The American Eel in Eastern Canada: Stock Status and Management Strategies
Proceedings of Eel Workshop, January 13-14, 1997, Quebec City, QC

Management

R. H. Peterson (Editor)

Biological Station
St. Andrews, NB E0G 2X0

December 1997

Canadian Technical Report of Fisheries and Aquatic Sciences No. 2196

Fisheries and Oceans Pêches et Océans

Canada

Canadian Technical Report of
Fisheries and Aquatic Sciences 2196

December 1997

The American Eel in Eastern Canada: Stock Status and Management Strategies
Proceedings of Eel Management Workshop, January 13-14, 1997, Quebec City, QC

R. H. Peterson (Editor)
Fisheries and Oceans Canada
Biological Station
St. Andrews, New Brunswick E0G 2X0 Canada

This is the two hundred and twenty-eighth Technical Report of
the Biological Station, St. Andrews, NB

Cat. No. Fs 97-6/2196E ISSN 0706-6457

Correct citation for this publication:

Peterson, R. H. (Editor). 1997. The American eel in eastern Canada: stock status and management strategies. Proceedings of Eel Management Workshop, January 13-14, 1997, Quebec City, QC. Can. Tech. Rep. Fish. Aquat. Sci. 2196: v + 174 p.

TABLE OF CONTENTS

ABSTRACT

Peterson, R. H. (Editor). 1997. The American eel in eastern Canada: stock status and management strategies. Proceedings of eel workshop, January 13-14, 1997, Quebec City, QC. Can. Tech. Rep. Fish. Aquat. Sci. 2196: v + 174 p.

This report contains the papers presented to a meeting held in January 1997 to review stock status and the different management regimes for the American eel (*Anguilla rostrata*) stocks inhabiting Canadian rivers, and to seek consensus on a common approach to managing this resource. The meeting was held in Quebec City with officials participating from the provinces of Ontario, Quebec, New Brunswick, Prince Edward Island and Newfoundland, and the three Atlantic Regions and Headquarters (Ottawa) of the Department of Fisheries and Oceans (DFO). The meeting was convened at the request of the Province of Quebec because of dramatic declines in eel landings in the St. Lawrence.

The North American eel is made up of a single population that spawns in the Sargasso Sea and migrates to freshwater habitats where it grows to sexual maturity. Between 1980 and 1995, Ontario eel landings declined almost 50%, Quebec's are down about 30%, Prince Edward Island's fell over 60%, New Brunswick's have not changed significantly, Newfoundland's increased by over 60% before falling off in 1995, and Nova Scotia's, while remaining constant during most of the 1980s, tripled recently. Experimental elver licenses were first issued in Nova Scotia and New Brunswick in 1989. Four of the 10 experimental licenses were made permanent in 1997. Landings reached about 3000 kg in 1995 and 1996. An additional seven experimental licenses have been issued in Newfoundland. All of the Canadian jurisdictions have varying degrees of effort controls in place: license restrictions, gear limits and seasons. All jurisdictions have license freezes in place except Newfoundland and, with the exception of Ontario, all have size limits in place. Management measures have, to varying degrees, been tightened in recent years, most notably in areas of catch declines, i.e. Quebec, Ontario and Prince Edward Island. Factors identified as principally responsible for the decline in eel stocks are habitat loss and overfishing. Changes in oceanographic conditions were also identified as a potential contributor. Because of the eel's life history characteristics and broad acknowledgment that the overall population is low, participants agreed that a concerted, continent-wide approach to eel management was urgently required. Participants explored options for approaching US fisheries administrations for the purpose of arriving at such an approach.

RÉSUMÉ

Peterson, R. H. (Editor). 1997. The American eel in eastern Canada: stock status and management strategies. Proceedings of eel workshop, January 13-14, 1997, Quebec City, QC. Can. Tech. Rep. Fish. Aquat. Sci. 2196: v + 174 p.

Le présent rapport contient des articles présentés à une réunion tenue en janvier 1997 et dont l'objet était d'examiner l'état des stocks d'anguilles d'Amérique (*Anguilla rostrata*) qui habitent les cours d'eau canadiens ainsi que les divers régimes de gestion en vigueur et de tenter d'en arriver à un consensus sur un seul plan de gestion de cette ressource. La réunion a eu lieu à la ville de Québec; y assistaient des participants des provinces de l'Ontario, du Québec, du Nouveau-Brunswick, de l'Île-du-Prince-Édouard et de Terre-Neuve ainsi que des trois administrations régionales de l'Atlantique et de l'Administration centrale (Ottawa) du ministère des Pêches et des Océans (MPO). La réunion a été convoquée à la demande du gouvernement du Québec à cause des baisses extrêmes de débarquements d'anguilles dans le golfe du Saint-Laurent.

Les anguilles de l'Amérique du Nord font toutes partie d'une seule et unique population qui se reproduit dans la mer des Sargasse avant de migrer vers un habitat d'eau douce où elle demeure jusqu'à maturité sexuelle.

Entre 1980 et 1995, les débarquements d'anguilles en Ontario ont baissé de presque 50 %, ceux du Québec d'environ 30 %, et ceux de l'Î.-P.-É. ont connu une chute de plus de 60 %. Les débarquements au Nouveau-Brunswick n'ont pas connu de changement important. Par ailleurs, les prises à Terre-Neuve ont augmenté de plus de 60 % avant de chuter en 1995, et en Nouvelle-Écosse, après être demeurés stables pendant presque toute la décennie de 1980, les débarquements ont presque triplé récemment. Des permis de pêche expérimentale de la civelle ont été délivrés pour la première fois en Nouvelle-Écosse et au Nouveau-Brunswick en 1989. Quatre des dix permis de pêche expérimentale ont été rendus permanents en 1997. Les débarquements ont atteint près de 3 000 kg en 1995 et en 1996. Sept permis de pêche expérimentale supplémentaires ont été délivrés à Terre-Neuve. Au Canada, chaque instance contrôle l'effort de pêche, mais à des degrés divers : restrictions visant les permis, limites d'engins et saisons. Toutes les instances ont maintenant un gel sur la délivrance de nouveaux permis, à l'exception de Terre-Neuve. De même, toutes sauf l'Ontario imposent des limites de taille. Depuis quelques années, les mesures de gestion ont été resserrées à divers degrés, surtout dans les régions où les prises ont chuté, p. ex. au Québec, en Ontario et à l'Î.-P.-É. Les principaux facteurs que l'on soupçonne être la cause du déclin des stocks d'anguilles sont la perte d'habitat et la surpêche. Les changements dans les conditions océanographiques ont aussi été pointés du doigt comme une cause possible. Étant donné les caractéristiques du cycle biologique de l'anguille et puisque tous les intervenants reconnaissent que la population globale est à un faible niveau, les participants à la réunion ont convenu de l'urgence d'établir un plan de gestion de l'anguille pour l'ensemble du continent. Les participants ont étudié diverses possibilités quant à la façon d'aborder les régimes de gestion des pêches aux États-Unis dans le but d'en arriver justement à une démarche commune.

ACKNOWLEDGMENTS

The workshop participants wish to thank the staff of Ministere de l'Environnement et de la Faune who hosted the workshop, the proceedings of which constitute this technical report, in Quebec for their organizational skills and hospitality.

Brenda Best, the word processor at St. Andrews Biological Station, devoted a great deal of time in skillfully organizing and formatting the manuscripts included in the report.

We also wish to thank the various people who served as internal referees for the included manuscripts.

REMERCIEMENTS

Les participants à l'atelier souhaitent remercier le personnel du ministère de l'Environnement et de la Faune du Québec, qui a organisé cet atelier et dont les travaux constituent le présent rapport technique, pour son accueil et son sens de l'organisation.

Brenda Best, opératrice de traitement de texte à la Station biologique de St. Andrews, a consacré énormément de temps aux communications incluses dans ce rapport afin de les organiser et de les présenter de façon logique.

Nous souhaitons aussi remercier toutes les personnes qui ont agi comme arbitres internes dans l'examen des communications.

Introductory Remarks

by

R. H. Peterson
Fisheries and Oceans Canada
Biological Station
St. Andrews, New Brunswick, Canada, E0G 2X0

BACKGROUND

All North American eels are currently thought to represent a single panmictic population whose adults spawn in the vicinity of the Sargasso Sea and whose elvers are distributed in a non-specific manner to estuaries along the coast of eastern North America.

Although all North American eels may form a single population, the management programs, knowledge of population abundances and exploitation rates, and of basic life history parameters vary among management jurisdictions. Furthermore, there are varied opinions as to how eel populations should be managed, along with the impression that exploitation may be uncontrolled and/or increasing in some jurisdictions. Much of the variation in approach stems from this lack of knowledge.

There is a concern by eel management bodies that the current levels of exploitation may be excessive for long-term economic sustainability. Since there is apparently a single North American population, it would seem desirable to develop a common and cooperative approach to managing the eel resource.

In view of these concerns, a workshop on eel biology and management was convened in Quebec City in January 1997 with the following objectives:

- to review existing information on the status of the population, the current management programs and optimal approaches to managing the eel resource;
- to the extent possible, arrive at a consensus among Canadian jurisdictions on how to manage the eel resource; and
- to document this consensus and formulate a strategy for negotiating with US jurisdictions toward a consensus on how to manage the American eel resource in the future.

This technical report is a compilation of the presentations and conclusions of the Quebec City workshop.

CONTEXTE

On croit actuellement que toutes les anguilles d'Amérique du Nord constituent une seule population panmictique, dont les adultes se reproduisent aux environs de la mer des Sargasses et dont les civelles sont réparties un peu au hasard dans les estuaires de la côte est de l'Amérique du Nord.

Bien que les anguilles d'Amérique du Nord forment une population unique, les programmes de gestion, les connaissances sur l'abondance des populations et les taux d'exploitation, ainsi que sur les paramètres biologiques fondamentaux varient d'un secteur de gestion à l'autre. De plus, les opinions diffèrent quant à la façon de gérer les populations d'anguilles, et il subsiste une impression selon laquelle l'exploitation se déroulerait sans restrictions ou augmenterait dans certains secteurs de compétence. Une grande part des différences d'approche vient du manque de connaissances.

Les autorités responsables de gérer l'anguille sont préoccupées par les niveaux actuels d'exploitation qu'ils jugent excessifs pour maintenir la viabilité économique à long terme. Puisqu'il n'y a apparemment qu'une seule population en Amérique du Nord, il semblerait souhaitable d'élaborer une démarche commune et coopérative de gestion des ressources d'anguilles.

Compte tenu de ces préoccupations, un atelier sur la biologie et la gestion des anguilles a eu lieu à Québec, en janvier 1997, avec pour objectifs :

- de passer en revue l'information existante sur l'état de la population, les programmes actuels de gestion et les démarches optimales de gestion des ressources d'anguilles;
- dans la mesure du possible, d'arriver à un consensus des différents secteurs de compétence canadiens sur la manière de gérer les ressources d'anguilles;
- de documenter ce consensus et de formuler une stratégie de négociation avec les secteurs de compétence des États-Unis, en vue d'en arriver à un consensus sur la manière de gérer les ressources d'anguilles américaines dans l'avenir.

Le présent rapport technique offre une compilation des présentations et des conclusions de l'atelier de Québec.

Chemical Contamination, Habitat Loss and Potential Impact of Oceanic Factors on American Eel Recruitment in the St. Lawrence River

by

M. Castonguay, P. V. Hodson[1] and C. M. Couillard
Fisheries and Oceans Canada
Institute Maurice-Lamontagne
C.P. 1000
Mont-Joli, Quebec G5H 3Z4

[1]Director, School of Environmental Studies
Queen's University
Kingston, Ontario K7L 3N6

ABSTRACT

We critically review four potential causes of a drastic decline in juvenile American eels, *Anguilla rostrata*, recruiting to Lake Ontario (100-fold decline from 1985-93), and in juvenile eel densities in tributaries to the Gulf of St. Lawrence and Newfoundland. In panmictic *Anguilla*, recruitment variability must be interpreted at the species level. Silver eels from the St. Lawrence River were much more contaminated and had a higher prevalence of deformities and lesions than a reference stock, although they were, on average, less contaminated in 1990 than in 1992 (1.12 vs. 4.54 $mg \cdot g^{-1}$ for PCB; 0.025 vs. 0.07 $mg \cdot g^{-1}$ for mirex). Lethal toxicity from chemical contamination has been known to occur in the St. Lawrence eels for the past 30 yr. Major habitat perturbations in the St. Lawrence took place in the 1950s (St. Lawrence Seaway and hydroelectric dams), about 30 yr before recruitment started declining; this long delay argues against these perturbations being primary causes of the decline, although an unpublished, long-term CPUE series (1930-65) argues for a decline occurring simultaneously with the above major habitat perturbations. We have little data to assess the impact of commercial fishing, but this is not to say that fishing has had no impact. There is, however, indirect evidence that oceanographic changes may have played a role in the decline. American eel recruitment decline occurred at the same time as that of the European eel (*Anguilla anguilla*). Since both species spawn in the Sargasso Sea and migrate as larvae to continental waters, the coincidence in recruitment failure suggests an Atlantic-wide cause due, perhaps, to ocean climate. There is indirect evidence that the Gulf Stream has weakened in the 1980s. A slower Gulf Stream could interfere with larval transport and generate observed patterns of declining abundance of American eel only in northern North America, and relatively uniform declines of European eel throughout Europe. Overall, we are forced to conclude that we do not know the relative importance of anthropogenic versus oceanic impacts in explaining the eel decline. While specific causes are still unclear, our data indicate a threat to both species and to their commercial fisheries.

RÉSUMÉ

Nous procédons à une analyse critique des causes possibles de la forte diminution des jeunes anguilles américaines, *Anguilla rostrata*, recrutées dans le lac Ontario (100 fois moins en 1993 qu'en 1985), et des densités de jeunes anguilles dans les tributaires du golfe du Saint-Laurent et de Terre-Neuve. Pour cette *Anguilla* panmictique, il faut interpréter les variations de recrutement à l'échelle de l'espèce. Les anguilles argentées du fleuve Saint-Laurent étaient beaucoup plus contaminées et affichaient une plus forte incidence de malformations et

de lésions qu'un stock témoin, bien qu'elles aient été, en moyenne, moins contaminées en 1990 qu'en 1992 (1,12 par rapport à 4,54 $mg \cdot g^{-1}$ pour les BPC; 0,025 par rapport à 0,07 $mg \cdot g^{-1}$ pour le mirex). La toxicité létale de la pollution par les produits chimiques est observée chez les anguilles du fleuve Saint-Laurent depuis une trentaine d'années. D'importantes perturbations de l'habitat du Saint-Laurent ont eu lieu au cours des années cinquante (voie maritime du Saint-Laurent et barrages hydroélectriques), environ 30 ans avant que le recrutement commence à diminuer; ce délai prolongé semblerait indiquer que ces perturbations ne comptent pas parmi les principales causes de la diminution, bien qu'une série chronologique inédite des PUE à long terme (1930 - 1965), viendrait confirmer qu'un déclin se serait produit en même temps que les grandes perturbations de l'habitat mentionnées ci-dessus. Nous n'avons pas beaucoup de données pour évaluer les conséquences de la pêche commerciale, ce qui ne veut pas dire qu'il n'y en a pas eu. Toutefois, il existe des preuves indirectes du rôle joué par les changements océanographiques dans le déclin des anguilles. La baisse de recrutement de l'anguille américaine s'est produite en même temps que celle de l'anguille européenne (*Anguilla anguilla*). Puisque les deux espèces se reproduisent dans la mer des Sargasses et migrent, au stade de larve, vers les eaux continentales, la coïncidence de l'échec du recrutement laisserait croire à une cause à la grandeur de l'Atlantique, attribuable, peut-être, au climat océanique. Selon certaines preuves indirectes, le Gulf Stream aurait faibli au cours des années 1980. Ainsi, un ralentissement du Gulf Stream pourrait nuire au déplacement des larves et produire les tendances observées de diminution de l'abondance de l'anguille américaine seulement dans les parties septentrionales de l'Amérique du Nord, en même temps que des baisses relativement uniformes de l'anguille européenne dans toute l'Europe. Dans l'ensemble, nous sommes forcés de conclure que nous ne connaissons pas l'importance relative des facteurs anthropiques par rapport aux facteurs océaniques qui pourraient expliquer la baisse de l'anguille. Bien que les causes précises en soient encore incertaines, d'après nos données, il existe une menace pour les deux espèces et pour leurs pêches commerciales.

The presentation was based mostly on these publications:

Castonguay, M., P. V. Hodson, C. M. Couillard, M. J. Eckersley, J.-D. Dutil, and G. Verreault. 1994. Why is recruitment of the American eel declining in the St. Lawrence River and Gulf? Can. J. Fish. Aquat. Sci. 51: 479-488.

Castonguay, M., P. V. Hodson, C. Moriarty, K. F. Drinkwater, and B. M. Jessop. 1994. Is there a role of ocean environment in American and European eel decline? Fish. Oceanogr. 3: 197-203.

Hodson, P. V., M. Castonguay, C. M. Couillard, C. Desjardins, E. Pelletier, and R. McLeod. 1994. Spatial and temporal variations in chemical contamination of American eels (*Anguilla rostrata*) captured in the estuary of the St. Lawrence River. Can. J. Fish. Aquat. Sci. 51: 464-478.

An Overview of European and American Eel Stocks, Fisheries, and Management Issues

by

B. M. Jessop
Department of Fisheries and Oceans
P.O. Box 550
Halifax, Nova Scotia
B3J 2S7

ABSTRACT

Concern about the origins and consequences of the recent decline in elver recruitment to European coasts, the decline in and present level of existing fisheries, and the sufficiency of spawning stock abundance has prompted a recommendation by the European Inland Fisheries Advisory Commission/International Council for the Exploration of the Sea Working Group on Eel for countries to implement the "precautionary principle" in management of European eel stocks. The "precautionary principle" advises maintenance of existing levels of fishing activity for elvers and larger eels, with no expansion except where demonstrably justified, and maintenance of, or increased effort in, stocking of inland waters and stock monitoring programs, and improvements to eel passage at obstructions. The wide variety among European countries of regulations governing elver and eel fisheries, and differences in national objectives, makes coordinated management of the continental eel resource difficult. Recent uncontrolled development of elver fisheries in the United States and uncertainty about the status of stocks of larger eels has prompted development of an Atlantic States Marine Fisheries Commission (ASMFC) interstate management plan for eels. This management plan should benefit the American eel resource by setting a common managerial objective, by mandating regulatory coordination among states, and by encouraging the stock monitoring and biological research necessary to manage effectively. Several Atlantic coast states have prohibited elver fisheries as a precautionary measure until the ASMFC interstate management plan for eels becomes available.

RÉSUMÉ

Les préoccupations au sujet des causes et des conséquences de la baisse récente du recrutement de civelles sur les côtes européennes, la baisse de l'exploitation et son niveau actuel, ainsi que la suffisance de l'abondance du stock reproducteur sont à l'origine de la recommandation, faite par la Commission européenne consultative pour les pêches dans les eaux intérieures / le Groupe de travail sur l'anguille du Conseil international pour l'exploration de la mer, afin que les pays mettent en application le « principe de précaution » pour la gestion des stocks d'anguilles européennes. Ce principe favorise le maintien des niveaux existants d'activités de pêche des civelles et des grandes anguilles, sans expansion, sauf lorsqu'on peut la justifier, et le maintien ou l'augmentation de l'effort de repeuplement dans les eaux intérieures et des programmes de surveillance des stocks, ainsi que de l'amélioration de la capacité de passage de l'anguille là où il y a obstacle. Il est difficile, compte tenu de la diversité des règlements de pêche des anguilles et des civelles dans les pays européens et des différents objectifs nationaux, d'assurer une gestion coordonnée des ressources d'anguilles continentales. La récente expansion désordonnée de la pêche des civelles aux États-Unis et les incertitudes au sujet de l'état des stocks de grandes anguilles ont mené à l'établissement, par l'Atlantic States Marine Fisheries Commission (ASMFC), d'un plan de gestion de l'anguille inter-États. Ce plan devrait être favorable aux ressources d'anguilles américaines, puisqu'il fixe un objectif de gestion commun, obligeant les États à coordonner leur réglementation et encourage la

surveillance des stocks et la recherche biologique nécessaires à une gestion efficace. Plusieurs États de la côte atlantique ont interdit la pêche de la civelle comme mesure de précaution jusqu'à ce que le plan de gestion inter-États de l'ASMFC soit mis en oeuvre.

INTRODUCTION

Apparent declines in, or uncertainty about, stocks of European (*Anguilla anguilla*) and American (*A. rostrata*) eels have generated concern among fishers, biologists, and fishery managers on both continents. American and European eels each comprise a single biological population, with a consequent requirement for consistent regional, international, and even continent-wide management to ensure conservation and optimum benefit from their exploitation. In North America in 1980, no need was perceived for an inter-regional approach to eel stock management (OMNR 1982). Recent support for consistent national and international management originates in current perceptions of recruitment and stock declines in Europe (Dekker et al. 1993; EIFAC/ICES In press; Moriarty 1996) and in parts of North America (Castonguay et al. 1994; CAEMM 1996; ASMFC 1997). In the United States, the Atlantic States Marine Fisheries Commission (ASMFC) has recently initiated development of a coordinated interstate plan to address resource conservation and fishery status and requirements, with the expectation of completion by mid-1998 (Field 1996; ASMFC 1997). The European Community Concerted Action AIR A94-1939 'Enhancement of the European eel fishery and conservation of the species' plan has produced a database of eel information (Moriarty 1996) and will accompany management advice with complementary plans for stock monitoring and research (EIFAC/ICES In press).

This paper summarizes the status of fisheries, eel stocks and management issues in Europe and the United States. The Canadian context has been covered by other papers in this report (Peterson 1997) and elsewhere, e.g., Castonguay et al. (1994), Jessop (1996), and Locke et al. (1995). The current status, by country, of European eel stocks, fisheries, and management issues has been thoroughly reviewed (Moriarty 1996; EIFAC/ICES 1993; EIFAC/ICES (European Inland Fisheries Advisory Committee/International Council for the Exploration of the Sea) 1994, In press). Comparable literature, by state, for U.S. eel stocks is currently unavailable but is being assembled for the ASMFC American Eel Management Plan. Preliminary data on American eel stocks in the United States provided by J. Field (ASMFC, pers.comm.) have been used in conjunction with other referenced documents.

In this report, stock status, if not simply unknown or uncertain, may be considered synonymous with fishery status, because rarely is information on stock abundance, size and age composition, growth rate, etc. known for the eel stock of any river let alone the numerous rivers of a geographic area. Fishery catch, rarely accompanied by fishing effort, is the primary source of information on the status of a regional or riverine stock in both Europe and North America. Annual catches, but not fishing effort, by country can be found for Europe in the United Nations Food and Agricultural Organization (FAO) yearbook Fishery Statistics: Catches and Landings. Comments on the validity of the national catch statistics for the year 1993 are given in Moriarty (1996), where the catch of European eel is concluded to be over 40% greater than that reported in FAO statistics. In the United States, annual catches and dollar values, but not fishing effort, are summarized for each state, where available, by the National Marine Fisheries Service (NMFS). These summaries are generally regarded as incomplete (CBP 1991; Gray 1991; Crawford 1996; NMFS 1997).

Much of the demand for large eels from North America originates in Europe, where catches of European eels are insufficient to supply the market; domestic demand is relatively minor. The market for *A. rostrata* elvers is driven by Asian requirements for aquaculture seed stock. About 70-80% of world cultured eel production is consumed in Japan and 20-30% in Europe (Heinsbroek 1991). The lower attractiveness, relative to domestic species, of *A. rostrata* in both European and Asian markets leads to volatility in demand and prices. Although the Japanese demand for *A. rostrata* elvers remains low due to past culturing experience and market preferences (Gousset 1992), the growing demand during the 1990s by Taiwan and China has fueled a rapid development and expansion of elver fisheries in North America. Occasional prices of over $500 US per kilogram (CAEMM 1996) have, despite high intra-seasonal and annual volatility, provided many fishers an incentive to enter the elver fishery.

EUROPE

ELVER FISHERY

Licensed commercial elver fisheries occur in most European countries with an Atlantic coast and in several countries with Mediterranean coasts. In Scandinavia, **Norway** does not permit elver fisheries, but the runs are perhaps too small to be attractive economically, while **Sweden** allows elver fishing only for restocking and transfer within river systems (elvers may be imported for stocking).

Danish fisheries have been inactive since elver abundance declined in the late 1980s but elvers are imported for culture, of which a portion (7.4 million in 1994) are stocked. **Ireland** (Republic) permits elver fisheries only for inland stocking and some aquaculture (catches <8 t), while **Northern Ireland** prohibits elver fisheries except that stocking occurs in one river. **England** has a major fishery (recent annual catches of about 20 t) in the Severn River estuary. Most English elvers are exported to continental Europe, primarily Scandinavia, for culture. The **Netherlands** prohibits elver fishing except that, as of 1995, 5% of the total run to the Ijsselmeer may be caught. **German** catches of elvers along the Baltic coast are low and declining; inland stocking mainly uses imported elvers. Extensive elver fisheries occur along the Atlantic coasts of **France** (primarily in the Bay of Biscay), **Spain**, and **Portugal**. The use of push nets by the French elver fishery developed rapidly in the late 1960s in response to increasing Spanish market prices (Castelnaud et al. 1994). In 1989, French fishers landed about 520 t of elvers (Castelnaud et al. 1994) while in 1994, elver catches were about 300 t in France, 200 t in Spain, and 5 t in the River Minho estuary of Portugal (Moriarty 1996). Uncontrolled, probably important, recreational fisheries for elvers occur in Spain and Portugal. France prohibits elver fishing along the Mediterranean coast but Spain and **Italy** have active fisheries. French elver catches are primarily exported to Spain for food consumption and to Asia for aquaculture but some are sent to northeastern Europe for stocking. Spain consumes its elver catch and imports large quantities for consumption while Italy uses its elver catches in culture and some restocking.

YELLOW/SILVER EEL FISHERIES

The size of European commercial fisheries for yellow/silver (large) eels often contrasts with the size of their elver fisheries, e.g., a minimal elver and major large eel fishery in **Sweden** and **Germany**, as compared with **Spain** and **Portugal** which have large elver and small large eel fisheries while **France** has major elver and moderate large eel fisheries (Moriarty 1996). In Sweden, small yellow eels are caught for restocking inland waters (about 60 t in 1995) while larger yellow and silver eels (recent annual catch of about 1,000 t; Table 1) are consumed locally or exported to Denmark and Germany.

Table 1. Catches of *A. anguilla*, by country, for 1993. Source: FAO Fishery Statistics: catches and landings (1995) as reported by Moriarty (1996).

Annual catch >100 t		Annual catch <100 t	
Country	Catch (t)	Country	Catch (t)
Albania	210	Belarus	13
Belgium*	125	Croatia	5
Denmark	1,837	Czech Rep.	32
France	1,676	Estonia	59
Germany	1,027	Finland	0
Greece*	354	Latvia	18
Hungary	263	Russian Fed.	35
Ireland	150	Slovakia	7
Italy*	3,490	Switzerland	4
Netherlands	418	UK England/Wales	88
Norway	340	Yugoslavia	8
Poland	1,116		
Portugal	537		
Spain*	245	*Catch values may include aquaculture	
Sweden*	1,336		
Turkey*	261		
UK N. Ireland	662		
Total European	14,316		

Danish catches of larger eels have declined by about 50% since 1980 to about 1,100 t in 1994, lagging the decline in glass eel recruitment. Yellow eels are caught mainly by fyke nets and baited pots in Sweden and by fyke and pound nets in Denmark while pound nets are used in the coastal waters of each country for fishing silver eels.

German commercial eel catches in the Baltic Sea in 1993 totaled about 1,200 t (FAO statistics in Table 1 underestimate by 200 t) while recreational (angling) catches were estimated at 200-400 t and perhaps as high as 1,000 t. The number of German eel licenses is declining, as is catch per hectare (from 3.5 $kg \cdot ha^{-1}$ in 1982 to about 2.2 $kg \cdot ha^{-1}$ in 1993), but the area fished per license is increasing.

Catches of larger eels in **Northern Ireland** may be closer to 730 $t \cdot yr^{-1}$ and 250 $t \cdot yr^{-1}$ in the **Irish Republic** than to the FAO values of Table 1 (Moriarty 1996). The Irish use longline and fyke nets in lakes and weirs and stow nets in streams. An angling fishery in the Irish Republic may take an unreported catch of about 100 t. **British** catches of larger eels are unreliably estimated as 40-300 t, primarily by fyke net.

The largest **Dutch** fishery occurs on Lake Ijsselmeer and has declined from over 1,000 t in the 1960s to less than 250 t in the mid 1990s, following the observed decline in glass eel recruitment. Yellow eels in the Ijsselmeer are overfished, with a fishing mortality rate of 0.45, about four times the optimum. No records are kept of eel fisheries in Dutch coastal or inland waters other than the Ijsselmeer.

In **France**, few freshwater fisheries exist for yellow eels but they are moderately important in coastal waters, particularly in Mediterranean lagoons. The silver eel fisheries of larger French rivers are affected by the high mortalities occurring when eels pass through the turbines of the hydroelectric dams on most rivers. Data on catch and effort for French yellow/silver eel fisheries is scarce but a minimal estimate of the 1993 catch is about 1,700 t. Eel densities in most or all watersheds have decreased drastically since the 1980s. Larger eels are exported to Germany, Belgium, or the Netherlands while smaller eels from the Mediterranean coast are shipped to Italy.

Spanish and **Portuguese** yellow/silver eel fisheries are poorly documented but minimal recent catch estimates are about 250 t and 540 t, respectively. No restocking occurs in Spanish or Portuguese rivers, most of which have hydroelectric dams. Most **Italian** catches of yellow/silver eels (about 3,000 t) derive from culture and managed fisheries in coastal lagoons in the upper Adriatic and Po River delta regions with minor catches in inland fisheries.

For 1993, the total annual catch of European eel was estimated as 20,000-30,000 t (Moriarty 1996), as compared with about 14,000 t by the FAO (Table 1). Glass eels accounted for 4% of the total weight and 33% of the landed value of 180 M ECU (Canadian $306 million). The annual capture of 2-3 billion elvers, of which more than 95% are utilized at that stage for food or aquaculture and less than 5% contribute to stock enhancement, implies that sufficient glass eels exist to support a much larger stocking program. Fewer than 500 fishers engage full-time in eel fishing. About 25,000 part-time fishers derive a significant economic benefit from participation in the fishery, particularly since capital investment requirements are low and many coastal fishing communities have high unemployment. The decline of many eel fisheries over the past 20 years or so has been attributed to recruitment failure and inadequate management measures.

AQUACULTURE

The European demand for eels as food cannot be satisfied by wild-stock fisheries. Recent improvements in techniques for intensive, recirculating system culture of eels have resulted in substantial growth of eel aquaculture in northwestern Europe. **Italian**, **Greek**, **Portuguese** and **Spanish** eel production remains primarily pond culture. Eel production in 1996 is estimated as follows (EIFAC/ICES in press):

Country	Number of farms	Production (t)
Belgium	2	140
Denmark	30	1,200
France	1	25
Germany	13	140
Greece	9	350
Holland	45	1,800
Hungary	1	?
Italy	120-150	3,000
Norway	1	200
Portugal	4	110
Spain	4	250
Sweden	4	200
U.K.	1	25
Total	235-265	7,440

MANAGEMENT ISSUES

Issues relevant to the management of the eel fisheries in Europe, such as fishery and licensing regulations and enforcement, catch statistics collection, regional and total stock status, habitat availability and quality, pollution and contamination, and fish disease, are common to each country. Each country may, however, address them in different ways. For example, although all countries license commercial eel fisheries, the nature and enforcement of such licensing varies and in many countries unregulated or poorly regulated recreational fisheries are quasi-commercial in nature. Not all countries have minimum length limits for eel retention and, of those that do, the lengths range from 200 mm in **Portugal** to 450 mm in **Danish** inland waters and 295-380 mm in coastal waters. Most countries control the types of gear that may be used to fish eels, but some do not control the quantities of gear employed. All countries with significant elver and yellow/silver eel fisheries regard them as important sources of seasonal employment and income to generally disadvantaged coastal fishers. The extensive geographic distribution of most fisheries, inadequate fisheries regulations, or inability to enforce regulations are recognized difficulties and contribute to incomplete catch statistics and general underreporting of catches. Recreational (angling) fisheries for larger eels are also important in many European countries and, in some, e.g., **France** (Cantrelle 1982; Castelnaud 1994), recreational fisheries for elvers occur, but their catches are uncontrolled, poorly known, and probably sold commercially. The decline in elver recruitment since the early 1980s (which may now have leveled

off or even begun to increase) has generated scientific interest in the nature of its origin (e.g., oceanic conditions) and concern over possible future effects on yellow/silver eel abundance (Moriarty 1990, 1996; Dekker 1996).

Although no explicit management recommendations have been made by the EIFAC/ICES Working Group on Eel because of inadequacies in the scientific data and lack of commonality in management objectives among countries, the "precautionary principle" has been recommended for use by nations to develop regulatory regimes that achieve stock conservation yet sustain fishery employment at current levels (EIFAC/ICES In press). Countries are encouraged to maintain, and enhance where possible, spawner escapement by maintaining fisheries for elvers, yellow, and silver eels at current levels, by maintaining or increasing enhancement activities such as restocking and improvements to upstream and downstream passage of eels at obstructions, and by maintaining or increasing monitoring programs to assess stock status so that the "precautionary principle" can be usefully applied.

Countries such as **Spain** and **Portugal** do not provide facilities for upstream or downstream passage of eels at obstructions and do not restock obstructed waters while some have recently recognized such a need, e.g., **England**. Others such as **Denmark**, **France**, and **Germany** either require passage facilities at obstructions, engage in active restocking of obstructed waters, or do both. France has perhaps the most active program to investigate appropriate methods of providing upstream passage for elvers and smaller eels and downstream passage for silver eels, where high mortality occurs during passage through hydroelectric turbines. Habitat degradation and loss due to development and pollution are also major concerns for the densely populated, more industrialized countries such as **England**, **Holland**, **France**, and **Germany**. All countries share concern over the spread and potentially deadly effects of the parasite *Anguillicola crassus*, and the importation of exotic species of eel should be more fully controlled to prevent introduction of further parasites (EIFAC/ICES In press).

Eels have been and remain extensively studied by university faculty and state agencies in many European countries, particularly those with large eel fisheries or substantial aquaculture. Consequently, the base of current and historical information on European eel biology and the fisheries is substantial even if often inadequate to fully answer the most urgent of current questions.

UNITED STATES

ELVER FISHERY

Interest in fishing for American elvers, primarily for export to Asia for aquaculture, developed in **Florida**, **North** and **South Carolina**, **Virginia** and **Maine** during the early 1970s (Fahay 1978; Keefe 1982; Mullis 1982). Elver fisheries failed to develop in Florida, ceased in 1977 in North Carolina and probably also in South Carolina, and were prohibited in 1977 by a 15 cm minimum size limit in Virginia (CBP 1991). Reported catches in Maine were 10 t in 1977 and 7.6 t in 1978 (Dow 1982) but catch statistics are unavailable for the other states. The Maine elver fishery collapsed after 1978 but continued at a low level until growing substantially in 1994, with reported catches of 3.3 t in 1994, 7.5 t in 1995, and 4.6 t in 1996 (CAEMM 1996; L. Flagg, Maine Department of Marine Resources, pers.comm.). With the exception of 1977 and 1978, elver catches in Maine cannot be separated from yellow/silver eel catches prior to 1994 when specific records of elver catches were initiated. During the late 1980s or early 1990s, elver fisheries were developed or reestablished in **Connecticut**, **Rhode Island**, **New York**, **New Jersey**, **Delaware** and South Carolina, but no catch data are available. Elver fisheries evidently do not occur in any **Gulf of Mexico** states.

The recent surge of interest in fishing for elvers and the sometimes chaotic nature of the fishery has evidently caught state fishery managers unprepared. Few states which presently permit elver fisheries (**Maine**, **Connecticut**, **New Jersey**, **Pennsylvania**, **South Carolina**, **Virginia** and **Florida;** Table 2) have comprehensive regulations for those fisheries. Although 10 (9 if Virginia is excluded) of 15 Atlantic coastal states presently ban elver fisheries, several states prohibited the elver fishery only recently in response to a perception of uncontrolled development. Permits to fish elvers may specify various conditions, such as quota, area to fish (all are restricted to tidal waters), gear types, season, etc.

Maine leads other elver fishery states in modernizing its elver/eel fishery regulations. It has recently proposed and/or implemented regulatory changes to increase elver/large eel license fees to $200.00 in an effort to reduce the number of licensed fishers and dedicate license fee revenues to eel

research. It will also impose a March 16-June 14 fishing season and two day weekly closed time for elvers (defined as eels less than 15 cm long), limit the number, type, and methods of operation of gear units available to each fisher in an attempt to control fishing effort, limit elver fishing to the intertidal area and the shoreward one-third of a stream (both shores), and prohibit both elver fishing within 46 m of any dam and bycatch of other species (CAEMM 1996).

The **Connecticut** regulations were minimal until 1996, e.g., no small mesh fyke nets, but pots and dipping are permitted; catch reporting requirements permit minimal interpretation of catches. In 1996, Connecticut defined the glass eel as less than 10 cm in length, instituted a March 1-May 21 glass eel fishing season with a weekly closed period from 6:00 am Saturday to 6:00 am Sunday, prohibited obstruction of more than 50% of the stream width and placement of traps within 7.6 m of each other, limited traps to a maximum of 10 within the state and 3 in any stream (dipnets are the preferred fishing gear) and required monthly catch reporting by logbook. The elver fishery in **New Jersey** was unregulated prior to 1996 when it was restricted to dip-nets only and a fishery season was implemented (February 15-April 20) with a Sunday closure (ASMFC 1997; J. F. McClain, New Jersey Division of Fish, Game and Wildlife, pers.comm.).

At various periods between 1957 and 1980, elvers (range 23,000 to 6,000,000 elvers) were annually stocked in the Susquehanna River, **Pennsylvania** upriver of hydroelectric dams, but no commercial elver fishery is permitted. After restoration of American eels to the Susquehanna River basin following fish passage construction (to be completed by the year 2000), Pennsylvania plans to adopt regulations preventing the overharvest of small eels (CBP 1991).

Virginia issued, in 1996, two permits to fish a total of about 800 kg of elvers for local aquaculture; no additional permits are planned for several years. When the cultured elvers have been reared to sale size, 10% must be returned to the state for release in the wild. **South Carolina** has an active elver fishery but no permit is required and no catch statistics are collected. No elver fishery occurs in **Florida** but one experimental permit has been issued to see if a fishery can be developed.

The number of elver fishers is generally unregulated in those states where an elver fishery occurs (excluding **Virginia** and **Florida** where permits have been limited to two and one, respectively). In **Maine**, the number of commercial finfish permits (which may be used to fish eels as well as other species) almost tripled between 1985 and 1995 and more than doubled between 1994 and 1995 to over 3,300 permits, of which over 1,500 are believed to be elver fishers (CAEMM 1996). **Connecticut** has had a moratorium on new commercial fishing licenses since 1995 but existing licensees can fish elvers if they choose. In **New Jersey**, over 2,100 licenses were issued for the 1997 elver dip-net fishery (J. McClain, New Jersey Division of Fish, Game and Wildlife, pers.comm.) . **South Carolina** had no mechanism for determining participation in the elver fishery in coastal waters until 1996 when a permit was instituted (B. McCord, South Carolina Department of Natural Resources, pers.comm.). In 1997, about 65 permits for elver hoop nets (a type of fyke net) and 11 permits for dip nets were issued. Each permit may authorize one or more units of gear.

Some states (**Maine**, **Connecticut**, **New Jersey**, **Pennsylvania**, **South Carolina**, **Florida**) have no minimum length limit for eel retention (Table 2). **New Hampshire** has a 10 cm minimum size limit as does **Massachusetts**, except for aquaculture (Amaral 1982). A 15-cm minimum size limit was imposed in **Virginia** in 1977 (CBP 1991) and has existed in **Georgia** since at least the early 1980s (J. Music, Georgia Department of Natural Resources, pers.comm.). **New York**, **Rhode Island**, **Delaware**, **Maryland** and **North Carolina** have only recently (1992-1995) imposed a minimum length limit of 15 cm so as to protect elvers for local aquaculture development or, more urgently, to prevent uncontrolled development of an elver fishery. These states await the recommendations on elver fishery development expected in the ASMFC fishery management plan for eels. In 1994, Maryland permitted a daily harvest per person of up to 25 eels of less than 15 cm for use as bait, primarily by anglers.

Table 2. Summary of selected commercial eel fishing regulations, by state, for the United States Atlantic coast. Regulations are subject to change; contact each state for current regulations. (Modified from Table 1, ASMFC 1997).

State	Minimum length (cm)	Pot mesh size (cm)	Freshwater fyke	Weirs	Fishing season	Comments
Maine	none	no	no	no	March 15-June 15	noon Sat. to noon Sun. closure; max. 5 elver traps/fykes per license
Maine	15	1.25x1.25	yes	yes	June 16-March 14	
New Hampshire	10	yes	no	no		
Massachusetts	10		no	no		
Rhode Island	15		no	no		
Connecticut	none	no	no	no	Feb. 1-May 31 (elvers)	License moratorium; max. 10 elver traps per license
New York (marine)	15	2.5x1.25				
New York (inland)	not >35.6	No opening < 5 cm dia.	yes	yes		
Pennsylvania	none		yes	yes		
New Jersey	15	0.48 bar	no	no	Feb. 15-Apr. 20 (elvers)	dipnet only for elvers; Sun. closure
Delaware	15	no	no	no		
Maryland	15	0.5x0.5	no	no		License moratorium
Virginia	15	1.25x1.25	no	no		
North Carolina	15	2.5x1.25	no	no		2 elver permits for aquaculture
South Carolina	none	1.25x1.25	yes (1 river)	no		
Georgia	15	3.8x1.25	no	no		
Florida	none	2.5x1.25	no	no		1 experimental elver permit

Maine has a defined elver fishing season (March 15-June 15) as does **Connecticut** (February 1-May 31) and **New Jersey** (February 15-April 20; Table 2). No states with an elver fishery, other than Maine, seem to have begun collection of catch statistics although this is expected to change when the ASMFC fishery management plan for eels has been developed. Poaching of elvers is believed a serious problem in many states but enforcement of the often minimal regulations is poor due to the nature of the fishery (very mobile, nighttime operation) and low administrative priority.

YELLOW/SILVER EELS

The United States fishery for American eels extends from Maine to the Gulf of Mexico. Different geographic regions (north, middle, and south Atlantic, Gulf of Mexico) exhibit differing time trends in, and magnitudes of, their fisheries which reflect the differing natures of their fisheries and of stock abundances (Fahay 1978). The 1955-73 fishery was most productive in the middle Atlantic region (New Jersey to Virginia), followed by the north Atlantic region (Maine to New York), south Atlantic region (North Carolina to Florida), and Gulf region where the catch was negligible (Fahay 1978). The regional catch summary statistics reported by Fahay (1978) are slightly lower than statistics recently available from the National Marine Fishery

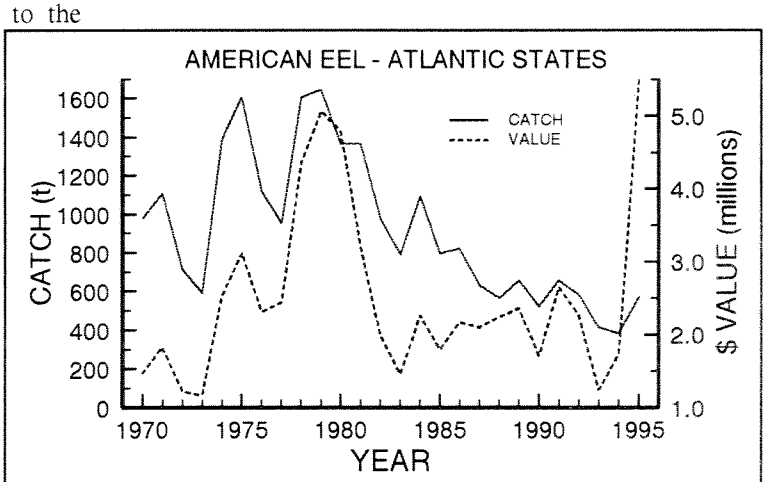


Fig. 1. Reported catch and value of American eels from the Atlantic coast (Maine-Florida), 1970-95.

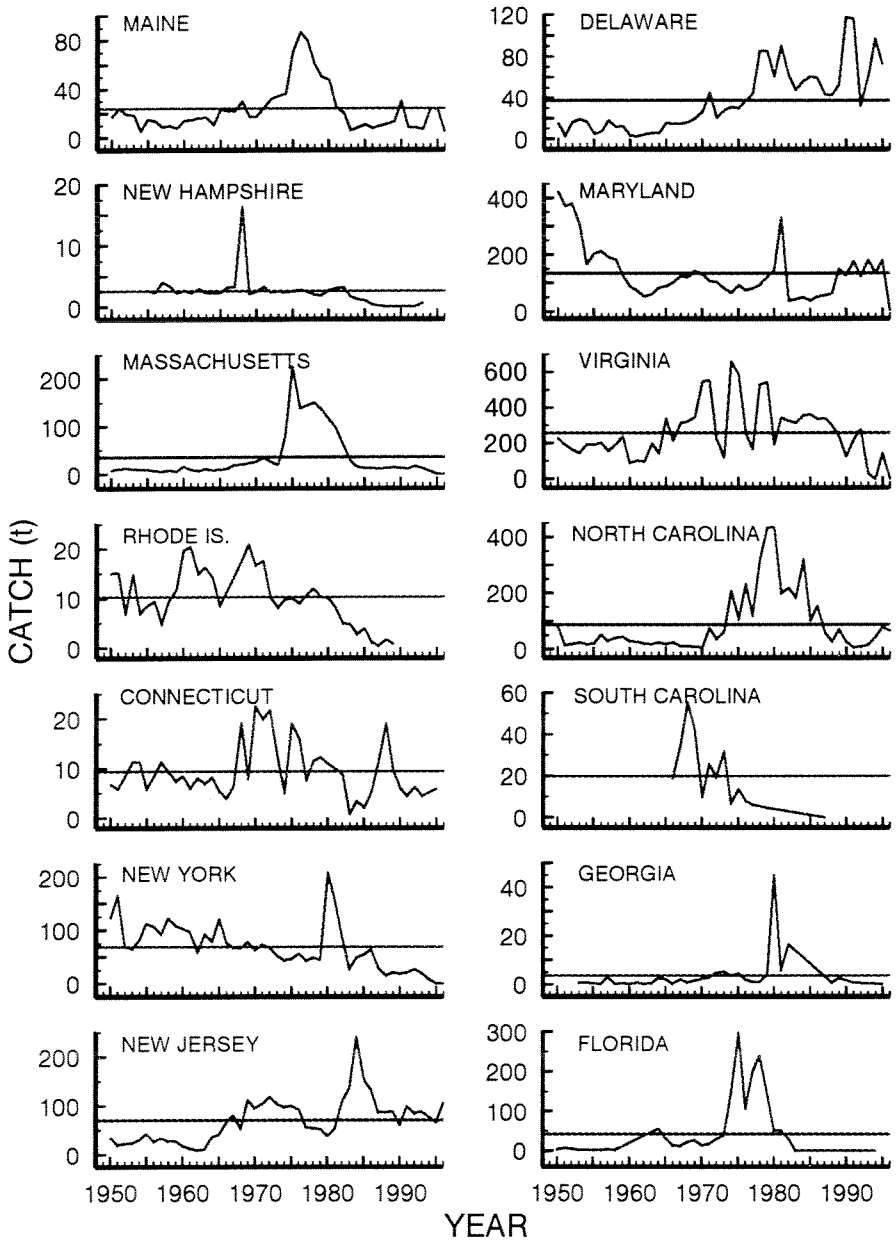


Fig. 2. Annual reported (NMFS) catches of American eels, by state, for the Atlantic coast, 1950-96. The horizontal line in each graph is the mean catch.

Service (NMFS 1997), but the regional rankings are unchanged. For the years 1955-1973, regional mean catches were 146 t (range 75-251 t) for the north Atlantic region, 429 t (range 152-930 t) from the middle Atlantic region, and 80 t (range 19-192 t) from the south Atlantic region. For the years 1974-1995, regional mean catches increased to 160 t (range 7-556 t) in the north Atlantic region, to 567 t (range 106-1,349 t) in the middle Atlantic region, and to 236 t (range 6-792 t) in the south Atlantic region. The higher regional mean catch in the 1974-1995 period is accompanied by higher annual variability, reflecting the declining catch in all regions (and most states) from peaks in the mid-1970s and early 1980s to the low values of recent years.

For the Atlantic coast (Maine-Florida), annual eel catch ranged from 384 t to 1,645 t between 1970 and 1995, with values between 1.17 and 5.49 million U.S. dollars (ASMFC 1997; Fig. 1). Eel catches averaged 1,179 t between 1970 and 1982 and 635 t between 1983 and 1995, indicating an overall decline in US catch.

Annual trends in reported eel catches by individual states (NMFS 1997) comprise three basic groups: declining catch, e.g., Rhode Island, New York; increasing catch, e.g., New Jersey, Delaware; and catches that have returned to values typical of those reported prior to the peak catches of the 1970s and early 1980s, e.g., Maine, Massachusetts, Florida (Fig. 2). Reported catches in some states declined sharply in 1996 but catch data may be incomplete.

Maine eel catches peaked in the late 1970s at 50-90 t annually and have since fluctuated between 4 t and 30 t, a level only slightly lower than reported between the early 1950s and early 1970s. In **Rhode Island**, eel catches varied moderately from about 9-30 t between 1962 and 1984, then increased to between 19 t and 56 t between 1985 and 1988 before collapsing to about 1 t during 1989 and 1990 (Gray 1991). The catches reported by Gray (1991) during the mid-1980s are not evident in Figure 2 yet both data sets originate from the National Marine Fisheries Service. The variability in Rhode Island eel catch during the 1980s has been attributed to market forces rather than resource status.

Annual reported eel catches in **Connecticut** have usually been less than 10 t since about 1980 but some fishers blame the recent low catches on overharvesting of elvers (NMFS 1997; S. Gephart, Connecticut Department of Environmental Conservation, pers.comm.). Eel fisheries in inland (primarily Lake Ontario and Hudson River) waters of **New York** state have been closed due to organochloride contamination since 1976, with the exception of a "limited" fishery for export that closed in 1982 (Blake 1982; Lary and Busch 1997). Historically, catches of eels in New York were several times higher in coastal waters (1960-78 mean catch of 68 t) than in inland waters (1960-79 mean catch of 18 t). The export fishery evidently generated high catches in inland (mean 36 t) and coastal waters during the years 1980-82 (Lary and Busch 1997; Fig. 2).

In **New Jersey**, eel catches in the primarily coastal pot fishery ranged from 61-98 t between 1989 and 1993, down from the mid-1980s peak of 134 t but near the long-term mean. **Pennsylvania** licenses a minor (less than 1 t) fishery but does not collect catch statistics.

In Chesapeake Bay (Maryland and Virginia) recent catches are near the long term (1945-94) mean of about 450 t (CBP 1995). In **Maryland**, reported eel catches steadily declined from the peak of about 590 t in 1946 to about 45 t in 1963 and have since usually fluctuated between about 45 t and 100 t (CBP 1995). The declining catch since the late 1980s evident in Fig. 2 differs from the relatively stable catch reported elsewhere (CBP 1995; Fig. 9.2). Reported catches in **Virginia** fluctuated between about 80 t and 190 t between 1946 and 1966 then increased irregularly to a peak of 659 t in 1974 before declining to 149 t in 1993 and rising to 360 t in 1994 (CBP 1995). Between 1984 and 1994, reported catches averaged 91 t (range 11-134 t) in Maryland (annual catch per fisherman increased from 0.9 to 2.0 t; CBP 1995) and 376 t (range 270-510 t) in Virginia (CBP 1995; Speir 1996). Reported catches in Maryland have thus shown no particular trend since about 1960 while Virginia catches remain near the long-term mean despite the decline from the 1974 peak.

Catches in **North Carolina** and **Georgia** have declined from the peaks in the early 1980s to levels not seen since the 1960s and early 1970s. Before 1970, annual eel catches in North Carolina were usually less than 45 t, then peaked at 436 t in 1980 (Keefe 1982) before declining to 6-26 t in the 1990s (Fig. 2). The mean annual catch of the minor fishery in Georgia declined from 8.5 t between 1972 and 1982 to 1.6 t between 1983 and 1995 (J. Califf, Georgia Department of Natural Resources, Brunswick, pers.comm.). Although catches of over 100 t were reported from **Florida** during the mid- and late 1970s, the only significant eel fishery in

Florida today is the minor pot fishery of the Saint John River where catches in recent years have declined, partly due to reduced fishing effort (NMFS 1997; J. Crumpton, Florida Game and Freshwater Fishery Commission, Eustis, pers.comm.).

Drawing conclusions from these trends is difficult because the available catch statistics are generally regarded as underestimates, perhaps varying in completeness over time, and fishing effort data is either unavailable or of questionable utility (Foster 1981; CBP 1991; Crawford 1996; NMFS 1997). The current status of the eel stock in most, if not all, states is unknown due to the absence of catch and/or effort statistics and an absence or scarcity of biological study of any kind. A widespread concern about the status of local eel stocks, except perhaps in Pennsylvania, Georgia, Florida, and the Gulf of Mexico where stocks and fisheries are minor, reflects more the absence of knowledge about the stocks rather than a well-founded knowledge of decline.

The economically important yellow/silver eel fishery in **Maine** occurs in both inland and tidal waters. The fishery is comparatively well documented and has recently received a comprehensive review and modernization of regulations (CAEMM 1996). Most large eel fisheries south of Maine seem to be primarily coastal pot fisheries with little management and few regulations, other than a license requirement and perhaps minimum size limit or gear and mesh size restrictions (Table 2). Eel fisheries are conducted during the period of natural availability; few, if any, states have defined fishing seasons. **New Hampshire** has little coastline and no available data on eel fishing. The coastal eel fisheries of **Massachusetts** (little if any eel fishing occurs inland) are managed by coastal town authorities; state regulations control permitted gear types (Amaral 1982). The tidal water, mainly pot fishery conducted between May and November in **Rhode Island** requires a commercial multispecies marine fishing license but no catch statistics are collected by state agencies for the eel fishery (Gray 1991). **Connecticut** has a relatively small, basically unmanaged, pot fishery for yellow eels in the tidal portions of, primarily, the Connecticut and Housatonic rivers (S. Gephard, Connecticut Dept. of Environmental Conservation, pers.comm.).

Licensed eel fishing in **New York** occurred, prior to the 1976 closure, primarily in Lake Ontario, the Hudson River and the upper Delaware River (Blake 1982). Only eels less than 36 cm may be fished in the Hudson River proper and other inland waters and must be used for bait because of organochloride contamination. Coastal fisheries are unlicensed and fishing effort is not monitored in either inland or coastal waters. New York enacted in 1995 a 15 cm minimum size limit and 1.25x2.5 cm minimum mesh size for trap nets in marine waters. **New Jersey** fishery regulations require a fishing license for fyke nets and pots, a minimum 0.48 mm bar mesh in pots and a 15 cm minimum size limit. Eel fisheries in **Delaware** were recently licensed and had a 15 cm minimum length limit set in 1995 but are otherwise unregulated and thus have no available catch data.

Maryland and **Virginia** operate primarily pot fisheries for eels in Chesapeake Bay, for which a management plan was developed in 1991 (CBP 1991, 1995; Speir 1996). Prior to the 1991 management plan, **Pennsylvania**, **Maryland**, and **Virginia** had no harvest quotas (**Pennsylvania** has a 50 eel per person per day creel limit), bycatch restrictions, or closed season nor do they exist under the management plan. Prior to the 1991 management plan, Virginia had a 1.25x1.25 cm minimum mesh size and requirement for two 1.25x2.5 cm escape panels for eel pots while, under the management plan, Maryland has implemented a similar minimum mesh size. Large eels are exported; small eels are used for bait in the crab trotline fishery but such use is declining in importance. Catch reports were not required in Virginia prior to 1973 and the Maryland eel fishery was unlicensed prior to 1981 and did not require reporting of eel catches until 1990 (Foster 1981; CBP 1995; Speir 1996) but estimates of commercial eel landings based on interviews with fishhouse managers were made by the National Marine Fisheries Service for both states from 1929 onward (CBP 1995).

North Carolina has a small, primarily coastal pot fishery, with no catch records maintained for inland waters, although they may be included in the total catch. **South Carolina** has little historical catch data and no means in place to obtain it (B. McCord, South Carolina Department of Natural Resources, pers.comm.). Traps and pots are permitted in coastal waters but fyke nets are prohibited while eel fishing inland is permitted only in the Cooper River and Santee-Cooper lake system. Fishing for eels in coastal waters is often conducted under the guise of fishing for crabs.

Eel fishing in **Georgia** was restricted to coastal waters prior to 1980 when inland fishing was permitted (Helfman 1982). Catch, but not effort,

data is available because no specific license is required to fish eels. The **Florida** pot fishery has a 1.25x2.5 cm minimum mesh size and no minimum catch size limit.

AQUACULTURE

Information on the size of the industry for culture of American eels has been unobtainable but at least one operation is located in Florida (Whiteside 1996).

MANAGEMENT ISSUES

The eel fishery of the United States was, prior to ASMFC involvement in 1995, given little or no recognition and attention relative to that given the eel fisheries of Europe. Fishery regulations vary among states but are minimal by any standard for most states. Management plans for eel fisheries have only been implemented by **Maine** (in 1996), by **Maryland** and **Virginia** for the Chesapeake Bay fishery (in 1991), and developed by **Connecticut**. States with the largest, most economically valuable fisheries tend to have the most developed management systems. Inland fisheries are usually licensed, if only under a general fishery license rather than a license specific to the eel fishery, but coastal fisheries are sometimes unlicensed. The requirement for catch statistics varies from minimal to nil and fishing effort data is essentially ignored. Consequently, stock status is considered unknown in most or all states, including those that collect some level of catch statistics, because of the lack of associated fishing effort data.

Lack of fish passage, upstream or downstream, at hydroelectric dams is recognized as denying access to upstream migrants to large areas of suitable habitat and as a mortality factor for downstream migrants. The level of concern has, to date, generally been insufficient to find or implement solutions to the problem (Haro 1996), except for a short lived elver restocking program on the Susquehanna River, Pennsylvania. In 1997, three dams on the Susquehanna River are scheduled for fish passage construction and by the year 2000 over 560 km of river habitat will be accessible as finfish habitat (CBP 1995), which is expected to restore the large quantities of eels once produced by the river. Other sources of habitat loss such as coastal wetlands development and water quality seem addressed only via their importance to other species. The significance of fishery mortality relative to stock reductions due to habitat loss and hydroelectric dam passage mortality is unknown and has been used by fishers to oppose reductions in fishing effort. Contamination of eels by organochlorine chemicals has resulted in closures of affected fisheries and issuance of consumption advisories in rivers such as the Hudson (closed 1976-present) and Delaware rivers but the general extent of such contamination has not been examined.

Although eels may be infrequently imported to the United States from Asia or Europe for aquaculture, such imports may be responsible for the recent detection of the parasite *Anguillicola crassus* in an aquaculture facility in Texas and its spread to South Carolina (Fries et al. 1996). Existing United States import regulations (Warren 1994) may be insufficient to prevent the spread of *A. crassus* via aquaculture activity. The potential exists for serious economic and stock effects such as have been observed in Europe (Fries et al. 1996; ICES/EIFAC In press). Scientific studies of eel biology are essentially based in a very few universities and sporadically conducted; state or federal agencies conduct little, if any, research on eels. Consequently, while the basic biology (Helfman et al. 1987) and distribution (Jury et al. 1994; Stone et al. 1994) of the American eel is well known, the detailed information necessary for effective stock management, on a specific or regional basis, is unknown. Uncertainty or concern about the status of stocks of larger eels in all states and uncontrolled development of elver fisheries in some states have prompted development of an interstate management plan for eels under the authority of the ASMFC (Field 1996). This management plan, if similar to the striped bass management plan (ASMFC 1995), will have the goal of maintaining the eel resource throughout its range so as to generate optimal social and economic benefits from its exploitation. The plan will provide a comprehensive review of existing state fishery regulations and biological data on American eels, specify management actions with specific measurable standards in fisheries regulation and monitoring that require state compliance, and make recommendations for protection and enhancement that are advisable but not requiring compliance. Implementation of the fishery management plan will be mandatory for ASMFC member states under the Atlantic Coastal Fisheries Cooperative Management Act (Public Law 103-206).

SUMMARY

Concern about the origins and consequences of the recent decline in elver recruitment to European coasts, the decline in and present level of existing fisheries, and the adequacy of spawning

stock abundance has prompted a recommendation by the EIFAC/ICES Working Group on Eel for countries to implement the "precautionary principle" in management of European eel stocks (EIFAC/ICES In press). The "precautionary principle" advises maintenance of existing levels of fishing activity for elvers and larger eels, with no expansion except where demonstrably justified, and maintenance of, or increased effort in, stocking of inland waters and stock monitoring programs, and improvements to eel passage at obstructions. The wide variety among countries of regulations governing elver and large eel fisheries and differences in national objectives makes coordinated management of the continental eel resource difficult. Recent uncontrolled development of elver fisheries in some American states and banning by other states, in response to inadequate regulations and biological knowledge with which to control such fisheries, and uncertainty about the status of regional stocks of larger eels has initiated development of an ASMFC interstate management plan for eels (Field 1996; ASMFC 1997). This management plan, which will be mandatory for Atlantic states to implement, should benefit the American eel resource by setting a common managerial objective, improving regulatory coordination among states, and encouraging the stock monitoring and biological research necessary to manage effectively.

ACKNOWLEDGMENTS

I thank J. Field for providing much useful information about the United States eel fishery and development of the ASMFC management plan and for his and D. Meerburg's constructive comments on an earlier version of this paper. I also thank the many other people who provided information on the eel fisheries in their jurisdiction.

REFERENCES

Amaral, E. H. 1982. Massachusetts eel fishery summary report. p. 42. *In* K. H. Loftus (ed.) Proceedings of the 1980 North American eel conference. Ont. Fish. Tech. Rep. Ser. No. 4: 97 p.

ASMFC (Atlantic States Marine Fisheries Commission). 1995. Amendment 5 to the Atlantic States Marine Fisheries Commission Interstate Striped Bass Management Plan. FMR No. 24. ASMFC, Washington, DC. 50 p.

ASMFC (Atlantic States Marine Fisheries Commission). 1997. American eel and horseshoe crab public information document. ASMFC, Washington, DC. 15 p.

Blake, L. M. 1982. Commercial fishing for eels in New York state. p. 39-41. *In* K. H. Loftus (ed.) Proceedings of the 1980 North American eel conference. Ont. Fish. Tech. Rep. Ser. No. 4: 97 p.

CAEMM (Committee on American Eel Management for Maine). 1996. American eel (*Anguilla rostrata*) species management plan. ME Dept. Mar. Res. and Dept. Inland Fish. and Wildl. 54 p.

Cantrelle, I. 1982. Etude de la migration et de la pêche de civelles (*Anguilla anguilla* L. 1758) dans l'estuaire de la Gironde. Thèse Doct. 3e cycle. Univ. Paris VI. 237 p.

Castelnaud, G., D. Guerault, Y. Desaunay, and P. Elie. 1994. Production et abondance de la civelle en France au début des années 90. Bull. Fr. Pêche Piscic. 335: 263-287.

Castonguay, M., P. V. Hodson, C. M. Coullard, M. J. Eckersley, J.-D. Dutil and G. Verreault. 1994. Why is recruitment of the American eel declining in the St. Lawrence River and Gulf? Can. J. Fish. Aquat. Sci. 51: 479-488.

CBP (Chesapeake Bay Program). 1991. Chesapeake Bay American Eel Fishery Management Plan. Agreem. Commitm. Rep. 1991. 28 p.

CBP (Chesapeake Bay Program). 1995. Fishery management plans 1994. Ann. Progr. Rep. CBP/TRS141/95: 81 p.

Crawford, R. E. 1996. A historical overview of the common eel fishery of southern New England. p. 108. *In* Abstracts, 52nd Ann. NE Fish and Wildl. Conf., March 31-April 3, 1996. Farmington, CT.

Dekker, W. 1996. Long term trends in the glass eels immigrating at Den Oever, the Netherlands. EIFAC/ICES Working Group on Eel, Ijmuiden, 23-27 Sept.

Dekker, W., B. Knights, and C. Moriarty. 1993. The future of the eel and eel fisheries. Annex E. EIFAC Occ. Pap. No. 27: 21 p.

Dow, R. L. 1982. The Atlantic eel (*Anguilla rostrata*) fishery of Maine. pp. 43-47 *In* K. H. Loftus (ed.) Proceedings of the 1980 North American eel conference. Ont. Fish. Tech. Rep. Ser. No. 4: 97 p.

EIFAC/ICES (European Inland Fisheries Advisory Committee/International Council for the Exploration of the Seas). 1993. Report of the eighth session of the Working Party on Eel. EIFAC Occ. Pap. No. 27: 21 p.

EIFAC/ICES (European Inland Fisheries Advisory Committee/International Council for the Exploration of the Seas). 1994. Report of the 1994 session of the EIFAC/ICES Working Group on Eel. EIFAC Occ. Pap. No. 30: 18 p.

EIFAC/ICES (European Inland Fisheries Advisory Committee/International Council for the Exploration of the Seas). In press. Report of the tenth session of the Joint Working Group on Eel.

Fahay, M. P. 1978. Biological and fisheries data on American eel, *Anguilla rostrata* (LeSueur). U.S. Nat. Oceanic Atmosph. Admin. Northeast Fish. Center Sandy Hook Lab., Tech. Series Rep. No. 17: 77 p.

Field J. 1996. Summary: Management of the American eel. 52nd Ann. NE Fish Wildl.Conf., March 31-April 3. Farmington, CT.

Foster, J. W. S. 1981. The American eel in Maryland - a situation paper. Tidal Fish. Div., Maryland Tidewater Admin., Annapolis.

Fries, L. T., D. J. Williams, and S. K. Johnson. 1996. Occurrence of *Anguillicola crassus*, an exotic parasitic swim bladder nematode of eels, in the southeastern United States. Trans. Am. Fish. Soc. 125: 794-797.

Gray, C. L. 1991. American eel *Anguilla rostrata* species profile. Rhode Is. Dept. Env. Mgmt., Div. Fish. Wildl., Mar. Fish. Sec. 53 p.

Gousset, B. 1992. Eel culture in Japan. Bull. Inst. océanogr., Monaco, n° spécial 10: 128 p.

