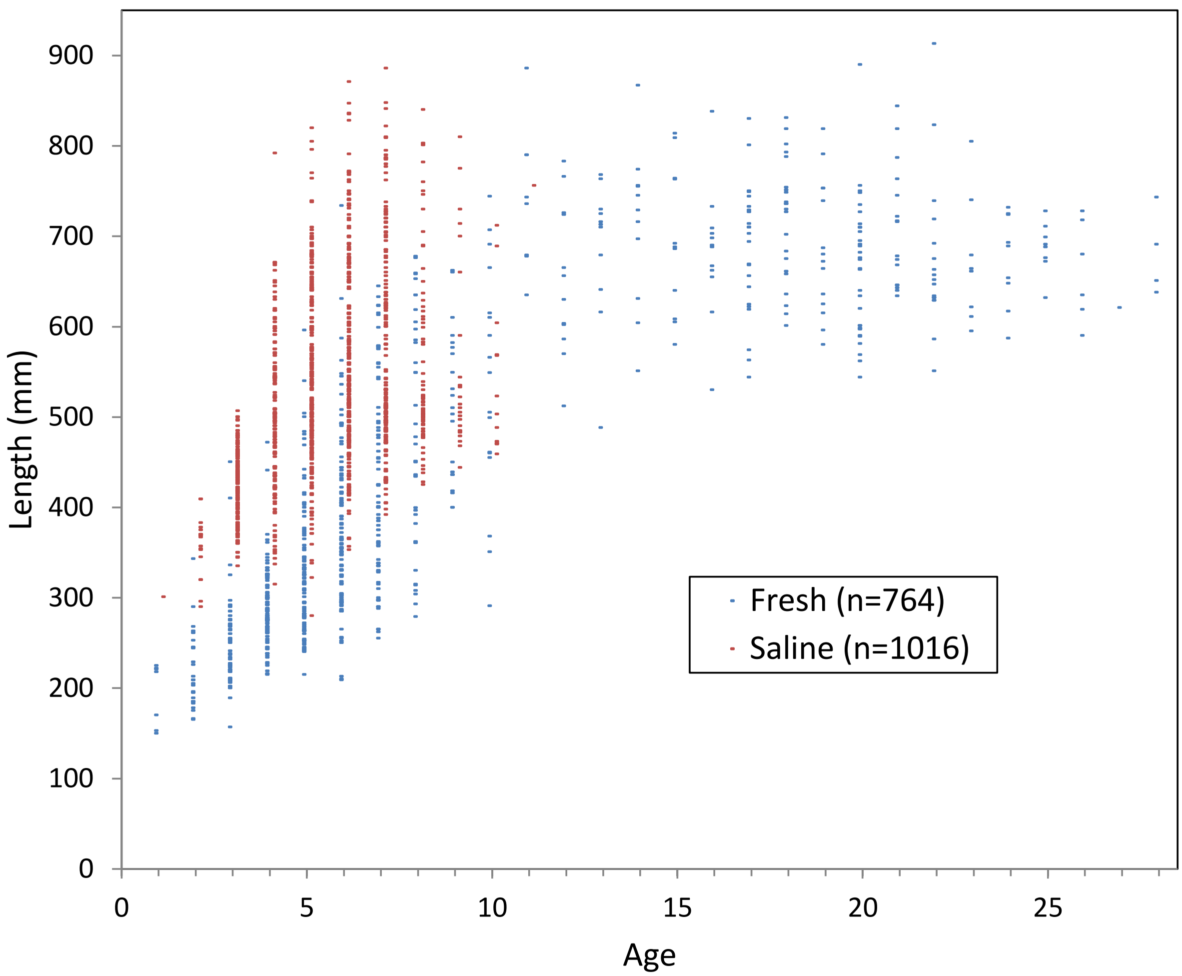

Figure 7.2.2. Length versus age scatter plot for American eels sampled in fresh and saline waters of the Southern Gulf of St. Lawrence.

