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2010 status of American eel (*Anguilla rostrata*) in Maritimes Region

Situation de l'anguille d'Amérique (*Anguilla rostrata*) dans la région des Maritimes en 2010

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ABSTRACT

American eel (*Anguilla rostrata*) occur in numerous estuaries, streams, rivers, and lakes within the Maritimes Region. The fisheries for large eel and elvers in Maritimes Region were last assessed in 1996. The present assessment was conducted 1) in support of the national re-assessment of the status of American eel by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and 2) to provide science advice on progress towards the 2006 (Draft) National Eel Management Plan objective of reducing human-induced mortality by 50 percent. Fisheries dependent data sources include commercial logbook returns from both the large eel and elver fisheries. Fisheries independent data sources include elver counts at an index site located on the East River-Chester, southwest Nova Scotia, bycatch of eels in juvenile salmonids electrofishing surveys of selected Maritimes Region Atlantic salmon rivers and May-June captures of eels in Rotary Screw Traps installed in two New Brunswick rivers. The increase in commercial landings of large eel between 1985 (80 mt) and 1996 (230 mt), and the decline to ≤ 100 mt in 2007, reflect change in number of participants in the fishery. Accurate estimates of fishing effort for large eels are not available for this time period. Elver landings exhibit no trend with time. Catch rates for eels in the 2009 juvenile salmonids electrofishing surveys on the Big Salmon and Nashwaak rivers, New Brunswick were not appreciably different from either the mean catch for the time series or the previous five year mean catch. Catch rates for eels in 2009 electrofishing surveys of St. Mary's and LaHave river, Nova Scotia were below the mean catch for the time series but near the mean of the previous five years. Elver abundance on the East River-Chester has varied interannually without trend since the inception of the index in 1996. The exotic swim bladder nematode, *Anguillicoloides crassus,* which may potentially reduce the likelihood that adults can successfully complete the spawning migration to the Sargasso Sea, was detected in eels collected from 8 of the 100 discrete river drainages surveyed during 2008 and 2009. Prevalence of infection (when detected) was estimated to be ≤ 27.3 percent and intensity of infection was ≤ 2.6 nematodes per eel. Compilation of all reported records of occurrence of the parasite is generally low and patchy but extending over a large range that includes the Bay of Fundy, Atlantic coastal Nova Scotia, and Cape Breton Island.

RÉSUMÉ

On trouve l'anguille d'Amérique (*Anguilla rostrata*) dans de nombreux estuaires, cours d'eaux, rivières et lacs de la région des Maritimes. La dernière évaluation de la pêche aux anguilles de grande taille et aux civelles dans la région des Maritimes datait de 1996. La présente évaluation a été menée 1) en appui de la réévaluation nationale de la situation de l'anguille d'Amérique menée par le Comité sur la situation des espèces en péril au Canada (COSEPAC) et 2) pour fournir un avis scientifique sur les progrès vers l'atteinte de l'objectif de réduction de 50 % de la mortalité causée par les humains fixé dans l'ébauche du Plan de gestion national de l'anguille de 2006. Les sources de données dépendantes des pêches comprennent les journaux de bord des pêches commerciales à la grande anguille et à la civelle. Les sources de données indépendantes des pêches comprennent les comptages de civelles effectués à un site témoin situé sur l'East River-Chester, au sud-est de la Nouvelle-Écosse, les prises accessoires d'anguilles lors des relevés par pêche à l'électricité de salmonidés juvéniles dans des rivières à saumons de l'Atlantique sélectionnées dans la région des Maritimes et les prises d'anguilles en mai et juin dans des pièges rotatifs placés dans deux rivières du Nouveau-Brunswick. L'augmentation des débarquements commerciaux de grandes anguilles entre 1985 (80 tm) et 1996 (230 tm) et leur diminution jusqu'à une valeur ≤ 100 tm en 2007, reflètent le changement du nombre de participants à la pêche. Il n'existe pas d'estimations exactes de l'effort de pêche à la grande anguille pour cette période. Les débarquements de civelles n'indiquent aucune tendance dans le temps. Les taux de prises d'anguilles dans les relevés par pêche à l'électricité de salmonidés juvéniles effectués en 2009 dans les rivières Big Salmon et Nashwaak, au Nouveau-Brunswick, n'étaient pas vraiment différents du taux de prises moyen pour la série chronologique ou du taux de prises moyen des cinq années précédentes. Les taux de prises d'anguilles dans les relevés par pêche à l'électricité effectués en 2009 dans les rivières St. Mary's et LaHave, en Nouvelle-Écosse, étaient inférieurs au taux de prises moyen pour la série chronologique, mais proches de la moyenne du taux de prises moyen des cinq années précédentes. L'abondance de civelles dans l'East River-Chester a varié d'une année à l'autre sans qu'une tendance se dégage depuis la création de l'indice en 1996. Le nématode exotique de la vessie gazeuse, *Anguillicoloides crassus,* qui peut potentiellement réduire la probabilité que les adultes puissent effectuer avec succès leur migration de frai vers la mer des Sargasses, a été décelé chez les anguilles capturées dans 8 des 100 bassins versants dans lesquels des relevés ont été effectués en 2008 et 2009. La prévalence de l'infection (une fois celle-ci détectée) a été estimée être ≤ 27,3 % et l'intensité de l'infection était ≤ 2,6 nématodes par anguille. La compilation de tous les enregistrements d'occurrences du parasite consignés est généralement faible et incomplète, mais elle s'étend sur un vaste territoire qui comprend la baie de Fundy, la côte de l'Atlantique de la Nouvelle-Écosse et l'île du Cap-Breton.

INTRODUCTION

American eel (*Anguilla rostrata*) occur in numerous estuaries, streams, rivers, and lakes within the Maritimes Region, the Department of Fisheries and Oceans (DFO) Administrative Region that comprises all waters draining to the Bay of Fundy, Atlantic coastal mainland Nova Scotia, and eastern Cape Breton, including the Bras D'Or Lakes drainages (Figure 1). Eel are fished for commercial, recreational and aboriginal purposes as both 'large' –resident yellow (growing) and silver (migrating and maturing) - and 'small' -elvers recruiting from the ocean to rivers and streams- eels (Jessop 1996a, 1996b). All fisheries for eel in Maritimes Region are pre-spawning fisheries, eel are catadromous and spawn at sea beyond Canadian territorial limits (see Biology below). The fisheries for large eel and elvers in Maritimes Region were last assessed by Jessop (1996b) and Jessop (1995, 1996a), respectively. Several indices based upon these fisheries and others derived from fisheries-independent monitoring activities were reported in COSEWIC (2006) and Cairns et al. (2008).

This update on the status of American eel in Maritimes Region was conducted 1) in support of the national re-assessment of the status of American eel by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and 2) to provide science advise on progress towards the 2006 (Draft) National Eel Management Plan objective of reducing human-induced mortality by 50 percent. The assessment is accordingly organized into two parts with the first providing information relevant to the status to both American eel and their fisheries and the second representing a Maritimes Region summary of the information that is relevant to COSEWIC's determination of risk for the species.

This document also provides a summary of reported captures of American eel at sea 1) during research surveys conducted by the Maritimes Region, Science Branch, and 2) as recorded in the fisheries observer database maintained by Science Branch. These data have relevance as an aid to description of the known distribution of American eel and their supporting habitat.

Previous assessment of the large eel fishery (Jessop 1996b) was based upon interpretations of the number of licences (commercial and recreational) issued and landings reported (commercial fishery) by Fishery Statistical District (FSD; Figure 1). Time series of biological data to support assessments of specific river stocks of large eel is lacking within Maritimes Region. Any information gathered by DFO concerning size, age, sex and maturity occurred during the 1980s and early 1990s and has already been reported in COSEWIC (2006) and Cairns et al. (2008).

AMERICAN EEL BIOLOGY

The American eel is widely distributed within the western North Atlantic Ocean with records of occurrence extending from southwestern Greenland, along the coast of North America from southern Labrador to the Gulf of Mexico, Panama, and the West Indies (Scott and Scott 1988). Mature eels spawn in the area of the Sargasso Sea during late winter and spring (McCleave et al. 1987). Larval eels (leptocephali) drift and swim in the upper 300 m of ocean while currents, particularly the Gulf Stream, distribute them along the Atlantic coast of North America. Upon metamorphosis, glass eels move coastward. Glass eels begin to ascend streams of the Maritimes Provinces about late April or early May, becoming elvers and increasingly pigmented as the run progresses upstream. Young eels continue, for perhaps years, to distribute themselves throughout the available habitats. After a variable period of time, ranging perhaps from five to twenty or more years in Atlantic Canada, juvenile (yellow) eels begin sexual maturation, become silver eels, and migrate to sea during late summer and autumn. Maturation is completed at sea. Spawning occurs in the Sargasso Sea. Adults die after spawning.

American eels of various life stages occupy a wide variety of habitats - the ocean, estuaries, streams, rivers, and lakes. Their extensive geographic range, ability to occupy a wide variety of habitats, and a panmictic (intermixing of eels from all geographic areas) breeding population (Avise et al. 1986) evidences and contributes to their adaptive plasticity. Growth rates of yellow eels are variable, depending upon the latitude (slower growth in northern areas) and nature (productivity) of the habitat. Within a given habitat, growth rates of individual eels vary greatly. Females are more abundant, older, and larger at sexual maturity than males in northern areas (Helfman et al. 1984; Jessop 1987). The proportion of female eel is positively correlated with lacustrine habitat area within Maritimes Region rivers (Jessop 1987).

Rational catch quotas for the stock of eels in any river are difficult to set in light of panmixia and uncertainty in knowledge of important life history parameters. Uncertainties include the dynamics of reproduction (e.g., required sex ratio), the causes and rates of larval/elver marine mortality, the factors affecting offshore and inshore coastal distribution and movement. Investigations into other aspects of eel biology indicate that variability among habitats and biogeographic regions can be anticipated including elver recruitment to rivers, yellow eel mortality rates, size- and age-at maturity, fecundity and silver eel escapement, and the contributions of geographic regions to the total spawning stock (COSEWIC 2006).

FISHERY MANAGEMENT

At least four pieces of federal legislation, in addition to the *Species at Risk Act*, have direct or indirect application to American eel, namely, the *Fisheries Act*, the *Fishery (General) Regulations* (F(G)R), the *Maritime Provinces Fishery Regulations* (MPFR), and the *Aboriginal Communal Fishing Licences Regulations* (ACFLR). The *Fisheries Act* is directed at protecting fish habitat while its supporting regulations provide the tools to protect conserve and manage fisheries. Some of the most important regulatory provisions as applied to American eel are:

- sections 36-38 of the MPFR, which establish gear restrictions, close times (fishing seasons), length restrictions and quotas for recreational fishing;
- section 6 of the F(G)R, which provides for the issue of variation orders to change or close any fishing season or size limit set out in regulations, and
- section 22 of the F(G)R's which provides for the issue of licence conditions.

LARGE EELS (YELLOW AND SILVER)

There are no management targets or catch quotas for 'large' American eel fisheries (commercial, recreational, or aboriginal) in the Maritimes Region. However, both regulations and licensing policies have changed with time in response to conservation concerns. Those presently in effect for large eel fisheries are summarized below.

Regulations require:

- a licence to fish commercially or recreationally except for angling or for spearing in tidal waters. Authorized fishing methods include angling, pots, traps (fyke nets and weirs), dip nets and spears. Longlines and setlines are permitted in New Brunswick. There is a closed season for eel traps in inland waters from November 1 to August 14 and for spears all year;
- that a distance of 200 m must be maintained from any fishing gear previously set;
- that fishing gear cannot be left unattended for more than 72 hours;

- that fishing gear must be marked with the owners name and, where a vessel is used, with the vessel registration;
- that from sunrise to sunset in inland waters of Nova Scotia, eel traps must have a 90 cm opening to allow fish to escape and fyke nets must be rendered incapable of catching fish;
- that eel less than 35 cm Total Length (TL) be returned live to the wild:
    - the minimum retention size was 20 cm TL prior to 2005, except for southwestern New Brunswick (including the Saint John River) where the minimum retention size had been 30cm TL since 1998.
- eels may not be retained as a bycatch in any fishery (section 33 of the F(G)R's).

Changes in licencing policy over time for the large eel fishery are as follows:

<u>May, 1993</u>

- commercial eel licences were frozen at current levels: new recreational eel licences were restricted to pots (maximum 4). Previous to the licence freeze, the eel fishery was open-access except for the Saint John River, New Brunswick where entry was limited after 1978;
- fishers must register in the Region; there is no residency requirement;
- licences are issued to persons, not companies;
- the re-issuance of licences is only permitted to fishers registered in the preceding year and who are actively engaged in fishing in the preceding year;
- fishers are not obligated to participate in the fishery; and
- licence holders must personally fish.

<u>February, 1997</u>

- recreational eel licences were frozen at current levels.

<u>May, 1998</u>

- minimum length increased from 20 cm to 30cm in southwest New Brunswick, including the Saint John River.

<u>May, 2005</u>

- increase in the minimum size limit for eels to 35cm in Scotia-Fundy portion of Nova Scotia and New Brunswick; and
- escape mechanisms with 1 inch by ½ inch openings are mandatory for all gear under licence for fishing large eels.

SMALL EELS (ELVERS)

Elvers are defined in regulations as eels less than 10 cm (4") in total length.

The elver fishery developed only relatively recently; experimental fishing began in 1989.

- In 1996, a total of nine experimental licences were issued.
- No new licences have been issued since 1998.
- The elver fishery was developed as an Enterprise Allocation fishery: licence holders have assigned fishing areas and (up to 2005) quotas of 1,000 kg per annum, with the exception of one licence where the assigned quota is only 300 kg.
- A formal Elver Advisory Committee was established in 1997.

- A formal Integrated Fishery Management Plan for elvers was implemented in 1998. One of the provisions of the plan allowed licence holders to apply for a 30% annual quota increase.
- The number of elver licences has remained frozen at nine (four regular commercial licences and five experimental licences of which five are for aquaculture purposes only with no direct sale) for 2005.
- The option for licence holders to apply for a 30% quota increase was removed (to be reviewed annually). Quotas were reduced by 10% for all licence holders. However, the 10% of reduced quota can be fished if the elvers are destined for conservation stocking in Canadian waters.

DATA SOURCES

FISHERIES DEPENDENT

No logbooks were distributed to commercial eel licence holders in 2008; therefore, no information on harvests are available for that year (records maintained by commercial elver harvesters have been requested but are not yet available except for the fishery on East River-Chester; see Fisheries Independent Indices below). New requirements came into effect in 2009 for the submission of all large eel and elvers fishery logbooks to Dockside Monitoring Companies for data entry. These records are not available at the time of writing.

Commercial Large Eel Fishery

Annual landings from the Maritimes Region large eel fishery are reported by FSD (Figure 1) and are available for the years 1950-2007. Prior to 1990, catch statistics for American eels were collected by Fishery Officers via sales slips (records of sales by individual fishers to commercial buyers) and by Supplementary As and Bs (Fishery Officer estimates of sales and personal uses, e.g., bait, not recorded by sales slips). In 1990, a mandatory logbook system was introduced throughout Maritimes Region as a means to improve catch statistics and to acquire effort data. Fishers record landings monthly and are asked to provide information concerning method(s) of capture and fishing locations. In combination with records of licence numbers and gear per licence, the logbook data is intended to provide a means to assess the extent to which observable trends in landings reflect variable effort and/or reporting, both of which were suggested by Jessop (1996b) as confounding factors in the interpretation of the reported landings.

Recreational Large Eel Fishery

Recreational eel fishers are not required to report catches. No data are available.

Commercial Small Eel (Elver) Fishery

Detailed reporting of location, effort (hours fished and number of gear) and catch (kg) by gear-type for all fishing activity directed daily at elvers has been a condition of licence since the inception of the fishery. However, reporting of the data is currently restricted to aggregate summaries of catch and effort. Because each fisher is assigned an exclusive area within Maritimes Region to fish reporting of fishing activities below the level of 'Region' is not possible owing to prohibitions under the *Privacy Act*. Annual catches are, therefore, reported for all of Maritimes Region to 2007. Catch per unit effort is considered in the context of total number of visits to rivers, and total hours fished.

FISHERIES INDEPENDENT

Large Eel

Electrofishing Surveys on Index Rivers

Electrofishing surveys have been conducted since 1968 on several Maritimes Region (index) rivers to assess the status of juvenile Atlantic salmon (*Salmo salar*). Annual assessments were relatively infrequent until 1984 but thereafter surveys occurred most years on at least some rivers. Many electrofishing sites are relatively fixed in location year over year and are generally representative of salmonids rearing habitat throughout the rivers. While sites were re-sampled in subsequent years, not all sites are visited every year. Bycatch of American eel has been recorded for many of the sites visited, although not always on a consistent basis. Non-reported catches are difficult to distinguish from null catches. Reporting of length-at-capture has been inconsistent with time.