Haro, A. 1996. Eel passage technologies and issues. p. 110. *In* Abstracts, 52nd Ann. NE Fish and Wildl. Conf., March 31-April 3, 1996. Farmington, CT.

Heinsbroek, L. T. N. 1991. A review of eel culture in Japan and Europe. Aquacult. Fish. Mgmt. 22: 57-72.

Helfman, G. S. 1982. Development of the fishery for American eels (*Anguilla rostrata*) in Georgia. p. 53. *In* K. H. Loftus (ed.) Proceedings of the 1980 North American eel conference. Ont. Fish. Tech. Rep. Ser. No. 4: 97 p.

Helfman, G. S., D. E. Facey, L. S. Hales, Jr., and E. L. Bozeman, Jr. 1987. Reproductive ecology of the American eel. Amer. Fish. Soc. Symp. 1: 42-56.

Jessop, B. M. 1996. The status of American eels *Anguilla rostrata* in the Scotia-Fundy area of the Maritimes Region as indicated by catch and license statistics. DFO Atl. Fish. Res. Doc. 96/118: 15 p.

Jury, S. H., J. D. Field, S. L. Stone, D. M. Nelson, and M. E. Monaco. 1994. Distribution and abundance of fishes and invertebrates in North Atlantic estuaries. ELMR Rep. No. 13. NOAA/NOS Strat. Envir. Assess. Div. Silver Spring, MD. 221 p.

Keefe, S. G. 1982. The American eel (*Anguilla rostrata*) fishery in the commercial waters of North Carolina. pp. 50-51. *In* K. H. Loftus (ed.) Proceedings of the 1980 North American eel conference. Ont. Fish. Tech. Rep. Ser. No. 4: 97 p.

Lary, S. J., and W.-D. N. Busch. 1997. American eel (*Anguilla rostrata*) in Lake Ontario and its tributaries: distribution, abundance, essential habitat and restoration requirements. U.S. Dept. of Interior, Fish and Wildl. Serv., Amherst, N.Y. Admin. Rep. No. 97-01: 27 p.

Locke, A., R. Claytor, C. LeBlanc and G. Chaput. 1995. Status of American eels, *Anguilla rostrata* in the Gulf Region. DFO Atl. Fish. Res. Doc. 95/79: 40 p.

Moriarty, C. 1990. European catches of elver of 1928-1988. Int. Revue ges. Hydrobiol. 75: 701-706.

Moriarty, C. 1996. Glass eel supply and demand in Europe in 1995 and 1996. EIFAC/ICES Working Group on Eel, Ijmuiden, 23-27 Sept.

Mullis, A. W. 1982. The American eel (*Anguilla rostrata*) fishery in the inland waters of North Carolina. pp 48-49. *In* K. H. Loftus (ed.) Proceedings of the 1980 North American eel conference. Ont. Fish. Tech. Rep. Ser. No. 4: 97 p.

NMFS (National Marine Fisheries Service) 1997. "MF_Annual_Landings Results". http://remora.ssp.nmfs.gov/MFPUBLIC/owa/mrfss. (12 May 1997).

OMNR (Ontario Ministry of Natural Resources) 1982. Proceedings of the 1980 North American eel conference. Ont. Fish. Tech. Rep. Ser. No. 4: 97 p.

Peterson, R. H. (ed.) 1997. The American eel in eastern Canada: stock status and management strategies. Proceedings of eel workshop, January 13-14, 1997, Quebec City, PQ. Can. Tech. Rep. Fish. Aquat. Sci. 2196: 173 p.

Speir, H. 1996. Implementation of an eel fishery management plan: a Chesapeake perspective. p. 111. *In* Abstracts, 52nd Ann. NE Fish and Wildl. Conf., March 31-April 3, 1996. Farmington, CT.

Stone, S. L., T. A. Lowery, J. D. Field, S. H. Jury, D. M. Nelson, M. E. Monaco, C. D. Williams, and L. Andreasen. 1994. Distribution and abundance of fishes and invertebrates in mid-Atlantic estuaries. ELMR Rep. No. 12. NOAA/NOS Strategic Envir. Assess. Div. Silver Spring, MD. 280 p.

Warren, J. W. 1994. Fish health and fish transport regulations: a federal perspective. Fisheries 19(6): 22-23.

Whiteside, D. 1996. An industry perspective: aquaculture and export issues. p. 109. *In* Abstracts, 52nd Ann. NE Fish and Wildl. Conf., March 31-April 3, 1996. Farmington, CT.

Eel Fisheries Management: Scotia-Fundy, Maritimes Region

by

G. Stevens
Senior Advisor, Anadromous
Fisheries and Oceans Canada
P. O. Box 550
Halifax, NS B3J 2S7

INTRODUCTION

- DFO is responsible for management and control of seacoast and inland fisheries.
- This includes the development of policy and implementation of fishing plans.
- Problems with management of the eel fishery are largely the result of:
  - ♦poor historical data
  - ♦inflexible and outdated regulations
  - ♦increasing demand for licenses
  - ♦no formal advisory process (except SWNB).
- Data collection has been improved.
- New regulations are in place (February 1993).
- Licenses have been frozen at current levels.
- The advisory process has begun.

ADULT EEL FISHERIES

REGULATIONS

- License is required to fish commercially or recreationally except for angling or for spearing in tidal waters.
- A distance of 200 m must be maintained from any fishing gear previously set.
- Gear cannot be left unattended for more than 72 h.
- Gear must be marked with owner's name and, where a vessel is used, with the vessel registration.
- Authorized fishing methods are angling, pots, traps, dip nets and spears (longlines and set lines permitted in NB).
- Closed season for eel traps in inland waters is from November 1-August 14 and for spears all year.
- From sunrise to sunset in inland waters of NS, eel traps must have 90-cm opening to allow fish to escape and fyke nets must be rendered incapable of catching fish.
- Minimum size limit is 20 cm.

LICENSING POLICIES

- On May 19/93, commercial eel licenses were frozen at current levels: new recreational eel licenses were restricted to pots only (maximum 4).
- Prior to the May 1993 freeze, the eel fishery was open access in Scotia-Fundy sector, except for Saint John River in NB, where entry was limited after 1978.
- Persons fishing must register in Region, no residency requirement.
- Licenses issued to persons, not companies.
- Re-issurance of licenses is only permitted to fishers registered in preceding year and who are actively engaged in fishing in preceding year.
- No participation is required.
- License holders must personally fish.

JUVENILE (ELVER) FISHERIES

- Elvers are defined as eels less than 10 cm (4") in length.
- An experimental fishery began in earnest in 1989.
- In 1996, a total of 9 experimental licenses were issued (3 for aquaculture purposes only).
- It is not anticipated that any new elver licenses will be issued in Scotia-Fundy sector in 1997.
- The elver fishery has been developed as an EA fishery with license holders getting assigned fishing areas and quotas.
- For 1997, a formal elver advisory committee will be established; 4 of the 9 license holders will be given regular licenses and dockside monitoring will be implemented.

FUTURE MANAGEMENT CONSIDERATIONS

- Evaluate the current freeze on elver and adult eel fishing licenses.

- Examine ways of eliminating unused commercial licenses, making them terminal or converting them to recreational licenses.

- Examine ways of reducing the amount of commercial gear authorized on existing licenses.

- Examine options for reducing the number of commercial licenses in some areas, in the immediate and long term.

- Reduce gear conflict and distribute fishing effort through more effective use of license conditions.

- Improve the yield per recruit by increasing the minimum size limit for silver eels.

- Review seasons for inland and tidal water fishing.

- Examine ways of reducing incidental catches of other fish species and mammals.

- Establish a formal advisory process for adult eels throughout Scotia Fundy sector.

INTRODUCTION

- Le MPO est chargé de la gestion et de la surveillance des pêches intérieures et côtières.

- Cela inclut l'établissement d'une politique et la mise en oeuvre de plans de pêche.

- Les problèmes de gestion de la pêche de l'anguille résultent principalement des facteurs suivants :
    - insuffisance de données historiques;
    - règlements rigides et désuets;
    - demande accrue de permis;
    - aucun processus consultatif officiel (sauf dans le sud-ouest du N.-B.).

- La collecte des données s'est améliorée.

- De nouveaux règlements ont été adoptés (février 1993).

- Le nombre de permis a été bloqué aux niveaux actuels.

- Le processus consultatif a commencé.

PÊCHES DES ANGUILLES ADULTES

RÉGLEMENTATION

- Le permis est obligatoire pour pêcher l'anguille à des fins commerciales ou sportives, sauf la pêche à la ligne ou la pêche au harpon dans les eaux à marée.

- Il faut respecter une distance de 200 mètres par rapport à tout engin de pêche préalablement installé.

- L'engin ne peut être laissé sans surveillance pendant plus de 72 heures.

- L'engin doit être marqué au nom de son propriétaire et, lorsqu'un bateau est utilisé, doit porter le numéro d'immatriculation du bateau.

- Les méthodes de pêche autorisées sont la pêche à la ligne, les nasses à anguilles, les carrelets et les harpons (les palangres et les lignes dormantes sont autorisées au N.-B.).

- La période pendant laquelle la pêche de l'anguille à la nasse est interdite dans les eaux intérieures est du 1er novembre au 14 août et, au harpon, pendant toute l'année.

- Du lever au coucher du soleil, dans les eaux intérieures de la Nouvelle-Écosse, les nasses à anguilles doivent avoir une ouverture de 90 cm pour permettre aux poissons de s'échapper et les verveux doivent être modifiés de façon qu'ils ne capturent pas de poisson.

- La limite de taille minimale est de 20 cm.

POLITIQUES DE DÉLIVRANCE DES PERMIS

- Le 19 mai 1993, le nombre de permis de pêche commerciale de l'anguille a été bloqué au niveau existant; quant aux nouveaux permis de pêche sportive de l'anguille, ils ont été limités aux nasses à anguilles seulement (maximum de 4).

- Avant le gel du mois de mai 1993, la pêche de l'anguille était pratiquée sans restriction dans le secteur Scotia-Fundy, sauf dans la rivière Saint-Jean, au N.-B., où l'accès avait été limité après 1978.

- Les personnes qui pêchent doivent s'inscrire dans la Région; il n'y a pas critère de résidence.

- Les permis sont attribués aux personnes, et non aux entreprises.

- Le renouvellement du permis n'est accordé qu'aux pêcheurs inscrits l'année précédente qui ont pratiqué activement la pêche.

- Aucune participation n'est requise.

- Les titulaires de permis doivent pêcher personnellement.

JEUNES ANGUILLES (CIVELLES)

- Les civelles sont définies comme des anguilles de moins de 10 cm (4 po) de long.

- Une pêche expérimentale a été entreprise avec intérêt en 1989.

- En 1996, neuf permis de pêche expérimentale ont été délivrés (trois à des fins aquacoles).

- On ne s'attend pas à ce que de nouveaux permis de pêche des civelles soient délivrés dans le secteur Scotia-Fundy en 1997.

- La pêche des civelles a été assujettie à un régime d'AE, les titulaires de permis étant assignés à des zones de pêche et à des quotas.

- En 1997, un comité consultatif officiel de la pêche des civelles a été formé; quatre des neuf titulaires de permis ont reçu des permis de pêche réguliers et les captures feront l'objet d'une vérification à quai.

CONSIDÉRATIONS POUR LA GESTION FUTURE

- Évaluer le gel actuel des permis de pêche des adultes et des civelles.

- Étudier les moyens d'éliminer les permis de pêche commerciale inutilisés, de leur donner un caractère définitif ou de les convertir en permis de pêche sportive.

- Étudier les moyens de réduire la quantité d'engins de pêche commerciale autorisés par les permis existants.

- Examiner les possibilités de réduire le nombre de permis de pêche commerciale dans certains secteurs, à court terme et à long terme.

- Réduire les conflits d'engin et répartir l'effort de pêche grâce à une utilisation plus efficace des conditions des permis.

- Améliorer le rendement par recrue en augmentant la limite de taille minimale des civelles argentées.

- Réviser les saisons de pêche dans les eaux intérieures et dans les eaux à marée.

- Étudier les moyens de réduire les captures accidentelles d'autres espèces de poisson et de mammifères.

- Établir un processus consultatif officiel pour les anguilles adultes dans tout le secteur Scotia-Fundy.

Eel Fishery in the Gulf Fisheries Sector, Maritimes Region

by

L. Paulin
Fisheries and Oceans Canada
Maritimes Region
P.O. Box 5030
Moncton, New Brunswick E1C 9B6

There are two categories of eel fishing activities in the Gulf Fisheries Sector, namely commercial and recreational fishing. Recreational fishing has been practiced by Maritimers for more than one century, not as much as a recreational activity but more as a food fishery (subsistence fishery).

Fishing effort is often related to economic returns to fishers, and eel fishing is no exception. To better appreciate the evolution of this fishery, it is important to have an appreciation of the prices paid for eel to fishers over the years. Documented prices are not available at this time but it was felt that corporate memory on the matter would nevertheless be acceptable, given its intended use.

Price per pound paid for eel to fishers is as follows:

Prior to 1985: prices paid were generally below 25 cents a pound

1985-86: $0.75 - $0.80 cents a pound
1986-87: $1.50 a pound
1987-88: $2.00 a pound
1988-89: $2.40 a pound
1989-96: $2.40 to $3.00 a pound

(Prices quoted above may have varied slightly from province to province.)

A breakdown of licenses and gear by province within the Gulf Fisheries Sector is provided in Annexes "A" to "D".

The following is an overview of the fishery by province within the Gulf Fisheries sector of the Maritimes Region.

PRINCE EDWARD ISLAND

Prior to 1961: Spears with a light (flamboying) and pots were the two main gears used to fish eel commercially.

1961-65: The PEI provincial government introduced fyke nets from Norway.

1973: Restrictions to address by-catch of trout and salmon were introduced. These were the minimum eel size of 46 cm and a fyke net fishing season from August 16-November 30.

1978: Limited entry in the fishery with fyke nets and pots.

Mid 80's: Introduction of a generator on board fishing vessels which produced lighting of up to 4000 watts compared to approximately 60 watts with a gas lantern. Eels could now be spotted in 15 ft of water compared to 5 ft with the lighting of a lantern. The length of the spear was extended accordingly. Some fishers say that it actually freezes the eel, making it easier to spear. Fishers are also spraying the surface of the water with vegetable oil making the view of the ocean floor clearer. Jim Jenkins described this as "Putting oil on the stormy water."

1993 (Feb 24): Maritime Regulations require a license to fish eel commercially with a spear and a longline.

1994: Introduction of the following fishing seasons:
Recreational: January 1-March 31 (voluntary daily catch limit of 6 eels)
Spearing with light: April 1-June 30
Closed to all gears: July 1-August 15
Fyke nets and pots: August 16-October 31

1994-95: Fishers who applied and had proof of eel fishing with a spear in any of the years 1987-90 were issued a spear fishing license.

EASTERN NEW BRUNSWICK

Since the early 1960s: Spears and pots are being used to fish eel.

1978: Limited entry licensing policy is implemented.

Since the 1980s: Commercial fishing season to all gears: November 15-September 1.

Late 80s: Recreational fishing becomes more popular.

1992: The transfers of licenses between fishing grounds (from river to river,

from lake to lake and from river to lake and vice versa) are prohibited.

1993 (Feb 24): Maritime Regulations require a license to fish eel commercially with a spear and a longline. Fishers who applied and had proof of eel fishing with longline were issued a longline fishing license. This license is non-transferable.

1995-96: Minimum eel size was set at 46 cm.

GULF PORTION OF NOVA SCOTIA

1970s: New licenses were available to bonafide fishers, with the exception of the Margaree River, using fyke nets and weirs. Licenses were also available to non-commercial fishers using eel pots. The seasons were from August 15-October 30. For spear fishing, there was no license requirement and fishers could fish all year.

1991: There was a freeze on all new licenses for eels for all gear types.

1993: Implementation of requirement to fish eels by spear on a commercial basis. Only those individuals who could show proof of participation in 1991, 1992 or 1993 were eligible to receive a license. The cut-off date for this was April 1994. Therefore, a license was required to fish commercially for eels.

1995-96: There was a restriction of seasons from April 1-30 and August 16-November 15 using fyke nets and eel pots. The commercial spear fishery was restricted from May 1-August 15. There was also the closure of Pomquet and Pictou Harbour for commercial eel fishing. The implementation of a minimum size to 46 cm was introduced. As for the recreational fishery, a voluntary possession limit of 10 eels was suggested. Will become a condition of license when regulations are amended.

1997: In the spear fishery, there will be the implementation of license conditions, which states that the only anticipated light is light produced from a flame that does not exceed 3400 lumens (200 watts), which will greatly reduce the effort. The season will be from January 15-June 30. The minimum length will increase to 50 cm. For the fyke net, pot and weir fishery, the season will be reduced from September 1-October 30.

GULF FISHERIES SECTOR, MARITIMES REGION

1996 Eel Licensing Policy

Main Features

1. No new commercial eel licenses are issued.
2. No additional fishing gears are authorized unless obtained by transfer.
3. Transfer of licenses between fishing grounds (from river to river, from lake to lake and from river to lake and vice versa) is prohibited/restricted.
4. Eel licenses may only be re-issued (transferred) to core fishers and to non-core fishers who qualify as new entrants (criteria to be met).

Note: Licensing policy for non vessel-based licenses (includes eel) is under review in consultation with industry.

Il existe deux catégories de pêche de l'anguille dans le secteur des pêches du Golfe, soit la pêche commerciale et la pêche récréative. Les habitants de la région des Maritimes s'adonnent à la pêche récréative de l'anguille depuis un siècle, moins comme activité de loisir que comme moyen de se nourrir – la pêche de subsistance.

L'effort de pêche est souvent motivé par des gains économiques pour les pêcheurs, et la pêche de l'anguille n'y fait pas exception. Pour mieux mesurer l'évolution de cette pêche, il importe de bien connaître les prix qu'ont touchés les pêcheurs d'anguilles avec les années. Nous ne disposons pas à l'heure actuelle de documents à cet égard, mais nous avons estimé que nous pouvons nous fonder sur les souvenirs des entrepreneurs sur ce chapitre étant donné l'usage que nous prévoyons d'en faire.

Voici les prix la livre d'anguille touchés par les pêcheurs :

Avant 1985, ce prix était généralement inférieur à 25 cents la livre.

1985-1986 : de 0,75 $ à 0,80 $ la livre
1986-1987 : 1,50 $ la livre
1987-1988 : 2 $ la livre
1988-1989 : 2,40 $ la livre
1989-1996 : de 2,40 $ à 3 $ la livre

(Ces prix peuvent avoir varié légèrement d'une province à l'autre.)

La ventilation des permis et des engins par province dans le secteur des pêches du Golfe se trouve aux annexes A à D.

Voici un résumé de la pêche par province dans le secteur du Golfe de la région des Maritimes.

ÎLE-DU-PRINCE-ÉDOUARD

Avant 1961: Les deux principaux engins de la pêche commerciale de l'anguille étaient la foène avec lampe (puissante) et la nasse.

De 1961 à 1965: Le gouvernement de l'Île-du-Prince-Édouard a introduit le verveux de Norvège.

1973 : Des restrictions visant les prises accidentelles de truites et de saumons ont été adoptées. La longueur minimale de l'anguille fut fixée à 46 cm, et la saison de pêche au verveux fut fixée du 16 août au 30 novembre.

1978 : La pêche au verveux et à la nasse devint à accès limité.

Au milieu des années 1980 : Les bateaux de pêche furent munis d'une génératrice pouvant produire jusqu'à 4 000 watts comparativement aux 60 watts de la lanterne au gaz. Il était alors possible de repérer les anguilles par 15 pieds de fond en regard des cinq pieds que permettait le flot lumineux d'une lanterne. La foène fut allongée en conséquence. Certains pêcheurs soutiennent que, à cause de la lumière, les anguilles tombent en arrêt et sont alors plus faciles à harponner. Les pêcheurs répandent aussi de l'huile végétale sur l'eau pour obtenir une vue plus claire du fond de la mer. Jim Jenkins a dit de cette pratique qu'elle consistait à « jeter de l'huile sur la mer orageuse ».

1993 (le 24 février) : *Le Règlement de pêche des provinces maritimes* rend obligatoire le permis pour la pêche commerciale de l'anguille à la foène et à la palangre.

1994 : Adoption de nouvelles saisons de pêche:

Pêche récréative : Du 1er janvier au 31 mars (limite de prises quotidiennes volontaires de six anguilles).
Pêche à la foène avec lampe : du 1er avril au 30 juin.
Clôture de la pêche à tous les engins : du 1er juillet au 15 août.
Pêche au verveux et à la nasse : du 16 août au 31 octobre.

1994-1995: Les pêcheurs qui présentaient une demande et qui pouvaient prouver qu'ils avaient pêché l'anguille à la foène au moins une année entre 1987 et 1990 ont obtenu un permis de pêche à la foène.

EST DU NOUVEAU-BRUNSWICK

Depuis le début des années 1960: La pêche de l'anguille se pratique au moyen de foènes et de nasses.

1978 : Une politique de pêche à accès limité est mise en oeuvre.

Depuis le début des années 1980: Saison de pêche commerciale à tous les engins: du 15 novembre au 1er septembre

À la fin des années 1980: La pêche récréative devint plus populaire.

1992 : La transmission de permis entre lieux de pêche – d'une rivière à une autre, d'un lac à un autre et d'une rivière à un lac et vice-versa – fut interdite.

1993 (24 février): *Le Règlement de pêche des provinces maritimes* rend obligatoire le permis pour la pêche commerciale de l'anguille à la foène et à la palangre. Les pêcheurs qui demandaient un permis et qui prouvaient qu'ils avaient pêché l'anguille avec une palangre obtenaient un permis de pêche à la palangre, non transmissible.

1995-1996: La longueur minimale de l'anguille fut portée à 46 cm.

PARTIE DU GOLFE CONTIGUË À LA NOUVELLE-ÉCOSSE

Années 1970: De nouveaux permis ont été offerts aux pêcheurs professionnels (*bona fide*), sauf pour la rivière Margaree, utilisant des verveux et des pêcheries à fascines. Les pêcheurs non commerciaux utilisant les nasses à anguilles pouvaient aussi obtenir un permis. La saison allait du 15 août au 30 octobre. Pour la pêche à la foène, aucun permis n'était obligatoire, et les pêcheurs pouvaient s'y adonner toute l'année.

1991 : La délivrance de nouveaux permis de pêche de l'anguille pour tous les types d'engins fut frappée par un moratoire.

1993 : L'obligation de pratiquer la pêche commerciale de l'anguille à la foène est adoptée. Seuls les particuliers pouvant prouver qu'ils avaient pratiqué la pêche en 1991, 1992 ou 1993 étaient admissibles à un permis. La date limite de cette mesure fut avril 1994. Dès lors, il fallait un permis pour pêcher l'anguille commercialement.

1995-1996: Les saisons furent restreintes; soit du 1er au 30 avril et du 16 août au 15 novembre pour la pêche aux verveux et aux nasses à anguilles. La pêche commerciale à la foène fut limitée à la période du 1er mai au 15 août. La fermeture de la pêche commerciale de l'anguille à Pomquet et à Pictou Harbour fut aussi proclamée. En outre, la longueur minimale de 46 cm fut adoptée. Quant à la pêche récréative, on proposa une limite de capture volontaire de dix anguilles. Cela deviendra une condition de délivrance du permis quand le règlement sera modifié.

1997: Pour la pêche à la foène, le permis sera délivré sous réserve de conditions, à savoir la seule lumière autorisée est celle d'une flamme ne produisant pas plus de 3 400 lumens (200 watts), ce qui limitera considérablement l'effort de pêche. La saison ira du 15 janvier au 30 juin. La longueur minimale passera à 50 cm. Quant à la pêche au verveux, à la nasse et à la fascine, la saison sera raccourcie, passant du 1er septembre au 30 octobre.

SECTEUR DES PÊCHES DU GOLFE, RÉGION DES MARITIMES

Politique de délivrance des permis de pêche à l'anguille en 1996

Principales caractéristiques

1. Aucun nouveau permis de pêche commerciale à l'anguille n'est délivré.

2. Aucun engin de pêche supplémentaire n'est autorisé sauf par voie de transmission.

3. Les transmissions de permis entre lieux de pêche – d'une rivière à une autre, d'un lac à un autre ou d'une rivière à un lac et vice-versa – sont interdites ou restreintes.

4. Le permis de pêche de l'anguille ne peut être délivré de nouveau (transmis) qu'à des pêcheurs du noyau et qu'aux pêcheurs ne faisant pas partie du noyau qui répondent aux critères régissant les nouveaux participants.

Note : La politique des permis non liés à un bateau (y compris la pêche de l'anguille) fait l'objet d'un examen en collaboration avec l'industrie.

ANNEX/ANNEXE "A"

GULF FISHERIES SECTOR / SECTEUR DES PÊCHES DU GOLFE

PROVINCE NEW BRUNSWICK / NOUVEAU-BRUNSWICK

NUMBER OF EEL LICENSES BY STATS DISTRICT /
NOMBRE DE PERMIS D'ANGUILLE PAR DISTRICTE STATISTIQUE

STATS DISTRICT/ DISTRICTE STATS	1996	1995	1994	1993	1992	1991	1990
63	1	1	1	1	1	1	1
64	1	0	0	0	0	0	0
65	4	5	6	6	7	7	7
66	8	8	7	8	8	9	9
67	15	15	16	18	17	19	21
68	19	20	20	20	20	19	21
70	50	52	55	57	58	59	61
71	10	10	10	11	12	12	11
73	11	11	11	10	10	10	10
75	18	19	19	15	17	17	17
76	23	24	23	13	15	17	17
77	24	26	28	27	27	26	26
78	7	6	6	6	7	7	6
80	3	3	3	2	2	2	4
TOTAL	**194**	**200**	**205**	**194**	**201**	**205**	**211**

ANNEX/ANNEXE "B"

GULF FISHERIES SECTOR / SECTEUR DES PÊCHES DU GOLFE

PROVINCE NOVA SCOTIA / NOUVELLE-ÉCOSSE

NUMBER OF EEL LICENSES BY STATS DISTRICT / NOMBRE DE PERMIS D'ANGUILLE PAR DISTRICTE STATISTIQUE

STATS DISTRICT / DISTRICTE STATS	1996	1995	1994	1993	1992	1991	1990
1	1	1	1	1	1	1	1
2	29	29	28	29	28	29	31
3	5	6	6	6	5	5	5
10	3	3	4	3	2	2	1
11	32	36	38	31	24	20	20
12	16	16	19	26	13	12	13
13	53	56	62	50	30	29	31
14	4	4	4	4	3	3	3
45	13	14	13	13	14	14	11
46	10	11	11	11	12	13	6
TOTAL	**166**	**176**	**186**	**174**	**132**	**128**	**122**

ANNEX/ANNEXE "C"

GULF FISHERIES SECTOR / SECTEUR DES PÊCHES DU GOLFE

PROVINCE PEI / Î-P-É

NUMBER OF EEL LICENSES BY STATS DISTRICT / NOMBRE DE PERMIS D'ANGUILLE PAR DISTRICTE STATISTIQUE

STATS DISTRICT / DISTRICTE STATS	1996	1995	1994	1993	1992	1991	1990
82	51	51	50	25	21	21	22
83	328	364	387	62	20	20	19
85	31	8	8	2	2	2	2
86	48	43	25	6	5	5	5
87	25	26	26	20	19	22	21
88	77	81	79	59	61	61	61
92	116	123	119	74	54	56	54
93	181	145	146	52	44	42	43
95	40	44	41	27	27	28	29
96	14	20	15	7	5	5	5
TOTAL	**911**	**905**	**896**	**334**	**258**	**262**	**261**

ANNEX/ANNEXE "D"

LICENSED EEL GEARS BY PROVINCE FOR 1990 TO 1996 IN THE GULF FISHERIES SECTOR

PROVINCE	GEAR	YEAR						
		1990	1991	1992	1993	1994	1995	1996
NB	Boxnet	0	0	0	0	2	2	2
	Eel pot	0	0	0	26	26	29	24
	Fyke	0	0	0	627	707	647	642
	Longline	0	0	0	600	600	600	600
	Misc.	664	534	533	0	0	0	0
	Trapnet	1655	1655	1666	1504	1401	1496	1478
	Pot/trap	162	162	69	0	0	0	0
	Weir	87	87	80	80	61	59	59
NB Total		2568	2438	2348	2837	2797	2833	2805
NS	Eel Pot	0	0	0	1978	1878	1881	1877
	Fyke	0	0	0	317	317	314	317
	Misc.	287	348	357	0	0	0	0
	Pot/trap	1502	1949	1899	0	10	0	0
	Spear	0	0	0	0	1	1	1
	Trapnet	73	63	73	73	73	72	73
	Weir	25	31	30	30	30	30	30
NS Total		1887	2391	2359	2398	2309	2298	2298
PEI	Eel Pot	0	0	0	917	761	843	838
	Misc.	70	70	70	0	0	0	0
	Pot/Trap	931	917	917	0	76	0	0
	Spear	0	0	0	1	43	43	42
	Trapnet	4988	5003	5003	5032	5087	5087	5085
PEI Total		5989	5990	5990	5950	5967	5973	5965
Southern Gulf	Boxnet	0	0	0	0	2	2	2
	Eel Pot	0	0	0	2921	2665	2753	2739
	Fyke	0	0	0	944	1024	961	959
	Longline	0	0	0	600	8175	8175	8225
	Pot/Trap	2595	3028	2885	0	86	0	0
	Spear	0	0	0	1	44	44	43
	Trapnet	6716	6721	6742	6609	6561	6655	6636
	Weir	112	118	110	110	91	89	89
	Misc.	734	604	603	0	0	0	0
All Gears		10157	10471	10340	11185	18648	18679	18693

The Newfoundland Eel Fishery: a Fisheries Management Perspective Past and Present

by

L. Knight
Fisheries and Oceans Canada
Newfoundland Region
P. O. Box 5667
St. John's, Newfoundland A1C 5X1

HISTORICAL OVERVIEW

Indications of an eel fishery in Newfoundland date back to the early 1900s. Although eel exports were reported as early as 1930, it was not until 1961 that the first official statistics on eel landings were recorded. The following year, 1962, witnessed the first orchestrated attempt by an established fish products company to organize an eel fishery in Newfoundland. The company, Bonavista Cold Storage, set up operations with local fishers around the Avalon Peninsula for the harvest of yellow eels using baited pots. Landings fluctuated dramatically, peaking at about 36 tonnes in the second year of operation, then falling to only 3 tonnes in 1965, whereupon the project was terminated. There are no recorded eel landings for Newfoundland from 1966 to 1970. In 1971 a yellow eel fishery emerged on the southwest coast. Again, annual landings fluctuated, peaking in 1972 at 80 tonnes and dropping to 7 tonnes by 1975.

River surveys carried out by various government agencies in the 1970s revealed a wide distribution of eels throughout the Island's freshwater systems and in some parts of southern Labrador. In 1979 the Provincial Department of Fisheries initiated a development program to assess the viability of the fishery and stimulate interest by providing fishing gear and technical advice to fishers. As a result of these efforts, annual landings of over 80 tonnes were reported for the first time in 1980 (see Table 1, Commercial Eel Landings). In an attempt to reduce the historic boom-bust nature of the yellow eel fishery, development initiatives were refocused toward the harvesting of silver (mature) eels in 1982. These initiatives, in addition to significant price increases for eels, are believed responsible for the historically high landings experienced from the late 1980s to the mid-1990s.

Prior to 1996 there was no formal advisory process in place to obtain the comments and recommendations of stakeholders in the fishery. Input into the management process was achieved through an ad hoc working group committee made up of a small number of DFO personnel, Provincial Department of Fisheries personnel, and fishers' union representatives. In 1994 and 1995 the Industry Development Division of DFO sponsored workshops with eel fishers and salmonid conservation groups to review and formulate solutions to the salmonid by-catch problem identified in the eel fishery. Although the focus of the workshops was on by-catch issues, discussions on other eel management measures also took place. On May 2, 1996, the first formal eel advisory meeting was convened.

SURVOL HISTORIQUE

Les mentions de la pêche de l'anguille à Terre-Neuve remontent au début du siècle. Bien qu'il soit question d'exportations d'anguilles dès les années 1930, ce n'est pas avant 1961 qu'ont été recueillies les premières statistiques officielles sur les débarquements de cette espèce. L'année suivante, en 1962, eut lieu la première tentative orchestrée par une société établie de produits de la pêche d'organiser une pêche de l'anguille à Terre-Neuve. Cette société, la Bonavista Cold Storage, a organisé, avec les pêcheurs locaux tout autour de la presqu'île Avalon, une pêche des anguilles jaunes, au moyen de nasses appâtées. Les débarquements ont fluctué considérablement, atteignant un sommet d'environ 36 tonnes la deuxième année d'exploitation, pour chuter à seulement trois tonnes en 1965, après quoi le projet a été interrompu. Aucun débarquement d'anguille n'a été enregistré à Terre-Neuve entre 1966 et 1970. En 1971, une pêche de l'anguille jaune a vu le jour sur la côte sud-ouest. Cette fois encore, les débarquements annuels ont fluctué, culminant en 1972 avec 80 tonnes pour dégringoler jusqu'à sept tonnes en 1995.

Des relevés réalisés dans les cours d'eau par différents organismes gouvernementaux au cours des années 1970 ont révélé une large distribution des anguilles dans tous les réseaux d'eau douce de l'île, et dans certaines parties du sud du Labrador. En 1979, le ministère provincial des Pêches a entrepris un programme d'expansion visant à évaluer la viabilité de la pêche et à stimuler l'intérêt, en fournissant des engins de pêche et des conseils techniques aux pêcheurs. À la suite de ces efforts, des débarquements annuels de plus de 80 tonnes ont été enregistrés pour la première fois en 1980 (voir le tableau 1, Débarquements d'anguilles à des fins commerciales). Cherchant à réduire les cycles de la forte expansion à l'effondrement de la pêche de l'anguille jaune, les mesures de développement ont été axées vers l'exploitation des anguilles argentées (adultes) en 1982. Ces initiatives, ajoutées à la forte augmentation des prix de l'anguille, seraient à l'origine des sommets historiques des débarquements observés à partir de la fin des années 1980 jusqu'au début de la décennie suivante.

Avant 1996, il n'existait pas de processus consultatif officiel permettant de recueillir les commentaires et les recommandations des

intervenants de la pêche. La contribution au processus de gestion était obtenue au moyen d'un groupe de travail spécial composé d'un petit nombre de membres du personnel du MPO, de membres du ministère des Pêches provincial et de représentants du syndicat des pêcheurs. En 1994 et en 1995, la Division de l'expansion industrielle du MPO a parrainé des ateliers avec les pêcheurs d'anguille et les groupes de conservation des salmonidés, en vue d'étudier et de formuler des solutions au problème des prises accidentelles de salmonidés observé dans le cadre de la pêche de l'anguille. Bien que les ateliers aient été axés vers les problèmes de captures accidentelles, les entretiens ont aussi porté sur d'autres mesures de gestion des anguilles. Le 2 mai 1996, était convoquée la première réunion officielle de consultation au sujet de la pêche de l'anguille.

IMPLEMENTATION OF REGULATORY MEASURES

The management style employed in the eel fishery is one based on limiting catch through effort controls by restricting the number of licenses in the fishery, the amount of gear used and the length of the fishing season. Due to the lack of scientific information on the population dynamics and recruitment characteristics of eels in the Newfoundland Region and because of the panmictic nature of the species (i.e., American eels found along the eastern North American continent come from a single spawning stock), a total allowable catch (TAC) strategy cannot be used. The long-term objectives for managing this species are to achieve biological sustainability and to improve economic viability.

Regulatory requirements put in effect prior to 1990 can be briefly summarized as follows. Section 34 of *The Newfoundland Fisheries Regulations* requires that a license be bought by all commercial and recreational fishers, other than when using angling gear. Fishers are required to use logbooks for catch and effort reporting. One-third of a river's width and two-thirds of main channels must remain open at all times when setting gear. The minimum eel size for harvesting and sale is 20 cm (8"). The season for use of fyke nets in inland waters at that time was August 15-November 30 and November 1-March 31 when using spears.

In 1990, for eastern Newfoundland, the coastal waters gear limit was set at 10 fyke nets and 50 eel pots, and new license issuance was restricted to a maximum of two fyke nets per river. In 1991 for the same Region, the gear limit for inland waters was set to 5-10 nets and 25 pots and for the coastal waters it was reduced to a maximum of 5 nets. The inland season was shortened to August 15-October 31. In 1992 new licenses on scheduled rivers were restricted to the lower one-half kilometer of a watershed for eastern Newfoundland.

In 1993 eastern and western Newfoundland amalgamated under one regional management structure. The gear amounts on licenses in NAFO Division 4R and Subdivision 3Pn (western Newfoundland) were capped at 1992 levels, and the issuance of new recreational licenses was terminated. In 1994 DFO imposed limited entry on commercial fishing licenses in established fishery areas and experimental licenses were issued only in unutilized areas under strict conditions. A restriction on transfer or reissuance of licenses was also invoked. An eel pot season was implemented in 1994 from July 1-October 31 for most of the Newfoundland Region and from April 15-October 31 from Grand Bruit to Cape St. Gregory. In 1995 the opening date was amended for eel pots in coastal waters from July 1-June 1. For that year, the use of fyke net by-catch exclusion devices was made mandatory for all experimental fisheries with a strategic plan for the phase in of these devises on all fyke net operations.

In 1996 exploratory license eligibility was limited to a core group of professional fishers (Core fishers), and a limited exploratory elver fishery was introduced (4 licenses) and restricted by the following conditions: eligibility was restricted to active licensed commercial eel fishers; elver harvest was permitted only in river systems devoid of an established eel fishery; all harvesting was conducted with dip net only; and the maximum quota per license was limited to 300 kg with no more than 150 kg taken from any one river system.

MISE EN OEUVRE DE MESURES DE RÉGLEMENTATION

Le régime de gestion employé pour la pêche de l'anguille est basé sur la réduction des prises par des mesures de limitation de l'effort, notamment la restriction du nombre de permis de pêche, de la quantité d'engins et de la durée de la saison de pêche. Étant donné les lacunes des informations scientifiques sur la dynamique des populations et les caractéristiques du recrutement des anguilles dans la région de Terre-Neuve, ainsi que la nature panmictique de l'espèce (les anguilles américaines que l'on trouve à l'est du continent nord-américain

proviennent d'un seul stock reproducteur), on ne peut utiliser une stratégie de total autorisé des captures (TAC). Les objectifs de gestion à long terme de cette espèce sont la viabilité biologique et l'amélioration de la viabilité économique.

Les exigences réglementaires mises en place avant 1990 se résument ainsi : l'article 34 du *Règlement de pêche de Terre-Neuve* exige que tous les pêcheurs commerciaux et sportifs se procurent un permis, sauf lorsqu'ils pêchent à la ligne. Les pêcheurs doivent noter leurs captures et leur effort de pêche dans des registres. Les engins installés doivent laisser sans obstruction le tiers de la largeur du cours d'eau et les deux tiers d'un chenal principal. La taille minimale de l'anguille exploitée et vendue est de 20 cm (8 po). La saison d'utilisation des verveux dans les eaux intérieures à cette époque était du 15 août au 30 novembre et du 1er novembre au 31 mars dans le cas du harpon.

En 1990, la limite du nombre d'engins dans les eaux côtières de l'est de Terre-Neuve était fixée à 10 verveux et 50 nasses à anguilles; les nouveaux permis étaient limités à un maximum de deux verveux par cours d'eau. En 1991, dans la même région, la limite d'engins dans les eaux intérieures était de 5 à 10 filets et de 25 nasses et, dans les eaux côtières, elle était abaissée à un maximum de cinq filets. La saison dans les eaux côtières avait aussi été réduite, du 15 août au 31 octobre. En 1992, les nouveaux permis de pêche dans les cours d'eau inscrits étaient limités au demi-kilomètre de la partie inférieure du bassin, dans l'est de Terre-Neuve.

En 1993, les régions de l'est et de l'ouest de Terre-Neuve ont été combinées en une seule structure de gestion régionale. La quantité d'engins prévue par les permis dans la division 4R et la sous-division 3Pn (ouest de Terre-Neuve) de l'OPANO était bloquée aux niveaux de 1992 et aucun nouveau permis de pêche sportive n'était délivré. En 1994, le MPO a limité l'accès aux permis de pêche commerciale dans les zones de pêche établies et les permis de pêche expérimentale ont été délivrés seulement dans les zones inutilisées à des conditions très restrictives. De plus le transfert ou le renouvellement des permis a aussi été restreint. Une saison de pêche à la nasse a été établie en 1994, du 1er juillet au 31 octobre, pour une grande partie de la Région de Terre-Neuve, et du 15 avril au 31 octobre de Grand Bruit à Cape St. Gregory. En 1995, la date d'ouverture de la pêche à la nasse dans les eaux côtières était modifiée et était fixée au 1er juillet, la saison s'étendant jusqu'au 1er juin. Cette année-là, l'utilisation de dispositifs d'exclusion des prises accidentelles dans les verveux devenait obligatoire pour toutes les pêches expérimentales, un plan stratégique prévoyant l'adoption graduelle de ces dispositifs dans tous les verveux.

En 1996, l'admissibilité au permis de pêche exploratoire a été restreinte à un groupe de pêcheurs professionnels (les pêcheurs du noyau) et une pêche exploratoire limitée des civelles a été autorisée (quatre permis), assujettie aux conditions suivantes : l'admissibilité était réservée aux pêcheurs commerciaux d'anguille; l'exploitation des civelles était autorisée seulement dans les cours d'eau où il n'y avait pas de pêche établie de l'anguille; toute exploitation devait être effectuée au moyen de carrelets seulement; et le quota maximum par permis était de 300 kg, pas plus de 150 kg ne pouvant provenir d'un même réseau hydrographique.

OVERVIEW OF THE 1996 MANAGEMENT PLAN

LICENSING

A. Licenses may be issued for either inland or coastal waters or a combination of both.

B. Fishers who held an eel license in 1995 are eligible to renew the license in 1996.

C. No new licenses will be issued. Exploratory commercial licenses may be issued to Core fishers in special zones isolated from areas of established eel harvesting activity where the possibility exists to develop a fishery. These special exploratory zones will be defined in consultation with DFO Area Offices. Exploratory licenses for fyke nets will include the requirement to use by-catch exclusion devices that are acceptable to DFO. Experimental eel licenses issued in 1995 may be reissued in 1996 for the same locations permitted in 1995, provided the operation of the experimental license did not negatively impact on other fisheries or fish species and all license conditions were complied with.

D. Reissuance (transfer) of eel licenses is not permitted other than through a transfer of a complete enterprise.

INLAND WATERS

A. The license will designate the river(s) which may be fished and the amount of gear which can be fished on each designated river. For each river the site to be fished shall be specified. Actual co-ordinates (latitude and longitude) should be used if possible.

B. Individuals who held a license in 1995 may renew their license for the same areas and gear quantities as in 1995 up to the maximum level stated in (D) below.

C. No licenses may be issued for a protected water supply area unless that area has been specifically exempted by the Province to permit fishing for eels.

D. The maximum amount of gear permitted on any license is five (5) nets and twenty-five (25) pots. Fishers who can show that they fished more than five (5) nets in 1995 can be licensed for two (2) nets per licensed river, up to a maximum of ten (10) nets. For 1996, fishers in NAFO Division 4R and Subdivision 3Pn may be licensed for the same amount of gear as in 1995. However, it is recognized that excessive amounts of gear held by some license holders on the west coast is a matter of concern and will be addressed through industry consultations during 1996 and 1997.

COASTAL WATERS

A. Licenses will be valid for the Fishing Area of residence only (1-14).

B. The maximum amount of gear permitted is 5 nets and 50 pots. For 1996, fishers in 4R and 3Pn may be licensed for the same amount of gear as in 1995. The issue of gear overcapacity in coastal waters will also be addressed through industry consultations during 1996 and 1997.

RECREATIONAL

No new recreational eel licenses will be issued in 1996. Recreational eel licenses are available to those individuals who held a license in 1995. The amount of gear (spears & pots) and areas permitted will be the same amount and areas permitted each individual license holder in the previous year. Details on quantity of gear, types of gear and areas of operation will be specified on the license.

SEASONS

A. A special early fishing season opening of Monday, August 12 will be permitted in 1996, on a trial basis, for the setting of fyke nets in inland waters. Only licensed eel fishers who use by-catch exclusion devices of a design acceptable to DFO will be permitted to set fyke net gear during the early season opening period. Fishers who use fyke nets without by-catch exclusion devices (in non-scheduled waters) will be restricted to the regular August 15 fyke net season opening date. The fyke net season will close on October 31.

B. The season for eel pots is July 1-October 31 for inland waters. For coastal waters the eel pot season is June 1-October 31 except for the area from Grand Bruit to Cape St. Gregory where the season is from April 15-October 31. Fyke nets may be fished in coastal waters during the same period as pots in coastal waters.

C. Where a scheduled salmon river is closed due to low water conditions no fishing for eels by means of fyke nets will be permitted. Low water conditions and high water temperatures may also result in the closure of non-scheduled rivers to fishing for eels.

DEPLOYMENT OF FYKE NETS

A. On scheduled salmon rivers by-catch exclusion devices of a design acceptable to DFO will be mandatory for the 1996 fishing season. (This requirement will be set as a condition of license.)

B. On non-scheduled rivers where a fyke net by-catch exclusion device is not in use, fyke nets (bags) are to be left open between 0800 hours and one (1) hour prior to sunset each day to reduce any by-catch of salmonids. (This requirement will be set as a condition of license.)

C. At least one-third of the width of any river or stream must be left open at all times. Not less than two-thirds of the main channel at low tide in every tidal stream must be left open at all times.

D. Fishers must ensure that there is no harmful alteration, disruption or destruction of fish habitat. This includes the movement of rocks, gravel or other materials that could alter the natural flow of the river.

EXPERIMENTAL ELVER FISHERY

A. Limited number of experimental elver licenses may be issued in 1996. Only currently licensed commercial eel fishers who were active in 1995 and reported eel landings for that year will be considered for an elver license.

B. Rivers and/or coastal waters approved for an elver fishery will be specified in the experimental license.

C. Rivers and coastal waters that were licensed in 1995 for a yellow or silver eel fishery will not be considered for an elver fishery.

D. The retention of eels greater than or equal to 10 centimeters in length will be prohibited in an experimental elver fishery.

E. The fishing gear permitted will be dip nets only.

F. The maximum quantity of elvers taken in any one river and in the fishery in total will be stipulated in the experimental license.

G. All by-catch of other fish species must be released immediately.

H. Elver license holders will be required to record their daily fishing activity in the elver fishing log and submit a copy of the log to the Department on a weekly basis.

I. Non-compliance with any condition of the experimental license or interference with established commercial fisheries may result in the cancellation of the license.

OTHER CONSIDERATIONS

A. In line with the long term strategy to address by-catch concerns in the eel fishery, it is the Department's intent to mandate, by condition of license, the requirement for fyke net by-catch exclusion devices in all inland and coastal waters in 1997.

B. All fishing gear must be clearly marked with the licensee's name and license number.

C. The minimum retention size for eels is 20 cm (8 inches) overall length (measured from the tip of the snout to the tip of the tail) in all eel fisheries other than authorized elver fisheries.

D. Fishing gear must be set in such a manner that it does not impede the upstream migration of fish.

E. Any by-catch in the eel fishery must be released.

F. All eel fishers must maintain a log reporting the areas fished, the amount of gear used and the catch. Fishing logs must be completed for each day of activity and be submitted to DFO on a weekly basis.

G. A license is required to transfer eels from one river to another. Unless otherwise stated, a fisher must maintain separate holding pounds for each river for which he is licensed.

ECONOMICS OF THE FISHERY

HARVESTING

The landed value of the eel fishery in Newfoundland averaged $390,000 annually from 1987 to 1995 (Fig. 1). The value of this fishery peaked at $564,000 in 1991. In 1996, fishers harvested approximately $427,000 worth of eels from Newfoundland rivers.

Eels have contributed to the fishery in most areas throughout the Region. Rivers flowing in Notre Dame Bay account for the largest share (37%) of the total landed value. Rivers in Bonavista Bay recorded 14% of the total landed value. Other significant areas for eels are Trinity Bay, Conception Bay, St. George's Bay, and the Northern Peninsula.

Increased prices have resulted in improved revenues from eel fishing in recent years. Fishers received a price in the range of 30-40 cents per pound in the early 1980s. However, since 1987 prices have averaged approximately $1.80/lb. The price peaked at $2.88/lb in 1996, up from $2.25/lb in 1995.

The primary costs in this fishery are the initial capital investment in nets and/or pots. Since a fishing vessel is not necessarily required to harvest eels, it can be assumed that operating costs are very low, and the majority of the fishing revenue can be considered to be earnings.

Approximately 300 fishers in Newfoundland were licensed to harvest eels in recent years(Fig. 2). Although there is no revenue data for individual license holders, it is estimated that a large percentage of the total eel catch is caught by a small group of these fishers. As a result, earnings for individuals who participated in this fishery may be significant.

PROCESSING

There are currently only five or six plants in this province processing eels, most of which are located in the Bonavista Bay area, where approximately 40 person-weeks of plant employment is generated annually. On average, 90% of the production is frozen with the remainder being live exports with an annual production averaging $750,000 in recent years.

FUTURE MANAGEMENT OPTIONS

The following items are potential future eel management options that may be employed to achieve economic viability and biological sustainability of the Newfoundland eel fishery. All of the foregoing options are subject to a consultative review by Newfoundland eel fishers and other resource stakeholders.

1. Increase eel minimum size to 40 cm (16 inches).

2. Cap the issuance of commercial regular and exploratory licenses at the 1995 level.

3. Evaluate the economic viability and biological sustainability of an eel vs. elver fishery.

4. Evaluate areas of gear overcapacity and, in conjunction with industry, develop strategies to reduce gear amounts.

5. Maintain overall gear and season limitations established in recent years.

REFERENCES

Blackwood, G. 1983. The Development of the Newfoundland Eel Fishery 1982. Development Branch Report No. 30, Department of Fisheries, Government of Newfoundland and Labrador.

Bruce, W.J. 1982. Proceedings at 1980 North American Eel Conference.

Eales, J.G. 1968. "The Eel Fishery of Eastern Canada." Fish. Res. Board Can. Bull. 166.

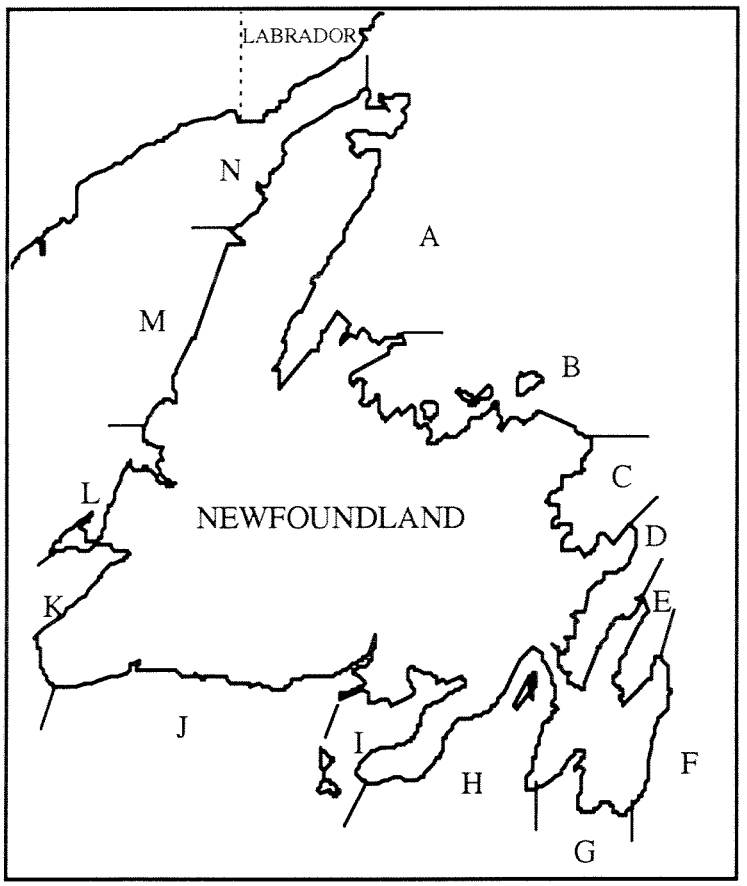
Mullins, C. Newfoundland Eel Fishery Development, 1979, Government of Newfoundland and Labrador, Development Branch (Report 1978 - Dev. B. #10)

Pinhorn, A. 1976. "Brief Review of the Eel Fishery in Newfoundland."

Dooley, T. "Report on the 1988 Newfoundland Eel Fishery." Data Series Report No. 28, April 1989. Government of Newfoundland and Labrador.

Table 1a. Commercial eel landings (metric tonnes) in insular Newfoundland for the years 1961-80 by statistical area as is shown in map below.

Area	1961	1962	1963	1964	1965	1966 -70	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
A	-	-	-	-	-		-	-	-	-	-	3.1	6.2	0.3	0.4	0.3
B	-	-	-	-	-		-	-	-	-	-	1.5	0.5	-	-	0.3
C	-	-	0.2	1.3	-		-	-	-	-	-	-	-	-	-	0.5
D	-	12.5	8.8	-	-		-	-	4.0	-	0.5	-	-	-	-	3.0
E	-	4.6	-	-	-		-	-	-	-	-	-	-	0.9	1.2	2.9
F	-	-	-	-	-		-	-	-	-	-	-	2.8	-	-	2.8
G	-	3.4	3.0	-	-		1.0	-	-	-	-	-	-	-	2.1	2.4
H	-	1.8	14.8	3.7	2.4		-	-	-	-	-	-	2.1	-	-	-
I	-	1.2	10.2	7.0	0.9		-	-	-	-	-	-	-	-	-	-
J	-	-	-	1.0	-		4.0	17.0	5.0	19.0	7.1	6.2	-	-	-	0.01
K	0.25	-	-	-	-		36.0	52.0	22.0	2.0	0.3	0.5	7.7	14.5	19.6	44.9
L	-	-	-	-	-		-	10.0	-	-	-	-	-	-	0.1	0.1
M	-	-	-	-	-		-	-	-	-	-	-	-	-	-	25.5
N	-	-	-	-	-		3.0	-	-	-	-	-	-	-	-	-
O	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
Total	0.25	23.5	37.0	13.0	3.3		44.0	79.0	31.0	21.0	7.4	11.3	19.3	15.7	23.4	82.7



Source: T. Dooley 1989, Nfld. Dept. of Fisheries. O = Labrador.

Table 1b. Commercial eel landings (metric tonnes) in Newfoundland and southern Labrador 1981-96 by statistical area.

Area	1981	1982	1983	1984	1985	1986[A]	1987[A]	1988[A]	1989	1990	1991	1992	1993	1994	1995	1996[B]
A	0	0	0	0	0	0	0	0.1	0.8	5.3	3.7	0.4	3.6	3.8	3.8	0
B	4.6	8.5	5.4	0	0.4	0.2	6.5	16.0	11.5	26.1	23.0	13.6	18.1	18.4	14.7	3.0
C	2.0	7.1	3.3	12.1	9.0	8.2	11.9	27.6	21.5	27.2	14.4	11.1	18.9	15.3	9.0	1.0
D	0.7	0	0	0	0	0.5	0.2	1.0	2.3	4.8	3.9	5.2	4.2	6.3	6.1	0.9
E	0.5	0	0	0	0	1.8	4.1	8.5	4.5	10.3	5.8	4.0	6.5	5.4	5.2	3.2
F	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0.2
G	1.1	0	0	0	0	0.5	1.1	0	0	0.5	0.3	1.3	1.9	2.7	0.8	0.4
H	0.3	0	0	0	0.1	0	0.1	3.4	0.4	2.4	4.2	2.9	1.5	4.7	1.6	0.1
I	1.1	0	0	0	0	0	0	1.3	0.5	0.2	0.9	0	0.4	1.3	1.7	0
J	3.7	0	2.2	0	0	0	0	0	0	4.1	3.3	5.3	22.3	6.0	2.3	1.6
K	13.5	20.3	16.9	1.3	2.7	7.9	5.4	1.8	24.1	40.0	62.5	40.0	26.3	31.1	23.2	4.6
L	0.1	0.1	0.2	0.6	6.9	0.5	1.1	0.8	0.6	1.0	0.5	0.4	2.3	0.3	1.3	0.4
M	13.9	0.7	0	0	1.6	5.3	0.2	0.4	8.1	15.7	4.6	4.5	6.9	11.1	9.0	3.6
N	0	0	0	0	0	1.6	0	0	9.1	9.3	6.8	1.3	3.0	4.6	6.3	3.3
0	0	0	0	0	4.3	0	0	0	0	0	0	0	0.1	0	0	0
Total	41.5	36.7	28.0	14.0	25.0	26.6	30.6	60.8	83.5	146.6	133.9	89.9	116.1	110.9	85.4	22.4

A. Provincial Dept. of Fisheries reported landings for 1986, 1987, and 1988 at approximately 77t, 58t and 116 t, respectively.
B. Data for 1996 is preliminary

Data Source: Statistics Division, DFO, Newfoundland Region.

Table 2. Eel landings and landed value, Newfoundland Region.

Year	Landings (kgs)	Value ($)	Ave. $CD / kg
1978	15,637	10,329	0.66
1979	23,397	19,334	0.83
1980	82,206	84,750	1.03
1981	41,496	43,119	1.04
1982	36,677	46,969	1.28
1983	27,990	36,391	1.30
1984	13,965	20,214	1.45
1985	24,958	29,226	1.17
1986	26,580	52,029	1.96
1987	30,596	105,123	3.44
1988	60,823	219,263	3.60
1989	83,539	307,989	3.69
1990	146,577	560,471	3.82
1991	133,932	564,072	4.21
1992	89,851	390,211	4.34
1993	116,062	484,770	4.18
1994	110,903	468,852	4.23
1995	85,419	423,903	4.96
1996*	67,181	426,876	6.35

*1996 Figures are preliminary.
All years include NAFO Division 4R and Subdivision 3Pn.

Table 3. Commercial eel fishing license holders, Newfoundland and Labrador.

Areas	1988 [1]	1994 [2]	1995 [2]	1996 [2 3]
1 (Avalon)	54	110	87	69
2 (South Coast)	81	42	37	22
3 (NE Coast)	103	123	107	95
4 (Labrador)	0	1	1	0
5 (West Coast)	70	86	84	62
TOTAL	308	362	316	248

[1] Area boundaries for 1988 are not exactly the same as for 1994 to 1996.
[2] Includes regular and exploratory licenses.
[3] Preliminary.

Eel fishing gear, maximum amounts permitted by license.

Areas	POTS Inland/Coastal	POTS Coastal	FYKE NETS	TOTAL
1 (Avalon)	1657	200	250	2107
2 (South Coast)	425	425	43	893
3 (NE Coast)	850	1975	270	3095
4 (Labrador)	0	0	0	0
5 (West Coast)	1857	400	1152	3409
TOTAL	4789	3000	1715	9504

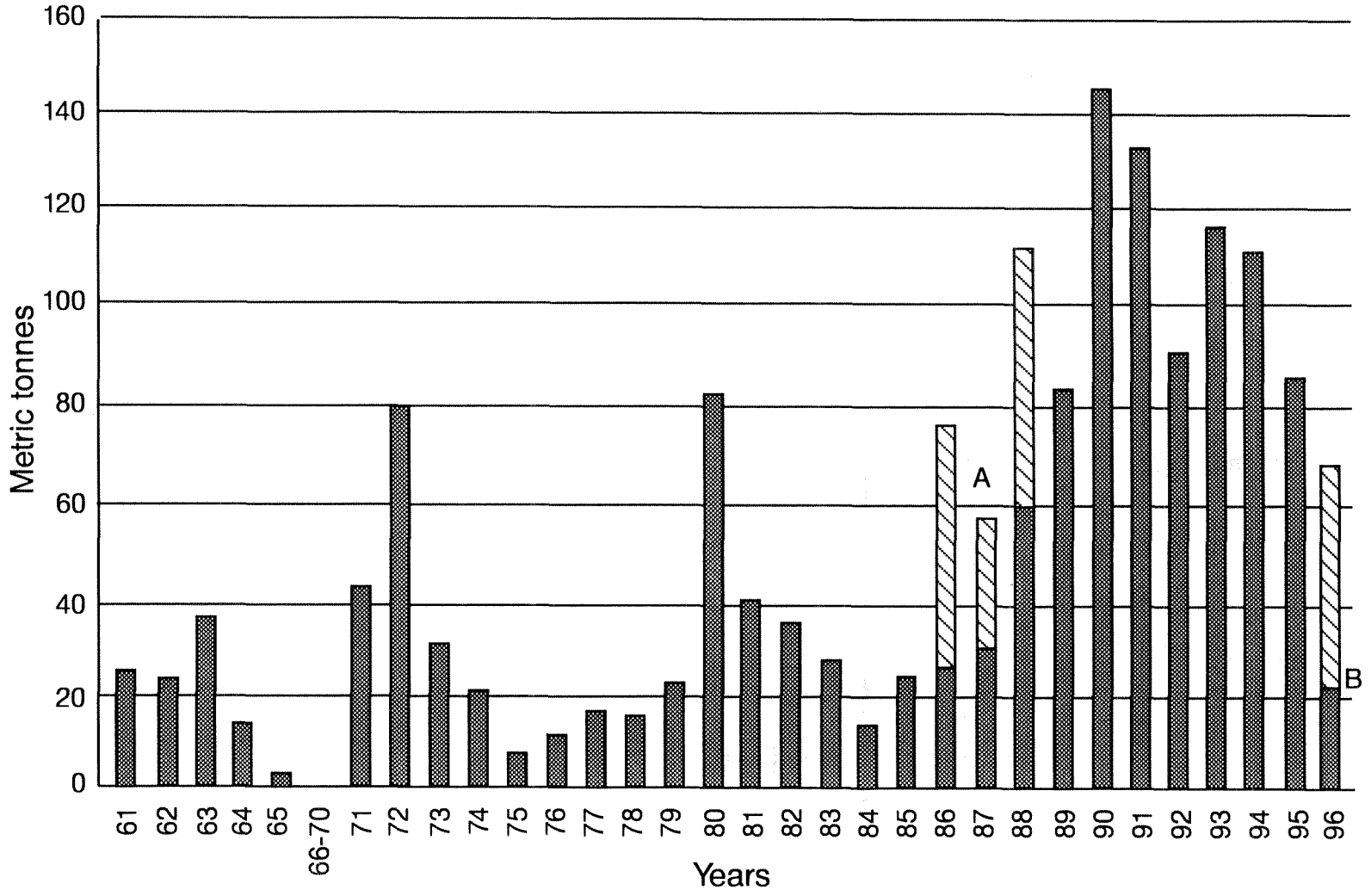


Fig. 1. Commercial landings in Newfoundland for years 1961-96.

A - Provincial Dept. of Fisheries reported landings for 1986, 1987 and 1988 at approximately 77 t, 58 t and 116 t, respectively.
B - Data for 1996 is preliminary.

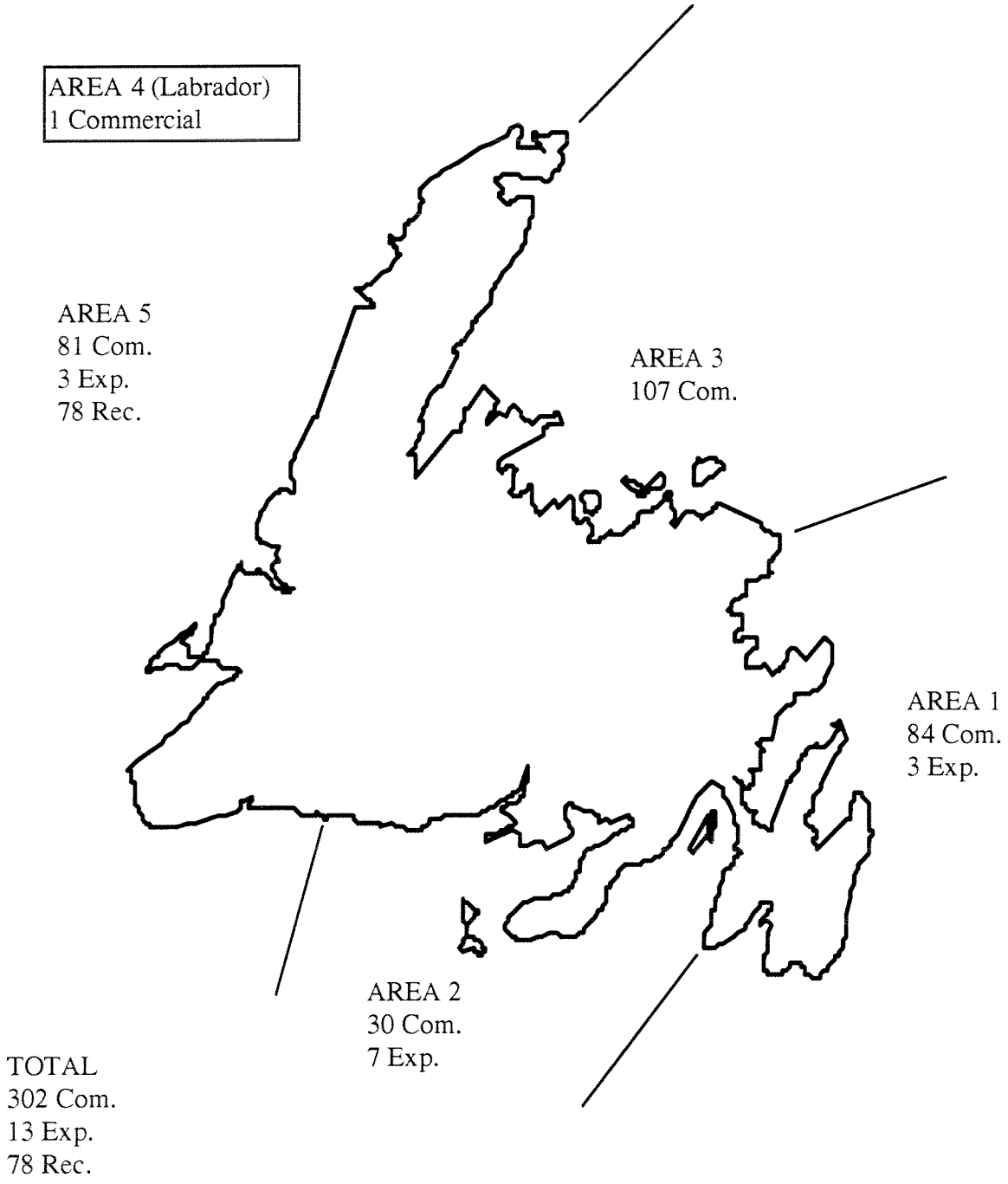


Fig. 2. Eel fishery - Newfoundland Region, license distribution 1995.

