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PROCEEDINGS OF A WORKSHOP ON BIOLOGY AND CULTURE OF STRIPED BASS (*MORONE SAXATILIS*)

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INTRODUCTORY COMMENTS

One of the mandates of the Dept. of Fisheries and Oceans, Aquaculture and Invertebrate Fisheries Division is to assess the potential of and develop culture techniques for new aquaculture species in the Scotia-Fundy Region.

The striped bass is indigenous to coastal waters of the Maritime Provinces, supporting a small commercial fishery in the past as a by-catch species in the shad fishery. It is becoming increasingly popular as a sport fish in the Maritimes. The development of culture techniques for the species has been a major success story in the United States over the past decade or so.

The current knowledge of the population biology of the striped bass in eastern Canada is summarized by G. Melvin in the first paper of the proceedings. Because of the species' marginal status as a fishery in the Maritimes, data on growth rates, spawning, population size, and migrations are far from comprehensive.

Both Melvin and B. Jessop, who discusses the history of the striped bass fishery in the Bay of Fundy, express concern for the recent apparent downward trend in numbers of striped bass in the area. Both angling and commercial harvests have declined over the past 30 years or so.

G. Ouellette also made a presentation describing the biology of an apparently extinct population that once inhabited the St. Lawrence River, and detailed plans for re-establishment of a population in that river.

L. Flagg and T. Squiers summarize the history of the striped bass fishery, principally of the Kennebec/ Androscoggin system in Maine and document some success in stocking cultured juveniles in this system subsequent to improvements in water quality since the early 1970s.

In the last presentation dealing with population biology-management aspects, W. Hooper presents and discusses various options for management and augmentation of natural populations in New Brunswick systems.

Two presentations dealt with the culture of eggs, larvae and juveniles of striped bass. B. Friedmann detailed methods used at the Verplanck, N. Y. Hatchery which successfully utilized intensive culture methods for production of striped bass fingerlings for stocking purposes. R. Harrell presented an equally detailed description of early striped bass culture, emphasizing the use of ponds as an alternate strategy to intensive culture. The strategies for using cultured bass in stocking programs were also discussed. Since much of Harrell's material is available in a recent American Fisheries Society publication (1), a written manuscript is not included, but a discussion paper by Harrell on management and culture possibilities for the species in the Maritimes has been included.

R. Meadows has provided ancedotal information on striped bass in the Shubenacadie system, based upon his 40 years experience as a commercial fisherman, as well as recent attempts to rear early life stages.

D. J. Martin-Robichaud, R. H. Peterson, and L. Crim provide preliminary results of some laboratory research on the species in the Maritimes.

The optimal temperatures for growth of striped bass are higher than that for Atlantic salmon, and may restrict its commercial culture to favourable regions. E. Mason includes a position paper on possible strategies and preliminary studies to determine the suitability of striped bass for culture in Prince Edward Island.

MOT D'INTRODUCTION

La Division de l'aquaculture et de la pêche des invertébrés du ministère des Pêches et des Océans a pour mandat, entre autres, d'évaluer le potentiel d'élevage de nouvelles espèces dans la Région de Scotia-Fundy et de mettre au point les techniques d'élevage nécessaires.

Le bar d'Amérique est une espèce indigène des eaux côtières des Maritimes. Il supportait autrefois une pêche commerciale restreinte à titre de prise secondaire de la pêche de l'alose. La pêche sportive de cette espèce devient de plus en plus populaire dans les provinces Maritimes. La mise au point de techniques d'élevage pour cette espèce a connu beaucoup de succès aux États-Unis au cours des quelque dix dernières années.

G. Melvin résume l'état des connaissances actuelles sur la biologie des populations de bar d'Amérique dans l'est du Canada dans le premier document des délibérations. En raison du statut marginal de cette espèce pour la pêche dans les Maritimes, les données sur les taux de croissance, la reproduction, la taille de la population et les migrations sont loin d'être complètes.

Melvin et B. Jessop, qui traite de l'historique de la pêche du bar d'Amérique dans la Baie de Fundy, se disent préoccupés par la récente tendance apparente à la baisse du nombre de bars d'Amérique dans la région. Les prises des pêcheurs à la ligne et des pêcheurs commerciaux ont toutes deux baissé depuis les quelque trente dernières années.

G. Ouellette décrit également dans un exposé la biologie d'une population apparemment disparue qui aurait jadis habité le Saint-Laurent et présente des plans détaillés en vue d'établir à nouveau une population dans le fleuve.

L. Flagg et T. Squiers résument l'historique de la pêche du bar d'Amérique, surtout dans le réseau de la Kennebec et de la Androscoggin au Maine et soulignent certains succès dans le déversement de juvéniles d'élevage dans ce réseau après les efforts d'amélioration de la qualité de l'eau qui ont été déployés au début des années 1970.

Dans le dernier exposé sur la gestion de la biologie des populations, W. Hooper présente et explique diverses options pour la gestion et l'augmentation des populations naturelles dans les réseaux du Nouveau-Brunswick.

Deux exposés portent sur l'éclosion des oeufs de bars d'Amérique et l'élevage des larves et des juvéniles. B. Friedman explique en détails les méthodes utilisées à l'écloserie de Verplanck dans l'État de New York, qui a appliqué avec succès des méthodes d'élevage intensif pour la production de fingerlings à des fins de repeuplement. R. Harrell présente une description également détaillée de l'élevage des jeunes bars d'Amérique, en mettant l'accent sur l'utilisation de bassins comme solution de rechange à l'élevage intensif. La discussion porte aussi sur l'utilisation de bars d'Amérique d'élevage pour les programmes de repeuplement. Aucun manuscrit n'est inclus, étant donné qu'une bonne part des documents de Harrell se trouvent déjà dans une récente publication de l'American Fisheries Society (1). On inclus toutefois un document d'information dans lequel Harrell traite des possibilités de gestion et d'élevage de cette espèce dans les Maritimes.

R. Meadows fournit des renseignements anecdotiques sur le bar d'Amérique dans le réseau de la Shubenacadie, en s'appuyant sur ses 40 années de pêche commerciale et sur ses tentatives récentes d'élever de jeunes poissons.

D. J. Martin-Robichaud, R. H. Peterson et L. Crim présentent les résultats préliminaires de certaines recherches effectuées en laboratoire sur cette espèce dans les Maritimes.

Les températures optimales pour la croissance du bar d'Amérique sont plus élevées que celles du saumon de l'Atlantique, ce qui pourrait en restreindre l'élevage commercial aux zones favorables. E. Mason présente un éconcé de principe sur les stratégies possibles et les études préliminaires permettant de déterminer dans quelle mesure le bar d'Amérique se prête à l'élevage à Île-du-Prince-Édouard.

BIBLIOGRAPHY

1. Harrell, R. M., J. H. Kerby, and R. V. Minton (eds.). 1990. Culture and propagation of striped bass and its hybrids. 323 p. American Fisheries Society, Bethesda, MD.

ACKNOWLEDGMENTS

I wish to thank the participants of the Workshop, particularly those who contributed manuscripts and presentations, and to Dr. R. H. Cook who provided encouragement to convene the workshop. Huntsman Marine Science Centre (B. Fullerton), The Gables Restaurant, and Cappy's Delicatessen provided lodging and meals. D. J. Martin-Robichaud assisted with the workshop organization. B. Garnett and B. Best typed the manuscripts, and F. Cunningham prepared and modified figures. M. Rudi proofed the manuscript. A.F.A.P. provided partial funding for the workshop.

A REVIEW OF STRIPED BASS, *MORONE SAXATILIS*, POPULATION BIOLOGY IN EASTERN CANADA

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Melvin, G. D. 1991. A review of striped bass, *Morone saxatilis*, population biology in eastern Canada, p. 1-11. In R. H. Peterson [ed.] Proceedings of a workshop on biology and culture of striped bass (*Morone saxatilis*). Can. Tech. Rep. Fish. Aquat. Sci. 1832: vi + 66 p.

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INTRODUCTION

The striped bass, *Morone saxatilis*, is an anadromous Percoid that inhabits the coastal waters of the eastern Atlantic from the St. Lawrence River, in Canada, to the St. John's River, Florida. In eastern Canada, striped bass can be divided into two stocks: those which originate from rivers entering the Bay of Fundy, and those from rivers that discharge into the Northumberland Strait/Gulf of St. Lawrence. Bousefield and Thomas (1975) suggested that the Northumberland Strait/Gulf of St. Lawrence stock has been isolated from the Bay of Fundy and U.S. stocks for the past 5000 yr by a coldwater mass off Cape Breton. Tagging studies undertaken since their report (to be discussed a little later), however, indicate that some movement between the two water bodies does occur.

In the Bay of Fundy, striped bass spawning has been reported for the Saint John, Annapolis, and Shubenacadie rivers (Dadswell 1976; Jessop and Doubleday 1976; Parker and Doe 1981). Although no direct evidence exists for spawning in rivers that flow into the Northumberland Strait/Gulf of St. Lawrence, spawning is inferred by the large number of young-of-the-year and juvenile bass observed in the rivers and estuaries. Rivers that are suspected to support spawning populations of striped bass include: Richibucto, Kouchibouguasis (St. Louis), Kouchibouguac, Miramichi, Tabusintac, Tracadie, Nipisiquit, and formerly the St. Lawrence (Fig. 1).

The purpose of this report is to summarize, in a general way, the limited available information concerning the Canadian stocks. It should be noted that the majority of studies conducted on striped bass in Atlantic Canada were undertaken during the late 1970's and early 1980's and that most of the results are published in the so-called "gray literature."

HISTORICAL LANDINGS

Unlike their American counterparts, the striped bass of eastern Canada have not played a significant role in the commercial landings of the region. Historically, commercial landings in the U.S. generally ranged in the order of thousands of metric tonnes compared with tens of metric tonnes for Atlantic Canada. Between 1930 and 1980, the Canadian landings represented an average of only 0.6% of the reported U.S. Atlantic commercial catch. During this 51-yr period, a maximum percentage of 5.4% occurred in 1943 when U.S. commercial catch reached a historical low (Fig. 2).

In recent years (1981-89), however, with the decline in U.S. landings (153 and 196 t for 1985 and 1986, respectively), and a relative increase in Canadian catches in the Northumberland Strait, this percentage averaged 3.56% with a peak of 6.1% in 1986 when U.S. landings were the lowest ever recorded (Fig. 2). Peak reported catches of striped bass in Atlantic Canada occurred in 1945 (50 mt) and 1981 (48 mt).

Historically, striped bass landings in both Canada and the U.S. have been cyclic in nature. Figure 2 compares the commercial catch of striped bass for Canada and the U.S. since 1930. Initial examination of the graph for U.S. landings does not depict the commonly accepted cycles in striped bass abundance as well as those of the Canadian reported catch. This is primarily due to annual differences in the contribution to overall landings of several major spawning populations. If the landings of individual populations (i.e., rivers) were examined, a trend similar to that observed for the Canadian landings would be expected.

There is serious concern that the current downward trend in commercial landings in both Canada and the U.S. may not be part of the natural cycle. Many studies in the U.S. have implied that overfishing, industrialization, pollution, hydro development, and general degradation of water quality in the spawning rivers are the major factors responsible for the dramatic declines being observed.

SPAWNING GROUNDS

The spawning grounds for striped bass in most rivers in eastern Canada are located just above the head of tide, but vary greatly between rivers. Large tidal excursions in the Bay of Fundy can place the head of tide, thus spawning grounds, many miles inland compared to the Northumberland Strait/Gulf of St. Lawrence. In the Saint John River, spawning is believed to

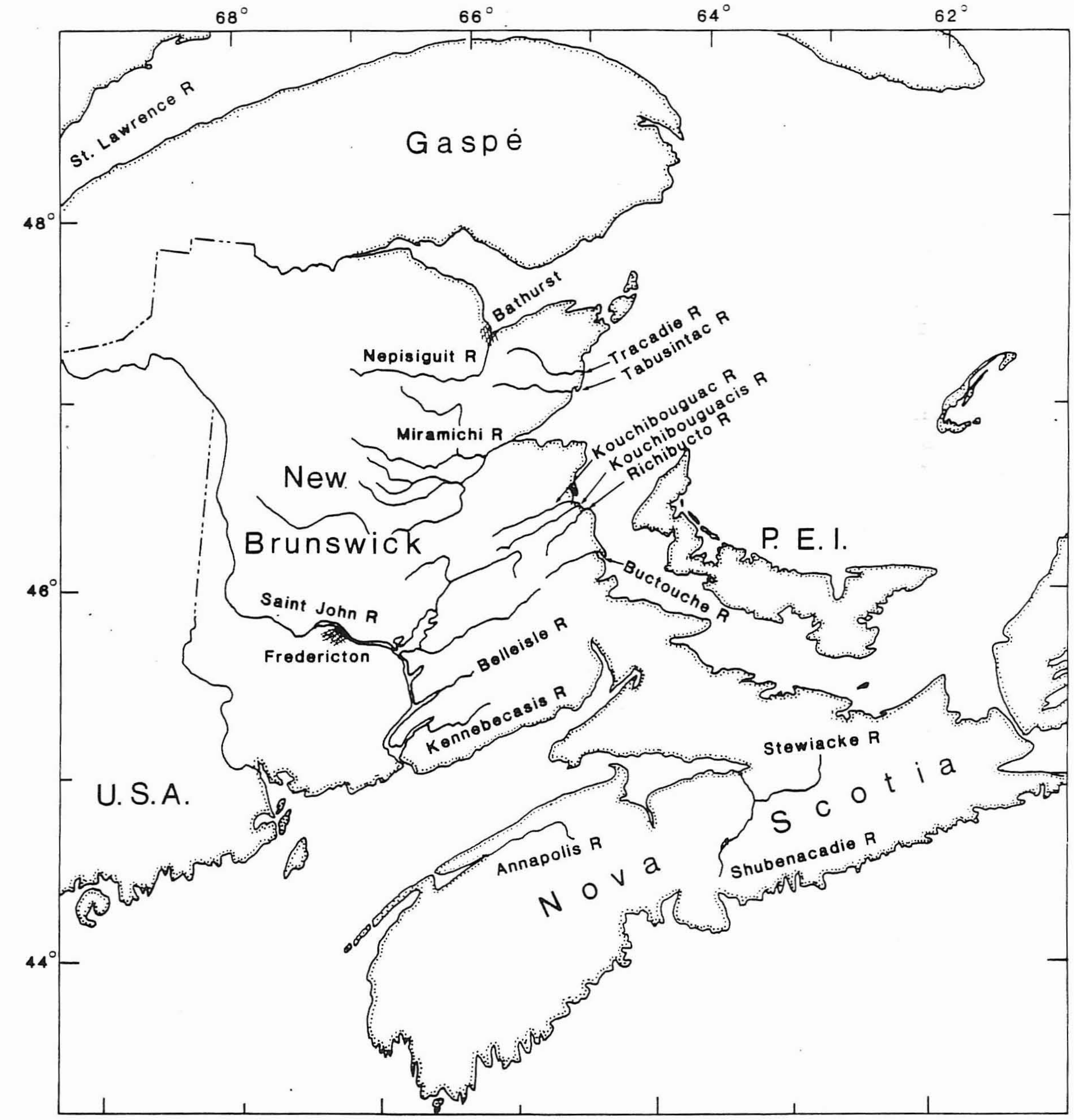

Fig. 1. Map of the Bay of Fundy/Gulf of St. Lawrence striped bass spawning rivers.

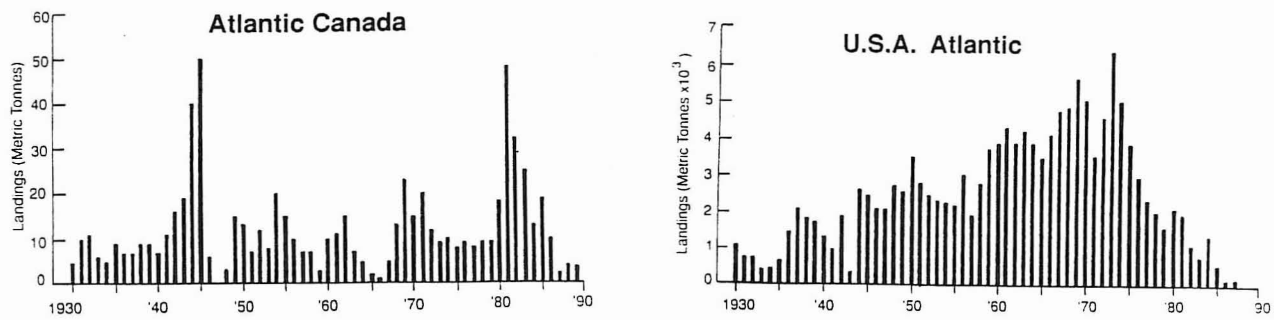

Fig. 2. Canada/U.S. historical commercial landings of striped bass.

occur, or have occurred in the past, near the mouth of the Kennebecasis and Belleisle rivers (Dadswell 1976) and around the islands just above Fredericton, N. B. On the Annapolis River, Parker and Doe (1981) collected striped bass eggs just above the head of tide, between Bridgetown and Paradise, N. S. This is consistent with earlier findings of Jessop and Doubleday (1976) and Jessop and Vithayasai (1979). Striped bass spawning in the Shubenacadie River has been reported by local fishermen to occur in the lower portion of the river near the confluence of the Shubenacadie-Stewiacke rivers. In 1989, a large number of eggs was collected in this area for rearing studies.

Along the Northumberland Strait, spawning ground location for most rivers is only inferred from discussions with local fishermen, but again, they are believed to be located just above the influence of the tide. In the Kouchibouguac, spawning activity was observed during the spring of 1983 approximately 2 km upriver of the estuarine lagoon just above the head of tide (Hogans and Melvin 1984).

SPAWNING

Striped bass spawning in eastern Canada generally occurs in May and June, depending upon the river and, as in the U.S., has been found to be temperature dependent. Studies by Dadswell (1976) and Parker and Doe (1981) have documented the abundance of striped bass eggs relative to water temperature for the Saint John and Annapolis rivers. Dadswell (1976) found a relatively narrow period of peak spawning, although eggs were first observed on May 7 in the Belleisle River, a tributary of the Saint John River, and continued to be present in the water until May 21. The maximum number of eggs was collected on May 15 at a temperature of 14.5°C (Fig. 3). Parker and Doe (1981) found

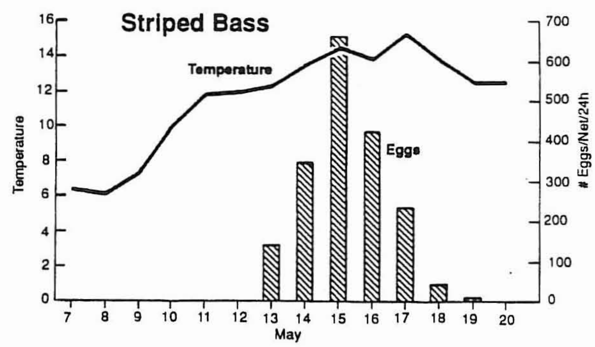

Fig. 3. Water temperature and egg abundance in the Belleisle River (source: Dadswell 1976).

eggs present in the Annapolis River for a slightly longer period with two peaks in egg abundance, one which occurred at approximately 15°C and another between 18 and 20°C. Both peaks were found to correspond to rising or peak water temperatures during the spawning period. The presence of eggs in the Annapolis River was approximately 1 mo later than the Saint John River. No information on egg distribution or abundance is available for the Northumberland Strait/Gulf of St. Lawrence stock.

AGE AT MATURITY

Age at first maturity of striped bass (i.e., 3-7 yr) is similar between river systems, although the percent of mature bass differs between regions. Williamson (1974) reported that 25% of male fish were mature at age 3 and 84% by age 5 in the Saint John River, while only 20% of female bass were mature by age 4 and 82% by age 6. However, Hogans and Melvin (1984) found that nearly all age 4 males and age 5 females were mature in the Kouchibouguac River. Mean lengths at maturity range from 40-62 cm for the Bay of Fundy stock (Jessop 1990) compared with 34-53 cm for the Northumberland Strait (Melvin 1978; Hogans and Melvin 1984).

In general, male striped bass mature 1 yr earlier than females, with fish from the Northumberland Strait region maturing a similar period of time (i.e., 1 yr) before those that originate from rivers flowing into the Bay of Fundy. Large differences in age of available fish have also been found between the Bay of Fundy and the Gulf of St. Lawrence stocks. Figure 4 summarizes the age and frequency distribution of fish collected from the Saint John and Kouchibouguac rivers. The maximum age of bass in the Kouchibouguac River was 6 compared to 16 for the Saint John River. This, in part, may account for the earlier age at maturity of the former river system.