The principle methods used throughout the years to estimate juvenile salmonids abundance in Maritimes Region rivers have been multi-pass removals from barriered sites (sample area contained within barrier nets), and a mark-recapture method on open sites (no barriers). Some sites for which abundance information has been acquired have been sampled over the years using both census methods. These are reported in Cairns et al. (2008) up to and including the year 2003. There is insufficient information to calibrate eel abundance estimates acquired at open sites to those acquired at closed sites, on all rivers. As well, eel bycatch was not always recorded on the recapture sweep at open sites. Therefore, the numbers reported here represent catch rates, standardized to 100 m^2 areas, as estimated from the first sweep of the census method in present use on individual rivers. The rivers and associated time series of data are:

River	Method	Years
Nashwaak (NB)	Open	1991-2009
Big Salmon (NB)	Barrier	1996-1997, 1999-2009
LaHave (NS)	Open	1995, 1997, 2000-2009
St. Mary's (NS)	Open	1985-1986, 1995-2009

Barriered and open sites that were not visited frequently during the years of surveys have been excluded from calculation of mean annual catch for individual rivers.

Rotary Screw Traps

A rotary screw trap (RST), also known as an auger trap, is a passive gear that takes advantage of the energy in the flowing water to assist in the capture and retention of downstream migrating fish. The operating mechanism of a RST consists of a cylinder/cone (drum) arrangement with an Archimedes screw in its central axis. The axis is oriented parallel to the water surface and into the direction of flow. Pontoons are attached to the sides of the RST's to maintain the gear at the surface of the water. Position in the stream is maintained either with instream anchors or overhead shorefast cables (see Chaput and Jones 2004).

Rotary screw traps have been used to monitor annual Atlantic salmon smolt migrations on the Nashwaak and Big Salmon rivers, New Brunswick (Figure 2) since 1998 and 2001, respectively. The traps were generally monitored once per day, usually in the morning (Chaput and Jones 2004). American eel captured during the operation of the traps were identified to species,

counted (in some cases as numbers smaller than 15 cm, or from 15 cm – 40 cm, or greater than 40 cm in TL) and released (Chaput and Jones 2004). Information on the rate of recapture for American eel in RST's is not presently available for either river.

Small Eel

Elver Counts on Index Rivers

Elver run sizes to Nova Scotia rivers have been estimated at two locations, East River-Sheet Harbour during the years 1989-1999, and East River-Chester during the years 1996-2002. These two time series were reported in COSEWIC (2006) and Cairns et al. (2008); only the East River-Chester counts, which were re-instated for the years 2008-2010, are considered here. Briefly, Irish style elver traps (O'Leary 1971) were operated at the mouth of the river, downstream of a physical barrier to upstream passage, and at or just upstream of the head of tide. The traps were operated from early May to mid-July in most years and were assumed to intercept the entire run of elvers that escaped the commercial fishery, which occurred several tens of meters downstream in most years. Elvers may continue to move through the sites into late September but at low numbers after late August (Jessop 2000a, 2000b, 2000c).

Elver catches were counted minimally each morning for each trap, with counts of individual elvers when numbers were low (less than about 150 elvers) or by volumetric estimation (graduated cylinders) when catches were high. The graduated cylinder was calibrated at least twice per season to account for the known decline in elver size during the run (Haro and Krueger 1988; Jessop 1998). Procedures for estimating the daily and seasonal total elver catch and 95% confidence intervals (95% CI) for the seasonal total catch were as described in Jessop (2000a, 2002b, 2002c). Elvers not sampled for biological data were returned alive to the wild above the barrier.

Total run size is calculated as the sum of the commercial catch, which is converted from kgs to number of elvers, plus the estimated escapement.

AMERICAN EEL CAPTURES AT SEA

Large Eel

The Maritimes Virtual Data Centre maintains a database of DFO research vessel surveys conducted by Maritimes Region Science Branch, and a database of fisheries observer records concerning the composition of catches in commercial fisheries for groundfish, pelagic fishes, and invertebrates. Each database was queried for all recorded catches of American eel for all years and for all surveys. The fisheries observer database was specifically queried for information on the fishery, gear type, year, date, and quantity of eel reported as captured. No attempt was made to assess the frequency of incidental captures of American eel in the observed fisheries. The information reported in this document, therefore, represents only the records of reported catches.

Small Eel

Annual and seasonal systematic surveys of plankton within the Gulf of Maine-Scotian Shelf area were an important component of several DFO Science projects, namely the Bay of Fundy Herring Project, the Scotian Shelf Ichthyoplankton Program, and the Fisheries Ecology Program, from the late 1960s until approximately the mid-1980s. Ichthyoplankton were routinely sorted, identified, and counted to species. The sorting records of these three projects were

searched for records of young eel catches, as leptocephalii larvae, or as glass eel juveniles. As was the case above for large eel, no attempt was made to assess the frequency of small eel captures.

RESULTS

FISHERIES DEPENDENT

Commercial Large Eel Fishery

Reported annual catches of American eels have varied between 11 mt and 230 mt (Tables 1, 2; Figure 3). There has been a tendency for landings to be reported from a greater number of fisheries statistical districts since 1990 in both New Brunswick and Nova Scotia (Table 1). This could be a consequence of improved resolution in the reporting of catch following implementation of compulsory logbook reporting or could reflect a geographic expansion of fishing effort.

Beginning in 1985, the number of licences to fish eel increased more than two-fold, and the quantity of fishing gear under licence increased more than five-fold (Table 2). The greatest increases occurred in the number of licenced pots and licenced traps (Table 2). Reported landings generally tracked total gear under licence from 1984 and 1999, but, thereafter, exhibited little relationship to the potential quantity of gear that could be fished annually (Figure 4a). However, not all licenced eel fishers returned their logbooks or reported having fished during the year of record (Table 2). Gear licenced to fishers that reported landings tracked reported landings since 1993 (Figure 4b). Gear licenced to fishers reporting landings explained approximately 90% of the interannual variability in reported landings between 1993 and 2004 (Figure 4c). The proportion of licenced gear that was deployed by licence holders reporting catches is not known.

Commercial Small Eel (Elver) Fishery

The total weight (kg) of elvers harvested varied between 478 kg (1999) and 2,158 kg (2005) with no discernible trend with time (Figure 5 upper panel). Total catch exhibited a positive correlation with effort expressed as both Total Number of River visits (df =11, r^2 =0.59, p <0.01; Figure 5 middle panel) or Total Hours Fished (df =11, r^2 =0.45, p =0.02; Figure 5 lower panel). Reduced catches during 1999 and 2000 corresponded to years of low prices for elvers (Figure 6 upper panel). However, there is no significant correlation between total annual catch and elver price (Figure 6 middle panel). Total effort was weakly correlated with elver price catch (df =11, r^2 =0.24, p =0.1; Figure 6 lower panel).

FISHERIES INDEPENDENT

Large Eel

Electrofishing Surveys: New Brunswick Rivers

Since 1996, the mean annual catch of American eels for the Big Salmon River has ranged from 0.34±0.27 eel per 100 m^2 (1996) to a high of 4.38±1.60 eels per 100 m^2 (1997). Mean catch in 2009 (1.97 eels per 100 m^2) did not differ from either the long-term mean (1.88 eels per 100 m^2) or the mean of the previous five years (1.47 eels per 100 m^2) (Table 3; Figure 7).

Since 1992, the mean annual catch of American eels for the Nashwaak River has ranged from a low of 0.39±0.19 eel per 100 m^2 (1994) to a high of 2.13±0.35 eels per 100 m^2 (2004). Mean catch in 2009 (0.84 eels per 100 m^2) was below both the long-term mean (1.27 eels per 100 m^2) and the mean of the previous five years (1.45 eels per 100 m^2) (Table 3; Figure 7).

Electrofishing Surveys: Nova Scotia Rivers

Since 1985, the mean annual catch of American eels for the St. Mary's River has ranged from a low of 0.47±0.12 eel per 100 m^2 (2004) to a high of 8.45±1.37 eels per 100 m^2 (1997). Mean catch in 2009 (1.03 eels per 100 m^2) was below the long-term mean (3.42 eels per 100 m^2) but the same as the mean of the previous five years (1.14 eels per 100 m^2) (Table 4; Figure 8).

Since 1995, the mean annual catch of American eels for the LaHave River has ranged from a low of 0.18±0.06 eel per 100 m^2 (2008) to a high of 3.64 ± 0.36 eels per 100 m^2 (2000). Mean catch in 2009 (0.44 eels per 100 m^2) was below the long-term mean (1.08 eels per 100 m^2) but the same as the mean of the previous five years (0.44 eels per 100 m^2) (Table 4; Figure 8).

Rotary Screw Traps

Rotary screw traps have been operated on the Big Salmon and Nashwaak rivers, New Brunswick, during the years 2002-2009 and 1998-2010, respectively (Figure 9). The average daily catch on both the Big Salmon River (1.0 eel per day) and Nashwaak River (1.6 eels per day) during the most recent year of data gathering were below both the mean daily catch of the time series (Big Salmon River =7.9 eels per day; Nashwaak River =2.4 eels per day) and the mean daily catch from the previous five years (Big Salmon River =5.8 eels per day; Nashwaak River =2.0 eels per day) (Figure 9).

Small Eel

Estimates of total run size to the East River-Chester have varied from approximately 450,000 elvers in 1999 to a high of approximately 1.9 million elvers in 2008 (Figure 10). Since 1996, elver run size has varied interannually without trend (Figure 10). Elver run sizes since 2008 were within the range estimated for 1996-2002 (Mean 981,065 ±520,169 standard deviation) or higher (1.9 million in 2008). Average run size (± standard deviation) for the ten years of monitoring was 1,054,606 ±538,398 elvers.

Fishing activity was sensitive to elver price. Both the number of daily visits and total effort (Hours Fished x Nets) exhibited an increase with increasing price per kg (Figure 11), although only the relationship between total effort and mid-price was statistically significant (degrees of freedom =13, r^2 =0.31, p =0.04).

AMERICAN EEL CAPTURES AT SEA

Large Eel

Large eel captures in DFO groundfish research surveys were rare (five of thousands of sets since 1978) and in low numbers (≤ 3 eel per tow) when captured (Figure 12). All recorded captures were during autumn. All of the captures occurred at sites with bottom depths exceeding 100 m.

There were 118 recorded occurrences of 'American eel' appearing as bycatch in commercial fisheries monitored by fisheries observers, a number vastly exceeded by the number of monitored catches (likely thousands). These are referred to from here on as *Anguilla* sp. because identification to genus (i.e., *A. rostrata* versus *A. Anguilla*) would likely not be possible from external examination. Many of these reported occurrences occurred at depths exceeding 100 m (Figure 13), but captures at lesser depths over submarine banks were also recorded.

Anguilla sp. have been reported as bycatch in several commercial groundfish fisheries: monkfish (Figure 14), cod/haddock/pollock (Figure 15), flatfish (Figure 16), halibut (Figure 17), redfish (Figure 18), silver hake (Figure 19), and in three invertebrate fisheries: scallop (Figure 20), shrimp (Figure 21), and lobsters (Table 6). The complete list of fisheries and surveys queried for records of *Anguilla* sp. captures at sea are available in Table 7.

The timing (month) of many of the reported occurrences of bycatch (Table 6) are not consistent with the American eel spawning paradigm in which maturing eel migrate to the Sargasso Sea to spawn during late winter – spring followed by death of post-spawners. Seventy one percent of the bycatch occurrences were recorded during the months of May, June, and July (Table 6).

Small Eel

Both leptocephali and elvers have been captured during DFO ichthyoplankton surveys conducted within the Bay of Fundy Herring Project (Figures 22 and 23), the Scotian Shelf Ichthyoplankton Program (Figure 24), and the Fisheries Ecology Program (Figure 25). The composite catches indicate that the life-history stages are broadly distributed along and across the coast shelves and embayments (e.g., Bay of Fundy).

DISCUSSION

FISHERIES DEPENDENT

Commercial Large Eel Fishery

Commercial catch from the large eel fishery (Figure 3) represents the lengthiest time series of data potentially relevant to eel abundance in Maritimes Region. However, the increase in landings that occurred between 1985 (80 mt) and 1996 (230 mt), and the decline to ≤ 100 mt in the most recent years of the time series, appear to reflect change in the number of participants in the fishery (Figure 4) more so than change in eel abundance with time. Estimates of potential effort (number of gear units) for individual fishers reporting catches are not considered to be sufficiently accurate to allow for use of catch per effort as an index of abundance.

Commercial Small Eel (Elver) Fishery

The lack of trend in elver landings with time (Figure 5) appears to reflect, in part, variation in incentive to fish (economic viability of fishing (cost) for a landed price (benefit) (Figure 6), in part availability of supply, as indicated by the positive correlation between catch and effort (Figure 5), and probably variability among licence holders in success in fishing the authorized quota. Incorporation of all three considerations into advice on overall status of the fishery is difficult because of constraints of the *Privacy Act* on the reporting of the annual fishing success of individual licence holders.

FISHERIES INDEPENDENT

Large Eel

Electrofishing Surveys on Index Rivers (New Brunswick)

Eel catches in 2009 on both the Big Salmon River and Nashwaak River (Figure 6) did not differ greatly from either the long-term mean or the previous five year mean abundance, although annual abundance for the five years ending in 2009 were all above the historical lows of the times series (1996 on Big Salmon River; 1994 on Nashwaak River).

Electrofishing Surveys on Index Rivers (Nova Scotia)

Eel abundance in 2009 on both the St. Mary's River and LaHave River were below the long-term mean but near the mean of the previous five years (Figure 7), which included the historic lows of both time series (2004 on St. Mary's River 2007 on LaHave River).

The combined electrofishing data for New Brunswick and Nova Scotia rivers may indicate differences in the general status of river resident American eel between Bay of Fundy and Atlantic coast Nova Scotia drainages.

Rotary Screw Traps

Mean daily catch during the most recent year of data gathering (Big Salmon River: 2009, Nashwaak River: 2010) are lower than mean daily catches of the time series and the mean daily catch for the previous five years. The relation between the number of downstream migrating eels during May-June, which is what the RST catches are thought to represent, and the standing stock of eels in the rivers is not understood. The relevance of RST catches to eel status is, therefore, not known,

Small Eel

Elver status on the East River-Chester from 2008-2010 is unchanged from the 1996-2002 time period, run strength varies inter-annually without trend (Figure 10). The time series is too short to evaluate elver status relative to the mid-1980s which represents the target abundance levels of the National Eel Management Plan.

AMERICAN EEL CAPTURES AT SEA

Large Eel

Captures of American eels during DFO research groundfish surveys are rare and have occurred during autumn surveys at depths greater than 100 m, which represent the deeper strata of the surveys. Observations on migration of silver American eel across continental shelves are lacking. However, the timing and locations of these captures are generally consistent with observations on European eel that outmigrating silver eel occur at progressively greater depths with distance from shore (Tesch 1989).

The timing of the majority of reported bycatches of *Anguillia* sp by fisheries observers is not consistent with the known timing of the spawning migrations for silver American eel (September-November; Jessop 1987; Bradford et al. 2009) from Atlantic Canadian waters. None of the specimens captured were returned for positive genus/species identification; therefore, it is not known if these records represent mis-identifications.

Small Eel

Eel leptocephali and elvers have been captured over a broad range of depths and distances from shore during DFO ichthyoplankton surveys of the Bay of Fundy and Scotia Shelf. The data suggest that the shelf areas may represent migration corridors for recruiting eel.

COSEWIC CRITERIA

DECLINING TOTAL POPULATION

Fisheries Dependent

- No information more recent than 2007 is presently available for either the large eel or small (elver) eel commercial fisheries.
- Commercial large eel catch data has limited use as an indicator of status because of uncertainty in the level of effort associated with annual landings.
- Use of commercial elver catch data as an indicator of eel status is complicated by the influences of market and limitations on the reporting of variability among licence holders in fishing success.

Fisheries Independent

- Electrofishing in Bay of Fundy New Brunswick rivers since the mid-1990s indicates no substantive change in eel abundance with time.
- Electrofishing in Atlantic coast Nova Scotia rivers indicates current eel abundances are below levels estimated during the late 1990s.
- The elver abundance index for East River-Chester, Nova Scotia has fluctuated interannually without trend since 1996.

AREA OF OCCURRENCE

- Reported landings to 2007 of large eel by Fishery Statistical Districts and elvers by area indicate that the American eel remains widespread in Maritimes Regions rivers and coastal embayments.

THREATS

Presence of the exotic swim bladder nematode *Anguillicoloides crassus* was first detected among Canadian populations of the American eel in 2007 (Aieta and Oliveira 2009; Rockwell et al. 2009). There are concerns that eels with a high *A. crassus* load may be less successful in completing the spawning migration thereby reducing overall eel productivity. Recent 2008-2009 surveys of freshwater resident eels in New Brunswick and Nova Scotia detected *A. crassus* in eight of the 100 discrete river drainages included in the survey (Table 7; see Campbell et al. 2012). Prevalence of infection was ≤ 27.3 percent and intensity of infection was ≤ 2.6 nematodes per eel. Compilation of all reported records of occurrence shows that overall distribution of the parasite – as measured by number of drainages where present – is low and patchy but extending over a large range that includes the Bay of Fundy, Atlantic coastal Nova Scotia, and Cape Breton Island.