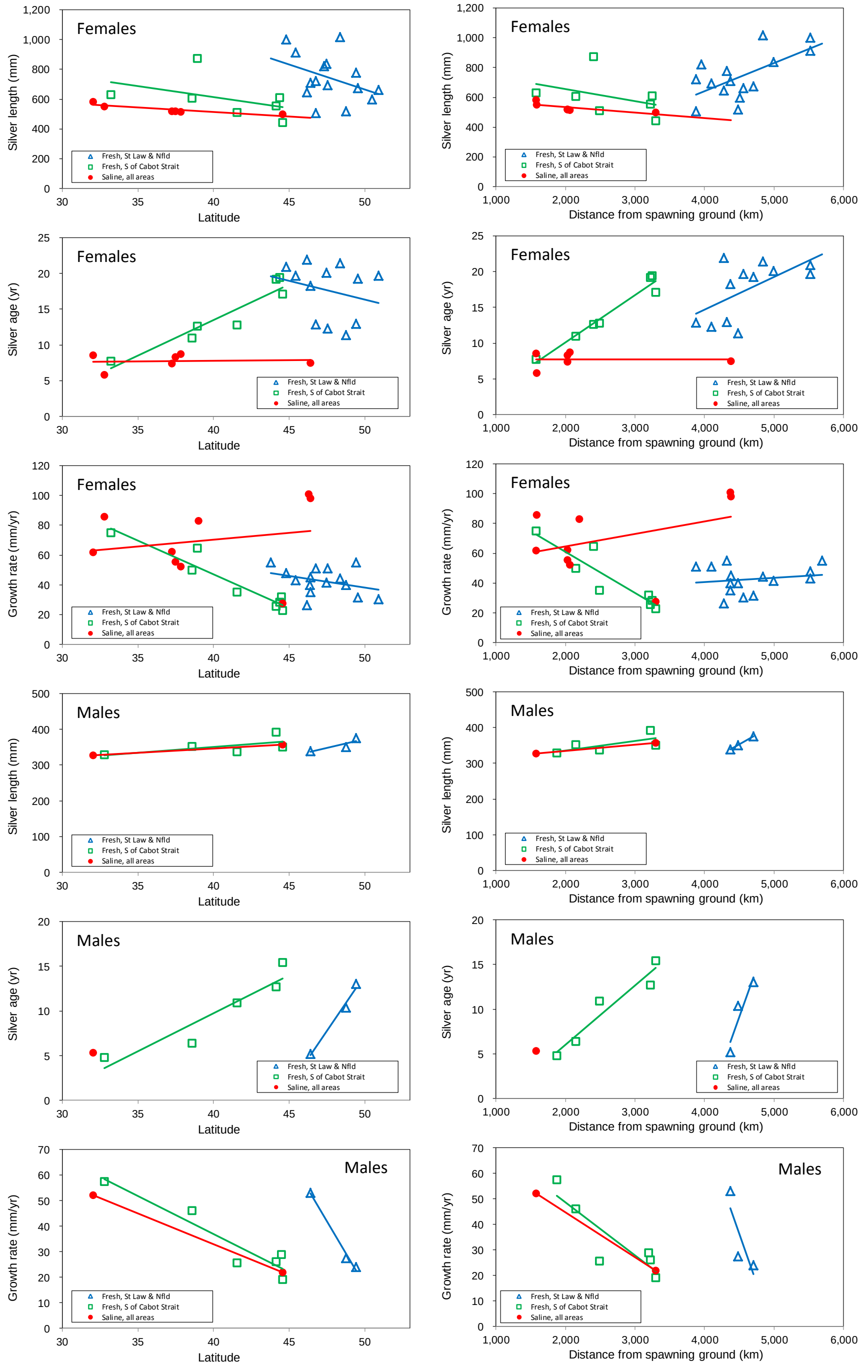

Figure 7.2.3. Relationships between American Eel silver length, silver age, and growth rate versus latitude (left panels) and distance from the spawning ground (right panel) by salinity habitat categories for females (rows 1 to 3) and males (rows 4 to 6).
Freshwater habitat sites are grouped as St. Lawrence River and Gulf and Newfoundland, and the Atlantic coast south of Cabot Strait.