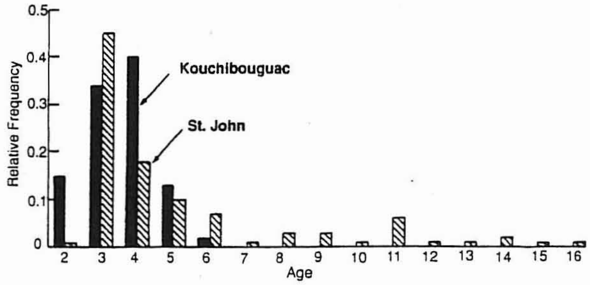

Fig. 4. Age distribution of striped bass collected from the Saint John and Kouchibouguac rivers.

FECUNDITY

Estimates of fecundity of Canadian striped bass populations are limited to studies by Williamson (1974) and Hogans and Melvin (1984). Regression of fish length with fecundity for Saint John River bass resulted in a poor relationship. Egg counts ranged from 38,400 for a 56.0-cm fish to 1.06 million for a 96.0-cm fish (Williamson 1974). Hogans and Melvin found the following significant ($p > 0.01$) linear relationship between fish length and fecundity for mature fish:

$$\text{Fecundity} = 9.65\ (\text{Fork length in cm}) - 381.50$$
$$r^2 = 0.89.$$

GROWTH

Once hatched, young striped bass spend their first 1-2 yr of life in the fresh and brackish waters of their native rivers. Very little is known about this stage of the bass' life cycle, especially in the Bay of Fundy. Several studies have been initiated, with very little success, to document the freshwater phase of the striped bass life cycle in the rivers that flow into the Bay of Fundy (Williams et al. 1984; Jessop 1990). However, in the Northumberland Strait, large numbers of young-of-the-year and yearlings are taken in commercial fishing gear set in the rivers and estuaries. No growth studies have been undertaken for this age group in the Gulf of St. Lawrence/Northumberland Strait.

Growth during the first 5-6 yr is rapid and comparable with that observed for Chesapeake Bay, but diminishes with increasing age compared to the more southern populations. Figure 5 compares the weight/length relationship of striped bass collected from the Saint John, Shubenacadie, and Tabusintac rivers in 1976/77 (Melvin 1979). As is clearly demonstrated, the Northumberland Strait bass are fatter at large sizes than the Saint John or the Shubenacadie River bass. However, it is important to note that

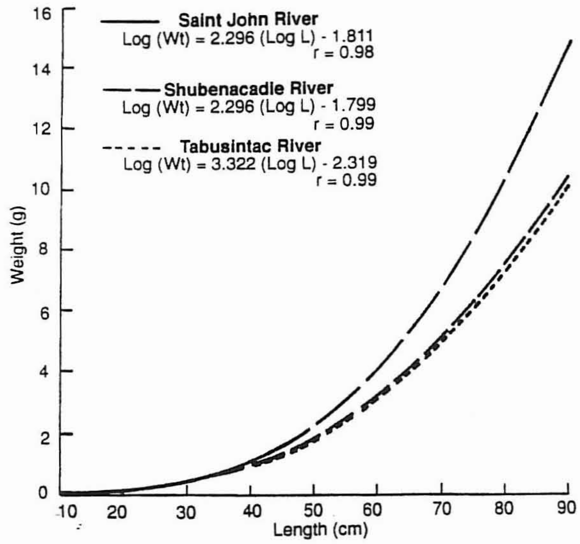

Fig. 5. Weight/length relationship of the Saint John, Tabusintac, and Shubenacadie rivers.

the relationship for the Tabusintac fish was estimated using samples which did not exceed 45 cm (4 yr old) and has been extrapolated for the larger sizes (interrupted portion of curve).

Perhaps a better indication of size can be found by comparing the length-at-age relationships of bass which use older fish from the St. Lawrence River as representative of the Gulf of St. Lawrence stock. Figure 6 compares the relative size of fish from the Saint John and St. Lawrence rivers and Chesapeake Bay. For comparison, Table 1 summarizes the estimated differences between regions for a 14-yr-old fish from each of the three areas.

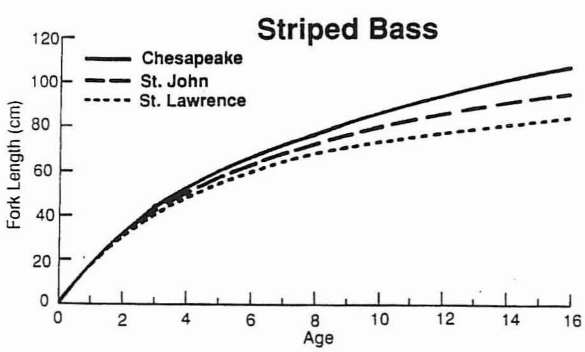

Fig. 6. Comparison of length at age between the Saint John, St. Lawrence, and Chesapeake Bay striped bass.

Table 1. Estimated length (cm) and weight (kg) of a 14-yr-old striped bass from Chesapeake Bay, the Saint John, and the St. Lawrence rivers (source: Dadswell 1976).

	Chesapeake Bay	Saint John River	St. Lawrence River
Length	105	95	75
Weight	20	11	8

MIGRATION

One method used to determine fish migration is tagging and the fish's subsequent recapture. Unfortunately, striped bass tagging programs in eastern Canada have been limited. Table 2 summarizes the extent of tagging undertaken between 1964 and 1984. By far the largest program was initiated in 1983 when 597 striped bass were marked and released, with 21 fish recaptured outside the Kouchibouguac River (Hogans and Melvin 1984). The majority of recaptures was taken within 50 km of the point of release; however, one bass was returned from the Wye River, Maryland, U.S.A. The percent of tag returns for the other programs was similar in order of magnitude and ranged from 2-5% with the exception of Dadswell (1976) who reported a return of 17%. The following discussion of migration is based on the results of these programs.

Striped bass migrations can be divided into two general categories: within river/estuary and coastal. During the summer, coastal migrants from U.S. rivers, predominantly the Hudson River, move into the Bay of Fundy to mix with the native stock. Although these migrants enter the lower portion of most rivers and estuaries of the Bay of Fundy, they do not venture very far inland. Figure 7 depicts the tag return data of striped bass marked in the Saint John River estuary. These fish are believed to be migrants and not native to the Saint John River.

Bass native to the Saint John River undertake seasonal movements from fresh water to marine. In the fall, adult and juvenile (>2 yr) fish move into the fresh water to overwinter in the deepwater (>25 m) areas of the river, such as

Table 2. Striped bass tagging programs in three river systems (Saint John, Annapolis, Kouchibouguac) 1964-84.

Organization/Individual	Year	River system	Number tagged
N.B. Fish and Game	1964	Saint John	110
Sports Fishing Magazine	1967	Saint John	100
Dadswell/Williamson	1975	Saint John	70
Jessop	1975	Annapolis	9
Jessop	1976	Annapolis	44
Melvin	1978	Kouchibouguac	78
Dadswell/Melvin	1981	Annapolis	37
Hogans/Melvin	1983	Kouchibouguac	597
Melvin/Dadswell	1984	Annapolis	15
TOTAL			1060

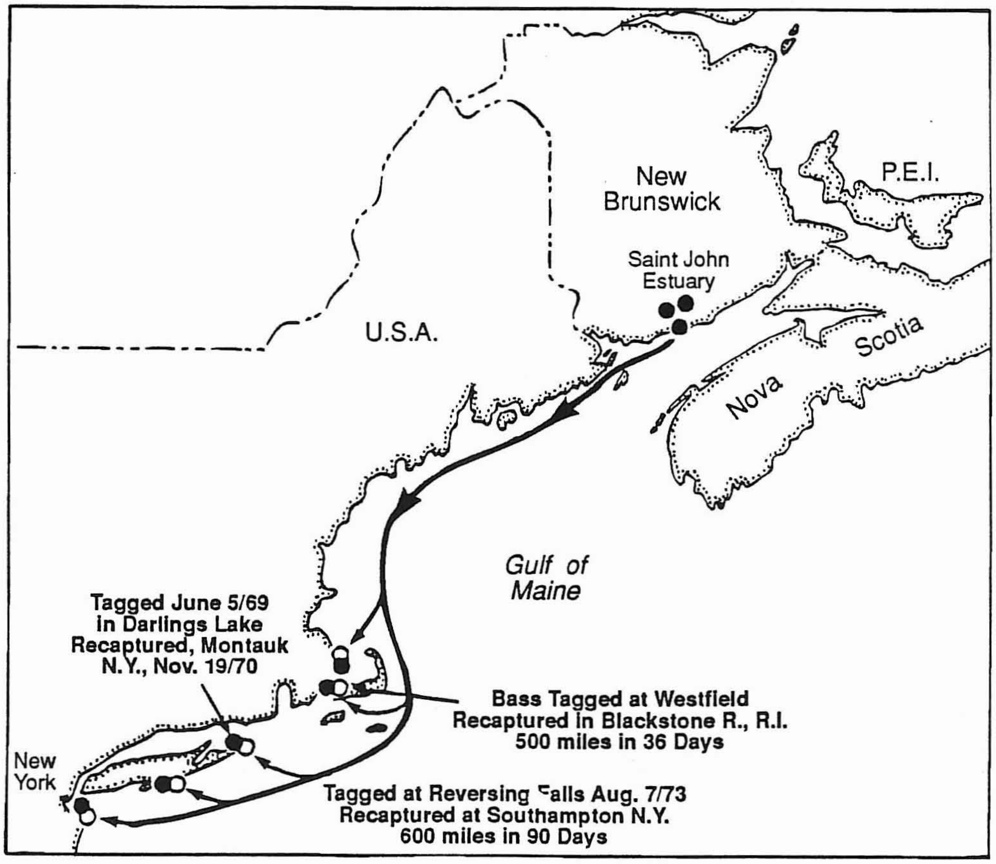

Fig. 7. Tag returns of striped bass released in the Saint John River and recovered along the U.S. coast (source: Dadswell 1976).

Belleisle Bay in the Saint John River and Shubenacadie Lake. Along the Northumberland Strait, where little if any deep fresh water is available, striped bass are generally found above the head of tide in freshwater pools. It has been postulated that they move in from the sea to avoid supercooling due to extremely cold seawater temperatures observed each year in the region. Both adult and juvenile fish overwinter in fresh water.

With the onset of spring and warming water temperatures, the bass move on to the spawning grounds. Upon completion of spawning, the adults leave the fresh water to undertake coastal feeding migrations. Juvenile fish tend to leave the fresh water before the adults. Figure 8 summarizes the within-river movement of the bass tagged in the Saint John River.

The extent of coastal migration of the Bay of Fundy stock is uncertain due to the known mixing with fish from more southern waters. However, it is believed that the majority remain within the Bay of Fundy during the summer. Kouchibouguac River striped bass were found to move as far north as Tabusintac during the summer, although it is assumed that some portion migrates into the Bay of Chaleur. Summer coastal movements determined from tag returns of Kouchibouguac River fish are shown in Fig. 9. One fish tagged in 1983 in the Kouchibouguac River was recovered in Chesapeake Bay, thereby demonstrating the movement of striped bass around Cape Breton. By September/October, striped bass begin to move into the fresh water of their native rivers where they remain throughout the winter.

STOCK DISCRIMINATION

Limited work has been undertaken on stock discrimination of Atlantic Canada striped bass. In 1974, Williamson compared meristic characters of bass from the Saint John and Annapolis rivers and found no significant differences between the two systems. Melvin (1978) investigated meristic, morphometric, and biochemical characteristics of striped bass from the Saint John, Schubenacadie, Tabusintac and, for comparative purposes, Montauk Point, Long Island, N.Y. Meristic and morphometric characters were found to differ significantly but, due to the degree of overlap of characters, did not provide a reliable mechanism for separating mixed individuals. Unique electrophoretic patterns were found for each of the three Canadian populations. However, when samples from Long Island were examined, the distinctiveness of the Saint John River was lost. This was attributed to the possible intermixing of the two populations or sampling bias (i.e., striped bass assumed to be Saint John River fish may have been of mixed origin).

STATUS

The current status of Canadian Atlantic coast striped bass stocks is unknown. However, assuming reported commercial landings and the CPUE at the Department of Fisheries and Oceans Millbank, N.B. trapnet are representative of the situation, then the striped bass of Atlantic Canada have reached a 25-yr low. Commercial landings over the past 3 yr are the lowest reported since 1965. A similar recent downward trend is observed in the CPUE of the Millbank trapnet when compared with the New Brunswick-Gulf of St. Lawrence (Fig. 10).

Given the current uncertainty of the striped bass status in eastern Canada, it is recommended that strict management policies be developed to protect this valuable resource. Several possible approaches and their constraints are presented in Jessop (1990).

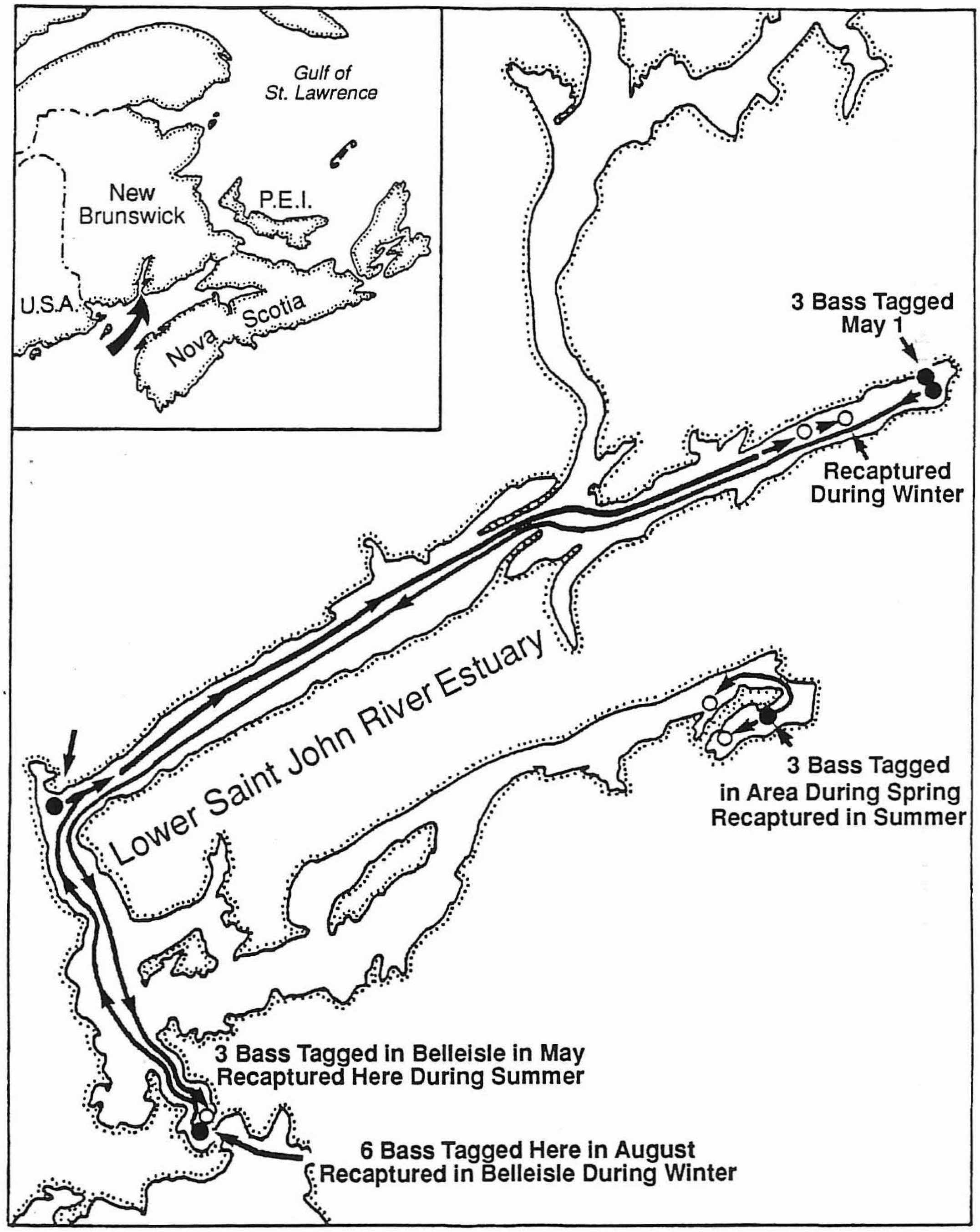

Fig. 8. Tag returns of fish marked in the Saint John River and recaptured within the river (source: Dadswell 1976).

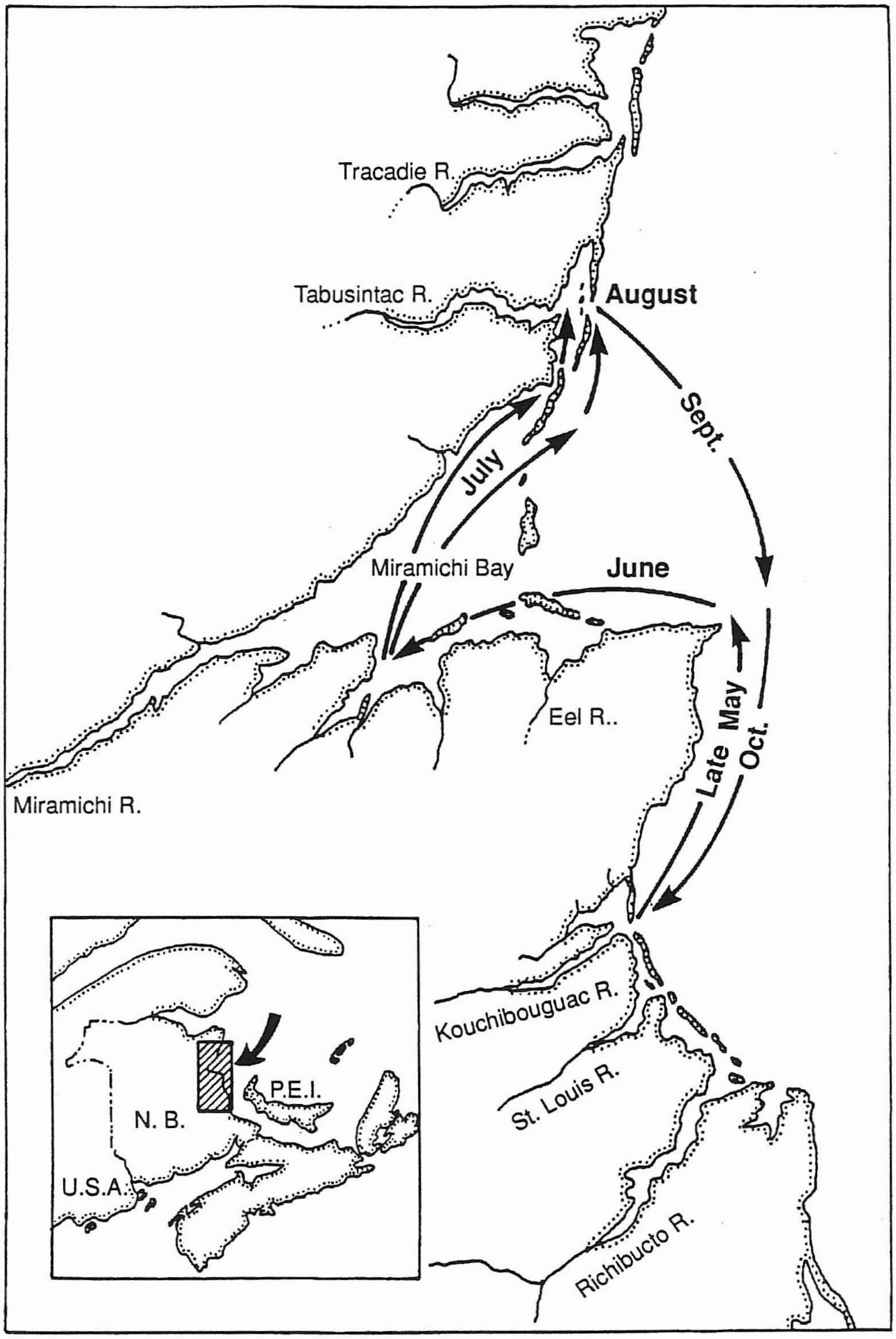

Fig. 9. Coastal movement of striped bass tagged in the Kouchibouguac River.

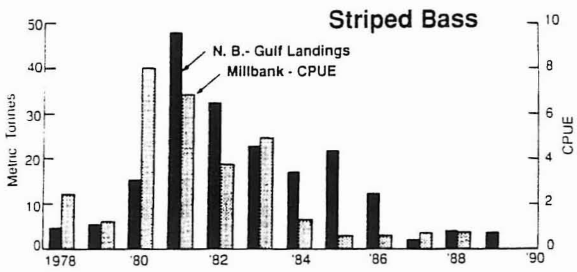

Fig. 10. Comparison of the N.B.-Gulf of St. Lawrence reported striped bass landings with the catch-per-unit effort (CPUE) at the DFO Millbank trapnet on the Miramichi.