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Table 1. Reported landings (mt) of large (yellow and silver) American eels in Scotia-Fundy, by statistical district. Data for the 1950-1993 are from Jessop 1996.

	Cape Breton							Eastern mainland Nova Scotia								Southwest Nova Scotia										
Year	1	3[a]	4	6	7	8	9	14	15	16	17	18	19	20	21	22	23	25	26	27	28	30	31	32	33	34
1950	-	-	-	-	-	-	-	1.8	-	-	-	-	-	5.4		-	-	-	-	-	7.3	-	-	-	6.3	-
1951	-	-	-	-	-	-	-	0.9	-	-	-	-	0.9	6.3		-	-	-	-	-	12.2	-	-	-	5.0	-
1952	-	-	-	-	-	-	-	-	-	-	-	-	3.2	6.8		-	-	-	-	0.9	19.0	0.9	-	-	4.5	-
1953	0.9	-	-	-	-	-	0.9	0.5	-	-	-	-	0.9	9.1		-	-	5.4	-	5.9	10.9	-	-	-	5.0	-
1954	-	-	-	-	-	-	1.8	0.5	-	-	-	-	0.5	10.4	0.9	-	-	1.8	-	14.5	15.9	-	-	-	4.5	-
1955	-	-	-	-	0.9	-	5.0	0.5	-	-	-	-	1.8	12.7	0.9	-	0.5	1.8	1.8	7.7	20.0	-	-	-	9.5	3.7
1956	-	-	-	-	-	-	1.8	0.5	-	-	-	-	2.3	10.9	0.9	-	1.8	0.5	0.5	2.7	19.5	1.4	-	-	5.4	-
1957	-	-	0.9	-	-	-	1.4	-	-	-	-	-	2.7	-		-	0.5	-	-	-	7.7	-	-	-	8.2	-
1958	-	-	1.4	-	-	-	2.7	-	-	-	2.7	-	5.4	-	0.9	-	-	-	-	4.5	16.3	-	-	-	5.0	-
1959	0.5	-	0.5	-	-	-	0.9	-	-	-	0.9	-	5.0	-	0.9	-	0.9	-	-	-	10.0	-	-	-	0.5	-
1960	-	-	0.9	-	-	-	3.6	1.8	-	-	1.4	-	0.5	-	0.5	-	-	-	0.5	2.3	5.9	-	-	-	3.6	-
1961	-	-	0.5	0.9	-	-	-	2.7	-	-	0.9	-	3.6	0.9		-	-	-	0.5	4.1	6.8	-	-	-	4.1	-
1962	-	-	0.5	-	-	-	1.8	0.9	-	-	-	-	2.7	1.8		-	1.8	-	0.5	3.6	2.7	0.5	-	-	7.7	-
1963	-	-	0.5	-	-	-	1.8	-	-	-	0.5	-	3.6	5.0		-	1.4	-	-	1.4	17.2	-	-	-	9.1	-
1964	-	-	1.4	-	-	-	0.5	-	-	-	-	-	0.9	5.0		-	-	-	-	4.1	8.6	-	-	-	6.8	0.5
1965	-	-	0.9	-	0.9	-	1.8	-	-	-	-	-	-	0.9	0.5	-	-	-	0.5	2.3	5.9	-	-	-	7.7	1.4
1966	-	-	-	-	-	-	0.5	-	-	-	-	-	0.5	2.7	0.9	-	0.5	-	-	5.4	7.7	-	-	-	8.6	-
1967	-	-	0.8	-	-	-	1.3	-	-	-	-	-	0.2	-	0.2	-	-	-	0.2	-	6.4	-	-	-	4.6	-
1968	-	-	-	-	6.5	-	0.5	-	-	-	-	-	1.4	0.2	0.6	-	-	-	0.2	2.0	3.9	-	-	-	4.4	2.2
1969	-	-	-	-	4.0	-	3.2	-	-	-	-	-	0.9	-	1.6	-	-	-	0.2	4.2	5.3	-	-	-	4.2	-
1970	-	-	0.1	-	0.4	-	1.6	-	-	-	0.6	-	1.0	-	1.0	-	-	-	0.9	3.3	3.4	-	-	-	16.7	-
1971	0.6	-	0.1	-	-	-	1.9	-	-	-	2.3	-	3.0	5.0	0.6	-	-	-	0.7	1.9	1.8	17.9	-	-	13.3	-
1972	0.4	-	0.1	-	-	-	0.6	-	-	-	0.1	-	1.4	0.1	0.5	-	-	-	0.2	3.5	4.3	-	-	-	13.8	-
1973	-	-	-	-	0.8	-	0.5	-	-	-	-	-	0.9	1.8	0.2	-	-	-	0.3	4.9	1.7	-	-	-	8.8	-
1974	-	-	-	-	0.9	-	2.3	-	-	-	-	-	1.3	-	-	-	-	-	-	0.5	3.6	-	-	-	5.0	-
1975	-	-	-	-	-	-	0.9	-	-	-	-	-	0.5	-	0.5	-	-	-	-	4.1	5.9	-	-	-	0.5	-
1976	-	-	-	-	-	-	1.0	-	-	-	-	-	1.0	-	-	-	-	-	-	5.0	-	-	-	-	2.0	-
1977	-	-	-	-	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.0	4.0	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	-	-	-	-	1.0	4.0	45.0	-	-	-	-	-
1979	-	-	-	-	1.0	-	5.0	-	-	-	-	-	-	-	-	-	-	-	4.0	1.0	8.0	1.0	-	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	-	-	1.0	9.5	-	-	-	-	1.0	5.0	13.0	-	-	-	-	-
1981	-	-	-	-	1.0	-	-	-	-	-	-	-	1.0	-	-	-	-	-	1.0	6.0	10.0	-	-	-	1.0	-
1982	-	-	-	-	-	-	-	2.0	-	-	-	-	-	-	-	-	-	-	4.0	5.0	6.0	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	2.0	-	-	-	-	-	1.0	1.0	13.0	-	-	-	1.0	-
1984	-	-	-	-	5.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	-	-	-	-	-
1985	-	-	-	-	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0	-	-	-	-	-
1986	-	-	-	-	2.0	-	-	-	-	-	-	-	-	-	-	-	-	-	4.0	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	13.0	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	-	-	-	-
1988	-	-	-	-	-	-	-	13.0	-	-	-	-	-	-	-	-	-	-	-	-	1.0	-	-	-	-	-
1989	-	-	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	5.0	-	-	-	-	-
1990	-	-	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<1	4.0	-	-	-	-	-
1991	-	-	<1	-	-	-	-	-	-	-	<1	-	1.0	10.0	-	-	-	-	11.0	3.0	9.0	-	-	-	-	-
1992	-	6.0	2.0	11.0	-	-	-	3.0	-	4.0	-	-	-	3.0	-	-	-	-	8.0	2.0	10.0	-	-	-	-	-
1993	1.0	9.0	2.0	10.0	17.0	-	1.0	1.0	-	-	-	-	-	6.0	<1	-	-	-	2.0	<1	4.0	-	-	-	15.0	-
1994[b]		3.7	1.0	0.3	0.4	-	1.9	0.1	-	-	0.0	1.0	0.8	6.2	0.0	0.3	0.0	0.1	6.6	7.1	11.8	0.4	0.8	-	0.6	0.1
1995[c]	3.2	0.1	2.1	3.3	2.1	0.0	5.8	0.2	-	-	0.4	0.4	0.2	1.2	0.0	0.5	-	0.3	3.4	9.4	13.5	1.4	0.3	0.3	2.6	7.5
1996	3.7	-	3.4	1.1	2.8	-	2.4	0.5	0.0	1.4	3.0	-	0.1	1.8	-	1.2	-	0.1	2.3	4.6	8.6	1.5	0.5	0.1	3.5	0.4
1997	3.3	0.1	0.1	0.7	1.5	0.1	0.7	0.3	0.0	1.4	7.6	-	0.4	0.2	-	-	0.0	0.8	3.2	6.5	8.1	0.8	0.6	-	6.7	1.0
1998	5.2	-	0.6	3.4	7.5	0.7	2.5	0.4	0.2	1.2	4.5	-	0.6	2.8	-	-	-	0.4	2.8	6.8	12.9	1.0	0.7	0.5	11.5	2.7
1999	3.2	0.1	0.0	9.3	0.1	3.9	1.2	0.7	0.3	2.1	0.1	-	0.2	3.3	-	0.0	0.0	0.3	1.5	5.1	11.5	0.4	0.8	1.1	12.8	3.0
2000	4.3	-	0.1	3.9	-	0.0	4.2	0.7	0.1	1.3	0.1	4.7	1.4	2.7	-	0.0	0.0	-	2.4	6.8	14.8	0.5	1.0	-	19.9	2.6
2001	0.9	-	0.1	7.3	0.7	1.7	0.7	3.4	0.2	1.1	0.1	8.3	0.3	1.7	-	0.1	0.0	0.0	1.6	7.1	10.3	0.5	2.4	-	7.3	1.7
2002	-	-	0.1	8.3	3.9	0.0	0.9	2.4	0.0	1.1	0.1	0.1	0.4	0.3	-	0.3	-	0.0	0.7	5.7	6.7	0.7	1.2	1.3	7.2	0.8
2003	3.0	-	0.0	3.1	1.5	0.1	1.6	0.5	0.1	0.6	0.0	5.1	0.4	1.0	-	-	-	-	1.2	2.6	1.5	0.1	0.8	0.9	5.4	0.9
2004	1.8	-	0.1	0.7	5.0	2.5	2.5	3.2	0.0	0.4	-	4.4	1.0	2.3	-	0.6	0.1	0.1	2.5	9.3	7.0	0.2	1.5	0.5	6.4	1.4
2005	5.4	-	0.2	1.8	1.5	0.6	2.0	1.8	0.0	-	2.1	2.3	0.1	2.3	-	-	-	0.1	1.3	2.0	5.7	0.1	1.0	-	10.8	1.6
2006	2.4	-	0.1	4.5	1.5	0.3	1.7	1.3	0.0	0.3	0.0	1.1	0.1	2.1	-	0.7	-	0.2	2.2	7.5	11.2	0.1	-	0.2	12.7	1.0
2007	1.9	-	0.4	3.1	4.8	2.4	1.6	0.2	0.0	0.0	0.1	2.7	-	2.0	-	-	0.1	-	1.2	0.7	2.8	-	0.2	0.1	1.1	0.2
2008[d]																										
2009[d]																										
2010[d]																										

[a]Recent landings from this FSD reported from Scotia-Fundy ports.
[b]Catches of 0.6, 0.2, 8.1, and 0.5 t were reported in FSDs 8, 18, 24, and 39.
[c]Catches of 0.4, 3.3, and 0.7 t were reported in FSDs 18, 24, and 39.
[d]Landings not available from database when this report was generated.

Table 1 continued. Reported landings (mt) of large (yellow and silver) American eels in Scotia-Fundy, by statistical district. Data for the 1950-1993 are from Jessop 1996b.

	Bay of Fundy Nova Scotia										Bay of Fundy New Brunswick										
Year	**24**	**35**	**36**	**37**	**38**	**39**	**41**	**42**	**43**	**44**	**48-49**	**51**	**52**	**53**	**55**	**56**	**57**	**58**	**59**	**79**	**81**
1950	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.7	14.0	0.8	-	-	-	-
1951	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.2	0.8	0.8	-	-	-	-
1952	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2.4	5.8	0.4	-	-	-	-
1953	-	-	-	-	0.5	-	-	0.5	-	-	-	-	-	-	3.7	16.9	0.4	-	-	-	-
1954	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	5.4	4.1	-	-	-	-	-
1955	-	-	-	-	-	-	-	0.5	-	-	-	-	0.5	-	4.1	28.8	6.2	-	-	-	-
1956	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.6	0.8	-	-	-	-	-
1957	-	-	-	-	-	-	-	0.5	-	-	-	-	0.5	-	4.5	-	-	-	-	-	-
1958	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	6.6	-	-	-	-	-	-
1959	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1960	-	-	-	-	-	-	-	0.5	-	-	0.8	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	1.2	-	-	-	7.4	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	7.8	0.4	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-	4.5	-	7.0	1.6	-	-	-	-	-
1964	-	-	-	-	15.0	-	-	-	-	-	0.5	-	0.9	-	8.3	-	-	-	-	-	-
1965	-	-	-	-	4.1	-	-	-	-	-	-	-	-	-	3.3	2.0	-	-	-	-	-
1966	-	-	-	-	1.4	-	-	-	-	-	-	-	-	-	18.9	0.4	0.4	-	-	-	-
1967	-	-	-	-	0.1	-	-	-	-	-	-	-	1.7	-	1.6	0.4	0.4	-	-	-	-
1968	-	-	-	-	0.2	-	-	-	-	-	-	-	0.8	-	10.3	0.4	0.8	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-	-	2.0	-	14.8	43.2	0.4	-	-	-	-
1970	-	-	-	-	-	-	-	-	-	-	-	-	2.3	0.1	13.2	30.5	7.0	1.2	-	-	-
1971	-	-	-	-	-	-	-	-	-	-	3.6	-	-	0.1	9.9	36.2	12.3	4.9	-	-	0.1
1972	-	-	-	-	-	-	-	-	-	-	1.3	-	-	-	0.8	25.9	7.4	-	-	-	-
1973	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.0	15.6	4.5	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4.9	13.2	-	-	2.8	-	-
1975	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4	33.7	11.5	-	[b]6.3	-	-
1976	-	-	-	-	-	-	-	-	-	-	1.0	-	-	-	7.0	56.0	14.0	-	-	-	-
1977	-	-	-	-	-	-	2.0	-	-	-	-	-	-	-	30.0	49.0	21.0	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-	-	17.0	24.0	3.0	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	2.167[b]	-	-	-	23.0	25.0	26.0	-	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	8.0	-	-	-	16.0	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-	-	4.0	-	1.0	-	20.0	9.0	-	1.0	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	-	-	-	-	-	-
1983	-	-	-	-	-	-	1.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.0	-	-	-	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	6.0	-	-	-	51.0	15.0	1.0	-	-	-	-
1986	-	-	-	-	-	-	-	-	-	-	5.0	-	-	-	32.0	17.0	1.0	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	-	2.0	-	-	-	10.0	23.0	9.0	-	-	-	5.0
1988	-	-	-	-	-	-	-	-	-	-	65.0	-	-	-	60.0	-	-	-	-	-	10.0
1989	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100.0	9.0	2.0	-	-	-	5.0
1990	-	-	-	-	-	-	-	-	-	<1	8.0	-	0.1	-	41.0	28.0	3.0	2.0	-	-	8.0
1991	-	-	-	-	-	-	-		<1	3.0	-	-	0.1		1.0	41.0	7.0	22.0	0.1	-	-
1992	-	-	-	-	-	-	1.0	1.0	-	-	-	-	1.0	0.1	2.0	49.0	2.0	-	10.3	-	3.0
1993	-	-	-	-	-	-	-	1.0	1.0	1.0	-	-	0.8	0.1	31.0	49.0	7.0	2.0	10.0	-	17.0
1994	-	-	0.8	-	0.0	0.5	0.1	1.0	0.0	0.1	1.0	-	0.5	-	9.5	48.0	7.7	-	19.8	-	0.0
1995	3.3	-	0.5	0.1	-	0.7	-	0.9	0.1	1.7	31.5	-	0.4	-	0.3	38.3	16.8	-	13.4	0.0	-
1996	3.4	-	0.8	-	-	-	-	0.8	0.1	2.1	13.3	-	0.2	0.0	2.2	25.1	21.8	-	-	-	-
1997	2.6	-	0.8	0.0	0.2	-	0.1	0.5	0.2	1.6	9.7	-	-	0.0	5.4	51.7	2.4	-	-	0.0	-
1998	-	1.4	0.9	-	0.7	0.6	0.7	0.7	0.3	-	36.1	-	-	0.0	3.4	39.9	7.5	-	0.6	-	0.1
1999	2.6	-	3.9	-	0.1	0.0	0.2	0.6	0.2	1.2	24.0	-	1.3	0.0	4.5	30.4	18.2	-	-	2.8	0.0
2000	3.7	0.1	5.6	0.0	0.1	0.0	0.1	3.7	0.0	4.7	12.6	-	0.1	-	5.4	29.4	14.6	-	-	0.2	0.3
2001	3.3	-	0.3	0.1	0.1	0.0	-	0.8	0.3	4.2	26.0	-	-	-	0.8	27.3	6.6	-	-	-	1.6
2002	4.7	-	3.4	-	-	-	-	0.2	0.4	1.4	11.6	-	-	0.0	1.8	32.3	14.8	-	-	-	2.8
2003	-	-	2.6	-	-	0.0	-	0.5	0.2	1.0	28.5	-	-	0.0	-	15.0	15.5	-	-	0.0	0.1
2004	3.2	-	1.1	0.0	0.0	0.0	-	0.5	0.0	-	18.4	-	-	-	-	14.6	22.7	-	-	0.0	0.1
2005	2.8	-	0.1	-	-	-	0.0	0.3	-	-	0.1	-	0.4	-	1.8	31.2	9.8	-	-	-	2.6
2006	4.8	-	2.8	0.0	0.0	-	-	1.5	0.0	4.4	4.0	-	-	0.0	2.2	26.7	12.7	-	-	-	3.0
2007	2.5	-	0.0	-	-	-	-	-	0.0	-	0.0	-	-	-	-	14.3	3.9	-	-	-	2.4
2008																					
2009																					
2010																					

Table 2. Summary of landings (mt) within Maritimes Region by province, logbooks issued annually since 1990, licences issued to fish a particular gear type and numbers of gear licenced to fish, fishers reporting a catch in the year or that they did not fish (DNF), potential number of gear set by fishers reporting a catch.