La gestion et la réglementation de la pêche commerciale de l'anguille d'Amérique (*Anguilla rostrata*) au Québec

by

Serge Tremblay
Ministère de l'Environnement et de la Faune du Québec
150 Rene-Levesque
5e etage, Quebec, Quebec G1R 4Y1

RÉSUMÉ

Au Québec, l'effort de pêche et le nombre de détenteurs de permis de pêche à l'anguille d'Amérique (n ≈ 200) sont constants depuis plusieurs années. Les principales zones de pêche sont distribuées le long du fleuve Saint-Laurent. Ces zones sont l'archipel de Montréal, la rivière Richelieu, le lac Saint-Pierre et la partie estuarienne du Saint-Laurent. Les secteurs les plus importants sont: le lac Saint-Pierre où les pêcheurs exploitent l'anguille verte à l'aide de verveux et l'estuaire maritime, où les pêcheurs utilisent des pêches à fascines afin de capturer l'anguille au stade argentée. La gestion de l'espèce est contrôlée dans chacune des zones de pêche par le nombre et le type d'engins de pêche et les saisons. Aucun quota n'est attribué. La réglementation actuelle répond bien à nos objectifs de gestion. Le moratoire sur l'émission de nouveaux de permis de pêche à l'anguille sera maintenu jusqu'à ce que l'ensemble des gestionnaires nord-américains conviennent d'un plan de gestion concerté de l'anguille d'Amérique.

ABSTRACT

In Quebec, the fishing effort and the number of American eel fishing licence holders (n ≈ 200) have remained constant over the last few years. The main fishing areas— the Montreal Islands, the Richelieu River and Saint-Pierre Lake and the St. Lawrence estuary— are found along the St. Lawrence River. The most important sectors are Saint-Pierre Lake where the fishers harvest green eels using fyke nets and the lower estuary where the fishers use weirs to catch silver eels. Species management is controlled in each fishing area by the number and type of gear and the seasons. No quota has been set. Current regulations closely reflect our management objectives. The moratorium on the issuing of new eel fishing licences will be maintained until all of the North American managers agree on a joint management plan for the American eel.

INTRODUCTION

Au Québec, l'anguille d'Amérique (*Anguilla rostrata*) a toujours été exploitée sur une base exclusivement commerciale. Comme l'espèce a toujours été considérée abondante, elle a été conséquemment recherchée par un grand nombre de pêcheurs dispersés le long du fleuve Saint-Laurent entre le lac Saint-François et l'estuaire maritime, soit sur une distance de près de 600 km. Le partage de cette ressource commune commandait donc l'implantation de mécanismes légaux et administratifs afin d'assurer une exploitation raisonnable de l'espèce et une bonne gestion des utilisateurs. Depuis plusieurs années, le nombre de détenteurs de permis de pêche à l'anguille est constant à près de 200 détenteurs de permis. Bien que l'effort de pêche demeure stable, la baisse graduelle des débarquements d'anguilles observée ces dernières années n'est pas sans inquiéter les gestionnaires et les pêcheurs quant à l'avenir de cette pêcherie (Fig. 1).

En 1993, les pêcheurs commerciaux ont alerté les gestionnaires que cette espèce montrait des signes de déclin. Un groupe de travail a donc été mis sur pied avec le mandat d'identifier les causes de cette baisse. Ce groupe est composé de gestionnaires et de scientifiques provenant des ministères provinciaux et fédéraux, d'Hydro-Québec et d'associations de pêcheurs commerciaux. De plus, des travaux ont été entrepris par notre ministère afin de caractériser la pêcherie de cette espèce, le taux d'exploitation, l'effort de pêche et le recrutement de l'anguille dans certaines rivières.

CONTEXTE LÉGAL

La pêche commerciale à l'anguille d'Amérique est sous la responsabilité de deux ministères provinciaux. Le ministère de l'Environnement et de la Faune (MEF) est responsable de la gestion et du contrôle de l'exploitation commerciale de l'espèce. Par voie réglementaire, le MEF détermine le type et le nombre d'engins de pêche, les saisons et l'effort de pêche dans chacune des zones de pêche. Le ministère de l'Agriculture, des Pêcheries et de l'Alimentation (MAPAQ) est responsable de la cueillette des données de débarquements, de l'émission des permis de pêche commerciaux et du partage entre les pêcheurs de l'effort de pêche autorisé par le MEF.

L'exploitation commerciale de l'anguille est régie par le Règlement de Pêche du Québec en vertu de la Loi sur les Pêches (Fisheries Act) du Canada. La délégation de gestion des pêches au gouvernement du Québec date de 1922. Sur son territoire, cette délégation porte exclusivement sur les espèces de poissons d'eau douce, anadromes et catadromes.

De plus, la Loi de la Conservation et de la Mise en Valeur de la Faune oblige le MEF à produire annuellement un Plan de gestion de la pêche commerciale, à la suite duquel le MAPAQ procède à l'émission des permis avec les conditions d'exploitation exigées par le MEF.

La gestion de l'espèce se fait par grandes zones de pêche. La pêche commerciale de l'anguille est concentrée dans quelques zones où généralement l'habitat et le type d'exploitation sont relativement homogènes. La figure 2 montre les limites des principales zones de pêche à l'anguille. Le nombre et le type d'engins de pêche, la dimension des mailles ou des hameçons, la longueur des guideaux et des ailes, les périodes de pêche sont définis pour chaque zone. Le permis reprend cette information selon les privilèges accordés à chaque détenteur. La localisation précise de certains engins telles les trappes à anguille, est généralement indiquée sur le permis. Une règle générale est appliquée à tous les engins de pêche exploitant l'anguille. En effet, il est interdit de conserver en sa possession une anguille dont la longueur est inférieure à 20 cm. Aucun quota n'est attribué pour gérer cette pêcherie, contrairement à l'Ontario. La réglementation actuelle répond bien à nos objectifs de gestion qui consistent essentiellement à conserver et à mettre en valeur l'anguille d'Amérique.

Le tableau 1 résume les modalités d'exploitation de l'anguille et le nombre de pêcheurs par zone de pêche à l'anguille d'Amérique. Les zones les plus importantes sont le lac Saint-Pierre et l'estuaire maritime.

Au Québec, l'anguille est exploitée seulement à deux stades de son développement: les anguilles vertes et les anguilles argentées. Au lac Saint-Pierre, les pêcheurs exploitent l'anguille verte et les autres espèces de poissons à l'aide de verveux (anglais: hoop net). Dans l'estuaire maritime, l'anguille argentée est capturée à l'aide de trappes (anglais: pound net) spécialisées conçues pour sa capture. Ces trappes sont communément appelées « pêche à fascines ».

CONCLUSION

À l'extérieur du Québec, le développement récent de nouvelles pêches à l'anguille à tous les stades de développement peut exercer une pression supplémentaire sur l'espèce. Sur le principe voulant que l'anguille soit effectivement panmictique, sa gestion doit être menée sur une base nord-américaine. Depuis 10 ans, le Québec a mis un frein au développement de nouvelles pêcheries; et il a toujours interdit l'exploitation de la civelle. Nous entendons maintenir un moratoire sur l'émission de nouveaux permis de pêche à l'anguille jusqu'à ce que tous les gestionnaires nord-américains se concertent afin de mettre sur pied un plan de gestion intégré de l'espèce.

Table 1. Fishing gears and fishing effort allowed for the exploitation of American Eel in Québec.

Fishing zones	Fishing gear			Fishermen	Fishing season
	Type	Size or Length	Number	(n)	
Montréal Archipelago	Longline	Hook <= 4/0 100 hooks/ longline	38	3	open year-round
	Eel trap		150	2	open year-round
Richelieu River	Pound net	360 fathoms	4	1	1 april - 30 november
Saint-Pierre Lake	Hoop net (multisp. fish. gear)		1680 2100	41	1 april - 30 november 1 june - 30 august
Freshwater Estuary	Hoop net (multisp. fish. gear)		1377	35	open year-round
	Pound net	3496 fathoms	24	12	open year-round
Marine Estuary	Pound net	31019 fathoms mesh size < 5,7cm	139	70	1 sept. - 30 november

Source: Commercial fishing licenses (MAPAQ 1995)

Tableau 1. Modalités d'exploitation de la pêche commerciale à l'anguille d'Amérique

Zones de pêche	Engins			Pêcheurs	Saison
	type	grosseur ou longueur	nombre	(n)	
Archipel de Montréal	ligne dormante	hameçon ≤ 4/0 100 hameçons/ ligne	38	3	ouvert à l'année
	cages à anguille		150	2	ouvert à l'année
Rivière Richelieu	trappes à anguille	360 brasses	4	1	1 avril - 30 novembre
Lac Saint-Pierre	verveux pour pêche-rie multispécifique		1680	41	1 avril - 30 novembre et 1 sept. - 30 nov.
			2100		1 juin - 30 août
Estuaire fluvial	verveux pour pêche-rie multispécifique		1377	35	ouvert à l'année
	trappes à anguille	3496 brasses	24	12	ouvert à l'année
Estuaire maritime	trappes à anguille	31019 brasses maille < 5,7cm	139	70	1 sept. - 30 novembre

Source: permis de pêche (MAPAQ 1995)

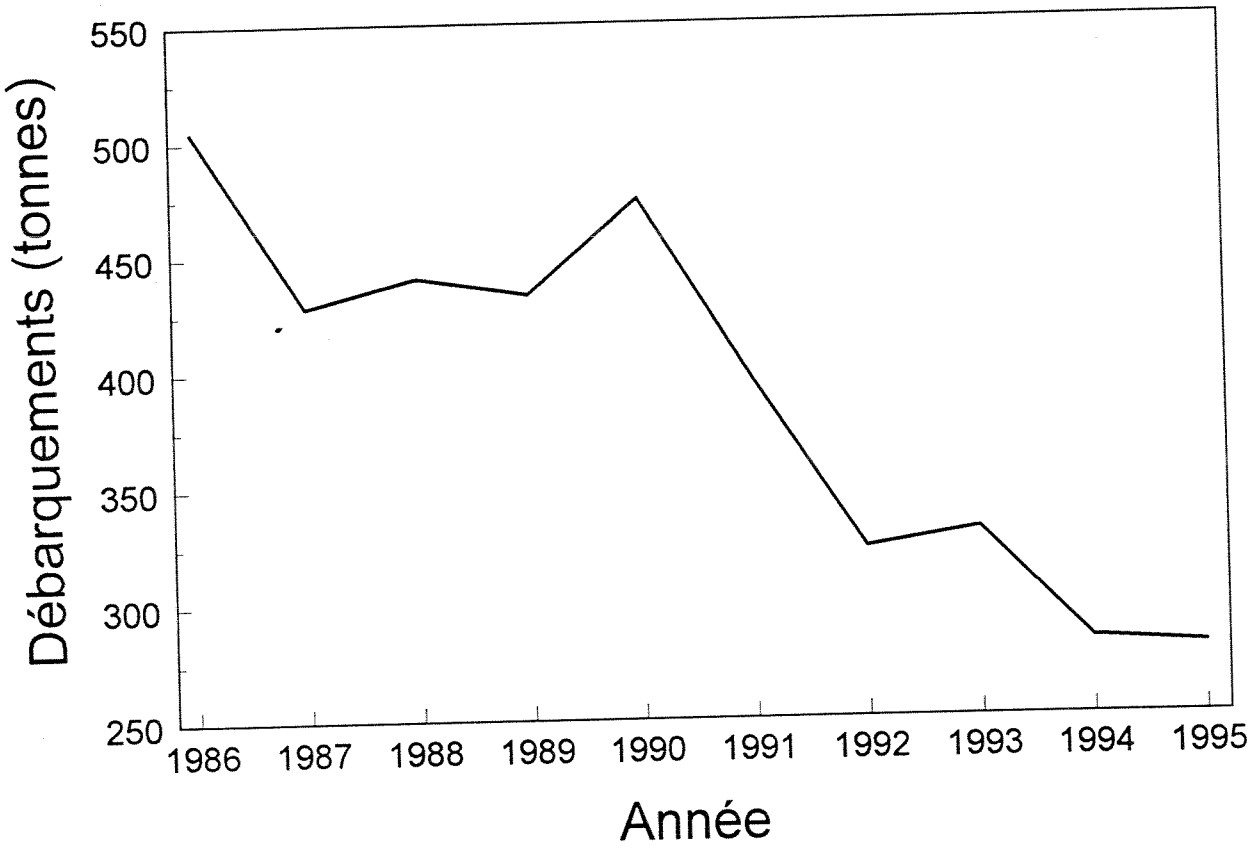


Figure 1. Évolution des débarquements d'anguille d'Amérique au Québec (1986-1995).

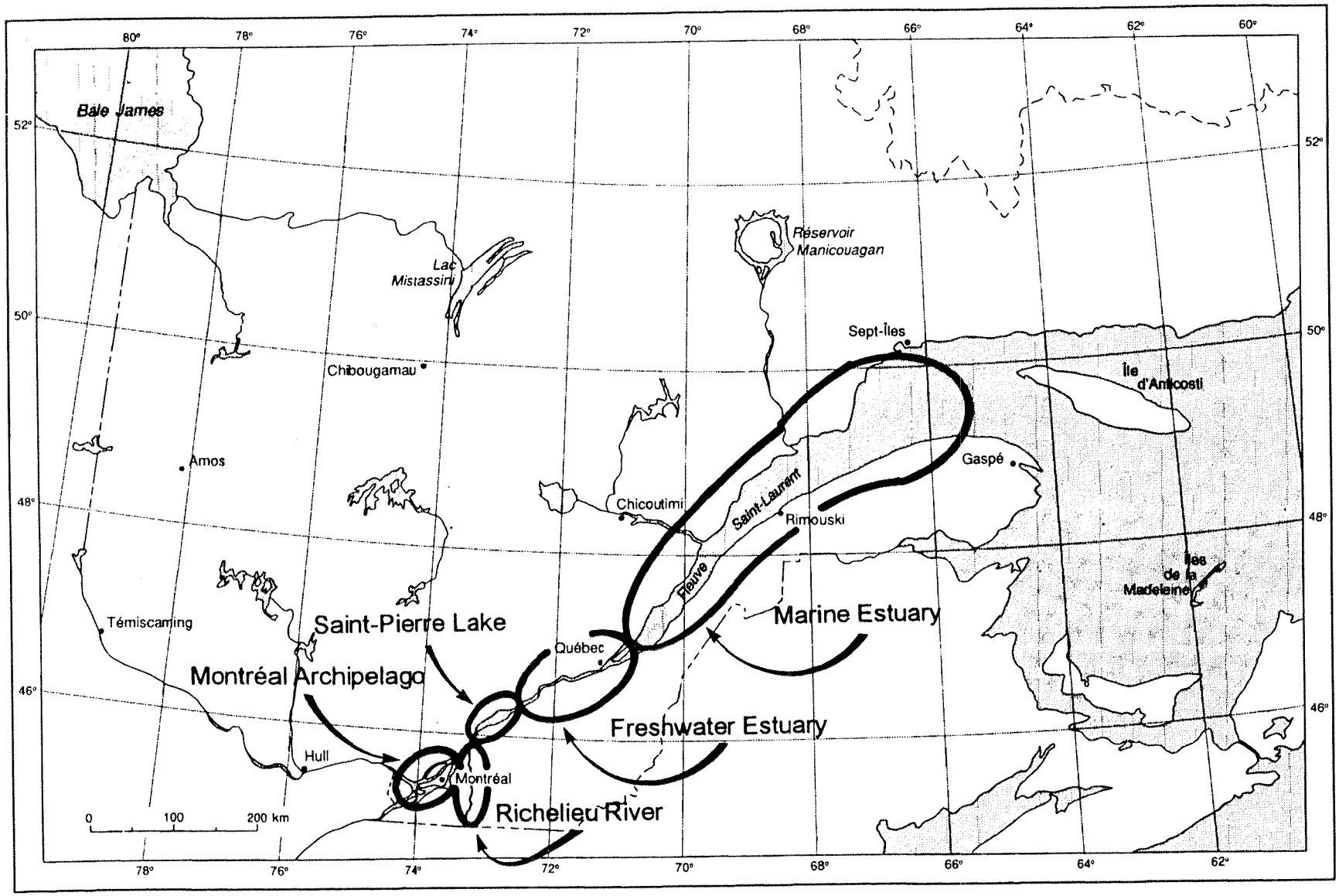


Figure 2. Secteurs de pêche à l'anguille d'Amérique (Québec).

Management of the American Eel, *Anguilla rostrata*, in Lake Ontario and the Upper St. Lawrence River

by

T. J. Stewart
Ontario Ministry of Natural Resources
Fish and Wildlife Branch
Lake Ontario Management Unit
Glenora Fisheries Station
RR # 4, Picton, Ontario KOK 2T0

J. M. Casselman and L. A. Marcogliese
Ontario Ministry of Natural Resources
Science Development and Transfer Branch
Aquatic Ecosystems Science Section
Glenora Fisheries Station
RR # 4, Picton, Ontario KOK 2T0

ABSTRACT

The American eel (*Anguilla rostrata*) from Lake Ontario and the upper St. Lawrence River is the third most valuable species harvested in the commercial fishery. There are 46 individual fishermen licensed to fish eels. The fishery harvests primarily maturing yellow eels using trapnets, hoopnets and hooklines. Total annual harvest for the period from 1984-1996 ranged from 57-124 metric tons. Harvest has declined recently in most regions. Harvest is restricted by limiting new licenses, individual quotas, and closed seasons. A quota management system was introduced in 1984. Buy-out programs reduced the quota by 29% from 1985 to 1988 and reduced the potential for future increases in fishing effort. Additional annual quota reductions have continued; however, harvest has remained well below total allocated quota.

RÉSUMÉ

L'anguille américaine (*Anguilla rostrata*) du lac Ontario et du haut Saint-Laurent se classe au troisième rang parmi les espèces exploitées à des fins commerciales qui ont le plus de valeur. Quarante-six pêcheurs détiennent des permis de pêche de l'anguille. La pêche vise principalement les anguilles jaunes en voie d'atteindre la maturité capturées au moyen de filets-trappes, de verveux et de lignes et d'hameçons. Le total des captures annuelles, pour la période de 1984 à 1996, a fluctué entre 57 et 124 tonnes métriques. Les prises ont diminué récemment dans la plupart des régions. On restreint l'exploitation en limitant le nombre de nouveaux permis, en imposant des quotas individuels et des saisons de fermeture. Un régime de gestion par quota a été adopté en 1984. Des programmes de rachat ont permis de réduire le quota de 29 % entre 1985 et 1988, et ont abaissé le potentiel d'augmentation future de l'effort de pêche. Les réductions additionnelles annuelles de quota ont continué, mais les captures demeurent bien en deçà du total du quota autorisé.

INTRODUCTION

The earliest record of the commercial harvest of American eel(*Anguilla rostrata*) in Ontario waters of Lake Ontario and the upper St. Lawrence River dates back to 1884 (Baldwin et al. 1979). The fishery has been previously described and assessed by Hurley (1973) and Kolenosky and Hendry (1982). Casselman et al. (1997a) assessed the status of eels based on analysis of long-term commercial harvest information. Recruitment indices for the Lake Ontario and upper St. Lawrence River eel stock were reviewed by Casselman et al. (1997b). In this paper we describe the present-day commercial fishery and its management.

METHODS

Annual harvest statistics, quotas, and licensing information were assembled from annual reports of the Lake Ontario Management Unit, Ontario Ministry of Natural Resources, annual minutes of the Lake Ontario Committee, Great Lakes Fishery Commission meetings, and Ontario Ministry of Natural Resources files. Daily catch reports were summarized for the years 1995-96 to determine distribution of harvest by gear.

RESULTS AND DISCUSSION

THE COMMERCIAL EEL FISHERY

In 1984, a quota zone management system for the commercial fishery was implemented, establishing eight quota zones for Lake Ontario and the upper St. Lawrence River (Fig. 1). Prior to that time, records of harvest were kept by statistical region, but there were no regionally specific quotas. Most harvest of eels comes from three major regions -- Lake Ontario proper (zones 1 and 2), Bay of Quinte (zone 3 and 4), and the upper St. Lawrence River (zone 5 and 7); harvest is minimal in western Lake Ontario (zone 8) and Lake Consecon (zone 6).

Annual eel harvest ranged from 57-124 metric tons (MT) since 1985 (Table 1). The total landed wholesale value of eels harvested in 1996 was $305,936, representing the third most important commercial fish species. Recent trends in the total annual harvest differ among regions. Harvests in Lake Ontario proper and the Bay of Quinte declined in recent years while harvests in the upper St. Lawrence showed no obvious trend (Fig. 2).

In 1995, there were 96 licenses with eel quota issued to 46 fishermen. Many fishermen have more than one license specific to gear, quota zone, season and other special conditions.

Trapnets, hoopnets and hooklines are the primary gear used to harvest eels, and one fishermen is licensed to catch eels by electrofishing. A small number of eels are caught incidentally in gillnets that are targeting other species. Baited hook-lines are set specifically to catch eels, whereas impoundment gear (trapnets and hoopnets) target a variety of nearshore fish species. During the 1970s, most of the eel harvest (48-73%) was from hooklines (Kolenosky and Hendry 1982). A summary of daily catch reports for 1995-96 indicate a shift to increased harvest using impoundment gear (65-66% of the eel harvest). Hooklines accounted for only 28-30% of the harvest in 1995-96.

The eels harvested are primarily maturing or yellow eels, with a size range of between 500-1100 mm total length, weighing approximately 1-3 kg, and ranging from 9-26 yr old in the early 1990s (J. M. Casselman unpublished data). In 1994, the last year of complete commercial harvest information, the mean total length of eels caught was 802 mm (S.D.=97.0) for hooklines and 793 mm (S.D. = 97.9) for impoundment gear.

MANAGEMENT OF THE COMMERCIAL EEL FISHERY

The current approach to managing the commercial eel fishery was influenced by a number of events. In the 1960s and 1970s, declines in whitefish (*Coregonus clupeaformis*), lake herring (*Coregonus artedii*), walleye (*Stizostedion vitreum*), white perch (*Morone americana*) and other commercially important species (Christie 1973; Hurley 1986) increased commercial interest in eels. During the 1970s, the eel fishery harvest increased rapidly in response to new markets, rising prices and an abundance of eels (Christie et al. 1987; Casselman et al. 1997b).

Quotas for eels in Lake Ontario were first established in 1980 at 295 MT (Kolenosky and Hendry 1982), based on the harvest levels of the late 1970s which were peak (Phil Smith, Ontario Ministry of Natural Resources, Lake Ontario Management Unit, RR# 4, Picton, Ontario, pers. comm.). Optimism towards the continued growth of the fishery was bolstered by the installation of a prototype eel ladder at the Moses-Saunders hydro electric dam in 1974 that passed over 3 million eels in the first 4 yr of operation (Whitfield and Kolenosky 1978). Although catch rates declined in 1979, it was thought that the quota might be sustainable if the high number of young eels passing

over the eel ladder achieved maximum biomass (Kolenosky and Hendry 1982).

Harvest continued to decline, however, and by 1981 was less than half of the peak level observed only 4 yr earlier (Casselman et al. 1997a). Kolenosky and Daniels (1982) concluded that the eels were exhibiting signs of overfishing (declining harvest rate, reduced mean length and weight), and recommended a reduction in total allocation because they considered the existing allocation to be unsustainable and unachievable.

In 1984, Ontario introduced a quota zone management system as part of a provincial commercial fishery "modernization" process. The system represented a radical change for the commercial fishery and was met with some opposition. An appeal process, established to review quotas assigned to individual fisherman, resulted in increases in eel quota for some license holders (Phil Smith, pers. comm.). Appeals were completed and quotas were finalized in 1985. Despite concerns about declining eel stocks, total eel quotas increased to 358 metric tons.

The first reduction in eel quotas resulted from buy-out programs implemented from 1985-88 by the Ontario Ministry of Natural Resources. The emphasis of the buy-out programs was to reduce the size of the commercial gillnet fishery and so relieve pressure on declining yellow perch (*Perca flavescens*) stocks and reduce associated incidental catch of non-target and sport fish in gillnets. The buy-out of complete commercial fishing operations resulted in retirement of 29 eel hookline licenses and incidental eel quota associated with other fishing gear. The four year buy-out reduced the eel quota by 102 MT, representing a 29% reduction from the 1985 allocation.

Concern over the status of eels led to further reductions in eel quota beginning in 1993. Despite quota reductions, total harvests have remained well below total quota allocated (Fig. 3). However, by reducing the overall quantity of licensed fishing gear and quota, the future maximum potential fishing effort and harvest was reduced. In 1996, the total quota allocated was 211 MT, the lowest since the introduction of quotas. New commercial fishing licenses are no longer issued for Lake Ontario and the upper St. Lawrence River. However, existing licenses can be sold to, or temporarily fished by, other licensed fishermen.

There are no limits on the size of eels harvested. Small eels, less than 0.9 kg, are marketed in Ontario, but because of higher contaminant levels that exceed federal guidelines, larger eels are sold for export only.

Seasonal restrictions have been implemented on some types of commercial fishing gear to reduce conflict with angling and pleasure boat traffic and to limit incidental catch of other non-target fish species. Hookline fisheries are open all year, while trapnet and hoopnet fisheries are closed during the summer months in the upper Bay of Quinte (quota zone 3), Lake Consecon (quota zone 6) and the St. Lawrence River (quota zone 5 and 7). The trapnet fishery is open all year in the lower Bay of Quinte (quota zone 4) and Lake Ontario proper (quota zone 1, 2, and 8).

FUTURE MANAGEMENT DIRECTION

The maintenance and operation of the eel ladder and counter at Moses-Saunders dam, at Cornwall, is an important part of Ontario's eel management program. The facility gives maturing eels access to productive habitat in Lake Ontario and associated watersheds, and provides a reliable index of recruitment (L. A. Marcogliese et al., unpublished manuscript). It seems unlikely that the decline in recruitment of the Lake Ontario and upper St. Lawrence River eel stocks (Castonguay et al. 1994; Casselman et al. 1997b) is due to overfishing by Ontario commercial fishermen. However, a prudent approach is proposed for the management of the Lake Ontario and upper St. Lawrence eel stock, that will:

1. Maintain a limited entry policy by issuing no new commercial eel fishing licenses.

2. Opportunistically reduce quota.

3. Cooperate with other Lake Ontario and St. Lawrence River agencies and partners to maintain the upstream eel ladder and associated counter at the Moses-Saunders hyrdo-electric dam at Cornwall.

4. Continue to offer support to programs that further our understanding and management of the American eel population.

REFERENCES

Baldwin, N. S., R. W. Saafeld, M. A. Ross, and H. J. Buettner. 1979. Commercial fish production in the Great Lakes 1867-1977. Great Lakes Fish. Comm. Tech. Rep. 3: 187 p.

Casselman, J. M., L. A. Marcogliese, and P. V. Hodson. 1997a. Recruitment index for the upper St. Lawrence River and Lake Ontario eel Stock--1996: a re-examination of eel

passage at the W. B. Saunders hydroelectric generating station at Cornwall, Ontario, 1974-1995, p. 160-168. In R.H. Peterson (ed.) The American eel in eastern Canada: stock status and management strategies. Proceedings of eel workshop, January 13-14, 1997, Quebec City, PQ. Can. Tech. Rep. Fish. Aquat. Sci. 2196: v + 173 p.

Casselman, J. M., L. A. Marcogliese, T. J. Stewart, and P. V. Hodson. 1997b. Status of the upper St. Lawrence River and Lake Ontario American eel stock--1996, p. 106-120. In R.H. Peterson (ed.) The American eel in eastern Canada: stock status and management strategies. Proceedings of eel workshop, January 13-14, 1997, Quebec City, PQ. Can. Tech. Rep. Fish. Aquat. Sci. 2196: v + 173 p.

Castonguay, M., P. V. Hodson, C. M. Couillard, M. J. Eckersley, J.-D. Dutil and G. Verreault. 1994. Why is recruitment of the American eel, *Anguilla rostrata*, declining in the St. Lawrence River and Gulf? Can. J. Fish. Aquat. Sci. 51: 479-488

Christie, W. J. 1973. A review of the changes in the fish species composition of Lake Ontario. Great Lakes Fish. Comm. Tech. Rep. 23: 65 p.

Christie, W. J., K. A. Scott, P. G. Sly, and R. H. Strus. 1987. Recent changes in the aquatic food web of eastern Lake Ontario. Can. J. Fish. Aquat. Sci. 44(Suppl. 2): 37-52.

Hurley, D. A. 1973. The commercial fishery for American eel *Anguilla rostrata* (Lesueur) in Lake Ontario. Trans. Am. Fish. Soc. 102: 369-377.

Hurley, D. A. 1986. Fish population in the Bay of Quinte, Lake Ontario, before and after phosphorus control, p. 201-214. In C. K. Minns, D. A. Hurley, and K. H. Nicholls [ed.] Project Quinte: point-source phosphorus control and ecosystem response in the Bay of Quinte, Lake Ontario. Can. Spec. Publ. Fish. Aquat. Sci. 86: 270 p.

Kolenosky, D. P. and M. E. Daniels. 1982. Status of American eels in eastern Lake Ontario - 1981. Lake Ontario Committee, 1982 Annual Meeting, March 2-3, 1982 (Minutes).

Kolensoky, D. P., and M. J. Hendry. 1982. The Canadian Lake Ontario fishery for American eel (*Anguilla rostrata*). In K. H. Loftus [ed.] Proceedings of the 1980 North American eel conference. Ont. Fish Tech. Rep. Ser. 4: 8-16.

Marcogliese, L.A., J. M. Casselman and P.V. Hodson. 1996. Dramatic declines in the American eel (*Anguilla rostrata*) stocks of Lake Ontario—quantifying long-term trends. Unpublished manuscript.

Whitfield, R. E. and D. P. Kolenosky. 1978. Prototype eel ladder in the St. Lawrence River. Prog. Fish Cult. 40: 153-54.

Table 1. American eel commercial harvest (kilograms) by quota zone between 1985 and 1996 (see map Fig. 1).

	Quota Zones								
Year	QZ-1	QZ-2	QZ-3	QZ-4	QZ-5	QZ-6	QZ-7	QZ-8	Total
1985	4212	56706	19311	4910	11983	82	7577	0	104781
1986	3205	62171	21523	8849	9927	79	11275	0	117028
1987	4391	57813	11158	7623	9523	55	13154	0	103718
1988	8791	59935	13334	5160	6100	32	12791	0	106143
1989	8138	68206	14741	7826	6692	27	16828	0	122458
1990	5792	59802	15108	9361	8685	57	21183	0	119988
1991	5359	63025	19904	9565	7929	3	12111	0	117896
1992	5679	61785	17267	11389	8322	10	19550	0	124003
1993	7732	60391	12505	7770	6214	27	11113	51	105802
1994	7674	38163	8673	5750	5584	120	15134	1873	82971
1995	4484	23606	9501	2629	4557	171	17060	663	62671
1996	2590	23981	8646	3102	5178	54	13650	0	57201

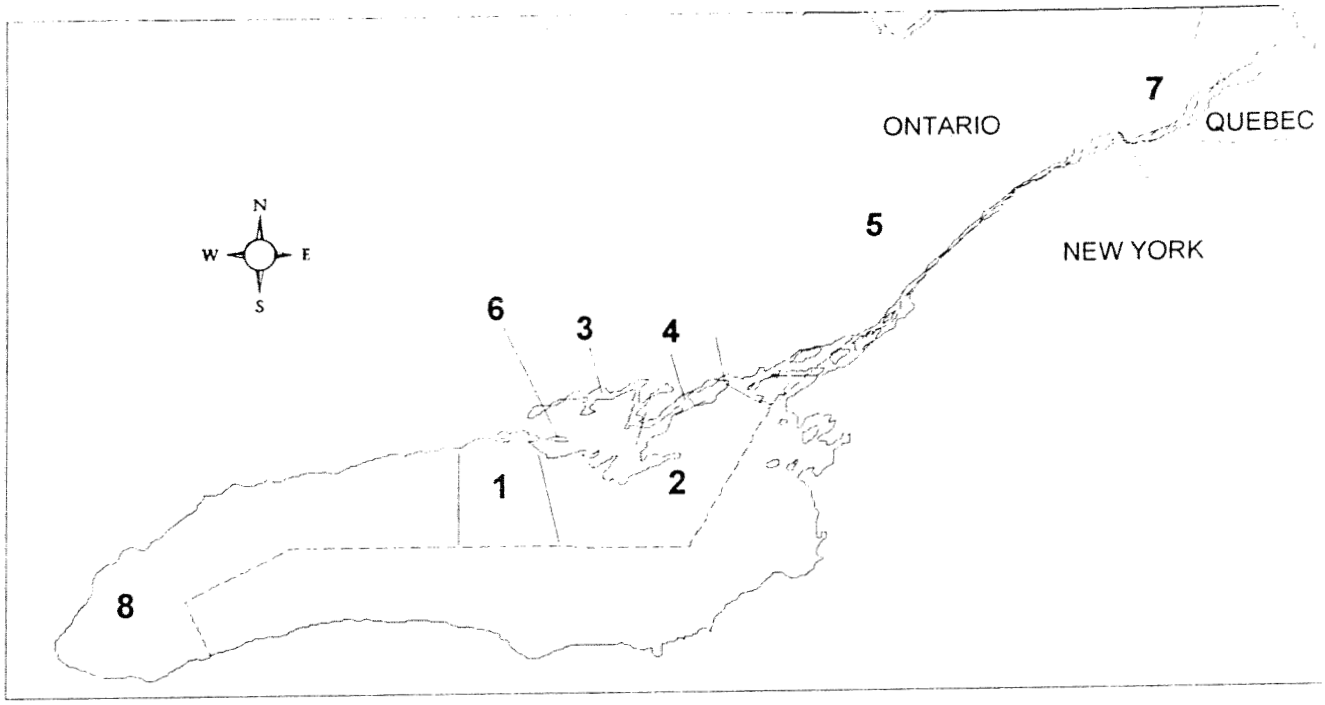


Figure 1. Ontario Ministry of Natural Resources quota zones for management of Lake Ontario and upper St. Lawrence River commercial fisheries.

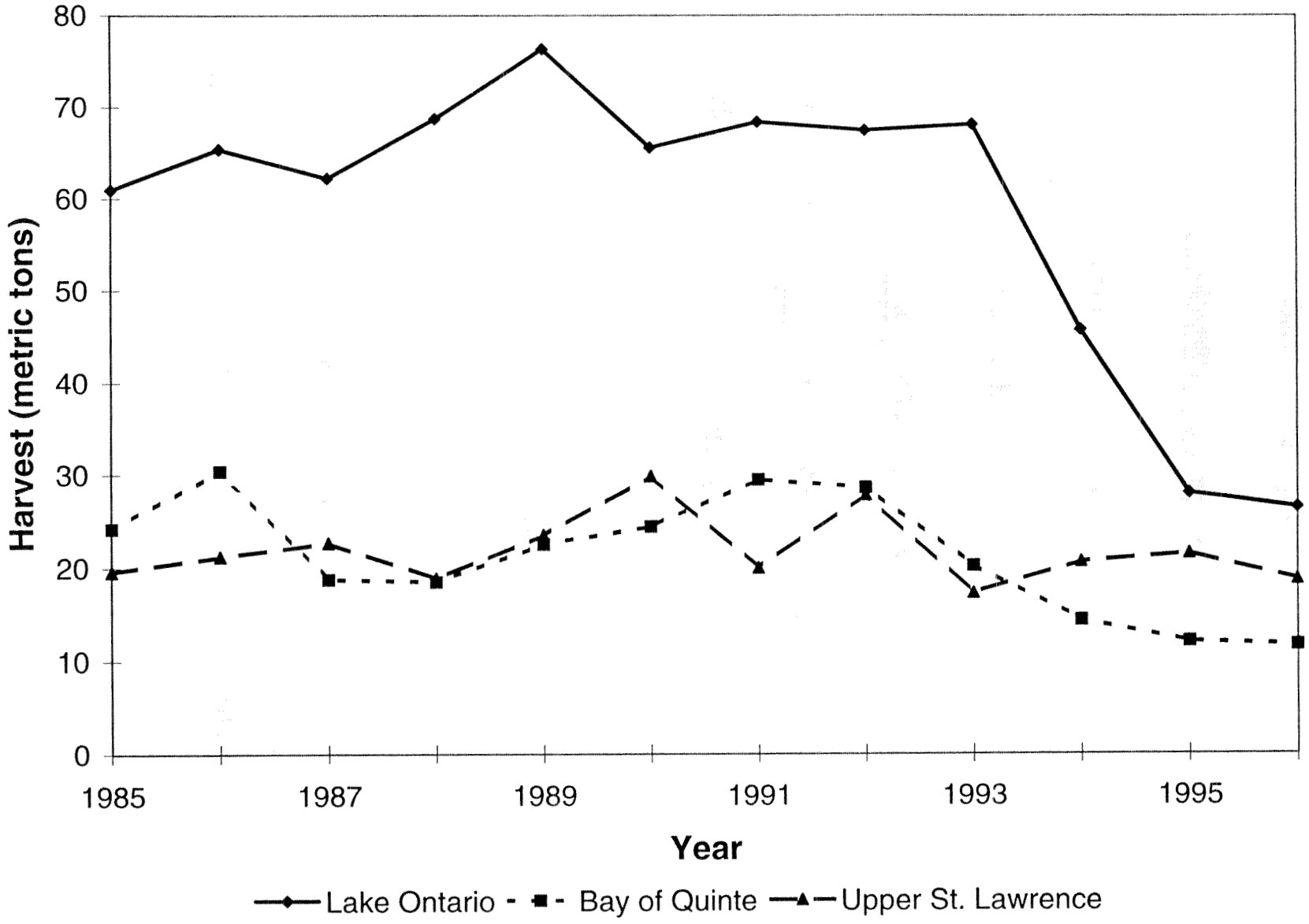


Figure 2. Commercial eel harvest by region from 1985-1996. Lake Ontario region includes quota zones 1 and 2, upper St. Lawrence region includes quota zones 5 and 7, and Bay of Quinte region includes quota zones 3 and 4.

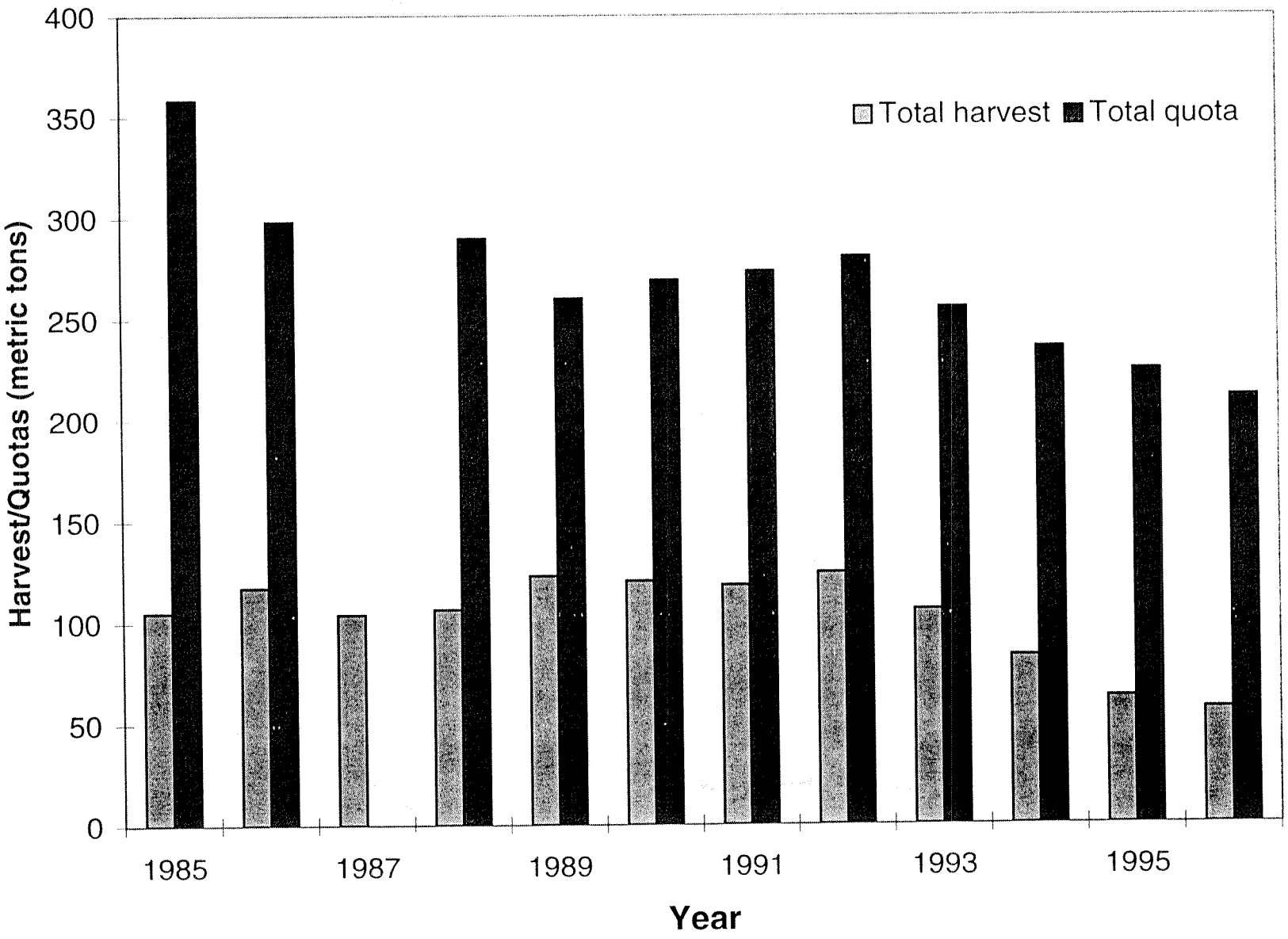


Figure 3. Total harvest and quota for Lake Ontario and the upper St. Lawrence River from 1985 to 1996. Quotas for 1987 were not established because of an active buy-out program.

Relative Value of Elver Versus Eel Fisheries

by

Gérald Chaput
Dept. of Fisheries and Oceans
Science Branch
P.O. Box 5030
Moncton, NB
E1C 9B6

ABSTRACT

The American eel has been harvested at the recruiting stage (elver) and at various juvenile (yellow eel) and maturing (silver eel) stages. The decision to harvest this resource at the elver stage can be justified on economic and biological parameters. Two factors are combined in a simple model to address the relative value of elver fisheries relative to eel fisheries: 1) the price differential between a harvested eel and a harvested elver, and 2) the survival rate from the elver to the eel stage. If the survival rate from the elver to the eel stage is high, then an eel fishery is favoured for even small price differentials. If survival rate is low, then eels must have a substantially greater value than elvers for the eel fishery to remain economically advantageous. The model can be used to determine the range of survival rates for which one of the fisheries is economically advantageous for known market value and size of the marketed product. But survival rates of wild eels are generally unknown.

RÉSUMÉ

L'anguille américaine est exploitée au stade de recrue (civelle) et à différents stades juvéniles (anguille jaune) et adultes (anguille argentée). La décision d'exploiter cette ressource au stade de civelle peut se justifier par des paramètres économiques et biologiques. Deux facteurs sont combinés dans un modèle simple en vue d'établir la valeur relative de la pêche de la civelle par rapport à la pêche de l'anguille : 1) la différence de prix entre une anguille capturée et une civelle capturée et 2) le taux de survie du stade de civelle jusqu'au stade d'anguille. Si le taux de survie de l'un à l'autre est élevé, la pêche de l'anguille est avantageuse, même si la différence de prix est minime. Si le taux de survie est faible, l'anguille doit avoir une valeur beaucoup plus grande que la civelle pour que sa pêche demeure avantageuse sur le plan économique. Ce modèle peut être utilisé pour déterminer l'échelle des taux de survie auxquels une pêche ou l'autre sera avantageuse sur le plan économique pour une valeur de marché donnée et pour une taille donnée de produit mis en marché. Mais les taux de survie des anguilles sauvages ne sont généralement pas connus.

INTRODUCTION

The American eel has been harvested at the recruiting stage (elver) and at various juvenile (yellow eel) and maturing (silver eel) stages. The choice of life stage at which to exploit a resource is frequently determined from life history characteristics, including age at first maturity, growth rates and mortality rates. Yield-per-recruit models use estimates of growth rates and natural mortality rates to estimate the fishing mortality which will produce the maximum yield in biomass from a cohort over its life-span (Ricker 1975). If the objective of the fishery is to maximize benefit with maximum yield in biomass as the currency, then only eel fisheries should be allowed. Based on growth rates from Bouillon and Haedrich (1985), maximum yield (in the absence of fisheries) occurs at ages greater than eight years. Harvesting at sub-optimal life stages relative to yield per recruit occurs in sardine fisheries in Atlantic Canada.

For some fish species, it has been argued that fish should be allowed to spawn at least once before being subjected to fishing exploitation (Sinclair 1993). Eels are a catadromous semelparous species and mature individuals do not survive to spawn more than once (Helfman et al. 1987). All eel fisheries therefore, regardless of the size or age of fish harvested, exploit immature fish. Even some iteroparous species, such as gaspereau, are harvested specifically during the spawning migrations with a large component of the harvest containing fish which are undertaking their first spawning migration (Claytor et al. 1995).

Economic criteria can also be considered especially when the costs of harvesting or the value of the landed product varies with the life stage exploited. An example of this is the previously mentioned juvenile herring (sardine) fisheries of Atlantic Canada and caviar fisheries. Jessop (1995) provided a simple model for the Amercian eel and concluded that the elver fishery was under most plausible conditions of greater economic value.

ECONOMIC MODEL FOR ELVER-EEL FISHERIES

The relative value of elver and eel fisheries is defined by five factors:

1 - average weight of an elver at harvest
2 - market value of elvers (per landed weight)
3 - average weight of an eel at harvest
4 - market value of eels (per landed weight)
5 - survival rate of an elver to the harvested eel stage

A general relationship involving all five parameters can be described. The following example illustrates how the isopleth defining the breakeven point in economic value of elver versus eel fisheries is determined.

The value of the elver fishery is calculated as:

$$V_{elver} = \text{Elvers harvested} \bullet \left(\frac{\text{Value per kg}}{\text{Elvers per kg}}\right)$$

The value of the eel fishery is calculated as:

$$V_{eel} = \text{Eels harvested} \bullet \left(\frac{\text{Value per kg}}{\text{Eels per kg}}\right)$$

For a given elver recruitment, the total eels captured is determined by the survival rate (S_E) of elvers to the life stage harvested in the eel fishery. Had the elvers not been harvested, all the survivors would have been harvested as eels.

We rewrite V_{eel} as:

$$V_{eel} = \text{Elvers harvested} \bullet S_E \bullet \left(\frac{\text{Value per kg}}{\text{Eels per kg}}\right)$$

We are interested in defining the combination of parameters which result in equal value of the elver and eel fisheries.

$$V_{elver} = V_{eel}$$

or $$1 = \frac{V_{eel}}{V_{elver}}$$

After substitution, we are left with:

$$1 = S_E \bullet \frac{\text{Value per Eel}_{kg} / \text{Eels per kg}}{\text{Value per Elver}_{kg} / \text{Elvers per kg}}$$

Simplifying to two parameters:

$$1 = S_E \bullet PD$$

where PD = price differential between an eel at harvest and an elver at harvest

$$= \frac{\text{Value per Eel}_{kg} / \text{Eels per kg}}{\text{Value per Elver}_{kg} / \text{Elvers per kg}}$$

The solution space of survival rates and price differential defining the relative value of an eel fishery compared to an elver fishery is shown in Fig. 1.

As survival rate increases, the price differential defining the greater value of the eel fishery relative to the elver fishery declines. Alternatively, if price and size at harvest values are known, the survival rate which defines the relative economic values of the two fisheries can be determined.

For example, using values for elvers and eels as in Jessop (1995):

> 6500 elvers per kg and a market value of $200 per kg
> 4 eels per kg and a market value of $3.85 per kg
> The price differential (eel to elver) = ($3.85/4)/ ($200 / 6500) = 31.2

The survival rate which results in equal value of the fisheries is directly calculated as:

$$S_E = 1 / PD = 1 / 31.2 = 0.032 \text{ (Fig. 1).}$$

The elver fishery is of greater economic value when the survival rates from the elver stage to the eel stage at harvest are less than 0.032. At survival rates greater than 0.032, the eel fishery is of greater economic value.

Survival rate is a critical factor but it is unknown in eels. If we assume that eels have a relatively high survival rate after the elver stage (for example M = 0.2 as assumed for many fish species translates to an annual survival rate of 82%), the proportion of the initial elver population remaining after 10 and 15 years of growth would be 14% and 5%, respectively. In the example above, a cumulative survival rate of 3.2% to the eel harvest size at an assumed annual survival rate of 82% (M = natural mortality = 0.2) indicates that eels weighing 250 g (average weight) would be 17 yr old. If the 250-g eels are 10 yr old or 8 yr old as inferred from size-at-age data from other authors (Bouillon and Haedrich 1987; Jessop 1987), then the annual survival rate would decline to 71% for the 10-yr-old eels and 65% for 8-yr-old eels.

Jessop (1995) suggested that the survival rate during the first year in the river may be much lower than in subsequent years. De Leo and Gatto (1995) described a size and age-structured model under the assumption that mortality rate in the European eel declined with age. These authors suggest a different survival trajectory than the constant survival rate assumption. There is evidence from anadromous species that survival rates during the transition phase from marine to fresh water and vice versa may be substantially lower than survival rates in the previous or subsequent habitat. For example, Atlantic salmon smolts have a higher mortality during their first year at sea (75-95%) than during their residence in fresh water (for parr, annual mortality rates of 35-72%) (Mills 1989).

Arguments for elver fisheries, on the basis that mortality rate in the first year is high relative to juvenile eels, are insufficient. The critical factor in the economic model is not the form of the survival trajectory, but rather the resultant cumulative survival rate at the eel harvest stage. For example, a survival rate of 3.2% after 10 yr can result from a constant mortality rate trajectory, a declining mortality rate with age as assumed by De Leo and Gatto (1987), or a high mortality rate in the first year followed by a constant mortality rate in subsequent years (Fig. 2). A loss of 81% of the elver recruitment in the first year with mortality rates of 18% in subsequent years results in the same cumulative survival rate after 10 yr as a constant mortality assumption of 29% per year.

Ultimately, the choice of whether elver fisheries should be promoted in favour of eel fisheries depends upon economics and biology. Information on survival rates in the wild is required to determine the relative merits of the fisheries.

REFERENCES

Bouillon, D. R., and R. L. Haedrich. 1985. Growth of silver eels (*Anguilla rostrata*) in two areas of Newfoundland. J. Northw. Atl. Fish. Sci. 6: 95-100.

Claytor, R. R., P. LeBlanc, R. Jones, and G. Chaput. 1996. Status of gaspereau in the Margaree River 1993 and 1994. DFO Atl. Fish. Res. Doc. 95/64.

De Leo, G.A., and M. Gatto. 1995. A size and age-structured model of the European eel (*Anguilla anguilla* L.). Can. J. Fish. Aquat. Sci. 52: 1351-1367.

Helfman, G. S., D. E. Facey, L. S. Hales, Jr., and E. L. Bozeman, Jr. 1987. Reproductive ecology of the American eel. Am. Fish. Soc. Symp. 1: 42-56.

Jessop, B. M. 1987. Migrating American eels in Nova Scotia. Trans. Am. Fish. Soc. 116: 161-170.

Jessop, B. M. 1995. Justification for, and status of , Amercian eel elver fisheries in Scotia-Fundy Region. DFO Atl. Fish. Res. Doc. 95/2: 10 p.

Mills, D. 1989. Ecology and Management of Atlantic Salmon. Chapman and Hall, New York.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191. 382 p.

Sinclair, A. (Editor). 1993. Report on the assessments of groundfish stocks in the Canadian Northwest Atlantic, May 4-14, 1993. Can. Tech. Rep. Fish. Aquat. Sci. 1946e: 200 p.

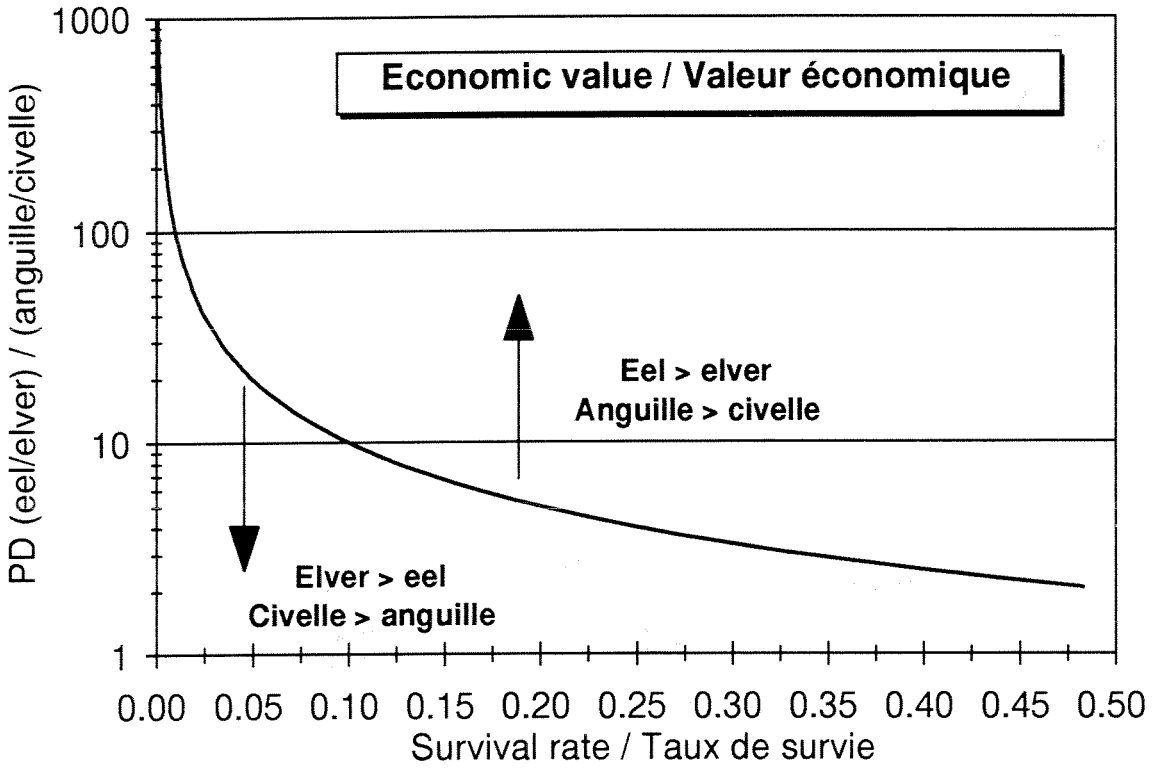


Fig. 1. Equilibrium isopleth defining the space where the economic value of eel fisheries and elver fisheries are equal. The survival rate is the rate for elvers to eel at harvested size. PD (price differential) is the ratio of the economic value of an eel relative to an elver. See text for an example.

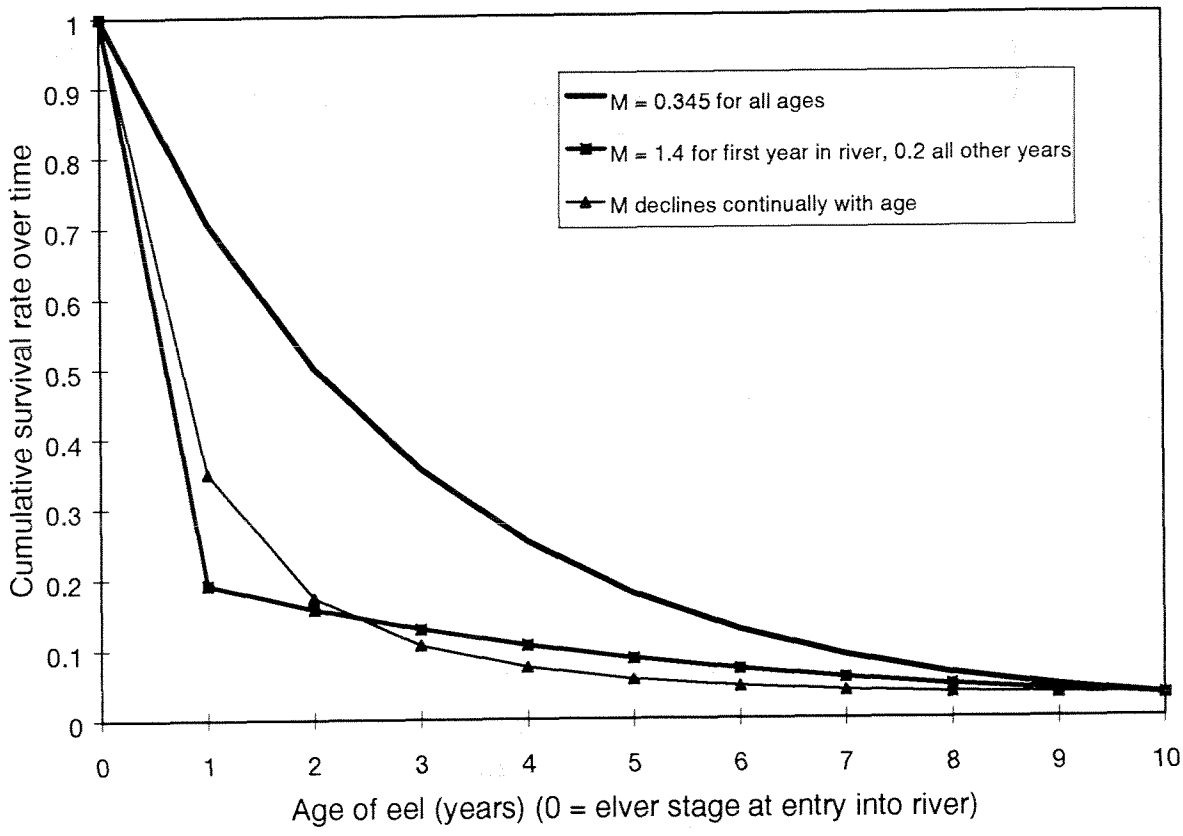


Fig. 2. Survival trajectories resulting in a 3.2% cumulative survival after 10-yr post-elver migration.

The status of American eels, *Anguilla rostrata*, in the Scotia Fundy area of the Maritimes Region as indicated by catch and license statistics

by

B. Jessop
Department of Fisheries and Oceans
P.O. Box 550
Halifax, Nova Scotia
B3J 2S7

ABSTRACT

Much variability has occurred since 1950 in annual reported catches of American eels by province within the Maritimes, and by Fishery Statistical District within the Scotia-Fundy and Gulf portions of the Maritimes Region. Maritimes catches of American eels peaked in 1971 at 778 t and have fluctuated between about 300 and 500 t. Since the mid-1980s, catches of eels within the Gulf Region have declined, but catches within Scotia-Fundy Region have increased, particularly in New Brunswick. Most American eels caught in Scotia Fundy Region come from a few Fishery Statistical Districts, particularly in the Saint John River area in New Brunswick and Lunenburg to Yarmouth counties, and less so from the Eastern Shore and eastern Cape Breton in Nova Scotia. The number of commercial licenses issued and gear units authorized increased annually between 1985 and 1993 when a freeze was imposed on new licenses. Commercial license numbers increased during this period about three times and gear units increased about six times, while recreational licenses and gear units increased about five and seven times, respectively. Licensing practices and the variety of gear types make comprehensive analyses of fishing effort impractical, but catch/effort has likely declined. Current biological data for stocks of American eels in Scotia-Fundy rivers are restricted to the Saint John River. The scarcity of current biological data, moderate quality of catch statistics, and crudity of information on fishing effort limit fishery management to the most basic actions.

RÉSUMÉ

Depuis 1950, les prises annuelles d'anguille d'Amérique signalées dans chacune des provinces Maritimes et dans chaque district statistique des pêches du secteur Scotia-Fundy et du Golfe de la région des Maritimes montrent une grande variabilité. Les prises ont atteint un pic de 778 t en 1971, puis ont fluctué depuis entre environ 300 t et 500 t. Depuis le milieu des années 80, les prises dans le secteur du Golfe ont diminué, mais les prises dans le secteur Scotia-Fundy ont augmenté, en particulier au Nouveau-Brunswick. La plupart des anguilles récoltées dans ce dernier secteur proviennent de quelques districts statistiques des pêches, plus particulièrement de la région de la rivière Saint-Jean, au Nouveau-Brunswick, et de la région s'étendant du comté de Lunenberg au comté de Yarmouth, en Nouvelle-Écosse, et, dans une moindre mesure, de la côte est de la Nouvelle-Écosse et de l'est du Cap-Breton. Le nombre de permis de pêche commerciale délivrés et d'unités d'engin autorisés a augmenté annuellement de 1985 à 1993, lorsqu'un gel a été imposé sur la délivrance de nouveaux permis. Le nombre de permis de pêche commerciale a presque triplé pendant cette période, tandis que le nombre d'unités d'engins autorisés a presque sextuplé, le nombre de permis de pêche récrécréative et d'engins autorisés pour cette pêche ayant qunituplé et septuplé, respectivement. Les pratiques de délivrance des permis et la diversité des engins de pêche rendent peu réalistes des analyses de l'effort de pêche, mais il est probable que les prises par unité d'effort ont diminué. Les données biologiques disponibles sur les stocks d'anguille des cours d'eau de Scotia-Fundy ne couvrent que la rivière Saint-Jean, tandis que la rareté de données biologiques courantes, la qualité modérée des statistiques sur les prises et la crudité de l'information sur l'effort de pêche limitent la gestion de la pêche aux mesures les plus fondamentales.

Status of American Eel (*Anguilla rostrata*) from the Southern Gulf of St. Lawrence

by

Gérald Chaput, Andrea Locke, and David Cairns
Dept. of Fisheries and Oceans
Science Branch
P.O. Box 5030
Moncton, NB
E1C 9B6

ABSTRACT

The southern Gulf of St. Lawrence rivers have important estuarine commercial fisheries for American eel (*Anguilla rostrata*) but relatively little is known about the species in this area. The Gulf New Brunswick (NB) fisheries account for half (60 to 210 t annually) of the total landings from the southern Gulf, followed by Prince Edward Island (PEI) (31 to 127 t annually) and Nova Scotia (NS) (16 to 89 t annually). Landings in thirteen districts have accounted individually for 3% or more of the total landings. The harvests are more important in the summer and autumn fisheries which use mostly net-type gears. Eel fisheries also occur during the winter (Jan. to April), mostly using spears. In the southern Gulf, the fisheries occur mostly in estuaries and exploit both "yellow" (immature) and "silver" (mature migrants) eels. Catch rates in net-type gears tend to be low but this is compensated by large quantities of effort. There appears to be an overall declining trend in the landings from the southern Gulf. Some of the changes in landings over time may be due to differences in effort, variations in reporting rate of harvests, and undoubtedly variations in abundance. Evidence of declines in abundance include trends in catches of eels in freshwater electrofishing surveys. In both the Miramichi and the Restigouche rivers, the abundance of eels was generally highest in the early 1970s followed by the mid 1980s. A similar pattern of abundance was suggested for the Morell River in PEI. Eels utilize diverse habitats including freshwater areas and estuaries. Habitat requirements for eels are diverse; one indicator of potential habitat is the drainage area of a river. The trends in relative landings (tons per km^2 of drainage area) from three districts are high and although this does not provide evidence of overexploitation, prudent management would be appropriate. Conservative management measures should attempt to distribute the fishing effort relative to the size and productive capacity of the river system.

RÉSUMÉ

Les cours d'eau qui se jettent dans le sud du golfe du Saint-Laurent font l'objet d'importantes pêches commerciales de l'anguille américaine (*Anguilla rostrata*) en estuaire, mais on dispose de très peu d'information au sujet de l'espèce dans ce secteur. Les pêches dans le golfe du côté du Nouveau-Brunswick représentent environ la moitié (60 à 210 t par année) du total des débarquements du sud du golfe, suivies de celles de l'Île-du-Prince-Édouard (Î.-P.-É.) (31 à 127 t par année) et de la Nouvelle-Écosse (N.-É.) (16 à 89 t par année). Les débarquements de 13 districts de pêche comptent individuellement pour 3 % ou plus du total des prises. Les captures sont plus importantes en été et à l'automne, lorsque les pêcheurs utilisent surtout des engins en filet. La pêche de l'anguille se pratique également en hiver (janvier à avril), principalement au harpon. Dans le sud du golfe, elle se pratique surtout dans les estuaires, visant les anguilles « jaunes » (immatures) et « argentées » (matures en migration). Les taux de capture dans les filets sont plutôt faibles, mais sont largement compensés par un grand effort. Il semble qu'il y ait une baisse générale des débarquements dans le sud du golfe. Une partie des changements survenus avec le temps en ce qui concerne les débarquements serait attribuable à la différence d'effort, au taux variable de déclaration des prises et fort probablement à des fluctuations de l'abondance. Les signes de diminution de l'abondance incluent la tendance des prises d'anguilles dans les relevés en eau douce par

pêche à l'électricité. Dans les rivières Miramichi et Ristigouche, l'abondance des anguilles était généralement à son sommet au début des années 1970, puis au milieu des années 1980. Une tendance semblable de l'abondance a été proposée pour la rivière Morell à l'Î.-P.-É. Les anguilles fréquentent des habitats divers y compris les eaux douces et les estuaires. Leurs besoins en habitat sont diversifiés; un des indicateurs d'habitat éventuel est le bassin hydrographique d'un cours d'eau. Les tendances des débarquements relatifs (tonnes par km^2 de bassin hydrographique) sont élevées dans trois districts et bien que cela ne soit pas un signe de surexploitation, il conviendrait d'adopter une gestion prudente. Les mesures de gestion prudente devraient viser à répartir l'effort de pêche en fonction de la taille et de la capacité de production du cours d'eau.

INTRODUCTION

The southern Gulf of St. Lawrence is that portion of the Maritimes Region where the rivers drain into the Gulf of St. Lawrence (herein called the southern Gulf) (Fig. 1). This region has important estuarine commercial fisheries for several species of diadromous fish including gaspereau, shad, smelt, tomcod and eel. The American eel (*Anguilla rostrata*) has the third largest annual landed tonnage after gaspereau and smelt (LeBlanc and Chaput 1991). A thorough description of the eel fisheries in eastern Canada is provided by Eales (1968).

Relatively little is known about the American eel in the southern Gulf of St. Lawrence. Collection of both biological and fisheries data has been very limited. Commercial landings of eels in 1917 to 1988 were summarized by LeBlanc and Chaput (1991). Locke et al. (1995) updated the landings data to 1994 and described the gear and regulations in effect in 1994. The data available are insufficient to permit a stock assessment of eels in this area; such an analysis would require knowledge of landings, the estimation of exploitation rates, the establishment of a conservation requirement, and estimates of eel abundance relative to the conservation requirement (Locke et al. 1995). At present, landings are incompletely recorded, there is no conservation requirement established for eels in this area, and the abundance of eels has not been estimated. Changes in management and licensed effort for the southern Gulf portion of the Maritimes Region have been summarized by Paulin (this report).