REFERENCES

Bousefield, E. I., and M. L. H. Thomas. 1975. Postglacial changes in distribution of littoral marine invertebrates in the Canadian Atlantic region. Proc. N.S. Sci. 27 (suppl. 3): 47-60.

Dadswell, M. J. 1976. Notes on the biology and research potential of striped bass in the Saint John estuary. In Baseline survey and living resource potential study of the Saint John River estuary, Vol. 3. Fish and Fisheries, Huntsman Marine Lab, St. Andrews, N.B., 106 p.

Hogans, W. E., and G. Melvin. 1984. Kouchibouguac National Park striped bass (*Morone saxatilis*) fishery survey. Aquatic Industries Ltd., St. Andrews, N.B.

Jessop, B. M. 1980. Creel survey and biological study of the striped bass fishery of the Annapolis River, 1978. Can. MS Rep. Fish. Aquat. Sci. 1566: 20 p.

Jessop, B. M. 1990. The status of striped bass in Scotia-Fundy Region. Can. Atl. Fish. Sci. Advis. Comm., Res. Doc. 90/36: 22 p.

Jessop, B. M., and W. G. Doubleday. 1976. Creel survey and biological study of the striped bass fishery of the Annapolis River, 1975. Environ. Can., Fish. Mar. Serv. Tech. Rep. MAR/T-76-3: 47 p.

Jessop, B. M., and C. Vithayasai. 1979. Creel surveys and biological studies of the striped bass fisheries of the Shubenacadie, Gaspereau, and Annapolis rivers, 1976. Fish. Mar. Serv. MS Rep. 1532: 32 p.

Melvin, G. D. 1978. Racial investigations of striped bass *Morone saxatilis* (Walbaum) 1772 (Pisces:Percichthyidae) for three Canadian Atlantic rivers: Saint John, Shubenacadie, Tabusintac. M.Sc. Thesis, Acadia Univ., Wolfville, N.S. 143 p.

Melvin, G. D. 1979. A survey of striped bass (*Morone saxatilis*) in Kouchibouguac National Park, N.B. Huntsman Marine Lab, St. Andrews, N.B. 76 p.

Parker, W. R., and K. G. Doe. 1981. Studies on the reproduction of striped bass *Morone saxatilis* (Walbaum) from the Annapolis River, Nova Scotia. Environ. Prot. Serv. EPS-5-AR-81-6: 89 p.

Williams, R. R. G., G. R. Daborn, and B. M. Jessop. 1984. Spawning of the striped bass (*Morone saxatilis*) in the Annapolis River, Nova Scotia. Proc. N.S. Inst. Sci. 34: 15-23.

Williamson, F. A. 1974. Population studies of striped bass (*Morone saxatilis*) in the Saint John and Annapolis rivers. M.Sc. Thesis, Acadia Univ., Wolfville, N.S. 60 p.

THE HISTORY OF THE STRIPED BASS FISHERY IN THE BAY OF FUNDY

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Jessop, B. M. 1991. The history of the striped bass fishery in the Bay of Fundy, p. 13-21. In R. H. Peterson [ed.] Proceedings of a workshop on biology and culture of striped bass (*Morone saxatilis*). Can. Tech. Rep. Fish. Aquat. Sci. 1832: vi + 66 p.

INTRODUCTION

The wealth generated by exploiting the abundant stocks of fish contributed importantly to the European colonization of what became the Maritime provinces. I will focus on the history of the striped bass fishery in the Bay of Fundy (Fig. 1), and to a lesser extent in the Scotia-Fundy region, but will first set the historical scene.

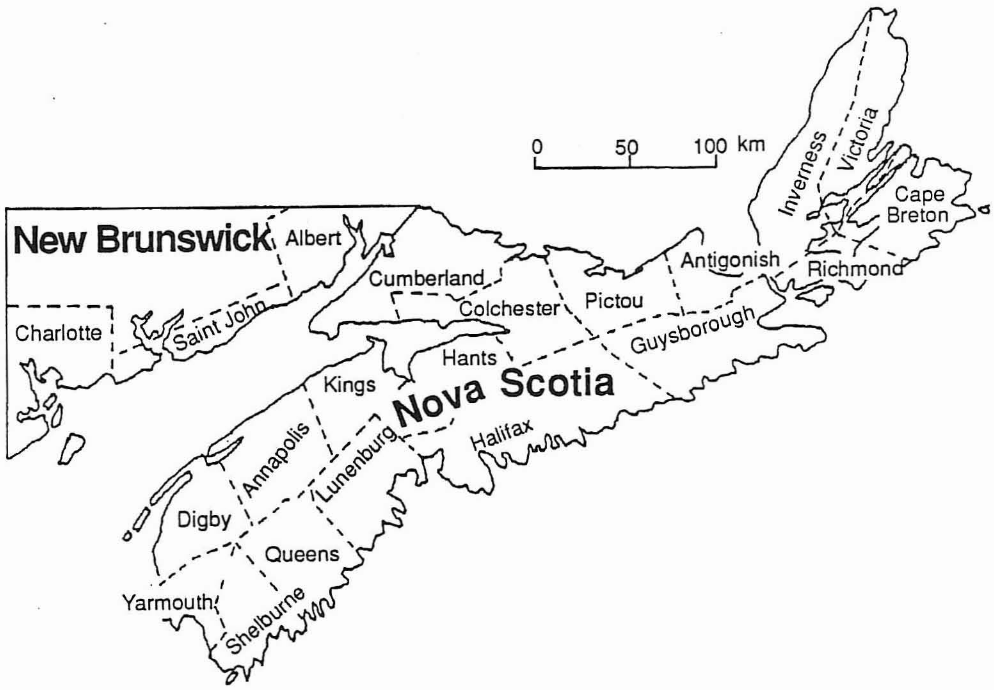

Fig. 1. Map of the Bay of Fundy Region.

Subsistence and commercial fisheries developed rapidly, as did industrialization in the form of mill dams constructed to process the harvest of the forests. Colonists often observed that the blockage of streams by impassable mill dams could destroy the runs of various anadromous fish species, but the relative value of the resource governed their actions, as it often does today. Laws requiring provision of fish passage at dams were routinely unenforced or exemptions were given. By 1853, the decline of the river fisheries of Nova Scotia was such that the Legislature enacted provincial laws to slow their destruction (Knight 1867). A system of closed seasons and fishery wardens was established and a general supervision of the fisheries was begun by government. New Brunswick had enacted similar provincial legislation in 1851 to replace the patchwork of county regulations. The concerns about the fisheries of New Brunswick and Nova Scotia expressed by observers such as Perley (1852) and Knight (1867) and early fishery supervisors and wardens (Annual Reports, Department of Marine and Fisheries) are uncomfortably similar to those of today. Despite our modern technology of resource management, we have not yet solved the difficulties of managing people exploiting resources that they value.

Historically, striped bass (*Morone saxatilis*) have been the focus of only minor fisheries in the Maritimes, relative to the fisheries for other, more abundant, anadromous species such as Atlantic salmon, alewife, American shad, and even smelt (Perley 1852; Knight 1867). For example, in 1867, Nova Scotian landings of shad totalled 5,577 barrels (each of 200 lb or 91 kg) worth almost $45,000, 7,611 barrels of alewife worth $217,000, and 8,055 lb of striped bass worth about $500. Within the Maritimes, the largest fisheries for striped bass occurred along the New Brunswick shores of the Gulf of St. Lawrence. In comparison, the striped bass fisheries of the Bay of Fundy were minor and had little economic impact.

Given the effects of strong and weak year-class phenomena on striped bass abundance coupled with the vagaries of a fishery, it is not surprising that annual catches of striped bass have greatly fluctuated since regular records began to be kept during the 1870's. In the Nova Scotia part of the Bay of Fundy, catches since 1895 have fluctuated between a low of about 0.5 t in 1920 and a high of 13 t in 1943 (Fig. 2). It is probable that all of the 15 t caught in Nova Scotia in 1962 came from the

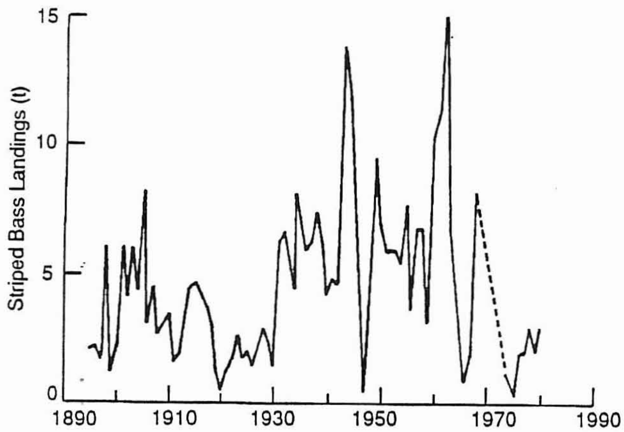

Fig. 2. Commercial landings (t) of striped bass in the Bay of Fundy counties of Nova Scotia, 1895-1980. Dashed line indicates missing values. (Source: Annual Report, Dept. of Marine and Fisheries 1875-1916; Fisheries Statistics of Canada 1917-1973; Statistics Branch, Halifax 1974-1977).

Bay of Fundy, although it is uncertain because of changes in the methods of recording catches which omit a breakdown by county. Catches of striped bass from the Nova Scotia portion of the Bay of Fundy have historically been divided among the Stewiacke River and, to a lesser extent, the north shore of Cobequid Bay in Colchester County; the lower Shubenacadie River and south shore of Cobequid Bay, primarily between Walton and Maitland, in Hants County; and the lower Annapolis River and Basin in Annapolis and Digby Counties. Striped bass were perhaps more abundant before the mid-1800's in areas such as the Minas and Annapolis Basins since Perley (1852) comments that striped bass there were once plentiful "... but are seldom taken now, having been thinned off by the weirs and other contrivances" and "... its unlimited destruction there at all seasons." Since the mid-1940's, little or no commercial landings have occurred in the Annapolis River area. Of particular interest are the irregular catches of up to 0.8 t of striped bass in Shubenacadie Grand Lake between the mid-1880's and about 1911. Occasional catches of up to 2.3 t of striped bass occurred between the late 1880's and early 1900's along the Atlantic coast of Nova Scotia in the Isaac's Harbour-St. Mary's River area of Guysborough County. On two occasions between 1904 and 1911, catches of up to 0.4 t of striped bass were reported in the Barrington and Lockeport areas of Shelburne County. Since the 1962 peak of striped bass catches in Nova Scotia, catches have irregularly declined and remained low in recent years, both because a regulation change in 1970 eliminated a directed fishery for striped bass and made their capture and retention legal only as bycatch in another fishery and because stock abundance had declined to a low level and has not yet recovered.

In the New Brunswick portion of the Bay of Fundy (Fig. 1), commercial catches of striped bass have historically occurred in the lower reaches of the Saint John River, primarily in the Belleisle and Kennebecasis Bays of Kings County, less so in Queens County. In the 1870's and 1880's, catches of up to 2.3 t of striped bass were also made upriver in Sunbury and York Counties as well as in the harbour and lower river in Saint John County.

As in Nova Scotia, the historical pattern of annual striped bass catches fluctuated greatly in New Brunswick (Fig. 3). Moderately large catches occurred between 1875 and the early 1890's, with a peak of almost 55 t in 1888 and large catches for the next 2 yr, after which catches sharply declined. A 3-yr closure of the fishery occurred from 1892 to 1894 to protect the stock. Comments by the Fishery Warden in 1895 indicate that fishermen were jubilant to be fishing striped bass again and that striped bass were now worth nearly as much as salmon. By 1899, the striped bass stock was again considered to be overfished (30 licenses to fish striped bass were issued that year) and the fishery was wholly confined to Belleisle Bay. By 1903, the Kings County fishery for striped bass was almost a failure; there were few applicants for licenses, of which only one was outside of Kings County. The decline in the striped bass fishery was attributed to wanton destruction of the stock during closed seasons in previous years. The increased catches of 1913 resulted in an increased market demand for striped bass and a request by a Fishery Warden for "the experts to

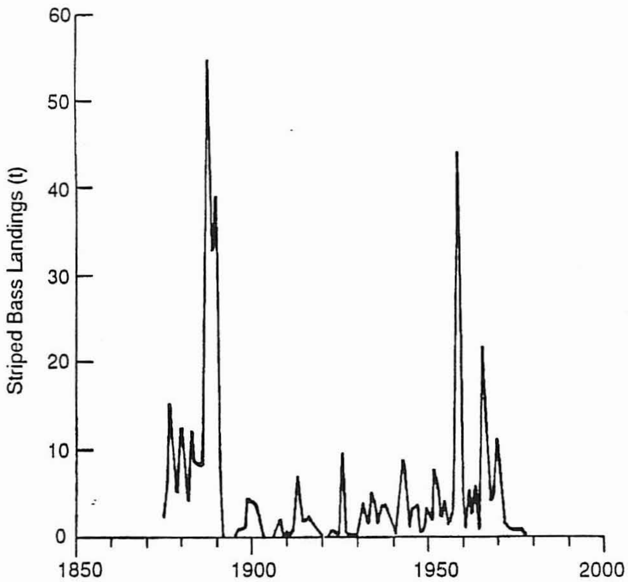

Fig. 3. Commercial landings (t) of striped bass in the inland Bay of Fundy counties of New Brunswick (Kings, Queens, Sunbury, York), 1895-1977. (Source: Annual Report, Dept. of Marine and Fisheries 1875-1916; Fisheries Statistics of Canada 1917-1973; Statistics Branch, Halifax 1984-1977).

tell why the bass act as they do in these waters." Annual catches of striped bass averaged less than 4.5 t between 1895 and 1955 but 4 yr of landings > 9 t occurred between 1958 and 1970, after which catches declined sharply. The commercial fishery was closed by regulation in 1978 for stock conservation and there has, as yet, been no recovery of the stock sufficient to justify reopening the fishery. Completion of the Mactaquac Dam in 1967 reduced the suitability of the historic spawning areas around the islands 5-11 km downstream of the dam and contributed to the decline in striped bass stock abundance in the Saint John River (Jessop 1990).

Capture methods employed in the early years of the striped bass fishery on the Saint John River are uncertain but undoubtedly included gill and trap nets. Fishing of some sort occurred almost year round. In early spring, striped bass were taken in the harbour fishery; in early summer catches were made by the salmon trap nets in the lower river; in winter, the under-ice gill net fishery operated. The introduction of power saws in 1958 greatly increased the efficiency of the winter ice fishery.

During the 1870's, striped bass in Nova Scotia were valued similar to trout and smelt on the fresh fish markets locally and in Halifax, where most were sold. Prices increased from about 4.6 cents/kg in 1872 to 22 cents/kg in the 1890's, after which they held relatively steady until the Second World War when they declined (Table 1). After the war, prices increased steadily until the mid-1960's when they levelled off at about 77 cents/kg. New Brunswick market prices for striped bass were often higher than in Nova Scotia and the war years did not reduce prices as much.

Table 1. Historical changes in the landed value of striped bass in Nova Scotia and New Brunswick.

Year	Nova Scotia Value (cents/kg)	New Brunswick Value (cents/kg)
1872	4.6	-
1876	13.2	-
1896	22.0	17.5
1910	22.0	22.0
1920	23.0	33.1
1925	22.0	39.7
1930	27.0	33.1
1935	22.1	22.1
1940	7.7	22.0
1945	10.0	44.1
1950	23.5	44.1
1955	29.8	71.1
1960	37.4	84.2
1965	33.0	50.9

In 1867, Knight reported that angling for striped bass had always been more popular in the United States than in Canada and this observation is true today. Nonetheless, early anglers considered the striped bass to be the most sporting fish of America, after the salmon family (Perley 1852). Little information is available on the fishing locations and habits of striped bass anglers in the Bay of Fundy area until the 1960's. Many of the presently active angling sites are located at or near areas that historically supported commercial fisheries for striped bass, such as the lower Kennebecasis River and Reversing Falls area of the Saint John River, the estuary of the Shubenacadie-Stewiacke Rivers, the estuaries of the Bass and Economie Rivers and Noel Shore of Minas Basin, the estuary of the Gaspereau River, and the Annapolis River estuary (Fig. 4). During the 1960's and 1970's, the estuaries of rivers such as the Bear and Sissiboo were also actively fished. Along the Atlantic coast, small or occasional angling fisheries occur in the estuaries of the Chebogue, Argyle, and Tusket rivers of Yarmouth County, the Lahave River in Lunenburg County, the Porters Lake area of Halifax County, and the St. Mary's River and Country Harbour area of Guysborough County. Angling for striped bass in the Scotia-Fundy Region today involves mostly small groups of local people active at a few locations, although sites such as the Annapolis River draw people from wider areas, including tourists from other provinces and the United States.

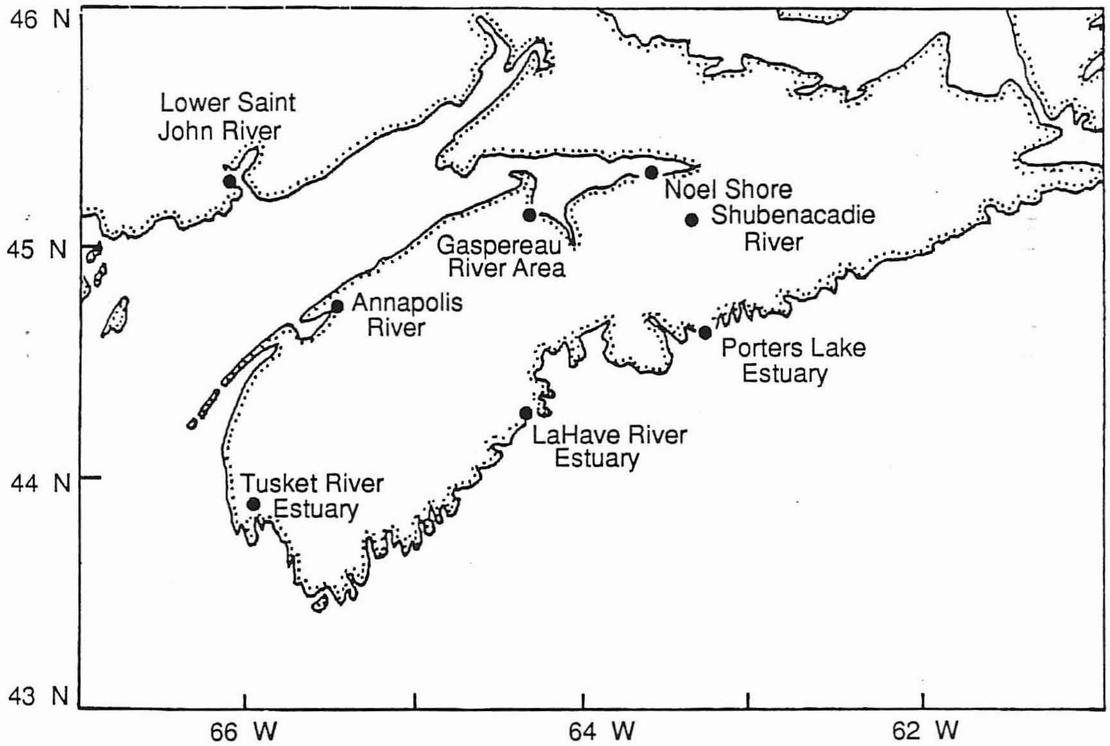

Fig. 4. Striped bass angling locations, Scotia-Fundy Region.

In the 1950's and 1960's, the Saint John River was the site of an active sport fishery for striped bass in the vicinity of the Reversing Falls but by the late 1970's, catches had declined drastically and few anglers bothered to fish. However, a 29.5 kg fish was reported caught in 1980 (Mosher 1986). A fishery for small striped bass (<2 kg) occurred downstream of the Tinker Dam on the Aroostock River prior to construction of the Beechwood Dam in 1957. No season or bag limit was ever imposed upon the sport fishery for striped bass in New Brunswick.

Spring fisheries for small (0.1-1.0 kg) striped bass occur along the shores of the Stewiacke River estuary and at the junctions of several tributaries to the Shubenacadie River estuary (Jessop and Vithayasai 1979). Boat-based fisheries in the Stewiacke River estuary take mostly medium sized (1-5 kg) striped bass and have a higher catch rate than does the shore-based fishery. Between 1951 and 1974, annual catches of striped bass averaged 370 fish (range 60-1010 fish), of which about 50% were angled on the Stewiacke River during June (Department of Fisheries and Oceans, Statistics Branch). More recent angling statistics are unavailable. The late summer fishery in Shubenacadie Grand Lake catches mostly fish of < 5 kg although a few larger fish are taken. The 1984-1986 Chronicle-Herald fishing derbies record a total of 178 striped bass, of which about 80% were less than 8 yr old and averaged 462 mm FL (range 235-660 mm) while the older group averaged 717 mm FL (range 590-919 mm).