	Reported Landings (mt)			Licences Issued to Fish a Gear Type					Number of Licenced Gear					Fishers Reporting		
Year	NB	NS	Total	Misc.	Pot	Trap	Weir	Total	Misc.	Pot	Trap	Weir	Total	Catch	DNF	Total
1975	52	12	64													
1976	78	9	87													
1977	100	9	109													
1978	44	52	96													
1979	120	21	141													
1980	24	30	54													
1981	35	20	55													
1982	3	17	20													
1983	0	19	19													
1984	3	8	11													
1985	73	7	80	16	148	42	16	195	235	5,041	830	30	6,136			
1986	55	6	61	15	166	58	14	216	365	9,648	1,490	32	11,535			
1987	49	14	63	13	191	68	21	240	284	11,559	2,005	56	13,904			
1988	135	15	150	10	211	65	22	262	259	12,294	1,979	55	14,587			
1989	116	6	122	10	293	71	23	343	259	19,386	2,199	57	21,901			
1990	90	5	95	7	296	74	24	341	225	19,781	2,552	47	22,605	30	2	32
1991	88	39	127	0	386	74	59	436	0	24,163	2,466	61	26,690	63	21	84
1992	67	62	129	2	462	99	34	511	8	32,090	2,818	65	34,981	82	24	106
1993	116	72	188	2	515	118	36	576	8	35,908	3,140	56	39,112	154	42	196
1994	131	99	230	2	456	118	32	510	8	33,072	3,102	54	36,236	135	20	155
1995	114	116	230	2	439	111	27	490	8	31,851	2,980	48	34,887	156	37	193
1996	102	72	174	1	411	101	26	456	6	31,290	2,726	43	34,065	127	35	162
1997	111	64	175	5	377	99	25	425	98	28,884	2,587	41	31,610	139	25	164
1998	88	75	163	5	391	98	26	437	98	30,155	2,573	43	32,869	172	83	255
1999	119	76	195	5	414	105	26	462	98	31,541	2,795	43	34,477	153	40	193
2000	69	90	159	5	416	107	26	462	98	31,681	2,850	43	34,672	132	81	213
2001	64	68	132	5	408	106	26	464	98	31,722	2,770	43	34,633	117	65	172
2002	63	52	116	5	416	106	26	463	98	31,622	2,770	43	34,533	103	69	172
2003	59	35	94	5	417	106	26	461	98	31,647	2,770	43	34,558	100	67	168
2004	56	58	114	5	417	106	26	452	98	31,647	2,770	43	34,558	79	31	112
2005[a]	46	46	92													
2006[a]	49	65	113													
2007[a]	21	28	49													
2008[b]																
2009[b]																

* 1995 to 1999 catch from stats website
2000 to 2003 catch from logs
Last 4 columns are from response summaries.
[a]No updated information available other than reported landings (mt).
[b]No information available

Table 3. Arithmetic annual mean (±standard error) of American eels per 100 m^2 in the first sweep of electrofishing surveys in barriered (B) and open (O) sites in New Brunswick rivers.

Year	Nashwaak - open				Big Salmon			
	Eels/100 m^2			Survey	Eels/100 m^2			Survey
	Mean	SE	N	type	Mean	SE	N	type
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989								
1990								
1991	3.10		1	O				
1992	0.73	0.40	4	O				
1993	1.18	0.36	9	O				
1994	0.39	0.19	10	O				
1995	0.61	0.31	8	O				
1996	1.40	0.22	9	O	0.34	0.27	5	B
1997	1.03	0.23	9	O	4.38	1.60	4	B
1998	1.23	0.25	8	O				
1999	0.92	0.20	10	O	3.16	0.94	5	B
2000	1.38	0.33	9	O	2.98	1.06	4	B
2001	1.53	0.27	10	O	0.80	0.57	3	B
2002	1.38	0.35	9	O	1.62	0.67	5	B
2003	0.66	0.25	7	O	1.88	0.92	5	B
2004	2.13	0.35	3	O	1.02	0.35	5	B
2005	1.57	0.27	6	O	1.94	0.58	5	B
2006	0.89	0.15	24	O	1.41	0.50	4	B
2007	1.43	0.19	26	O	1.20	0.66	5	B
2008	1.23	0.33	20	O	1.80	0.75	5	B
2009	0.84	0.13	17	O	1.97	0.74	5	B

Table 4. Arithmetic annual mean (±standard error) of American eels per 100 m^2 in the first sweep of electrofishing surveys in open (O) sites in Nova Scotia rivers.

Year	St. Marys - open				Lahave - open			
	Eels/100 m^2			Survey	Eels/100 m^2			Survey
	Mean	SE	N	type	Mean	SE	N	type
1967								
1968								
1969								
1970								
1971								
1972								
1973								
1974								
1975								
1976								
1977								
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985	6.89	1.12	8	O				
1986	6.48	0.57	9	O				
1987								
1988								
1989								
1990								
1991								
1992								
1993								
1994								
1995	6.61	1.20	10	O	0.81	0.17	4	O
1996	3.51	0.70	8	O				
1997	5.04	0.75	10	O	1.60	0.58	4	O
1998	8.45	1.37	10	O				
1999	5.42	1.19	10	O				
2000	1.66	0.23	10	O	3.64	0.36	2	O
2001	1.68	0.48	6	O	1.90	0.60	2	O
2002	1.40	0.32	8	O	1.86	0.37	3	O
2003	1.83	0.60	6	O	0.57	0.11	4	O
2004	0.47	0.12	6	O	0.46	0.25	3	O
2005	1.41	0.25	9	O	0.45	0.17	12	O
2006	1.11	0.26	11	O	0.31	0.11	9	O
2007	1.90	0.50	14	O	0.05		1	O
2008	0.80	0.15	11	O	0.18	0.06	6	O
2009	1.03	0.15	17	O	0.44	0.13	8	O

Table 5. Number of reported occurrences and total weight (kg) of Anguilla sp. bycatch in marine fisheries by fishery, gear-type, and year and month of capture as reported by fisheries observers.

			Number of Recorded Catches by Month												
Fishery	**Gear Type**	**Year**	**Jan**	**Feb**	**March**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Weight (kg)**
4X Monkfish	Bottom Otter Trawl (Stern)	1999										1			1.0
Cod/Haddock/Pollock	Bottom Otter Trawl (Stern)	1981				1									5.0
	Bottom Otter Trawl (Side)	1981			5										18.0
	Bottom Otter Trawl (Stern)	1984	1												5.0
	Bottom Otter Trawl (Stern)	1999						2							2.0
	Bottom Otter Trawl (Stern)	2001						4	2	1					86.0
	Gear unspecified	2007						1			2				70.0
Flatfish	Bottom Otter Trawl (Stern)	1980					7								72.0
	Bottom Otter Trawl (Side)	1984			1										5.0
	Bottom Otter Trawl (Stern)	1994										1			2.0
	Bottom Otter Trawl (Stern)	1999							1						1.0
Halibut	Longline (Not Specified)	1996	1												4.0
Lobster*	Covered Pots (Lob,Crab)	2001					1								4.0
	Gear unspecified	2008							1						1.0
Redfish	Bottom Otter Trawl (Stern)	1981							2						3.0
	Bottom Otter Trawl (Stern)	1984				4	1					2			60.5
	Bottom Otter Trawl (Stern)	2002						1							1.0
	Bottom Otter Trawl (Stern)	2004						3							7.0
Scallop	Dredge (Boat)	2004											1		1.0
	Gear unspecified	2008				11				3	3				42.0
Shrimp	Shrimp Trawl	1989					1								1.0
	Shrimp Trawl	2000							7						7.0
	Shrimp Trawl	2004						13	3						25.7
	Gear unspecified	2006						1							2.0
Silver Hake	Bottom Otter Trawl (Stern)	1985						1	3						12.0
	Bottom Otter Trawl (Stern)	1990					2								17.0
	Bottom Otter Trawl (Stern)	1992				1									3.0
	Bottom Otter Trawl (Stern)	1998					15	12							80.0
Totals			**2**		**6**	**17**	**27**	**38**	**19**	**4**		**4**	**1**		**538.2**

*No location provided

Table 6. Commercial fisheries for which fishery observer information is available.

Type	Fishery
Groundfish	4 vn Sentinel Survey
	4 vsw Sentinel Program
	4 vwx Halibut Port Survey
	4 vwx Halibut Survey
	4 vwx Skate Survey
	4 x Mobile Gear Survery
	5 z Fixed Gear Survey
	Cod/Haddock/Pollock
	Mixed Commercial and Survey
	Monkfish
	Sculpin
	Skate
	Turbot
	White Hake
Pelagic	Grenadier
	Herring
	Mackerel
	N. Atl. Bluefin Survey
	Porbeagle
	Silver Hake,Squid,Argentine
	Swordfish
	Tuna, Swordfish
Invertebrate	Lobster
	Scallop
	Sea Cucumber
	Sea Urchin
	Snow Crab Survey
	Squid

Table 7. Summary of reported occurrences of A. crassus in American eel collected from Nova Scotia and New Brunswick (Source Campbell et al. (2012).

Province	Area	Drainage	Year	Lat (dd)	Long (dd)	Sampling Method*	Source	No. eels collected	No. eels infected	Prevalence (%)	Intensity Mean	Intensity SD	Source
NS	NS-Atlantic	Lochaber Lake (SMR)	2007	45.40880	62.03225	CS	Non-Tidal	27	4	14.8	2.5		Aieta and Oliveira 2009
NS	NS-WCB	Margaree Harbour	2007	46.44305	61.10993	CS	Tidal	26	8	30.8	6.1		Aieta and Oliveira 2009
NS	NS-ECB	Bras d'Or Lakes	2007	45.84694	60.81833	CS	Tidal	28	4	14.3	4.0		Aieta and Oliveira 2009
NB	NB-OBoF	Saint John River	2007	45.29571	62.15201	CS	Non-Tidal	28	1	3.6	1.0		Aieta and Oliveira 2009
NS	NB-IBoF	Silver Lake (Amherst)[1]	2007			CS	Non-Tidal	32	1	3.1	1.0		Aieta and Oliveira 2009
NS	NS-ECB	Mira River	2007	46.04707	60.01897	EP	Tidal	10	6	60.0	2.7	2.3	Rockwell et al. 2009
NS	NS-ECB	Sydney Harbour	2007	46.13250	60.19593	EP	Tidal	5	1	20.0	11.0	0.0	Rockwell et al. 2009
NS	NS-Atlantic	St. Mary`s River	2008	45.26770	62.32597	EF	Non-Tidal	88	1	1.1	2.0	0.0	This Study
NS	NS-Atlantic	Medway River	2008	44.17233	64.65322	EF	Non-Tidal	37	1	2.7	2.0	0.0	This Study
NS	NS-Atlantic	Mersey River	2008	44.09335	64.84616	EF	Non-Tidal	40	1	2.5	2.0	0.0	This Study
NS	NS-Atlantic	Salmon River (Lawrencetown)	2008	44.69250	63.37917	EF	Non-Tidal	37	1	2.7	2.0	0.0	This Study
NS	NS-WCB	Mill Brook (Troy)	2008	45.66947	61.42190	EF	Non-Tidal	11	3	27.3	1.3	0.6	This Study
NB	NB-OBoF	Saint John River	2009	45.29571	62.15201	EF	Non-Tidal	375	37	9.9	2.6	4.1	This Study
NS	NS-IBoF	Stewiacke River	2009	45.13785	63.37170	EP	Tidal	12	2	16.7	2.5	2.0	This Study
NS	NS-Gulf	West River (Antigonish)	2009	45.55450	62.08845	EF	Non-Tidal	2	2	100.0	2.0	1.4	This Study

*Sampling methods CS: Commercial sampling, EP: Eel pots, EF: Electrofishing

[1] probably Silver Lake, near Sackville, New Brunswick

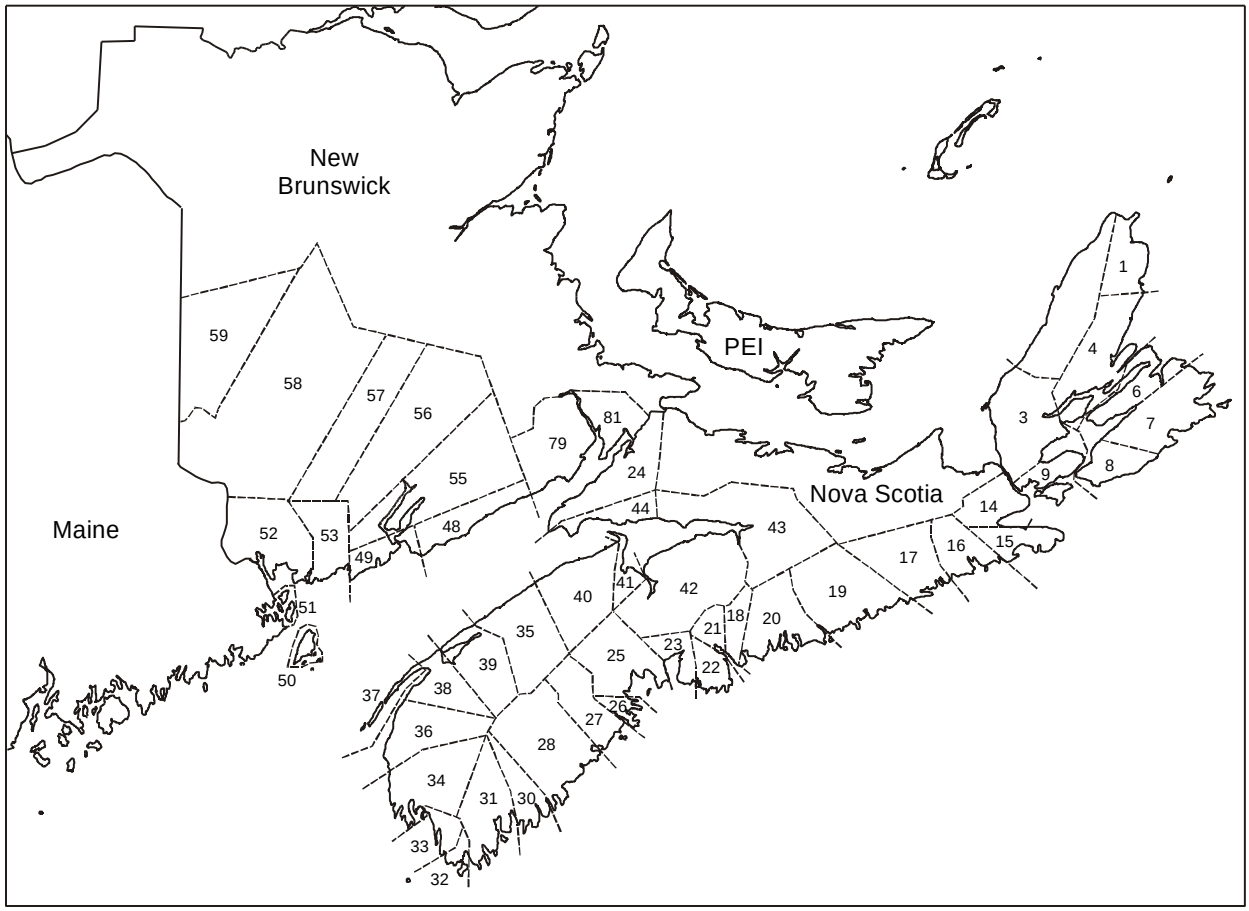

Figure 1. Map of Maritime Provinces showing the distribution of Fishery Statistical Districts.