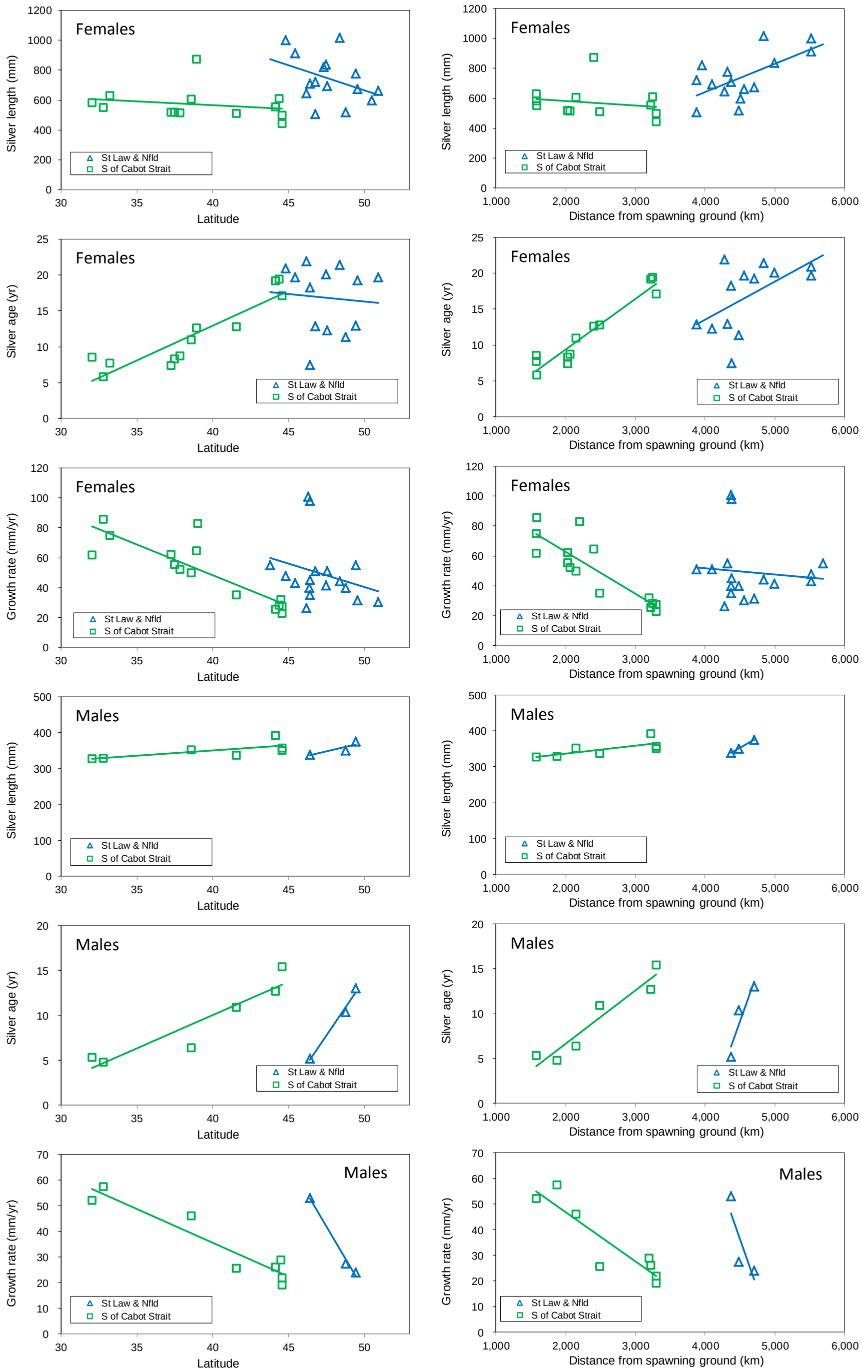

Figure 7.2.4. Relationships between American Eel silver length, silver age, and growth rate versus latitude (left column) and distance from the spawning ground (right panel) for female (rows 1 to 3) and males (rows 4 to 6) for two regions of eastern North America.
St Law & Nfld region includes the St. Lawrence Basin, the Northern Gulf of St. Lawrence and Newfoundland, and the Southern Gulf of St. Lawrence RPA zones. The S of Cabot Strait region includes Scotia-Fundy, Atlantic Seaboard-North, Atlantic Seaboard-Central, and Atlantic Seaboard-South RPA zones.