Before the Annapolis River causeway was built in 1960, most striped bass fishing was by trolling or from shore in the vicinity of the Paradise Bridge due to prevailing tidal conditions (Joudrie 1974). After construction of the causeway, fishing activity shifted to the shore along the causeway and at Allain Creek, and to trolling in the Annapolis Basin. Later, trolling downstream of Bridgetown became popular in April and May, with shore fishing upriver of Bridgetown in May and June. Fishing at the causeway occurred from spring through autumn, with peak fishing activity usually in July and August.

Between 1951 and 1978, annual angling catches of striped bass in the Annapolis River reported by Fishery Officers ranged from a low of 153 in 1959 to over 58,000 in 1979 (Fig. 5). Annual landings greater than about 5,000 fish were regularly reported after the mid-1960's. These values are improbably high, lead to other improbable results, and conflict with other available data. For example, in June of 1969, 14,300 striped bass were reported angled for an average of 476 fish/d (Table 2). These fish averaged 1.8 kg each for a harvest weight of 25,850 kg. In June of 1970, an average of 457 striped bass each averaging 3.6 kg were reported angled. The 1970 annual catch of 58,135 fish was estimated to weigh 172,604 kg. In contrast, creel surveys which covered most of the angling season in 1975, 1976, and 1978 estimated angling catches of 478, 351, and 115 striped bass as compared with the Fishery Officer reports of 26,465, 35,240, and 14,960 striped bass (Table 3). Creel surveys in 1980 and 1987 also reported low catches. Between 1870 and 1945, when commercial fishing was active, reported annual catches from Annapolis County

Fig. 5. Angling catch of striped bass in the Annapolis River from Fishery Officer Annual Reports, 1951-1978.

did not exceed 3,000 kg, or less than 10% of some of the purported angling catches. Finally, striped bass catches, as determined by angling license stub returns (N. Adams, Nova Scotia Department of Fisheries, pers. comm.), are of similar magnitude (usually smaller; Fig. 6) as the

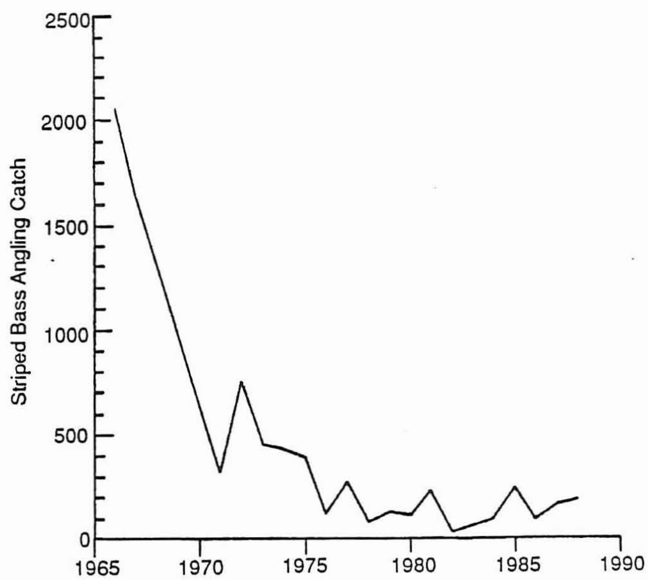

Fig. 6. Angling catch of striped bass in Annapolis County (mainly from the Annapolis River) as estimated from provincial fishing license stub returns, 1966-1988.

Table 2. Examples of reported monthly angling statistics for striped bass in the Annapolis River downstream of Paradise.

Date	Catch	Average fish/d	Weight (kg)	Average wt/fish
June 1969	14,300	476	25,850	1.8
Sept.	13,100	436	35,646	2.7
June 1970	13,700	457	49,705	3.6
Aug.	14,200	458	41,950	3.0
Sept.	10,300	343	23,809	2.3
June 1974	8,860	295	36,163	4.1
July	11,340	365	40,535	3.6
Aug.	6,680	215	24,236	3.6

Table 3. Estimated striped bass catch, effort, and catch/effort statistics, by creel survey, Annapolis River Causeway.

Survey[1]	Duration	Total effort (h)	Total catch	Average fish/h
1975	May 13-Sept 11	9,799	478	0.05
1976	Jun 18-Sept 17	7,261	351	0.05
1978	May 15-Sept 8	5,618	116	0.02
1980	Jun 3-Sept 2	~1,500	~40	0.01
1987	Jun 1-Oct 22	3,757	190	0.05

[1]1972 survey data incomplete

creel survey estimates. Because no license is required to angle striped bass in the tidal waters where most are caught, license stub returns would be expected to underestimate the actual catch. The Annapolis River might be one of the finest sites to fish striped bass in the Maritimes, but it was not as good as some reported angling catches would suggest. The reported angling catches from some other Nova Scotia rivers during the 1970's (Table 4) are much lower than catches from the Annapolis River but they should also be accepted with caution as potentially overestimated.

During the 1970's, the size and age composition of striped bass angled in the Annapolis River increased (Table 5). This reflected a lack of successful reproduction (Jessop 1990). The cause of the reproductive failure is uncertain but the available evidence suggests the toxic effects of low pH and elevated dissolved aluminum levels on the survival of larval striped bass. The eggs are viable and produce healthy young if reared in water of suitable quality. The creel survey in 1987 indicated an influx of younger fish into the area, perhaps from reproduction in the Annapolis River or from migrants (Harris and Rulifson 1988). Evidence from tagging studies indicates that an unknown portion of striped bass in the estuaries of Bay of Fundy rivers are migrants from other local or even American rivers. The potential numbers of migrants seems insufficient to support a truly healthy sport fishery and until the survival rate of young striped bass in the Annapolis River increases, the sport fishery will remain below its potential. Of course, any mortality due to passage through the turbine of the tidal power station will also reduce the striped bass stock, particularly the older, larger fish. As a stock conservation measure, the sport fishery of the Annapolis River has been closed since 1977 in the spawning area during the spawning season and the daily bag limit has been reduced to 2 fish from the 5 permitted in the rest of Nova Scotia.

To summarize, I think it is fair to say that, historically, striped bass commercial fisheries in the Bay of Fundy area were never of great significance nor of more than local interest at a few sites. The decline of striped bass abundance over the last 30 or more years and changes in regulations to reduce commercial exploitation and conserve the spawning stock have eliminated the directed commercial fishery in the Bay of Fundy region, although a significant bycatch of striped bass occurs in some other fisheries. The sport fishery reflects the decline in stock abundance and is now of no more than minor significance, except of course, to those few who are dedicated to fishing striped bass and remember the fishery's better days.

REFERENCES

Harris, P. J., and R. A. Rulifson. 1988. Studies of the Annapolis River striped bass sport fishery, 1987. I. Creel survey. Inst. for Coastal and Marine Res., East Carolina Univ., Rep. to Tidal Power Corp., Halifax, Nova Scotia (ICMR Tech. Rep. 88-03).

Jessop, B. M. 1990. The status of striped bass in Scotia-Fundy Region. CAFSAC Res. Doc. 90/36.

Jessop, B. M., and C. Vithayasai. 1979. Creel surveys and biological studies of the striped bass fisheries of the Shubenacadie, Gaspereau, and Annapolis Rivers, 1976. Department of Fisheries and Oceans, Resource Branch. Fish. Mar. Serv. MS Rep. No. 1532.

Joudrie, C. M. 1974. Valley striped bass endangered. Chronicle-Herald, Halifax, Nova Scotia, Jan. 29.

Knight, T. F. 1867a. Report on the fisheries of Nova Scotia. A. Grant, Queen's Printer, Halifax, Nova Scotia.

Knight, T. F. 1867b. The River fisheries of Nova Scotia. A. Grant, Queen's Printer, Halifax, Nova Scotia.

Mosher, E. 1986. The mysterious sea bass. Eastern Woods and Waters, July-Aug.

Perley, M. H. 1852. Report upon the fisheries of the Bay of Fundy. (Second Edition). Queen's Printer, Fredericton.

Table 4. Striped bass angling catches from selected streams in Nova Scotia[1].

Year	Annapolis	Bear	Shubenacadie	Gaspereau	Sissiboo	Chebogue	Tusket
1972	29,080	233	350	525	141	-[2]	675
1973	25,365	173	-	725	60	-	225
1974	40,325	524	275	300	408	940	-
1975	26,465	113	-	175	10	352	355
1976	35,240	55	675	201	55	395	-
1977	22,580	-	97	1,675	-	160	-
1978	14,960	-	1,810	315	-	-	-

[1]From Fishery Officer reports.
[2]Data unavailable or no catch reported.

Table 5. Mean age, fork length (cm), and weight (kg) of striped bass examined in the creel surveys of 1972, 1975, 1976, 1978, 1980, and 1987 (after Jessop (1980), Jessop (unpublished data), and Harris and Rulifson (1987)).

Year	n	Length	n	Weight	n	Age
1972	232	55.9	232	2.70	182	6.0
1975	215	66.0	191	3.95	204	7.8
1976	160	76.0	155	5.89	159	9.4
1978	131	80.2	126	6.38	130	10.9
1980	24	77.1	24	6.25	0	-
1987	49	70.3	49	4.23	35	6.3

MANAGEMENT, ENHANCEMENT, AND RESTORATION OF STRIPED BASS IN THE STATE OF MAINE, U.S.A.

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Flagg, L. N., and T. S. Squiers, Jr. 1991. Management, enhancement, and restoration of striped bass in the State of Maine, U.S.A., p. 23-28. In R. H. Peterson [ed.] Proceedings of a workshop on biology and culture of striped bass (*Morone saxatilis*). Can. Tech. Rep. Fish. Aquat. Sci. 1832: vi + 66 p.

INTRODUCTION

From New Hampshire to the Canadian border, migratory striped bass support an important recreational fishery in the inshore coastal waters of Maine. Coastal anadromous striped bass inhabit Maine waters as far inland as the first upstream dam on major river systems and seaward to the outer Maine islands. The species is seasonally available to Maine anglers from May through October, although striped bass are occasionally caught in Maine waters as early as mid-April and as late as the latter part of November. Since the 1950's, overwintering of striped bass has been known to occur in the Penobscot and Sheepscot estuaries. The availability of striped bass to the Maine fishery is highly variable from year to year and depends upon year class strength and migratory patterns of stocks originating from south of Maine. Based on recent tag return data, the origins of striped bass in the Maine fishery are primarily Hudson River and Chesapeake Bay fish, although the proportional contribution of these stocks has yet to be determined. Adult striped bass tagged on Hudson River and Chesapeake Bay spawning grounds during the spawning season have been recaptured in the spring and summer fisheries in the Saco, Kennebec, and Androscoggin River estuaries.

During the past 60 yr, the annual relative abundance of migratory striped bass has been highly variable. Historical records, coastal warden reports, commercial landings, and recreational angler reports indicate that from 1930-1935 striped bass were very scarce in Maine. From 1936-1939, striped bass were abundant due to a large 1934 year class production in Chesapeake Bay, which initially became available to Maine anglers and commercial fishermen in 1936. Striped bass were scarce again in 1940-1941, moderately abundant in 1942-1943, scarce from 1944-1956, and very abundant from 1957-1975. Since 1975, stocks appeared to decline rapidly until the mid-1980's when the population began to rebound due to stringent conservation measures applied throughout the range of the coastal migratory stocks. The major sportfishery occurs in southwestern Maine adjacent to the urban areas of Portland, Saco, Biddeford, and Bath/Brunswick. Striped bass surf fisheries occur primarily from sandy beaches and rocky promontories south of the Kennebec River. Estuarial striped bass fisheries occur in the Saco, New Meadows, Kennebec, Sheepscot, Damariscotta, St. George, Penobscot, Union, Narraguagus, and St. Croix Rivers. With the exception of the Sheepscot and Damariscotta Rivers, striped bass fishing pressure east of the Kennebec River is considered to be light. As an example of the magnitude of the fishery, Otto (1970) estimated that the total 1969 striped bass fishery effort for mid-coastal Maine (Kennebunk to Port Clyde) of 176,000 angler hours produced a catch of 23,500 striped bass and a 1970 effort of 114,000 angler hours produced a catch of 6,500 fish.

HISTORICAL FISHERIES

Prior to the late 1920's and early 1930's, native spawning populations of striped bass were known to occur in the Kennebec/Androscoggin River estuary. Although historical accounts indicate that small commercial fisheries occurred in the Penobscot, St. Croix, and Saco Rivers, the Kennebec/Androscoggin estuary was considered to be the major production area in Maine. The large expanse of tidal fresh water in the Kennebec/Androscoggin estuary was well suited to the reproduction of striped bass. These two large rivers (Kennebec and Androscoggin), in addition to three smaller tributaries (Eastern, Cathance, and Abagadasset) form an 11,000 acre tidal complex known as "Merrymeeting Bay". As late as 1830, striped bass catches in the Merrymeeting Bay district exceeded the capacity of markets to absorb them. Some weirs were known to take 1,000 lb on a single tide. Winter gill net fisheries on the Eastern and adjacent Sheepscot River remained active as late as the 1920's. The native spawning population of striped bass in the Kennebec/Androscoggin estuary was believed exterminated in the late 1920's or early 1930's due to heavy industrial and municipal pollution. From the 1930's to the mid-1970's, dissolved oxygen levels in this estuary routinely dropped to zero (0) throughout late summer and during low river flow periods.

MANAGEMENT

Prior to 1969, striped bass management in Maine was minimal, piecemeal, and uncoordinated. Some individual rivers had harvest (hook and line only) and/or creel limit restrictions; however, no statewide regulations were in effect. In 1969, statewide striped bass harvesting was restricted to hook and line only or by spear gun. No further regulations were imposed until the adoption of an Interstate Fisheries Management Plan by the Atlantic States Marine Fisheries Commission, of which Maine is a member. In October, 1981, an Interstate Fisheries Management Plan for Striped Bass was adopted by unanimous vote of the ASMFC. This plan promotes uniform regulation of the striped bass resource through its migratory range from Maine through North Carolina. Due to a precipitous decline in Chesapeake Bay stocks since the mid-1970's, increasingly restrictive regulations on striped bass harvesting in Maine have been imposed as follows:

Year	Method	Min. Size	Creel Limit	Disposition
1969	Hook&Line Spear Gun	---	---	Sale Allowed
1983	Hook&Line Spear Gun	16"FL	4*	Sale Allowed
1984	Hook&Line Spear Gun	16"FL	4	No Sale
1985	Hook&Line Spear Gun	24"FL	4	No Sale
1986	Hook&Line	33"TL	2	No Sale
1989	Hook&Line	36"TL	2	No Sale
1990	Hook&Line**	36"TL	1	No Sale

*Between 15 and 24"FL; no creel limit on fish over 24"FL

**Kennebec/Androscoggin Rivers closed from 1 Dec. to 30 June annually

RESTORATION

Coincidentally, with recent efforts to rehabilitate Chesapeake Bay striped bass stocks, local interest arose to restore a native stock of striped bass to historical spawning areas in Maine. Extensive pollution abatement efforts of the early 1970's brought about dramatic improvement in water quality of the lower Kennebec/Androscoggin River estuary. Since 1977, minimum dissolved oxygen levels in this estuary have been 7.0 ppm during worst case conditions of low river flows and high water temperatures. Maintenance of good dissolved oxygen levels from 1977-1981 prompted the Department of Marine Resources to initiate an experimental striped bass restoration program. In 1982-1983, wild young-of-the-year striped bass were captured from the Hudson River and transferred to the Kennebec River. Because only small numbers (319 in 1982 and 572 in 1983) could be obtained from seining wild fish, the program was shifted to hatchery production in 1984. Striped bass fry were obtained from a private grower (Multi-Aquaculture Systems, Inc., of Amagansett, NY) and raised to fall fingerlings by the USF&WS at its North Attleboro (Massachusetts) National Fish Hatchery. From a lot of 7,500 4-wk-old fry transported to North Attleboro, 2,306 fall fingerling striped bass were stocked into the Kennebec River at Richmond. An additional 200 fall fingerling striped bass were transferred from Ecological Analysts' Verplanck Striped Bass Hatchery on the Hudson River. From 1985-1989, with the approval of the New York State Department of Environmental Conservation and the Consolidated Edison Company of New York, Inc., striped bass fry were procured from EA's Hudson River Hatchery, raised to fall fingerling size at the USF&WS North Attleboro Hatchery, and stocked into the Kennebec/Androscoggin River estuary. From 1982-1989 a total of 187,600 Phase II fall fingerlings were stocked during the aforementioned period, ranging from a low of 319 in 1982 to a high of 66,000 in 1988 (Table 1). Due to a fry production deficit at the Verplanck Hatchery, no striped bass were stocked in 1987.

Since 1979, a beach seine 17 m long, 1.8 m deep, comprised of 6.35 mm stretch mesh nylon, has been employed in a juvenile alosid survey of the Kennebec/Androscoggin River estuary. The net has a 1.8 m x 1.8 m bag which was added in 1982. The net is set from a boat with the inshore end held stationary at the land/water interface while the other end is extended perpendicular to the shore. The net is towed in an up-current arc toward shore and pulled ashore. All sampling is done on an outgoing tide and each site is sampled every two weeks from mid-July through October. Most sites are sampled six times per season and no site is

Table 1. State of Maine striped bass stocking program.

Year	# Stocked	Size (TL)	Origin	Location
1982	319	2-4"	Hudson River (W)	Androscoggin
1983	572	2-4"	Hudson river (W)	Kennebec
1984	2,306 200	4-5" 2-4"	Unknown (H)[a] Hudson River (H)	Kennebec Kennebec
1985	46,759	3-4"	Hudson River (H)	Kennebec
1986	30,246	3-5"	Hudson River (H)	Kennebec & Androscoggin
1987	None	N/A	N/A	N/A
1988	66,623	2-5"	Hudson River (H)	Kennebec & Androscoggin
1989	40,535	3-5"	Hudson River (H)	Kennebec & Androscoggin

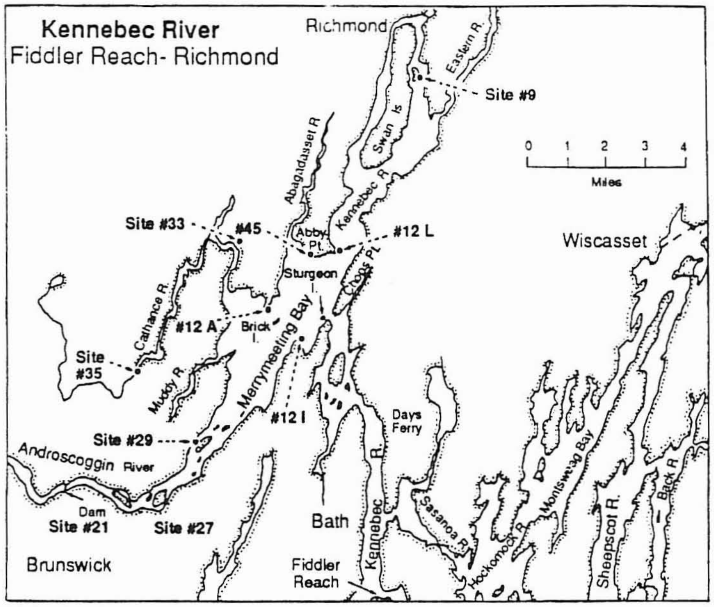
[a]Fish obtained from Multi-Aquaculture Systems, Inc., Amagansett, Long Island. Broodstock captured in Long Island coastal waters could be of Hudson or Chesapeake origin.

sampled less than three times per season. In 1987, while conducting the juvenile alosid survey, 26 wild young-of-the-year striped bass, 2-4" in length, were collected at three separate sample locations. This represented the first documented spawning success of striped bass in the Kennebec/ Androscoggin River estuary in over 50 yr. In subsequent years, transfers of Hudson River hatchery fish to Maine were deferred until the latter part of the beach seine survey in order to determine the presence of wild young-of-the-year in this system. Wild young-of-the-year stripers have been collected each consecutive year from 1987-1990. However, recruitment of striped bass in the estuary has been minimal since first documented in 1987. A total of 15 sites have been routinely sampled for juvenile alosids since 1979. Table 2 provides a listing of the sample sites and the attached map (Fig. 1) delineates the locations of the seine sites. Striped bass young-of-the-year have been collected at Sites 9, 12A, 12J, 29, 45, and 51. The catch-per-seine haul by year was as follows:

Year	Catch/ haul	Total catch	Total # hauls
1987	0.35	26	74
1988	0.03	3	98
1989	0.01	1	92
1990	0.01	6[a]	98

[a]Two fish caught after fall stocking of hatchery fish.