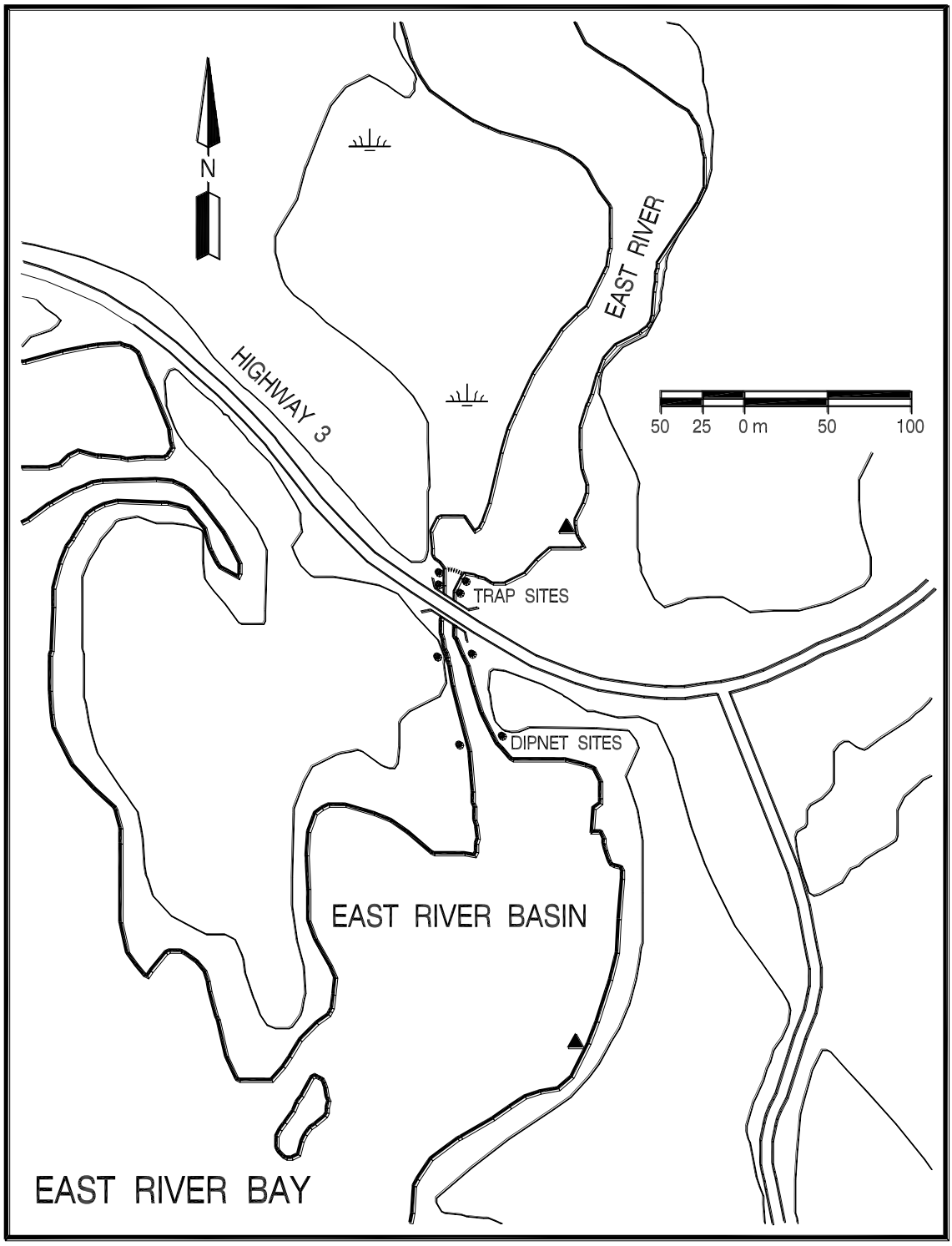

Figure 2. Elver trap and range of dip net fishing locations on the East River, Chester, Nova Scotia. Solid triangles indicate thermograph sites.

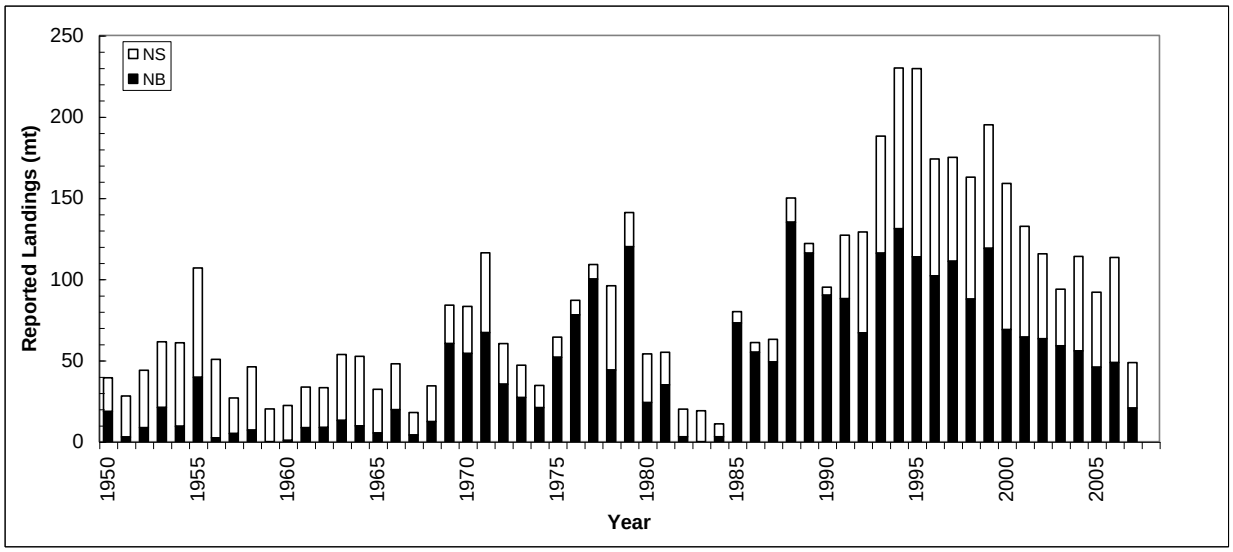

Figure 3. Reported landings (mt) of large American eels, within the New Brunswick (solid bar) and Nova Scotia (open bar) portions of Maritimes Region, 1950-2007.

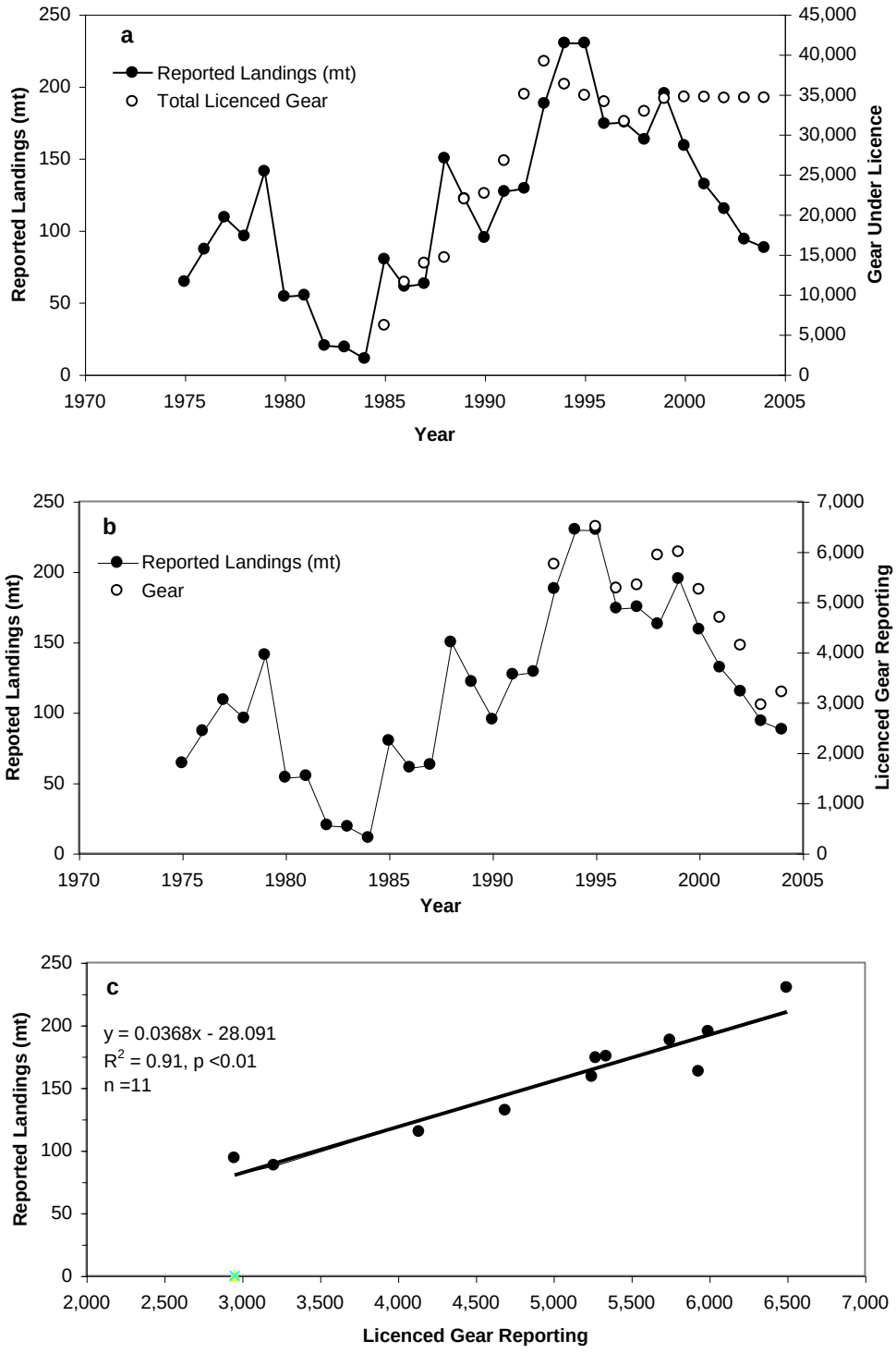

Figure 4. (a) Reported annual landings (1974-2004, solid line) and number of gear licenced to fish annually (1985-2004, open circles), (b) Reported annual landings (solid line) and number of gear licenced to fishers reporting catch (1993-2004,open circles, and (c) Reported annual landings versus gear licenced to fishers reporting catch (1993-2004).

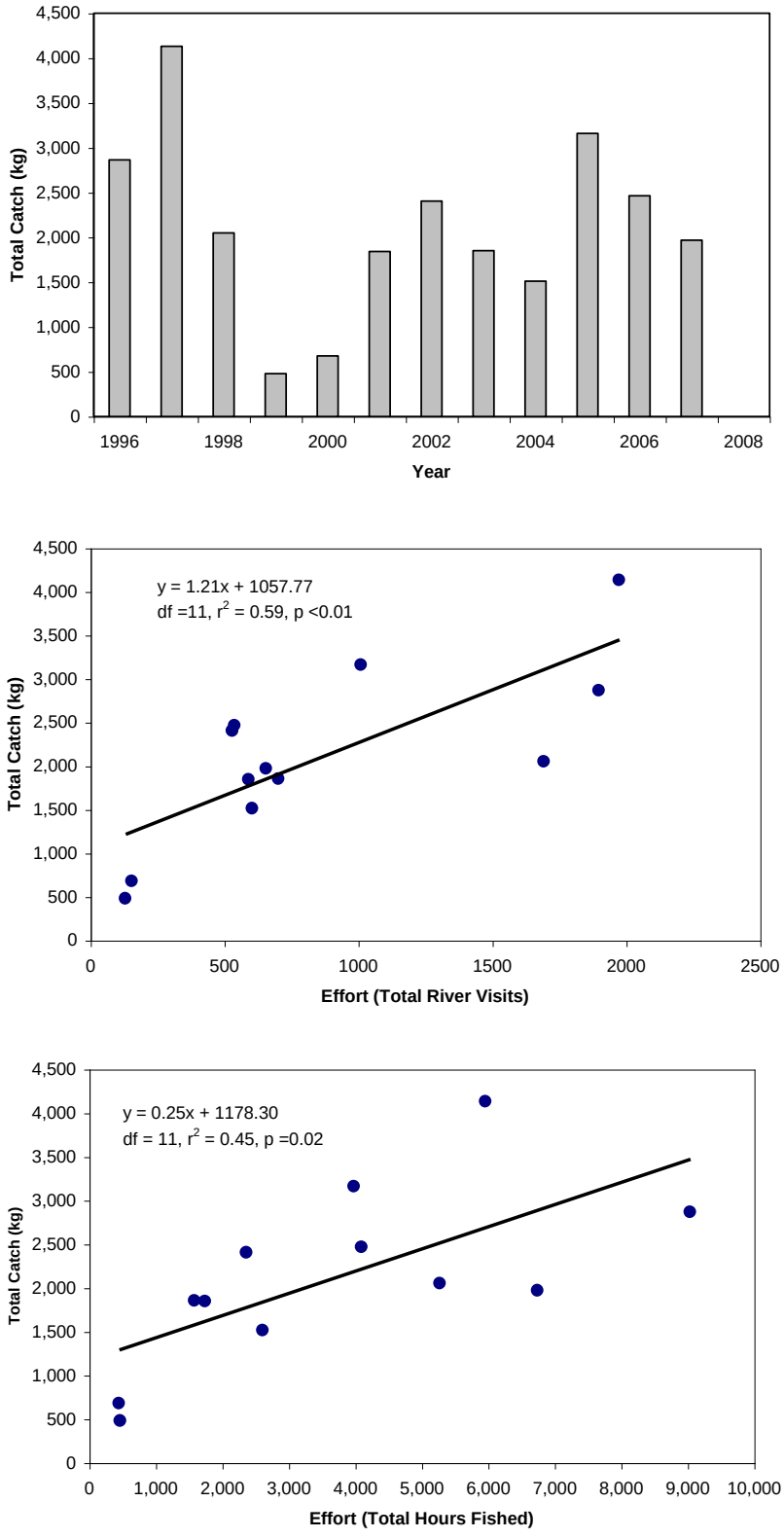

Figure 5. (Upper panel) Annual commercial elver harvest (kg) 1996-2007. (Middle panel) Total annual elver harvest versus number of river visits. (Lower panel) Total annual catch (kg) versus total hours fished.

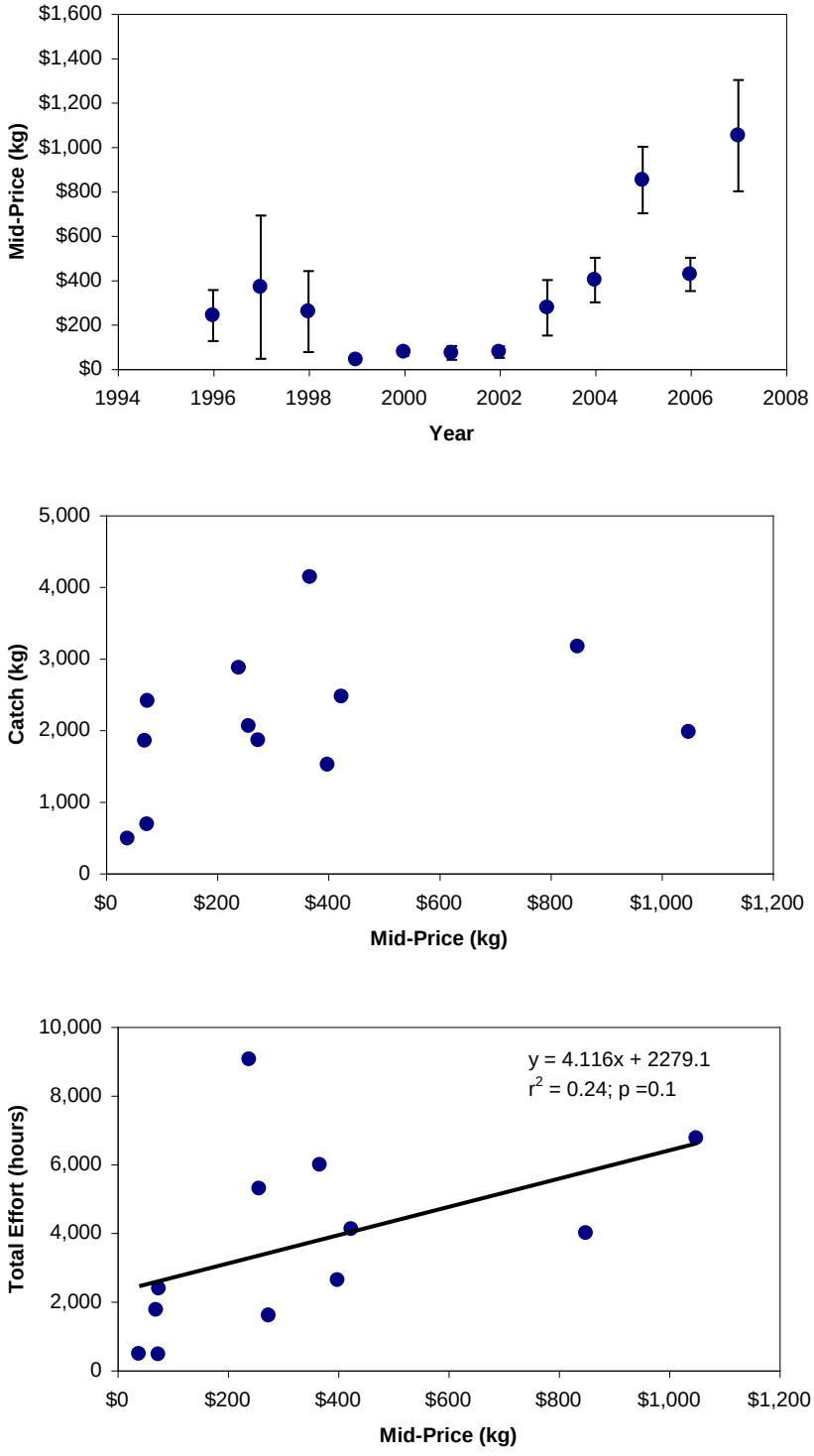

Figure 6. (Upper panel) Estimated upper, lower, and mid-range price ($US) per kg for elvers versus year. (Middle panel) Total annual catch versus mid-range price. (Lower panel) Total hours fished versus mid-range price.