This document summarizes the available data on changes in landings and indices of fresh water abundance of eels. An analysis of statistical area, gear type and seasonal patterns of exploitation illustrates the complex nature of the eel fishery as it is presently prosecuted. Minimal data from logbook programs provide additional information regarding the timing and catches in a few local fisheries. The temporal trend in abundance of eels in fresh water, as indicated by catches in electrofishing surveys in two New Brunswick watersheds and one Prince Edward Island river, is examined.

MATERIALS AND METHODS

The data set on eel landings from Canada dates to 1917 (LeBlanc and Chaput 1991). The landings data for 1968 to 1995 come from the database of the Department of Fisheries and Oceans (DFO Statistics Branch). This data set contains no effort data. The information registered in the database allows the summarization of landings by date, community, statistical district, gear type and slip type. Slip type refers to the type of data recorded and has three categories:

- purchase slips: a compulsory slip which records landings by individual fishers, by species and location landed. These are filled in by the buyers and submitted to DFO
- supplementary "A": slips which are completed by buyers from outside the fishing area. The information on these slips includes the amount of fish purchased, the date and the location of the purchase
- supplementary "B": monthly summaries of the harvests by species and community which were either sold or consumed locally. These *estimates* are provided by DFO field staff of the Conservation and Protection Branch.

Recreationally fished eels are not recorded.

The statistical districts of the southern Gulf are shown in Figure 1. For summary purposes, three seasons are considered: winter = January-April, summer = May-August, fall = September-December.

Drainage areas of Gulf New Brunswick and Gulf Nova Scotia rivers were obtained from the database originally derived by the Maritime Resource Management Service (Amherst, Nova Scotia) and provided by S. O'Neil (DFO, Maritimes Region, Halifax, NS).

RESULTS AND DISCUSSION

Eels have historically been exploited throughout the southern Gulf. Landings were minimal before 1965 but rose sharply in the mid-1960s (Fig. 2). In all regions of the southern Gulf, eel catches peaked between 1969 and 1971. Catches declined precipitously soon after, with the exception of the Gulf Nova Scotia area, fluctuating at less than one-half the peak catches. The catches from Gulf Nova Scotia for the period 1968-76 are of questionable accuracy (LeBlanc and Chaput 1991) especially in terms of the acutely steep increase in landings followed by an equally precipitous drop. The erratic catch trends were reported in the two Cape Breton statistical districts (2 and 3).

The commencement of high landings of eels in the southern Gulf of St. Lawrence in the mid-1960's, followed by a drop in the early 1970's, closely paralleled the pattern of catches recorded in the Quebec sea

fisheries, and in the Northwest Atlantic (NAFO areas 0-6) (Fig. 2). Anecdotal accounts of commercial fishers in New Brunswick and Prince Edward Island correlate the commencement of high landings with substantially increased effort and the introduction of fyke nets (Locke et al. 1995).

In the last 7 yr, the Gulf NB districts have accounted for 50% of the landings reported from the southern Gulf, followed by landings from PEI (Table 1). Thirteen of the 33 statistical districts in the southern Gulf individually account for about 3% or greater of the total landings. The greatest proportion of the annual landings were registered in district 76 of southeast New Brunswick (17.5% of total) followed by district 93 in PEI (11.1%) and district 13 from Nova Scotia (8.6%) (Table 1). The trends in landings from these 13 districts are examined in a subsequent section.

RELIABILITY OF LANDINGS DATA

The reliability of the landings data was considered in terms of the proportion of the landings registered from purchase slips relative to those registered from supplementary "B" forms. Purchase slip data, considered more accurate, have represented more than 75% of the recorded landings in 14 of the 33 districts from the southern Gulf. Less than 50% of the recorded landings were registered from purchase slips in six districts (Fig. 3). The Nova Scotia District 13 had the second highest landings of all the southern Gulf districts but less than 50% of these landings were recorded from purchase slips (Table 1, Fig. 3).

The consistency of annual recorded landings also provides an indication of the reliability of the information. Since 1917, three districts from Gulf NB and one district from Gulf NS have had landings registered during more than 90% of the years (Table 1). For PEI, seven districts have had landings recorded in more than 90% of the years since 1957 (landings were not recorded by individual districts prior to 1957). Over a similar time period for Gulf NB, landings were recorded every year for districts 68 and 76 and in greater than 90% of the years for three other districts. For Gulf NS, district 2 has had landings recorded every year and district 13 has had landings more than 90% of the years.

Patterns relative to gear type

Gear type does not explain the discrepancies in the proportion of the landings registered from purchase slips. In many statistical districts, eels harvested with spears tended to be reported from supplementary "B" forms although in some districts (71, 73 and 80 in New Brunswick; 92 in PEI), all the landings from spearing are recorded from purchase slips (Table 2). Trap nets and eel pots had a higher proportion of the landings registered from purchase slips; these gears may be favoured by a large proportion of the dedicated commercial fishers. Spearing in some districts is more of an opportunistic undertaking requiring minimal preparation and investment (Eale 1968).

Patterns relative to season

For the whole southern Gulf, the summer and autumn landings are represented by a high proportion of purchase slip records (Table 3). The highest proportion of purchase slip landings were from the autumn fishery in PEI followed by the summer fisheries from NS and PEI. In the NB districts, the higher landings in the summer and fall season are recorded mostly from Supplementary "B" reports. Winter landings in NB have a very high proportion from purchase slips in essentially all the districts, the opposite was true in NS and PEI.

SEASONAL AND GEAR-TYPE DISTRIBUTIONS OF LANDINGS

Eel fishery landings occur mostly during summer and fall in the southern Gulf of St. Lawrence (Fig. 4). Landings from the winter are generally minimal compared to the other seasons; in only 3 districts are landings in the winter greater than those from one of the other seasons. More than 50% of the landings are recorded from each of the fall and summer seasons in 12 statistical districts. The fall season was most important in the Gulf NB districts, but summer and fall seasons are equally important in the NS and PEI districts (Fig. 4).

Net gears (trap net, fyke net) account for more than half of the harvests in 71% of the districts from the southern Gulf (Fig. 5). Spears are dominant in the remaining eight districts (29%). The dominant gear in PEI is trap nets whereas trap nets and spears are important in both NS and NB. Eel pots are an important gear in one NS district (Fig. 5). Spearing is the gear of choice during the winter throughout the southern Gulf (Fig. 6). Not surprisingly, net gears are infrequently used during the winter season. Net gears are dominant in the summer fishery in NB and PEI and in the fall fisheries of PEI and NS.

DISTRIBUTION OF SIZES WITHIN THE CATCHES

Most of the eel fisheries are prosecuted in estuaries and within tidal water influence. This is also the case for the spear fisheries. This reflects three aspects of eel biology: 1) eels maturing in freshwater must pass through the estuaries during their spawning migrations to sea, 2) estuaries contain large numbers of suitable forage species (fish and invertebrate), and 3) eels use soft sediments for burrowing during the winter which are most accessible in the estuary. As such, the estuary fisheries in the southern Gulf harvest both large silver eels and smaller "green" or "yellow" eels. The proportion of each varies with the fishing location and over the fishing season.

In a fall fyke net fishery in Nova Scotia, the proportion of silver eels in the catch was negligible in early September but reached proportions of 20% to 35% at the end of September and into October (Fig. 7). Catch per effort in the New Brunswick fishery varied between 2 to 7 eels per net-day over the season extending from mid-July to early October (Fig. 8). As in the Nova Scotia fishery, catch rates were low but increased from summer to fall. Low catch rates are compensated by a large amount of effort; there were almost 7600 net-type gears licensed in the southern Gulf in 1996 but an unknown proportion were fished (see L. Paulin presentation).

STATUS OF STOCKS

Trends in landings over time are described for the 13 statistical districts having a high proportion of annual reports, where landings were important in the overall catches from the southern Gulf (about 3% individually) and for which the records were based mostly on purchase slip data (Fig. 9).

There are large fluctuations in eel landings in all districts of the southern Gulf. Between 1968 and 1995, there were negative trends in the landings in 7 of the 13 districts analysed although only four of these were significant ($P<0.05$) (Table 4; Fig. 9). There were no statistically significant ($P > 0.05$) positive trends. In 10 of these 13 districts, the landings reported in the 1990's have been lower than landings reported in previous decades. The only exceptions were the two districts in Nova Scotia (12, 13) and one district from New Brunswick (75) (Fig. 9). Over a shorter time period, 1984-95, 9 of the 13 districts had negative trends but only 4 of these trends would be considered statistically significant (Table 4). Three significant negative trends over the 1968-95 time period were without a trend in the shorter time period (districts 67, 68, 71). The landings in the PEI districts have declined significantly in 3 of the 4 districts over the 1984-95 time period. Landings in Nova Scotia district 13 had a significant positive trend although landings as high or higher than those reported in the 1990s were reported in the late 1960s from this district (Fig. 9).

There appears to be an overall declining trend in the landings of American eel from the southern Gulf of St. Lawrence. There are no long-term increases in landings in any districts. A widespread opinion of fishers consulted in 1994 was that catch-per-unit-effort had declined substantially in recent years (Locke et al. 1995). One fisher from Nova Scotia indicated that catches were fairly stable for over two decades in his area but in the last five years, his annual catches have declined by more than half.

The trend in decreasing landings is partly consistent with reduced reporting of catches and reduced effort in the fisheries. One indicator of the consistency in the reporting of catches is the number of purchase slip and Supplementary "B" records in the database. The number of records in 1989 and 1990 were compared to the number of records in 1994 and 1995 (see text table). The total number of communities (there are varying numbers of communities in individual statistical districts) with reported sales of eels increased slightly in Nova Scotia and New Brunswick but more than doubled for PEI between 1989-90 and 1994-95. The total number of landings reports, both purchase slip and Supplementary "B", increased by 15 times for Nova Scotia. There were important declines in the number of purchase slip reports in the other two provinces: by four times in New Brunswick and by one-third in PEI. The frequency of Supplementary "B" reports were consistent between the two time periods for NB and PEI.

Province	Total Communities	Purchase slips: Number of communities 89-90	Purchase slips: Number of communities 94-95	Purchase slips: Number of reports 89-90	Purchase slips: Number of reports 94-95	Supplementary "B": Number of communities 89-90	Supplementary "B": Number of communities 94-95	Supplementary "B": Number of reports 89-90	Supplementary "B": Number of reports 94-95
Nova Scotia	17	6	9	16	272	12	53	11	59
New Brunswick	22	14	16	2087	545	12	19	143	151
PEI	27	11	25	1494	1094	16	12	34	43

The decreased landings from the New Brunswick and PEI districts and the corresponding increased landings from NS parallel the relative change in number of purchase slip reports during the two time periods. This would suggest that the trends in landings cannot be attributed uniquely to changes in abundance. Increased landings from NS were the result of an increase in reports from these districts. The lower number of eels reported sold in NB and PEI could be a reflection of reduced catch rates. Eels are generally purchased in live condition and fishers retain the eels alive until there are sufficient quantities for collection. Buyers may undertake fewer trips to purchase eels because of lower catches which would result in a reduced number of slips completed relative to periods of high catch rates. Unfortunately, in the absence of effort data, no definitive conclusions can be drawn.

Other indicators of abundance

Only a small amount of commercial index fishery data is available for the southern Gulf. The only time-series of index data has been collected by personnel of Kouchibouguac National Park for commercial fisheries operating in Kouchibouguac River and St. Louis River from 1989-95. The very limited data suggest that catch rates in the spring fisheries are lower than in the fall (Fig. 10). However, the effort (i.e., numbers of net-days fished) was not recorded.

A time-series of electrofishing records from the Miramichi (1970-93) and Restigouche (1972-94) rivers showed relatively low catches of eels at most sites in most years but fewer high catches since 1985 in the Miramichi River and since 1990 in the Restigouche River (Fig. 11). Maximum catches per site (<25 eels) in the Restigouche River were much lower than those in the Miramichi, where eel catches sometimes exceeded 100 per site. This probably relates to both the latitude (Restigouche is further north) and elevation (Restigouche sites are, on average, more elevated) of the two river systems. Eel catches in the Miramichi River were strongly associated with the elevation of the electrofishing site. Eels were observed at essentially all electrofishing sites in the Miramichi River but were observed at only 75% of the highest elevation sites (Fig. 12; Chaput 1995). The average catch of eels exceeded ten per site at elevations less than 50 m (Fig. 12). Eel occurrence in the Restigouche river was less strongly influenced by elevation than in the Miramichi River, although there was a tendency for eels to be present in a lower proportion of high-elevation (>99 m elevation) sites (Fig. 12). Eels were caught only at sites with elevations < 250 m and there was a tendency for mean abundance of eels to be higher at low-elevation sites. There were large annual variations in catches of eels at the sites and at four index sites in the Miramichi (surveyed every year), there were no significant ($P>0.05$) trends in catches over time (Fig. 13). In the Restigouche River, high annual variation in catches was also observed but at three of four index sites, there were significant ($P < 0.05$) declining trends in catches between 1972 and 1994 (Fig. 13). In the Miramichi, the abundance of eels was generally highest in the early 1970s and the 1982-86 period. In the Restigouche River, eel abundance declined through the 1980s and 1990s.

In the Morell River PEI, electrofishing surveys conducted intermittently between 1975 and 1996 suggest that there has been a decline in eel abundance in the 1990s relative to an earlier time period (Fig. 14). At the Leard's Bridge site, eels were most abundant in 1984 and 1985, a pattern consistent with the increased catches of eels in the Miramichi and Restigouche rivers for the same time period.

Landings relative to drainage area

Eels utilize diverse habitats including freshwater areas and estuaries (Moriarity 1987). There are large populations of eels in estuaries as evidenced by the extensive fishing which occurs there. Although eels are highly tolerant of habitat variability, we assume that production potential is finite and that habitat would invariably constrain the standing stock of eels in a river system. One indicator of potential habitat is the drainage area of a river. Landings by statistical district for 1968 to 1995 were scaled by the respective drainage areas of all the rivers within the district (Fig. 15). The relative landings in districts 68, 76 and 12 are high compared to the other southern Gulf districts. The trends in landings from these districts (Fig. 9) do not immediately suggest overexploitation but prudent management would be appropriate. Vladykov (1971) indicated that eels do not move between estuaries and in fact appear to have an affinity for their home estuaries when displaced. This suggests that estuaries and streams could be overexploited (fished out of larger individuals). Conservative management measures should attempt to distribute the fishing effort relative to the size of the river system (including the estuary).

CONCLUSIONS

The limited data available indicate that both commercial landings and freshwater abundance of eels in the southern Gulf have declined in recent years. Commercial fishers from watersheds in both New Brunswick and Prince Edward Island have provided anecdotal support for this trend. Electrofishing surveys indicated that abundance of eels in the more northerly, higher-elevation portion of the watershed. In districts where landings have increased, the probable cause is increased fishing effort. Some districts are being exploited at high levels relative to their production areas. The poor quality of the landings data should be addressed - this could be done by eliminating some of the "artisanal" fisheries, e.g. spearing, especially in the winter period. The appropriateness of spearing for eels should be reconsidered. Non-catch mortality (from injury) is unknown but may be high. This fishery is extensively practised in the winter when eels are inactive and likely unable to survive both injury and displacement from their burrows.

REFERENCES

Cairns, D. 1997. Status of Atlantic salmon on Prince Edward Island in 1996. DFO Atlantic Fisheries Res. Doc. 97/##.

Chaput, G. J. 1995. Temporal distribution, spatial distribution, and abundance of diadromous fish in the Miramichi River watershed, p. 121-139. *In* E.M.P. Chadwick [*editor*]. Water, science, and the public: the Miramichi ecosystem. Can. Spec. Publ. Fish. Aquat. Sci. 123.

Ducharme, L. J. A. 1977. Atlantic salmon enhancement in the Morell River, Prince Edward Island. Environment Canada Fisheries and Marine Service Tech. Rep. Ser. MAR/T-77-2.

Eales, J. G. 1968. The eel fisheries of eastern Canada. Fish. Res. Board Can. Bull. 166: 79 p.

LeBlanc, C. H., and G. J. Chaput. 1991. Landings of estuarine fishes in the Gulf of St. Lawrence 1917-1988/ Débarquements de poissons estuariens dans le golfe du Saint-Laurent 1917-1988. Can. Data. Rep. Fish. Aquat. Sci. 842.

Locke, A., R. Claytor, C. LeBlanc and G. Chaput. 1995. Status of American eels, *Anguilla rostrata*, in the Gulf Region. DFO Atl. Fish. Res. Doc. 95/79.

Moriarity, C. 1987. Factors influencing recruitment of the Atlantic species of Anguillid eels. Am. Fish. Soc. Symp. 1: 483-491.

Vladykov, V.D. 1971. Homing of the American eel, Anguilla rostrata, as evidenced by returns of transplanted tagged eels in New Brunswick. Can. Field-Nat. 85: 241-248.

Table 1. Annual landings of American eel (1989 to 1995) from the southern Gulf of St. Lawrence statistical districts and the percent of total southern Gulf landings reported from individual districts. % of years is the frequency of annual landings recorded during 1917 to 1995 (1957 to 1995 for PEI).

Tableau 1. Débarquements annuels de l'anguille d'amérique (1989 à 1995) des districts statistiques du sud du Golfe du Saint-Laurent et le pourcentage par district du total débarqué. % des années représente la fréquence des enrégistrements de débarquements annuels durant la période 1917 à 1995 (1957 à 1995 pour I-P-E).

District	% of years / % des années	Year / Année							% of southern Gulf / % du sud du Golfe
		1989	1990	1991	1992	1993	1994	1995	
63	21	.	.	.	.	.	.	.	.
64	8	.	.	.	.	.	.	.	.
65	23	1.4	.	0.7	.	.	.	0.5	0.1
66	22	.	3.6	1.3	0.7	0.1	0.3	2.3	0.4
67	40	1.4	21.9	9.6	3.0	7.0	7.9	3.5	2.9
68	99	30.5	7.2	17.1	27.6	12.8	9.0	11.8	6.2
70	81	13.1	26.5	4.7	3.0	10.8	5.7	4.2	3.6
71	47	8.8	10.9	10.5	9.1	8.9	7.3	4.4	3.2
72	56	.	.	.	.	.	.	.	.
73	46	1.2	5.0	.	0.3	0.2	.	0.5	0.4
75	49	11.2	9.6	25.2	14.9	20.0	14.3	6.0	5.4
76	94	109.2	44.8	49.4	52.6	26.3	21.2	24.2	17.5
77	90	31.3	19.5	11.7	8.4	2.1	1.4	2.0	4.1
78	33	0.9	.	.	.	0.0	0.1	0.3	0.1
80	46	0.0	0.1	0.0	0.0	0.1	0.9	0.0	0.1
NB / N-B		209.0	149.1	130.2	119.6	88.3	68.1	59.7	50.0
45	29	3.0	0.7	0.0	0.3	1.7	2.5	0.2	0.4
46	13	4.3	9.0	2.8	1.4	.	.	.	0.9
10	17	.	.	1.4	1.0	.	.	.	0.1
11	64	1.2	1.7	0.8	5.0	9.9	1.7	1.3	1.2
12	79	4.4	6.6	6.2	20.2	13.8	2.7	1.2	3.0
13	96	15.2	10.3	18.3	20.9	58.5	26.9	10.5	8.6
3	74	0.1	1.3	1.3	3.4	1.6	.	0.3	0.4
2	51	2.0	0.2	6.8	5.2	3.7	8.4	2.6	1.5
NS / N-E		30.2	29.8	37.6	57.4	89.2	42.2	16.1	18.4
82	64	.	.	2.1	.	0.7	1.9	0.8	0.3
83	97	1.5	3.2	14.0	3.3	2.5	1.6	0.3	1.4
85	28	.	.	.	.	.	.	.	.
86	92	0.6	.	.	.	0.6	0.4	0.1	0.1
87	90	9.2	10.3	1.6	2.2	14.5	3.3	2.1	2.3
88	95	17.0	17.7	18.0	23.1	3.3	5.9	0.2	4.6
96	90	1.6	.	1.7	0.3	2.0	5.1	1.4	0.6
95	82	18.6	16.7	13.6	8.7	9.0	8.1	3.9	4.2
93	97	13.9	56.3	68.3	10.4	23.6	12.8	21.6	11.1
92	97	7.1	15.6	7.3	6.0	17.8	6.7	0.7	3.3
PEI/I-P-E		69.5	119.8	126.6	54.0	74.0	45.8	31.1	31.6
Southern Gulf / sud du Golfe		346.6	359.8	369.1	277.5	251.4	156.2	107.1	

Table 2. Percent of total annual landings by statistical district and gear type reported from purchase slip records as compared to Supplemetary "B" slips. A blank indicates no landings were reported from that particular gear and statistical district. Data are for the years 1989-1990 and 1994-1995.

Tableau 2. Pourcentage des débarquements annuels par district statistique et engin de pêche provenant de bordereaux d'achats relativement aux fiches supplémentaires de type "B". Un blanc indique qu'aucun débarquement a été enrégistré pour ce type d'engin et district. Les données sont pour les années 1989-1990 et 1994-1995.

	Gear type / Engin de pêche					
District	Fyke-net / Cerceaux	Trap-net / Filet-trappe	Weir / Entonnoir	Spear / Harpon	Eel-pot / Casier	Misc. / Divers
65	.	.	.	0	.	.
66	.	100	.	0	.	.
67	75	45	.	0	100	0
68	36	35	.	0	.	.
70	0	66	.	75	.	0
71	100	96	.	100	.	.
73	.	100	.	100	.	.
75	100	87	.	36	.	0
76	100	93	.	96	.	.
77	.	94	.	96	.	.
78	.	100	.	82	.	.
80	.	100	.	100	.	.
NB / N-B	74	73	.	83	100	0
45	100	30	.	.	.	.
46	.	90	.	.	.	.
11	.	100	.	55	.	0
12	.	8	.	36	.	0
13	78	57	.	40	.	.
3	.	87	.	0	.	.
2	20	0	0	0	83	.
NS / N-E	32	57	0	40	83	0
82	.	100	.	.	.	.
83	.	100	.	84	.	.
86	.	82	.	.	.	.
87	.	57	.	0	.	.
88	.	96	.	10	.	.
96	0	0	.	98	.	.
95	0	95	.	95	100	.
93	100	98	.	83	.	.
92	.	100	.	100	.	.
PEI/I-P-E	0	81	.	54	100	.
Southern Gulf / sud du Golfe	60	73	0	72	83	0

Table 3. Percent of total annual landings by statistical district and season reported from purchase slip records. A blank indicates no landings were reported from that district in that season. Landings (in brackets) are average landings for the season for the period 1989-1990 and 1994-1995.

Tableau 3. Pourcentage des débarquements par district statistique et saison provenant de bordereaux d'achats. Un blanc indique qu'aucun débarquement a été enrégistré pour ce district statistique pour cette saison. Débaarquements (en parenthèse) sont la moyenne par saison pour les années 1989-1990 et 1994-1995.

	Season / Saison		
District	Summer / Eté	Fall / Automne	Winter / Hiver
65	100	100	50
66	0	100	71
67	61	100	80
68	56	100	57
70	52	.	73
71	8	0	100
73	0	0	100
75	28	91	78
76	6	15	99
77	0	20	95
78	.	.	87
80	.	.	100
NB / N-B	24	33	83
(t)	(51)	(57)	(14)
45	100	46	.
46	94	73	.
11	74	0	23
12	74	0	0
13	96	10	21
3	.	87	0
2	.	24	.
NS / N-E	91	22	19
(t)	(10)	(13)	(7)
82	100	100	.
83	100	100	0
86	.	71	100
87	12	97	0
88	63	99	0
96	73	80	0
95	89	98	0
93	98	98	78
92	100	100	.
PEI / I-P-E	84	98	50
(t)	(31)	(34)	(2)
Southern Gulf / sud du Golfe	80	78	51
(t)	(93)	(103)	(23)

Table 4. Trends analysis of landings of American eel from selected districts in the southern Gulf of St. Lawrence for two time periods, 1968 to 1995 and the more recent 1984 to 1995. Slope values in bold have a significant level less than 0.05.

Tableau 4. Tendances des débarquements d'anguille par districts statistiques dans le sud du Golfe du Saint-Laurent durant 1968 à 1995 et depuis 1984 à 1995. Les chiffres en gras correspondent aux pentes dont la probabilité statistique est inférieure à 0,05.

District	1968 to 1995		1984 to 1995	
	Slope / Pente	Probabilité Slope / Pente = 0	Slope / Pente	Probabilité Slope / Pente = 0
67	**-0.27**	0.002	+0.09	0.646
68	**-0.21**	0.001	-0.09	0.334
70	-0.14	0.302	-0.00	0.969
71	**-0.81**	0.000	+0.08	0.877
75	-0.30	0.201	-0.03	0.897
76	+0.07	0.129	**-0.07**	0.005
77	+0.06	0.505	-0.08	0.095
12	+0.80	0.058	+0.15	0.403
13	+0.01	0.919	**+0.13**	0.043
88	-0.23	0.064	**-0.26**	0.000
92	**-0.32**	0.000	**-0.23**	0.003
93	+0.14	0.142	-0.06	0.276
95	+0.12	0.330	**-0.18**	0.014

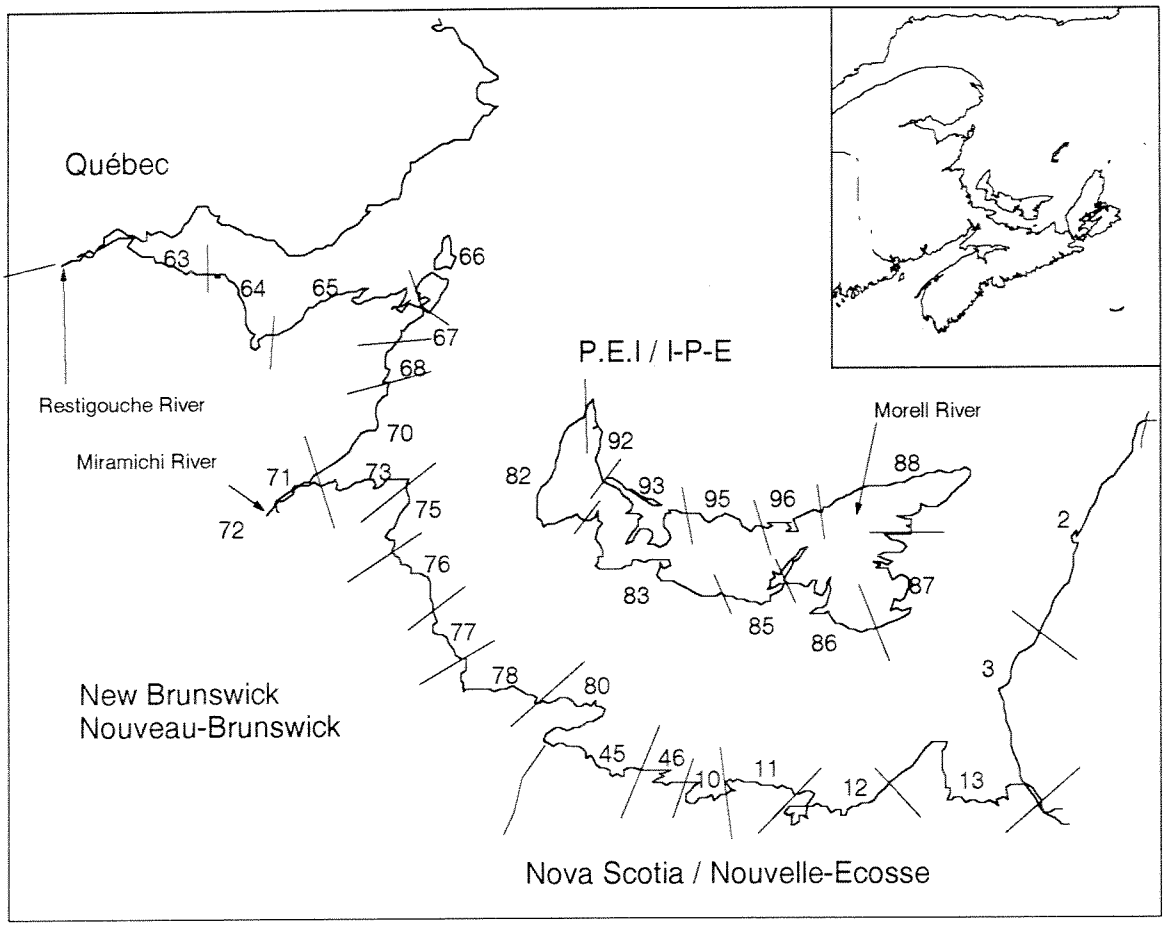


Fig. 1. Statistical districts in the southern Gulf of St. Lawrence, Maritimes Region, and location of rivers mentioned in the text.

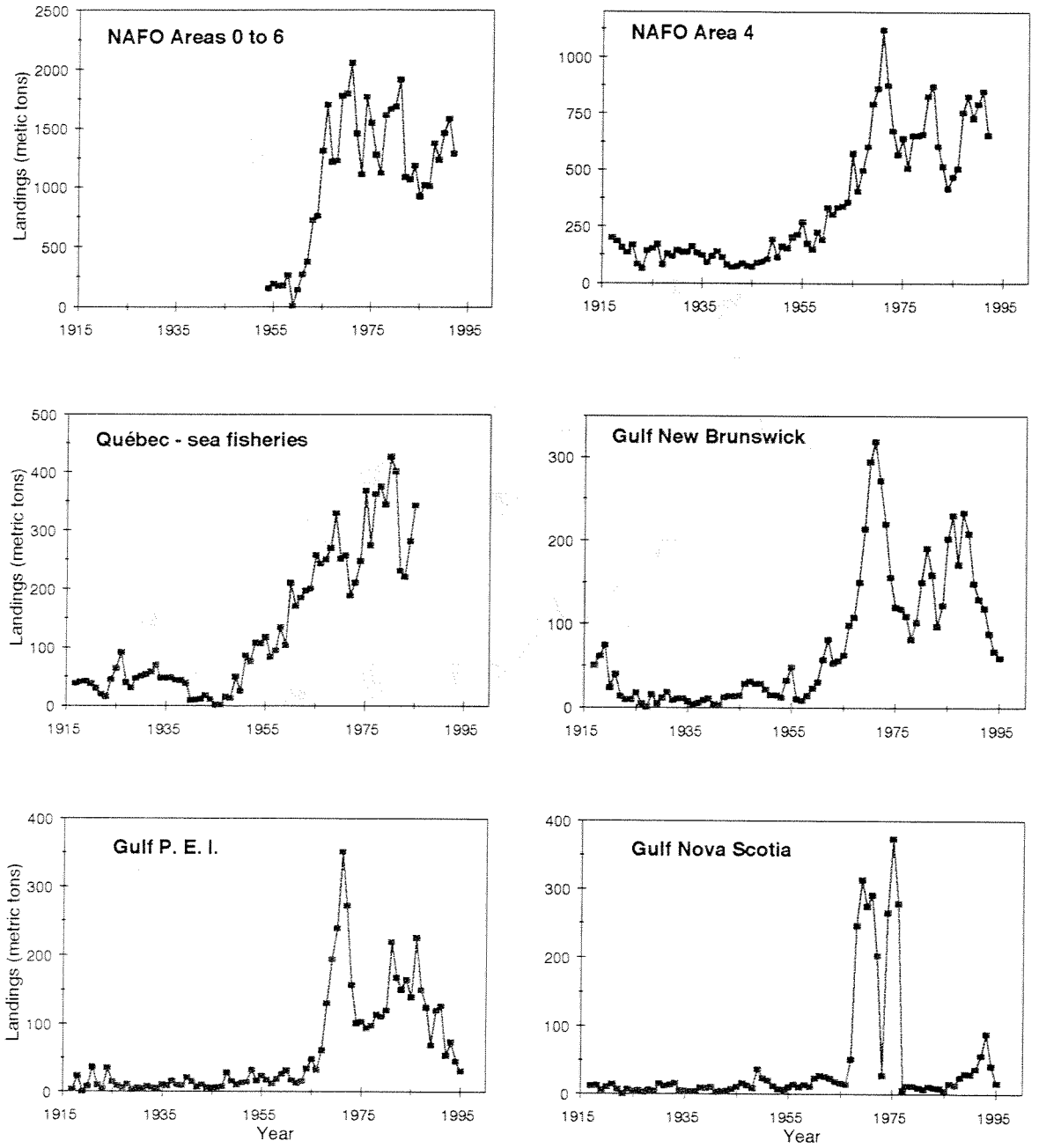


Fig. 2. Landings (metric tons) of American eels in the Northwest Atlantic (NAFO Areas 0 to 6) and in the Gulf of St. Lawrence.

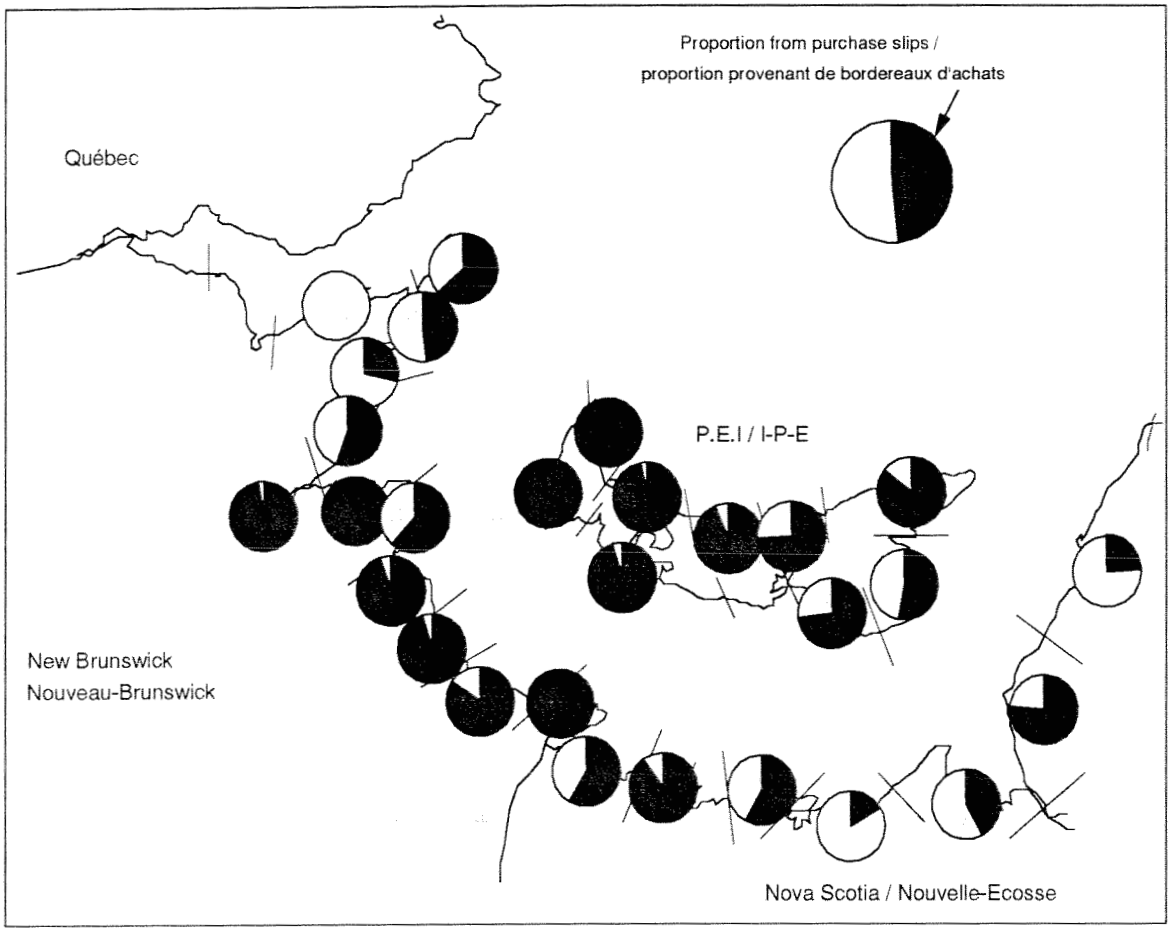


Fig. 3. Proportion of the reported annual landings derived from purchase slips (black slice) and from Supplementary 'B' forms (white slice) by statistical district in the southern Gulf of St. Lawrence.

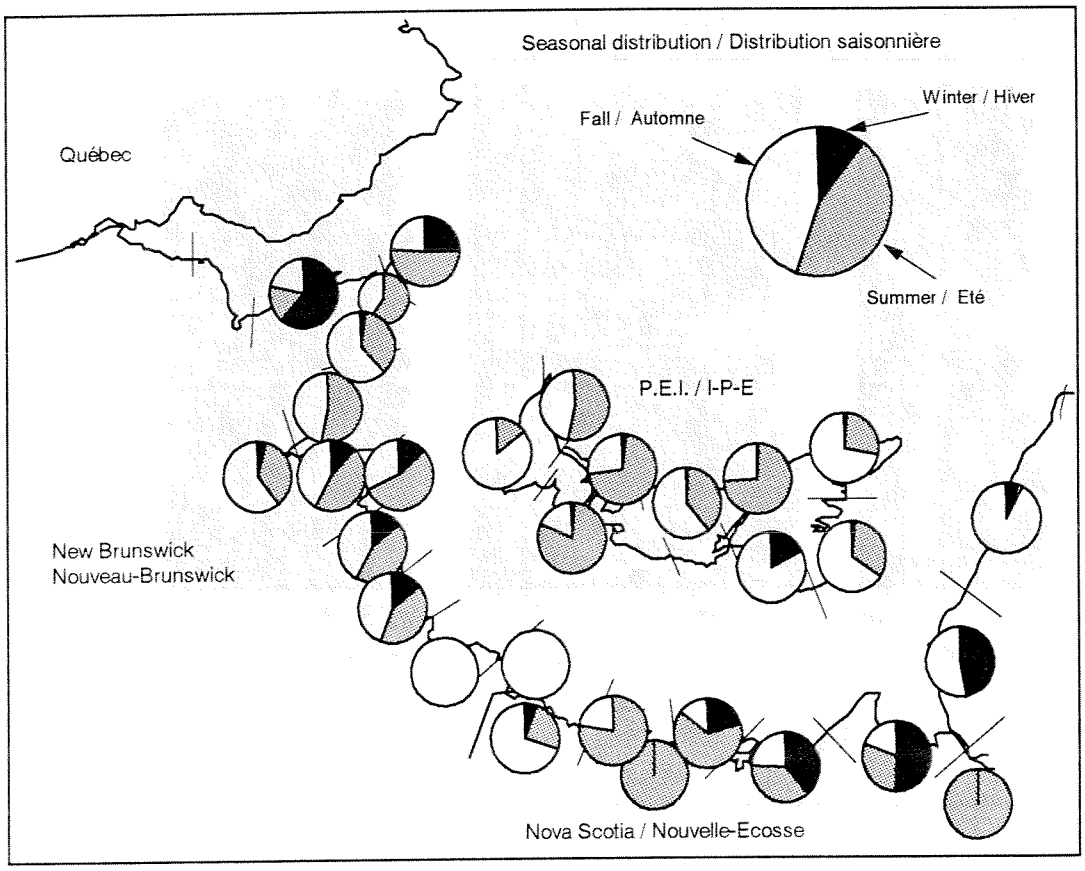


Fig. 4. Seasonal distribution of landings of American eels by statistical district in the southern Gulf of St. Lawrence for the 1968 to 1995 period.

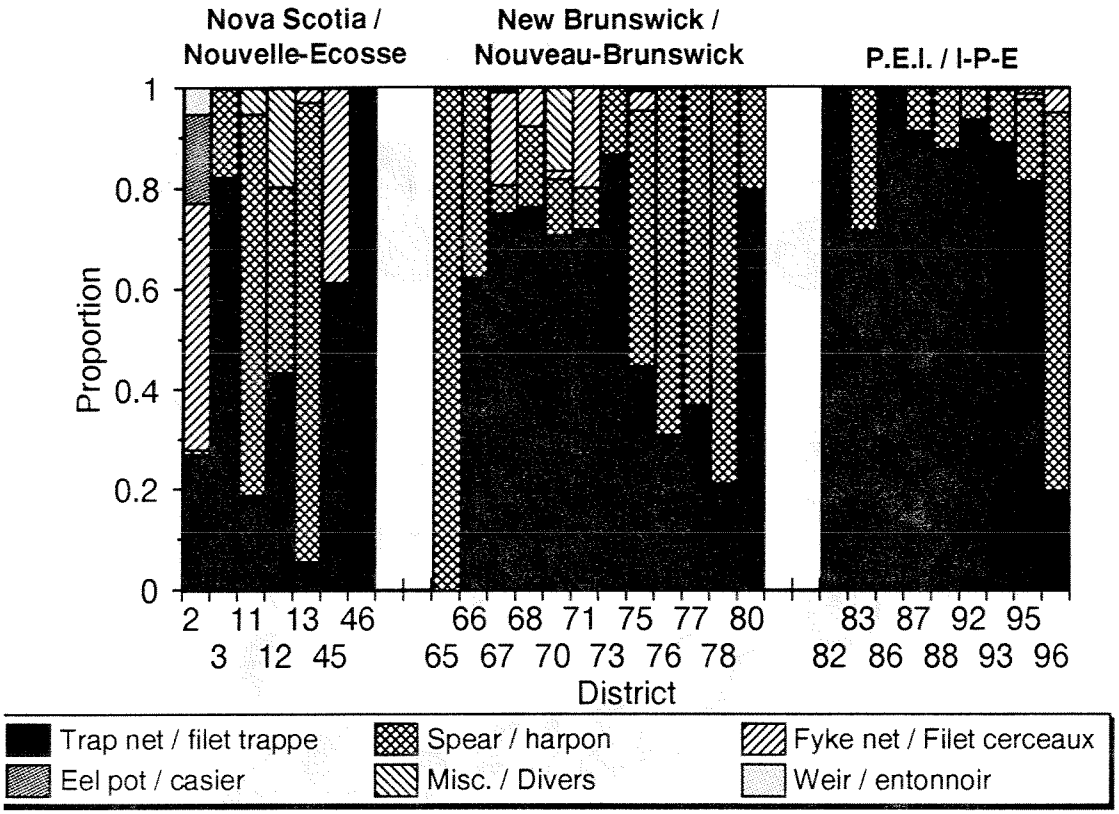


Fig. 5. Proportion of landings by gear type in the statistical districts of the southern Gulf of St. Lawrence.

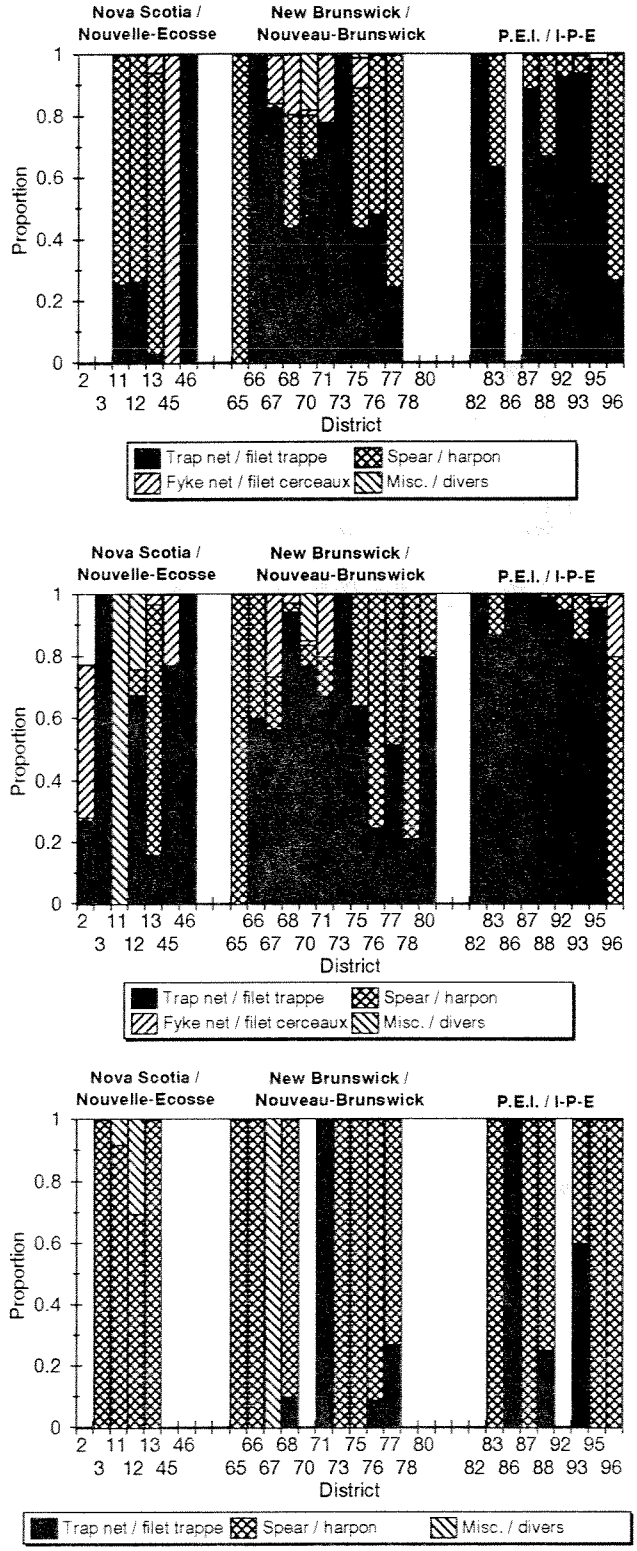


Fig. 6. Proportion of landings by gear type and season (upper = summer, middle = fall, lower = winter) in statistical districts of the southern Gulf of St. Lawrence.

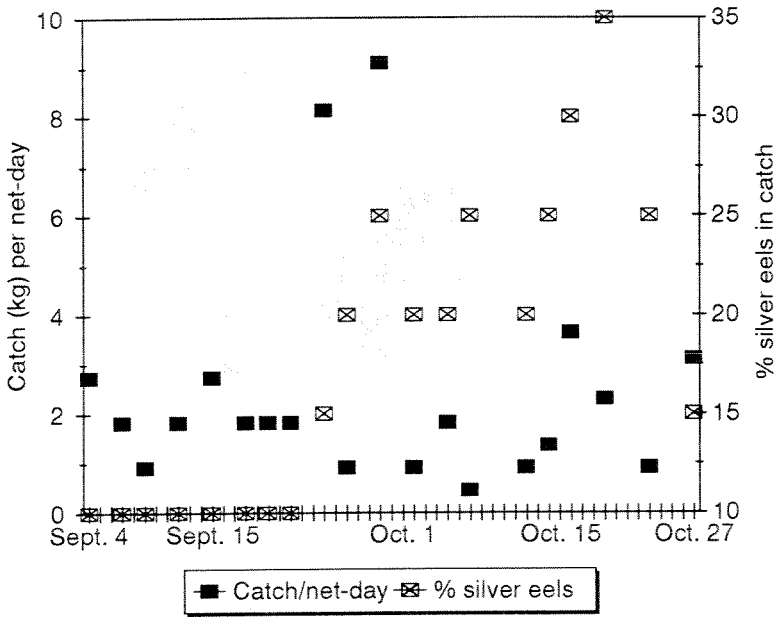


Fig. 7. Catch per unit of effort and percent of the catch which was silver eels in the catches from a fisher in Gulf Nova Scotia in 1995.

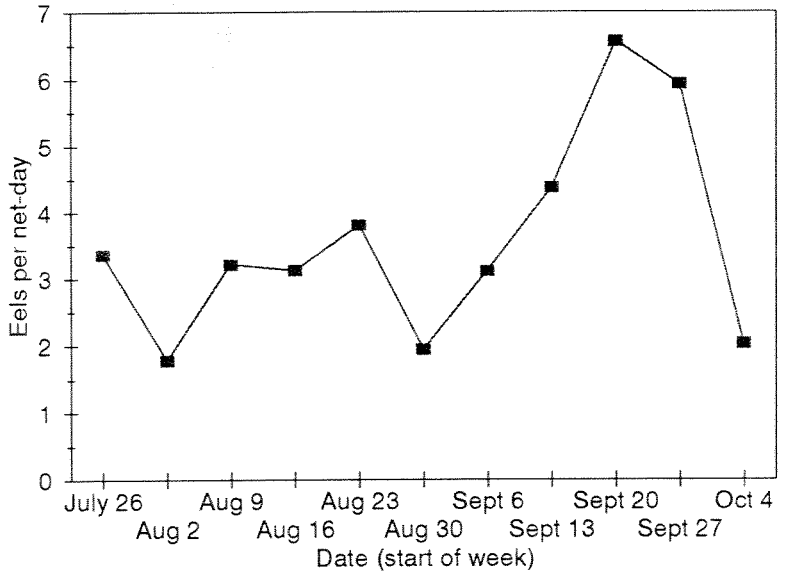


Fig. 8. Catch per unit of effort from a net fishery in an estuary of Gulf New Brunswick in 1993.

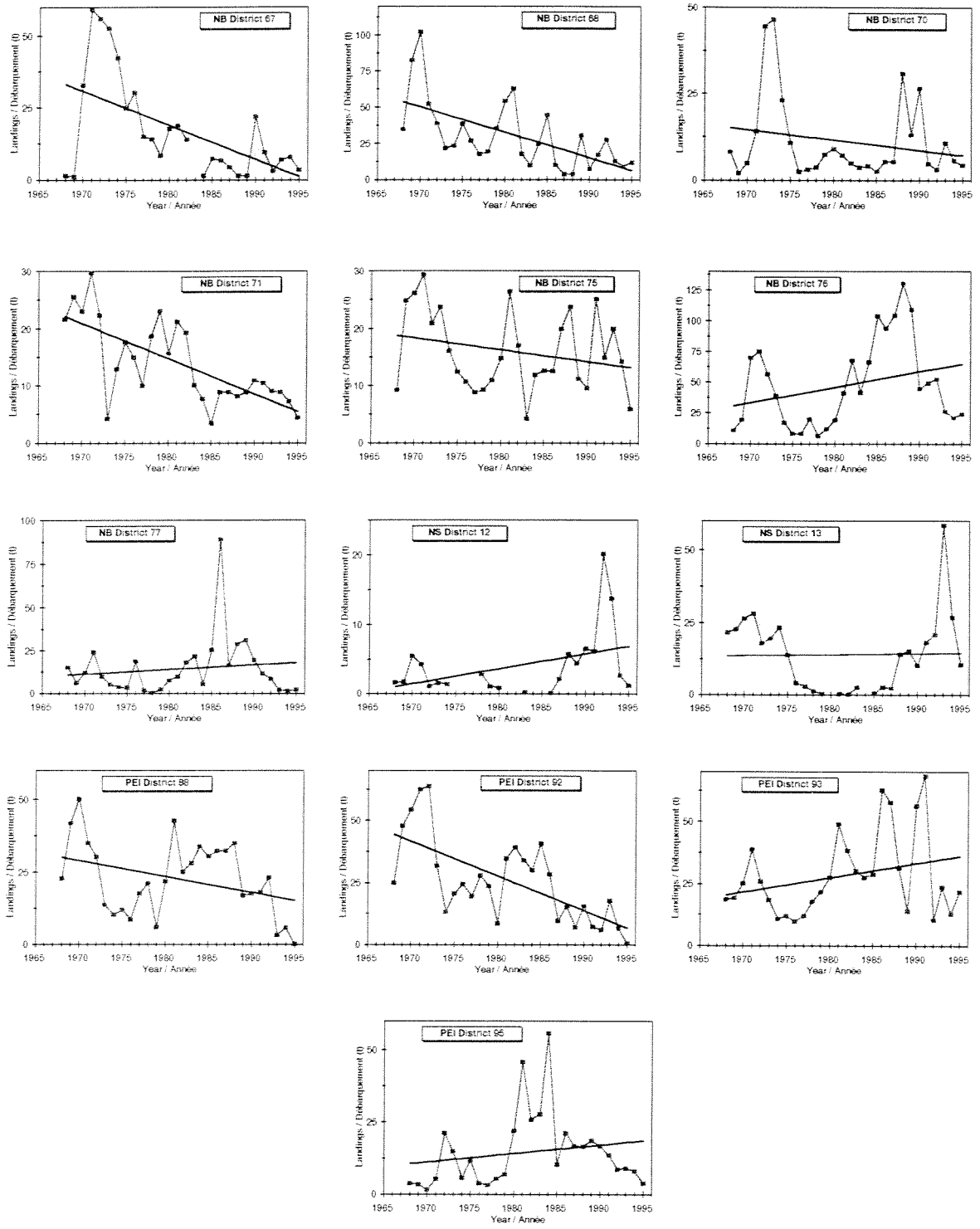


Fig. 9. Trends in landings over time in 13 statistical districts in the southern Gulf of St. Lawrence for 1968 to 1995.

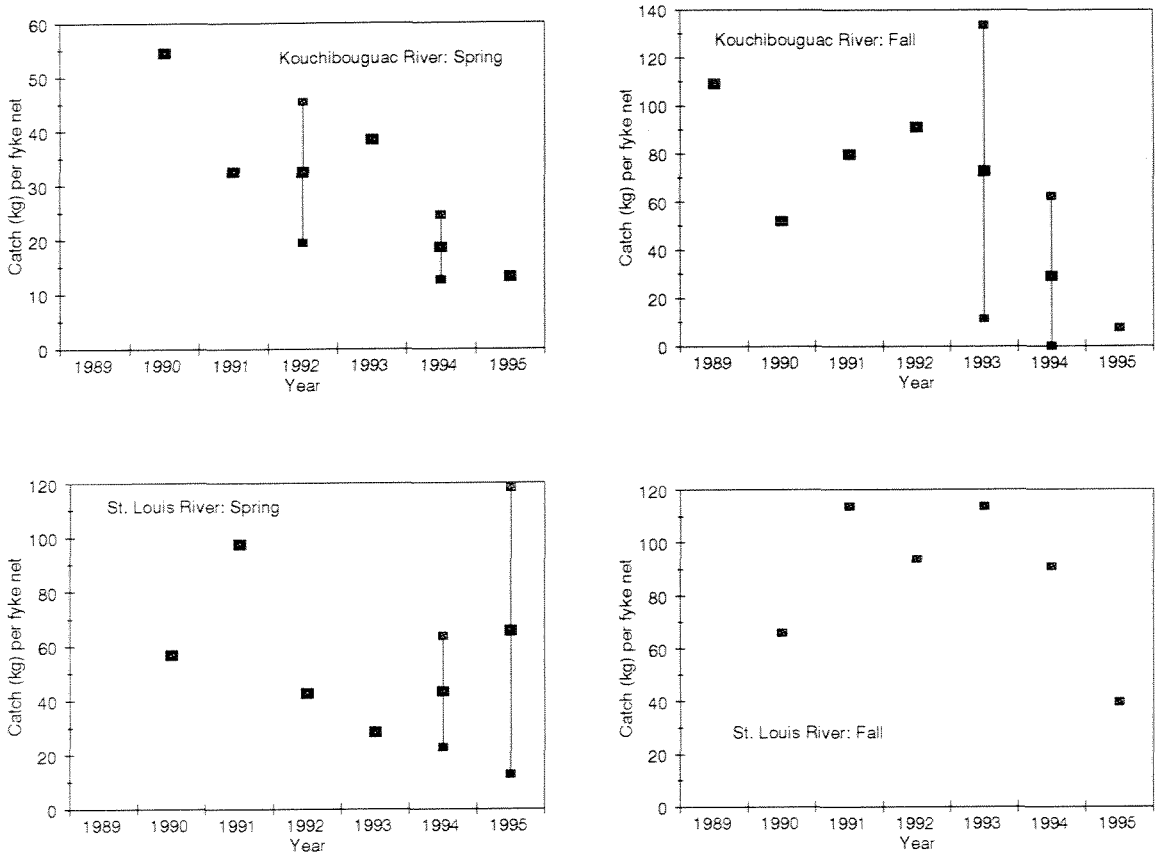


Fig. 10. Trends in catch per net by commercial fishers in the spring and fall eel fisheries of the Kouchibouguac and St. Louis rivers (District 75, Gulf New Brunswick), 1989 to 1995.

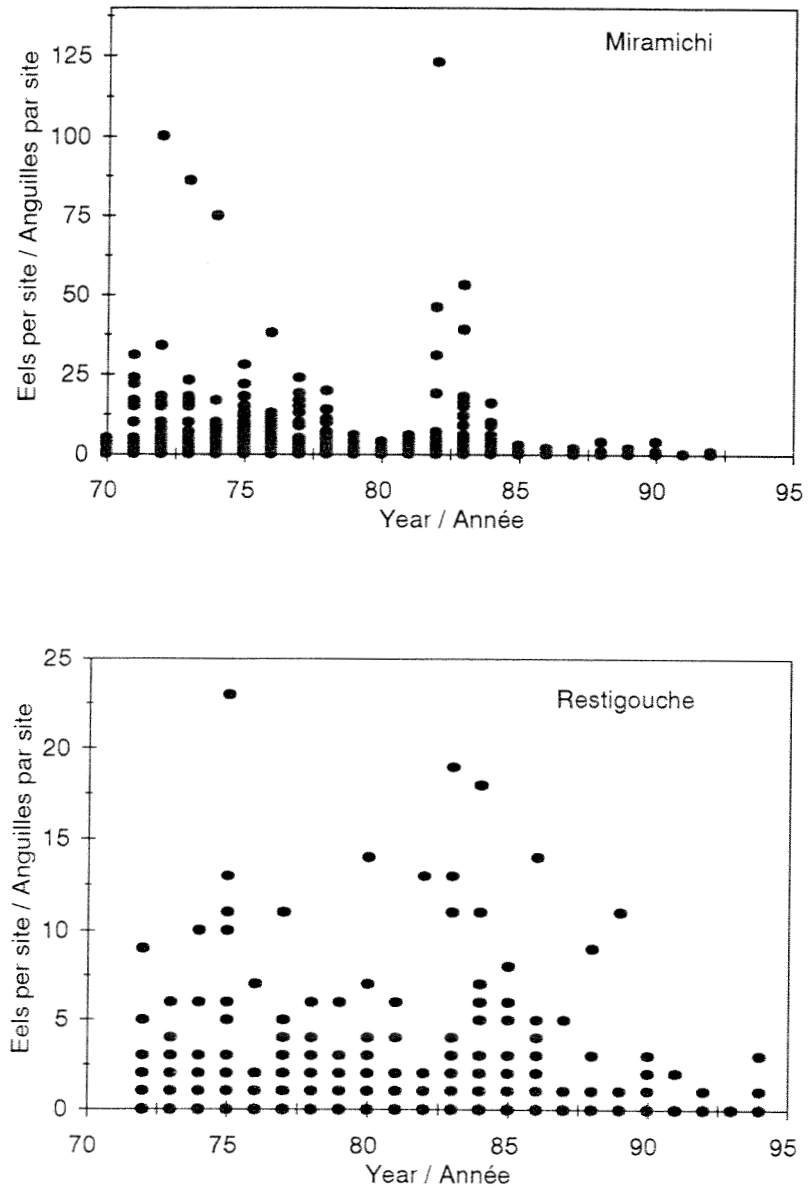


Fig. 11. Trend in abundance of eels at electrofishing stations in the Miramichi River (upper) and the Restigouche River (lower) for 1970 to 1994.

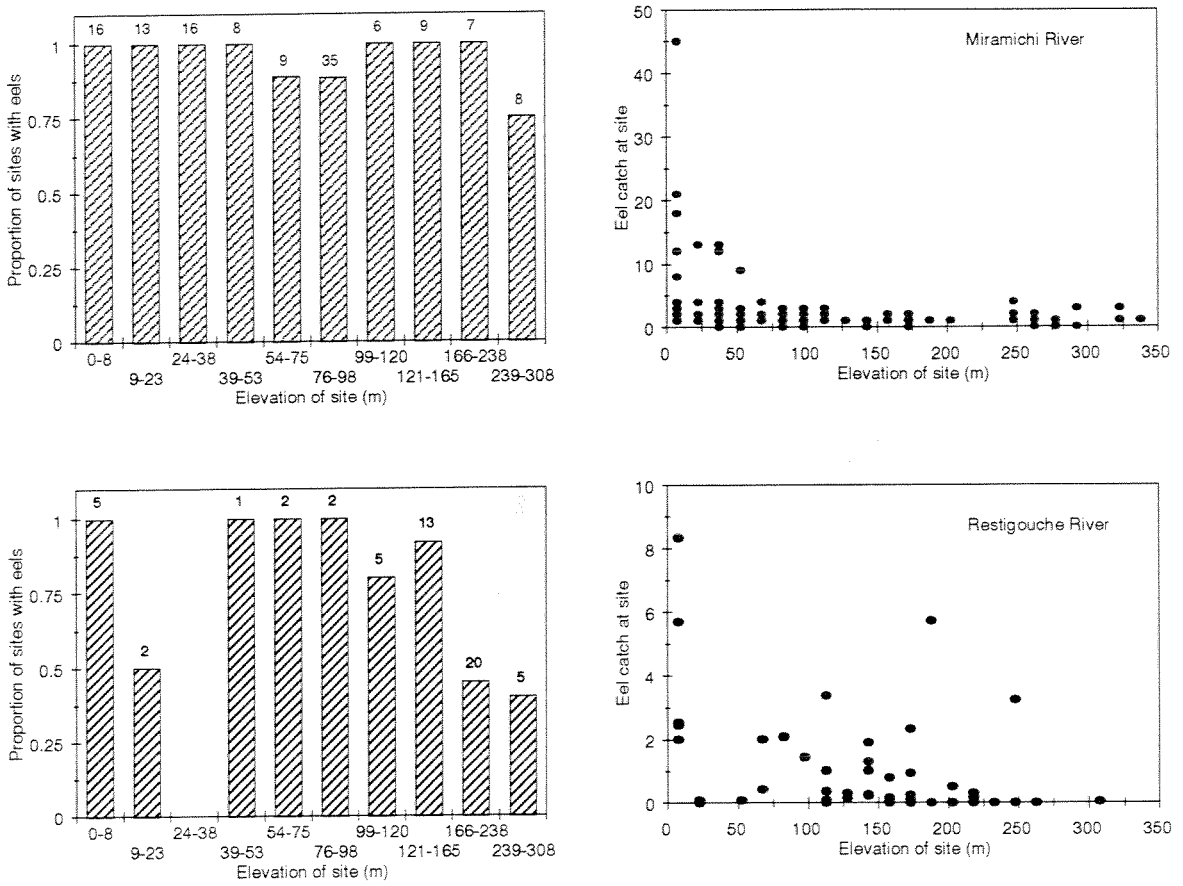


Fig. 12. Freshwater distribution of eels in the Miramichi River (upper panels) and the Restigouche River (lower panels) relative to the elevation of the site surveyed. Numbers above bars indicate the number of sites sampled for each elevation category.

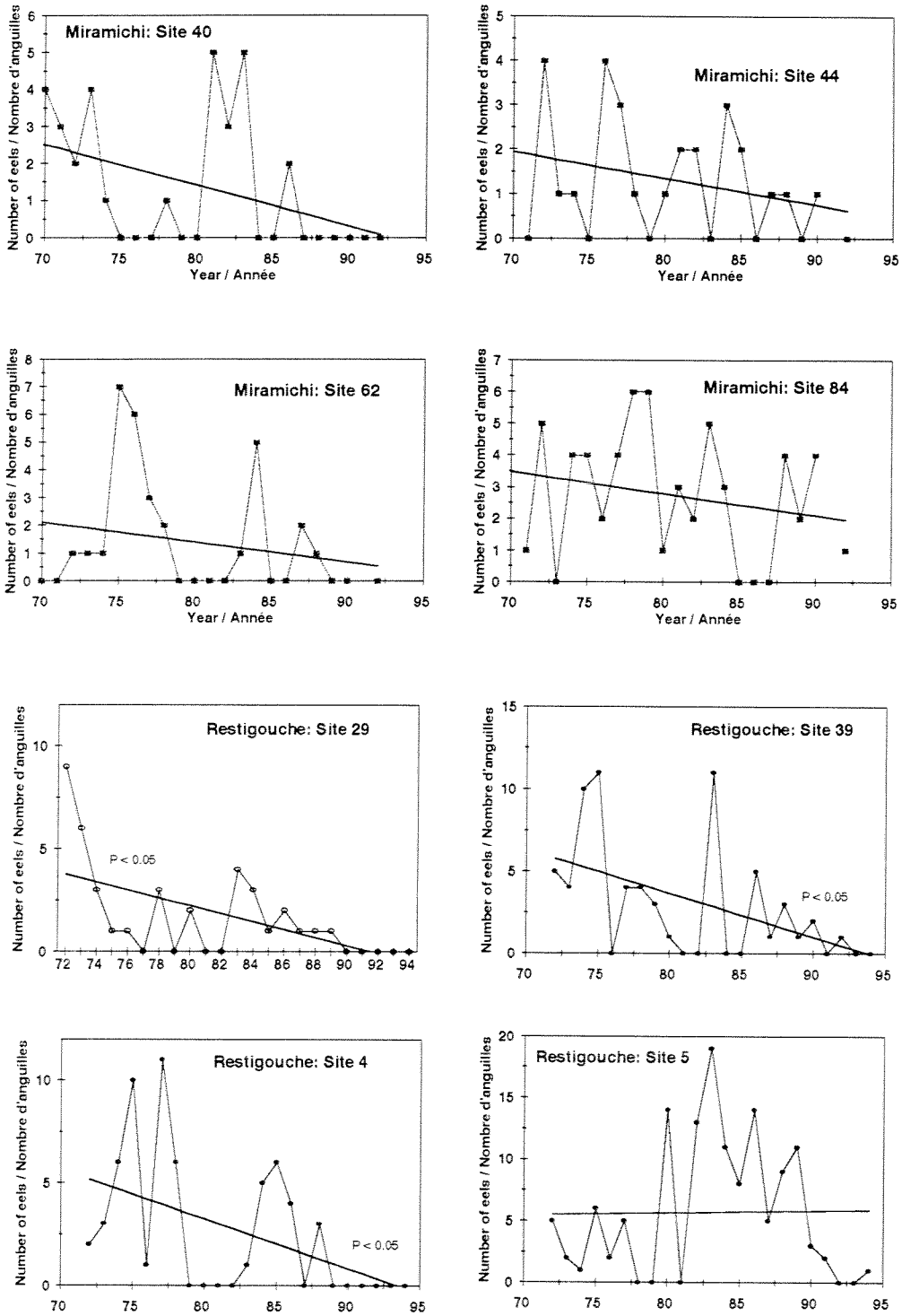


Figure 13. Trend in abundance of American eels at individual electrofishing sites (upper four panels Miramichi; lower four panels Restigouche) for 1970 to 1994.