In addition, ichthyoplankton surveys have been carried out on the Kennebec and Eastern Rivers annually since 1988. Analysis of 1988 samples yielded two (2) larval striped bass taken from the mid-estuary area of the Eastern River, one (1) on June 10, 1988, and the second on June 21, 1988, at water temperatures of 17.5 and 24.0°C, respectively.



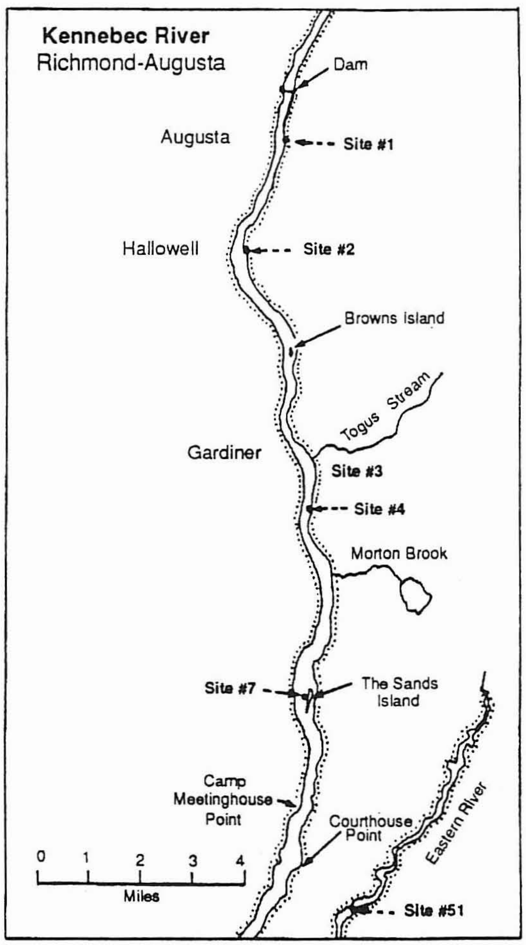


Fig. 1. Location of seining sites for juvenile alosids.

Table 2. Descriptive location of beach seining sites.

Site #	River	Description
1	Upper Kennebec River	Augusta boat launch
2	Upper Kennebec River	Chelsea boat launch
3	Upper Kennebec River	Mouth of Togus Stream
7	Upper Kennebec River	Sands Island
9	Merrymeeting Bay	Little Swan Island
12A	Merrymeeting Bay	Beach opposite Brick Island
12J	Merrymeeting Bay	Butler Cove
12L	Merrymeeting Bay	Abby Pt.
21	Androscoggin River	Zeke's Fishing Site
27	Androscoggin River	Cove below Cow Island
29A	Androscoggin River	Bay Bridge Road
33	Cathance River	River Bend
35	Cathance River	Head-of-tide
45	Abagadasset River	Mouth of river, east shore
51	Eastern River	Middle Bridge

SUMMARY AND CONCLUSIONS

Stocking of hatchery-reared striped bass juveniles can be used to reestablish spawning stocks in reclaimed historical spawning habitat. Although the full restoration of the Kennebec/ Androscoggin River striped bass population has not yet occurred, the modest results to date are encouraging and should be viewed as a positive contribution to the well-being of the resource.

REFERENCES

Atkins, C. G. 1887. The River Fisheries of Maine. In Fisheries and Fishery Industries of the U. S. Sect. 5, Vol. 1, pp. 673-728.

Bigelow, H. B. and W. C. Schroeder. 1953. Fishes of the Gulf of Maine. Fish. Bull., U.S.F.W.S., No. 74, Vol. 53, 577 pp.

Koo, T. S. Y. 1970. The Striped Bass Fishery in the Atlantic States. Chesapeake Science, Vol. II, No. 2, pp. 73-93.

Otto, Robert S. 1971. Design of a Creel Census for the Striped Bass Sprot Fishery Along the Central Maine Coast. M.S. Thesis, University of Maine at Orono, 96 pp.

State of Maine. 1946-1976. Maine Landings. Department of Marine Resources, State House, Augusta, Maine.

State of Maine. 1867-1895. Reports of the Commissioner of Fisheries of State of Maine, Augusta, Maine.

State of Maine. 1896-1939. Biennial Reports of the Commissioner of Sea and Shore Fisheries of the State of Maine, Augusta, Maine.

United States Bureau of Fisheries. 1921-1930. Statistics of New England Fisheries.

United States Bureau of Fisheries. 1931-1941. New England Fishery Statistics. In Ann. Reports, Fishery Statistics of the U. S. for 1930-1939.

United States Fish & Wildlife Service. 1942-1952. New England Fisheries Statistics. In Ann. Reports, Fishery Statistics of the U. S. for 1939-1949.

STRIPED BASS MANAGEMENT IN NEW BRUNSWICK

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INTRODUCTION

This report provides an overview of past and current striped bass (*Morone saxatilis*) management in North America and New Brunswick. This foundation is required to justify measures needed to restore bass stocks to levels that will eventually generate substantial social and economic benefits to New Brunswickers.

Striped bass thrive in fresh, estuarial and ocean waters, often migrating from river to river along the Eastern seaboard. They are opportunistic feeders, growing 0.5-2.0 kg/yr for up to 30 yr. The striped bass is the preferred sport and table fish where it occurs, except in New Brunswick and Nova Scotia where it is not a regulated sport fish. The Atlantic coast sport and commercial fisheries for striped bass generate more social and economic benefits than do any other anadromous or catadromous species. These fisheries for bass generated over $200 million in economic output, annually supporting over 5,600 jobs in 1980, a low catch year (Norton et. al. 1983).

Striped bass and their hybrids are stocked in over 500 reservoirs and 15 to 20 streams in 36 states, with over 40 million fingerling bass planted each year by U.S. state and federal hatcheries. The first successful introductions (and probably management activity) for striped bass occurred in 1879 and 1882 when a total of 432 fingerling bass from two New Jersey rivers were transported by railroad and released into San Francisco Bay, California (Bonn et al. 1976). A substantial sport and commercial fishery expanded throughout the Pacific coast from the early 1900's until present from the two plantings.

As adults, striped bass were not considered a freshwater sport fish until 1954 when an impounded anadromous population from 1941 was found to have spawned successfully in the Santee-Cooper Reservoir in North Carolina.

HATCHERY PRODUCTION

Although striped bass eggs were successfully hatched in jars in 1884 by Weldon, successful fish culture techniques were not developed for another 82 yr when R. F. Stevens developed methods for induced spawning of captured brood stock for reservoir stocking (Stevens 1966).

Today striped bass and bass hybrids are being reared extensively for use in put, grow and take stocking programs in freshwaters where natural reproduction is usually not possible. A native New Brunswick species, the white perch (*Morone americana*), has been utilized to produce a successful hybrid to supplement natural populations of striped bass and white perch in estuaries (Kerby et al. 1987), although the most common hybrid cross is with white bass (*Morone chrysops*). Hybrid bass display faster early growth and better survival than striped bass and grow to a larger size than white perch. Further studies are suggested however, prior to utilizing any bass hybrids in coastal waters to determine potential for back crossing. Competition between hybrids and endemic striped bass or white perch could be harmful to parent populations, particularly important in areas where parent populations may be very depressed.

New York, Maryland and California state and/or federal agencies rear millions of striped bass fingerlings and yearlings annually in attempts to augment or restore anadromous populations. Private production of striped bass and bass hybrids for freshwater aquacultural purposes is increasing rapidly and will soon exceed U.S. state and federal production.

ANADROMOUS FISHERIES

Striped bass populations were once abundant throughout Atlantic Coast waters, including Gulf of Mexico waters. Tagging studies have determined that migratory populations along the East Coast originate primarily from the Hudson River in New York and the Chesapeake Bay in Virginia and Maryland. South Carolina also produces coastal migratory bass. The Delaware River once made important contributions to coastal stocks, but industrial effluents and municipal sewage have all but eliminated this population (Rago 1989).

Threats to coastal stocks were recognized in the late 1970's when scientists concluded overfishing and, to a lesser extent, contaminants, were key factors responsible for stock decimation. United States striped bass landings peaked in 1973 and declined steadily thereafter (Table 1). Stringent management regulations prohibiting the catch of mature bass in the sport and commercial fisheries were imposed by all coastal states in 1981 and enforced until present (Table 2). Subsequent year classes of older, mature bass have demonstrated a large increase in abundance since 1986. Moreover, strong year classes of 0+ and 1+ age juveniles were found in 1989 and 1990 by various state beach seine surveys indicating successful adult reproduction. Future bass landings from the 0+ and 1+ age classes may result in excellent fishing in the mid- to late 1990's, as juvenile indices account for 83% of the variation in reported subsequent commercial landings from 1964 to 1983 (Richards 1987).

Contributions of hatchery striped bass to Atlantic Coast commercial or recreational fisheries are unknown at this time primarily due to the above-mentioned fishery closures. Over 66 million fingerling and 18 million bass fry stocked in Gulf of Mexico waters have created sport fisheries in or adjacent to most major coastal tributaries. Unfortunately self-sustaining spawning populations have yet to be re-established, probably due to large scale habitat destruction in estuarial and fresh waters (Rago 1989).

NEW BRUNSWICK STOCKS

New Brunswick commercial fisheries account for most of the Canadian harvest of striped bass. Most bass are harvested within or near the Miramichi Bay or within the Saint John River. Catches have varied from 1-48 metric tonnes (MT) representing 0.1-6.1% of the total Atlantic coast harvest (Table 1). Catch estimates may be conservative as many juvenile bass are "unintentionally" caught and not reported in nets, traps and weirs set for other fish.

Catches from the Saint John River estuary are very depressed and have not exceeded 4 MT since 1975 (Table 1). Sustained production is believed to be low or negligible (Jessop 1990). Gulf of St. Lawrence catches have fluctuated from 9-48 MT since 1968. Gulf populations appear to be sustained at low levels (Chaput and Randall 1990).

New Brunswick striped bass include migrant fish from the United States, but most bass are believed to be of Canadian origin. Several age, growth, maturity and tagging studies indicate New Brunswick bass grow slower and may mature earlier (females at age 4 or 5) than U.S. stocks. Populations move to various coastal areas and estuaries, including U.S. waters (Dadswell 1976; Melvin 1978; Hogans and Melvin 1984; Madden 1984; Bujold 1985; Watling 1985; Meagher 1987). Fingerlings or yearling striped bass have been reported by New Brunswick biologists or commercial fishermen in the Saint John, Nepisiquit, Pokemouche, Tabusintac, Miramichi, Richibucto, and Kouchibouguac Rivers since 1980, indicating successful natural reproduction. Dadswell, 1976, suggested Belleisle Bay (Saint John River) area striped bass eggs contained high levels of organochlorines (DDT, PCB), possibly causing a high incidence of membrane fragility and embryo mortality. Contaminated eggs may not be a factor considering the high fingerling indices and broad span of age groups now present in the Hudson River stock which possess PCB concentrations in excess of FDA human health standards.

New Brunswick striped bass populations are subjected to catch in a variety of commercial fishing gear due to their extensive migratory habits throughout estuaries and coastal waters as well as their fresh water overwintering behaviour. Striped bass have always been considered a bonus fish by "non-bass" commercial fishermen who select 20 cm or larger bass from their nets. Very few bass caught by anglers or commercial fishermen exceed 40 cm. Sport fishermen target striped bass for angling only within the Nepisiquit, Tabusintac, Miramichi, and Richibucto estuaries. Angling usually occurs during June, August and September. There is no coastal angling for striped bass. A few striped bass are angled each year in the Saint John estuary, especially within the city limits of Saint John at Reversing Falls and at the confluence of the Nashwaak River.

Estimating past catch of bass, as well as separating recreational and commercial fishing catch and effort for Gulf of St. Lawrence rivers, is almost impossible due to the variety and numbers of fishermen. For example, a portion of the commercial harvest not recorded originates from hook and line fishing, in the Richibucto and Tabusintac estuaries during August and September. A 5% survey of New Brunswick anglers estimated 80,000 bass caught in 1980 and 31,000 caught in 1985; some of these were probably sold thereafter (Table 3).

Table. 1. Commercial catch (metric tonnes) of striped bass from the Atlantic coast, 1930 to 1987. NAFO divisions are illustrated in Fig. 7 (from Chaput and Randall, 1950).

	Canada[a]				USA Atlantic[a]			[b]
Year	St. Lawrence 4T	Fundy 4X	Total	% of Atlantic	SA 5	SA 6	Total	Total SA 5 & 6
1930			5	0.5				1090
1931			10	1.3				757
1932			11	1.4				739
1933			6	1.5				424
1934			5	1.0				456
1935			8	1.3				629
1936			6	0.4				1442
1937			6	0.3				2080
1938			7	0.4				1816
1939			6	0.4				1707
1940			4	0.3				1320
1941			5	0.5				947
1942			5	0.3				1780
1943			14	4.0				332
1944			12	0.5				2579
1945			8	0.3				2437
1946			4	0.2				2077
1947								2085
1948			3	0.1				2727
1949			15	0.6				2543
1950			13	0.4				3490
1951			7	0.3				2762
1952			12	0.5				2445
1953			8	0.4				2304
1954			20	0.9				2268
1955			15	0.7	44			2194
1956			10	0.5	32			2032
1957			7	0.4	35			1890
1958			7	0.2	42			2763
1959			3	0.1	46			3712
1960			10	0.3	89			3878
1961			11	0.3		3955		4291
1962			15	0.4		3006		3906
1963			7	0.2	246	3205	4201	4213
1964			5	0.1	53	3733	3059	3881
1965			2	0.1	216	4308	3421	3497
1966		1	1	0.0	372	4590	4105	4116
1967	2	3	5	0.1	358	5086	4666	4749
1968	6	7	13	0.3	428	4350	5018	4835
1969	9	14	23	0.4	532	3078	5618	5623
1970	11	4	15	0.3	681	3723	5031	5051
1971	13	7	20	0.6	412	5167	3490	3548
1972	9	3	12	0.3	120	4108	3843	4584
1973	6	3	9	0.1	169	3135	5336	6335
1974	5	5	10	0.2	137	2464	4245	4997
1975	7	1	8	0.2	716	1858	3851	
1976	7	2	9	0.2	498	1606	2962	
1977	5	3	8	0.2	469	1045	2327	
1978	5	4	9	0.2	398	1691	2004	
1979	7	2	9	0.6	450	1479	1495	1572
1980	15	3	18	0.8	378	679	2069	2114
1981	48		48	2.4	439	728	1918	1937
1982	32		32	2.8	377	1231	1056	1104
1983	23	2	25	3.1	192	472	920	780
1984	12	1	13	1.0	74	104	1305	1333
1985	19		19	3.3	82		552	560
1986	10		10	6.1	50		154	153
1987								196

[a]Canada: Total 1930 to 1954 from Fisheries statistics of Canada.
Total 1955 to 1986 from NAFO Statistical Bulletin.

USA: Total 1955 to 1986 from NAFO Statistical Bulleton.

[b]USA: Total 1930 to 1974 from Setzler et al. 1980.
Total 1979 to 1987 from Rago & Dorazio 1989.

Table 2. State regulations in place as of January 13, 1989 that affect fishing for striped bass in U.S. Atlantic waters (from Rago and Dorazio 1989).

State	Min. size limit (TL) (in.)	Creel limit (per day)	Recreational Season	Commerical Season	Gear Restrictions	Other
ME	33	2[a]	No closed season	No commercial fishery	Hook & line only	No sale if caught in ME
NH	33	2	No closed season	No commercial fishery	Hook & line only	No sale regardless of origin
MA	33	1[a]	No closed season	Closed Oct.1-May 31	Hook & line only	Sale allowed; dealers may not possess Oct. 6-May 31
RI	33	1	No closed season	Floating trap nets prohibited Oct, Jan, Feb; gillnets prohibited Oct	Gill net restrictions	No sale (PCB contamination)
CT	33	1	Closed Dec 15-Mar 31	No commercial fishery	Hook & line only gaffing prohibited	No sale if caught in CT
NY (Hudson River)	18	1[a]	Closed Dec 1-Mar 31	Closed Dec 1-Mar 15; restricted Mar 15-June 15	Seines, hoop nets, fykes & trawls prohibited; gill restrictions Mar 15-Jun 15	No sale (PCB contamination)
NY (Marine waters)	33	1[a]	Closed Dec 1-May 7	Closed Dec 1-May 7	None	No sale (PCB contamination)
NJ	33	5	No closed season	No commercial fishery	Hook & line and spear fishery only	No sale regardless of origin
PA	33	2	No closed season	No commercial fishery	Hook & line only	No sale if caught in PA
DE						Moratorium, no possession
MD						Moratorium, no possession
PRFC[b]	24	5	Closed Dec 1-May 31	Closed Dec 1-May 31	Gillnet restrictions	34 in. maximum size limit; sale if licensed only June 1-Nov 30
DC	24	2	Closed Dec 1-May 31	No commercial fishery	Hook & line only	No sale if caught in DC
VA (Bay) (Ocean)	24 38	5	Closed Dec 1-May 31	Closed Dec 1-May 31	No trawl or drag nets in inland waters	40 in. TL maximum size limit except 2/day over 40 in.
NC (Sounds & tributaries) (Roancke R., inland) (Ocean)	14 16 33	3	No closed season	By area, various months closed	Gill net restrictions by area	Hook & line caught fish may not be sold; sale allowed in season only

[a]Catch and possession
[b]Potomac River Fisheries Commission

Table 3. Angler catch of striped bass as estimated from 1980 and 1985 Angler surveys, undertaken by the New Brunswick Department of Natural Resources and Fisheries and Oceans Canada.

Area	# Striped bass reported caught	
	1980	1985
Bay of Fundy (Saint John River)	0	261
Gulf of St. Lawrence	80,747	31,836

New Brunswick estuaries, especially Gulf of St. Lawrence estuaries, offer exceptionally good nursery and overwintering habitat for juvenilestriped bass. The waters are unpolluted and possess at least 80,000 hectares of productive rearing area.

JUSTIFICATION TO MANAGE

Legislators and fishery managers require accurate social and economic information on striped bass potential to decide whether government personnel and expenditures should be allocated to implement harvest regulation, management-research activities and stock augmentation through hatchery propagation.

Through 1990, the striped bass has not been a legally recognized sport fish in New Brunswick. Anglers may harvest any size bass during any season. Conversely, in the United States, the striped bass is the favoured game and sport fish throughout its range. Sport and commercial fishing has been strictly regulated there since 1982 through minimum size limits and catch limits (Table 2).

New Brunswick striped bass stocks of all sizes have been intensively harvested by direct and indirect commercial gill net fisheries and as well as incidental catches in gaspereau, eel, smelt, and shad commercial nets. Only ten striped bass licences (127 mm stretch mesh for gill or bow nets) were issued in 1990 in DFO statistical districts 75 and 76 (Fig. 1). However, for New Brunswick, there are 1,493 other Bay of Fundy and 4,906 Gulf of St. Lawrence commercial fishermen who may harvest unrestricted quantities of any sized bass unintentionally caught. The following regulations to limit commercial bass exploitation have been implemented by Fisheries and Ocean Canada:

- designated bass commercial fishermen in statistical districts 75 and 76 (Kent Co.) are prohibited from retaining striped bass <38 cm (15") in length

- in Kouchibouguac National Park anglers are restricted to five bass/angler/d, a minimum size of 38 cm and an angling season 01 July to 15 November

- The Belleisle Bay (Saint John River) commercial fishery was closed in 1978.

Unfortunately, the Kent County length regulation has not been enforced. The overwintering Belleisle Bay population was probably fished to near extinction prior to the 1978 regulation.

Commercial catch statistics indicate 9,000 to 63,000 bass have been harvested in the Gulf of St. Lawrence since 1968 assuming a base size of 0.68 kg (1.5 lb). Nearly all bass harvested are immature 2+ and 3+ age and sell for about $2.20/kg. The landed fishery value for all commercial fishermen has ranged from $13,000 to $105,000 (or $2.03-$16.40/fisherman). Prohibiting angler and commercial exploitation would allow several thousand bass to spawn providing maximum opportunity for a large annual increase in 0+, 1+ and 2+ juvenile bass stock recruitment. Striped bass fecundity is very high

Fig. 1. New Brunswick rivers with fingerlings or yearling striped bass populations; also DFO fishery statistical districts containing ten striped bass licencees.

ranging from 136,400 to 246,000 eggs/kg of body weight (Levis and Bonner 1966). Moreover, juvenile recruitment is density independent (Goodyear 1984) and directly related to subsequent adult stock abundance.