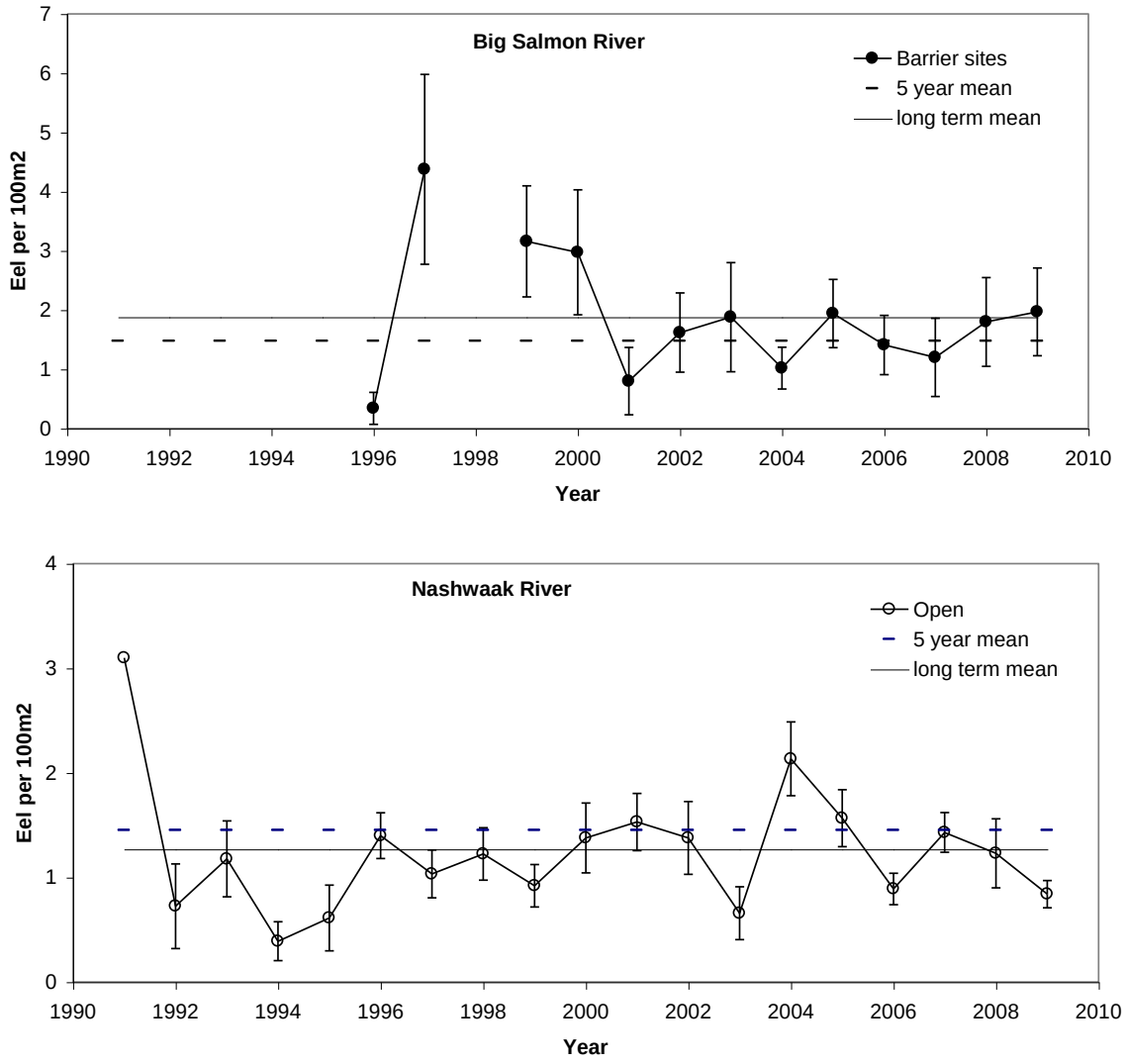

Figure 7. Arithmetic annual mean (±standard error) catch (per 100 m^2) of American eel within the Big Salmon River and Nashwaak River. Estimates are generated using eel catches during the first pass with an electrofisher.

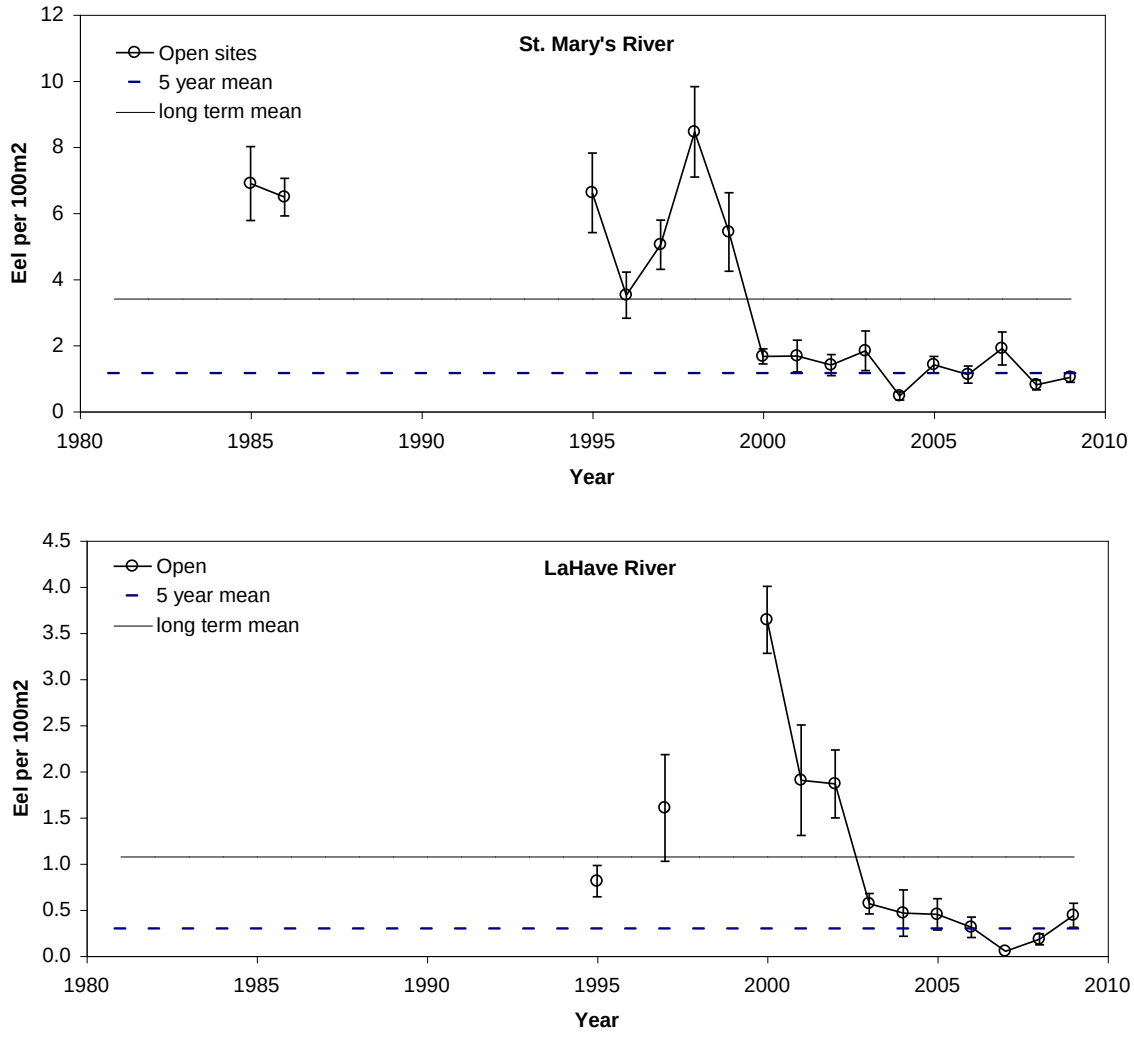

Figure 8. Arithmetic annual mean (±standard error) catch (per 100 m^2) of American eel within the St. Mary's River and LaHave River, Nova Scotia. Estimates are generated using eel catches during the first pass with an electrofisher.

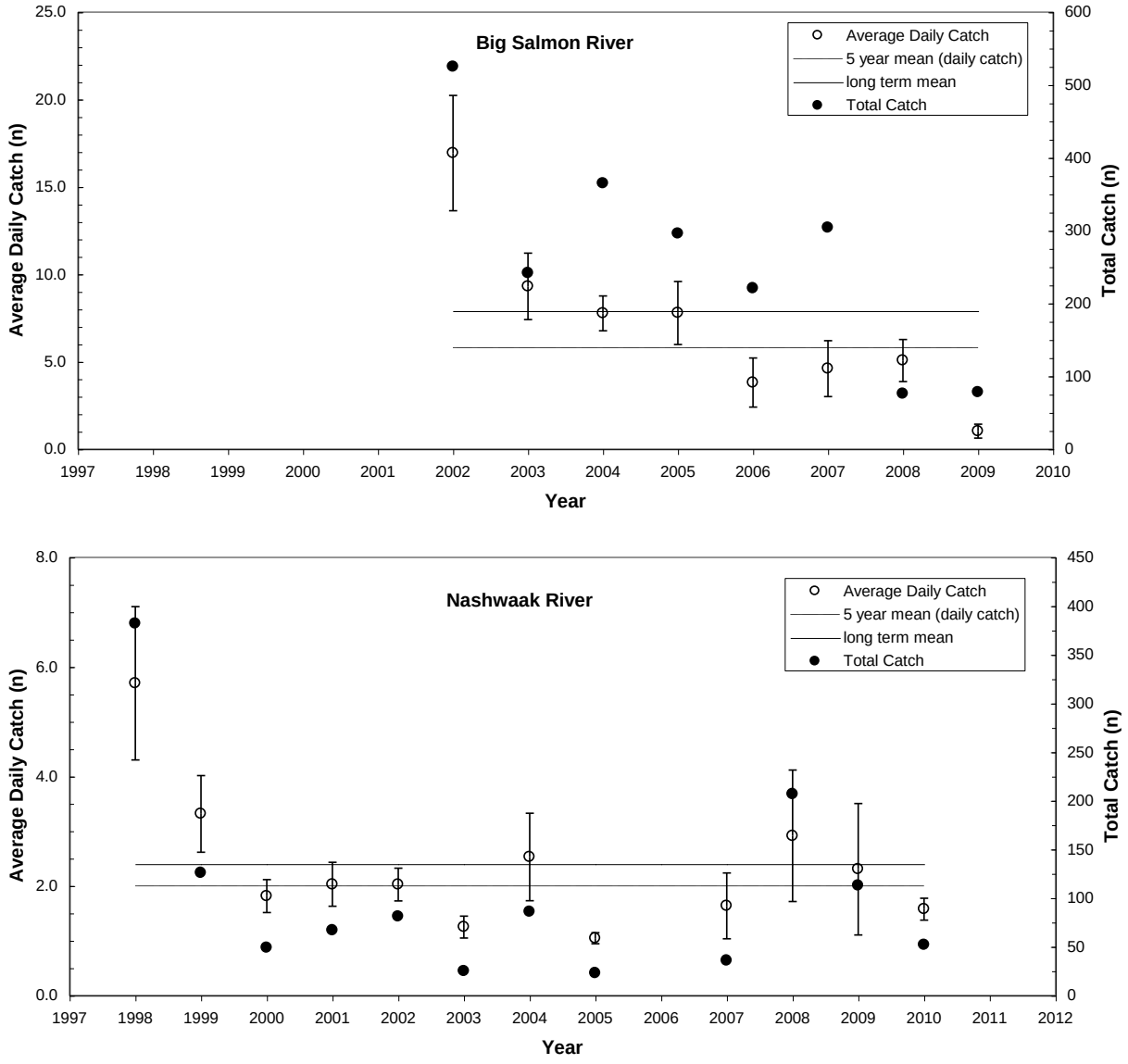

Figure 9. Total catch (n) and arithmetic mean (±standard error) catch per year in rotary screw traps installed in the Big Salmon River and Nashwaak River, New Brunswick.

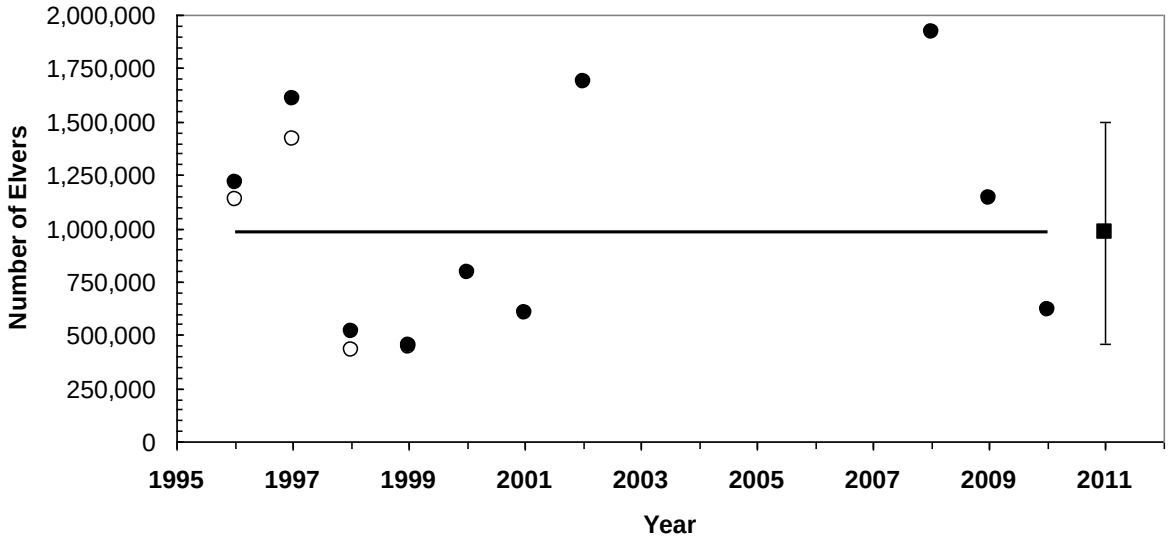

Figure 10. Estimated annual elver run size to East River-Chester versus year for the years that monitoring occurred between 1996 and 2010. Solid circles represent the current annual estimate. Open circles represent those previously reported in COSEWIC (2006) and Cairns et al. (2008). The mean (± standard deviation) of the 1996-2002 time series is represented by the solid square.

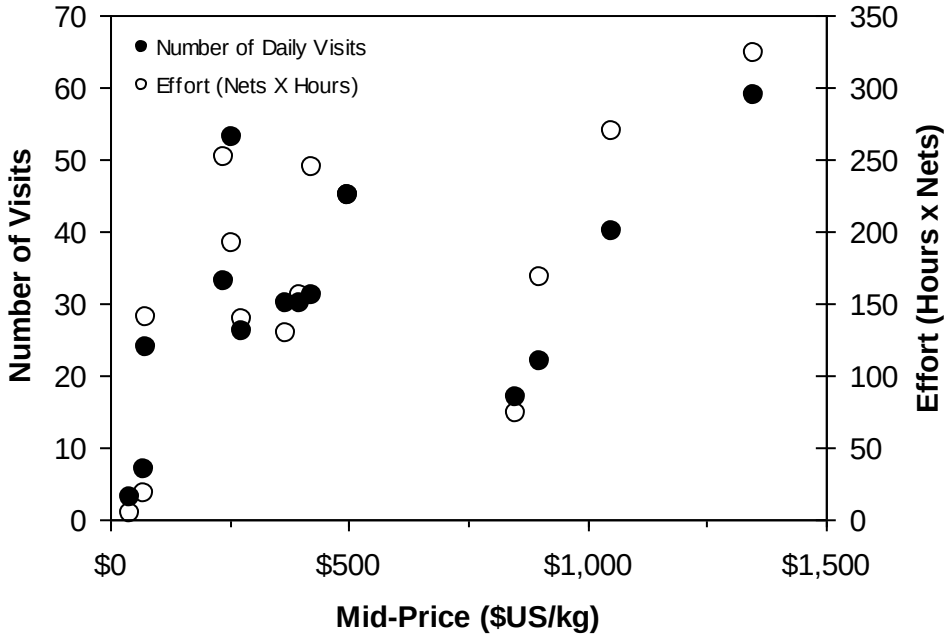

Figure 11. Number of visits to East River-Chester and total effort (hours x nets) versus mid-price for elvers (1996-2010).