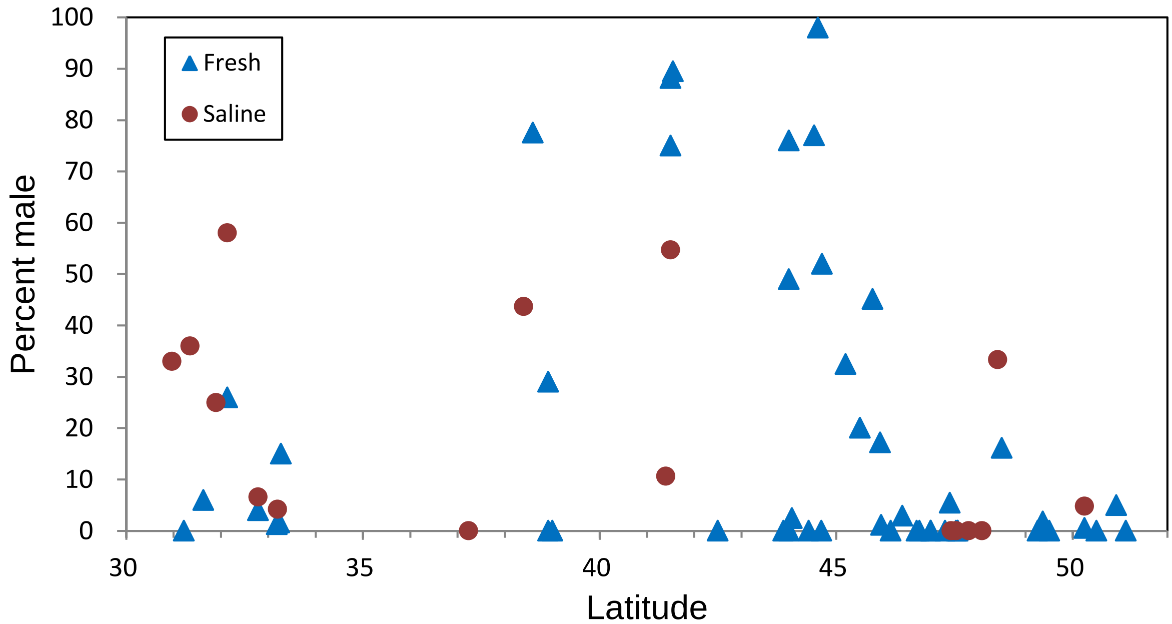

Figure 7.3.1. Percent of sexed American eels from fresh and saline water that are male relative to latitude of sampling site.

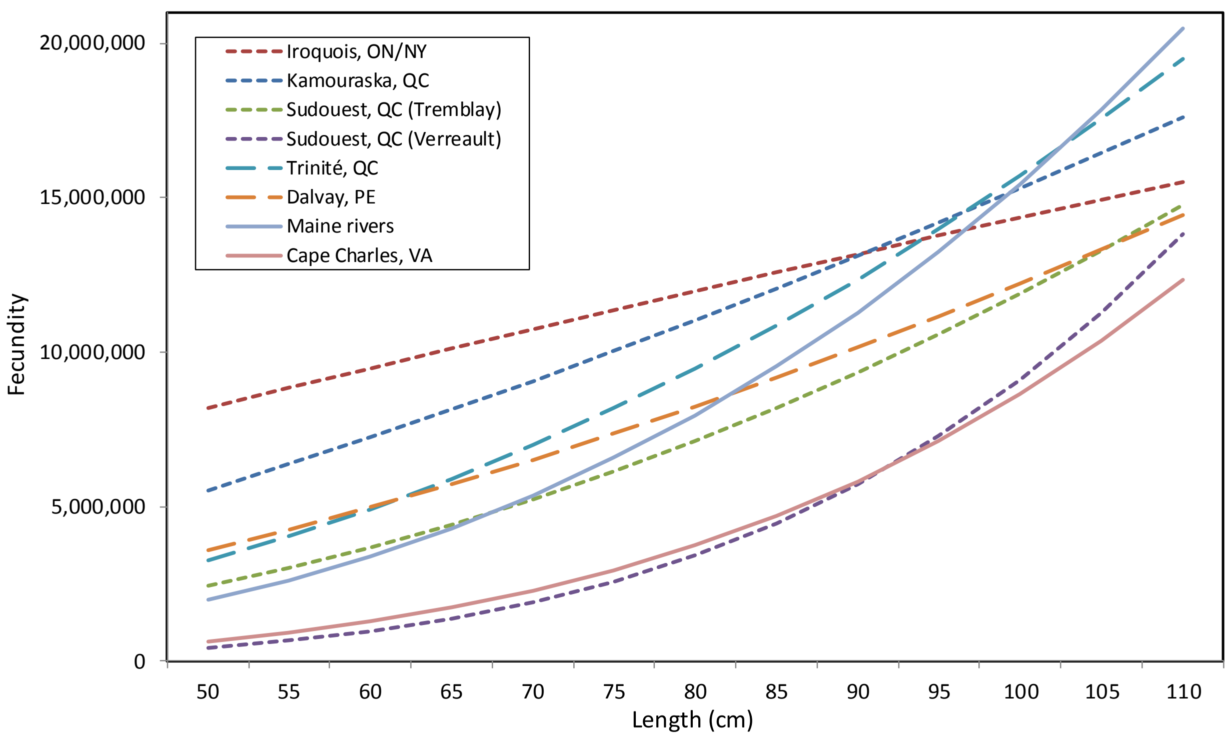

Figure 7.3.2. Fecundity of American Eel as predicted from length by sampling location using equations in Table 7.2.6.