Subsequent to stock recovery, angling should replace commercial exploitation as much larger social and economic benefits can be generated. Norton, et al. 1983 found the net economic value of angling was more than double the commercial fishing net value for the U.S. Atlantic coast; U.S. anglers in 1979 spent $90 million to fish bass, or an average of $41/trip. A striped bass angling fishery throughout New Brunswick estuarial and coastal waters could attract at least as many anglers (about one-fifth who could be non-residents) as Atlantic salmon, considering the abundant coastal and estuarial areas present and the premier game fish status bass has throughout North America. A several million dollar fishery appears possible, directly employing up to 50 people. Charter boats, surf casting techniques, if introduced, could provide for a diversity of angling experiences for bass. The new angling industry, based on a self-sustaining bass population, would fit well with present community life-styles.

Bay of Fundy stocks appear to have very low potential to produce a sport fishery in the near future. Fish culture methods should be considered, perhaps in perpetuity, to prevent possible stock extinction.

U.S. biologists have studied striped bass intensively and extensively and have implemented a management framework including hatchery propagation, which may be successful in restoration of some stocks. Close liaison with U.S. biologists will help refine and minimize the expense of our management attempts especially in identifying a limiting environmental factor(s) which could be overcome with an innovative hatchery technique to restore Saint John bass stocks.

MANAGEMENT OBJECTIVES

To achieve management objectives necessary to restore, increase and perpetuate New Brunswick striped bass stocks, a formal working agreement is required supported by government, university, industry, and public representatives. Suggested ojectives include:

(1) Maximize recruitment of juvenile striped bass until 1996 through nonharvest regulation control.

(2) prevent extinction of Saint John River striped bass stocks by undertaking environmental and hatchery studies in 1991 to determine (a) present and potential stock recruitment, (b) environmental limitations and, (c) need for hatchery propagation.

(3) A formal management committee and action plan to identify priority projects, co-ordinate management efforts and assess results.

(4) Complete a study for Gulf of St. Lawrence bass rivers and potential bass rivers in 1992 identifying the social and economic potential of a sport fishery; the study should identify goods and services available as well as those required to support a new sport fishery.

(5) Manage to provide for a diversified sport fishery with discreet harvesting allowances, in Gulf of St. Lawrence by 1996.

OPERATION PLAN

New Brunswick striped bass stocks should be managed in the next 2 yr, utilizing the best information available. Management actions are required immediately to increase the size of threatened spawning stocks for Gulf of St. Lawrence rivers and to preserve Bay of Fundy stocks now threatened with extinction. Short term actions involving regulations may be all that required to develop a Gulf of St. Lawrence sport fishery. Saint John River management requires environmental and behavioral studies to determine limiting factors preventing juvenile production and a review of simple innovative management techniques which may help re-establish Saint John stocks.

SHORT TERM ACTIONS

1. Striped bass should be declared a sport fish.

2. All angling and commercial exploitation and sale prohibited.

3. A regulation measure is required prohibiting the retention of live or dead striped bass caught unintentionally in any commercial gear set for other fish species.

4. Anglers may be allowed to catch striped bass, but by hook and release regulation only. This will allow, as with the release of MSW Atlantic salmon, the public to enjoy and develop the sport as well as provide economic benefit locally without negatively impacting on the resource and other user groups.

5. Angling with live or dead bait should be prohibited to minimize hooking mortality.

6. Gulf of St. Lawrence commercial fishermen should be,

   a) advised of the new striped bass no harvest regulations including the reasons for regulations and,

   b) encouraged to consider the advantages of sport fishery development in estuarial and coastal areas. If nonharvest regulations cannot be implemented in 1991, governments should make every effort to individually advise all commercial fishermen of the necessity of returning live, small bass which cannot be marketed.

7. A co-ordinated Federal-Provincial effort is required immediately to strategically monitor commercial gear catches, in particular gaspereau trap nets, smelt nets and eel traps. This project should include a stratified sampling routine to obtain some estimate of bass populations and also include age and growth sampling. Field rangers, wardens, and fishery officers and perhaps, paid observers must participate in this effort to ensure sufficient manpower.

8. A field inventory to assess Saint John River stocks is required for 1991 to:

   - determine by beach seining, whether natural reproduction has occured in recent years.

   - assess age and growth characteristics of Mactaquac Dam trapped fish, including tagging studies.

   - determine relative population size, maturity and behavioral characteristics of the numerous large (>8 kg) bass present at the Mactaquac Dam tailrace pool during June and early July (Table 4). Consider electrofishing and tagging tailrace fish as well as a radio/tracking program to monitor movement of bass in the Saint John estuary.

9. New Brunswick waters during August and September may appear to have numerous large bass after 1990, a result of coastal migrants from the U.S. Anglers and commercial fishermen in New Brunswick should be advised of this potential phenomenon, i.e. that the increase of large bass is from past U.S. management activities. Also, anglers should be advised large bass from Hudson River stocks may contain high levels of PCB's.

10. A U.S. consultant with successful "hands on" experience in striped bass culture should be contracted in 1991 to evaluate potential summer use of existing Mactaquac and Grand Lake warm water fish culture rearing facilities as well as to provide and demonstrate techniques to identify when Mactaquac Dam bass would spawn. The consultant or some other designated professional should also prepare an ecologically sound stocking policy for the Saint John River. For example, perhaps hatching of bass eggs at Mactaquac early rearing facilities and subsequent planting of larvae may

Table 4. Striped bass captures[a] from the Mactaquac Dam DFO fish lift, Saint John River, 1968-1990.

Year	Number striped bass trapped[a]	Fish lift operator remarks
1968	872	large bass in May/June; small bass in Sept/Oct
1969	307	
1970	127	
1971	13	
1972	5	
1973	49	
1974	0	
1975	17	
1976	0	
1977	0	
1978	54	
1979	16	
1980	6	
1981	187	
1982	141	
1983	22	
1984	12	
1985	32	
1986	15	
1987	80	
1988	20	predominantly large mature bass 8 kg in June/July
1989	29	predominantly large mature bass 8 kg in June/July
1990	26	predominantly large mature bass 8 kg in June/July

[a]Most fish captures were released into Mactaquac Headpond.

be sufficient to restore stocks, providing planting procedures were satisfactory.

LONGER TERM ACTIONS

11. N.B. Power should be approached to discuss possibilities of flow deregulation below Mactaquac during projected peak of striped bass spawning.

12. A New Brunswick striped bass management committee involving government, industry, university and public representatives is required, formalized by a Memorandum of Understanding. DFO and NBDNRE should perform the lead role in management activities; the committee's representatives would co-ordinate and help implement action plans and recommend future management alternatives. The committee would maintain a working relationship with key U.S. biologists as well as encourage pragmatic co-operative research among Canadian biologists. The committee would also serve to inform public groups about stock restoration progress, management requirements and options as well as seek public perceptions and inputs.

13. Monitoring of bass juvenile populations by standardized beach seines should occur annually on Nepisiquit, Tabusintac, Miramichi, Richibucto and Kouchibouguac rivers. Adult bass populations should not be assessed by gill netting; it is juvenile population indices which best determine stock recruitment.

14. The DFO St. Andrews Biological Station pilot project to obtain Saint John adult bass to produce viable eggs for hatching and subsequent fingerlings production should be continued. Hybrid bass culture or management is not recommended.

15. Assemble a biological and environmental data base for existing striped bass rivers and develop a habitat suitability index for at least one Gulf of St. Lawrence River and the Saint John River.

16. The socio-economic potential for developing a sport fishery in the Gulf of St. Lawrence should be assessed by goverment biologists through fishery officer and commercial fishermen interviews, past catch records and past angler information. Commercial fishermen should be encouraged (employed?) to identify past and new areas for sport fishery development as well as estuarial and coastal behaviour of bass. A successful U.S. charter boat captain and several surf casters should be encouraged to help develop the new sport fishery, perhaps through the N. B. Department of Tourism, Recreation and Heritage.

17. Other Gulf of St. Lawrence rivers, e.g. Buctouche, may contain or have potential to produce a self-sustaining population of striped bass. Past catch records should be reviewed; also, commercial fishermen should be interviewed as to bass presence in the 1930's and 1940's.

REFERENCES

Bonn, E. W. (Ed.) 1976. Guidelines for Striped Bass Culture. Striped Bass Committee, So. Div., Amer. Fish. Soc. 103 p.

Bujold, R. 1985. Bathurst Harbour striped bass survey - 1984, Bathurst New Brunswick. Manuscript.

Chaput, G. J. and R. G. Randall. 1990. Striped bass (*Morone saxatilis*) from the Gulf of St. Lawrence. CAFSAC Research Document 90/71. Dept. of Fisheries and Oceans, Moncton, New Brunswick, 29 p.

Dadswell, M. J. 1976. Notes on the biology and research potential of striped bass in the Saint John estuary. In Baseline survey and living resource potential study of the Saint John River estuary, Vol. 3, Fish and Fisheries, Huntsman Marine Lab., St. Andrews, N. B., 106 p.

Goodyear, C. P. and S. W. Christensen. 1984. On the ability to detect the influence of spawning stock on recruitment. North Am. J. Fish. Manag. 4: 186-193.

Hogans, W. and G. Melvin. 1984. Kouchibouguac National Park striped bass (*Morone saxatilis* Walbaum) fishery survey. Aquatic Industries Limited, St. Andrews, N. B., 9 p.

Jessop, B. M. 1990. The status of striped bass in Scotia-Fundy Region. CAFSAC Research Document 90/36. Dept. Fisheries and Oceans, Halifax, Nova Scotia, 22 p.

Kerby, H. and E. B. Joseph. 1978. Growth and survival of striped bass and striped bass x white perch hybrids. Proc. Ann. Conf. S. E. Assoc. Fish and Wildlife Agencies 32: 715-726.

Lewis, R. M. and R. R. Bonner, Jr. 1966. Fecundity of the striped bass, *Roccus saxatilis* (Walbaum). Trans. Am. Fish. Soc. 95: 328-331.

Madden, A. 1984. Characteristics of the striped bass fishery at Bathurst, N. B., 1978-1983. Department of Natural Resources, Campbellton, N. B., 29 p.

McCraren, J. P. (Ed.) 1984. The aquaculture of striped bass -- proceedings. Maryland Sea Grant Publication. University of Maryland, College Park, Maryland, 262 p.

Meagher, J. D. and Field Staff. 1987. Bathurst Harbour striped bass (*Morone saxatilis*) tagging and assessment program. Manuscript, 65 p.

Melvin, G. D. 1978. Racial investigations of striped bass (*Morone saxatilis*) (Walbaum) 1772 (Pisces:Percichthyidae) for three Canadian Atlantic rivers: Saint John, Shubenacadie, Tabusintac. M. Sc. Thesis. Acadia University, Wolfville, N. S., 143 p.

Norton, V., T. Smith and I. Strand. 1983. The economic value of the Atlantic Coast commercial and recreational striped bass fisheries. Maryland Sea Grant Publication No. VM-SG-TS-83-12. University of Maryland, College Park, Maryland, 55 p.

Rago, P., A. Henderson-Arzapalo and C. Lemm. 1989. Striped bass research plan-special report. National Fisheries Research Center, Leetown, West Virginia, 37 p.

Richards, A. and D. G. Devel. 1987. Atlantic striped bass: stock status and the recreational fishery. Marine Fisheries Review, p. 58-66.

Setzler, E. M., W. R. Boynton, K. V. Wood, H. H. Zion, L. Lubbers, N. K. Mountford, P. Frere, L. Tucker and J. A. Mihursky. 1980. Synopsis of biological data on striped bass, *Morone saxatilis* (Walbaum). NOAA Tech. Rep. NMFS Cire. 433, 68 p.

Stevens, R. F. 1966. Hormone-induced spawning of striped bass for reservoir stocking. Prog. Fish. Cult. 218(1): 19-28.

STRIPED BASS (*MORONE SAXATILIS*) RESEARCH AT THE BIOLOGICAL STATION, DFO, ST. ANDREWS, N. B.

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INTRODUCTION

Finfish aquaculture in New Brunswick is concentrated primarily on the cage culture of Atlantic salmon. Diversification is recommended in any culture environment to attenuate the economic impact of unpredictable catastrophes on a particular species and of market uncertainties. Research at the Department of Fisheries and Oceans Biological Station in St. Andrews has recently been directed to address this challenge of developing and evaluating the culture potential of other finfish.

Striped bass is considered a possible aquaculture candidate for this region. The species is native to the Maritimes, ranging from the Gulf of St. Lawrence to Nova Scotia and into the Bay of Fundy. Several rivers in new Brunswick support viable (although reduced) spawning populations. Presently, the species supports a minimal bycatch fishery in some rivers and is a highly desirable sport fish. High market demand for striped bass in the United States allows fish farmers to obtain approximately U.S. $3.-4/lb.

To assess the culture possibilities of striped bass in New Brunswick, rearing techniques suitable to this environment must be developed. Since natural populations probably cannot support the practice of annual broodstock collection at present, it will be necessary to maintain broodstock under suitable domestic environmental conditions to provide eggs for culture. Climatic conditions also necessitate the need to evaluate alternative larval rearing procedures. Growth and survival of juvenile striped bass in tanks or sea cages should also be investigated to determine if striped bass culture is an economically feasible venture.

BROODSTOCK DEVELOPMENT

Five adult bass were collected with gill nets from the Shubenacadie River, N. S. in May 1988. The average weight and length were 4.4 (2.7-6.1) kg and 64.3 (54.3-73.3) cm FL, respectively. Another five were collected from the Saint John River, N. B. in July 1989 but were not weighed initially. Both groups are held separately in 1.8 m diameter tanks. Their diet consists of herring, alewives and moist Atlantic salmon brookstock pellets. The initial five fish gained 0.5 kg on average and their mean length increased 3.8 cm from Oct. 1988 to Dec. 1989. When weighed in Dec. 1989 the Saint John River fish had a mean weight and length of 6.5 (5.0-8.9) kg and 76.8 (72.5-84.2) cm FL, respectively.

Observations of fishermen and biologists indicate that striped bass populations residing in Bay of Fundy and Northumberland Strait rivers tend to move into lower salinity water in the fall and remain there overwinter. This may be a mechanism to tolerate the cold sea temperatures (down to -10 to -2.0°C) at these higher latitudes. Osmoregulatory studies conducted in relation to temperature and salinity adaptation may reveal interesting results relating to this behaviour pattern.

The environmental regime we chose for the broodstock over winter simulated the conditions the bass might encounter naturally if they migrated upstream to lower salinity water for the winter (Fig. 1). The Shubenacadie stock

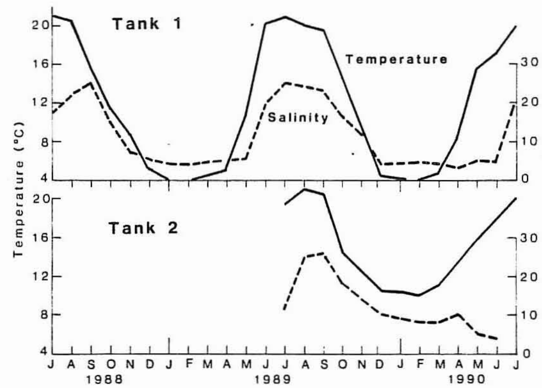

Fig. 1. Temperature and salinity regimes for holding Shubenacadie River Stock (tank 1) and Saint John River stock (tank 2) from June 1988 to July 1990.

in tank 1 were held at 4°C and 4 ppt overwinter before allowing the temperature to increase in the spring. After spawning the salinity was raised to full seawater. The second group of fish in tank 2 were held at 10°C and 10 ppt overwinter to see if we could still maintain some growth and yet provide adequate environmental conditions for egg production.

In June 1989 the five fish in tank 1 were injected with gonadotropin. The eggs were collected from the tank within 24-48 hr but were not viable. During the 1990 spawning season we wanted the broodstock to spawn naturally in the tanks without induction. Egg collectors were set up and checked regularly but no eggs were produced.

To investigate the plasma steroid profiles leading up to spawning we sampled blood from the bass via cardiac puncture monthly from Dec. 1989 to April 1990 (Fig. 2). The plasma samples were analyzed for testosterone, 11-ketotestosterone and estrogen. It is possible to infer the sex of individual fish by comparing the androgen and estrogen levels (Fig. 3). The Shubenacadie stock consists of three males and 2 females based on the fact that the males were running ripe with milt when initially collected. Higher concentrations of testosterone and 11-ketotestosterone relative to estrogen such as seen in P07, P09, P02, are consistent with the observation that these fish are males. High estrogen levels such as P05 and P10 are indicative of females. We were unable to sex five of the broodstock based on steroid concentrations because frequently the levels of estrogen and androgen were similar such as in P12.

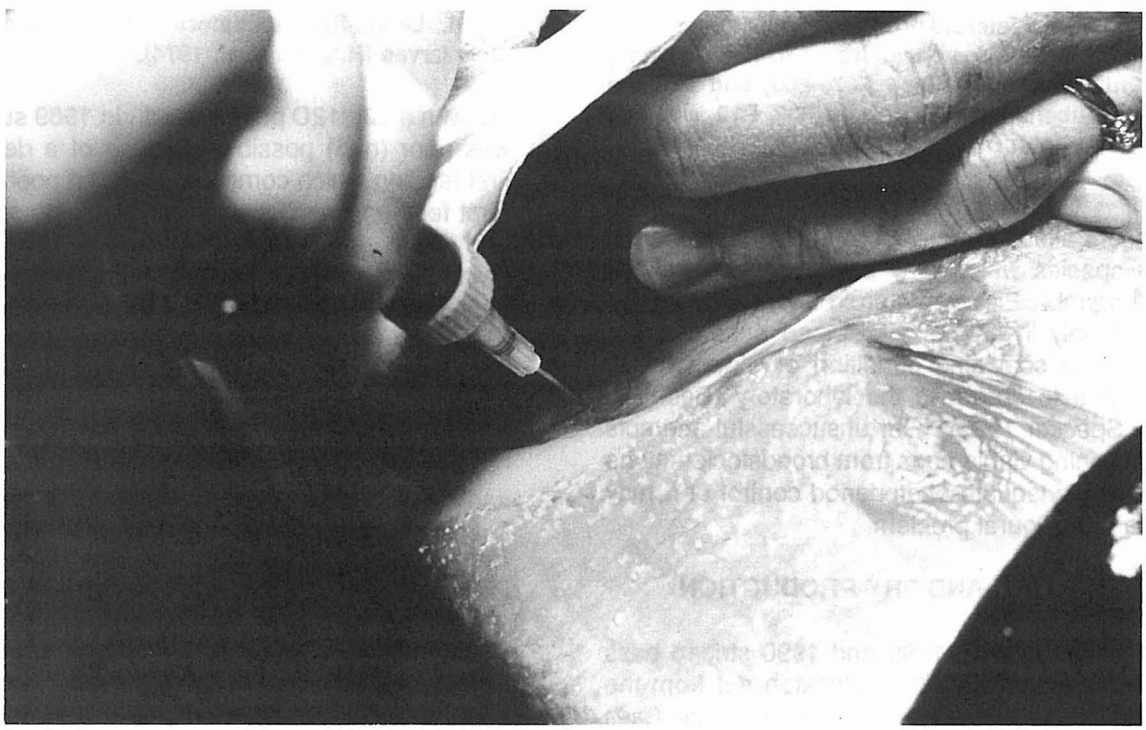

Fig. 2. Blood sample being taken from an adult striped bass via cardiac puncture.

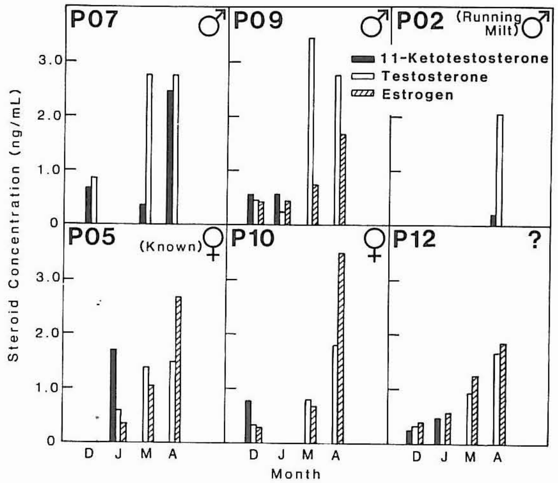

Fig. 3. **Plasma steroid profiles of individual striped bass during the 5 mo leading up to the spawning period. Profiles labelled P07, P09, and P05 are from Shubenacadie River fish; P02, P10, and P12 are Saint John River fish.**

Our striped bass have very low steroid concentrations compared to some other marine fish species which may contain concentrations >50 ng/mL. Elevated steroid levels seem to be found only in broodstock striped bass that are caught in spawning condition or induced with hormone to spawn in the laboratory (Bedinsky and Specker 1991). Our unsuccessful attempts at obtaining viable eggs from broodstock may be due to inadequate photoperiod control or it may be a behavioural problem.