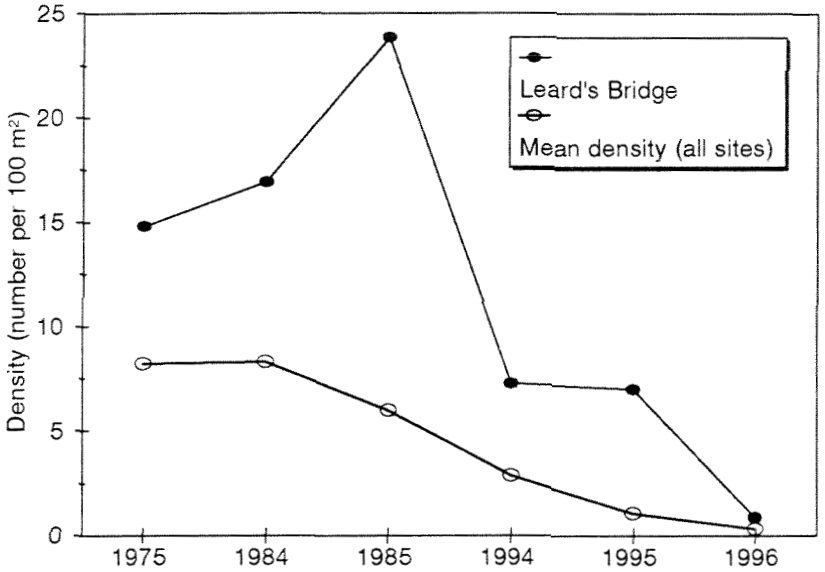


Figure 14. Eel densities (number per 100 m²) at one site and estimates of mean density over several sites in the Morell River (PEI). The 1975 data are from Ducharme (1977). Data for other years are from D. Cairns (unpubl. data). Sites are defined in Cairns et al. (1997).

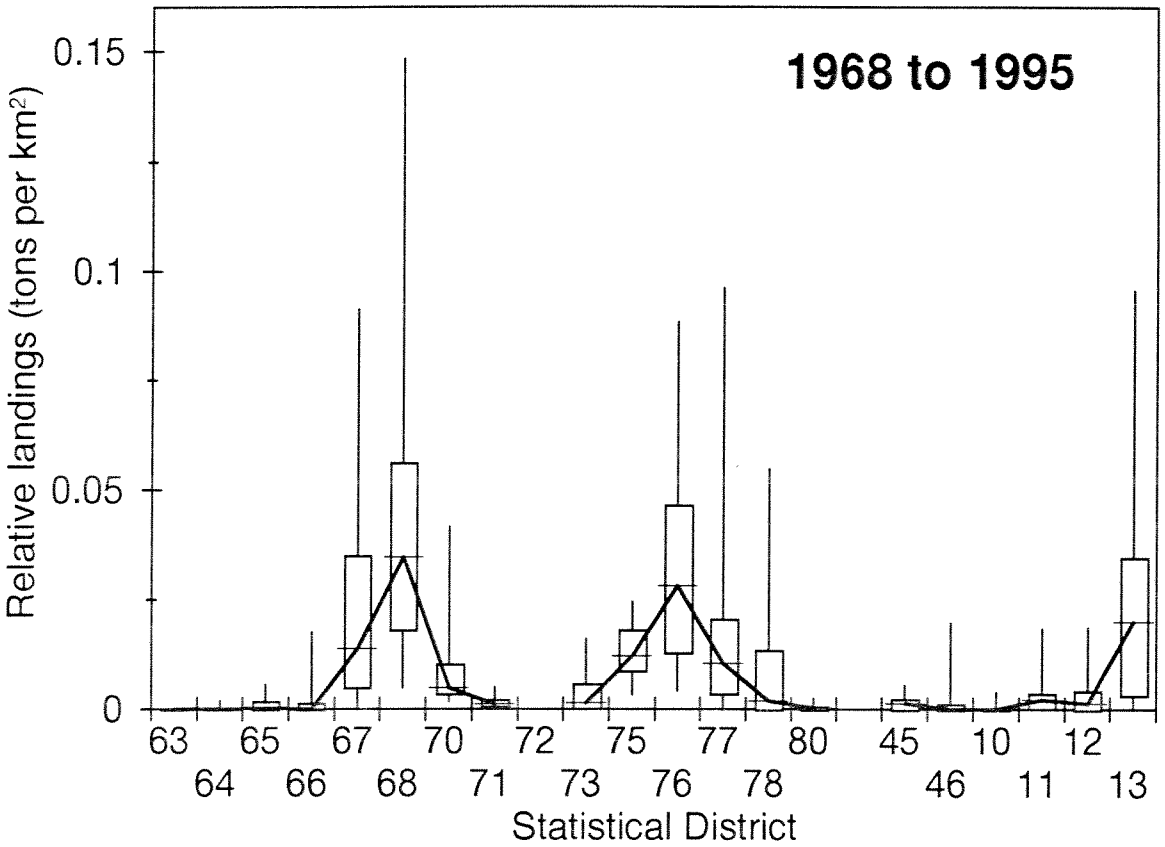


Figure 15. Relative annual landings of eels (tons per km² of drainage area) by statistical district in Gulf NB and Gulf NS. Box plots are interpreted as follows: horizontal line is the median relative annual landing for 1968 to 1995, rectangle defines the 25th and 75 th percentiles, the vertical line defines the 5th and 95 percentiles.

Estimation du stock d'anguille d'Amérique (*Anguilla rostrata*) argentée en dévalaison dans le bas Saint-Laurent et son taux d'exploitation en 1996

par

François Caron
Ministère de l'Environnement et de la Faune du Québec
150 Rene-Levesque
5e' etage, Quebec, Quebec G1R 4Y1

et

Guy Verreault
Ministère de l'Environnement et de la Faune
506 Lafontaine
Riviere du-Loup, PQ GsR 3C4

INTRODUCTION

L'anguille (*Anguilla rostrata*) remonte le fleuve Saint-Laurent jusqu'aux Grands-Lacs (Scott et Crossman 1974), colonisant les rivières qui lui sont accessibles. Après un séjour de cinq à vingt-cinq ans en eau douce, l'anguille verte subit des changements physiologiques pour devenir une anguille argentée au moment de sa migration vers la mer.

L'estuaire fluvial du Saint-Laurent, à la hauteur de Québec, est caractérisé par de l'eau douce et de fortes marées; la capture d'anguilles argentées s'échelonne de la mi-août à la fin octobre, avec un sommet vers la mi-octobre. Dans l'estuaire moyen, où se fait la transition entre l'eau douce et l'eau salée, l'anguille est alors exploitée par des pêches à fascines dans l'estran, principalement entre Saint-Rock des Aulnaies et Rimouski, soit dans la région qui se prête bien à l'installation de ce genre d'engin. Passé cette région, l'anguille n'est, à toute fin utile, plus exploitée. La majorité des anguilles capturées dans cette région proviennent de la partie fluviale du Saint-Laurent, voire même des Grands-Lacs (Dutil *et al.* 1985; Castonguay *et al.* 1989; Couillard *et al.* sous presse).

Pour l'Estuaire du Saint-Laurent, les statistiques de prises disponibles depuis 1920 (sept années manquent dans la série) montrent de grandes fluctuations dans la récolte. De 1920 à 1955, les captures se sont essentiellement maintenues sous le niveau des 100 tonnes annuelles pour connaître, par la suite, une croissance qui a culminé à près de 400 tonnes au début des années 1980 et décliner jusqu'à 121 tonnes en 1996 (Robitaille et Tremblay 1994; Verreault en préparation).

Le déclin de la récolte soulève à la fois la question de la viabilité de cette pêcherie et la question du recrutement des géniteurs, d'autant plus que près de 99 % des anguilles capturées sont des femelles (Vladykov 1966; Larouche *et al.* 1974; Desjardins *et al.* 1983; Dutil *et al.* 1985). Sur la base des données de débarquements, les tonnages déclarés dans cette région représentent plus de la moitié de l'ensemble des captures du Québec.

En dépit de l'importance socio-économique de cette espèce, aucune évaluation du taux d'exploitation n'avait été tentée puisque le nombre d'anguilles argentées en dévalaison n'avait jamais été estimé. Cette étude vise donc à estimer la quantité d'anguilles argentées qui quittent la partie fluviale du Saint-Laurent et à évaluer son taux d'exploitation dans la principale zone de pêche à cette espèce au Québec.

INTRODUCTION

The eels (*Anguilla rostrata*) move up the St. Lawrence River to the Great Lakes (Scott and Crossman 1974) and into rivers that are accessible to them. After spending five to twenty-five years in fresh water, the green eel undergoes physiological changes, becoming a silver eel when starting its migration to the sea.

The St. Lawrence estuary around Quebec City is characterized by fresh water and strong tides; silver eels are harvested from mid-August to late October, with a peak in mid-October. In the middle estuary, where the water changes from fresh to salt water, eels are harvested in weirs along the littoral shore, mainly between Saint-Rock des Aulnaies and Rimouski, an area well suited to installing this type of gear. Beyond this area, there is for all intents and purposes no eel harvesting. Most of the eels captured in this area come from the riverine part of the St. Lawrence or the Great Lakes (Dutil *et al.* 1985; Castonguay *et al.* 1989; Couillard *et al.* in press).

For the St. Lawrence estuary, catch statistics available from 1920 on (seven years are missing from the series) show large fluctuations in the harvest. From 1920 to 1955, catches remained more or less stable at around 100 tonnes per year, climbing to about 400 tonnes at the start of the 1980s and then falling to 121 tonnes in 1996 (Robitaille and Tremblay 1994; Verreault in preparation).

The decline in the harvest raises the question of the viability of this fishery and the issue of spawner recruitment, since almost 99% of the eels caught are females (Vladykov 1966; Larouche *et al.* 1974; Desjardins *et al.* 1983; Dutil *et al.* 1985). According to landing data, the tonnages declared in this region make up over half of all Quebec catches.

In spite of the socio-economic significance of this species, no assessment of the exploitation rate has been attempted since the number of downstream-migrating silver eels has never been estimated. The purpose of this study is therefore to estimate the number of silver eels leaving the riverine part of the St. Lawrence and evaluate the exploitation rate in the primary eel fishing area in Quebec.

MATÉRIEL ET MÉTHODE

LE SECTEUR À L'ÉTUDE

La zone de marquage et de remise à l'eau se situe dans la région immédiate de la ville de Québec, soit à l'extrémité est de la section fluviale du Saint-Laurent (figure 1). La zone de recapture débute en eaux saumâtres dans l'estuaire moyen, à 120 km en aval de la zone de marquage, à la hauteur de Saint-Roch-des-Aulnaies, et se termine à Saint-André de Kamouraska, à une distance de 180 km en aval du site de relâché.

La zone de pêche débute à Montmagny ou Saint-Jean-Port-Joli et se termine à Métis-sur-Mer. On y retrouve 96 trappes à anguilles dont la longueur totale est de 62 250 m. Sur la rive nord du Saint-Laurent, on retrouve trois pêches à anguilles sur l'île aux Coudres et six sur la rive nord, mais les captures d'anguilles sont négligeables.

La zone de recapture se trouve donc uniquement sur la rive sud, entre Saint-Roch-des-Aulnaies et Saint-André de Kamouraska. On y retrouve 69 trappes à anguilles dont la longueur totale est de 50 590 m, soit 81,3 % de l'effort de pêche de cette zone.

LE MARQUAGE

Pour marquer les anguilles, nous avons cherché une marque qui soit peu apparente pour les pêcheurs, facilement repérable par du personnel qualifié, rapide d'application, peu coûteuse, qui ne demande pas d'anesthésier les anguilles afin de ne pas modifier leur comportement migratoire et finalement, qui offre la possibilité d'utiliser différents codes de manière à pouvoir distinguer plusieurs groupes d'anguilles. Nous avons emprunté la méthode de thermo-marquage déjà utilisée sur des saumonneaux (Caron et Guérard 1996); il s'agit d'un fil métallique, chauffé à rouge par une batterie de 12 volts, que l'on applique superficiellement sur la peau en évitant de transpercer l'épithélium.

Des marques ont été expérimentées à différents endroits sur quatre anguilles qui ont été gardées en captivité pendant deux semaines, puis remises dans un petit lot d'anguilles provenant de la pêche commerciale, avant d'être vérifiées à l'usine de transformation. Aucune blessure ou infection n'était alors apparente. L'observateur ayant réussi à repérer sans difficulté les anguilles marquées, ce type de marquage a donc été retenu pour l'étude. Nous avons choisi, comme emplacement de marquage, la partie abdominale située entre les deux nageoires pectorales.

PROVENANCE ET LIEU DE REMISE À L'EAU DES ANGUILLES MARQUÉES

Un premier groupe de 102 anguilles a été capturé en rive droite (sud) du fleuve, à quelques centaines de mètres du pont Pierre-Laporte par ce qu'il est convenu d'appeler « La pêcherie de l'Aquarium du Québec ». Les anguilles ont été marquées d'un code spécifique pour chaque semaine (comme cela fut également fait pour le second groupe) et relâchées au point A, juste en aval du lieu de capture. Le second groupe de 516 anguilles a été acheté d'un pêcheur, en plusieurs petits lots tout au long de la saison de pêche, sur la rive gauche du fleuve, à environ 5 km en aval du premier groupe, et relâché au point B, à environ 1 km plus en aval de leur point de capture. Le troisième groupe de 429 anguilles provenait de deux rivières du Bas-Saint-Laurent, les rivières Rimouski et du Sud-Ouest, dont la taille des bassins de drainage est respectivement de 1 637 km^2 et 197 km^2. Ces anguilles ont été capturées par un piège installé dans une passe migratoire sur la rivière Rimouski et par une trappe en grillage métallique fin sur la rivière du Sud-Ouest. Les pièges étaient visités quotidiennement et les anguilles, retenues dans une cage de rétention jusqu'à ce qu'elles soient transportées en cinq lots et relâchées au point C, sur la rive droite du fleuve, à la pointe de Lauzon. Les détails des dates de marquage apparaissent au tableau 1.

OBSERVATION DES ANGUILLES MARQUÉES

Nous avons observé 28 714 anguilles, provenant de la zone de recapture, dans une usine. Les anguilles ont été examinées et comptées, une à la fois, sauf à deux occasions, soit le 12 octobre et le 5 novembre où le nombre d'anguilles a été estimé à partir du poids du débarquement (poids moyen utilisé de 1,33 kg/anguille), ce qui concerne respectivement 500 et 239 anguilles, ou 2,6 % de l'échantillon total. Lors des visites directement auprès des pêcheurs, nous avons vérifié 1 129 anguilles. Ces dernières étaient vendues à différents poissonniers, de telle sorte qu'il est possible qu'une partie d'entre elles se soient retrouvées dans l'échantillonnage fait à l'usine.

CARACTÉRISTIQUES DES ANGUILLES

Les anguilles en provenance des rivières Rimouski et du Sud-Ouest, ainsi que celles vérifiées chez les pêcheurs commerciaux, ont été mesurées au millimètre près et pesées au gramme près. Les anguilles achetées à Québec ont été pesées en lot, au 500 gr près.

RÉSULTATS

CARACTÉRISTIQUES DES ANGUILLES

Les anguilles capturées dans le Saint-Laurent (rive gauche de Québec et pêcheurs de l'estuaire marin) ont des caractéristiques de poids et de longueur similaires; celles provenant des rivières Rimouski et du Sud-Ouest ont une longueur et un poids moyens sensiblement plus élevés. Ces anguilles ont été capturées entre le 16 août et le 15 octobre; on note un pic de migration important sur la rivière du Sud-Ouest le 15 septembre, et le même phénomène en début octobre sur la rivière Rimouski (figure 2). Dans iles deux cas, l'augmentation des captures suit de près une augmentation de débit reliée à des précipitations.

	Poids (kg)		Longueur totale (cm)		
	Moyenne	Écart-type	Moyenne	Écart-type	N
Rive gauche de Québec	1,399				516
Estuaire marin	1,330	0,540	86,1	9,8	1 081
Rivière Rimouski	1,827	0,684	94,8	13,7	234
Rivière du Sud-Ouest	1,978	0,448	97,2	7,9	122

VITESSE DE DÉVALAISON

La vitesse de dévalaison ne peut être calculée de façon précise du fait qu'on utilisait une seule marque par site de marquage pour une période d'une semaine et que, particulièrement en début de saison, il arrive que les pêcheurs accumulent les anguilles dans un coffre de rétention pendant quelques jours avant qu'elles ne soient acheminées vers l'usine.

Les résultats montrent que les anguilles ont mis de une à sept semaines pour se rendre de la zone de marquage à la zone de recapture (distance médiane de 150 km). Au cours des premières semaines, le rythme de dévalaison est assez lent, alors que les anguilles mettent en moyenne quatre semaines et plus avant d'être recapturées; le rythme de dévalaison s'accélère à la fin septembre et en octobre, les anguilles mettant en moyenne moins de deux semaines pour franchir la même distance (tableau 2). La vitesse de migration approximative serait donc de 6 à 10 km/jour. Toutefois, quelques anguilles ont mis aussi peu que trois jours pour franchir cette distance en novembre, ce qui montre une vitesse de migration d'environ 50 km par jour.

TAUX DE RECAPTURE

Les vérifications effectuées sur les anguilles ont permis d'observer 10 anguilles sur les 102 (9,8 %) provenant de la pêcherie de l'Aquarium du Québec, 29 sur 516 (5,6 %) provenant du pêcheur commercial à Québec, et 24 des 429 (5,6 %) anguilles en provenance des deux rivières du Bas-Saint-Laurent (tableau 3). Si on considère les recaptures en fonction de la rive où elles ont été relâchées, nous avons observé 34 des 531 (6,4 %) anguilles en provenance de la rive droite, contre 29 des 516 (5,6 %) en provenance de la rive gauche. Toutes ces proportions ne sont pas significativement différentes (Test de χ^2).

ÉVALUATION DE LA POPULATION

Étant donné que nous n'avons pas observé de différence significative entre les trois groupes d'anguilles, les données ont été mises ensemble pour l'estimation de la population. L'estimateur de Petersen nous apparaît donc convenir à cette analyse sommaire. On retrouve, au tableau 4, les détails de ce calcul qui donne une estimation de 488 696 anguilles (383 291 - 622 542, $\propto = 0,05$).

ESTIMATION DE LA CAPTURE

Le nombre total d'anguilles capturées par les pêcheurs est estimé à partir des captures faites par les 69 pêches qui ont fait l'objet d'un suivi (figure 3). Ainsi, nous estimons que pour l'ensemble de la zone de recapture, la récolte aura été de 83 969 anguilles (78 179 - 89 759, $\propto = 0,05$), ce qui représente un poids au débarquement de 112 tonnes d'anguilles (104 - 119) pour l'ensemble de la zone.

TAUX D'EXPLOITATION

Si l'estimation précédente des captures s'avère juste, le taux d'exploitation des anguilles argentées en provenance du Saint-Laurent, en amont de Québec, aura été de 17 % (13 % - 23 %).

DISCUSSION ET CONCLUSION

La présente étude permet d'avoir, pour une première fois, une estimation approximative du stock d'anguilles qui atteignent la zone maritime du Saint-Laurent et de son taux d'exploitation. L'évaluation de près d'un demi-million d'anguilles nous semble assez faible puisque, au cours des deux dernières décennies, le nombre d'anguilles capturées a vraisemblablement approché cette estimation à quelques reprises.

Cette évaluation vaut pour la proportion du fleuve en amont de la zone de recapture. Il faut noter que l'anguille est présente dans un grand nombre de rivières en aval de cette zone, autant dans les rivières de la Côte-Nord, de la Gaspésie et de l'île d'Anticosti, et que la contribution de ces rivières n'entre pas dans la présente évaluation; les anguilles en provenance de ces rivières ne font, pour l'instant, l'objet d'aucune exploitation et leur contribution au nombre de reproducteurs est sans doute importante. Sur les rivières du Sud-Ouest et Rimouski, la date de la migration semble fortement influencée par les conditions environnementales. Dans les deux cas, on enregistre un pic de capture qui correspond à une augmentation rapide du niveau d'eau. Notons toutefois que ces captures ne représentent pas nécessairement l'ensemble de la production de ces rivières puisque des anguilles ont pu dévaler avant ou après la période de capture ou encore éviter le piège.

L'exploitation de l'anguille est évaluée, ici, pour une première fois. Le taux d'exploitation, situé à 17 %, semble peu élevé. Notons toutefois qu'il concerne en grande partie le stock en provenance du lac Ontario et de l'estuaire d'eau douce du Saint-Laurent, stock qui a été l'objet d'une exploitation au stade « anguille jaune » et à un degré moindre, au moment de sa migration dans l'estuaire d'eau douce. De plus, il semble qu'une partie importante des anguilles en provenance du lac Ontario ait pu mourir en franchissant les barrages de Mooses Sanders et de Beauharnois (Desrochers 1995).

La contribution des rivières au nord et à l'est de ces zones de pêche qui ne sont soumises à aucune exploitation pourrait être importante. En effet, les 356 anguilles argentées capturées dans deux petites rivières (Rimouski et du Sud-Ouest) ne représentent qu'un nombre minimal d'anguilles produites par ces rivières puisque les pièges de capture n'ont pas été en opération durant toute la dévalaison. De plus, nous avons de nombreuses indications démontrant que la quasi totalité des rivières, au nord et à l'est de cette zone, accueillent des stocks d'anguille. Si on admet que cette espèce est panmixiste, ces rivières pourraient jouer un rôle important en suppléant partiellement pour les stocks fortement exploités.

Le taux d'exploitation observé cette année ne saurait être appliqué pour des années antérieures, malgré le fait que l'effort de pêche est demeuré stable depuis quelques décennies. En effet, de l'avis même des pêcheurs, le rendement de la pêche est fortement influencé par les conditions de vent et de marée. La répétition de cette expérience devrait nous renseigner davantage à ce sujet.

DISCUSSION AND CONCLUSION

The present study provides, for the first time, an estimate of eel stocks in the lower estuary of the St. Lawrence and their exploitation rate. The assessment of almost half a million eels seems, in our opinion, to be quite low since, over the last two decades, the number of eels harvested probably came close to this estimate on a number of occasions.

This assessment is valid for the part of the river upstream from the recapture area. Eels are found in a large number of rivers downstream from this area, including North Shore, Gaspé and Anticosti Island rivers, and the contribution of these rivers has not been included in this assessment. Eels from these rivers are, at the present time, not being harvested and their contribution to the spawning population is likely quite significant. The date of migration on the Sud-Ouest and Rimouski rivers seems strongly influenced by environmental conditions. In both cases, a peak in catches, corresponding to a rapid rise in the water level, has been recorded. However, these catches do not necessarily correspond to the overall production of these rivers since eels could have migrated downstream before or after the catch period or avoided the trap.

This is the first eel harvest assessment. The exploitation rate of around 17% seems quite low. However, the stock involved is, in large part, from Lake Ontario and the freshwater estuary of the St. Lawrence and has been harvested at the yellow eel stage and, to a lesser extent, when migrating in the freshwater estuary. In addition, it seems that a significant number of eels from Lake Ontario could have died when going through the Moses Sanders and Beauharnois dams (Desrochers 1995).

The contribution of rivers located north and east of these fishing areas where no harvesting is done could be significant. The 356 silver eels caught in two small rivers (Rimouski and Sud-Ouest) only represent a minimal number of the eels produced by these rivers since the traps do not operate during the entire downstream migration. In addition, there are many indications that almost all the rivers, to the north and east of this area, have eel stocks. If we accept that this species is panmictic, these rivers could play an important role in partially replacing highly exploited stocks.

The exploitation rate noted this year cannot be applied to previous years, in spite of the fact that the fishing effort has remained stable over the past

decades. According to the fishers themselves, fishing yields are highly influenced by wind and tide conditions. Repeating this experiment should provide more information on this topic.

REMERCIEMENTS

Nous tenons à remercier toute l'équipe de terrain dont, Bruno Baillargeon, Conrad Groleau, Denise Deschamps, Denis Labonté, David Routhier et Louis Mathieu.

Des remerciements s'adressent également à MM Gérald Chaput, Martin Castonguay et Pierre Dumont qui ont accepté de commenter la première version de ce document.

RÉFÉRENCES

Caaron F. et N. Guérard. 1996. Rapport d'opération de la rivière Saint-Jean en 1995. Ministère de l'Environnement et de la Faune, Direction de la faune et des habitats, Service de la faune aquatique. 75 p.

Castonguay, M., J.D. Dutil, et C. Desjardins. 1989. Distinction between American eels (*Anguilla rostrata*) of different geographic origins on the basis of the organochlorine contaminant levels. Can. J. Fish. Aquat. Sci. 46: 836-843.

Couillard, C., P.V. Hodson, et M. Castonguay. 1997. Correlations between pathological changes and chemical contamination in American eels (*Anguilla rostrata*) from the St. Lawrence River. Can. J. Fish. Aquat. Sci. Sous presse.

Desjardins, C., J.D. Dutil, et R. Gélinas. 1983. Contamination de l'anguille (*Anguilla rostrata*) du bassin du fleuve Saint-Laurent par le mirex. Rapp. can. ind. sci. halieut. aquat. 141: v+52 p.

Desrochers, D., 1995. Suivi de la migration de l'anguille d'Amérique (*Anguilla rostrata*) au complexe Beauharnois, 1994 [par] MILIEU & Associés inc., [pour] le service Milieu naturel, vice-présidence Environnement, Hydro-Québec, 107 p.

Dutil, J.D., B. Légaré, et C. Desjardins. 1985. Discrimination d'un stock de poisson, l'anguille (*Anguilla rostrata*), basée sur la présence d'un produit chimique de synthèse, le mirex. Can. J. Fish. Aquat. Sci. 42: 455-458.

Larouche, M., G. Beaulieu, et J. Bergeron. 1974. Quelques données sur la croissance de l'anguille d'Amérique (*Anguilla rostrata*) de l'estuaire du Saint-Laurent. Ministère de l'Industrie et du Commerce, Direction générale des Pêches maritimes, Direction de la Recherche, Rapport annuel 1973: ;109-116.

Moussette, M. 1979. La pêche sur le Saint-Laurent. Répertoire des méthodes et des engins de capture. Boréal Express, 212 p.

Robitaille, J.A., et S. Tremblay. 1994. Problématique de l'Anguille d'Amérique (*Anguilla rostrata*) dans le réseau du Saint-Laurent. Ministère de l'Environnement et de la Faune, Direction de la faune et des habitats. Rapp. tech. ix + 70 p.

Scott, W.B., et E.J. Crossman. 1974. Poissons d'eau douce du Canada. Ministère de l'Environnement, Service des Pêches et des Sciences de la mer. Bulletin 184: 1026 p.

Verrault, G. (en préparation).

Vladykov, V.D. 1966. Remarks on the American eel (*Anguilla rostrata* Le Sueur). Sizes of elvers entering streams; the relative abundance of adult males and females; and present economic importance of eel in North America. Verh. Internat. Verein. Limnol., 16: 1007-1017.

Tableau 1. Nombre d'anguilles marquées et relâchées, 1996.

Date	A	B	C
09/05		8	
09/06		7	
09/09		23	
09/10		14	
09/11	4	15	
09/12	2	23	37
09/13	4	29	
09/16	8	13	123
09/17	9	31	
09/18	2	20	
09/19	2	28	
09/20		20	
09/23	4	26	
09/24	3	15	
09/25	2	21	
09/26	4	48	
09/27	3		
09/30	4		
10/01	2	26	
10/02		22	97
10/03	16		
10/04			97
10/07	7		
10/08	5	25	
10/09		2	
10/10		20	
10/11		22	75
10/15	21	25	
10/16		14	
10/17		5	
10/18		6	
10/22		2	
10/23		1	
10/24		5	
Total	**102**	**516**	**429**

Tableau 2. Temps de dévalaison approximatif pour chaque recapture.

Numéro du spécimen	Semaine de marquage		Endroit de capture	Date de recapture	Site de remise à l'eau	Nombre de jours écoulés		
	début	fin				Minimum	Maximum	Moyenne
1	09/05	09/13	Riv. Ouelle	10/27	B	44	52	48,0
2	09/05	09/13	Kamouraska	10/15	B	32	40	36,0
3	09/05	09/13	Riv. Ouelle	10/15	B	32	40	36,0
4	09/05	09/13	Kamouraska	10/12	B	29	37	33,0
5	09/05	09/13	Riv. Ouelle	10/11	B	28	36	32,0
6	09/05	09/13	Kamouraska	10/10	B	27	35	31,0
7	09/05	09/13	Riv. Ouelle	10/10	B	27	35	31,0
8	09/05	09/13	Riv. Ouelle	10/02	B	19	27	23,0
9	09/05	09/13	Kamouraska	10/02	B	19	27	23,0
10	09/05	09/13	Riv. Ouelle	10/10	B	14	17	15,5
11	09/11	09/13	Kamouraska	10/12	A	29	31	30,0
12	09/12		Kamouraska	10/03	C		21	
13	09/16		Riv. Ouelle	10/24	C		38	
14	09/16	09/20	Riv. Ouelle	10/24	B	34	38	36,0
15	09/16		St-Rock des Aulnaies	10/13	C		27	
16	09/16		Kamouraska	10/16	C		26	
17	09/16		Riv. Ouelle	10/12	C		26	
18	09/16		Riv. Ouelle	10/12	C		26	
19	09/16		Riv. Ouelle	10/11	C		25	
20	09/16	09/20	Riv. Ouelle	10/12	B	22	27	24,5
21	09/16		Kamouraska	10/08	C		22	
22	09/23	09/27	Kamouraska	10/31	A	34	38	36,0
23	09/23	09/26	Riv. Ouelle	10/10	B	27	35	31,0
24	09/23	09/26	Riv. Ouelle	10/24	B	28	31	29,5
25	09/23	09/26	Riv. Ouelle	10/16	B	20	23	21,5
26	09/23	09/27	Kamouraska	10/14	A	17	22	19,5
27	09/23	09/26	Kamouraska	10/13	B	17	20	18,5
28	09/23	09/26	Kamouraska	10/12	B	16	19	17,5
29	09/23	09/26	Riv. Ouelle	10/12	B	16	19	17,5
30	09/23	09/26	Riv. Ouelle	10/11	B	15	18	16,5
31	09/23	09/27	Riv. Ouelle	10/11	A	14	18	16,0
32	09/23	09/26	Kamouraska	10/10	B	14	17	15,5
33	09/23	09/27	Kamouraska	10/02	A	5	9	7,0
34	09/30	10/03	Kamouraska	10/15	A	12	15	13,5
35	09/30	10/03	Kamouraska	10/10	A	6	10	8,0
36	10/01		Kamouraska	10/08	B		7	
37	10/02		Riv. Ouelle	10/17	C		15	
38	10/02		Kamouraska	10/12	B		10	
39	10/02		Riv. Ouelle	10/10	B	5	9	7,0
40	10/04		Kamouraska	10/15	C		11	
41	10/04		Riv. Ouelle	10/14	C		10	
42	10/04		Kamouraska	10/13	C		9	
43	10/04		Kamouraska	10/12	C		8	
44	10/04		Kamouraska	10/12	C		8	
45	10/04		Riv. Ouelle	10/11	C		7	
46	10/04		Riv. Ouelle	10/10	C		6	
47	10/07	10/08	Kamouraska	10/17	A	9	10	9,5
48	10/08	10/11	Riv. Ouelle	10/31	B	20	23	21,5
49	10/08	10/11	Kamouraska	10/28	B	17	20	18,5
50	10/08	10/11	Kamouraska	10/20	B	9	12	10,5
51	10/11		Riv. Ouelle et Kam	10/17	C		6	
52	10/11		Kamouraska	10/17	C		6	
53	10/11		Kamouraska	10/16	C		5	
54	10/11		Kamouraska	10/16	C		5	
55	10/11		Riv. Ouelle et Kam	10/16	C		5	
56	10/11		Kamouraska	10/15	C		4	
57	10/11		Riv. Ouelle	10/14	C		3	
58	10/11		Riv. Ouelle et Kam	10/14	C		3	
59	10/15	10/18	Riv. Ouelle et Kam	11/04	B	17	20	18,5
60	10/15	10/18	Kamouraska	10/27	B	9	12	10,5
61	10/15		Riv. Ouelle	10/24	A	9	9	9,0
62	10/15	10/18	Riv. Ouelle	10/24	B	6	9	7,5
63	10/15		Kamouraska	10/22	A	7	7	7,0

Tableau 3. Temps de dévalaison estimé entre le moment du relâché et de la recapture et taux de recapture, pour chacun des sites de mise à l'eau, 1996.

	Nombre marqué				Nombre recapturé					Temps de recapture																								
										sem 1			sem 2			sem 3			sem 4			sem 5			sem 6			sem 7			Temps moyen (semaine)			
Date de marquage	A[2]	B[2]	C[2]	Total	A	B	C	Total	% recapture	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	Total
05 - 14 sept.	10	119	37	166	1	10	1	12	7,2								2	1		4		1	3						1		5,0	4,4	3,0	4,3
15 - 21 sept.	21	112	123	256	0	2	7	9	3,5									2		1	4		1	1								4,5	3,9	4,0
22 - 28 sept.	16	110		126	4	8	0	12	9,5	1			1	3		1	4			1		1									2,8	2,8	0,0	2,8
29 - 05 oct.	22	48	194 [1]	264	2	3	8	13	4,9	1	2	2	1	1	6																1,5	1,3	1,8	1,6
06 - 12 oct.	12	69	75	156	1	3	8	12	7,7	1		8		1			2														1,0	2,7	1,0	1,4
13 - 19 oct.	21	50		71	2	3	0	5	7,0	2	1			1			1														1,0	2,0		1,6
20 - 26 oct.		8		8	0	0	0	0	0,0																									
Total	**102**	**516**	**429**	**1 047**	**10**	**29**	**24**	**63**	6,0	**5**	**3**	**10**	**2**	**6**	**6**	**1**	**9**	**3**	**0**	**6**	**4**	**2**	**4**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**2,2**	**3,2**	**2,2**	**2,7**

[1] 97 anguilles ont été remises à l'eau le 2 octobre et 97 autres le 4 octobre.

[2] A = Pêche de l'Aquarium du Québec, rive droite

B = Québec, rive gauche

C = Rive droite de Québec, en provenance des rivières Rimouski et du Sud-Ouest

Tableau 4. Évaluation préliminaire du nombre d'anguilles en dévalaison, en 1996.

Formule de Petersen utilisée $$\mathbf{N = \frac{(M+1)\,(C+1)}{(R+1)}}$$

où N: effectifs estimés
M: nombre de poissons marqués
C: taille de l'échantillon prélevé
(nombre de poissons prélevés dans la zone de recapture)
R: nombre de recapturés dans l'échantillon

Poissons marqués:	Point A	102
	Point B	516
	Point C	429
	M:	**1 047**
Poissons échantillonnés	Usine	28 714
	Pêcheurs	1 129
	C:	**29 843**
Nombre de recapture	Usine	62
	Pêcheur	1
	R:	**63**

Marqués	Capturés	Recapturés
M	**C**	**R**
1 047	29 843	63

Evaluation:

N min	**N**	N max	R min	R max
383 291	**488 696**	622 542	49	81

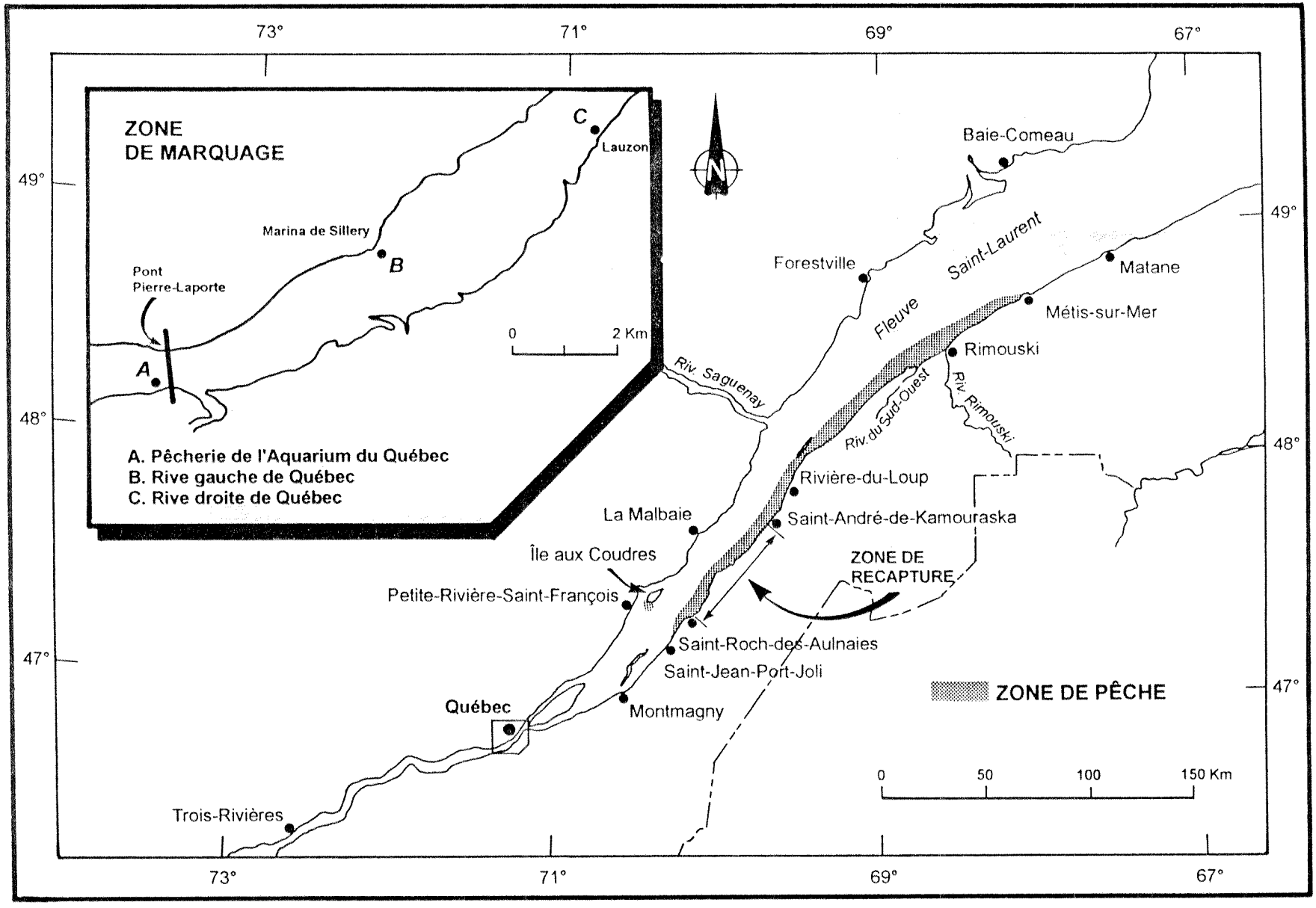


Figure 1. Localisation du secteur d'étude.

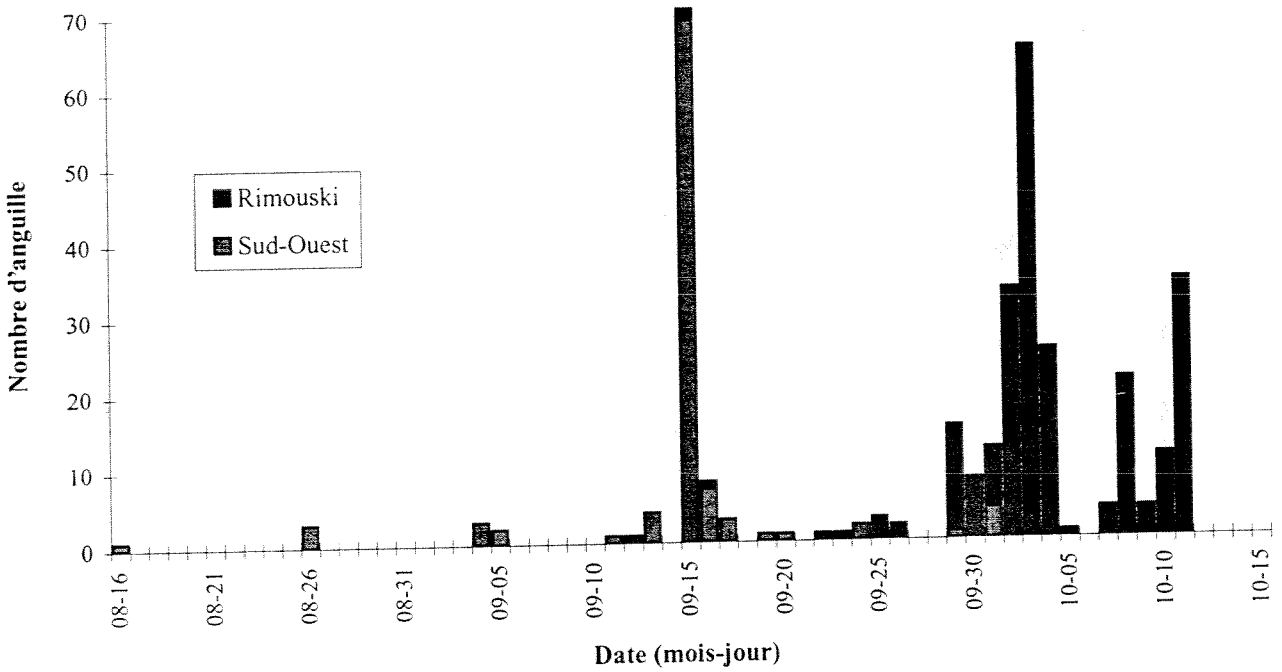


Figure 2. Capture d'anguilles, rivière Rimouski et du Sud-Ouest, 1996.

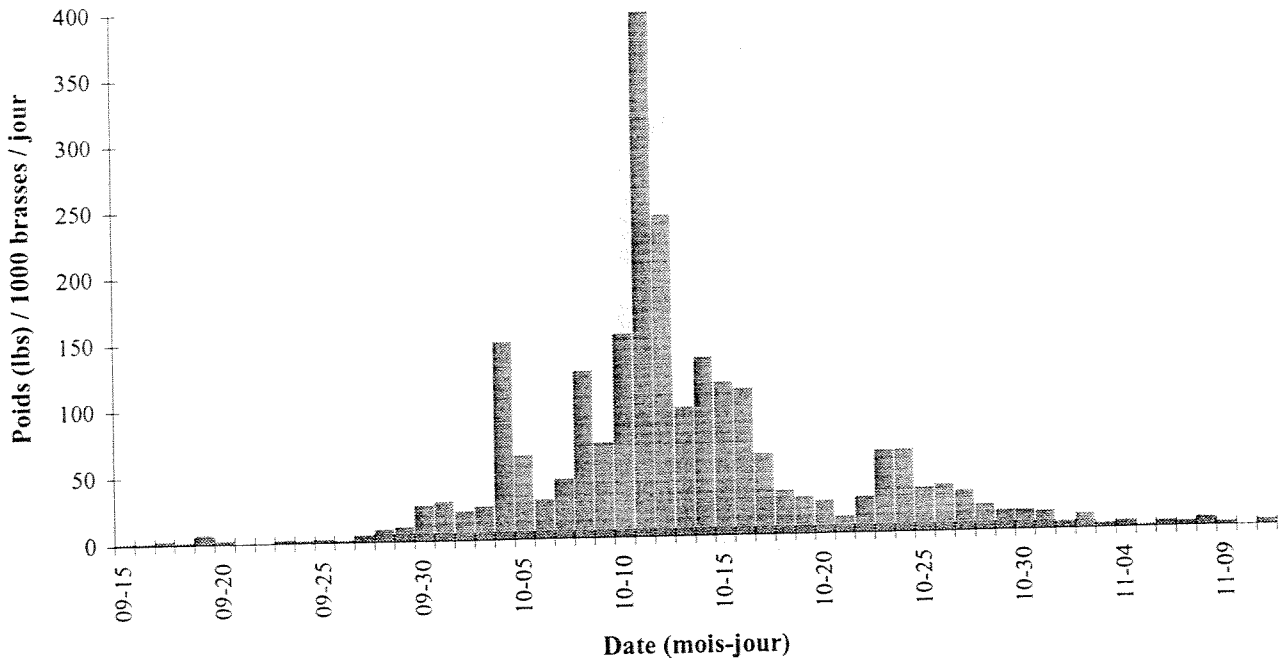


Figure 3. Captures journalières d'anguilles, par les pêcheurs repères, 1996.

Status of the Upper St. Lawrence River and Lake Ontario American Eel Stock -- 1996

by

J. M. Casselman and L. A. Marcogliese
Ontario Ministry of Natural Resources
Science Development and Transfer Branch
Aquatic Ecosystems Science Section
Glenora Fisheries Station
R.R. 4, Picton, Ontario K0K 2T0

T. Stewart
Ontario Ministry of Natural Resources
Lake Ontario Fisheries Management Unit
Glenora Fisheries Station
R. R. 4, Picton, Ontario K0K 2T0

P. V. Hodson
School of Environmental Studies
Department of Biology
Queen's University
Kingston, Ontario K7L 3N6

ABSTRACT

Commercial catch of American eels (*Anguilla rostrata*) from the upper St. Lawrence River-Lake Ontario stock has varied widely over the 113 yr of recorded data. From 1993-96, there is an unprecedented 4-yr progressive decrease in catch. Also, since 1993, price has increased by 153% while harvest has decreased by 51%. Community index trawling in the Bay of Quinte indicated that in the 1990s, eel densities are less than half levels in the 1970s. Commercial electrofishing in eastern Lake Ontario indicated that a 10-fold decline commenced in 1991 and 1992; abundance has been significantly less since 1993 than in the 1980s. Correlation analyses indicate that 34.3% of the variance in trawl catches in the Bay of Quinte, 70.4% of the variance in the commercial electrofishing catches and 41.5% of the variance in the overall commercial catches, were explained by the numbers of eels ascending the ladder during the peak migration period 4 yr, 5 yr, and 8 yr earlier, respectively. Very low levels of immigration in the 1990s indicate that abundance and harvest will probably continue to decrease for at least 4-8 more years. Eel ladder passage and commercial electrofishing have the lowest coefficient of variation (38.4 and 48.6%, respectively) and are the most reliable indices of recruitment and abundance. Exploitation and mortality rates need to be measured, and escapement must increase if the next generation is to sustain a commercial fishery. Overall total annual mortality rate must be reduced to the 20% level if this stock is to maintain its reproductive contribution to this panmictic species. The age-migration chronology should be described precisely if the cause of this dramatic decline is to be understood and stemmed.

RÉSUMÉ

Les captures commerciales d'anguilles américaines (*Anguilla rostrata*) du haut Saint-Laurent et du lac Ontario ont connu de grandes fluctuations au cours des 113 années de collecte de données. Entre 1993 et 1996, on a constaté une diminution progressive sans précédent des captures pendant quatre ans. De plus, depuis 1993, le

prix a augmenté de 153 %, tandis que les prises ont diminué de 51 %. Le chalutage repère communautaire dans la baie de Quinte a indiqué qu'au cours des années 1990, la densité des anguilles est inférieure à la moitié des niveaux des années 1970. La pêche commerciale à l'électricité dans l'est du lac Ontario révèle une abondance dix fois moins grande dont la tendance aurait commencé en 1991 et 1992; l'abondance est beaucoup plus faible depuis 1993 qu'au cours des années 1980. Selon les analyses de corrélation, 34,3 % de la variance des captures au chalut dans la baie de Quinte, 70,4 % de la variance des captures de la pêche commerciale à l'électricité et 41,5 % de la variance des captures globales de la pêche commerciale s'expliquent par le nombre d'anguilles qui ont escaladé la passe migratoire en période de pointe de la migration, quatre ans, cinq ans et huit ans auparavant, respectivement. Les très faibles niveaux d'immigration au cours des années 1990 semblent indiquer que l'abondance et l'exploitation continueront probablement de diminuer pendant au moins quatre à huit autres années. Le passage des anguilles dans les passes migratoires et la pêche commerciale à l'électricité affichent les plus faibles coefficients de variation (38,4 et 48,6 %, respectivement) et sont les indices les plus fiables du recrutement et de l'abondance. Il faut mesurer les taux d'exploitation et de mortalité et accroître les échappées si l'on veut que la prochaine génération puisse soutenir une pêche commerciale. Le taux de mortalité annuel total global doit être abaissé à 20 % pour que le stock maintienne sa contribution par la reproduction à cette espèce panmictique. Il faut pouvoir décrire la chronologie âge-migration avec précision si l'on veut pouvoir comprendre et expliquer la cause de cette baisse radicale.

INTRODUCTION

The number of eels ascending the ladder at the R. H. Saunders Hydroelectric Generating Station at Cornwall, Ontario (Whitfield and Kolenosky 1978; Eckersley 1982), has dramatically declined in recent years (Castonguay 1994a). When a newly developed peak passage index is considered (Casselman et al. 1997; Marcogliese et al. 1997), it is now apparent that a significant reduction in juvenile recruitment to the upper St. Lawrence River-Lake Ontario stock first occurred in 1986 and, with the possible exception of 1994, there have been record-low numbers; the lowest was in 1993. From the 1980s to the 1990s, the reduction has extended over two orders of magnitude (Casselman et al. 1997).

This stock is considered to be a major component of the species, assuming that its contribution is reflected by the relative freshwater discharge of the Great Lakes Basin (Castonguay 1994a, 1994b), and the large majority are females. Now that a new, more consistent and comparable index has been prepared from daily passage estimates during the 31-d peak immigration period, we decided to examine other indices to assess long-term changes in abundance associated with this stock. We consider this component of the eel population to be a "stock" because it is a discrete management unit that has ecological integrity.

There is concern that the ladder may account for the majority of the juvenile eels immigrating into the subadult habitat of the extreme upper St. Lawrence River and Lake Ontario habitat. If this is the case, then this recent precipitous decrease in abundance has far-reaching implications and is cause for major concern. Other long-term data on relative abundance exist for this moderately well assessed stock of American eels. These data sets have the length and sampling intensity to make it possible to correlate cause and effect associated with these extreme changes in abundance.

For 6-14 yr, eels inhabit the upper St. Lawrence River and Lake Ontario, where they grow and mature as "yellow" and "silvering" subadults before they migrate back to the sea and spawn. These subadults provide a valuable fisheries resource, which has been used for many centuries and well before European colonization. This is documented from the fish middens associated with ancient Iroquoian fishing villages along the upper St. Lawrence River (e.g., in the Morrisburg area, Junker-Andersen 1984, where evidence exists that eels were trapped, speared, dried, and exported for sustenance and trade). Commercial use of this species continues to the present. Indeed, in 1995, in the upper St. Lawrence River and Lake Ontario, it was the third most valuable species, accounting for a total of 13.5% of the overall commercial value, and fourth in biomass, or 7.4% of the total. Since the commercial eel fishery is a longstanding and historically important component of not only the upper St. Lawrence River and Lake Ontario but also the lower St. Lawrence, and since the lower St. Lawrence commercial fishery is mainly for silver emigrants, the abundance and well-being of the upper St. Lawrence River-Lake Ontario stock has major overall commercial ramifications. Indeed, because the species is panmictic (Williams and Koehn 1984; Avise et al. 1986, 1990) and this stock is considered to be a major component of the species (Castonguay et al. 1994b), the status of this stock may reflect the overall well-being of the entire population.

Since juvenile recruitment of this stock is decreasing, it is especially important to assemble and review the status of the best and longest available indices. The upper St. Lawrence River-Lake Ontario eel stock has been monitored for many years by research, assessment, and management units of the Ontario Ministry of Natural Resources (OMNR). The majority of these data are associated with Lake Ontario and are archived at the ONMR Glenora Fisheries Station.

For the upper St. Lawrence River-Lake Ontario eel stock, we will (1) compile and present all of the long-term data associated with three valuable quantitative indices: (i) commercial harvest and value (113 years), (ii) community-index trawling (25 yr) in the Bay of Quinte, and (iii) commercial electrofishing (13 yr) in the outlet basin of Lake Ontario; (2) examine these data series for trends that may be correlated with the eel ladder index of juvenile recruitment; and (3) provide a review of present status, predict future trends in commercial harvest and make recommendations.

MATERIALS AND METHODS

Of the three indices that will be presented here, the overall commercial harvest is the longest but least quantitative, mainly because there is no means of reporting or quantifying effort.

COMMERCIAL HARVEST AND VALUE

In Lake Ontario, the commercial fishery is localized in Canadian waters mainly at the east end of the lake. A commercial U.S. fishery existed up to 1982; however, it was relatively small (Baldwin et al. 1979, Lary and Busch 1997). At that time, the United States permanently closed the fishery because of mirex contamination (Castonguay et al. 1994a). The majority of the commercial harvest of this stock is associated with the Bay of Quinte, eastern Lake Ontario, and the upper St. Lawrence River (Fig. 1).

Records of the commercial harvest of eels from Canadian waters of the upper St. Lawrence River and Lake Ontario date back to 1884 (Department of Fisheries and Oceans [DFO] 1955, Baldwin et al. 1979). Total value of the commercial eel harvest was first recorded between 1945 and 1953 (DFO 1955). In 1956, Lake Ontario and the upper St. Lawrence River were divided into statistical districts, and the commercial harvest and value of the eels were reported by district until 1983 (OMNR 1972a, 1972b; Ridgley 1975, 1976; Montgomery 1982, 1984; Muldoon 1983; commercial harvest records, OMNR, Napanee, Ontario, unpubl. data). Beginning in 1984, OMNR eliminated the statistical districts and replaced them with quota zones that are still used today, although the boundaries have been altered somewhat throughout the years. Each year, OMNR reports quota allocation and harvest (pounds) by quota zone, and the average total value of the eel fishery (Montgomery 1985, 1987, 1989, 1991; LOFU 1988, 1990; Hart 1991; Mabee 1992; Kerr 1993; Bendig 1994; Hoyle et al. 1994, 1995; Hoyle and Harvey 1996; commercial harvest records, OMNR, Napanee, Ontario, unpubl. data).

We examined the total harvest and value ($Cdn.) and their relationship, along with trends over time to determine long-term changes and status of the stock as reflected by the commercial eel fishery.

COMMUNITY INDEX TRAWLING OF THE FISH COMMUNITY OF THE BAY OF QUINTE

In 1962, the fisheries research section of the OMNR at the Glenora Fisheries Station began community index trawling in eastern Lake Ontario and the Bay of Quinte (Casselman and Scott 1992) (Fig. 1). The trawling was designed to provide an index of the fish community; eels were not specifically targeted but were caught with sufficient consistency in the Bay of Quinte to provide a statistically valuable index. Routine community indexing in the Bay of Quinte began in 1972; a ¾ "western" bottom trawl (polyfilament twine) with a 0.5 in. (1.27 mm) cod-end mesh size was hauled for ¼ nautical mile (463.3 m).

Catches of eels followed a poisson distribution; therefore, catch data were log-transformed and geometric mean annual catches per unit effort were calculated, along with 95% confidence limits and coefficients of variation. Except for 1989, when the vessels were retrofitted, data exist for each year of the 25-yr period from 1972-96. Annual means were tested statistically (ANOVA) and compared (multiple range tests).

COMMERCIAL ELECTROFISHING, OUTLET BASIN, LAKE ONTARIO

In 1984, OMNR issued an experimental licence that permitted the development and use of an electrofishing boat to commercially harvest eels in the outlet basin of eastern Lake Ontario and the upper St. Lawrence River. Between 1984 and 1996, very precise records of midsummer inshore harvest and electrofishing effort were recorded, providing a quantitative commercial electrofishing index for eels (Casselman and Rorabeck, Fisheries Research Section, OMNR, Glenora Fisheries Station, Picton, Ontario, unpubl. data). Annual catch per unit effort is presented as the mean catch·h^{-1} of daytime electrofishing, along with 95% confidence limits and the coefficient of variation. Among-year means were tested statistically (ANOVA), and homogeneous groups were identified (multiple-range test).

COMPARATIVE ANALYSES

The index of peak passage up the eel ladder (Casselman et al. 1997) was compared with the three above-mentioned long-term measures of abundance to determine whether it predicted subsequent abundance and harvest of this stock in the upper St. Lawrence River and Lake Ontario. We examined this by means of various annual time-lapse correlation analyses (unweighted least squares linear regression). Each data set was regressed separately on the eel ladder peak midsummer passage index (predictor). The most significant correlations were flagged and are presented and discussed. Statistical tests were performed with Statistix (Anonymous 1996).

RESULTS

COMMERCIAL HARVEST

Between 1884 and 1996 (113 yr) reported commercial harvest of eels in Lake Ontario and the upper St. Lawrence River varied widely (Fig. 2). Fluctuations in harvest, however, are difficult to assess because there is no relative measure of fishing effort. Beginning in 1909, commercial harvest increased substantially, and in 1910 exceeded 100,000 lb for the first time. Harvest continued to increase over the next 4 yr, reaching a peak in 1914 (299,900 lb) before sharp reductions occurred; total harvest in 1914 was the second highest ever reported. Subsequently, harvest declined until the early 1940s, reaching a low in 1942 (15,700 lb), which was the lowest catch of eels this century. Harvest remained low for many years but gradually increased. By 1958, commercial harvest surpassed 100,000 lb for the first time since 1927 (Fig. 2).

A second peak in commercial catch started in the early 1960s (1963--149,700 lb), reached a maximum in 1964 (245,700 lb) and declined in the late 1960s (1967--115,667 lb) (Fig. 2). Although not as large as the first peak, the second peak period was followed by a trend of increasing rather than decreasing harvest. Between 1970 and 1972, a partial closure of the eel fishery due to mercury contamination (Baldwin et al. 1979) did not seem to affect harvest significantly, as an increasing trend continued, leading to the third peak of the century.

Peak harvest in the 1970s and 1980s started in 1974 (221,915 lb); this harvest was by far the greatest this century (Fig. 2). This substantial increase continued until 1978 and 1979 (508,225 and 492,282 lb, respectively). Afterwards, harvest declined dramatically, reaching a low in 1982 (64,486 lb) when the European eel market was closed because of mirex contamination (Muldoon 1983). In 1984, quota-zone management and harvest allocations were implemented, and for the next 10 yr, eel harvest was stable and well above 200,000 lb. Harvest decreased in 1993 and subsequently showed a marked and progressive decline that continues to the present (1996). This is the only 4 yr of consecutive decline during the 113 yr that records have been kept, and harvest was not affected by contaminants.

Price ($Cdn) was significantly correlated with the total commercial harvest of eels in the upper St. Lawrence River and Lake Ontario over the years (Fig. 3). However, between 1945 and 1984, two different direct relationships have occurred. From 1945 to 1978, there was a strong relationship between increased harvest and value ($P > 0.001$, $r^2 = 0.846$). However, from 1979 to 1984, the relationship indicates an increase in value but a downward trend over time ($P > 0.002$, $r^2 = 0.937$), which was related to mirex contamination and the closure of the European eel markets. Between 1993 and 1996, a considerably different inverse trend has emerged. Prices increased by 153%, and harvest decreased by 51%; this indicates a marked decline in harvestable eels, with increasing demand (value) and decreasing supply.

COMMUNITY INDEX TRAWLING

Eels are an important species in the fish community of the Bay of Quinte. Replicate sampling effort was available, so variance could be measured, and was high with this sampling technique (mean CV = 133.1%). Nevertheless, the index provided a measure of the relative abundance of eels. Between 1972 and 1996, the geometric mean trawl haul catch of eels was 0.30 ± 0.07 (95% C.I.; $N = 24$) (Fig. 4). During this period, the catch of eels varied significantly ($P < 0.0001$) (critical T = 1.96). Overall, however, the mean catch of eels in the Bay of Quinte showed a downward trend. Between 1987 and 1996, eel catches were very low except for a slight increase in 1994. In the 1970s, >2 eels were caught per nautical mile of trawling, while most catches in the 1990s were < 1 per nautical mile.

COMMERCIAL ELECTROFISHING INDEX

Detailed catch records allowed quantitative analysis of the commercial electrofishing catch in Lake Ontario and the upper St. Lawrence River. From 1984-96, commercial electrofishing was conducted for 208 d; over the years, the mean catch of eels·h^{-1} of electrofishing (CUE) was 55.2 ± 14.4. Mean CV was low (48.6%). Over this 13-yr period, however, CUE declined significantly ($P < 0.0001$) (Fig. 5). From 1984-90, commercial electrofishing CUE ranged from 63.1-93.0 (mean CUE = 77.9 ± 19.6). The greatest catch occurred in 1989 (93.0 ± 32.2). A multiple range test indicated that dramatic declines in CUE commenced in 1991 (38.5 ± 7.0) and 1992 (44.4 ± 9.7). By 1993 (22.7 ± 3.5), CUE was significantly lower than all catches in the 1980s (critical T = 3.47). Declines in CUE continued in the 1990s, reaching a low in 1995 (10.5 ± 4.9).

CORRELATION ANALYSES

The eel ladder recruitment index (Casselman et al. 1997; Marcogliese et al. 1997) showed highly significant correlations with the other indices reported here. The best correlation with the overall commercial harvest involved an 8-yr time lapse (P = 0.009). With this time lapse, the commercial harvest from 1982-96 was best correlated with eel ladder passage from 1974-88. Indeed, 41.5% of the variance in the commercial catch could be explained by the number of eels that ascended the ladder 8 yr earlier. The best correlation between immigration up the eel ladder and trawl catches in the Bay of Quinte involved a shorter time lapse, only 4 yr (P = 0.011). This explained less of the variance (34.3%), probably because of the variability associated with eel catches in the community index trawling program.

Commercial electrofishing showed the best correlation, with a time lapse of 5 yr (P = 0.0003). Indeed, 70.4% of the variance in the commercial electrofishing catch of eels was explained by the number of eels that ascended the ladder 5 yr earlier. Hence, the recruitment index provided by the eel ladder predicted the subsequent commercial catch and abundance of eels in the Bay of Quinte and eastern Lake Ontario. The correlation between the commercial electrofishing catch of eels and eel passage up the ladder was remarkably high because these two indices had the lowest variability.

The decline in commercial harvest in recent years is unrelated to changes in harvest regulations. Although quota allocations were established in 1984, they were set when, unbeknownst to anyone, the harvest was at record-high levels. Although quotas have been adjusted downward annually, they have not curtailed harvest. In 1985-88, OMNR bought out commercial licences (Stewart et al. 1997). Harvest remained relatively constant afterwards, but would no doubt have been higher had it not been for the buy-out program. Since implementation of the allocation system, total harvest has ranged from only 25-47% of total allocation. The total harvest of eels, therefore, has not been significantly restricted by allocation (Marcogliese et al. 1997).

Juvenile recruitment decreased, and there has been a significant and associated decrease in the commercial harvest and abundance of eels in the Lake Ontario and upper St. Lawrence River stock in the 1990s.

DISCUSSION

Although eel harvest and abundance have varied over the years, it is now apparent that in the 1990s, this stock is at record-low levels. Long-term monitoring (13-113 yr) has been important in quantifying and documenting these reductions. All indices presented here show a dramatic decline in the stock. A significant decline was first observed in 1986 in juveniles at the eel ladder at the R. H. Saunders hydroelectric dam at Cornwall, Ontario. Declines in abundance were next seen in the late 1980s in the subadult catch in trawls in the Bay of Quinte, followed by commercial electrofishing decreases in 1991-93 and overall commercial harvest declines in 1993 and 1994. The true significance of these changes and trends would not have been apparent without these long-term data.

The eel ladder at Cornwall provides the longest and most complete index of juvenile recruitment for the species. Standardization of this index to the peak period of migration has added increased precision (Casselman et al. 1997; Marcogliese et al. 1997). The commercial electrofishing data provide the strongest corraboratory evidence that not only has recruitment decreased but that the numbers of subadult and maturing eels in the upper St. Lawrence River and Lake Ontario started to decline significantly in 1993. Of all indices, the electrofishing index showed the strongest correlation with eel passage up the ladder; this was expected because these two series had the lowest coefficient of variation (ladder = 38.4, electrofishing = 48.6).

A time lapse between the commercial electrofishing catch and eel ladder passage was reasonable, given preliminary age interpretation data. Recent age interpretations of otoliths from a subsample of commercially electrofished eels gave a mean age of 17.8 ± 0.9 yr, while in 1993, a subsample of juvenile eels ascending the ladder had a mean age of 11.9 ± 1.1 yr (B. Mounaix and J. M. Casselman, Fisheries Research Section, OMNR, Glenora Fisheries Station, Picton, Ontario, unpubl. data). This is a difference of approximately 5.9 yr, which is similar to the 5-yr difference indicated by correlation analysis. Recent age interpretations are not available for the overall commercial catch, but the correlation analysis would suggest that, on average, older eels are caught in the commercial harvest and that their ages would range from 18-22 yr.

To determine the causes of the decline of the abundance of eels in this stock, a better understanding of their life cycle is needed, especially age and migration chronology. In the 1960s, the age of emigrant "silver" eels caught in the upper St. Lawrence River was 19.7 ± 1.1 yr (Casselman, unpubl. data). This is older than has been previously considered to be the case (Hurley 1972 and 1973; Castonguay et al. 1994b). This may in part be related to difficulties in otolith age determination of this species. Nevertheless, it appears that eels of this stock mature late, possibly taking an average of 21 yr (Casselman and Marcogliese, unpubl. data). It is essential that the long-term total annual mortality rate be low, < 20% (Casselman et al. 1996), if adequate numbers of eels are to survive to maturity and reproduce and contribute to the population in proportion to its relative abundance and sex ratio.

The reasons for the recent decline are unknown. However, these quantitative indices are now available to examine cause and effect more precisely. This stock suffers from being a common resource migrating great distances, through several jurisdictions, and spawning at sea and is at the added disadvantage that it is panmictic. Age is difficult to decipher, it has a long life cycle, and its migration chronology is poorly understood.

It is now apparent that commercial catch of this stock will continue to decline, with the possible exception of the late 1990s (1999) for commercial electrofishing and shortly after the turn of the century (2004) for overall commercial harvest related to increased immigration in 1994. If escapement of maturing females does not increase in this or other stocks, in another generation this stock will not produce the present level of commercial harvest. Indeed, it is important that there be good emigration of the juvenile cohort that ascended the eel ladder in 1994.

The eel ladder and commercial electrofishing provide the two best indices, and these should be maintained if changes in recruitment and abundance of this stock are to be assessed.

Otoliths should be collected from eels at all stages of encounter and harvest so that an accurate and complete age-migration chronology can be constructed. Commercial exploitation of all life stages should be assessed as has been done for the lower St. Lawrence River silver eel fishery (Caron and Verreault 1997), and hydroelectric turbine mortality should be quantified while stock abundance is high enough to provide meaningful results. It is essential that mortality be quantified and partitioned if we are to understand the substantial reduction that occurred in this stock from the mid-1980s and to the 1990s.