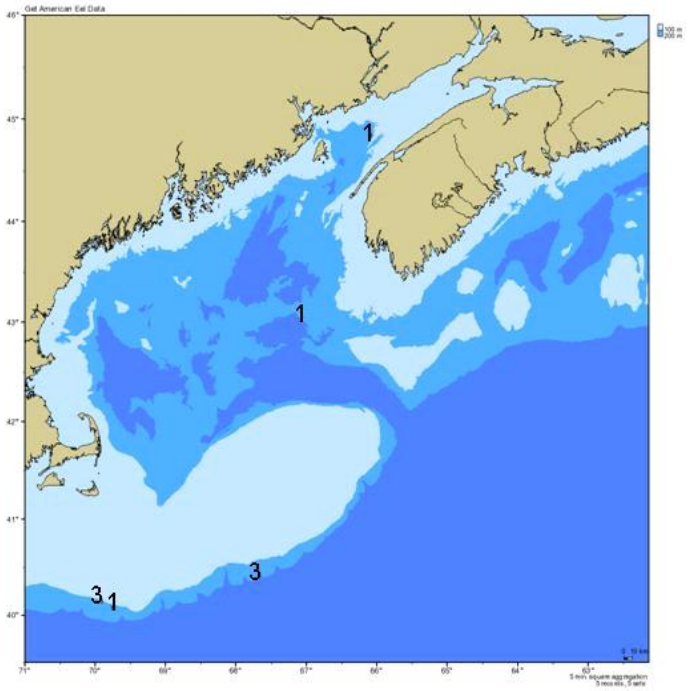

Figure 12. Summary of all large eel captures in DFO groundfish research vessel surveys in the Gulf of Maine-Scotian Shelf area since 1978. The numbers represent the number of eel captured in individual sets. Null catches are not shown.

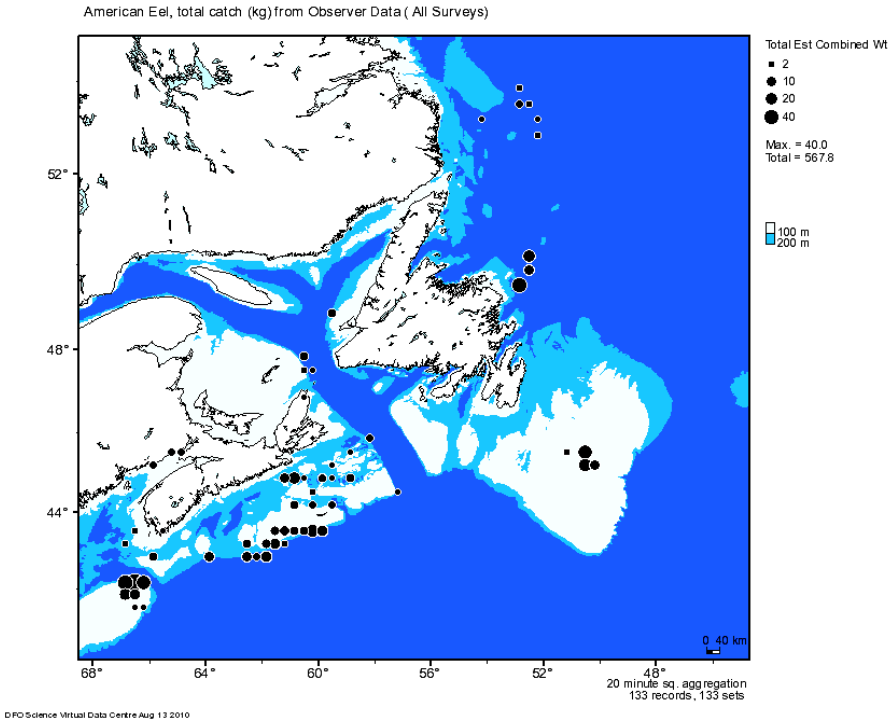

Figure 13. Composite figure of reported American eel bycatch occurrences and weight of catch in individual sets (1977-2010) from the northwest Atlantic as recorded by commercial fisheries observers reporting information to DFO, Science Branch, Maritimes Region.

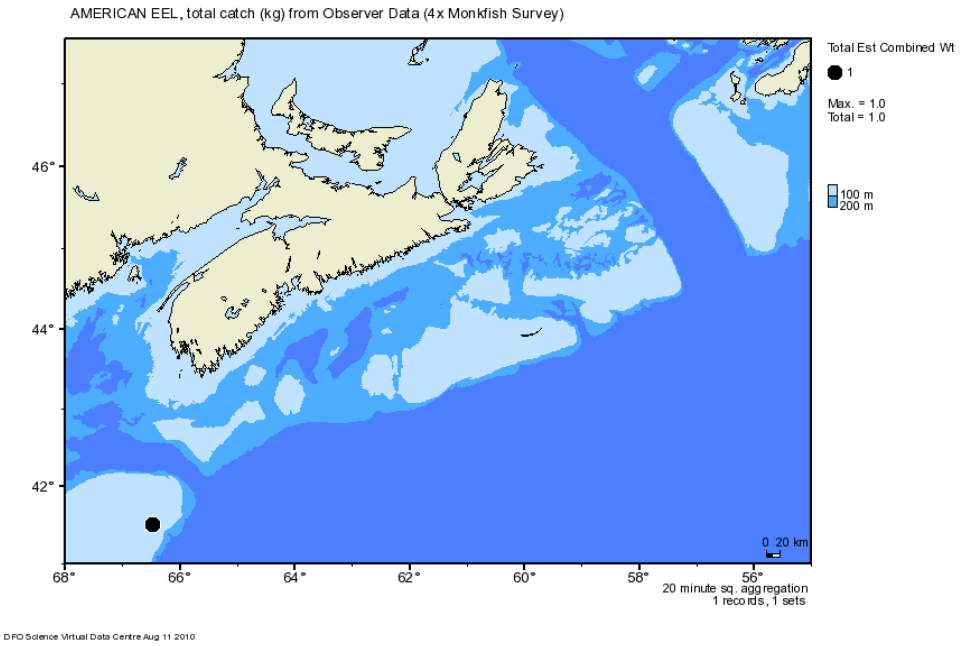

Figure 14. Occurrences and weight of American eel bycatch in individual sets as reported by observers monitoring the Northwest Atlantic Fisheries Organization 4X Division monkfish fishery (1977-2010) and reporting information to DFO, Science Branch, Maritimes Region.

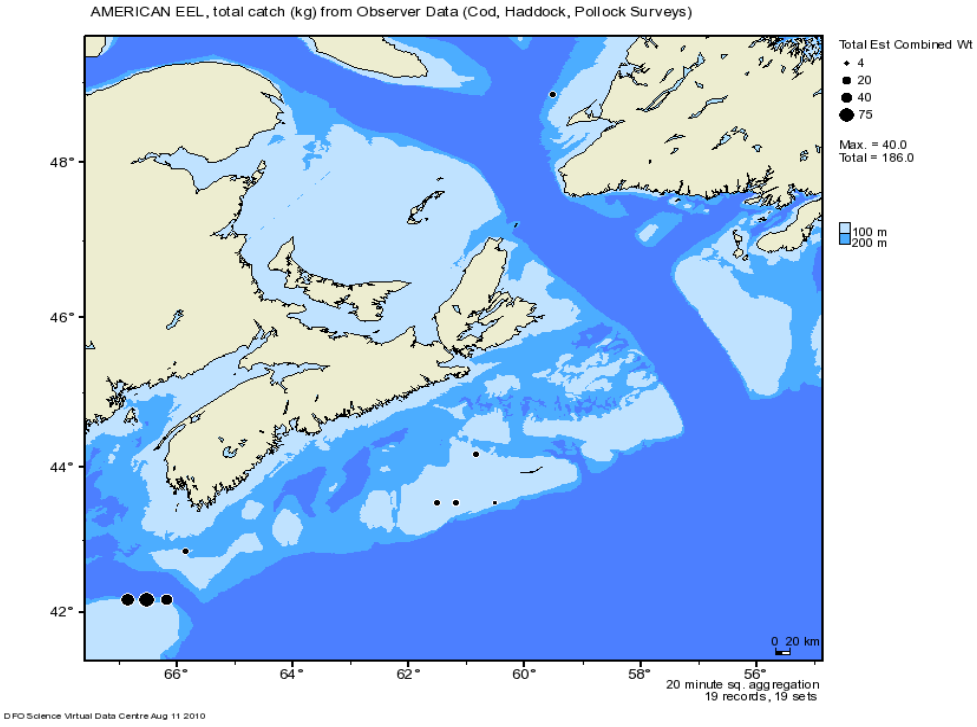

Figure 15. Occurrences and weight of American eel bycatch in individual sets as reported by observers monitoring northwest Atlantic cod, haddock and pollock fisheries (1977-2010) and reporting information to DFO, Science Branch, Maritimes Region.

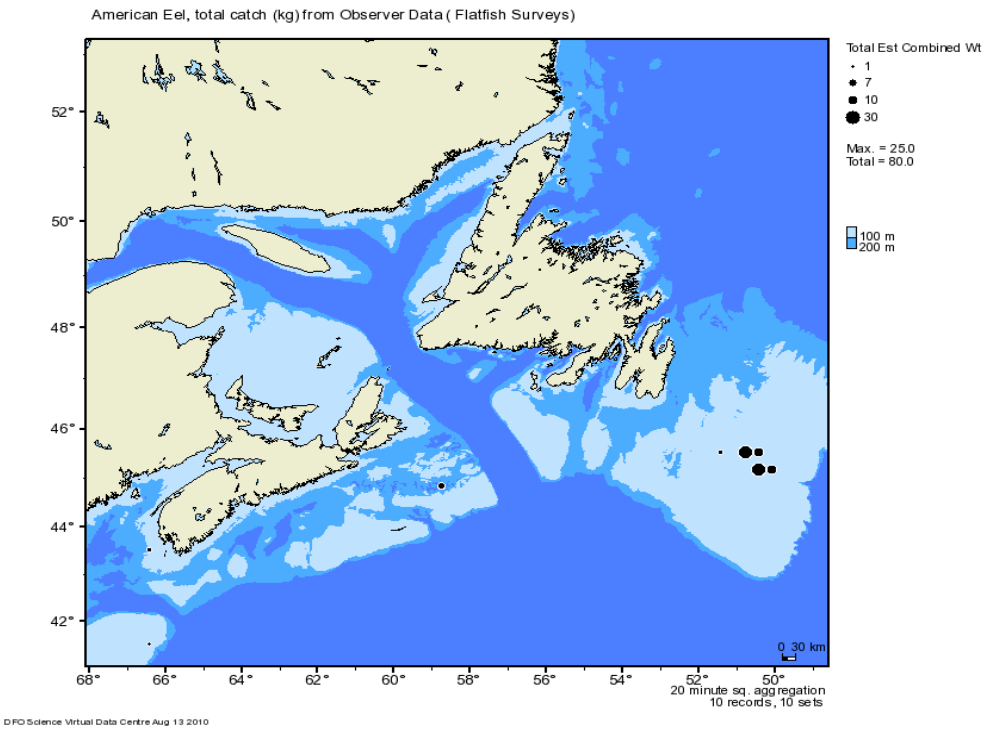

Figure 16. Occurrences and weight of American eel bycatch in individual sets as reported by observers monitoring northwest Atlantic flatfish fisheries (1977-2010) and reporting information to DFO, Science Branch, Maritimes Region.

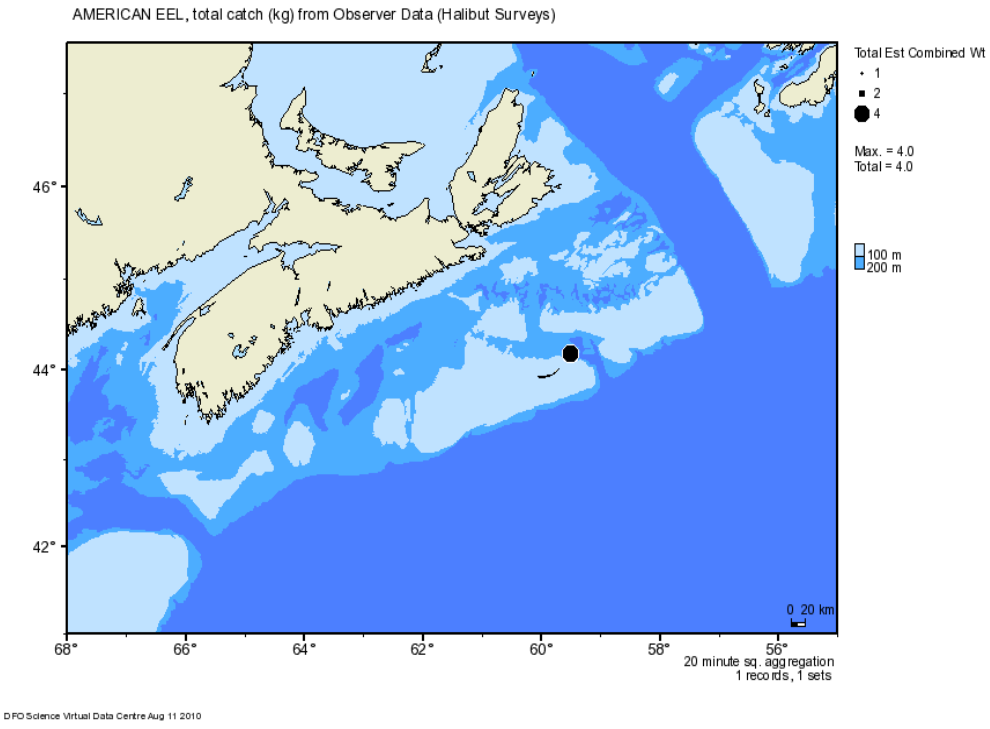

Figure 17. Occurrences and weight of American eel bycatch in individual sets as reported by observers monitoring northwest Atlantic halibut fisheries (1977-2010) and reporting information to DFO, Science Branch, Maritimes Region.

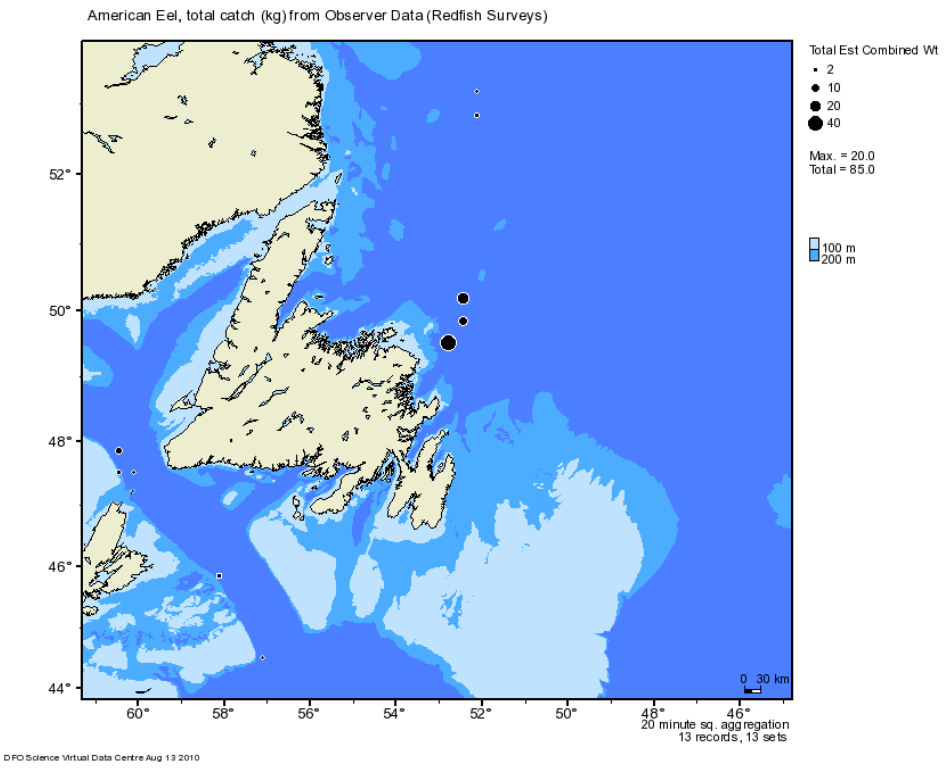

Figure 18. Occurrences and weight of American eel bycatch in individual sets as reported by observers monitoring northwest Atlantic redfish fisheries (1977-2010) and reporting information to DFO, Science Branch, Maritimes Region.