LARVAE AND FRY PRODUCTION

In June of 1989 and 1990 striped bass eggs were seined with a plankton net from the Shubenacadie River, N. S. (Two Rivers Bass Hatchery), then transported to the lab in 2-L containers in a cooler. Upon arrival they were placed in 40-L larval incubators with a flow-through water supply which maintained the eggs in the water column via an upwelling current (Fig. 4). The eggs were incubated at 17.5°C and 4.5

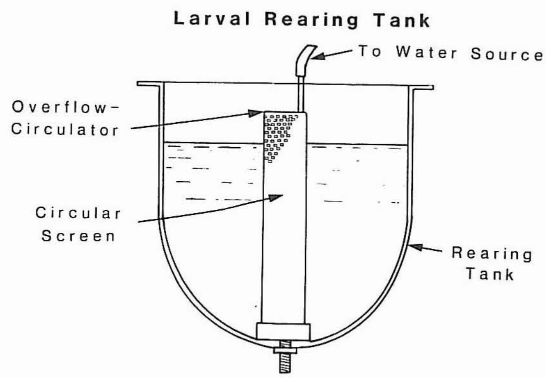

Fig. 4. Larval fish incubators used to rear striped bass larvae (Hughes et al. 1974).

ppt with a 12L:12D photoperiod. In 1989 survival was poor (n=5) possibly because of a delay in first feeding which commenced at 7 d posthatch. First feeding was delayed until this time since it had been speculated that more successful swimbladder inflation occurs if feeding is delayed until after this developmental event. Frequently a surface film develops once food has been introduced which obstructs the larva from filling its swimbladder.

The larvae collected in 1989 were fed a varied diet consisting of Artificial Plankton® Microcapsules (size 50 μm), Hatchfry Encapsulon® (50-150 μm), live freshwater plankton, enriched brine shrimp and occasionally rotifers. When about 30 mm long the fry were transferred to a 32 L tank at 20°C and fed frozen brine shrimp and moist salmon pellets. These fry died abruptly for unknown reasons but had reached 7-10 cm after 3 mo.

The larvae hatched in 1990 had poor survival because the the eggs were of poor quality, most being dead when collected. Again the larvae were held at 18°C and 4.5 ppt. Feeding was started earlier, at 3 d post-hatch and the survival rate improved. The installation of "skimmers" (Fig. 5) on the surface of the

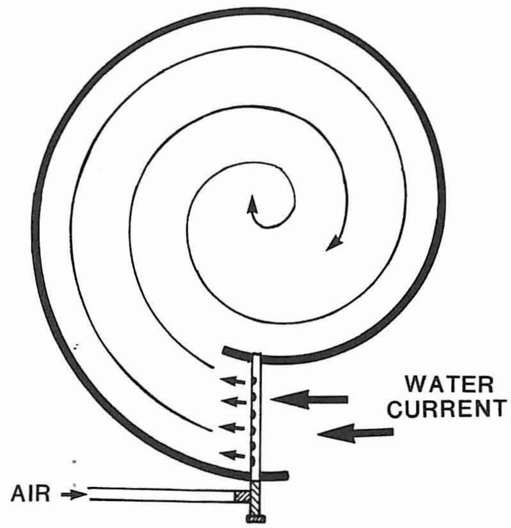

Fig. 5. "Skimmer" apparatus used to collect the oily surface film which accumulates on the water surface in larval rearing containers (Chatain and Ounais-Guschemann 1990).

water to remove the oily film that accumulates after feeding may also have been a factor in the increased survival. Brine shrimp (at various developmental stages) that had been enriched with Artificial Plankton® were fed to the larvae.

At 5 d post-hatch 20 larvae were transferred to a low salinity pond (4 ppt) (Fig. 6). Twenty-eight days later 12 fry were transferred to a higher salinity pond (10 ppt) after salinity acclimation in the larval containers.

The ponds (3.9x2.7x0.7 m deep; held about 7400L) were initially fertilized with 50 lb of cow manure each and a few liters of Micro Algae Grow®. Within a few weeks an alga bloom appeared and the ponds were then innoculated with brine shrimp, chlorella and rotifers. Both ponds developed a diverse zooplankton population. The low salinity pond contained a dense population of rotifers and chironomid larvae. The more brackish pond contained a dense population of brine shrimp. The temperature of the water from June to August ranged from 17 to 29°C.

After 2 mo the ponds were seined. From the low salinity pond which had originally been stocked with 20 5-d-old fry, 16 fry were collected with a mean length and weight of 6 cm FL and 2.9 g, respectively. Surprisingly, the higher salinity pond, which was stocked with 1-mo-old fry that had initially fed well on brine shrimp, had no fish. B. Friedmann, (these proceedings), demonstrated that post-larval stages (the stages which were transferred to the second pond) are very sensitive to handling.

BEHAVIOURAL OBSERVATIONS

Preliminary behavioural observations have been conducted on larvae less than 1-mo-old to determine their response to light. A petri dish (150-cm diameter, 1-cm deep) with a gridded (1 cm) bottom was placed under a uniform light source. The observation dish was shielded from external disturbances with a black curtain which surrounded the set up except for the viewing portal. A constant temperature was maintained by placing the dish in an ice cooled water bath.

One striped bass larva was collected from the rearing containers using gentle suction and placed into the dish for 10 min before observations were recorded. The position of the larva on the gridded background was recorded every 10 s for 10 min resulting in a total of 60 recordings. The overhead uniform lighting was extinquished and a microscope tungsten illuminator was placed over the dish to produce a spotlight effect. The fish was allowed to adjust to this illumination for 5 min before the observation procedure was repeated. Brine shrimp nauplii were then added to the dish and observations repeated after a 5-min acclimation period.

Under uniform light intensity the fish moved around the dish in a fairly random pattern (Fig. 7A). With spotlight illumination the larva showed some indication of being positively phototactic (Fig. 7B). When brine shrimp nauplii were added, which tended to concentrate in the higher intensity area, the larva also moved into this area searching for prey (Fig. 7C). Further observations need to be conducted using various light intensities.

Fig. 6. Ponds used to rear larval striped bass for 2 mo.

Additional research is required to determine optimal environmental conditions for maintaining striped bass broodstock. The viability of striped bass aquaculture may rely on the success of investigations in this field since the decline in natural populations will restrict access to wild fish for broodstock requirements. Studies at the Biological Station will focus on manual stripping techniques, and phototperiod, temperature and salinity control.

REFERENCES

Berlinksy, D. L. and J. L. Specker. 1991. Changes in gonadal hormones during oocycle development in the striped bass, *Morone saxatilis*. Fish. Physiol. Biochem. 9: 51-62.

Chatain, B. and N. Ounais-Guschemann. 1990. Improved rate of initial swimbladder inflation in intensively reared *Sparus auratus*. Aquacult. 84: 345-353.

Hughes, J. J., R. A. Shleser and G. Tchobanoglous. 1974. Prog. Fish-Cult. 36(3): 129-132.

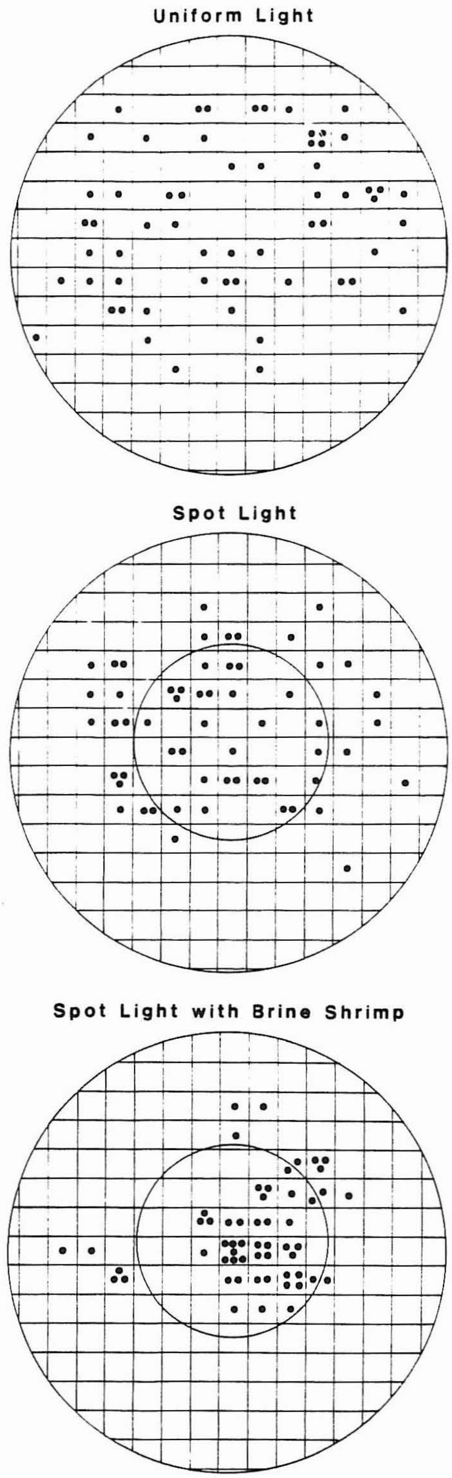

Fig. 7. Distribution pattern of striped bass larvae. A) Under uniform light conditions. B) With light directed to produced a "spotlight" effect. C) Spot lightning and brine shrimp nauplii.

INTENSIVE CULTURE TECHNIQUES FOR STRIPED BASS FINGERLINGS

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INTRODUCTION

Numerous intensive culture and pond culture facilities have "gone commercial" within the last decade and raised striped bass fingerlings to table size from an initial stockout of 25-50 mm fingerlings. However, very few of these intensive culture facilities produce the 25-50 mm fingerlings needed to initiate these operations. Presently, almost all fingerlings sold by suppliers to support the expanding enterprise of striped bass and hybrid striped bass food fish production are produced by out-of-doors pond culture operations within the southern half of the United States (Posadas and Homziak 1991; Smith 1989). In spite of this dependence on pond culture operations to supply fingerlings, techniques have been developed that support the production of striped bass and hybrid bass by enclosed, intensive tank culture operations. These techniques have been primarily used by, and are especially adaptable to, production efforts conducted in the cooler, more northerly states and provinces of North America where the generally higher costs associated with producing fish intensively can be justified. The proceedings of workshops that are summarized by McCraren (1984), Hodson (1986), and Newton and Nerrie (1989) provide summaries of most all of the early research, pilot, and production scale intensive culture projects directed at striped bass culture, including pilot scale studies conducted as far north as New York State along the Atlantic seaboard. During the 1980's, three additional tank culture facilities, supported generally by electric utility striped bass stock enhancement studies, were constructed in the northeastern United States. In Maryland, Baltimore Gas and Electric Company began tank farm operations in 1983 while Potomac Electric Power Company began pilot-scale tank culture experiments in 1986. In New York, EA Engineering, Science, and Technology began production-scale tank culture operations in 1983. Much of the recent developmental work oriented towards applying and improving intensive culture techniques for striped bass fingerling production is reflected in or has occurred at the Hudson River Striped Bass Hatchery in Verplanck, New York.

Since 1973, studies have been conducted at Verplanck, New York, to develop techniques for intensive culture of striped bass fingerlings. This effort has centered on the use of small (6- to 12-ft diameter), circular tanks in the production of large quantities of eggs, larvae, and 75-150 mm fingerlings. The primary function of this production has been to support various research programs concerned with either the development of aquaculture techniques for the species or directed towards exploring the success with which striped bass fingerlings can be used in inland stocking and estuarine enhancement projects. While many of the eggs and larvae produced at the Hudson River hatchery were shipped to various federal and state hatcheries throughout the eastern United States for grow-out, fingerling production has been conducted at the Hudson River hatchery in each of the years of operation. This history has made the Hudson River hatchery, at once, both one of the oldest continuously operating tank culture hatcheries for striped bass, as well as the largest tank culture hatchery ever operated for the production of advanced fingerling striped bass from incubated eggs.

BACKGROUND OF PILOT SCALE PRODUCTION OF HUDSON RIVER FINGERLING STRIPED BASS

This hatchery project originated in the early 1970's with concerns over the effects of cooling water withdrawals at several existing and proposed electric power stations along the 150-mi tidal length of the Hudson River. Up until 1970, almost all of the experience gained with striped bass fish culture had been localized within the southeastern United States and, in particular, at the Moncks Corner State Fish Hatchery located on the Santee-Cooper River system in South Carolina. From this work, Jack Bayless, the Moncks Corner Hatchery Manager, produced the first general manual for the production of striped bass, which was later updated by Bonn et al. (1976) and then most recently as Culture and Propagation of Striped Bass And Its Hybrids by the Striped Bass Technical Committee of the American Fisheries Society in 1990. In order to most quickly and successfully transfer and adapt this information to the more northern location of New York, Mr. Bayless was brought to New York during the startup phase for the initial years of operation to both train our local staff as well as to participate in the development of spawning techniques specific to the cooler waters of the Hudson River.

The first 2 yr of production were used to prove the feasibility of controlled spawning of the Hudson River broodstock and also to evaluate survival of hatchery reared striped bass fingerlings released in the Hudson River. Fingerlings for this project were generated by shipping out the newly hatched larvae in oxygenated and boxed plastic bags at densities of 100,000 yolk-sac fry per 3 gal of water to numerous southern states for pond culture growout through the summer. In the fall, the 75-250 mm fingerlings that were harvested from these ponds were shipped back to New York, either within hatchery tank trucks or back in plastic bags -- only this time at just 24-36 fish per box, or approximately 60-120 g/L in the shipping water. Prior to release into the river, all the fish were marked by the insertion of color-coded 1-mm wire tags (CWT's) into their snouts. All aspects of this program went well; however, the link with the South had not been broken as only the spawning and hatching and then the final act of tagging the fish were conducted in New York, the growout of the fry to fingerlings was still dependent on the movement back and forth of millions of fish to southern culture ponds.

In 1975, therefore, research work began which was aimed at the establishment of purely artificial tank culture techniques that would ultimately serve to replace the need for ponds in the large scale production of striped bass fry and fingerlings. Tank culture facilities were built for this purpose at Verplanck and at the Fisheries Research Station of the Southern Illinois University (SIU) at Carbondale, Illinois. The facility at Verplanck consisted of fifteen 12-ft diameter by 1.5-ft deep tanks which supplied an effective rearing volume of 71 m^3. This facility used water in a once-through mode from either a flooded limestone quarry or the adjacent Hudson River. Pretreatment prior to use was limited to pressure sand filtration for the silty river water or ultraviolet sterilization for the clear quarry water. Intensification of culture was not a primary goal of this facility; however, up to 165,000 50-125 mm fingerlings were produced on an annual basis. The facility at SIU consisted of 34 6-ft diameter by 3-ft deep tanks which supplied a rearing volume of 50 m^3. This facility used well water in a recycle mode and treated the water with biofiltration, pressure sand filtration, and ultraviolet sterilization on each reuse. Production goals at this facility included maximizing production by simultaneously optimizing survival as well as rearing densities. Through 1980 up to 120,000 75-150 mm fingerlings were produced annually. Fry to fingerling survival of about 20% was typically achieved as standardized procedures became refined during the last years of production at this research station.

In 1981, the research at SIU led to the publication of the second general handbook available for striped bass culturists, A Tank Culture Manual for Striped Bass (SIU 1981). In contrast to the Guidelines for Striped Bass Culture which had focused strongly on pond culture techniques, this document provided guidelines for the enclosed, artificial rearing of bass in tanks. Both the experience at Verplanck and at SIU stressed the importance of three concerns that have strongly controlled the success with which striped bass culture has been moved from ponds into artificial conditions. These are the needs to provide adequate live larval feed during the initial growth phase; the need to actively promote the swimbladder inflation process, and the need to control losses due to cannibalism.

DESIGN AND OPERATION OF A PRODUCTION SCALE TANK FACILITY FOR FINGERLING BASS

In 1981, EA Engineering, Science, and Technology was contracted by Consolidated Edison Company of New York, Inc., a New York-based electric utility corporation, to build and operate what would be the largest intensive culture facility for raising fingerling striped bass. The design and operation of this hatchery borrowed heavily from the previous pilot studies conducted at both Verplanck and SIU. In addition, operational reports from the Gulf Coast Research Laboratory (GCRL) in Gulf Springs, Mississippi, were reviewed for practical input. The GCRL has remained the only other continuously operating production scale facility for striped bass fingerlings through the 1970's and 1980's. The GCRL facility typically produces several hundred thousand 20-25 mm fry in a rearing volume of 140 m^3 that consists of 6-ft wide by 3-ft deep by 24-ft long fiberglass raceways and other circular tanks. Finally, the limited but informative research of early investigators into intensive striped bass culture techniques such as Rhodes and Merriner (1973) and Rodgers et al. (1982) was also referenced.

Since 1983, a hatchery built around these specifications has been operated by EA at Verplanck on the Hudson River with an annual production goal of 600,000 75-mm fingerling striped bass. The hatchery has an effective rearing volume of 170 m^3 which consists of 84 6-ft diameter by 3-ft deep circular fiberglass tanks and four rectangular 6-ft by 3-ft by 16-ft fiberglass raceways. Water is supplied to the hatchery from either a flooded limestone quarry pond or from the adjacent Hudson River. A maximum pumping capacity of 5,700 lpm is available to the hatchery at peak carry capacity (3,000 kg), although pure oxygen must be supplied to the tanks in order to attain this loading rate. Oxygen gas is supplied from cryogenic liquid oxygen tanks to meet this need. In order to conserve water from the finite supply of the quarry pond, as well as to conserve heating energy during the occasional cold spring, the hatchery is designed to operate over a range of water re-use from 100 to 0 percent. Adjustment of the percent reuse is made simple by the operation of discharge weir gates in the pump sump pit. Heat for the process water is supplied via water-to-water exchangers and oil fired boilers, which at our location in southern New York State have only been required to operate in about 1 yr out of 3.

All water is filtered prior to use by gravity passage through rotary drums with 20-micron mesh screening. This relatively expensive method of filtration was chosen in this application due to the need to assure removal of protozoan and larger parasites from the natural water sources that are being utilized as well as to remove particulate matter from the water flow when the hatchery is operating in a recycle mode. These microscreens have a filtering surface of 30 m^2 and are capable of handling the full flow (5,700 lpm) through the hatchery. Next in line is a bank of biofilters that serves to remove ammonia and other nitrogenous waste productions of the fish, again only when the hatchery is operating in a recycle mode. As a final conditioning prior to use in the rearing building, all water is passed through an ultraviolet sterilization chamber that provides a drinking-water standard irradiation dose of 35,000 microwatts/second/cm^2 which acts to inactivate disease associated bacteria and small protozoans.

Broodfish are typically collected in mid- to late May as mature fish on the spawning grounds within the Hudson River. Fish are collected by anchored gill nets which are run continuously in order to retrieve fish that are minimally stressed by the capture process. Selected fish are transported by pick-up truck while being held in circular 0.5-m^3 tanks that contain oxygenated water that is salted with rock salt (i.e., water softener salt) to a salinity of 10 ppt. Upon receipt at the hatchery, the fish are unloaded, sexed, injected with HCG hormone, and then segregated by sex into the four rectangular raceways. During the initial hour of holding in the raceways, fish are again treated by a 1-hr static bath of 10 ppt rock salt, and all female fish are staged for readiness by the temperature-adjusted methods of Watson (in press.). Release of eggs usually occurs within the first 2-3 d after receipt. Fish that do not ovulate within this time frame usually die due to the accumulated stress of capture and repeated handling. Females from 2 to 25 kg have been successfully ovulated; however, the smaller females of 2-5 kg often fail to ovulate successfully, and there is some evidence that larger fish may more frequently produce larvae with poorer survivability. Fish within this overall size range may produce from 250,000 to 2 million eggs when manually stripped. Fertilization at our facility typically averages 60%, for a size specific average production range from 150,000 to 1.2 million fertilized eggs for 2- to 25-kg adult female fish.

Fertilized eggs are held in 6-L McDonald hatching jars at densities of 200,000-300,000 eggs per jar. Hatching occurs in 48-72 hr at temperatures of 19-15°C, respectively. The hatchery has 90 hatching jars mounted on wall shelving in a floor area of 5.5 m^2. With this capacity, and a water supply of only 190 lpm, almost 30 million fry can be incubated simultaneously. Upon hatching, the 3- to 4-mm fry are moved by bucket into the 6-ft circular fish culture tanks (FCT's) which each have a capacity of 1.5 m^2.