ACKNOWLEDGMENTS

We greatly appreciate the help that many people of the Ontario Ministry of Natural Resources gave over the years in collecting and maintaining these data sets. We are especially indebted to Mike Eckersley for his interest in and commitment to this species and the immense amount of information that he has thoroughly and carefully maintained over the years and very generously made available to us. Special thanks to John Rorabeck, who voluntarily collected data and provided enlightened field notes on the commercial electrofishing operation he has conducted over the years, and for his insights and collaboration with JMC. We appreciate the funds provided by Environment Canada to PVH and JMC as part of the Ecological Monitoring and Assessment Network (EMAN), which enabled LAM to assemble and prepare much of the data reported here. We appreciate the constructive reviews of Yves Mailhot and Guy Verreault. This is contribution number 97-04 of the Aquatic Ecosystems Science Section, Science Development and Transfer Branch, Ontario Ministry of Natural Resources.

REFERENCES

Anonymous. 1996. Statistix. User's Manual, version 1.0 for Windows, Analytical Softrware, Minnesota.

Avise, J. C., G. S. Helfman, N. C. Saunders, and L. S. Hales. 1986. Mitochondrial DNA differentiation in North Atlantic eels: population genetics consequences of an unusual life history pattern. Proc. Nat. Acad. Sci., USA 83: 4350-4354.

Avise, J. C., W. S. Nelson, J. Arnold, R. K. Koehn, G. C. Williams, and V. Thorsteinsson. 1990. The evolutionary genetic status of Icelandic eels. Evolution 44: 1254-1262.

Baldwin, N. S., R. W. Saalfeld, M. A. Ross, and H. J. Buettner. 1979. Commercial fish production in the Great Lakes 1967-1977, p. 20. *In* Gt Lakes Fish. Comm. Tech. Rep. 3. Ann Arbor, Michigan.

Bendig, A. 1994. 1993 commercial food fish industry on the St. Lawrence River, p. 1-1 - 1-6. *In* 1994 Annual Report, St. Lawrence River Subcommittee to the Lake Ontario Committee and the Great Lakes Fishery Commission. Ont. Minist. Natur. Resour. and N.Y. State Dept. Environm. Conserv.

Caron, F., and G. Verreault. 1997. Estimation du stock d'anguille d'Amérique (*Anguilla rostrata*) argentée en dévalaison dans le bas Saint-Laurent et son taux d'exploitation en 1996. This proceedings.

Casselman, J. M., and K. A. Scott. 1992. Research project: Fish community dynamics of the outlet basin of Lake Ontario. Ont. Minist. Natur. Resour., Lake Ontario Fisheries Unit, 1991 Ann. Rep., Sect. 18-1 - 18-8.

Casselman, J. M., E. J. Crossman, and C. J. Robinson. 1996. Sustainability of trophy muskellunge fisheries, p. 29-39. *In* Kerr, S. J., and C. H. Olver [eds.]. Managing Muskies in the '90s. Workshop Proceedings. Ont. Minist. Natur. Resour., Southern Region Science and Technology Transfer Unit Workshop Proceedings WP-007. 169 p.

Casselman, J. M., L. A. Marcogliese, and P. V. Hodson. 1997. Recruitment index for the upper St. Lawrence River and Lake Ontario eel stock: a re-examination of eel passage at the R. H. Saunders Hydroelectric Generating Station at Cornwall, Ontario, 1974-1995, p. 160-168. In The American eel in eastern Canada: stock status and management strategies. Proceedings of Eel Management Workshop, January 13-14, 1997, Quebec City, PQ. Can. Tech. Rep. Fish. Aquat. Sci. 2196.

Castonguay, M., P. V. Hodson, C. M. Couillard, M. J. Eckersley, J.-D. Dutil, and G. Verrault. 1994a. Why is recruitment of the American eel, *Anguilla rostrata*, declining in the St. Lawrence River and Gulf? Can. J. Fish. Aquat. Sci. 51: 479-488.

Castonguay, M., P. V. Hodson, C. Moriarty, K. F. Drinkwater, and B. M. Jessop. 1994b. Is there a role of ocean environment in American and European eel decline? Fish. Oceanogr. 3(3): 197-203.

Department of Fisheries and Oceans. 1955. The Canadian commercial fisheries of the Great Lakes. Basebook on fishery statistics No. 2, section B p. 10, Section C p. 2, Markets and Economics Service, Department of Fisheries and Oceans, Ottawa, Ontario.

Eckersley, M. 1982. Operation of the eel ladder at the Moses-Saunders Dam, Cornwall 1974-1979, p. 4-7. *In* K. H. Loftus [ed.] Proceedinigs of the 1980 North American Eel Conference. Ont. Fish. Tech. Rep. Ser. No. 4.

Hart, M. L. 1991. 1990 commercial food fish industry on the St. Lawrence River, p. 1-1 - 1-3. *In* S. J. Kerr and A. Schiavone [ed.] 1991 Annual Report, St. Lawrence River Subcommittee to the Lake Ontario Committee and the Great Lakes Fishery Commission. Ont. Minist. Natur. Resour. N.Y. State Dept. Environm. Conserv.

Hoyle, J., P. Smith, and S. Orsatti. 1994. Commercial fishery, p. 4.1-4.8. *In* Lake Ontario Management Unit, 1993 Ann. Rep., Ont. Minist. Natur. Resour.

Hoyle, J., P. Smith, and S. Orsatti. 1995. Commercial fishery, p. 4.1-4.8. *In* Lake Ontario Management Unit, 1994 Ann. Rep., Ont. Minist. Natur. Resour.

Hoyle, J. A., and R. Harvey. 1996. Commercial fisheries, p. 4.1-4.3. Lake Ontario Management Unit 1995 Ann. Rep.

Hurley, D. A. 1972. The American eel (*Anguilla rostrata*) in eastern Lake Ontario. J. Fish. Res. Board Can. 29: 535-543.

Hurley, D. A. 1973. The commercial fishery for American eel, *Anguilla rostrata*, (LeSueur), in Lake Ontario. Trans. Am. Fish. Soc. 102(2): 369-377.

Junker-Andersen, C. 1984. Estimation of American eel (*Anguilla rostrata*) live length and weight from certain skeletal elements: A preliminary report. Unpublished report, University of Toronto, Dept. Anthropol., 49 pages.

Kerr, J. 1993. Commercial fish harvest in Lake Ontario in 1992. Appendix 4, p. 1-11. *In* Lake Ontario Management Unit, 1992

Annual Report to the Great Lakes Fishery Commission's Lake Ontario Committee. Ont. Minist. Natur. Resour., Picton, Ontario.

Kolenosky, D . P., and M. J. Hendry. 1982. The Canadian Lake Ontario fishery for American eel (*Anguilla rostrata*), p. 7-16. In K. H. Loftus [ed.] Proceedings of the 1980 North American Eel conference. Ont. Fish. Tech. Rep. Ser. No. 4.

Lary, S. J., and W.-D. N Busch. 1997. American eel (*Anguilla rostrata*) in Lake Ontario and its tributaries: Distribution, abundance, essential habitat and restoration requirement. U.S. Fish Wildl. Serv. Admin. Rep. 97-01, 27 p.

LOFU. 1988. Summary of the 1987 commercial fish harvest in eastern Lake Ontario, p. 13-1. *In* Lake Ontario Fisheries Unit, 1987 Annual Report to the Great Lakes Fishery Commission's Lake Ontario Committee. Ont. Minist. Natur. Resour., Picton, Ontario.

LOFU. 1990. Commercial landings in Napanee District, p. 1-5. *In* Lake Ontario Fisheries Unit, 1989 Annual Report to the Great Lakes Fishery Commission's Lake Ontario Committee. Ont. Minist. Natur. Resour., Picton, Ontario.

Mabee, P. 1992. Commercial fish landings in Lake Ontario, Napanee District, p. 1-13. *In* Lake Ontario Management Unit, 1991 Annual Report to the Great Lakes Fishery Commission's Lake Ontario Committee. Ont. Minist. Natur. Resour., Picton, Ontario.

Marcogliese, L. A., J. M. Casselman, and P. V. Hodson. 1997. Dramatic declines in the American eel (*Anguilla rostrata*) stock of Lake Ontario--quantifying long-term trends. Unpublished manuscript.

Montgomery, D. 1982. Ontario Ministry of Natural Resources 1982 Lake Ontario Committee report summary of the 1981 commercial fish harvest in Ontario waters of Lake Ontario. Appendix XXIII, p. 259-261. *In* 1981 Ann. Rep., Gt. Lakes Fish. Comm.

Montgomery, D. 1984. Ontario Ministry of Natural Resources 1984 Lake Ontario Committee report summary of the 1983 commercial fish harvest in Ontario waters of Lake Ontario. Appendix XI, p. 375-376. *In* 1983 Annual Report to the Great Lakes Fishery Commission's Lake Ontario Committee. Ont. Minist. Natur. Resour., Picton, Ontario.

Montgomery, D. 1985. Summary of the 1986 commercial fish harvest in eastern Lake Ontario, p. 57-61. *In* 1984 Annual Report to the Great Lakes Fishery Commission's Lake Ontario Committee. Ont. Minist. Natur. Resour., Picton, Ontario.

Montgomery, D. 1987. Summary of the 1986 commercial fish harvest in eastern Lake Ontario, p. 10-1 - 10-2. *In* 1986 Annual Report to the Great Lakes Fishery Commission's Lake Ontario Committee. Ont. Minist.f Natur. Resour., Picton, Ontario.

Montgomery, D. 1989. Commercial landings in Napanee District, p. 1-9. *In* Lake Ontario Management Unit, 1988 Annual Report to the Great Lakes Fishery Commission's Lake Ontario Committee. Ont. Minist. Natur. Resour., Picton, Ontario.

Montgomery, D. 1991. Commercial landings in Napanee District, Appendix 5, p. 1-12. *In* Lake Ontario Management Unit, 1990 Annual Report to the Great Lakes Fishery Commission's Lake Ontario Committee. Ont. Minist. Natur. Resour., Picton, Ontario.

Montgomery, D. 1991. Commercial landings in Napanee District, Appendix 5, p. 1-12. *In* Lake Ontario Management Unit, 1990 Annual Report to the Great Lakes Fishery Commission's Lake Ontario Committee. Ont. Minist. Natur. Resour., Picton, Ontario.

Muldoon, J. 1983. Ontario Ministry of Natural Resources 1983 Lake Ontario Committee report summary of the 1982 commercial fish harvest in Ontario waters of Lake Ontario. Appendix XXVII, p. 361-362. *In* 1982 Annual Report to the Great Lakes Fishery Commission's Lake Ontario

Committee. Ont. Minist. Natur. Resour., Picton, Ontario.

OMNR. 1972a. Ontario commercial fish industry, statistics on landings, 1961-1965, p. 11-12. Commercial Fish and Fur Branch, Division of Fish and Wildlife 1972. Ont. Minist. Natur. Resour., Toronto, Ontario.

OMNR. 1972b. Ontario commercial fish industry, statistics on landings, 1966-1970, p. 11-12. Commercial Fish and Fur Branch, Division of Fish and Wildlife 1972, Ont. Minist. Natur. Resour., Toronto, Ontario.

Ridgley, J. I. 1975. Ontario commercial fish industry, statistics on landings, 1956-1960, p. 11-12. Commercial Fish and Fur Branch, Division of Fish and Wildlife 1975. Ont. Minist. Natur. Resour., Toronto, Ontario.

Ridgley, J. I. 1976. Ontario commercial fish industry, statistics on landings, 1971-1975, p. 11-12. Commercial Fish and Fur Branch, Division of Fish and Wildlife 1976. Ont. Minist. Natur. Resour., Toronto, Ontario.

Stewart, T. J., J. M. Casselman, and L. A. Marcogliese. 1997. Management of the American eel (*Anguilla rostrata*) in Lake Ontario and the upper St. Lawrence River. Presented at the Eel Management Meeting, Quebec City, January 13-14, 1997. These proceedings.

Whitfield, R. E., and D. P. Kolenosky. 1978. Prototype eel ladder in the St. Lawrence River. Prog. Fish-Cult. 40: 152-154.

Williams, G. C., and R. K. Koehn. 1984. Population genetics of North Atlantic catadromous eels (*Anguilla*), p. 529-560. *In* B. J. Turner [ed.] Evolutionary genetics of fishes. Plenum, New York.

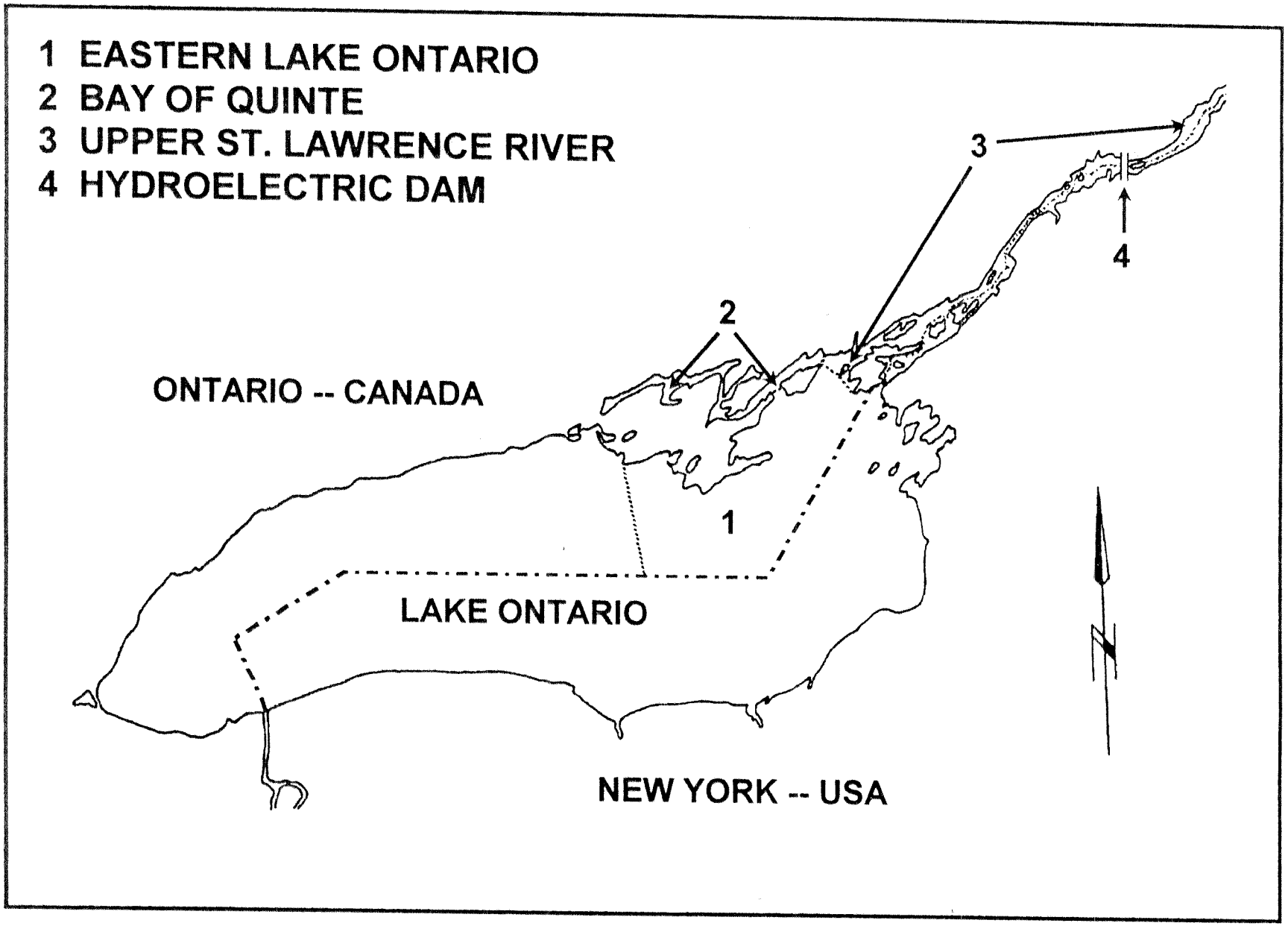


Fig. 1. Map illustrating the upper St. Lawrence River and Lake Ontario, showing the major commercial fishing areas for American eels in the Canadian waters of the province of Ontario. The location of the R.H. Saunders Hydroelectric Dam is indicated.

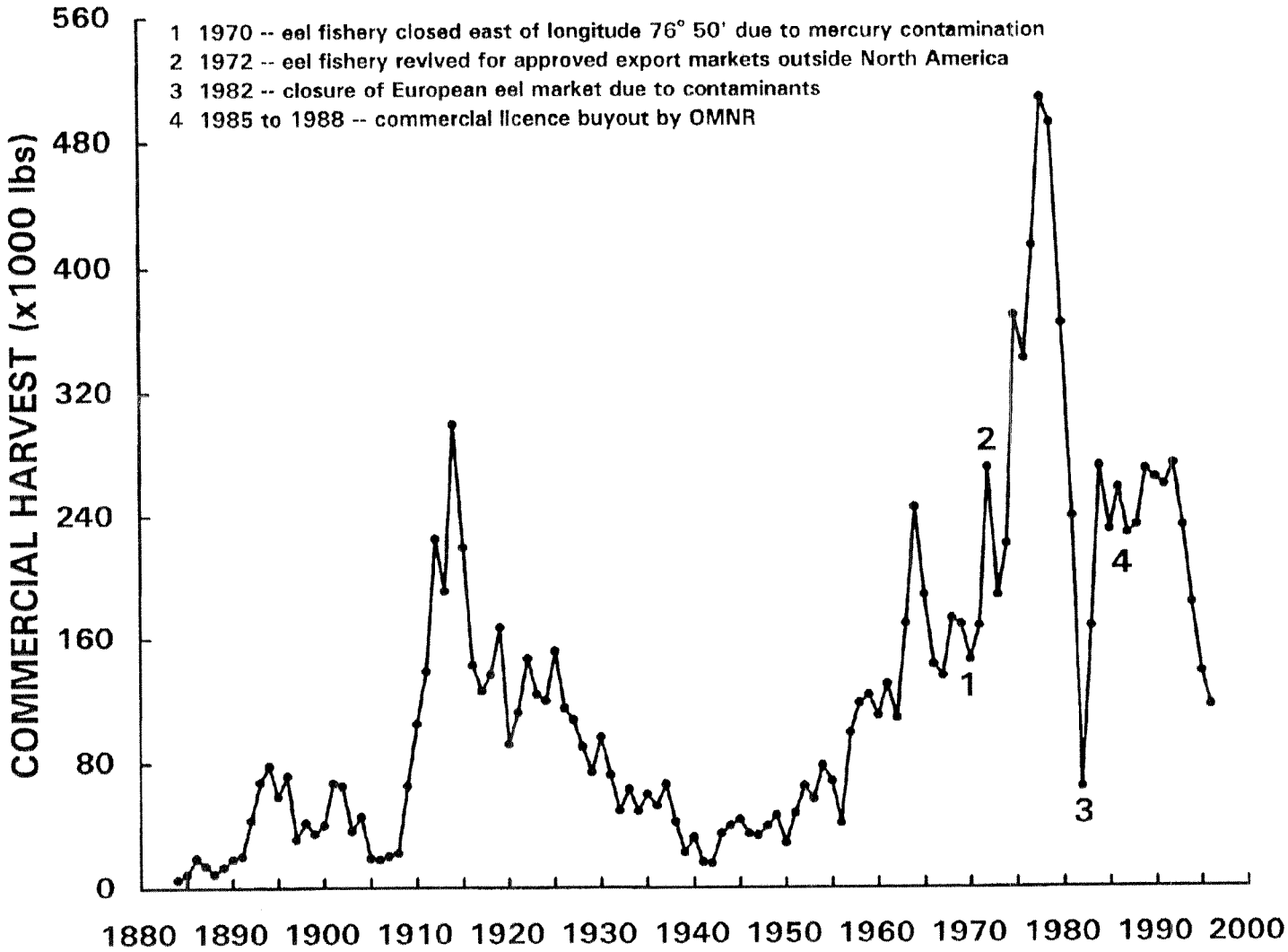


Figure 2. Commercial harvest of American eels combined for all statistical districts and quota zones from the Canadian waters of Lake Ontario and the upper St. Lawrence River, province of Ontario (× 1000 lb), from 1884 to 1996. Major events that could have affected the commercial eel fishery are indicated. Data are from Baldwin et al. (1979), DFO (1955) and annual Ontario Ministry of Natural Resources commercial fish harvest reports.

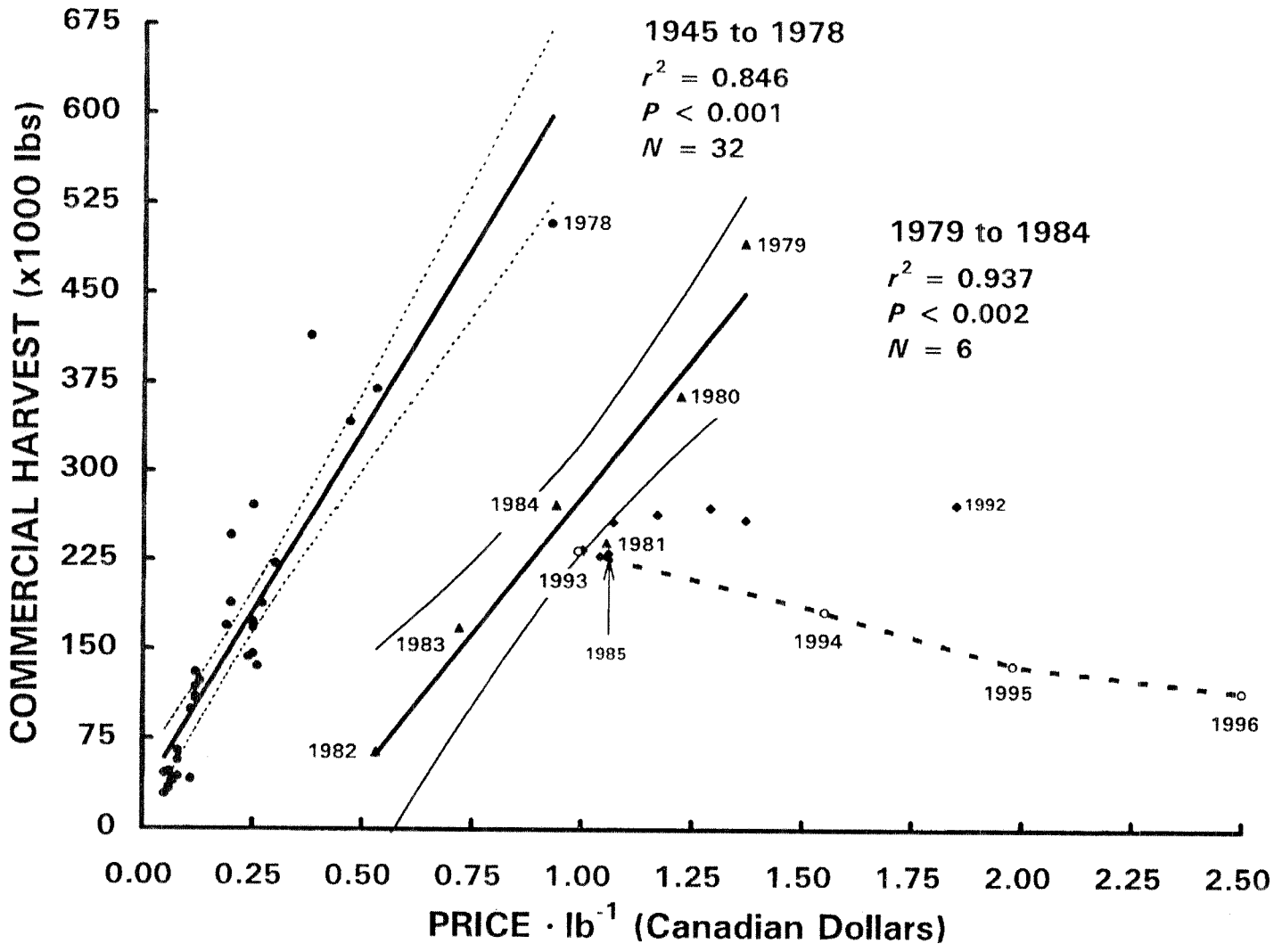


Figure 3. Relationship between commercial harvest and value in price per pound for American eels harvested from the Canadian waters of Lake Ontario and the upper St. Lawrence River, province of Ontario, from 1945-78 (closed circles) and 1979-84 (closed triangles). Regression lines, 95% confidence limits, and correlation statistics are provided. Commencing in 1994 and extending to 1996, a different relationship existed of increasing value with decreasing harvest (indicated by open circles and joined by dashed lines).

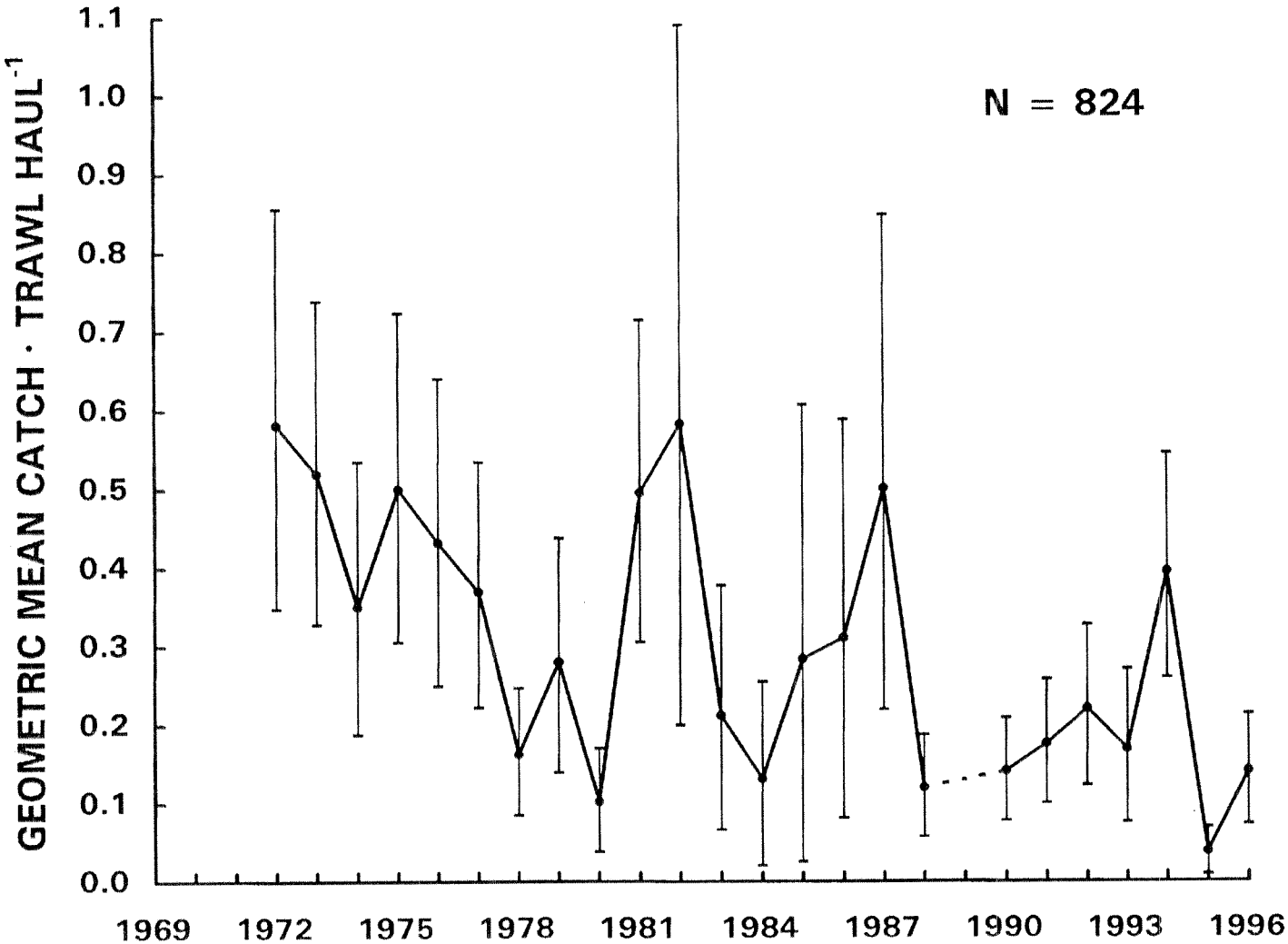


Figure 4. Geometric mean catch of American eels in a ¼-nautical-mile haul of a ¾-inch "western" bottom trawl from the Bay of Quinte for a 25-yr period commencing in 1972. The 95% confidence intervals and limits are indicated.

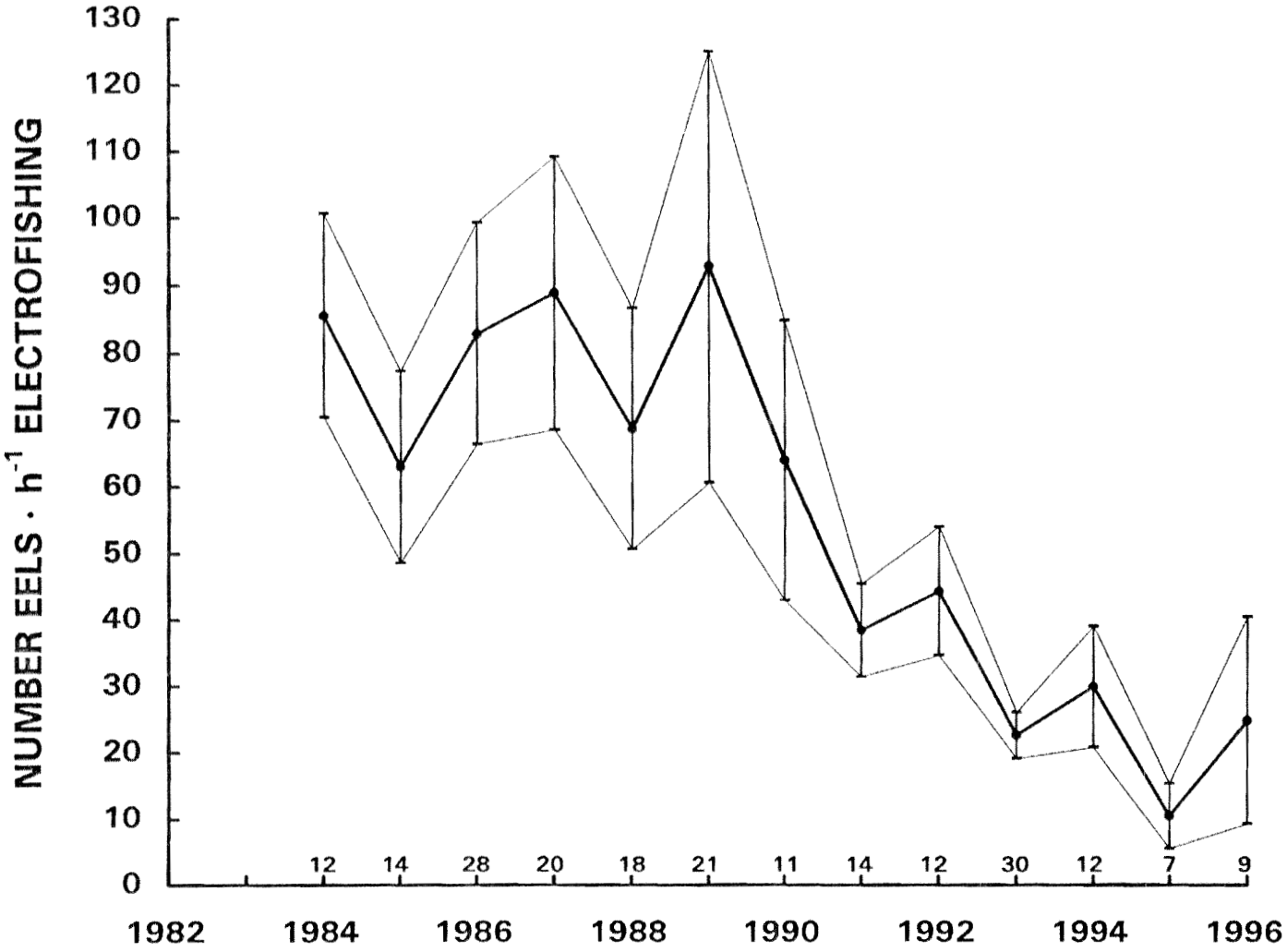


Figure 5. Mean catch of American eels · h^{-1} of daytime commercial electrofishing in eastern Lake Ontario for a 13-yr period commencing in 1984. The number of days of electrofishing are indicated on the x axis. The 95% confidence interval is delineated by light solid lines.

The Status of the American eel (*Anguilla rostrata*) Stock in Québec

Fritz Axelsen
Direction de l'Innovation et des Technologies
Ministère de l'Agriculture, des Pêcheries et de l'Alimentation
200, chemin Sainte-Foy, 12e étage
Québec (Québec) G1R 4X6

ABSTRACT

The assessment of the St. Lawrence eel stock in Québec is based on catch and effort data. The total landings have decreased since 1981, with a major decrease (47.5 %) between 1990 and 1996. The C.P.U.E. data for the weir fishery show a decrease in abundance of silver eels since 1984. It is suggested that the drastic decline in catch in the St. Lawrence Estuary since 1990 is to a great extent a result of the recruitment decline at Cornwall after 1983. The traditionally important weir fishery in the Richelieu River has virtually collapsed. The trends in landings in Ontario follow the same pattern as the Québec fishery. The St. Lawrence/Lake Ontario eel stock is in a depressed condition. The regions of the Atlantic Provinces, within the confines of the Gulf of St. Lawrence, have also exhibited an important downward shift in landings since 1990. Catch data from the National Marine Fisheries Service (Maryland) show a decrease in annual U.S. landings of 67 % between 1981 and 1990, followed by a relatively stable state.

This signals that there is a species-wide problem, requiring species-wide management action.

RÉSUMÉ

Une évaluation du stock des anguilles du Saint-Laurent a été faite au Québec à partir de données sur la capture et l'effort de pêche. Les débarquements ont diminué à partir de 1981, avec une baisse importante (47,5 %) entre 1990 et 1996. Les données de P.U.E. pour les engins de pêche fixes indiquent qu'il existe une diminution de l'abondance des anguilles argentées depuis 1984. Il semble que la grande diminution des prises, observée dans l'estuaire du Saint-Laurent depuis 1990, est, dans une large mesure, le résultat du déclin du recrutement à Cornwall après 1983. Dans le Richelieu, la pêche traditionnelle avec engins fixes a presque disparu à cause de la diminution de la ressource. En Ontario, la tendance observée dans les débarquements suit une courbe semblable à celle de la pêche au Québec. Le stock d'anguilles du Saint-Laurent / lac Ontario est en mauvais état. Les débarquements dans les régions des provinces Atlantiques, qui se trouvent à l'intérieur du golfe du Saint-Laurent, connaissent aussi une importante diminution depuis 1990. Sur la côte est des États-Unis, les données fournies par National Marine Fisheries Service (Maryland) montrent une diminution de 67 % des débarquements annuels entre 1981 et 1990, diminution suivie d'une stabilisation.

Selon les résultats de l'étude, nous avons affaire à un problème qui touche toute l'espèce et qui, donc, demande une action de gestion coordonnée pour toute l'espèce.

INTRODUCTION

A serious concern for the future of the Quebec commercial eel fishery was voiced in 1992 by fishermen. Three factors were responsible for the concern expressed: a general decline in total landings since 1981, two important consecutive annual decreases (a drop of 16.5 % from 1990-91 followed by a drop of 18.4 %) and the information that the recruitment of juvenile eels, counted annually at the Moses-Saunder's dam eel ladder at Cornwall, Ontario, had been declining drastically since 1985.

This prompted the two Eel Fishermen's Associations of the Upper St. Lawrence Estuary to request the Quebec government to look into the matter. The Ministère de l'Environnement et de la Faune (MEF) subsequently organized an eel workshop in March of 1993 (Tremblay 1993). Participants (fishermen and biologists) concluded that there had been a serious decline in the St. Lawrence River eel stock and the situation warranted further study. The study was carried out over the next 2 yr, in order to identify possible causes of the decline, particularly the recruitment decline. Several potential causes were identified (Castonguay et al. 1994), but none could be singled out as a major contributor to the decline, or quantified. High rate of exploitation was also mentioned as a potential cause. An analysis of catch and effort data was undertaken for the Quebec fishery; the results of it are presented in this paper.

COMMERCIAL FISHERY IN QUEBEC

The American eel fishery in Québec, as in all eastern North America, has a long history since it was practised by native people before the arrival of the European settlers. Then, in New France the eel, like the beaver pelt, was a currency as well a valuable staple (Le Jeune 1634; Sagard 1636; Nicolas, 1672).

Since that time, and until the early 90s, the species was one of the principal contributors to the commercial inland fishery, both in terms of landings and value (40% of the total landed value). In spite of the recent decline in catches, the eel fishery in Québec still brings in 2 million $ Can. (dock-side value) for about 150 fishermen.

The commercial eel fishery is pursued along the St. Lawrence, from Tadoussac (north shore) and Métis-sur-Mer (south shore) upstream to Lake St. Francois, as well as in the Ottawa and the Richelieu rivers (Fig. 1). There are three main fishing zones: the south shore of the Upper St. Lawrence Estuary, the St. Lawrence River between Sorel and Québec city and the Richelieu River. It is to be noted that there is no eel fishery on the Gaspé Peninsula, on the Anticosti Island, or along the coast stretching from Tadoussac to the Strait of Belle-Isle, but eels are present in most of the watersheds of those regions.

Fishing strategies used today are similar to those used by the native people in the distant past -- an interception of the eels when they leave their wintering areas for their spring and summer feeding grounds and when the silver eels migrate towards the spawning grounds in the Sargasso Sea.

There are four types of fishing gear in use: weirs, hoop nets (fyke nets), pots and hook lines. In the St. Lawrence Estuary, downstream from the east point of Orleans Island, only weirs are deployed and are permitted from August 1st to November 30, but the actual season generally runs from September to the first days of November. It is predominantly a silver eel fishery. Upstream from the east point of Orleans Island to Trois-Rivières, both weirs and hoop nets are used; both gears have no season. It is a mixed yellow and silver eel fishery. In the lake Saint-Pierre area (between Trois-Rivières and Sorel) only hoop nets are permitted; fishing is allowed between April 1st and November 30; it is principally a yellow eel fishery.

In Lake Saint-François, both pots and hook lines can be used the whole year. In the Ottawa River, only hoop nets are permitted, with no season. The fishery in Richelieu River is carried out exclusively with river weirs; no season is imposed but the actual fishing season normally extends from the beginning of May to early October; it is a mixed yellow and silver eel fishery.

No catch quotas exist for the eel fishery in Quebec, however the numbers of the various gear types permitted is restricted and set forth in the annual Quebec Management Plan (Ministère de l'Environnement et de la Faune, Plan de gestion de la pêche, 1997-1998). A total of 4477 hoop nets, 167 weirs (for a total of 63,980 m of leader), 3800 hooks and 350 pots are permitted. Presently there are about 150 licensed fishermen engaged in the eel fishery. There is no recreational or bait fishery in Quebec.

LANDING TRENDS

A continuous record of commercial eel landing statistics for Québec is available from 1917

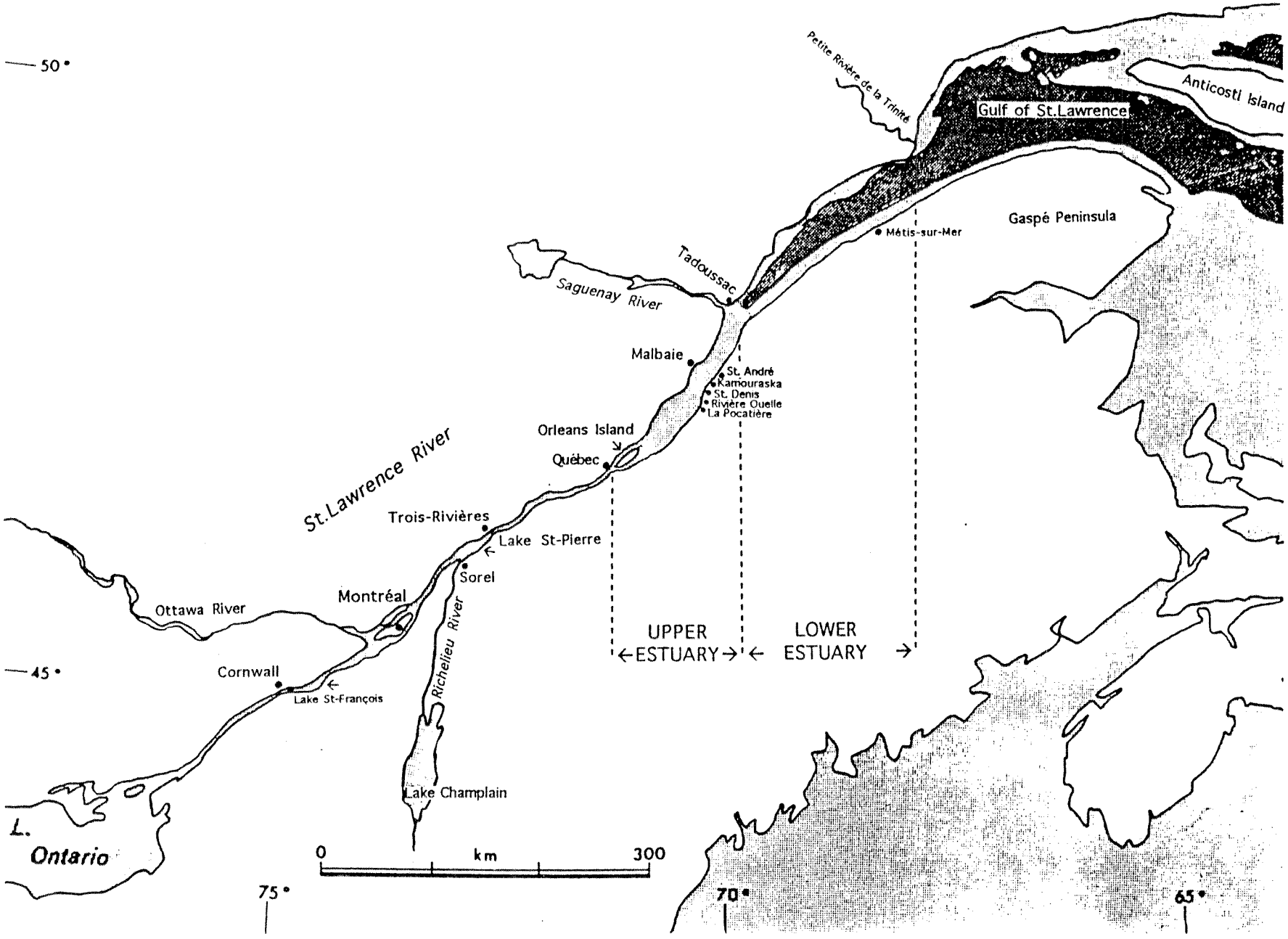


Fig. 1 : St. Lawrence River and its Estuary divisions (upper and lower)

onward. Historically, the fishery can be divided into several time-periods (Fig. 2).

1) An early period from 1917-39. - The catches increased from 272 t (1917) to 550 t by 1923. The period from the mid-20s is characterized by elevated landings with a peak of 1123 t in 1930; the average annual landing between 1931 and 1939 was 945 t.

2) A later period from 1940-49. - The overall landings decreased drastically. The Second World War obviously had an effect on the fishery. The average annual catch was 340 t.

3) The period from 1950-69. - The annual landings increased from 298 t in 1950 to a peak of 577 t in 1957. Then between 1957 and 1962 there was a drop (annual average of 433 t), followed by an increase from 1963-69 (annual average of 496 t).

4) The period 1970-74. - Landings declined to slightly above 300 t. This was due to the mercury contamination problem and the commercial fishery in the inland waters was closed. Although it reopened in 1971 the effect of the ban lingered until 1974 when landings started to increase.

The landings described above for the whole period of 1917-74, can be characterized by not only large periodic fluctuations, but also by large, mostly unexplained interannual variations.

5) The period from 1975-96, in which the fishery exhibits a distinct pattern of a long term decline, a pattern which has given rise to the present concern for the future of the Quebec eel fishery. We observe (Fig. 2) important periodic downward shifts as follows : a mean annual catch of 529 t between 1975 and 1981, then a drop to 442 t (1983-90), then a further drop to 308 t (1991-96), i.e. two consecutive decreases of 16.5 and 30.3%, respectively.

What makes this downward trend even more significant is the fact that fishing effort and harvesting patterns have hardly changed over the period : the number of active licenses has not changed, and the increased market demand and prices have kept the activity level high (dock-side price in 1996 : 8.80 $ Can./kg). Nor have the type and quantity of fishing gear deployed changed. Some technological improvement however was made to almost every weir in the St. Lawrence Estuary. In 1980 the traditional leader was replaced with 12 ft (4 m) high netting introduced from Scandinavia (Association des Pêcheurs, 1974); thus eels swimming close to the head rope of the leader and at the highest tide could be caught. The greater increase in catch observed in 1980 and in 1981 may have been the result; 70 % of this increase came from the estuary. It is not known if it was entirely due to the more efficient gear. If it was, then the drop in catches in the following years carry even more weight.

The question about inaccurate catch reporting has always been a contentious issue; therefore fluctuations in annual landings or catch trends over longer periods are difficult to assess. This is certainly true to some extent for the periods prior to 1975, but from 1975 the reported catches are close to reality. In 1986 a detailed catch logbook was introduced, furnishing data on daily landings by fishing location and on effort -- data which are regularly validated.

The decline in catches has been observed in all fishing districts (Table 1) and the pattern of annual fluctuations between the fresh and the saltwater sectors is very similar. The percentage contribution of each sector to the total annual catch has remained fairly stable (Table 1, 2) up to 1991. The mean annual contribution of the freshwater sector between 1986 and 1991 was 35 % (range : 34-37 %); this increased to 44 % between 1992 and 1996 (range: 38-49 %). We also observe a fairly consistent pattern between neighbouring fishing locations within a given sector (Table 3). However, since 1990 we detect a noticeable difference between the salt and the freshwater sectors (Fig. 3).

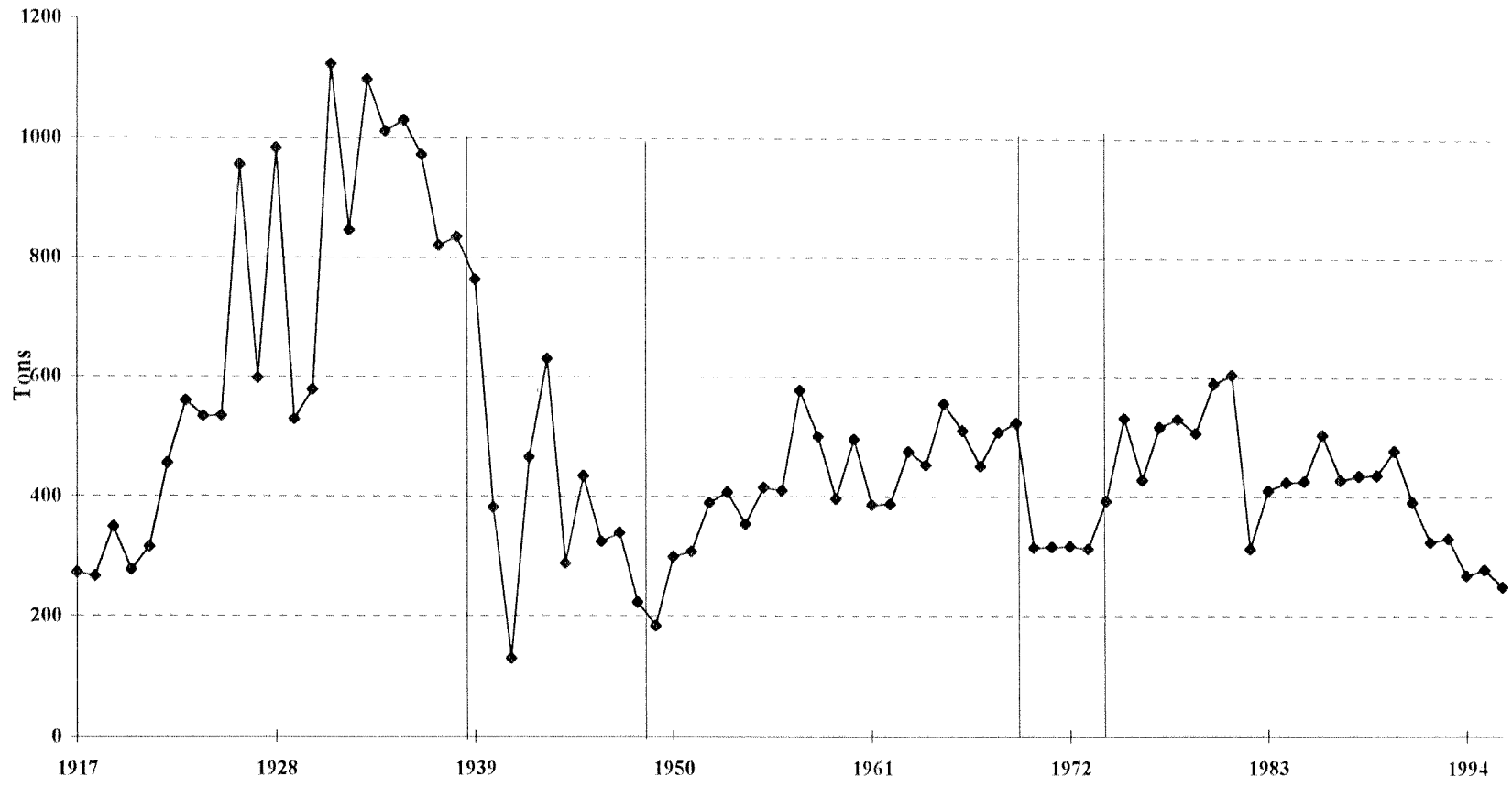


Fig. 2 : Commercial eel landings (t) in Québec from 1917 to 1996 (1996 : preliminary)

Table 1. - Commercial eel landings (kg.) for all 9 fishing districts from 1986 to 1995

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
					Fresh water					
District										
2	96	99	184	323	170	55	74	569	231	161
4	4686	4238	5179	9205	15686	15662	6808	2204	3493	10037
6	48094	37994	34383	26175	17683	23266	22934	13990	8402	12641
8	72634	51282	43459	58190	51411	48434	42855	51287	46304	37404
9	30061	22623	20955	35784	60597	26226	34856	31470	30469	34540
10	27630	29723	42987	22956	25720	25839	35428	27160	30515	41219
Sub-total	183201	145959	147147	152633	171267	136482	142955	126880	119414	136002
					Salt water					
District										
11	235188	192031	211559	213113	235766	199141	131679	148397	111998	109980
18	79644	85364	70017	67258	65517	58573	47590	54591	34846	30523
15	4393	3749	5443	2165	3455	3122	1944	857	2053	995
Sub-total	319225	281144	287019	282536	304739	260836	181213	203844	148897	141498
Total	**502426**	**427103**	**434166**	**435169**	**476006**	**397318**	**324168**	**330524**	**268311**	**277500**

Districts : Témiscamingue (2), Lake Saint-François (4), Richelieu (6), Lake Saint-Pierre (8), Trois-Rivières (9), Upper St. Lawrence Estuary (10, Québec - 11, east - 15, Malbaie - 18, west.)

Table 2. - Distribution of the total annual catch (%) between the fresh and saltwater sectors in the Québec region, 1986-95

	1986-90	1991-93	1986-93	1994	1995
Fresh water	35.18	38.60	36.26	44.23	49.02
Salt water	64.82	61.40	63.74	55.70	50.98

Table 3. - Distribution of eel catches (%) between 2 locations of the Upper St. Lawrence Estuary from 1986-95

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Kamouraska and Saint-Denis	44.16	47.92	44.99	44.66	43.18	55.80	53.09	44.26	53.30	48.10
Rivière-Ouelle and Ste-Anne-de-la-Pocatière	55.84	52.08	55.01	55.34	56.82	44.20	46.91	55.74	46.70	51.90

Fig. 3 : Commercial eel landings (t) , 1986 - 1995

The total annual landings dropped from 476 t to 276 t between 1990 and 1995 (42% drop) of which 82.2% was from the Upper St. Lawrence Estuary. It has been shown by Desjardins et al. (1983) that a substantial portion (60-70%) of the eels caught in the St. Lawrence River are coming from Lake Ontario (mirex was used as a biological indicator); as about 60 % of the total annual catch between 1990-96 has been coming from the Upper St. Lawrence Estuary. I suggest that the most recent decline in the Estuary is a direct result of the recruitment decline observed at the Moses-Saunder's dam eel ladder at Cornwall, Ontario. It had been predicted that the adverse effect of the drastic recruitment decline would be seen in the landings by 1996 or earlier (Axelsen 1994).

There is also a drastic decline in the landings from the Richelieu River (Fig. 4). This fishery has historically been very important, contributing almost 10% of the total annual catch in Quebec and 26% of the freshwater sector catch. Since 1986 the total landings have dropped from 48 t in 1986 to 2 t by 1996 - a virtual collapse of the fishery over a 10-yr period.

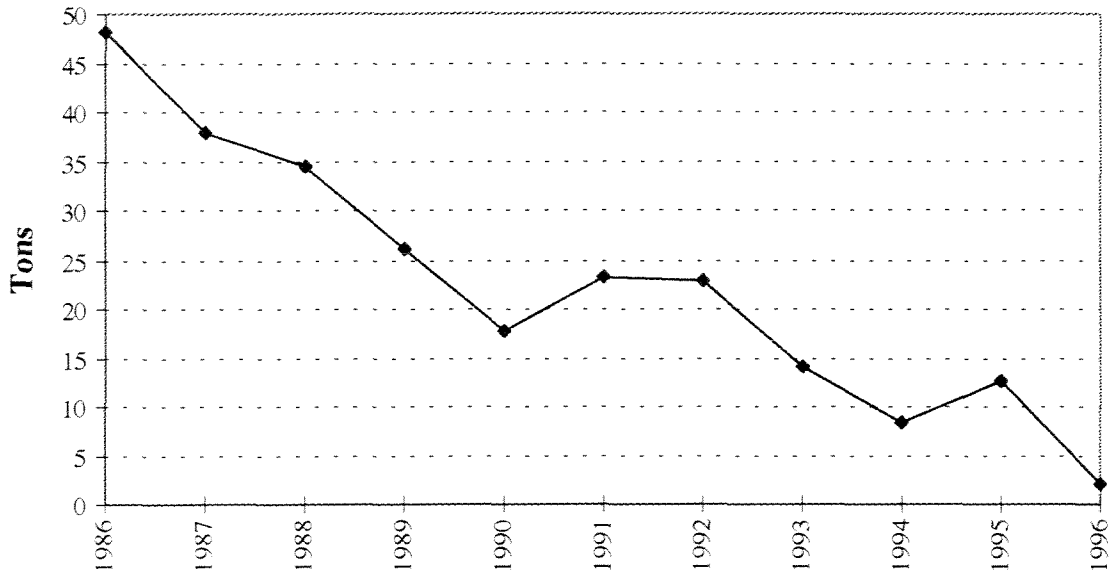


Fig. 4 : Commercial eel landings (t) from the Richelieu River , 1986 - 1996

CATCH AND EFFORT DATA FROM THE FIXED-GEAR FISHERY

The catch per unit of effort data from the fixed-gear is a good abundance indicator of the adult eels of the St. Lawrence-Lake Ontario stock. This type of fishing gear has contributed to about 70% of the total annual catch in the province of Quebec. The gear is stationary and the total length of leader, once installed perpendicular (different for Richelieu River) to the shoreline, does not change during the fishing season. Moreover, the actual length of leader deployed each season by the fishermen is controlled and measured by the conservation officers.

The total length of leaders available, according to the Quebec Fisheries Management Plan, is 73,817 m for the section downstream from Trois-Rivières (to Ruisseau-à-Rebours on the south shore, and to the Saguenay on the north shore) for a total number of 236 traps. However, about 12,796 m are not used because of the present eel problem.

We have analyzed the C.P.U.E. data from 1979-95 for the county of Kamouraska, for the four fishing districts of the Upper St. Lawrence Estuary from 1986-93 and for the Richelieu River from 1986-95.

COUNTY OF KAMOURASKA (1979-95)

The county of Kamouraska covers the fishing locations between La Pocatière and St-André (Fig. 1). In 1995, the catch of the 39 licensed fishermen made up 37.3% of the total landings of the province. Between 1979 and 1994, the catch made up 49.2% (range: 44-55%) of the total.

There has been an important decrease in the C.P.U.E. since 1983 (Table 4). The important peak in 1982 (Fig. 5) can paradoxically be explained by a considerable reduction in effort: because of the mirex problem (temporary loss of market), many fishermen did not install their gear and only 8204 m of leader were used that year (24%) out of a total of 34,599 available, with a total catch of 149 t. Fewer fishermen and fewer traps made more migrating eels available to those who did fish. In 1983, the effort increased to 47%, with a catch of 220 t. In 1984, the effort increased by 65.9% over the previous year but the catch only increased by 10 t. Over the following 7 yr, the total catches remained at levels comparable to 1983, while the effort increased by 10-13%. From 1991-92, the C.P.U.E. dropped 35.5%, and they are still decreasing.

Table 4. Effort, catch and catch per unit of effort (C.P.U.E.) for the county of Kamouraska from 1979-95.

Year	Total length of leader soaked m	Total catch kg	C.P.U.E. kg/m
1979	29502	243368	8.25
1980	29489	297350	10.08
1981	31266	313160	10.02
1982	8204	148870	18.15
1983	18073	219491	12.14
1984	29987	229600	7.66
1985	29155	216388	7.42
1986	36511	247885	6.79
1987	37087	208197	5.61
1988	36759	203007	5.52
1989	37969	213325	5.62
1990	36589	258131	7.05
1991	37730	220210	5.84
1992	37511	141676	3.78
1993	38664	168572	4.36
1994	33246	118567	3.57
1995	30932	97094	3.14

The decline in the C.P.U.E. presented here reflects an overall decline in the St. Lawrence River stock.

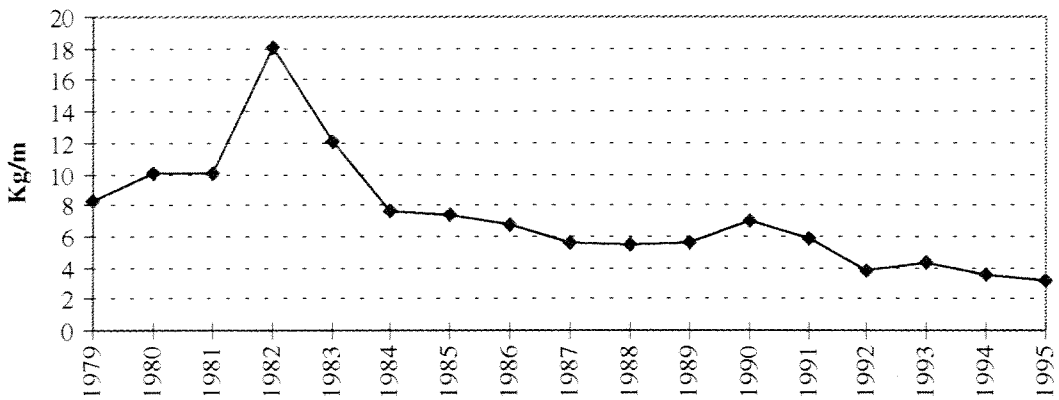


Fig. 5 : Catch per unit of effort (Kg/m) for the eel weir fishery of the county of Kamouraska (1979 - 1995)

Table 5. Catch per unit of effort (kg/m) for the four fishing districts of the Upper St.Lawrence Estuary from 1986-93.

District	1986	1987	1988	1989	1990	1991	1992	1993
10	6.42	6.87	8.75	4.39	4.48	4.42	6.11	4.71
11	7.05	5.79	6.57	6.06	7.51	6.15	3.98	4.80
18	4.07	4.11	3.39	3.05	2.89	2.66	2.21	2.14
15	1.31	1.12	1.24	0.61	0.66	0.78	0.45	0.22
C.P.U.E	5.65	5.00	5.31	4.52	5.09	4.47	3.34	3.62

UPPER ST. LAWRENCE ESTUARY (1986-93)

The four fishing districts of the Upper St. Lawrence Estuary have contributed 71% of the total annual landings of the Province between 1987 and 1993. A decline in catch per unit of effort has been observed for all districts (Table 5). The overall decline between 1986 and 1993 amounts to 36%. There are differences among the various districts: for instance, the Lower St. Lawrence east (district 18) has seen a continuous decline since 1987, whereas the other districts show a step-wise decrease.

RICHELIEU RIVER (1986-96)

The commercial exploitation of the American eel in the Richelieu River represents a unique case. The majority of the catches comes from four river weirs, V shaped (with the apex of the «V» downstream) made to block off 2/3 of the width of the river. The Richelieu River drains the Lake Champlain basin. The fishing generally takes place from mid-May to the beginning of October, which implies that the catches are not composed entirely of migrating eels but also of yellow ones. However, in the last three years, the catches have been composed of only very large eels (P. Dumont, Ministère de l'Environnement et de la Faune du Québec, Montréal, personal communication). Indirectly, that indicates a recruitment failure over a long period.

The C.P.U.E for this fishery points clearly to a recruitment failure (Fig. 6: due to the confidentiality of the data, the C.P.U.E. is indicated as percentage, with 1986 as point of reference).

LANDING TRENDS FOR OTHER AMERICAN EEL STOCKS

A sharp decline in eel landings since the early 90s, similar to what has been observed for the St.Lawrence River stock, has been reported for other Canadian eel stocks. The annual catches in Ontario have declined about 50% between 1992 and 1996 (Casselman 1997).

Of the four Atlantic Provinces, New Brunswick and Prince Edward Island are the only ones which have had an important commercial eel fishery for many years. Their combined annual catches have amounted to over 85% of the total catches of the four Provinces between 1975 and 1986, but have since decreased progressively; they decreased by 57.6% between 1990 and 1994 (Jessop 1996). Chaput and Locke (1997) indicated that both landings and freshwater abundance of eels in the southern Gulf have declined in recent years. This is significant because all regions considered so far within the confines of the Gulf of St.Lawrence and the St.Lawrence River system display an important decline in landings in recent years.

The commercial eel fishery in Newfoundland is recent, one of the reasons being the closure of the groundfish fisheries. The total landings increased from 25 t in 1985 to a peak of 147 t by 1990, but they have dropped since to a low of 85 t by 1995 (DFO, Newfoundland Region 1997).

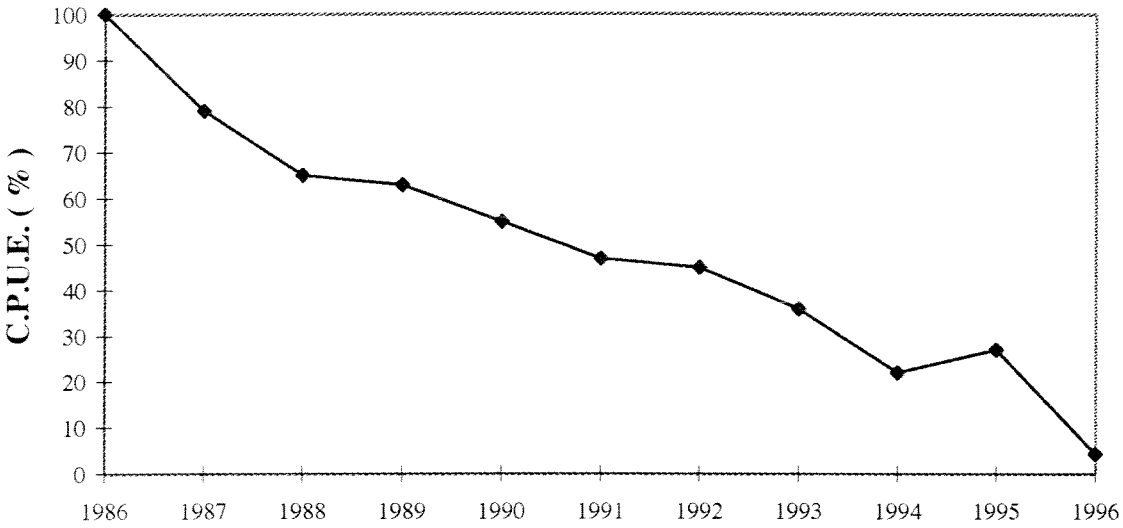


Fig. 6 : Catch per unit of effort (%) for the Richelieu River weir fishery , 1986 -1996)

Thus, a general decline has been evident in the overall Canadian eel fishery since the early 90s. It is also pertinent to point out that the commercial eel fishery on the east coast of the U.S. is faced with a decrease in eel abundance. Peak catches were reached in the late 70s. The landings then declined over the next decade. The total decrease in annual catches over an 11-yr period (1979-90) amounted to about 67% (National Marine Fisheries Service, Springfield, Maryland). It is to be noted that the Quebec fishery suffered an overall drop of 46% between 1981 and 1992.

DISCUSSION

The data presented show that the Lower[1] St.Lawrence River eel stock is under great stress.

From a commercial fishery perspective, the current situation is being viewed as critical. The overriding reason is that the observed long-term downward trend in eel abundance spans the approximate average life of the species. It has been argued that there were low catches in the past, with subsequent recovery, and that the observed inter-annual variations only reflected normal between-years variations in recruitment. However the long-term decline in C.P.U.E. for the Quebec fixed-gear fishery and the 11 yr of extreme low level of recruitment (as witnessed by the juvenile counts at the Moses-Saunder's dam eel ladder) should be sufficient reasons to discard such arguments.

It is suggested that the effect of the first pronounced drop of 1986 in juvenile eel counts at the Saunder's dam eel ladder is evident in the most recent catches in Quebec. In this context, it is important to mention that the catches of the St. Lawrence-Lake Ontario basin are composed entirely (as far as it is known) of females. If those which escape to spawn make up a major portion of the female breeding population, any further decline in recruitment ot the St. Lawrence will be invariably felt, not only in the basin but in all other regions, because the factors which affect the survival to maturity anywhere may influence abundance everywhere.

Several factors (such as habitat losses or modifications, construction of physical barriers impeding the ascent and descent of eels, chemical pollutants over most of the geographical range of the species and possible changes in oceanic currents, e.g. Gulf Stream) have most likely been implicated to various degrees in the long term decline of the eel population, but the relative importance of each one remains unknown. Recent data show a high mortality of migrating eels at the Beauharnois dam (85 km downstream from the Cornwall dam) in Québec. Depending on the type of turbine, the

[1] Lower as opposed to Upper St.Lawrence River (Ontario).

mortality is 24% (turbine hélice) and 16% (turbine Francis) (Hydro-Québec, 1995) for eels less than 90 cm (TL). According to Kolenosky (1976), the mortality of eels 90 cm or longer would reach 100% for turbine hélice of the size used in Cornwall and Beauharnois dams.