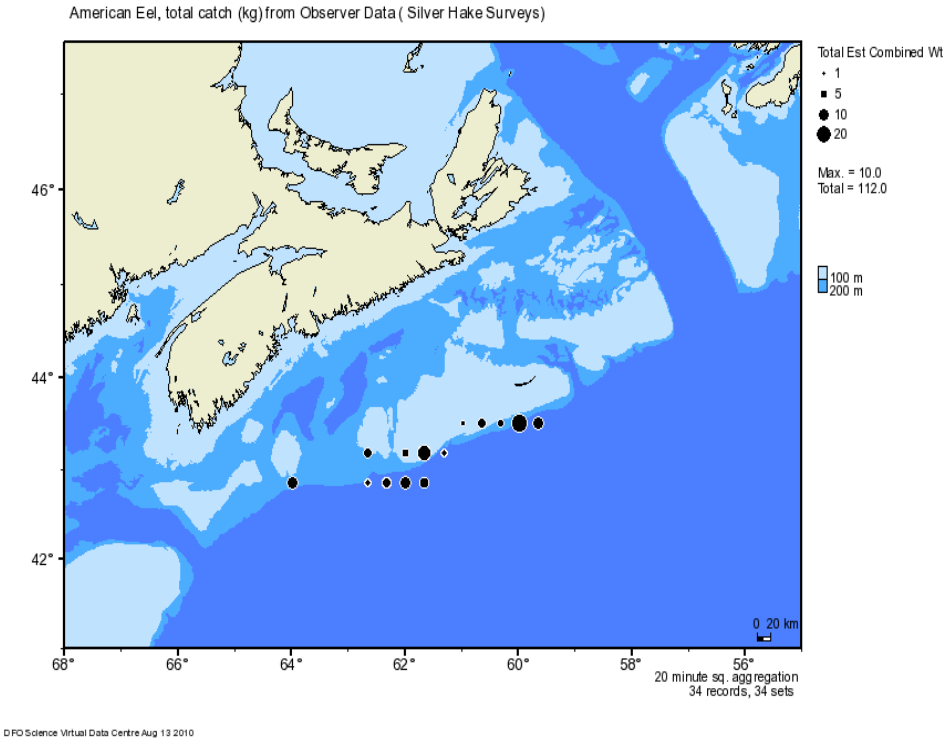

Figure 19. Occurrences and weight of American eel bycatch in individual sets as reported by observers monitoring northwest Atlantic silver hake fisheries (1977-2010) and reporting information to DFO, Science Branch, Maritimes Region.

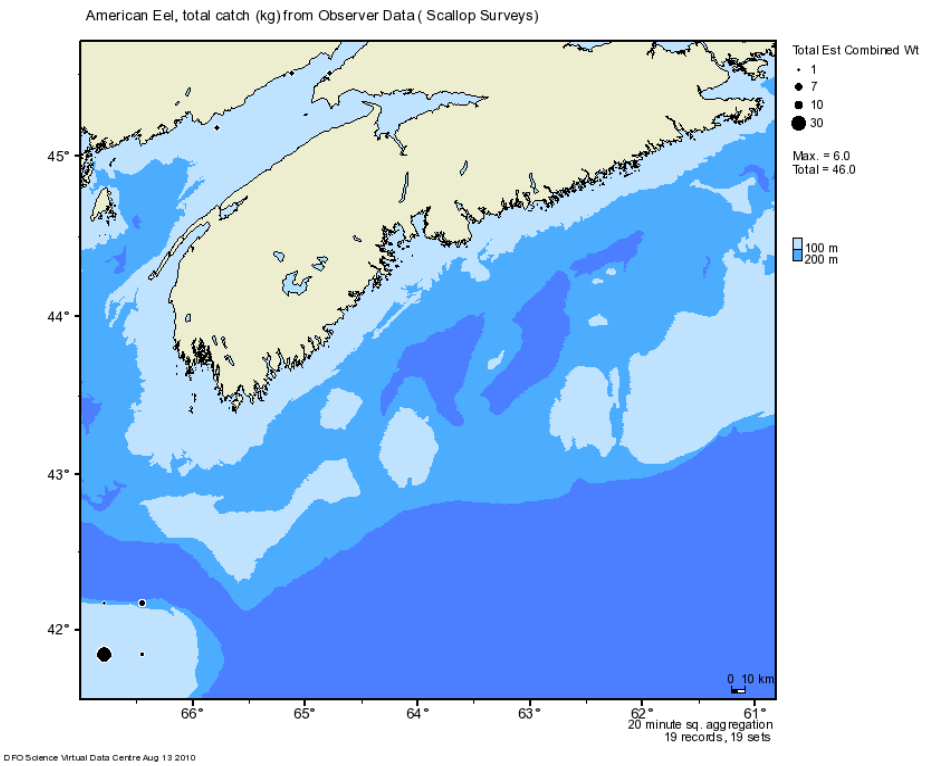

Figure 20. Occurrences and weight of American eel bycatch in individual sets as reported by observers monitoring scallop fisheries (1977-2010) and reporting information to DFO, Science Branch, Maritimes Region.

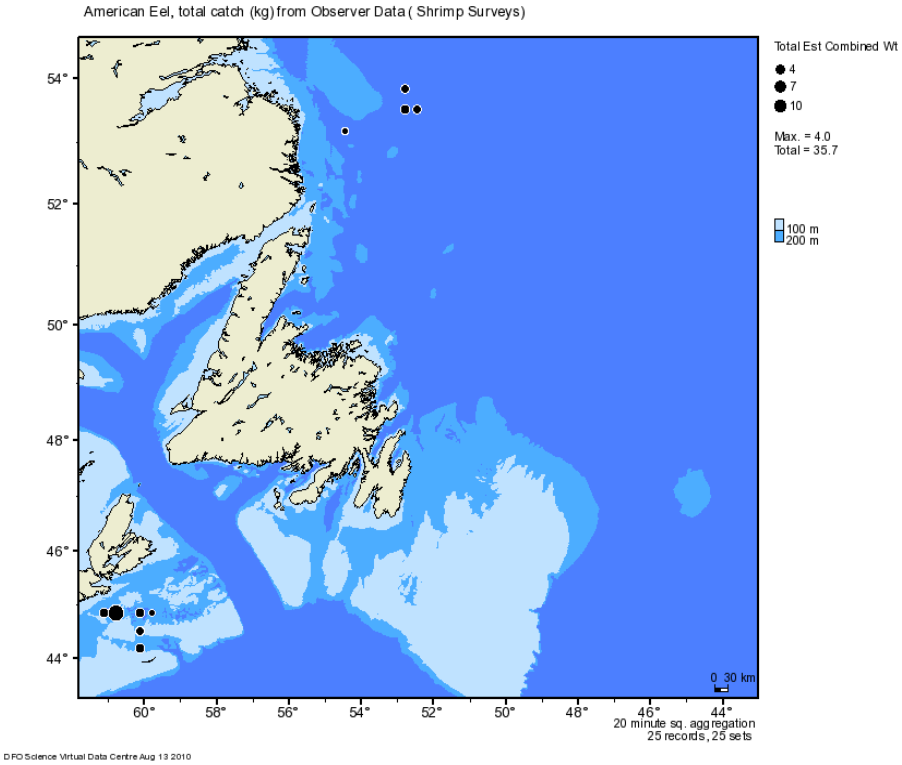

Figure 21. Occurrences and weight of American eel bycatch in individual sets as reported by observers monitoring northwest Atlantic shrimp fisheries (1977-2010) and reporting information to DFO, Science Branch, Maritimes Region.

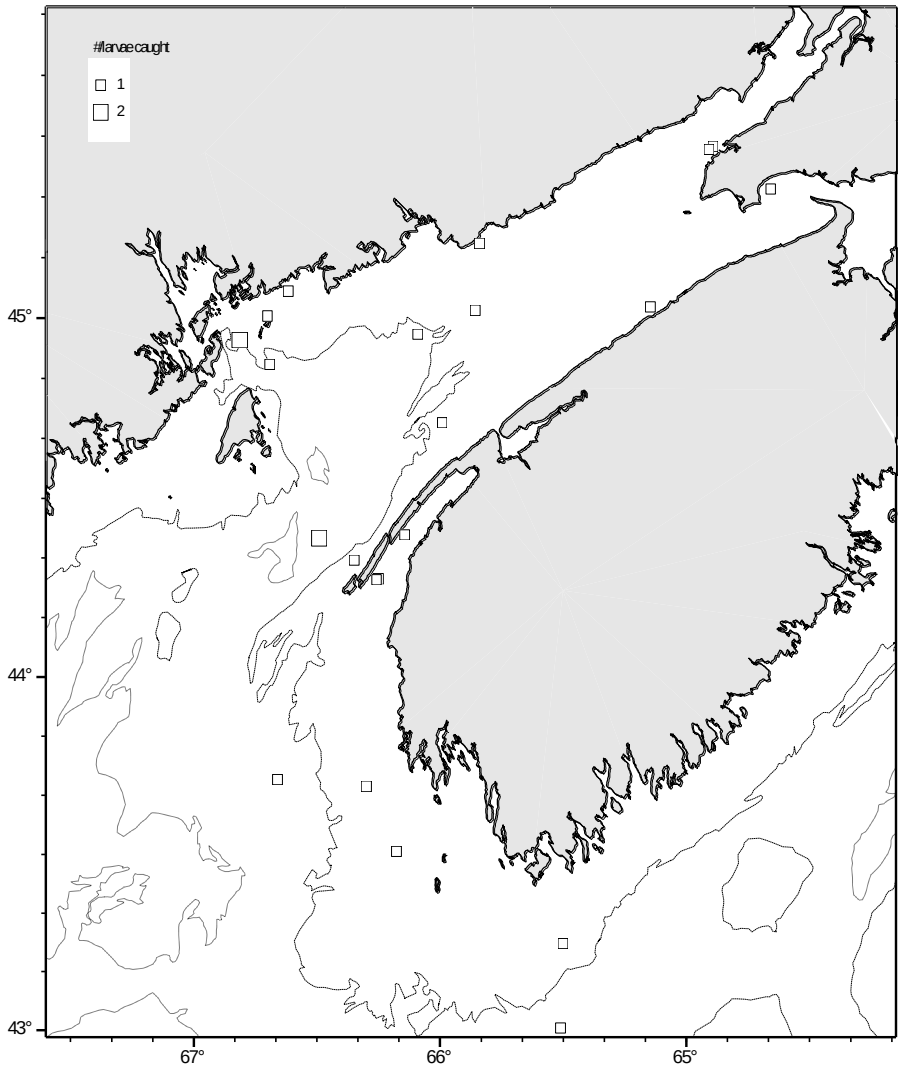

Figure 22. Eel abundance for all port bongo surveys (raw results; sorted stations only).

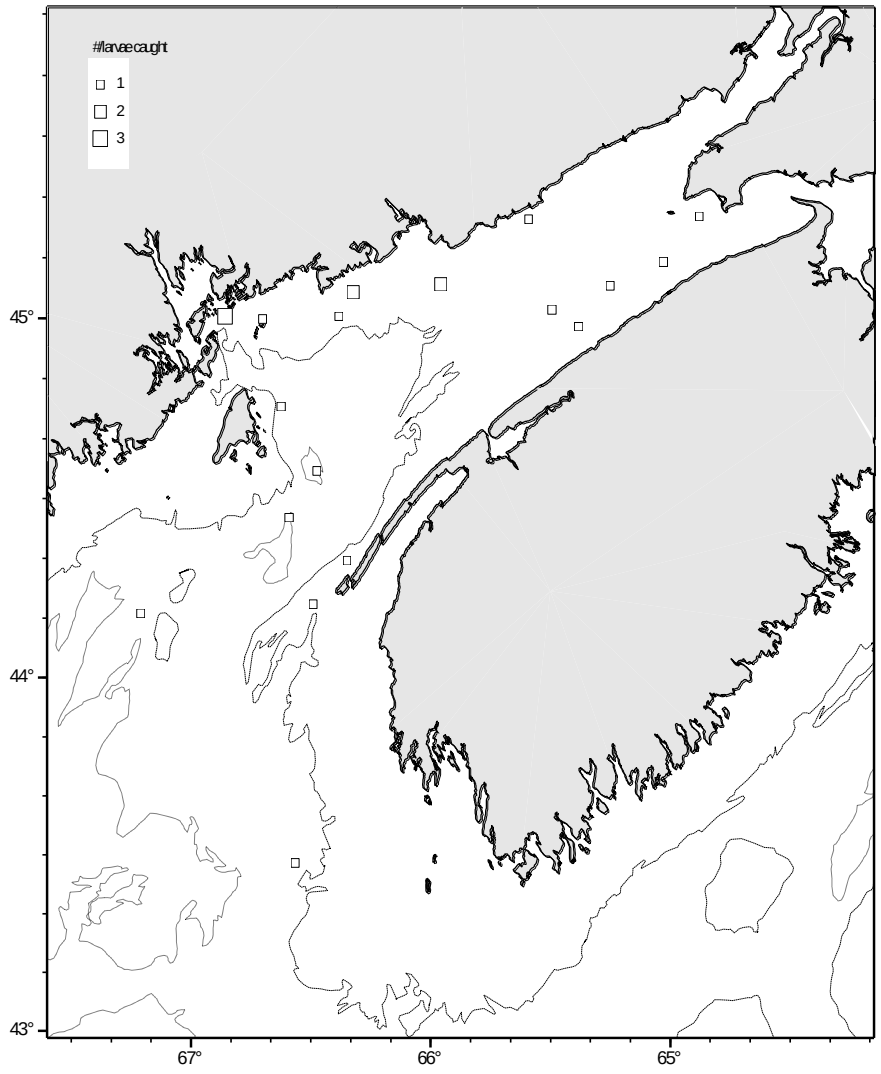

Figure 23. Eel abundance for all starboard bongo surveys (raw results; sorted stations only).

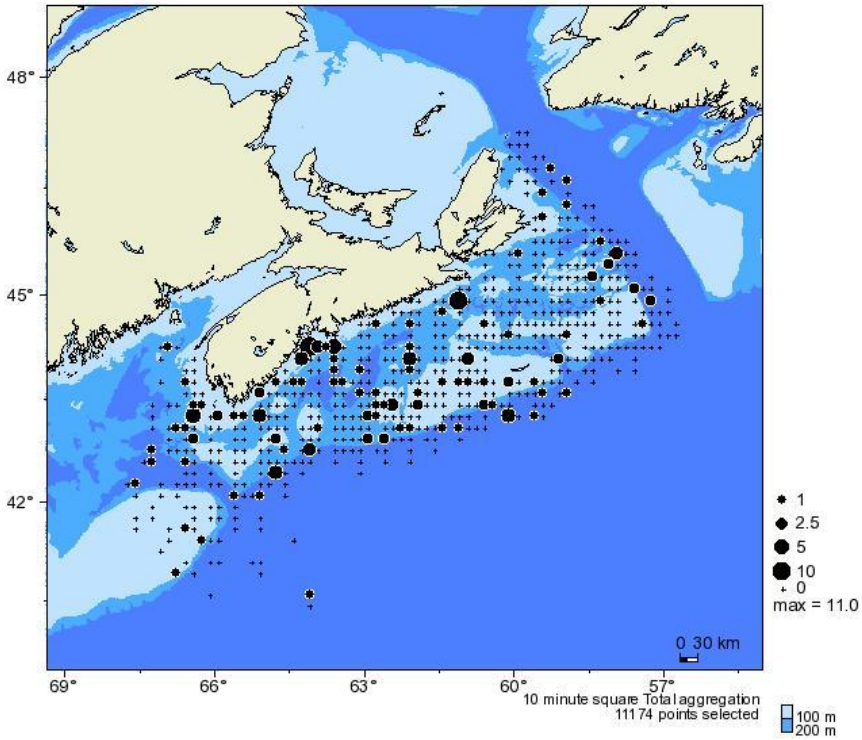

Figure 24. Distribution of leptocephali and glass eel catches (combined) during the Scotian Shelf Ichthyoplankton Program.

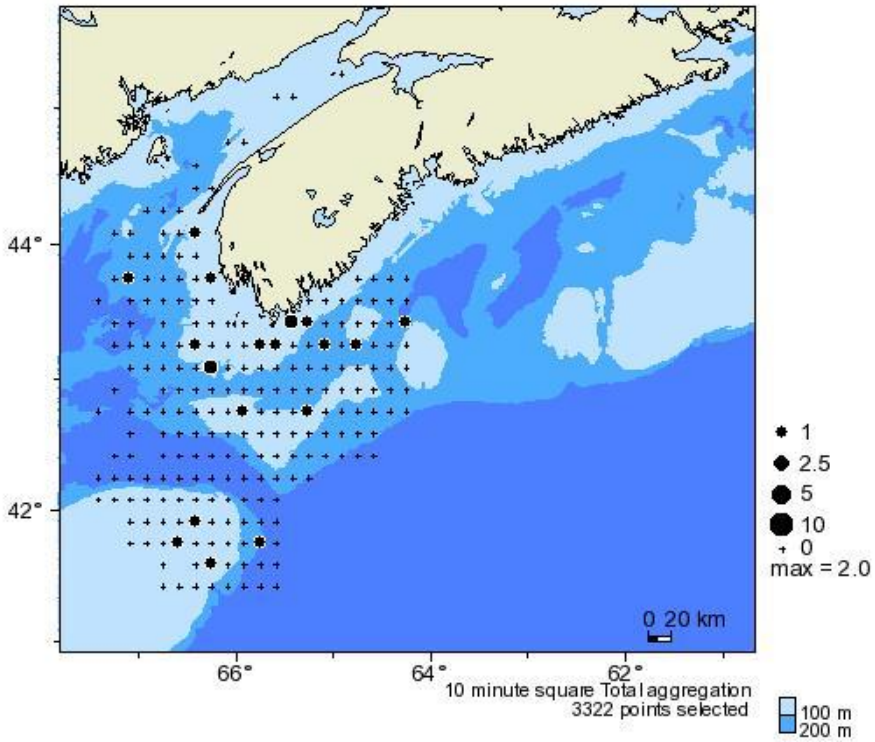

Figure 25. Distribution of leptocephali and glass eel catches (combined) during the Fisheries Ecology Program.