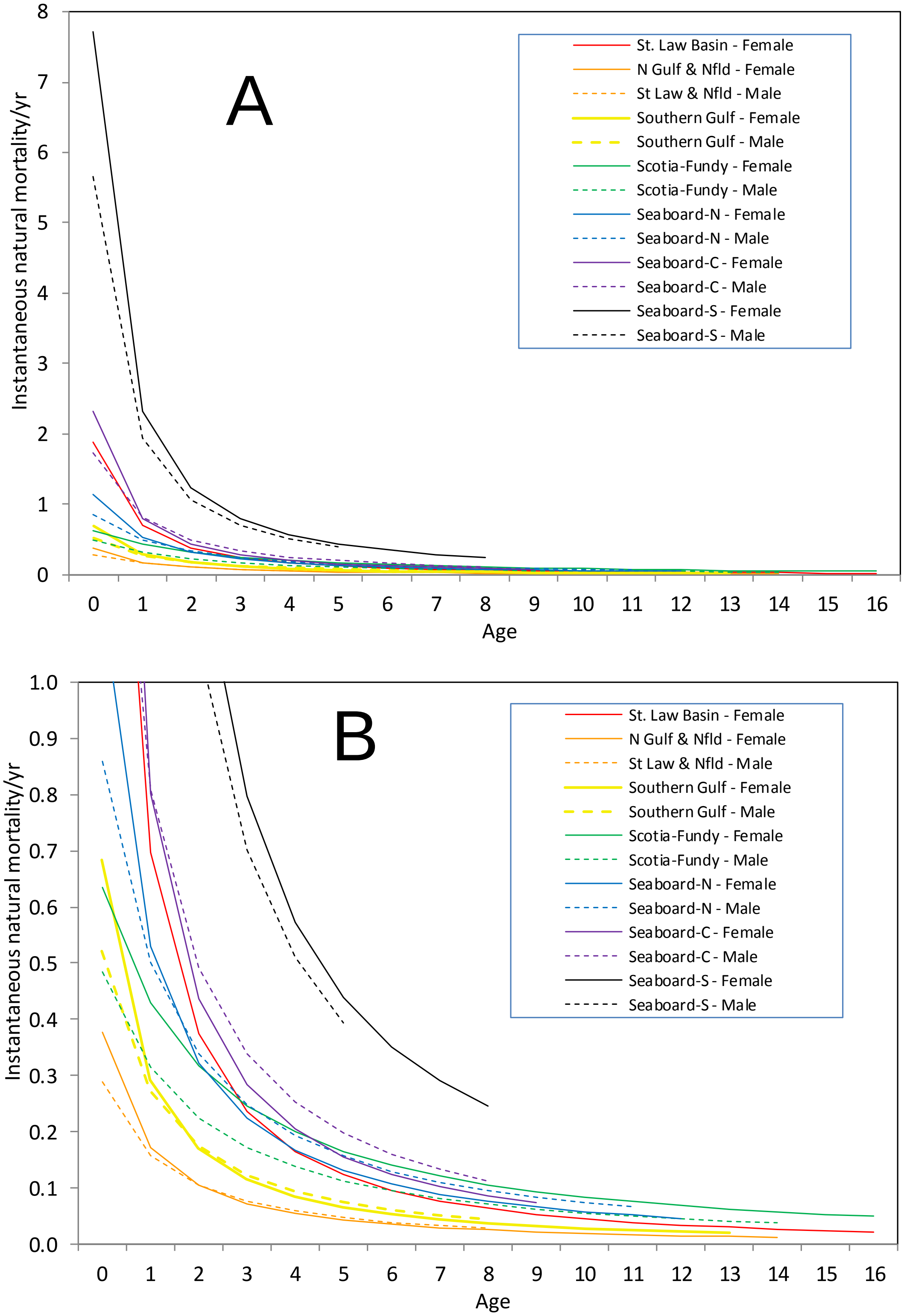

Figure 7.4.1. Natural mortality rate estimates as predicted by the equations in Bevacqua et al. (2011), by age, RPA zone, and sex. Upper panel (A) shows the full range of natural mortality predictions. Lower panel (B) shows predicted values within the range <1.