Effective management actions are urgently needed in order to enhance the eel stocks and, hence, the fishery in the long run. However, the present eel problem is a species-wide one and requires a species-wide management action. It is pertinent here to mention that the European Inland Advisory Commission recently (1993) decided that the time had come to reconsider the needs for stock-wide management actions for the European eel (*Anguilla anguilla*) in view of the long-term recruitment decline of this species, although it did not consider the European eel problem as severe as the North American one (Dr P.V. Hodson, Dept. of Biology - Queens University Kingston, Ontario.)

The abundance of the species is declining; just maintaining the current level of fishing effort would decrease further the spawning portion of the population -- which will lead to a still further drop in recruitment and eventually to a collapse of the North American commercial fishery. Time has come to worry about the species. Stock recovery cannot begin until there is production and survival to maturity of a significant number of new recruits.

SUMMARY

In spite of the lack of precise biological information on many aspects of the North American eel life cycle, there are a number of trends and observations which should be a cause of concern for the future commercial eel fishery throughout the geographical range of the species :

1. A stepwise decrease in the total annual eel landings in Quebec since 1981 (or 1982). The catch is now at an all time low of 249 t in 1996 -- a drop of 58.8% compared to 1981. Between 1990 and 1996, the drop of 47.7% in landings is rather disconcerting and may well be a direct result of the recruitment decline observed at Cornwall after 1985;

2. A continuous drop in the Richelieu River annual C.P.U.E. and landings since 1986, representing a decrease of over 95% between 1986 and 1996;

3. A continuous decline in the Matapedia River eel « stock » density since 1982 (Quebec);

4. A stepwise and important drop in the C.P.U.E. for the fixed gear fishery in the lower St. Lawrence west fishery between 1984 and 1996, indicating a serious decline in the abundace of the species;

5. A decline, since 1983, in the number of juvenile eels moving up the Saunder's eel ladder at Cornwall, Ontario -- a decline particularly pronounced after 1985;

6. A decline in the number of elvers in the Petite-Trinité River (Quebec) between 1982 and 1985;

7. A continuous decline in commercial eel landings in Ontario since 1992.

8. An overall declining trend in the eel landings from the southern Gulf of St. Lawrence in recent years;

9. Diminishing catches in Newfoundland since 1990 ;

10. An important drop in eel landings in the United States since 1979 -- a decrease of 67% between 1979 and 1990; and

11. A considerable increase in the total North American catch between 1975 and 1981, followed by a progressive drop of more than 45% over the next 13 yr.

ACKNOWLEDGMENTS

The author extends thanks to the following departments and ministries for providing commercial catch statistics : National Marine Fisheries Service, Silver Springs Maryland; Ontario Ministry of National Resources; Fisheries and Oceans, Canada (provinces Atlantiques).

I thank Dr. J.M. Casselman (Ontario Ministry of Natural Resources, Picton) and Guy Verreault (Ministère de l'Environnement et de la Faune du Québec, Rimouski) who critically reviewed the manuscript. I thank also P-B. Axelsen for designing the map.

REFERENCES

Association des Pêcheurs d'anguille du Québec. 1974. Rapport du voyage d'études en Suède et au Danemark. 23 p.

Axelsen, F. 1994. État de la pêche commerciale à l'anguille d'Amérique (*Anguilla rostrata*) en Amérique du Nord. Direction du Développement et des Activités régionales. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (Document de travail). 63 p.

Casselman, J. M., L. A. Marcogliese, T. Stewart and P. V. Hodson. 1997. Status of the Upper St. Lawrence River and Lake Ontario American eel stock - 1996. Eel Management Meeting. Québec. January 13-14, 1997. 7 p.

Castonguay, M, P.V. Hodson, C.M. Couillard, M.J. Eckerly, J.-D. Dutil, and G. Verreault. 1994. Why is recruitment of the American eel, *Anguilla rostrata*, declining in the St. Lawrence River and Gulf? Can. J. Fish. Aquat. Sci. 51: 479-488.

Chaput, G and A. Locke. 1997. Status of America eel from the southern Gulf of St. Lawrence. Eel management Meeting. Québec. January 13-14, 1997. 22 p.

Desjardins, C., J.-D. Dutil, and R. Gélinas. 1983. Contamination de l'anguille (*Anguilla rostrata*) du bassin du fleuve Saint-Laurent par le mirex. Rapp. can. ind. sci. halieut. aquat. 144: 51 p.

Dutil, J.-D. M. Michaud and A. Giroux. 1989. Seasonal and diel patterns of stream invasion by American eels (*Anguilla rostrata*) in the northern Gulf of St. Lawrence. Can. J. Zool. 67:182-188.

European Inland Fisheries Advisor Commission. 1993. Report of the eighth session of the working party on eel. Olsztyn, Poland, 24-29 May, 1993.

Hydro-Québec, 1995. Suivi de la migration de l'anguille d'Amérique du Nord (*Anguilla rostrata*) au Complexe Beauharnois 1994.

Jessop, B.M. 1996. The Status of American Eels (*Anguilla rostrata*) in the Scotia-Fundy Area of the Maritimes Region as indicated by catch and License Statistics. DFO Atl. Fish. Res. Doc. 98/118: 15 p.

Kolenosky, D.P. 1976. Eel mortality resulting from Robert H. Saunders St. Lawrence generating station. Ontario Ministry of Natural Resources, Lake Ontario Fisheries Assessement unit (unpublished).

Le Jeune, P. 1634. Relation de la Nouvelle-France.

Ministère de l'Environnement et de la Faune. 1997. Plan de gestion de la pêche, 1997-1998. 55 p.

Nicolas, L. 1672. Histoire naturelle des Indes occidentales.

Sagard, G. 1636. Histoire du Canada et voyages que les Frères Mineurs Récollets y ont faits pour la conversion des Infidèles, réédité par Edwin Tross, Paris, 1866.

Tremblay, S. 1993. Compte rendu de l'atelier sur l'anguille d'Amérique (*Anguilla rostrata*), Sainte-Foy, mars 1993. Ministère du Loisir, de la Chasse et de la Pêche, Direction de la faune et des habitats. 129 p.

American eel elvers and their fishery in the Scotia-Fundy area of Atlantic Canada: An Overview

by

B. M. Jessop
Department of Fisheries and Oceans
P.O. Box 550
Halifax, Nova Scotia
B3J 2S7

ABSTRACT

The elver fishery of the Scotia-Fundy area of Atlantic Canada has developed steadily, since its inception in 1989, from a catch of 26 kg to about 3,000 kg in 1995 and 1996. Development of the fishery has been tightly controlled, with only nine experimental licenses issued to date and license conditions that include specified fishing areas, a quota (usually one tonne), and a logbook of daily catch and fishing effort, among other requirements.

Annual and seasonal variation in the elver fishery catch, within and among geographic regions, can be linked to marine and estuarine/riverine environmental conditions. Elver run size was not proportional to river size within the Scotia-Fundy area, perhaps because of differences among geographic areas in elver abundance. No time trend occurred in the size of the annual elver run to the East River, Sheet Harbour, between 1990 and 1996. The exploitation rate by the dip net fishery for elvers was estimated at about 30% in the East River, Chester. Elver lengths and weights increase with increasing latitude and, within a river, may vary among years as well as decrease throughout the run. The daily abundance of upstream-migrating elvers is influenced by environmental factors such as stream water temperature and discharge and nighttime tide height.

RÉSUMÉ

La pêche des civelles dans le secteur Scotia-Fundy du Canada atlantique a connu une croissance constante depuis ses débuts, en 1989, passant d'un total de captures de 26 kg à environ 3 000 kg en 1995 et 1996. L'expansion de cette pêche a été sévèrement contrôlée, seulement neuf permis de pêche expérimentale ayant été délivrés jusqu'à maintenant avec des conditions telles que des zones de pêche précises, un quota (habituellement une tonne) et un registre d'inscription des captures et de l'effort de pêche quotidiens.

Les variations saisonnières et annuelles des captures de civelles, dans les zones géographiques et entre elles, peuvent être reliées aux conditions du milieu marin et des estuaires / rivières. La montée des civelles n'était pas proportionnelle à la taille du cours d'eau dans le secteur Scotia-Fundy, peut-être à cause de différences entre les zones géographiques et l'abondance des civelles. Aucune tendance chronologique n'a été observée pour ce qui est de l'importance de la migration annuelle des civelles dans la rivière East, à Sheet Harbour, entre 1990 et 1996. Le taux d'exploitation des civelles au carrelet a été estimé à environ 30 % dans la rivière East, à Chester. La longueur des civelles et leur poids augmentent avec la latitude et, dans un cours d'eau, peuvent varier d'une année à l'autre, aussi bien que diminuer pendant la migration. L'abondance quotidienne des civelles qui migrent vers l'amont est influencée par différents facteurs du milieu, comme la température du cours d'eau, son débit et la hauteur de la marée nocturne.

areas (Jessop 1996b): 1. the lower Bay of Fundy, N.B. (LBFNB), extending from the Maine border to the Saint John River; 2. Chignecto Bay (CHIGNECTO), extending from the Saint John River through Chignecto Bay to Cape Chignecto; 3. Minas Basin (MINAS), from Cape Chignecto through Minas Basin to, and including, Kings County, N.S.; 4. lower Bay of Fundy, N.S. (LBFNS), comprising Annapolis and Digby Counties, N.S.; 5. South Shore, N.S. (SSNS), extending from Queens County, N.S. to Halifax Harbour; 6. Eastern Shore, N.S. (ESNS), covering north of Halifax Harbour to the Canso Causeway; 7. Eastern Cape Breton (ECB), from the Canso Causeway to Meat Cove on the Cabot Strait (Fig. 1).

The fishery is maturing in the sense that no additional licenses are being considered, experimental fishing permits are being converted to regular licenses, and the fishers have acquired substantial fishing and marketing skills. In most fishing territories, the fishing pressure applied may be near the maximum justified by economics because the high value of elvers provides incentive to achieve quotas even at relatively low catch rates.

ELVER FISHERY AND BIOLOGY

Elver catches have increased from 26 kg in 1989 to about 3,000 kg in 1995 and 1996 (Table 1). The 1996 elver fishery in the Scotia-Fundy area was primarily a dip-net fishery (66% of catch); trap nets contributed 9% of catch, fyke nets 2%, pots 1%, while mixed gear accounted for 21% of the catch. An attempted elver fishery in eastern Cape Breton (ECB) was unsuccessful in 1996 due to improper fishing techniques. Detailed discussion of elver fishery catches by geographic area is restricted by the Canadian Privacy Act and Access to Information Act because of possible linkage of specific catch values, and thus of economic data, to an individual fisher.

Annual and seasonal variation in elver catch occurs within and among the six geographic regions where elver fishing presently occurs (Jessop 1996b). Between 1994 and 1996 (the years with the highest annual catches), catches varied up to about eight-fold within a region and 12-fold among regions. Catches were consistently highest along the South Shore and lower Bay of Fundy, N.S., moderately high in the lower Bay of Fundy, N.B., lower along the Eastern Shore, N.S., and lowest (and similar) in the upper Bay of Fundy areas of Chignecto Bay and Minas Basin. In 1996, total dip-net fishing effort was almost 5,200 h, ranging from about 300 h in the LBFNB area to over 1,700 h in the SSNS area. Mean (by night and river within a region) dip net catch per unit fishing effort (CPUE) differed among all regions in 1996 except for similar values in the lower Bay of Fundy of Nova Scotia and New Brunswick and in the Chignecto Bay and Eastern Shore areas (Jessop 1996b). Dip-net CPUE varied from 0.63 $kg \cdot hr^{-1}$ (95% CI 0.48-0.79) in the LBFNB area to 0.07 $kg \cdot hr^{-1}$ (95% CI 0.05-0.09) in the CHIGNECTO area, 0.70 $kg \cdot hr^{-1}$ (95% CI 0.58-0.85) in the LBFNS area, 0.27 $kg \cdot hr^{-1}$ (95% CI 0.23-0.31) in the SSNS area, and 0.08 $kg \cdot hr^{-1}$ (95% CI 0.06-0.10) in the ESNS area. A conclusion of regional differences in elver abundance is supported by: 1. a high fishing effort in all regions, which implies that elver abundance is reliably measured; 2. no significant correlation among regional means of dip net catch (kg) and fishing effort (h); 3. correlation among regional means of CPUE and catch (possibly overestimated due to collinearity); and 4. significant differences in mean CPUE among regions. Annual and regional variability in glass eel/elver catches, as well as long-term changes over a wide geographic area, have been reported within a country (Holland) and within western and northern Europe (Dekker 1986; Moriarty 1990).

The geographic distribution of elvers in the Scotia-Fundy area is generally reflected in the fishery for larger eels, where the largest fisheries occur in southwest New Brunswick (LBFNB) and along the southern Atlantic coast of Nova Scotia (SSNS) (Jessop 1982, 1996c). Elver fishery mean catch (1990-96), by geographic region, was marginally correlated ($n = 6$, $r = 0.71$, $0.05 < P < 0.10$; one-sided significance test) with eel fishery mean (1950-95) catch. A high elver catch but low eel catch in LBFNS reduced the correlation; with the LBFNS excluded, the correlation increased ($n = 5$, $r = 0.92$, $P < 0.025$).

The proportion of the regional elver catch occurring in April rises from zero along the Eastern Shore of Nova Scotia to 29% along the South Shore then consistently declines along a route progressing into the lower Bay of Fundy, N.S. (25%) and counter-clockwise through the upper Bay of Fundy from Nova Scotia (9%) to New Brunswick (8%) and towards the lower Bay of Fundy, N.B. (2%) (Jessop 1996a,b; Fig. 2). During May, the proportion of regional elver catch increases to 67% along the Eastern Shore, N.S., to 57-62% along the South Shore and lower Bay of Fundy, N.S., to 80-83% in Minas and Chignecto Bays, and 89% in the lower Bay of Fundy, N.B. June catches decline in a similar

pattern from 33% along the Eastern Shore to 9% in the lower Bay of Fundy, N.B. Along the north shore of the Gulf of St. Lawrence, elver migration begins after mid June and continues until late July (Dutil et al. 1989).

Jessop (1996b) concludes that the differences in elver relative abundance and seasonal run timing among geographic areas may result from complex oceanographic conditions. A greater travelling time in the Gulf Stream before detrainment and movement shoreward could delay elver arrival in more northern areas. Greater warm-core eddy activity southwest of, than northeast of, Halifax, may contribute to greater elver detrainment from the Gulf Stream to the southern portion of the continental shelf. The southwest flow of the offshore and inshore branches of the Nova Scotia current and counter-clockwise current in the Bay of Fundy may transport elvers in the direction of current flow during some portion of their passage across the Scotian Shelf. Deep, shoreward-flowing currents (Lauzier 1967), particularly through the deep channels between offshore banks, may assist elver movement inshore across the Scotian Shelf. These channels most frequently occur in the southern portion of the Scotian Shelf. Diel vertical migrations by leptocephali and elvers (McCleave 1987) may expose them to both the southwestward flowing Nova Scotia Current and the inshore flowing deep currents. Behavioural changes following metamorphosis from larval to elver stages, particularly a change from diurnal to semidiurnal (tidal) vertical migration, may also assist in utilizing inshore flowing bottom currents and tidal flows in estuaries to move upstream (McCleave 1987). The greater width of the Scotian Shelf off Cape Breton than off southwestern Nova Scotia could, by increasing transit times, tend to shift elvers southwestward with the Scotian Current and to delay arrival inshore in more northerly areas. Finally, the generally cooler and later warming marine and freshwater temperatures in the northern than in the southern part of the Scotian Shelf and rivers of Atlantic coastal Nova Scotia may both delay transit across the northern portion of the Scotian Shelf and delay freshwater entrance relative to more southern areas (Fig. 3; Jessop 1996b). The oceanic complexities of the Scotian Shelf and Bay of Fundy may extend into the Gulf of Maine but it has its own characteristics. Thus, in Maine, elvers enter earlier and provide higher catches in southern than in northern areas. Both oceanic factors, which may influence nearshore accumulation, and inshore factors, which may influence the entrance of elvers into freshwater, may regulate regional run timing and abundance.

Over wide geographic areas, elver run size may not be proportional to river size (drainage area, discharge) because elver density varies regionally (Jessop 1996b). Within the Scotia-Fundy area, mean dip net CPUE was uncorrelated with river drainage area ($r = 0.50$, $P = 0.13$) for 19 rivers, ranging from 8 to 1,833 km^2 in drainage area, of which at least two rivers came from each fishery area. The lack of significant correlation may be explained by the obscuring effect of differing elver abundance among regions within the larger Scotia-Fundy area and by the possibility that catchability by dip-net may decrease with increasing river size. In 1996, the elver run to the East River, Chester (SSNS) was estimated at 1,120,000 elvers (Jessop 1996d). A run density of 8,400 elvers·km^{-2} of river drainage area for the East River, Chester (drainage area = 134 km^2) and of 640 elvers·km^{-2} for the East River, Sheet Harbour (ESNS; drainage area = 526 km^2) is consistent with the observed differences in geographic distribution of elver catch by the commercial fishery and with absence of a positive proportional relation between elver run size and river drainage area. Elvers were captured by Irish-style elver traps (O'Leary 1971) on each bank immediately downstream of a 3-m-high, vertical-face concrete barrier dam located at the head of tide on the East River, Sheet Harbour and downstream of a waterfall on the East River, Chester. These obstructions are believed to be virtually complete barriers to elver upstream migration during the run (Jessop 1995; Jessop 1996d). The hypothesis that elver run size within a geographic region may be proportional to river size has not yet been examined.

Estimation of regional elver abundance based on fishery catch and CPUE or on estimates of stream run size assume that most elvers enter freshwater or at least the upper estuary. The proportion of elvers that become estuarine rather than freshwater resident and the role of intra-annual, seasonal migration between river and estuary (Jessop 1987) is unknown. Substantial estuarine stocks have been fished in Nova Scotia and Prince Edward Island and estuarine/marine residence for eels is well known (Tesch 1977; Helfman et al. 1987).

In the northeastern portion of their range, elver runs typically experience several (2-5) modes or waves of daily immigration of varying magnitude (Groom 1975; Hutchison 1981; Martin 1995; Jessop 1996d). Elvers may appear in estuaries several weeks (Jessop 1996d) or even months (Haro and

Krueger 1988) prior to entering rivers. Both mean length and weight of American elvers increase with increasing latitude along the Atlantic coast such that elvers from the Scotia-Fundy area are smaller than elvers from the north shore of the Gulf of St. Lawrence (Haro and Krueger 1988; Dutil et al. 1989; Jessop 1996d). Elver mean length and weight decline slowly throughout the run although length may increase for a short time during the start of the run and growth may become evident near the end of the run (Haro and Krueger 1988; Jessop 1996d; Jessop unpublished data). Length declined about 3.5 mm (5%) and weight about 0.05 g (26%) over the 1996 run to the East River, Chester. Mean lengths and weights (and condition factors) of elvers were significantly smaller ($P < 0.001$) in the East River, Sheet Harbour (61.49 mm, 0.159 g) than in the East River, Chester (62.24 mm, 0.179 g) in 1996. Elver size may also vary significantly among years (Haro and Krueger 1988; Jessop unpublished data). For example, in the East River, Sheet Harbour, mean elver lengths ranged from 56.57 mm (95% CI ± 0.012 mm) in 1990 to 61.49 mm (95% CI ± 0.30 mm) in 1996 while mean weights ranged from 0.159 g (95% CI ± 0.003 g) in 1996 to 0.192 g (95% CI ± 0.003 g) in 1994.

Environmental factors such as river temperature, river level, and nighttime tide height affect daily abundance and seasonal pattern of elver migration between estuary and stream (Sorensen and Bianchini 1986; Martin 1995; Jessop 1996d). Elver daily run size on the East River, Chester, increased with increasing water temperature beyond a threshold temperature of 8-10 °C (Jessop 1996d). Daily run size initially decreased with increasing water level then increased after a lag of four days. Daily abundance lagged rising maximum nighttime tide level by three days. The relative importance of each factor may vary as run stage and hydrographic conditions change. Relations between daily elver abundance and environmental factors may differ among North American studies because of differences in the nature of the data, study conditions, etc.

The elver run to the East River, Sheet Harbour (ESNS) has annually averaged 242,500 elvers (range 101,500-376,000 elvers) between 1990 and 1996, with no obvious temporal trend:

Year	Count
1990	220,100
1991	376,000
1992	219,200
1993	134,100
1994	309,900
1995	101,500
1996	336,500

In the Gulf of St. Lawrence, relative abundance of glass eels and elvers declined along the North Shore during the early 1980s (Dutil 1989) while yellow eel densities declined in Gaspé Peninsula rivers and the upper St. Lawrence through the 1980s and early 1990s (Castonguay et al. 1994). Catches of yellow eels also have declined since the mid 1980s in the Gulf portion of New Brunswick and Nova Scotia and Prince Edward Island (Locke et al. 1995; Chaput et al. this report). Comparable declines in yellow/silver eel abundance were not observed in the Scotia-Fundy area (Jessop 1996c).

Dipnet fishing exploitation rate was estimated at about 30% for the East River, Chester (Jessop 1996d). Although the efficiency of dipnetting probably declines on large rivers (verification of this assumption may be difficult), many fishers dipnetting a specific area may have a large effect (Cantrelle 1982). The appropriateness of an elver fishery mortality rate may best be judged in the context of the total exploitation applied to eels of all ages within a stream and the natural mortality rates that they would otherwise experience. The range of exploitation rates for which compensatory biological effects such as increased survival and growth at lower elver densities may reduce the impact of an elver fishery on future instream stock size is unknown. One year survival rates for elvers in a freshwater pond ranged from 47-88% and decreased with increasing stock density (Klein Breteler 1992). Density-dependent mortality, beyond a threshold density, of elvers and young eels reduced the yield of silver eels in a small Norwegian river (Vøllestad and Jonsson 1988).

CONCLUSION

The development of a fishery for American elvers and a small amount of DFO-initiated research has recently added to our limited existing knowledge of elver biology. Rapid, but controlled, development of the present valuable elver fishery in the Scotia-Fundy area was guided primarily by the general knowledge of elver/eel fisheries elsewhere. Geographic variability in elver abundance has implications for fishery management. Annual and seasonal changes in elver length and weight are of interest to fishers because buyers may purchase either on a weight basis or by piece count, where decreasing elver weight means increased numbers per kilogram. A better understanding of the influence of environmental factors on elver distribution and arrival inshore and on migration upstream will enable fishers to become more efficient and managers to better regulate the fishery. The future success of this elver fishery will depend greatly on the continued development of regional knowledge of elver/eel biology relevant to effective fishery management and its integration within a cooperative, continental perspective to that management.

ACKNOWLEDGEMENTS

I thank J. McCleave and G. Chaput for their constructive reviews of an earlier manuscript.

REFERENCES

Cantrelle, I. 1982. Etude de la migration et de la pêche de civelles (*Anguilla anguilla* L. 1758) dans l'estuaire de la Gironde. Thèse Doct. 3e cycle. Univ. Paris VI. 237 p.

Castonguay, M., P. V. Hodson, C. M. Couillard, M. J. Eckersley, J.-D. Dutil, and G. Verreault. 1994. Why is recruitment of the American eel, *Anguilla rostrata*, declining in the St. Lawrence River and Gulf? Can. J. Fish. Aquat. Sci. 51: 479-488.

Chaput, G., A. Locke, and D. Cairns. 1997. Status of American eel (*Anguilla rostrata*) from the southern Gulf of St. Lawrence, p. 69-93. *In* R. H. Peterson. (ed.) The American eel in eastern Canada: stock status and management strategies. Proceedings of Eel Management Workshop, January 13-14, 1997, Quebec City, PQ. Can. Tech. Rep. Fish. Aquat. Sci. 2196.

Cushing, D. H. 1975. Marine ecology and fisheries. Cambridge Univ. Press. Cambridge. 278 p.

Dekker, W. 1986. Regional variation in glass eel catches an evaluation of multiple sample sites. Vie Milieu 36: 251-254.

De Leo, G. A., and M. Gatto. 1995. A size and age-structured model of the European eel (*Anguilla anguilla* L.). Can. J. Fish. Aquat. Sci. 52: 1351-1367.

Dutil, J.-D., M. Michaud, and A. Giroux. 1989. Seasonal and diel patterns of stream invasion by American eels (*Anguilla rostrata*) in the northern Gulf of St. Lawrence. Can. J. Zool. 67: 182-188.

Fahay, M. P. 1978. Biological and fisheries data on American eel, *Anguilla rostrata* (LeSueur). Northeast Fisheries Center, Nat. Mar. Fish. Serv., Tech. Ser. Rep. 17: 77 p.

Gousset, B. 1990. European eel (*Anguilla anguilla* L.) farming technologies in Europe and in Japan: application of a comparative analysis. Aquaculture 87: 209-235.

Groom, W. 1975. Elver observations in New Brunswick's Bay of Fundy Region. Res. Develop. Br., N.B. Dept. Fish., Fredericton. 156 p.

Heinsbroek, L. T. N. 1991. A review of eel culture in Japan and Europe. Aquacult. Fish. Mgmt. 22: 57-72.

Helfman, G. S., D. E. Facey, L. S. Hales, Jr., and E. L. Bozeman, Jr. 1987. Reproductive ecology of the American eel. Am. Fish. Soc. Symp. 1: 42-56.

Hilborn, R., and C. J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics and uncertainty. Chapman and Hall. London. 570 p.

Hutchison, S. 1981. Upstream migration of the glass-eel (*Anguilla rostrata*) in Nova Scotia-1981. N.S. Dept. Fish., Man. Tech. Rep. Ser. 81-02. 41 p.

Jessop, B. M. 1982. A review of the status and management of commercial fisheries for American eels (*Anguilla rostrata*) in the Maritime Provinces. p. 28-31. *In* K. H.

Loftus (ed.) Proc. N. Amer. Eel Conf., Ont. Min. Nat. Res., Ont. Fish. Tech. Rep. 4.

Jessop, B. M. 1987. Migrating American eels in Nova Scotia. Trans. Am. Fish. Soc. 116: 161-170.

Jessop, B. M. 1995a. Justification for, and status of, American eel elver fisheries in Scotia-Fundy Region. DFO Atl. Fish. Res. Doc. 95/2. 10 p.

Jessop, B. M. 1995b. *Ichthyophthirius multifiliis* in elvers and small American eels from the East River, Nova Scotia. J. Aquat. Anim. Health 7: 54-57.

Jessop, B. M. 1996a. Review of the American eel elver fisheries in Scotia-Fundy area, Maritimes Region. DFO Atl. Fish. Res. Doc. 96/04. 7 p.

Jessop, B. M. 1996b. The management of, and fishery for, American eel elvers in the Maritime Provinces, Canada. Presented EIFAC/ICES Joint Working Group on Eel, Ijmuiden, The Netherlands, 23-27 Sept.

Jessop, B. M. 1996c. The status of American eels *Anguilla rostrata* in the Scotia-Fundy area of the Maritime Region as indicated by catch and license statistics. DFO Atl. Fish. Res. Doc. 96/118. 15 p.

Jessop, B. M. 1996d. The biological characteristics of, and efficiency of dip-net fishing for, American eel elvers in the East River, Chester, Nova Scotia. Rep. Joint Proj. Agreem. Elver Fish. Study, F286-5-0418.

Jessop, B. M. 1997. An overview of European and American eel stocks, fisheries, and management issues, p. 6-20. In R. Peterson (ed.) The American eel in eastern Canada: stock status and management strategies. Proceedings of Eel Management Workshop, January 13-14, 1997, Quebec City, PQ. Can. Tech. Rep. Fish. Aquat. Sci. 2196.

Klein Breteler, J. G. P. 1992. Effect of provenance and density on growth and survival of glass eels *Anguilla anguilla* (L.) in mesocosm experiments. p. 15-22. *In* Moriarty, C. (ed.) Irish Fish. Invest., Series A (Freshwater), No. 36. 152 p.

Krueger, W. K., and K. Oliveira. 1997. Sex, size and gonad morphology of silver American eels *Anguilla rostrata*. Copeia 2: 415-420.

Lauzier, L. M. 1967. Bottom residual drift on the Continental Shelf area of the Canadian Atlantic coast. J. Fish. Res. Board Can. 24: 1845-1858.

Locke, A., R. Claytor, C. LeBlanc, and G. Chaput. 1995. Status of American eels, *Anguilla rostrata*, in the Gulf Region. DFO Atl. Fish. Res. Doc. 95/79. 40 p.

Martin, M. H. 1995. The effects of temperature, river flow, and tidal cycles on the onset of glass eel and elver migration into fresh water in the American eel. J. Fish Biol. 46: 891-902.

McCleave, J. D. 1987. Migration of *Anguilla* in the ocean: signposts for adults! Signposts for leptocephali? p. 102-107 *In* W.F. Herrnkind and A. B. Thistle [ed.] Signposts in the sea. Florida State Univ., Tallahassee, Fla.

McCleave, J. D. 1995. Testimony presented to the Committee on Marine Resources re: H.P. 137, An act to restrict the taking of eels less than 6 inches in length from Maine coastal waters (emergency). 13 p.

Moriarty, C. 1990. European catches of elver of 1928-1988. Int. Revue ges. Hydrobiol. 75: 701-706.

O'Leary, D. P. 1971. A low head elver trap developed for use in Irish rivers. p. 129-133. *In* C. J. McGrath (ed.). EIFAC Tech. Pap. 14.

Sorensen, P. W., and M. L. Bianchini. 1986. Environmental correlates of the freshwater migration of elvers of the American eel in a Rhode Island brook. Trans. Am. Fish. Soc. 115: 258-268.

Tesch, F.-W. 1977. The eel: biology and management of anguillid eels. Chapman and Hall. London. 434 p.

Vøllestad, L. A., and B. Jonsson. 1988. A 13-year study of the population dynamics and growth of the European eel *Anguilla anguilla* in a Norwegian river: evidence for density-dependent mortality, and development of a model for predicting yield. J. Anim. Ecol. 57: 983-997.

Table 1. Annual catch (kg) of American eel elvers in Scotia-Fundy area, by province, and number of licenses issued 1989-1996.

Year	New Brunswick	Nova Scotia	Total Catch	Number of Licenses
1989	0	26	26	2
1990	132	42	174	2
1991	65	0	65	2
1992	227	0	227	3
1993	534	179	713	3
1994	650	924	1,574	4
1995	549	2,689	3,238	7
1996	449	2,413	2,862	9

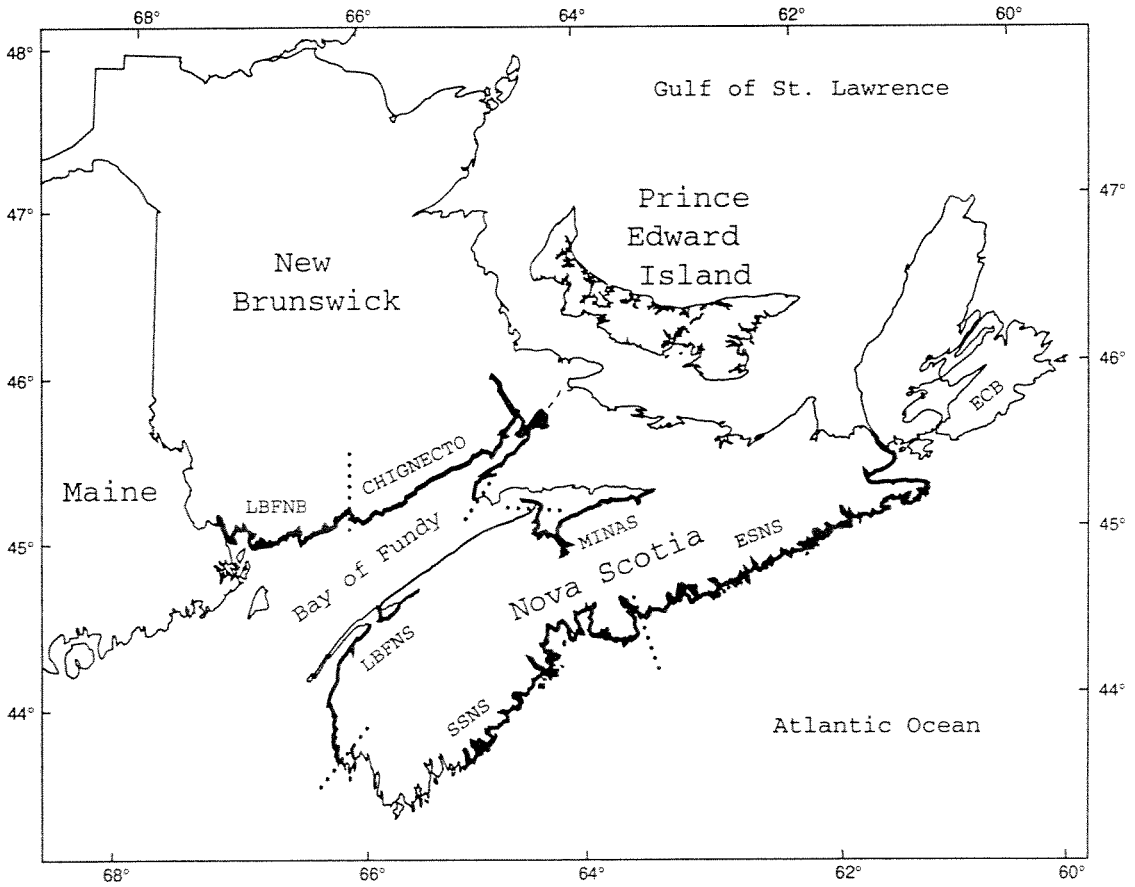


Figure 1. Map of the Maritime Provinces with boundaries of the geographic areas where fisheries for American eel elvers occur, 1996.

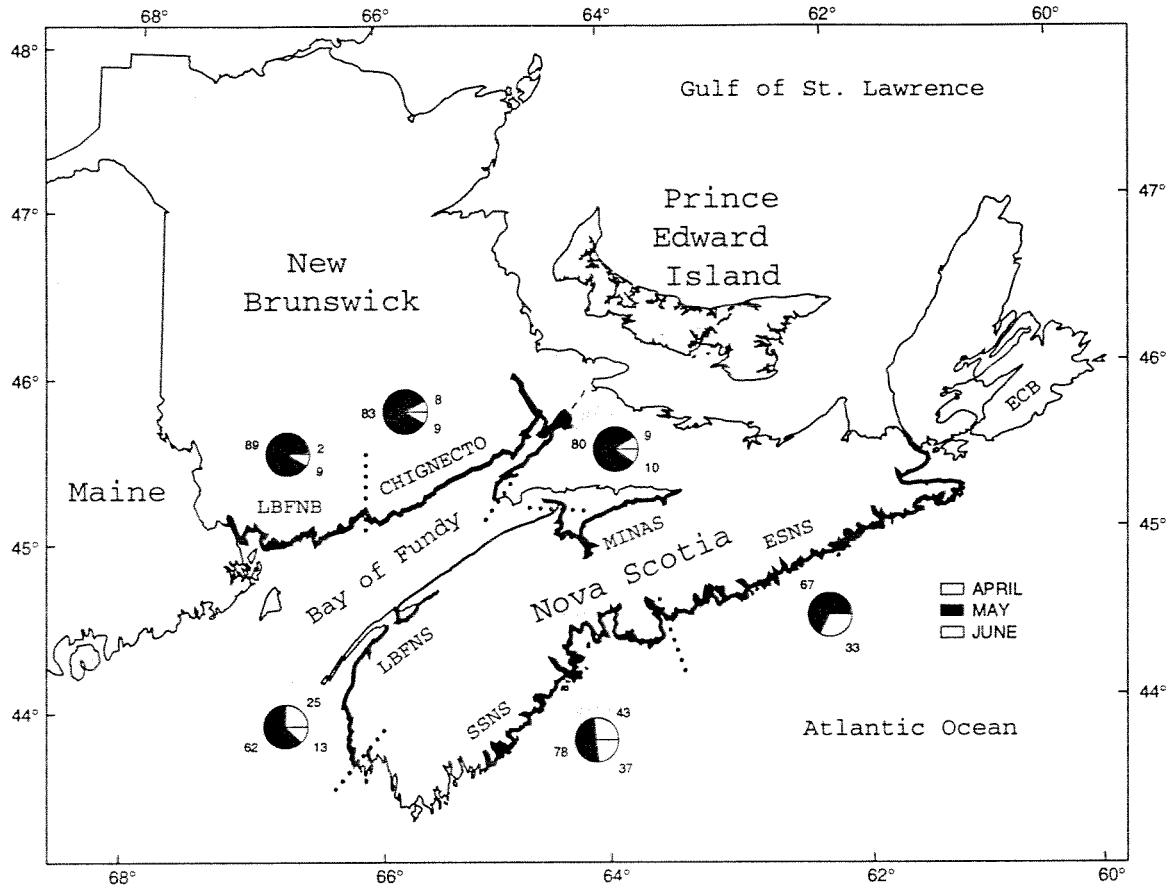


Figure 2. Weighted mean of monthly percentages of total catch (kg) of American eel elvers, by geographic area, for the years 1994-1996 (except CHIGNECTO and ESNS areas which have data only for 1995-1996).

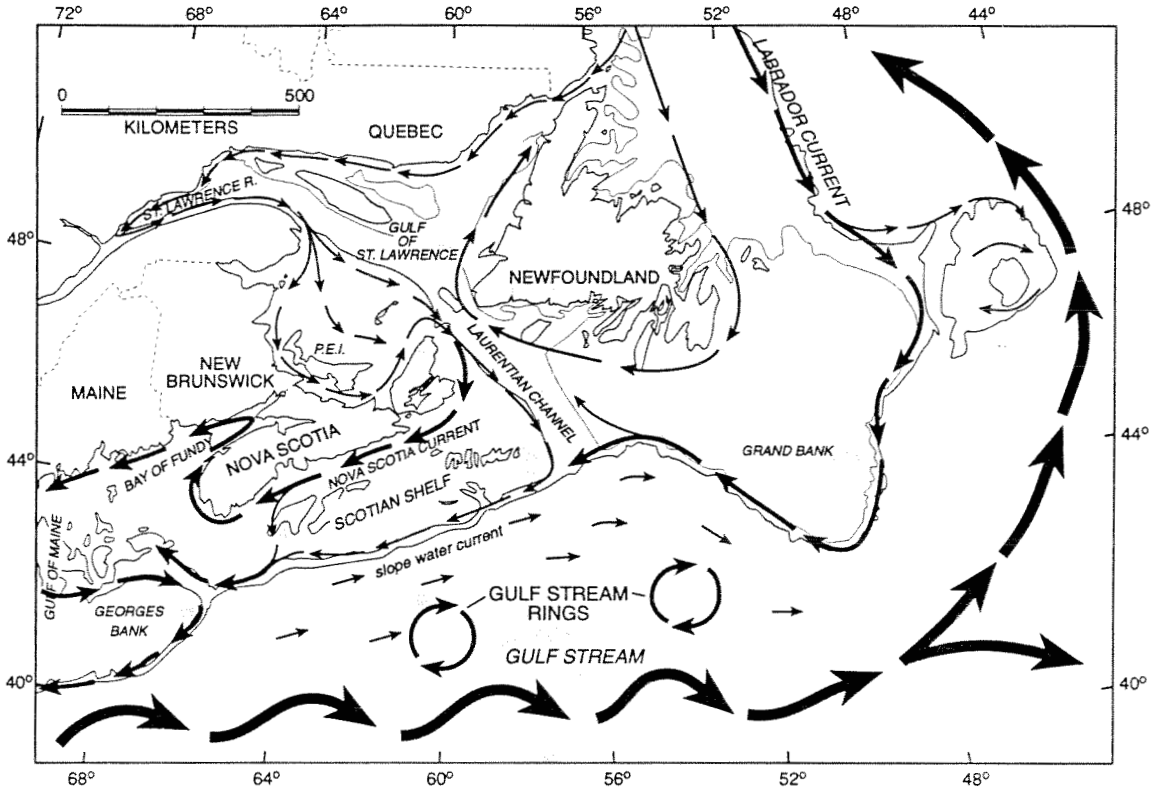


Figure 3. Map of Atlantic Canada showing the major oceanographic surface currents and bottom features within the continental shelf.

Le Réseau Sentinelle de l'Anguille

par

F. Caron
Ministère de l'Environnement et de la Faune du Québec
150 Rene-Levesque
5e' etage, Quebec, Quebec G1R 4Y1

et

Guy Verreault
Ministère de l'Environnement et de la Faune
506 Lafontaine
Riviere du-Loup, PQ GsR 3C4

INTRODUCTION

L'anguille d'Amérique (*Anguilla rostrata*) et l'anguille d'Europe (*Anguilla anguilla*) connaissent une popularité croissante au moment où plusieurs indices de déclin se font sentir. Étant donné que ces deux espèces catadromes se reproduisent dans la mer des Sargasses, il se pourrait que des causes communes affectent les deux espèces.

Au Québec, le déclin de la pêcherie d'anguilles argentées et l'indice de recrutement en provenance de la passe migratoire du barrage hydroélectrique de Cornwall font craindre que nous assistions actuellement à un problème durant l'engraissement dans nos cours d'eaux?

Pour pouvoir répondre à cette question, il faudrait avoir en place un système d'évaluation pour le recrutement des civelles et pour les échappements de géniteurs, systèmes qui ne sont pas en place actuellement.

Au cours des dernières années, des tentatives d'évaluation de recrutement ont été menées sur les rivières Rimouski, Petit-Saguenay, du Sud-Ouest, de la Trinité et Bec-Scie. Les données de 1996, pour ces trois dernières rivières, sont présentées ainsi que quelques comparaisons avec les observations faites antérieurement.

INTRODUCTION

The popularity of the American eel (*Anguilla rostrata*) and the European eel (*Anguilla anguilla*) is on the rise at a time when there are a number of indicators of a decline in stocks. Given the fact that these two catadromous species reproduce in the Sargasso Sea, there could be common causes affecting both species.

In Quebec, the decline of the silver eel fishery and the index of recruitment from the fish ladder at the Cornwall hydroelectric dam have led to fears that there is a problem during the feeding stage in our waterways.

To answer this question, elver recruitment and spawner escapement assessment systems that currently do not exist would have to be put in place.

Over the last few years, attempts to evaluate recruitments have been made on the Rimouski, Little Saguenay, Sud-Ouest, de la Trinité and Bec-Scie rivers. The 1996 data for the last three rivers are presented as well as a few comparisons with earlier observations.

MATÉRIEL ET MÉTHODE

La méthodologie utilisée sur les rivières de la Trinité et Bec-Scie n'a pas subi de modifications significatives en 1996 (Raymond et Tremblay 1995 et 1996). Dans les deux cas, elle reprend des travaux qui permettent d'avoir une série de données, étalée sur plusieurs années. Les données présentent des indices relatifs d'abondance, sans prétendre fournir des valeurs absolues de recrutement.

Sur la Petite rivière de la Trinité (figure 1), le protocole s'inspire des travaux que Dutil a réalisés de 1981 à 1985. Des décomptes d'anguillettes qui franchissent une cascade se font trois fois par nuit (21 h 00, 22 h 00 et 23 h 00) de 10 à 12 reprises annuellement. Des échantillonnages de tailles sont aussi faits à quelques reprises durant la saison.

Sur la rivière Bec-Scie (figure 2), il s'agit de d'inventaires de 16 stations de pêche à l'électricité, effectués pour le saumon atlantique (*Salmo salar*) juvénile depuis 1988, et poursuivis spécifiquement pour l'anguille depuis 1994. Les stations sont pêchées à trois reprises ou plus, de manière à estimer la densité totale d'anguille dans la station déchantillonnage.

Sur la rivière du Sud-Ouest, une passe migratoire munie d'un piège de dénombrement a été installée sur une chute d'environ cinq mètres, que les anguillettes doivent habituellement franchir sur des parois verticales. Un obstacle a été installé sur cette parois, de mainière à forcer les anguillettes à utiliser la passe migratoire.

RÉSULTATS

Sur la Petite rivière de la Trinité, la montaison d'anguillettes a débuté tôt (fin juin). Toutefois, une crue importante vers la mi-juillet a complètement arrêté la migration pour plueieurs jours après quoi, la montaison a repris pour se poursuivre jusqu'à la fin août (figure 3). Pour l'ensemble de la saison, on observe 48 % des anguilles au décompte de 22 h 00, 36 % à 23 h 00 et 16 % à 21 h 00 (tableau 1).

Au total, le nombre d'antuilles observées a été de 5658, ce qui est le total le plus élevé des sept années pour lesquelles nous possédons des données depuis 1982 (tableau 2). Les 1402 anguilles de la

nuit du 2 juillet représentent également le comptage quotidien le plus élevé depuis le début de ces travaux (tableau 3).

Cette migration se compose principalement d'anguillettes de moins de 100 mm, ce qui correspond à des poissons qui sont entrés en rivière l'année précédente (Dutil et al. 1989).

Sur la rivière Bec-Scie, l'inventaire s'est fait aux mêmes stations au cours des huit dernières années (tableau 4). La densité mesurées est de 14,4 anguilles par 100 m^2 pour l'ensemble des stations et de 24,8 par 100 m^2 dans le tronçon principal, soit respectivement la troisième et la deuxième meilleure année de la série (tableau 4). La densité observée sur le principal tributaire de la rivière, le ruisseau Castor, est par contre de 1,1 par 100 m^2, soit la plus faible densité observée depuis le début (tableau 5).

Les gammes de taille des anguilles récoltées sur cette rivière sont très différentes de celles de la Petite rivière de la Trinité. Les anguilles de moins de 100 mm ne représentent que 3,5 % de la population, alors que les anguilles plus grandes que 150 mm composent 80,7 % de l'échantillon (figures 5 et 6).

Sur la rivière du Sud-Ouest, la montaison d'anguillettes a débuté vers le 19 juin; les pics de montaison ont été enregistré au début juillet et la migration a été interrompue par une crue importante le 20 juillet (figure 7). À cette date, 760 anguillettes avaient emprunté la passe migratoire.

La taille des anguillettes présente une distribution normale entre les classes de 105 et 435 mm, avec un sommet à la classe de 225 mm (figure 8).

DISCUSSION

Les observations sur la Petite rivière de la Trinité, les densités de la rivière Bec-Scie et les montaisons sur la Sud-Ouest concernent des anguilles qui appartiennent principalement à des groupes d'âge différents. Sur la première, il s'agit principalement d'anguillettes qui sont à leur première ou deuxième année en rivière alors que sur la Bec-Scie et sur la Sud-Ouest, il s'agit d'anguilles qui appartiennent principalement à des groupes d'âge plus élevé.

Il n'y a pas actuellement d'indice de recrutement de civelles et il serait difficile d'en établir un à des coûts raisonnables dans de brefs délais. L'indice obtenu sur la Petite rivière de la Trinité concerne les anguillettes et est donc le plus rapproché d'un indice de recrutement. Sur les rivières Bec-Scie et du Sud-Ouest, plusieurs classe d'âge sont représenté, principalement celles des anguilles plus âgées, ce qui reflète d'avantage la situation d'anguilles vertes en engraissement.

Contrairement à ce qui a été observé à la passe migratoire de Cornwall, nos indicateurs sur la Petite rivière de la Trinité et sur la rivière Bec Scie n'indiquent pas d'affaissement des stock. L'indicateur provenant de la passe migratoire de Cornwall concerne les anguilles qui se rendent le plus loin dans le Saint-Laurent et qui sont âgées de 2 à 15 ans (Liew 1982). Malgré la valeur incontestable de cet indice pour le lac Ontario, il est loin d'être certain que ceci a un quelconque rapport avec la situation du recrutement dans nos rivières. Les anguilles qui franchissent ce barrage ont du d'abord franchir emprunter soit la voie maritime au niveau de Beauharnois ou emprunter l'ancien lit du Saint-Laurent qui est lui-même harnaché en très grande partie. Ailleurs dans les Maritimes et sur la Côte Atlantique des États Unis, il ne semble pas y avoir d'indice de baisse de recrutement.

L'an prochain, la construction d'une passe migratoire pour l'anguille sur la rivière Rimouski pourrait apporter un élément nouveau et plus stable dans le réseau, permettant vraisemblablement d'obtenir un recrutement en nombre absolue pour l'ensemble de la rivière. Toutefois, il serait prudent d'attendre les premières observations avant de fonder tous nos espoirs sur cette rivière; les espoirs déçus que nos avons eus antérieurement sur cette rivière et sur les rivières du Petit-Saguenay et du Sud-Ouest doivent nous inciter à la prudence.

Actuellement, les deux meilleurs indices proviennent de la Petite rivière de la Trinité et de la rivière Bec-Scie; elles fournissent des informations complémentaires du fait qu'elles concernent principalement pour la première des anguillettes et pour la seconde desanguilles vertes. Les deux rivières peuvent vraisemblablement nous fournir des indices utiles à la prise de décision pour la gestion de cette espèce à long terme.

Le défaut de ces deux indices provient du fait qu'elles n'offrent pas d'évaluation quantitative pour l'ensemble de leur réseau hydrographique, ce qui rend difficile leur utilisation pour des fins de comparaison avec d'autres rivières. Dans le cas de la Petite rivière de la Trinité, il faudrait faire une étude sur l'importance de la montaison,

vraisemblablement par une étude de capture-recapture. Sur la rivière Bec-Scie, on sait qu'une quantité importante d'anguille quitte la rivière au printemps pour se randre dans l'estuaire et reviennent passer l'hiver en rivière. Cers informations proviennent des observations faites lors de la dévalaison des saumonneaux, étude qui a été arrêté en 1996. Il faudrait évaluer l'intérêt soit de reprendre cette étude, soit de mettre des efforts pour mieux comprendre ce que représente la population résidentes par rapport à la population migrant au printemps dans l'estuaire de cette rivière.

Beaucoup d'autres informations font défaut sur l'anguille pour pouvoire baser la gestion de cette espèce sur des bases scientifiques. L'évaluation de la quantité d'anguilles argentées quittant la partie fluviale du Saint-Laurent et leur taux d'exploitation réalisé en 1996 est un premier pas important. Toutefois, il faudrait y ajouter plusieurs autres éléments: la provenance des adultes, les déplacements de juvéniles, l'évaluation de la production de petite et moyenne rivière pour n'en nommer que quelques-unes.

À moyen terme, il faudrait tenter d'obtenir un réseau de rivière qui offrirait un indice de recrutement et idéalement un indice de production d'anguilles adultes. À cette fin, il faudrait songer, lors de la construction ou de la réparation de passes migratoires, à doter ces équipements d'un système de comptage d'anguilles qui deviendrait autant d'indicateur de recrutement susceptible de fournir des données annuelles de base importante à peu de frais pour la prise de décision dans la gestion de cette espèce.

DISCUSSION

Observations on the Petite Rivière de la Trinité, the densities of the Bec-Scie River and the upstream migrations on the Sud-Ouest River involve eels that mainly belong to different age groups. Observations on the first river mainly involve little eels that are spending their first or second year in the river while eels in other rivers belong for the most part to older age groups.

There is currently no index of recruitment for elvers and it would be difficult to establish one at a reasonable cost within a short time. The index obtained on the Petite Rivière de la Trinité is for little eels and comes closest to an index of recruitment. On the Bec-Scie and Sud-Ouest Rivers, several ages classes are represented, mainly older eels, so that the data reflects more closely the situation of green eels in the feeding stage.

Contrary to what has been observed at the Cornwall fish ladder, our indicators for the Petite rivière de la Trinité and the Bec-Scie River do not indicate any stock collapse. The indicator from the Cornwall fish ladder concerns eels that go the farthest up the St. Lawrence and that are between 2 and 15 years old (Liew 1982). In spite of the incontrovertible value of this index for Lake Ontario, it is far from certain that this is connected in any way to recruitment in our rivers. The eels ascending the dam's fish ladder first had to travel up the Seaway around Beauharnois or the old bed of the St. Lawrence which has also in large part been harnessed for hydroelectricity. Elsewhere, in the Maritimes and on the Eastern Seaboard of the United States, there does not seem to be any drop in the index of recruitment.

Next year, the construction of a fish ladder on the Rimouski River could bring a new and more stable element to the system, which would probably enable us to obtain absolute recruitment figures for the whole river. However, it would be prudent to wait for the initial observations before pinning all our hopes on this river, especially given the disappointments we have previously experienced on this river and the Little Saguenay and Sud-Ouest Rivers.

Currently, the two best indices come from the Petite Rivière de la Trinité and the Bec-Scie River and provide complementary information. For the first river, they involve primarily little eels and, for the second, green eels. The two rivers may be able to provide us with indices useful in making decisions concerning long-term management of this species.

The drawback of these two indices is that they do not provide a quantitative assessment for the watershed as a whole, which makes it difficult to use them for comparison purposes with other rivers. In the case of the Petite Rivière de la Trinité, a study should be done on the extent of upstream migration, likely by means of a mark-release-recapture study. On the Bec-Scie River, we know that a significant number of eels leave the river in the spring for the estuary and return to winter in the river. This information comes from observations made during the downstream migration of salmon smolt, a study which was stopped in 1996. An assessment should be done on whether this study should be resumed or whether efforts should be made to gain a better

understanding of what constitutes the resident population compared to the population that migrates to the river estuary in the spring.

There is insufficient information on eels to constitute a scientific basis for the management of this species. The assessment of the number of silver eels leaving the riverine part of the St. Lawrence and the 1996 exploitation rate is an important first step. However, a number of other elements are required for management purposes, such as the origin of the adults, juvenile movements, and assessment of the production of small and medium rivers.

In the middle term, efforts would have to be made to obtain a river system that could provide an index of recruitment and, ideally, a index of adult eel production. This must be kept in mind when constructing or repairing fish ladders so that eel counting equipment can be installed not only to provide recruitment indicators but also to obtain important basic annual data at little cost for making management decisions concerning this species.

RÉFÉRENCES

Dutil, J. D., B. Légaré, et C. Desjardins. 1985. Discrimination d'un stock de poisson, l'anguille (*Anguilla rostrata*), basée sur le présence d'un produit chimique de synthèse, le mirex. Can. J. Fish. Aquat. Sci. 42: 455-458.

Dutil, J. D., M. Michaud, and A. Giroux. 1989. Seasonal and diel patterns of stream invasion by American eels (*Anguilla rostrata*) in the northern Gulf of St. Lawrence. Can. J. Zool. 67: 182-188.

Liew, P. K. L. 1982. Impact of an eel ladder on the upstream migration of the American eel in the St. Lawrence River: 1974-1978, p. 17-22. *In* K. H. Loftus (ed.) Proceedings of the 1980 North American Conference. Ontario Min. Nat. Res., Ont. Fish. Tech. Rep. Ser. 4: 97 p.

Raymond, C., et S. Tremblay. 1995. Rapport d'opération: Décompte des anguillettes (*Anguilla rostrata*) de la Petite rivière de la Trinite et de la rivière Petite-Saguenay en 1994. Ministère de l'Environnement et de la Faune, Direction de la faune et des habitats, Service de la faune aquatique. 413 p.

Raymond, C., et S. Tremblay. 1996. Rapport d'opération: Inventaire des anguillettes (*Anguilla rostrata*) à la pêche à l'électricité sur la rivière Bec-Scie en 1995. Ministère de l'Environnement et de la Faune, Direction de la faune et des habitats, Service de la faune aquatique. 23 p.

Robitaille, J. A., et S. Tremblay. 1994. Problématique de l'anguille d'Amérique (*Anguilla rostrata*) dans le réseau du Saint-Laurent. Ministère de l'Environnement et de la Faune, Direction de la faune et des habitats. Rapp. Tech. ix + 70 p.

Tableau 1. Nombre d'anguillettes comptées à la première chute, Petite rivière de la Trinité, 1996.

Date	Niveau	Température de l'eau (°C)	Heure d'échantillonnage 21:00	22:00	23:00	Total
06-28	40	18,0	16	367	212	595
07-02	38	20,5	121	755	526	1 402
07-06	46	14,9	9	50	45	104
07-10	55	14,8	4	18	19	41
07-14	42	20,6	114	508	450	1 072
07-18	60	20,5	12	103	48	163
07-22	70	14,5				**crue**
07-26	70	17,2				**crue**
07-31	60	20,2	82	181	126	389
08-04	51	21,0	230	324	266	820
08-08	45	22,4	151	235	232	618
08-12	38	18,8	68	86	63	217
08-16	36	17,2	49	50	27	126
08-20	33	18,9	30	44	37	111
Total			886 (16%)	2 721 (48%)	2 051 (36%)	5 658 (100%)

Tableau 2. Décompte d'anguilllettes et indice de recrutement, Petite rivière de la Trinité, pour 1982 à 1985 et 1993 à 1996.

Année	Nombre de décompte	Capture	< 100 mm %	100 à 150 mm %	> 150 mm %
1982	10	4 576	57,3	20,6	22,1
1983	10	4 389	54,1	18,8	27,1
1984	10	1 046	34,1	35,8	30,1
1985	10	1 117	22,1	25,9	52,0
1993	10	3 681	23,0	8,7	68,3
1994	11	763	24,6	39,4	36,0
1995	11	4 047	53,5	31,1	15,4
1996	12	5 658	39,6	24,4	36,0

1993 et 1996 : échantillonnage effectué 10 jours après le pic de la dévalaison

Tableau 3. Nombre et pourcentage d'anguilles par période, Petite rivière de la Trinité, 1993 à 1996.

Date des décomptes par période

Année	1				2				3			4			Total
	Juin	Juillet								Août					
1993				10	14	18	22	26	30	3	7	11	15		10
1994			6	10	14	18	22	26	30	3	7	11	15		11
1995		3	7	11	15	19	23	27	31	4	8	12			11
1996	28	2	6	10	14	18			31	4	8	12	16	20	12

Nombre d'anguilles par période

Année	1				2				3			4			Total
	Juin	Juillet								Août					
1993				1 203	575	358	163	475	335	328	160	9	75		3 681
1994			32	49	48	185	116	154	97	35	20	9	18		763
1995		138	1 135	682	602	181	263	257	334	234	84	137			4 047
1996	595	1 402	104	41	1 072	163			389	820	618	217	126	111	5 658

Total du nombre d'anguilles par période

Année	1	2	3	4	Total
1993	1 203	1 571	823	84	3 681
1994	81	503	152	27	763
1995	1 955	1 303	652	137	4 047
1996	2 142	1 235	1 827	454	5 658

% du nombre d'anguilles par période

Année	1	2	3	4	Total
1993	32,7	42,7	22,4	2,3	100
1994	10,6	65,9	19,9	3,5	100
1995	48,3	32,2	16,1	3,4	100
1996	37,9	21,8	32,3	8,0	100

Tableau 4. Dénombrement des anguilles à la pêche à l'électricité, rivière Bec-Scie 1988, 1989, 1991, 1992, 1994, 1995 et 1996 (1) (2)

		Nombre d'anguilles						
Station	No	1988	1989	1991	1992	1994	1995	1996
				Ruisseau Castor				
BA	125	20	3	0	3	1	1	2
ME	121	7	6	5	1	3	2	0
SE	118	10	2	0	0	1	1	0
ME	115	7	6	0	2	2	6	1
SE	112	10	3	4	1	1	2	1
CH	111	11	0	0	0	3	0	1
ME	109	10	5	10	3	2	3	3
Sous-total		**75**	**25**	**19**	**10**	**13**	**15**	**8**
				Rivière Bec-Scie				
SE	49	(100)	(50)	(40)	(30)	137 (125)	35 (30)	69
SE	44-1	(20)	(50)	(20)	14	34 (30)	8	34
SE	44-2	12	0	15	10	15	9	4
SE	41	5	7	(30)	5	0	5	5
SE	38	15	18	10	6	11	7	11
CH	23	5	2	5	1	1	2	1
SE	22	25	6	8	5	19	16	70
SE	2	6	4	3	1	12	5	13
CH	1	12	6	6	5	12	8	16
Sous-total		**200**	**143**	**137**	**77**	**241** (225)	**95** (90)	**223**
Total		**275**	**168**	**156**	**87**	**254** (238)	**110** (105)	**231**

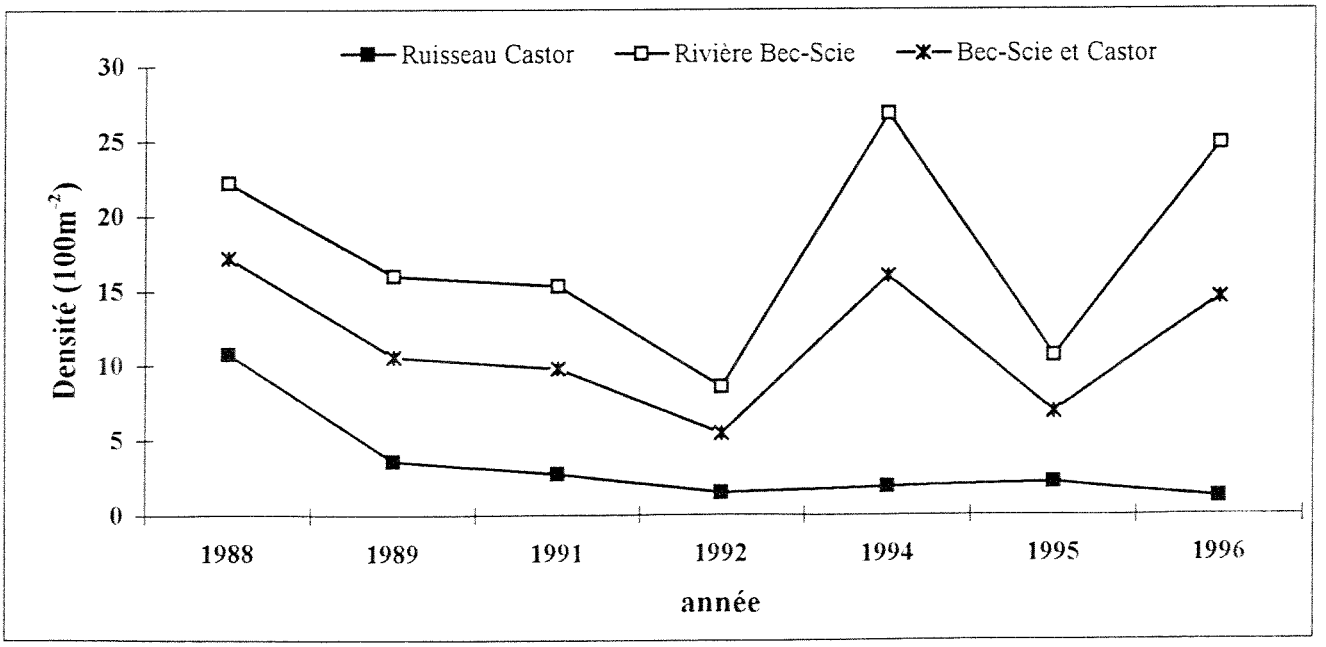
Remarque : Le nombre entre les parenthèses est une estimation ; en 1988 , plus de 100 anguilles ont été dénombrées à la station 49.

(1) En 1990, un inventaire en station ouverte a été effectué mais les données sont incomplètes pour les anguilles. Nous avons éliminé cette année de l'analyse.

(2) En 1993, aucun inventaire n'a été réalisé compte tenu des niveaux d'eau trop élevés.

Tableau 5. Densité relative des anguilles (100 m^{-2})calculée sur la rivière Bec-Scie et le ruisseau Castor de 1988 à 1996.

	Année d'échantillonnage						
	1988	1989	1991	1992	1994	1995	1996
Ruisseau Castor	10,7	3,6	2,7	1,4	1,9	2,1	1,1
Rivère Bec-Scie	22,2	15,9	15,2	8,4	26,8	10,6	24,8
Total	17,2	10,5	9,8	5,4	15,9	6,9	14,4



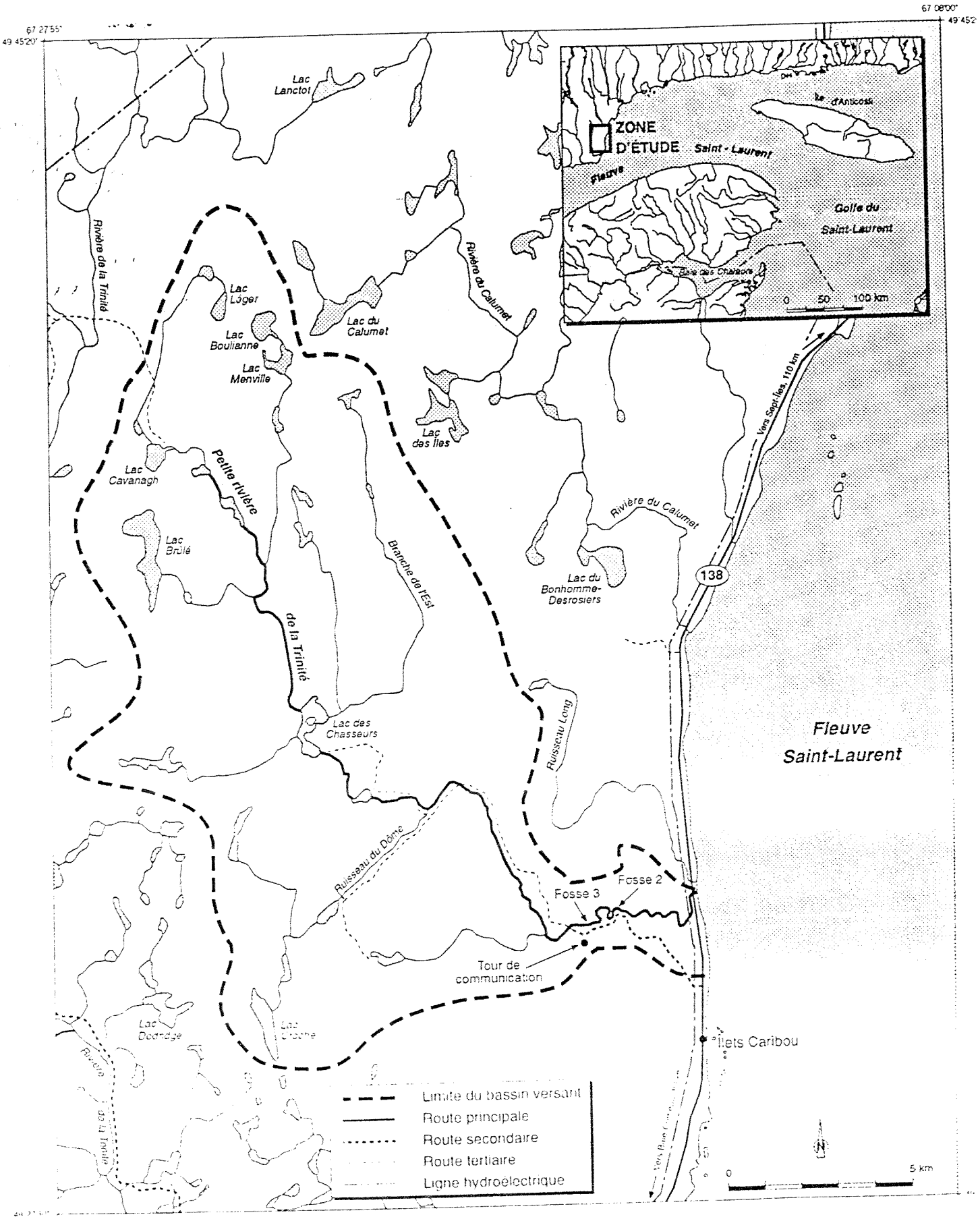


Figure 1. Localisation de la zone d'étude et bassin de drainage de la Petite rivière de la Trinité

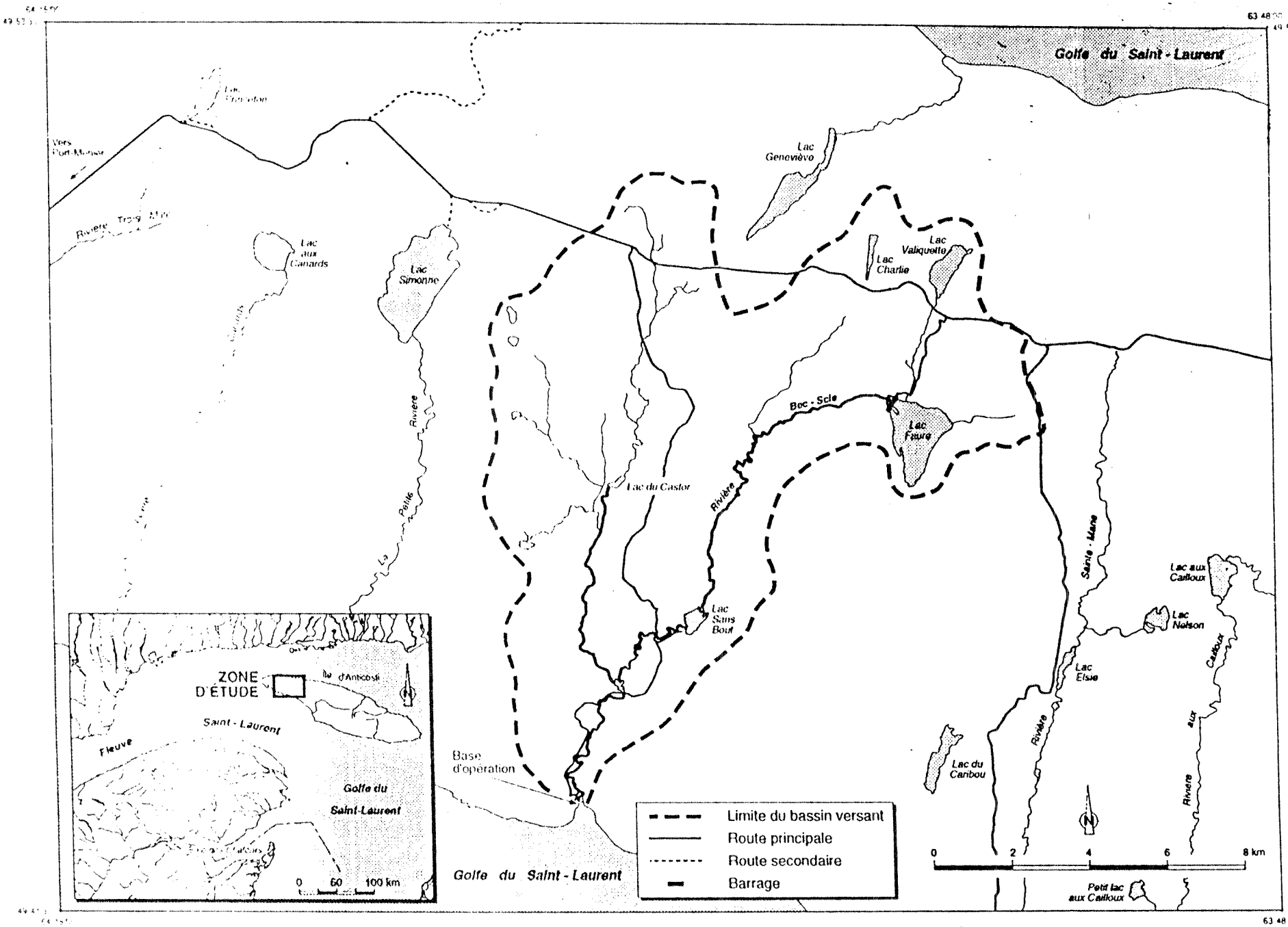


Fig. 2. Localisation de la zone d'étude et bassin de drainage de la rivière de la Bec-Scie.

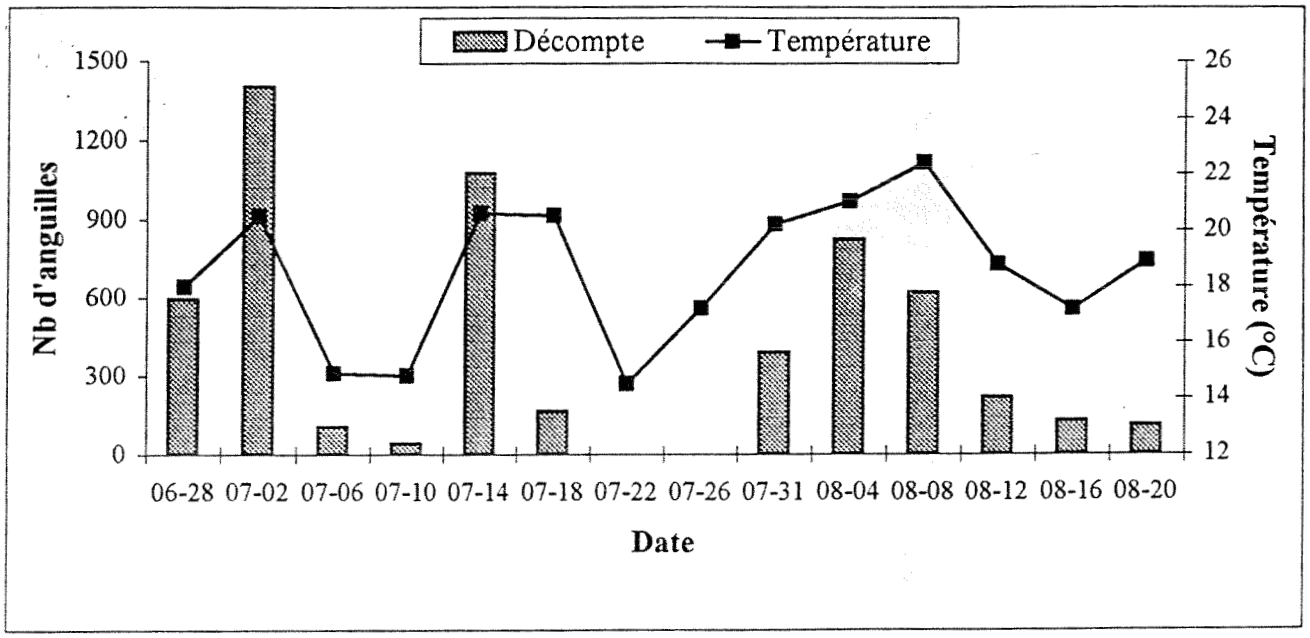


Figure 3. Diagramme de dispersion du nombre d'anguillettes comptées et de la température de l'eau à 21 h 00, Petite rivière de la Trinité, 1996.

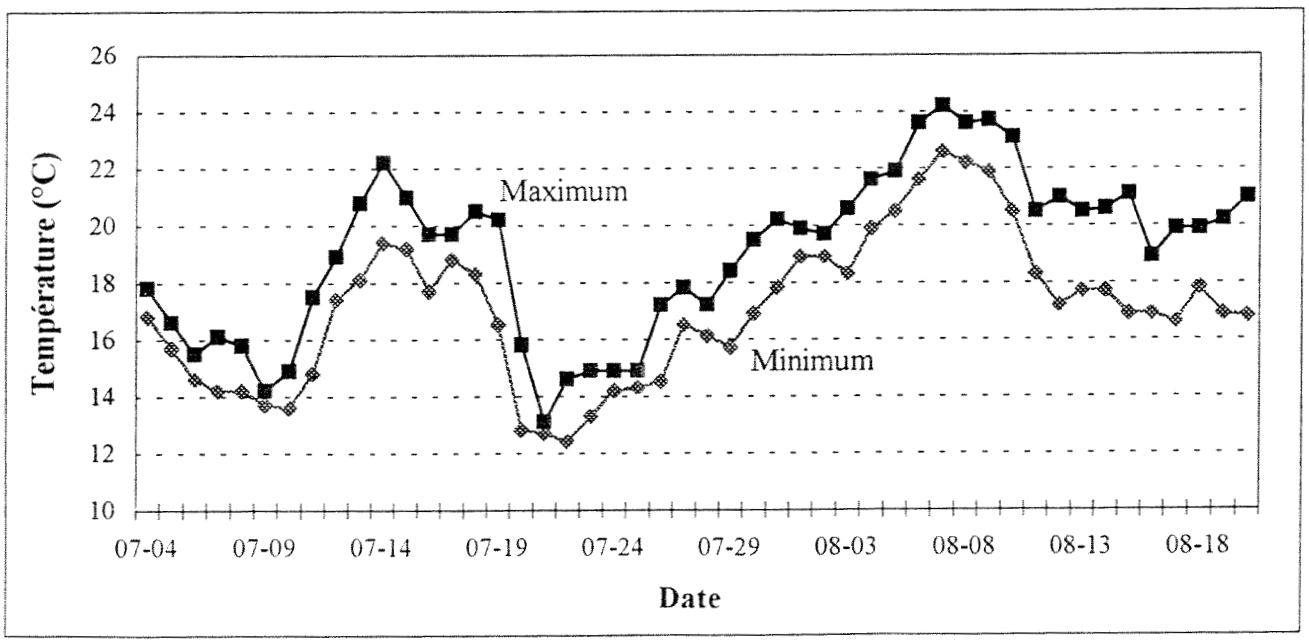


Figure 4. Minimum et maximum journalier de la température de l'eau, Petite rivière de la Trinité, 1996.

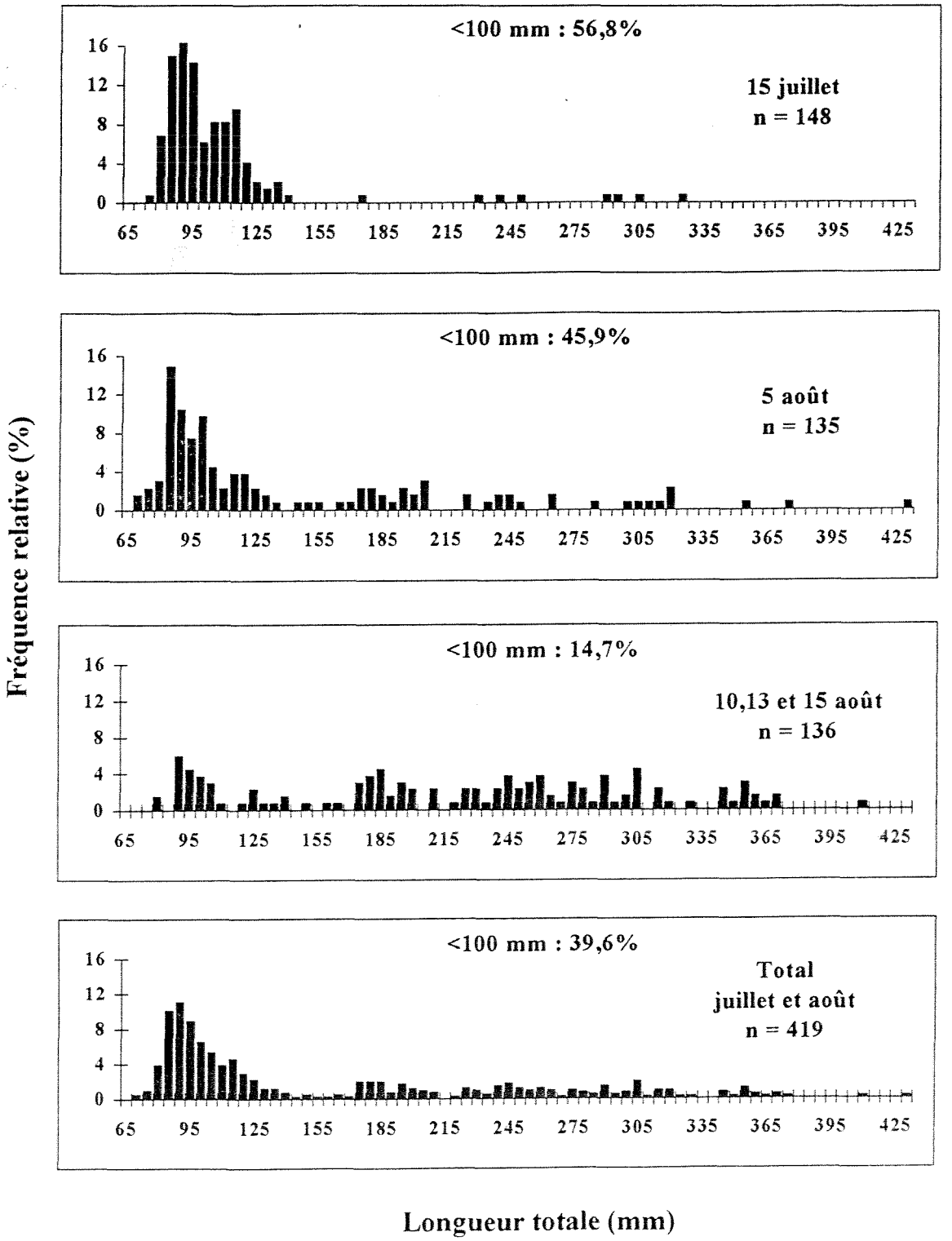


Figure 5. Distribution des fréquences de longueur des anguillettes pour chaque période d'échantillonnage, Petite rivière de la Trinité, 1996.

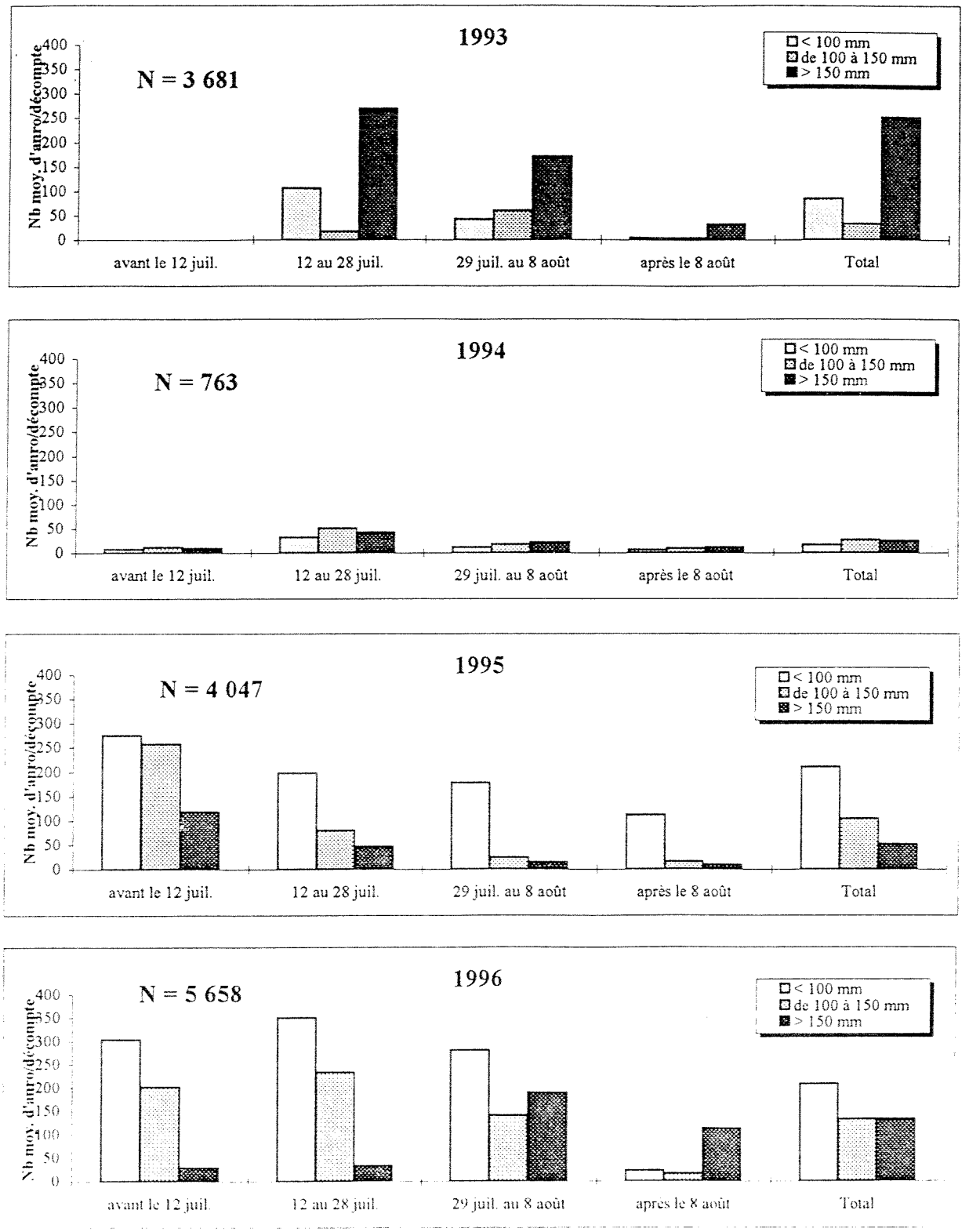


Figure 6. Nombre moyen d'anguille par décompte, Petite rivière de la Trinité de 1993 à 1996.

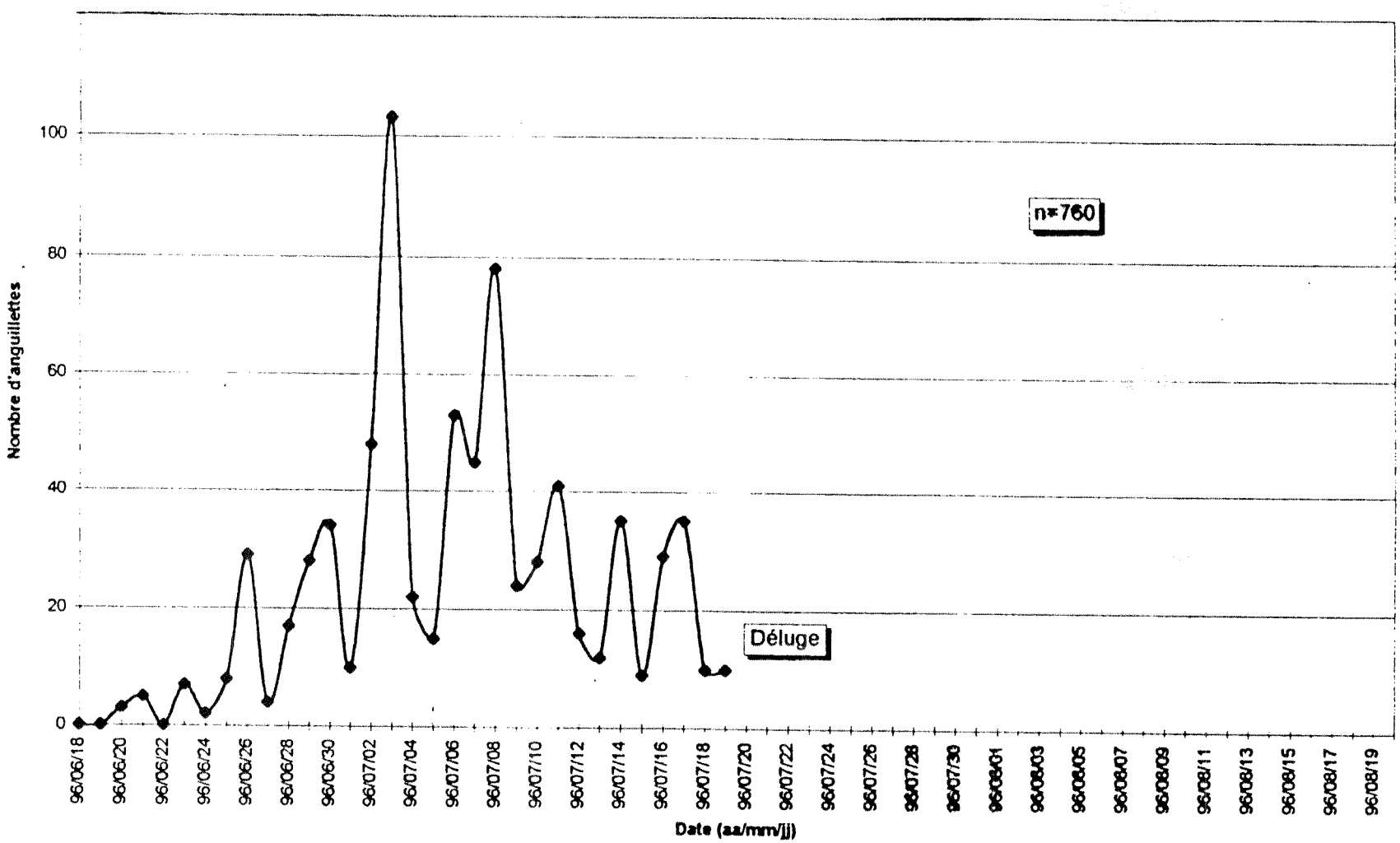


Fig. 7. Variatioon temporelle du nombre d'anguillettes sur la rivière du Sud-Ouest du 18 juin au 20 août 1996.

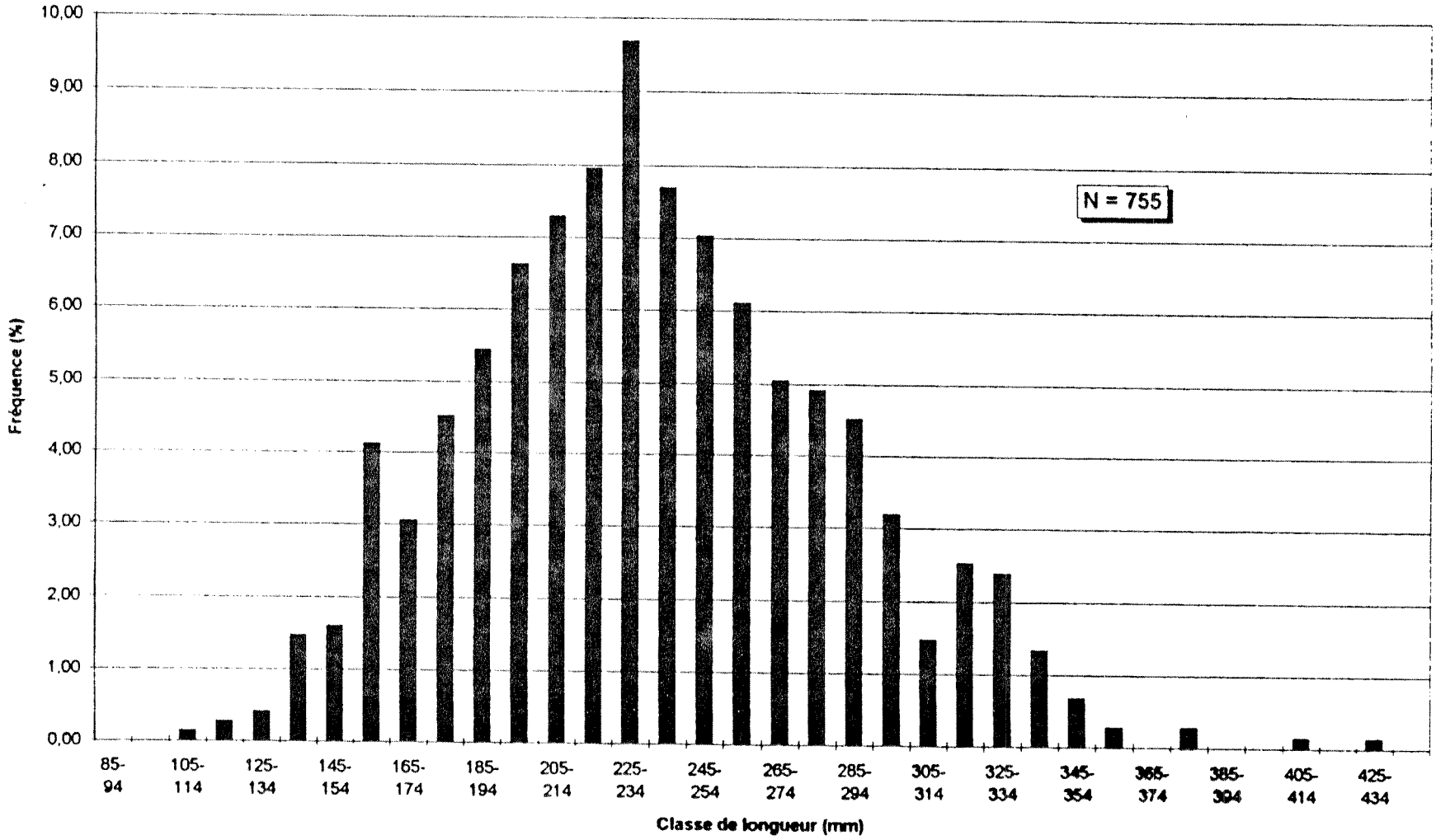


Fig. 8. Distribution des anguillettes en fonction de la longueur sur la rivière du Sud-Ouest du 18 juin au 20 août 1996.

Recruitment index for the upper St. Lawrence River and Lake Ontario eel stock: a re-examination of eel passage at the R.H. Saunders hydroelectric generating station at Cornwall, Ontario, 1974-1995

by

J. M. Casselman and L. A. Marcogliese
Ontario Ministry of Natural Resources
Science Development and Transfer Branch
Aquatic Ecosystems Science Section
Glenora Fisheries Station
R. R. 4, Picton, Ontario K0K 2T0

and

P. V. Hodson
School of Environmental Studies
Department of Biology
Queen's University
Kingston, Ontario K7L 3N6

ABSTRACT

An eel ladder was installed at the R. H. Saunders Hydroelectric Dam in 1974 and was upgraded with a more permanent structure in 1980-81. Data collected on eel passage since 1974 provide the longest, most complete index of recruitment for the species. However, operating conditions and counting strategies varied widely over the years. We evaluated daily passage to create a more comparable and quantitative index. We chose an index involving a 31-day period during peak migration, which, on average, commenced July 18 and ended August 17 (median August 2). During the peak period, daily migration was quite consistent (C.V.,x = 38.4%), accounting for the majority of the total annual passage (x = 71.5%, range 42.7-94.8%). Over the 22-yr period, abundance appeared to be cyclic, with lower passage in the mid-1970s than previously estimated. Abundance peaked at a record level in the early 1980s (1982--27,489 d^{-1}), then declined steadily and significantly after 1986. In recent years, record-low numbers have ascended the ladder; the lowest in 1993 (232 d^{-1}), a 118-fold decrease from 1982. The peak passage index of recruitment and emigration for the upper St. Lawrence River-Lake Ontario eel stock maximizes counting effort and provides a statistically more consistent index for analyzing and evaluating long-term trends and cause and effect associated with the dramatic declines in recent recruitment.

RÉSUMÉ

Une passe migratoire à anguilles a été installée au barrage hydroélectrique R.H. Saunders, en 1974; elle a été remplacée par une structure permanente en 1980-1981. Les données recueillies sur le passage de l'anguille depuis 1974 constituent l'indice de recrutement de l'espèce le plus long et le plus complet dont on dispose. Cependant, les conditions de fonctionnement et les stratégies de dénombrement ont beaucoup varié au fil des ans. Nous avons évalué le passage quotidien afin de définir un indice quantitatif et plus facilement comparable. Nous

avons choisi un indice portant sur une période de 31 jours, au moment du point culminant de la migration qui, en moyenne, commençait le 18 juillet et se terminait le 17 août (médiane, le 2 août). Pendant la période de pointe, la migration quotidienne était assez constante (C.V., x = 38,4 %), représentant la plus grande partie du passage annuel total (x = 71,5 %, échelle 42,7 — 94,8 %). Pendant la période de 22 ans, l'abondance semble cyclique, le passage ayant été plus faible au milieu des années 1970 qu'on ne l'avait d'abord évalué. Elle a atteint un sommet record au début des années 1980 (1982 – 27 489 d^{-1}), puis a diminué de manière constante et notable après 1986. Ces dernières années, le nombre d'anguilles qui escaladent la passe migratoire est plus faible que jamais, le total le plus bas ayant été celui de 1993 (232 d^{-1}) qui était 118 fois moindre qu'en 1982. L'indice maximum de passage pour le calcul du recrutement et de l'émigration dans le haut Saint-Laurent et le lac Ontario permet de maximiser l'effort de dénombrement et constitue un indice plus cohérent sur le plan statistique pour l'analyse et l'évaluation des tendances à long terme, ainsi que des causes et effets associés aux fortes baisses récentes du recrutement.

INTRODUCTION

The American eel, *Anguilla rostrata*, is a catadromous species that spawns in the Sargasso Sea (Schmidt 1925; McCleave et al. 1987). The eel leptocephali drift in the Gulf Stream, arrive along the east coast of North America, and undergo metamorphosis, and the small "glass" eels migrate into the rivers and estuaries (McCleave 1987). Over a 1- to 3-yr period, female elvers of the upper St. Lawrence River-Lake Ontario stock migrate up the St. Lawrence River (Casselman 1987) to the upper part of the river and Lake Ontario, where they reside for 8-12 yr, grow and develop, and emigrate back to the sea as maturing "yellow" or "silver" eels. In Lake Ontario, eels are an important commercial species (Stewart et al. 1997) that has been heavily exploited and accounts for one-third of the value of the commercial fish harvest.

The construction of a large hydroelectric development impounded the upper St. Lawrence River in the late 1950s. In the early 1970s, concern developed that the impounding dam at Cornwall restricted the migration of young eels into the upper St. Lawrence River and Lake Ontario. Great numbers of rather large eels were seen congregating below the dam (Whitfield and Kolenosky 1978). In 1974, a wooden ladder designed by the Ontario Ministry of Natural Resources (OMNR) was installed by Ontario Hydro at the R. H. Saunders Hydroelectric Dam (Reid 1981). This wooden prototype ladder effectively passed large numbers of eels (Whitfield and Kolenosky 1978; Eckersley 1982) for 6 yr. It deteriorated, however, and was replaced in 1980-81 by a permanent aluminum ladder (Reid 1981). From 1974 to mid-1987, OMNR personnel estimated by various observational techniques the total numbers of eels that ascended the ladder each year. An electric counter was installed in July 1987. These estimates of the annual passage of eels over a 22-yr period, 1974-95, provide the longest and most thorough annual recruitment index for juvenile eels in North America. In recent years, this index has been widely referenced (e.g., Castonguay 1994a, b) because it has documented a dramatic decline in abundance. Unfortunately, because of financial and personnel constraints, no counts were made in 1996, although the ladder functioned for 75 d.

Operating times, counting techniques, and conversion estimates varied widely over the years, so estimates of the total number of eels passed during ladder operation are not truly comparable on an annual basis. The purpose of our study was to re-examine all existing data and develop a more comparable and quantitative index of immigration and recruitment. We assume that the overall trends of any new index when compared with previous estimates will show the same general trends. We plan to refine the index by examining the period of peak migration to determine whether it would provide a more consistent standard.

MATERIALS AND METHODS

All diaries and document reports containing data on the eel ladder were obtained from the Cornwall OMNR District Office. From 1974 to mid-1987, the total number of eels ascending the ladder each year was estimated in OMNR reports (Eckersley 1982; Hendrick 1991; Hartley 1992; Bond 1994). Various protocols were used to make visual counts and extrapolate these to estimate total passage. Over the years, methods were altered to improve the estimate, and direct verification was routinely conducted. Visual counts were collected regularly for a 10-to-15-minute period several times during the day (up to 20 times on some days). Both day and night counts were made. These counts were used to estimate hourly passage, which were projected to a 24-h period and were combined to estimate the total number of eels ascending the ladder during the operating period. For detailed procedures, see the protocols referenced in the aforementioned reports.

In July 1987, an electric counter was installed and validated with visual counts (OMNR 1987). The electric counter was more accurate than the visual counts because it eliminated daily projections and provided total counts. However, anomalous counts, resulting from disruptions in flow, were sometimes detected.

Over the years, the operation of the ladder ranged widely, from 60-125 d (Eckersley 1982; Hendrick 1991; Hartley 1992; Bond 1994), but it was always operated during at least the peak migration period. Standardization was necessary to produce a consistent and comparative index. Following the procedure used by Casselman et al. (1990), we standardized total annual counts to the period of peak migration each year. Peak migration occurs usually from mid-July to mid-August, a period of maximum annual water temperature (Casselman et al. 1990). We chose a peak migration period of 31 consecutive days and estimated the mean and variance associated with daily migration during that period. It should be emphasized that this does not

provide total eel passage, but an index, although a good correlation between the two would be expected.

To calculate passage during the period of peak migration, we used daily counts. Occasionally only accumulative counts for several days were recorded. In these instances, we used the average. We determined the peak migration period, which was defined as the 31-d period in which the greatest number of eels ascended the ladder. We calculated mean eel passage, 95% confidence limits, and coefficient of variation for the period. For some years, the peak migration period could not be determined and was not used in calculating the overall peak period. In 1974, the ladder was not installed until August, and daily counts were available only after installation. In 1975, daily counts were available for only three days during July and August. For these 2 yr, we calculated mean passage by using the period of greatest accumulative passage. Daily counts could not be obtained for 1977 and 1978. For these years, we estimated the mean number of eels that passed during the peak period by regressing for all years the mean peak passage on total annual passage.

RESULTS AND DISCUSSION

Eel passage during the peak period helped standardize the recruitment and migration index for the eel ladder. Regardless of operating conditions and counting methods, the best and most thorough data were available for the peak period; often counts were recorded each day for this period. This peak migration index is much more precise and descriptive and provides more comparable quantitative data to compare with other abundance indices (Casselman et al. 1997; Marcogliese et al. unpubl. MS).

Total eel passage estimates for the ladder are really just an overall index of relative juvenile eel migration up the St. Lawrence River, because other routes must also be used at the Moses-Saunders Dam. Between the late 1950s, when the hydroelectric project was completed, and the mid-1970s, when the ladder was installed, juvenile eels continued to move up the upper St. Lawrence River and into Lake Ontario and supported a major commercial fishery (Hurley 1973). During this time, juvenile eels must have bypassed the dam by using the canal systems. American eels are known to migrate through the locks of the St. Lawrence Seaway (R. Verdon, Hydro-Québec, Montréal, QC, pers. comm.) Hence, eels have several possible immigration routes up the St. Lawrence, and until there are quantitative data, total ascent up the ladder is only a relative index of annual migration and not an absolute measure. If eel immigration could be quantified, then total ascent up the eel ladder during the entire year would be desirable. Lacking absolute measures, however, any refinement of this ladder index of passage would make it more useful and statistically powerful.

From 1976 to 1995, the mean starting and ending dates for monitoring eel passage up the ladder were June 24 and September 23—a 91-d period—but ranged from June 8 to October 14—a 129-d period (Marcogliese et al. unpubl. MS). Peak passage during this time ranged from July 3 to August 31, a period of 60 d (Table 1). Mean starting date, median date, and mean ending date for the 31-d peak period were July 18, August 2, and August 17.

The majority of eels ascended during that peak migration period, and the eels that ascended were younger (Casselman and Marcogliese, unpubl. data). For 18 of the 22 yr, peak migration accounted for an average of 71.5% of the total passage but ranged from 42.7-94.8% (Table 1). Eel passage during that time was least variable, with an average coefficient of variation of 38.4%. However, in recent years, as numbers decreased, this variation increased. The total annual estimated eel count was strongly correlated with the mean daily passage during peak migration ($P<0.001$, $r = 0.979$). The unweighted least squares linear regression was: Mean Peak Passage = 0.0207 Estimated Total Annual Passage. Although the estimates are comparable, the index of daily passage during the peak period provides a more quantitative and statistically powerful index.

The immigration of eels in 1979 and 1987 was very significantly different. The mean peak period missed a large portion of the peak migration in those years. In 1979, migration was later—August 1-31—and in 1987 was earlier—July 3-August 2. Therefore, if it is necessary to monitor this period of peak daily passage, a longer assessment period is required.– It is recommended that both July and August be monitored.

Initial estimates of total eel passage gave the impression that from the mid-1970s to the mid-1980s, eel passage was high and moderately consistent (Table 1). However, because of early operating and estimating procedures, total passage may have been overestimated during early years. The index of daily passage during the peak period suggests that when the ladder was first installed and

operated, from the mid- to late 1970s, peak passage, as a proportion of total passage, was significantly lower (1974, 1976, and 1981) than in subsequent years, especially after it peaked in the mid-1980s. Assuming that the seasonal migration pattern has been similar over the years, this evidence indicates that passage may not have been as uniformly high from the mid-1970s to the mid-1980s, as was indicated from single annual estimates of total passage. We believe numbers were lower and are better reflected by peak passage during the peak migration period, suggesting more cyclic abundance over the years, with record-high peak abundance and passage in 1982 (27,489·d^{-1}) and 1983 (26,426·d^{-1}). Nevertheless, it remains obvious that since the mid-1980s, there has been a significant and dramatic decrease in the number of eels ascending the ladder. The means and confidence intervals indicate that this significant trend in decreased passage commenced in 1986 (5,380·d^{-1}). Passage was lowest in 1993 (232·d^{-1}), a 118-fold decrease from 1982. The significant increase in 1994 is interesting, although unexplained at the present time, but probably is important in understanding the factors affecting overall abundance. Accurate age assessment of archived samples, which permits year-class recruitment chronology analysis, is required.

This index of passage during the peak period provides a useful quantitative measure that not only describes relative passage but is more consistent and comparable than total passage as previously calculated and will permit more detailed analysis and comparisons. In addition, we recommend that it is a more efficient and standard way of indexing passage with a minimum of effort. With present financial and personnel constraints, assessment of peak migration would maximize the use of diminished resources. We recommend that counting be conducted each year to provide this index. Some might like to estimate total passage as previously reported from peak passage; we calculate that the mean daily passage during the peak period multiplied by 46.3 estimates total annual passage for the mean operating conditions during 1974-95.

All agencies interested in the American eel stock should be interested in maintaining the eel ladder and associated indices, since historically the upper St. Lawrence River-Lake Ontario stock was considered to be especially important in maintaining the overall abundance of this panmictic species (Axelsen 1994; Castonguay 1994a; Casselman et al. 1997). It is essential that as many juveniles of this stock as possible be passed into the upper St. Lawrence River and Lake Ontario to maintain a strong, viable stock. In addition, this stock supports an important commercial fisheries in these areas (Casselman et al. 1997) and during emigration, this stock makes a significant contribution to the silver eel commercial fisheries in the lower St. Lawrence (Dutil et al. 1985; Castonguay 1994a; Axelsen 1997). Eel production would be enhanced if this passage were as direct and as quick as possible. Indeed, all impounding hydroelectric structures on the upper St. Lawrence River should be fitted with eel passage facilities (ladders) to facilitate immigration to historically important and productive habitats.

We recommend that research be conducted to quantify total upstream migration at the Moses-Saunders hydroelectric impoundment and associated locks so that passage up the ladder can be used to estimate the absolute abundance of juvenile recruitment for the upper St. Lawrence River–Lake Ontario stock. We also recommend that all otolith archives be maintained and that otoliths be collected from a subsample of fish during passage and at all stages of encounter, especially commercial harvest. Research studies should be conducted to collect age data to build year-class strength, life-history tables, and an age-migration chronology for the species. Only if this is done can cause and effect be properly understood and the factors associated with the significant decline in ladder passage and recruitment be properly evaluated.

ACKNOWLEDGMENTS

Special thanks to Mike Eckersley, who allowed us to examine copies of reports, diaries, and data files at the OMNR District Office, Cornwall. The Department of Fisheries and Oceans Canada, in conjunction with Environment Canada as part of the Ecological Monitoring and Assessment Network (EMAN), gave some financial support to L.M., which helped make this study possible. We appreciate the constructive reviews of Marvel Benard and Martin Castonguay.

REFERENCES

Axelsen, F. 1994. Etat de la pêche commerciale à l'anguille d'Amérique (*Anguilla rostrata*) en Amérique du Nord. Direction du Développement et des Activités régionales. Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (Document de travail). 63 p.

Axelsen, F. 1997. The status of the American eel (*Anguilla rostrata*) commercial fishery in

North America., p. 121-133. *In* R. H. Peterson (ed.) The American eel in eastern Canada: stock status and management strategies. Proceedings of Eel Management Workshop, January 13-14, 1997, Quebec City, PQ. Can. Tech. Rep. Fish. Aquat. Sci. 2196

Bond, S. 1994. 1993 operation of the eel ladder at the R. H. Saunders Generating Station, Cornwall, Ontario, p. 2-1 - 2-3. *In* 1994 Annual Report, St. Lawrence River Subcommittee to the Lake Ontario Committee and the Great Lakes Fishery Commission. Ontario Ministry of Natural Resources and New York State Department of Environmental Conservation.

Casselman, J. M. 1982. Chemical analysis of the optically different zones in eel otoliths, p. 74-82. *In* K. H. Loftus (ed.) Proceedings of the 1980 North American Eel Conference. Ontario Ministry of Natural Resources, Ont. Fish. Tech. Rep. Ser. 4: 97 p.

Casselman, J. M. 1987. Determination of age and growth, p. 209-242. *In* A. H. Weatherly and H. S. Gill. The biology of fish growth. Academic Press, London.

Casselman, J. M., T. Penczak, L. Carl, R. H. K. Mann, J. Holcik, and W. A. Woitowich. 1990. An evaluation of fish sampling methodologies for large river systems. Polskie Archiwum Hydrobiologii 37: 521-551.

Casselman, J. M., L. A. Marcogliese, T. J. Stewart, and P. V. Hodson. 1997. Status of the upper St. Lawrence River and Lake Ontario American eel stock--1996., p. 106-120. *In* R. H. Peterson (ed.) The American eel in eastern Canada: stock status and management strategies. Proceedings of Eel Management Workshop, January 13-14, 1997, Quebec City, PQ. Can. Tech. Rep. Fish. Aquat. Sci. 2196.

Castonguay, M., P. V. Hodson, C. M. Couillard, M. J. Eckersley, J.-D. Dutil, and G. Verrault. 1994a. Why is recruitment of the American eel, *Anguilla rostrata*, declining in the St. Lawrence River and Gulf? Can. J. Fish. Aquat. Sci. 51: 479-488.

Castonguay, M., P. V. Hodson, C. Moriarty, K. F. Drinkwater, and B. M. Jessop. 1994b. Is there a role of ocean environment in American and European eel decline? Fisheries Oceanography 3:3, 197-203.

Dutil, J.-D., B. Légaré, and C. Desjardine. 1983. Discrimination d'un stock de poissons, l'anguille (*Anguilla rostrata*), basée sur le présence d'un produit chemique de synthese, le mirex. Can. J. Fish. Aquat. Sci. 42: 455-458.

Eckersley, M. 1982. Operation of the eel ladder at the Moses-Saunders Dam, Cornwall 1974-1979, p. 4-7. *In* K. H. Loftus (ed.) Proceedings of the 1980 North American Eel Conference. Ont. Fish. Tech. Rep. Ser. 4.

Hartley, K. A. 1992. 1991 operation of the eel ladder at the R. H. Saunders Generating Station, Cornwall, Ontario, p. 2-1–2-3. *In* S. J. Kerr and A. Schiavone (ed.) 1992 Annual Report, St. Lawrence River Subcommittee to the Lake Ontario Committee and the Great Lakes Fishery Commission. Ontario Ministry of Natural Resources and New York State Department of Environmental Conservation.

Hendrick, A. 1991. 1990 operation of the eel ladder at the R. H. Saunders Generating Station, Cornwall, Ontario, p. 4-1–4-2. *In* S. J. Kerr and A. Schiavone (ed.) 1991 Annual Report, St. Lawrence River Subcommittee to the Lake Ontario Committee and the Great Lakes Fishery Commission. Ontario Ministry of Natural Resources and New York State Department of Environmental Conservation.

Hurley, D. A. 1973. The commercial fishery for American eel, *Anguilla rostrata* (Lesueur), in Lake Ontario. Trans. Am. Fish. Soc. 1973: 364-377.

Liew, P. K. L. 1982. Impact of the eel ladder on the upstream migrating eel (*Anguilla rostrata)* population in the St. Lawrence River at Cornwall: 1974-1978, p. 17-22. *In* K. H. Loftus (ed.) Proceedings of the 1980 North American Eel Conference. Ont. Fish. Tech. Rep. Ser. 4.

Marcogliese, L. A., J. M. Casselman, and P. V. Hodson. 1997. Dramatic declines in the American eel (*Anguilla rostrata*) stock in Lake Ontario--quantifying long-term trends. MS report.

McCleave, J. D. 1987. Migration of *Anguilla* in the ocean: signposts for adults! Signposts for leptocephali?, p. 102-117. *In* W. F. Hernkind and A. B. Thistle (ed.) Signposts in the sea. Florida State University, Tallahassee, Florida.

McCleave, J. D., R. C. Kleckner, and M. Castonguay. 1987. Reproductive sympatry of American and European eels and implications for migration and taxonomy. Am. Fish. Soc. Symp. 1: 286-297.

OMNR. 1987. Operation of the R. H. Saunders Generating Station eel ladder 1987. MS report, Cornwall District, Ontario Ministry of Natural Resources, Cornwall, Ontario.

Reid, D. A. 1981. Design of a replacement eel ladder at the R. H. Saunders Generating Station, Cornwall, Ontario. Presented at the 22nd annual meeting of the Canadian Society of Environmental Biologists, Montreal. 7 pages. Underwood McLellan, Rexdale, Ontario.

Schmidt, J. 1925. The breeding places of the eel. Smithsonian Institute Annual Report 1924: 279-316.

Stewart, T. J., J. M. Casselman, and L. A. Marcogliese. 1997. Management of the American eel, Anguilla rostrata, in Lake Ontario and the upper St. Lawrence River., p. 54-61. *In* R. H. Peterson (ed.) The American eel in eastern Canada: stock status and management strategies. Proceedings of Eel Management Workshop, January 13-14, 1997, Quebec City, PQ. Can. Tech. Rep. Fish. Aquat. Sci. 2196 p.

Whitfield, R. E., and D. P. Kolenosky. 1978. Prototype eel ladder in the St. Lawrence River. Prog. Fish-Cult. 40: 152-154.

Table 1. Recruitment index for the Lake Ontario-upper St. Lawrence River eel stock. Eel passage at the ladder at the W. B. Saunders hydroelectric dam at Cornwall, Ontario, for a 22-year period commencing in 1974 are given. The total operating periods and estimated total annual passage (N) are provided. A relative abundance index was calculated for a 31-day period (consecutive) during peak migration. The daily mean, 95% confidence interval (C.I.), and coefficient of variation (C.V.) were calculated for this index period; the proportion of the total annual estimated passage is provided. Daily counts were not available for 1977 and 1978, and too few counts were made in 1975; therefore, mean passage during the peak periods had to be estimated.

	Operating period		31-day peak period						
			Date (m d)						
Year	Days	N	Start	End	Days	Mean	95% C.I.	C.V.	Proportion of total
1974[a]	33	130 000	08 12	08 21	7	7 934	2 400	32.7	42.7
1975[a]	88	936 128	07 14	08 13	3	14 403			
1976	98	659 478	07 20	08 19	31	10 363	514	13.5	48.7
1977[b]		966 800				20 013			
1978[b]		794 600				16 448			
1979	91	869 135	08 01	08 31	31	18 977	657	9.4	67.7
1980[c]	70	253 758	07 21	08 20	20	9 046	3 196	75.5	71.3
1981	105	748 724	07 15	08 14	31	13 796	1 459	28.8	57.1
1982	100	1 013 848	07 18	08 17	31	27 489	1 992	19.8	84.1
1983	94	1 313 570	07 16	08 15	31	26 426	1 088	11.2	62.4
1984	75	647 480	07 20	08 19	31	15 051	1 458	26.4	72.1
1985	110	935 320	07 24	08 23	31	18 510	453	6.7	61.2
1986	95	230 570	07 29	08 28	31	5 380	551	28.0	72.3
1987[d]	125	465 364	07 03	08 02	28	9 277	818	22.7	55.8
1988	78	213 187	07 10	08 09	31	5 442	765	38.3	79.1
1989	87	258 622	07 10	08 09	31	5 795	905	42.6	69.5
1990	85	121 907	07 09	08 08	31	3 096	367	32.3	78.7
1991	84	40 241	07 14	08 13	30	1 226	344	75.1	91.4
1992	101	11 534	07 18	08 17	31	277	69	67.3	74.3
1993	60	8 289	07 31	08 30	31	232	36	42.2	86.8
1994	86	163 518	07 08	08 07	31	4 998	1 389	75.8	94.8
1995[b]	92	35 076	07 17	08 16	31	671	185	75.2	59.3
Mean	91	487 551	07 18	08 17	30	10 626		38.4	71.5

[a] Mean daily passage, based on a 31-day period estimated from the mean dates demarcating the 95% confidence limits for the mean peak period over the 22-year period.

[b] Mean daily passage, estimated using the regression equation:

$$Y_{(\text{mean for the peak period})} = 0.0207X_{(\text{estimated total annual passage})}.$$

[c] Construction of a new eel ladder resulted in reduced total counts.

[d] Installation of an electronic eel counter between July 27 and August 2.

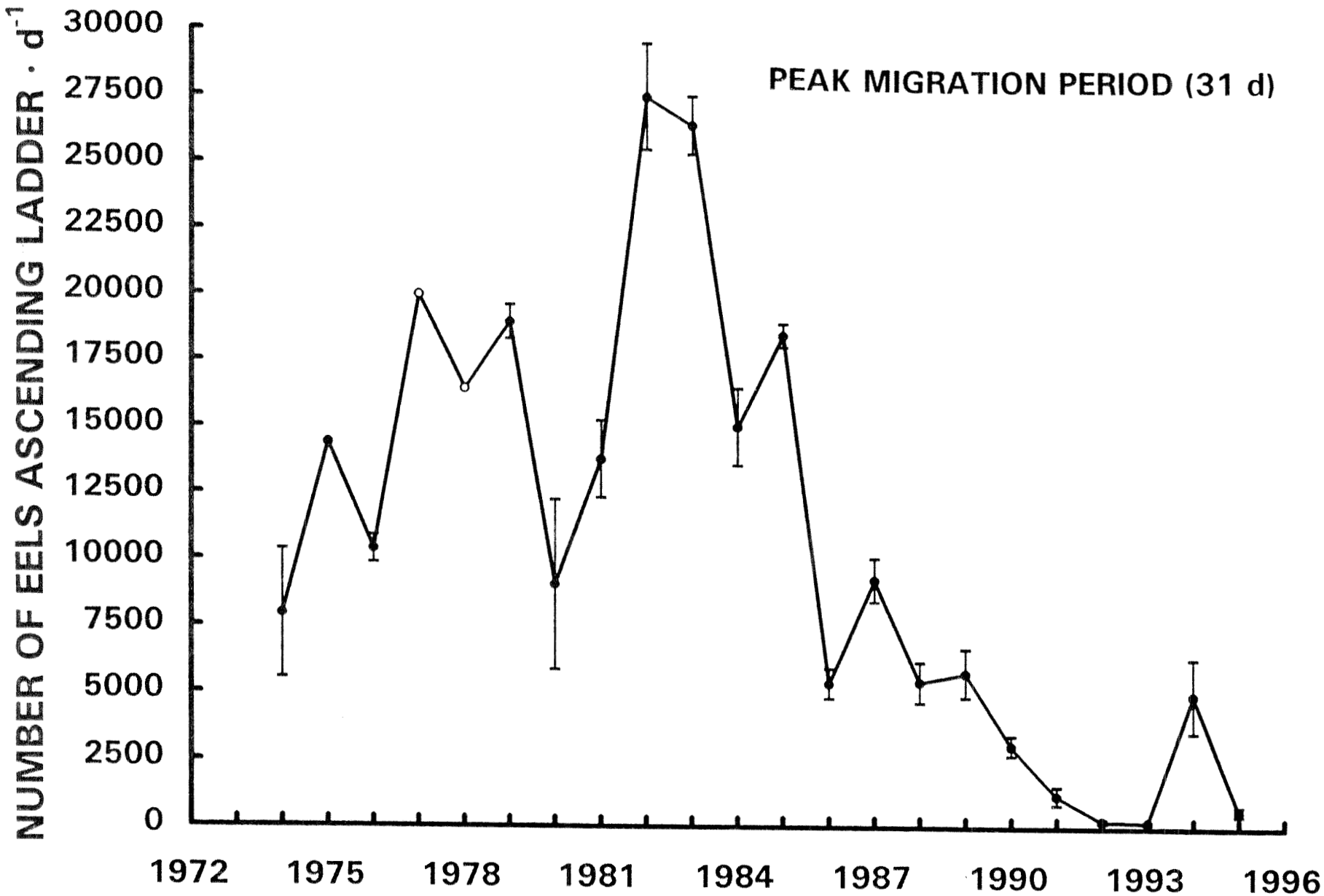


Fig. 1. Mean number of eels ascending the eel ladder per day at the W.B. Saunders Hydroelectric Dam at Cornwall, Ontario, during a 31-d peak migration period for a 22-yr period from 1974-95. Vertical bars indicate the 95% confidence intervals. Daily data could not be obtained for 1977 and 1978 (open circles), so peak migration was estimated from the conversion equation. Too few daily counts were collected in 1975 to calculate confidence limits.

Final Discussion

by

J. A. Ritter
Fisheries and Oceans Canada
P.O. Box 550
Halifax, Nova Scotia B3J 2S7

M. Stanfield
Fisheries and Oceans Canada
200 Kent Street
Ottawa, Ontario K1A 0E6

and

R. H. Peterson
Fisheries and Oceans Canada
Biological Station
St. Andrews, New Brunswick, Canada, E0G 2X0

The final discussion of the workshop focussed on five issues: current stock status, causes of current status, management objectives, research requirements, and the concept of a National plan as a step toward development of an international strategy.

STOCK STATUS

Stock status was discussed in relation to 3 eel life cycle stages; elver, yellow eel, and silver eel for each of 7 geographic areas: (1) Lake Ontario and the Upper St. Lawrence River, (2) the middle St. Lawrence between Cornwall and Quebec City, (3) the lower St. Lawrence, (4) The Richelieu R. - L. Champlain, (5) the Gulf of St. Lawrence (a) northern and (b) southern, (6) Newfoundland, and (7) Atlantic coast (Nova Scotia and Bay of Fundy). The evaluations of the various stocks were classified, somewhat subjectively but based on managers' experiences with the various stocks, as: -1, declining; -0, uncertain, possibly declining; 0,stable; +0,uncertain, possibly increasing; +1, increasing; ?, unknown.

The stock evaluations are tabulated below.

Geo-graphic area		Eel Life Stage Elver	Yellow eel	Silver eel
1		-1	-1	0
2		?	0	-1
3		?	NA	-1
4		NA	-1	-1
5	northern	?	?	?
5	southern	?	-1	-1
6		?	-0	0
7		?	0	0

Two obvious features of the table are the uncertain status of most elver populations, and the general impression of declining numbers of yellow and silver eels - particularly in the more northern geographic areas.

CAUSES OF POSSIBLE DECLINES IN CURRENT STATUS

If the view that North American eels also constitute a single panmictic population, then the stock - recruitment relationship for the various stocks are interdependent. Although there is a current lack of understanding as to what constitutes a critical level, there has been some evidence of recruitment failure in recent years - possibly confined to the northern geographic areas. Even within certain systems, the St. Lawrence, for example, there appeared to be no recruitment problem as yet in the middle part of the system (geographic area 2). This uncertainty raises the question as to the causes of stock decline: are they symptomatic of a population - wide decline or are they due to local causes?

The possible factors contributing to stock decline in the Upper St. Lawrence were considered to be habitat loss and deterioration (e.g. dams), overfishing, and environmental change in the northern Atlantic Ocean. It should be noted that these 3 factors may be cumulative in their effect. Each factor will now be considered in turn.

Hydro dams are a documented, significant source of mortality, possibly as high as 100% of downstream migrants at some locations. They were considered by some workshop participants as possibly of more significance than fishing mortality of silver eels.Obstructions to upstream migrants also occur.

There is also a concern that decline in northern stocks could be due to recruitment overfishing. It is thought that natural mortality must be very low to sustain the stock, because eels are so long - lived in freshwater; therefore it is essential to be concerned about overfishing and passage mortalities.

Changing oceanic conditions (e.g. cooling of the northern Atlantic) are also considered to be factors affecting recruitment variability - particularly in northern stocks.

MANAGEMENT OBJECTIVES

1) HABITAT LOSS AND DETERIORATION

Improve efficiency of passage and reduce mortality at upstream, and particularly downstream obstructions - with an emphasis on hydroelectric facilities. Passage must be restored through application of existing laws and regulations, and the Federal strategy of no net loss should be applied. Hydro companies should be urged to fulfill their obligations.

2) OVERFISHING

There is a need to emphasize the precautionary principle to harvest and management of eel stocks. Caution should be exercised when

considering any fisheries expansion. Exploitation rates will be frozen, or reduced where possible, through reductions of active fishing effort.

Any fishery can potentially impact on stock status; therefore different harvest stages should not be distinguished and consistent conservation principles should be applied across the board.

Each region must develop gear and effort restrictions as a start toward a National action plan.

RESEARCH REQUIREMENTS

Eleven research areas were identified and are ranked below in the order of importance as assessed by the workshop participants.

1. Continued operation and monitoring of the Cornwall fish ladder.

2. Creation of an inventory of fish passage problems for each management area.

3. Improved determination of exploitation rates.

4. Improved estimates of downstream survival to improve knowledge of the impact of hydro facilities.

5. Removal of downstream obstacles and assessment of the results.

6. Studies of immigration and emigration to and from "feeding basins", along with age determination studies to understand stock dynamics.

7. Up-to-date fishing effort analysis from all jurisdictions.

8. Accumulation and analysis of sex-ratio data throughout the population range.

9. Establish valid estimates of mortality from the elver to the silver eel stage.

10. Bring Maritimes log books up to date, and develop more indices of survival and abundance in various rivers.

11. Determine the contribution of non-exploited areas, such as the North Shore of the Gulf of St. Lawrence and the Gaspé to the spawning population.

The need for a continent-wide approach to managing and conserving eels was clearly identified. It was acknowledged, however, that developing a joint Canada-US approach to managing eels could be a long, drawn-out process, especially if the approach involved the development of a separate eel conservation treaty and considering the highly decentralized nature of US fisheries administration. It was suggested that the US cpi;d be approached through the regular bilateral channels to determine the most appropriate avenue to follow. It was also suggested that an organization like the North Atlantic Salmon Conservation Organization (NASCO) could have its mandate broadened to include eels, rather than developing an entirely new arrangement. There was agreement that both these options could be complementary and should be pursued. ICES, the scientific advisory body to NASCO, already has a scientific working group for eels. The similarities between the European (*Anguilla anguilla*) and American eels and the need for continent-wide management of the species suggests that NASCO's adoption of eels could be a good approach.

La discussion finale de l'atelier a porté sur cinq points : l'état actuel du stock, les causes de cet état, les objectifs de gestion, les besoins de recherche et l'élaboration d'un plan national comme première étape vers l'établissement d'une stratégie internationale.

ÉTAT DU STOCK

L'état du stock a été évalué en fonction de l'examen de trois stades du cycle biologique de l'anguille (la civelle, l'anguille jaune et l'anguille argentée) dans chacune des sept zones géographiques : 1) lac Ontario et haut Saint-Laurent, 2) moyen Saint-Laurent, entre Cornwall et Québec, 3) bas Saint-Laurent 4), rivière Richelieu — lac Champlain, 5) golfe du Saint-Laurent a) nord et b) sud, 6) Terre-Neuve et 7) côte atlantique (Nouvelle-Écosse et baie de Fundy). Les évaluations des différents stocks ont été classées, de façon un peu subjective, mais selon l'expérience des gestionnaires des divers stocks : -1, en baisse; -0, incertain, peut-être en baisse; 0, stable; +0, incertain, peut-être en hausse; +1, en hausse; ?, inconnu.

Les évaluations des stocks sont indiquées dans le tableau ci-dessous.

Zone géo-graphique		Civelle	Stade de l'anguille jaune	Anguille argentée
1		-1	-1	0
2		?	0	-1
3		?	n.d.	-1
4		n.d.	-1	-1
5	nord	?	?	?
5	sud	?	-1	-1
6		?	-0	0
7		?	0	0

Les deux caractéristiques qui ressortent de ce tableau sont la situation incertaine de la plupart des populations de civelles et l'impression générale de diminution des anguilles jaunes et argentées — particulièrement dans les zones septentrionales.

CAUSES POSSIBLES DES BAISSES ACTUELLES

Si l'on considère que les anguilles d'Amérique du Nord constituent également une population panmictique unique, la relation stock-recrutement des divers stocks est alors interdépendante. Bien qu'on comprenne mal pour le moment ce qui constituerait un niveau critique, on a pu observer des signes d'échecs du recrutement ces dernières années — peut-être limitées aux régions septentrionales. À l'intérieur même d'un réseau hydrographique, le Saint-Laurent par exemple, il semblait ne pas y avoir eu de problème de recrutement jusqu'ici dans la partie moyenne du réseau (zone géographique 2). Cette incertitude soulève des questions quant aux causes de la baisse des stocks : sont-elles symptomatiques d'une population en déclin ou sont-elles dues à des causes locales?

Les facteurs possibles qui contribuent à la diminution des stocks dans le haut Saint-Laurent étaient considérés comme étant la perte et la détérioration de l'habitat (p. ex. à cause des barrages), la surexploitation et les changements survenus dans le milieu, dans l'océan Atlantique nord. Il convient de noter que ces trois facteurs pourraient avoir des effets cumulatifs. Chaque facteur est étudié tour à tour.

Les barrages hydroélectriques constituent une cause importante, bien documentée, de mortalité, ' atteint parfois 100 % des migrants vers l'aval à endroits. Ils sont considérés par certains participants de l'atelier comme plus importants que la mortalité par pêche des anguilles argentées. Ils constituent aussi des obstacles à la migration vers l'amont.

On est également préoccupé par la baisse des stocks septentrionaux qui pourrait être due à la surexploitation des recrues. On croit aussi que la mortalité naturelle doit être très faible pour assurer le soutien du stock, étant donné que les anguilles vivent très longtemps en eau douce; il est donc essentiel de se préoccuper de la surpêche et de la mortalité au passage des obstacles.

Les conditions océaniques changeantes (p. ex. refroidissement de l'Atlantique Nord) sont aussi considérées comme un facteur qui pourrait influencer les fluctuations du recrutement - surtout chez les stocks septentrionaux.

OBJECTIFS DE GESTION

1) PERTE ET DÉTÉRIORATION DE L'HABITAT

Améliorer l'efficacité du passage aux obstacles et réduire la mortalité au passage vers d'amont et particulièrement vers l'aval — notamment dans le cas des installations hydroélectriques. Le passage aux obstacles doit être assuré par l'application des lois et règlements existants, ainsi que de la stratégie fédérale d'aucune perte nette. Il faudrait insister auprès des compagnies hydroélectriques pour qu'elles remplissent leurs obligations.

2) SUREXPLOITATION

Il faut mettre l'accent sur l'application du principe de précaution à la pêche et à la gestion des stocks d'anguilles. Il faut faire preuve de prudence lorsqu'on envisage une expansion de la pêche. Les taux d'exploitation seront bloqués ou réduits lorsque c'est possible, par une diminution de l'effort de pêche actif.

Toute exploitation peut avoir des incidences sur l'état du stock; par conséquent, il ne faut pas faire de distinction entre les stades d'exploitation et il faut appliquer des principes de conservation uniformément à tous les niveaux.

Chaque région doit établir des restrictions concernant les engins et l'effort comme point de départ de l'établissement d'un plan d'action national.

BESOINS DE RECHERCHE

Onze sujets de recherche ont été définis. Ils sont classés ci-dessous par ordre d'importance, d'après l'évaluation des participants à l'atelier.

1. Fonctionnement et surveillance continus de la passe migratoire de Cornwall.

2. Création d'un répertoire des problèmes de passage du poisson pour chaque zone de gestion.

3. Amélioration de la détermination des taux d'exploitation.

4. Amélioration de l'évaluation du taux de survie en aval, afin d'accroître les connaissances des répercussions des installations hydroélectriques.
5. Retrait des obstacles en aval et évaluation des résultats.

6. Études du taux d'immigration et d'émigration dans les bassins « d'engraissement », et étude de la détermination de l'âge afin de comprendre la dynamique des stocks.

7. Analyse à jour de l'effort de pêche de tous les secteurs de compétence.

8. Accumulation et analyse des données sur les proportions des sexes au sein de la population, à l'échelle du territoire.

9. Établissement d'estimations valides du taux de mortalité, à partir du stade des civelles jusqu'à celui d'anguille argentée.

10. Mise à jour des registres des Maritimes et recherche d'autres indices de survie et d'abondance dans les divers cours d'eau.

11. Détermination de la contribution des zones non exploitées, comme la Côte-Nord du Saint-Laurent et la Gaspésie, aux populations de reproducteurs.

Même si les participants ont reconnu la nécessité d'élaborer un plan canado-américain de gestion et de conservation de l'anguille, ils ont aussi reconnu qu'il pourrait s'agir d'un long processus, surtout si la démarche doit impliquer l'élaboration d'un traité distinct sur la conservation de l'anguille et compte tenu de la nature fortement décentralisée de la gestion halieutique aux États-Unis. Il a été proposé d'approcher les Américains au moyen des voies hiérarchiques normales afin de déterminer la meilleure façon d'aborder la question. Il a aussi été proposé d'élargir le mandat d'un organisme comme l'Organisation pour la conservation du saumon de l'Atlantique Nord (OCSAN) pour y inclure la gestion des anguilles, plutôt que d'élaborer une entente entièrement nouvelle. Les participants ont convenu que ces deux possibilités pourraient être complémentaires et qu'elles méritent un examen plus approfondi. Le Centre international pour l'exploration de la mer (CIEM), qui donne des conseils scientifiques à l'OCSAN, a déjà un groupe de travail scientifique sur l'anguille. Les similitudes entre l'anguille d'Europe (Anguilla anguilla) et l'anguille d'Amérique et la nécessité d'adopter un plan de gestion de l'espèce pour l'ensemble du continent amènent à penser que ce serait une bonne idée que l'OCSAN assume la gestion des anguilles.