FCT's are stocked at densities of 20,000-1 million fry per tank. The higher densities are only sustainable if some of the fry are to be soon removed from the tanks for redistribution or sale. For grow-out, densities of 20,000-40,000 (approximate densities of 15-25 fry/L) are appropriate at initial stock-out. As early survival may be variable, we practice redistribution and thinning, if appropriate, so that at 20 d post hatch (dph) each FCT holds approximately 18,000-

20,000 fish and at 30 dph each FCT holds 12,000-15,000 fish. Holding higher densities may reduce production through the effects of cannibalism and/or water quality deterioration.

Tanks that are stocked with fry should have 0.5 mm screening on the discharge in order to effectively retain the fish. The surface area of screening in each tank should be great enough to provide only a very slow flow rate through the screen as the fry are poorly swimming for the initial week after hatch. We use a screen with a surface area of 0.5 m^2 to discharge a flow of 4-8 lpm from each FCT during the initial week of culture. The screens with their supporting frames are removable from the tank so that all cleaning of the screens can be done by high pressure hose over a waste drain. In-tank cleaning of the settled waste load within the larval tanks is by gravity primed suction hoses. Siphon cleaning of a FCT may require 15-45 min of labor when the fry are small. The labor requirement is reduced as the fish grow and the water input and the circular flow within the tank is increased. By 50 dph, when the fish are approximately 40-50 mm, the tanks are self-cleaning due to the increased circular flow allowable with fish of this size.

During the larval stage (i.e., from 5-12 dph) striped bass inflate their swimbladders, apparently by accessing the air/water interface at the surface of the tank. While the mechanism by which this occurs is being widely investigated within the United States, two aspects of the phenomena are generally accepted. The first is that any oil or scum film on the surface will strongly inhibit successful inflation; and the second is that, if inflation does not occur within this time frame of approximately 1 wk, the loss of the ability to inflate is permanent. This is due to the fact that, unlike trouts and salmons, striped bass lose the ability to move gases between their alimentary tract and the swimbladder after the early larval stage. We have found that the least laborious way to maintain a film-free surface is to design the water inlet as an angled radial sprayer bar positioned just a few inches over the tank water surface. This imparts a slight circular flow to the water within the circular tanks and thus provides a continuous cleaning action at the air/water interface. We have also used commercially available oil spill absorption pads made of spun polypropylene to remove heavier films of oil that are occasionally caused by the decomposition of dead eggs and larvae. Others have used obstructions set at the level of the water surface to gather surface film deposits, which are then removed manually by dipping. Without attention being given to removal of surface films from high density tank cultures of striped bass fry, swimbladders may typically be inflated in less than half of the cultured fish. With careful attention being given to this process over this week interval each year, we have typically achieved inflation in > 90% of our cultured fish.

The feed regime for striped bass from fry to fingerlings depends on the production of large quantities of live food during the initial 20-30 dph and then a quick and easily achieved conversion onto commercial salmon or trout starter diet (Webster and Lovell 1990). Live feed is sometimes presented as early as 5 dph, as soon as the larvae develop a functional alimentary system. We first feed at 7 dph in order to maximize feed usage and to help maintain a clean tank environment for the encouragement of successful swimbladder inflation.

The live food that is almost universally used to feed larval striped bass is the brine shrimp, *Artemia*. Brine shrimp cysts, or "eggs," are a commercially produced product that is available in cans, bags, buckets, or drums. Currently, the price for cysts with good hatching ability (80% or greater hatch) is U.S. $20-30/kg. Price, hatching ability, and fatty acid content are the three qualities that most operators consider when making their purchase of cysts, although the requirement for any specific fatty acid content of cysts used for striped bass culture has not been indisputably proven. Approximately 200 kg of good quality cysts is required to produce 1 million fry at 25 dph. Cysts are incubated in warm salted water for approximately 24 hr to induce the hatching of the live shrimp nauplii. Incubation densities can range up to 5 g of cysts/L of water. Approximately 1-1.5 million nauplii will be produced from 5 g of cysts if the hatching rate is about 80%. For the 1,000,000 fry scenario just given, a shrimp incubation capacity of 2,250 L daily is reasonable. Nauplii are collected by straining onto a 125- to 150-micron mesh sieve and are rinsed with clean water prior to being fed to the fish. The nauplii are distributed to the fish either by automatic feeders that incorporate a reservoir of aerated, salted water, or directly fed to the fish by hand. When hand-feedings are used, the interval between feeding should not exceed 3 h, the approximate gut evacuation time of the fish. Striped bass feed around the clock and provision for night-time feeding is required in order to control losses due to cannibalism.

The number of nauplii needed to feed various ages of fish has been reported by Tuncer et al. (1990) to vary from 80 nauplii/fish on the initial day of feeding to 575 nauplii/fish on the twentieth day of feeding, which would be just prior to the period of conversion of the fish to commercial feeds.

After 40 dph, the fish are hardy enough to be graded, a process which is then conducted on a weekly basis for 5-6 wk as the fish often are aggressively cannibalistic; these gradings are required in order to achieve good survival. Grading is initially conducted by utilizing a radial crowder bar which is moved around the tank, crowding the fish into a more confined wedge-shaped portion of the tank. All the fish are then dipnetted into floating-box bar-graders. It is important that on the first grading all of the fish are graded so that all of the oversized fish are removed, as substantial losses of fish due to cannibalism can occur rapidly during this early period. The most narrow bar spacing we have used, at 40 dph, has been 4-mm openings. For larger grader sizes, the arms of the radial grader are fitted with slotted grader panels and not all the fish are moved through the floating box-grader as many will pass through the panels, thus reducing the labor requirements of this task. After grading, all fish are treated with a 1-h static bath of rock salt at 10 ppt. At the end of this extended grading interval of 5-6 wk, little or no further grading appears necessary in order to control cannibalism. Further grading is only for size selection for harvest.

A survival rate of 20-30% from 3-mm hatchling fry to 75- to 150-mm fingerling should be reasonably achievable. At the Hudson River hatchery, as well as at others, control over two important aspects of survival during the fry to fingerling growout phase has been most significant in attaining the higher survival rates. Cannibalism may occur as early as 10 dph, but should be substantially reduced if an effective grading operation is conducted when the fish are from 40-60 dph. The other source of substantial losses during the fry stage may be due to the susceptibility of the fry to bacterial gill disease (BGD) under crowded rearing conditions. Rhodes and Merriner (1973) first reported a phenomena similar to this when they noted that 90% of their fish were lost within a 1-wk interval when the fish were from 25-30 dph. The Hudson River hatchery has experienced losses during the same interval that were nearly of the same magnitude. Recently, we appeared to have controlled the magnitude of the fish loss caused by BGD by effectively thinning and redistributing our fry throughout the rearing process. Densities of 15 fish/L at 20 dph and 7-10 fish/L at 30 dph appear prudently low while still allowing for large scale production to be achieved. Studies undertaken at the Hudson River hatchery during 1991 will be directed at exploring the relationship between stocking densities and relative survival. These studies will culminate by the end of the year with the production of an updated operating manual for techniques of intensive tank culture for striped bass fry and fingerlings.

The routine production of fingerlings of striped bass and its congener hybrid striped basses has only recently been widely practised by governmental and private fish culturists, but numerous large scale facilities have already begun production for commercial or stock enhancement purposes. Almost all of the current commercial production occurs in ponds and, in 1989-1990, this production of > 50 million fry and fingerlings yielded gross revenues in excess of U.S. $6,000,000 pondside for United States producers (Posadas and Homziak 1991). Posadas and Homziak cite results of their survey of commercial producers which indicate a price scale from approximately U.S. $900/100,000 fry at 2-4 dph to an average of U.S. $0.15/in for 25- to 200-mm fingerlings. Governmental agencies meanwhile released nearly 1,400,000 hatchery-produced fingerling striped bass, many of which were tagged with CWT's for life long stock management studies. These stockings of public waters occurred throughout sections of the Atlantic Coast from Chesapeake Bay to Maine as part of numerous stock enhancement projects for the native estuarine populations of striped bass. Almost one-half of these fish originated at intensive tank culture facilities. This proven record of production indicates that intensive culture techniques for fingerlings are a production reality for governmental stock enhancement programs and, given the proper economic incentives, may be readily adaptable to appropriate sectors of the commercial industry that continues to be developing around striped bass products.

REFERENCES

Bonn, E. W., W. M. Baily, J. D. Bayless, K. E. Erickson, R. E. Stevens. 1975. Guidelines for Striped Bass Culture. Am. Fish. Soc. Bethesda, MD. 103 pp.

Tuncer, H., R. M. Harrell, and E. D. Houde. 1990. Acceptance and Consumption of Food by Striped Bass and Hybrid Larvae. J. World Aqua. Soc. 21(3): 225-234.

Hodson, R. G. 1986. Workshop on the Culture of Striped Bass and Striped Bass Hybrids. Univ. NC Sea Grant Program. Raleigh, NC. 75 pp.

McCraren, J. P. (ed.). 1984. The Aquaculture of Striped Bass: A proceedings. Univ. of Md. Sea Grant Publ. No. UM-SG-MAP-84-01. 262 pp.

Newton, S. H. and B. L. Nerrie. 1989. A Workshop on the Culture of Hybrid Striped Bass. Cooperative Extension Program, Aquaculture Program. VA State Univ., Petersburg, VA. 70 pp.

Posadas, B. C. and J. Homziak. 1991. Survey of Hybrid Striped Bass Fry and Fingerling Producers. Aqua. Mag. 17(1): 39-45.

Rhodes, W. and J. V. Merriner. 1973. A Preliminary Report on Closed System Rearing of Striped Bass Sac Fry to Fingerling Size. Prog. Fish-Cult. 35: 199-201.

Rodgers, B. A., D. T. Westin, and S. B. Saila. 1982. Development of Techniques and Methodology for the Laboratory Culture of Striped Bass, *Morone saxatilis*. U.S. E.P.A., PB-82-217795. 264 pp.

Smith, T. I. J. 1989. The Culture Potential of Striped Bass and its Hybrids. World Aqua. 20(1): 32-38.

Southern Illinois University (SIU). 1981. Tank Culture of Striped Bass Production Manual. Illinois Striped Bass Project. IDC F-26-R. Fisheries Research Lab. SIU. Carbondale, IL. 115 pp.

Watson, L. C. (in press.). Temperature-Modified Prediction of Ovulation for Striped Bass. Prog. Fish. Cult.

Webster, C. D. and R. T. Lovell. 1990. Comparison of Live Brine Shrimp Nauplii and Nonliving Diets as First Food for Striped Bass Larvae. Prog. Fish-Cult. 52(3): 171-176.

OBSERVATIONS ON STRIPED BASS IN THE SHUBENACADIE RIVER SYSTEM, 1950-1990

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Meadows, R. 1991. Observations on striped bass in the Shubenacadie River System, 1950-1990, p. 57-60. In R. H. Peterson [ed.] Proceedings of a workshop on biology and culture of striped bass (*Morone saxatilis*). Can. Tech. Rep. Fish. Aquat. Sci. 1832: vi + 66 p.

INTRODUCTION

A brief history of fishing on the Shubenacadie River system, including fishing of striped bass, is presented with personal anecdotal reminiscences included.

In 1950, I started commercial fishing with a boat and drift net. I was still going to school, and so I didn't have a great deal of time for fishing. There were about 40 fishing boats at this time. We fished gaspereau, shad, bass, and salmon. Gaspereau sold for $.02 each, shad for $.20 each, and bass was $.10/lb. Salmon sold for $.50/lb. There were a good number of each species, except the salmon, which were scarce. At peak season for each species you would catch 1,000 gaspereaux/d, or 80 shad/d, and maybe 30-40 lb bass/d, but only 1-2 salmon/wk.

In the late 1950's a new major highway was started, and the Kelly Lake International Airport was constructed near the headwaters of the Shubenacadie River. By the 1960's the chemical residue from the exposed rocks had found its way into the river and killed almost all of the juvenile gaspereau which were 3-4 mo old. At this time we had to fish hard to catch 75-100 gaspereau/d. The shad did decline somewhat but not as much as the gaspereau. The bass stayed about the same as before and the salmon were good for 2 yr in the late 1960's.

The gaspereau made a comeback over a period of years, and by the late 1970's, we could catch 300-400/d. The shad and bass didn't change much from the 1960's but the salmon seemed to be increasing, as we could catch anywhere from 2-10/d.

During the 1980's the gaspereau had increased to the point we could catch up to 1200/d, and the shad were more plentiful than ever before. We are not sure about the numbers of striped bass in the river, as the DFO had closed the part of the river where we would likely catch a larger number. The salmon season was closed in 1985. In the mid 1980's a biologist came up from the U.S.A. to study the striped bass, and a scientist from the University of North Carolina came here to tag bass in another study.

In 1987 the biologist returned with fish tanks, plankton net, MacDonald jars and a microscope. We were able to catch a large number of eggs with the plankton net, and also a 10-lb female bass, that we were able to strip; but had trouble finding a male and so were unable to hatch any eggs. However, we did hatch several hundred eggs from the plankton nets. Shortly after that, all hatched larvae were lost due to failure of the air supply.

During 1988 nothing was done in the field of bass experiments. Early in 1989 I got in touch with three other men who were interested in the bass industry, and started a limited company - The Two Rivers Bass Hatchery Ltd. Our purpose in starting the company was two fold - one to help save the bass, and also to raise bass to be sold for stock for other areas. We were granted an experimental permit and started our project.

During our work on this project we found out that the bass migrate out of Grand Lake in the first 5 d of May and work their way down stream for about 2 wk to the mouth of the Stewiacke River (Fig. 1). Then they go up the Stewiacke River about 3 mi to their spawning grounds. While they are on their spawning grounds they appear to mix with bass that come up from the Cobequid Bay. The fish play back and forth over the spawning grounds for several days before spawning. After the bass spawn we are able to catch several hundred eggs and have no trouble hatching them, but from the fifth day on we lose them, although they were fed rotifers and brine shrimp.

The reason we lost so many was probably due to poor water quality, and also that the fish were very cannibalistic.

We did manage to save 10 fish until Christmas time (7 mo). They were then about 10 cm (4 in) long. Six were then lost during one water change for unknown reasons. The four survivors were maintained until April of 1990 at 18 cm (6 in). They then died, probably due to ingestion of contaminated food.

In 1990, the fishing was good for all species, perhaps even better than some. We seemed to have more shad than the previous year, and had trouble finding enough markets. There were about twice as many bass caught in less fishing time, and it seemed that we caught more 10-lb fish than usual.

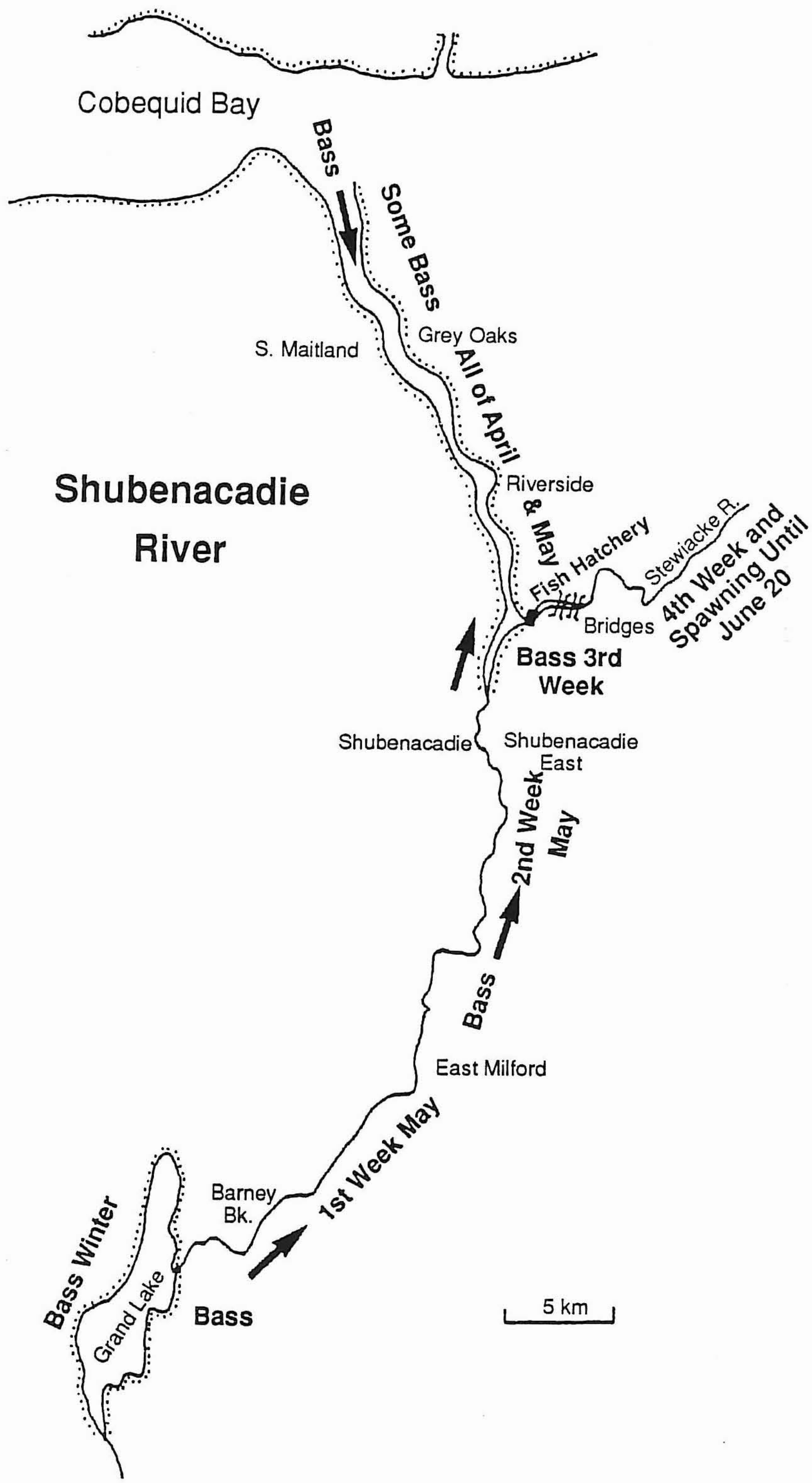

Fig. 1. Pattern of striped bass movements within the Shubenacadie River System.

The first Sunday in June, the river was full of bass eggs. A 15-min collection using a plankton net yielded more eggs than we could manage. We didn't count them, but next morning several thousand had hatched. We had a power failure that day and any eggs that were not hatched settled to the bottom, and did not hatch. Eggs were present till about the middle of June. We had difficulty keeping them alive after they were 5 d old. They were fed brine shrimp and zooplankton that we caught in the plankton net, but by the end of August all our fish had died.

In summary, there appears to be a good supply of bass eggs each year in this river system, but we need more time to work on raising these fish, or even be able to hire some help and obtain better equipment to make this project a success.

RETROSPECTIVE INSIGHT TO STRIPED BASS CULTURE AND MANAGEMENT IN THE CANADIAN MARITIMES

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MANAGEMENT

It was evident that there is a reasonably sized population in the Gulf of St. Lawrence while the Bay of Fundy populations were more tenuous. I would try to obtain some good population characteristics about the two regions to determine if they are indeed reproductively isolated or if there is a high percentage of overlap. This can be accomplished through some of the new molecular DNA probes that have been developed (i.e., mitochondrial DNA, oncogene probes, or the single locus nuclear DNA probes that are available). I doubt if more traditional mechanisms (meristics, morphometrics, and electrophoretic) are sensitive enough to detect differences.

This racial identification is crucial if restoration is the ultimate goal. One must procure and maintain stocks of known genetic origin to maximize the success possibilities. If the two regions are genetically distinct, I would not cross introduce the two. If the two regions have sympatric populations, then I would work with the simplest system I could to produce large numbers of juveniles for stocking. The reasoning behind racial segregation is that there may be some unique trait that the animal has adopted to allow it to better adapt to the region. This is especially true for the Gulf of St. Lawrence region.

One must cross-validate the age and growth information available or procure new animals and validate those -otolith would be a good possibility. I have some concerns on the aging techniques and projected growth of the Canadian populations during those first 3-yr of life. It would be very easy to miss the first annulus on scales if the first year's growth is slow (the planktivorous stage). If the growth is not as fast as expected, it could significantly influence management decisions such as harvest regulations, and size of fish protected.

One must also put an intensive effort into delineating the potential spawning grounds in all of the provinces. If these can be identified, the river or given location needs to be closed during spawning seasons to protect the brood stocks. At the same time, evaluate the success or failure of recruitment to the system for at least the first 100 d of life, at which time the majority of recruitment mortality has already taken place.

Lastly, regarding management of the St. Lawrence estuary, protect whatever stocks are still there. Devise a genetically sound long-range restoration plan that will maximize diversity of native fishes. Identify any abiotic factors that may influence production success and, if possible, remove them. If not possible, then consider the establishment of a put-and-take fishery.

First and foremost for the entire region, it is essential to devise a well thought-out management plan with realistic, definable, and achievable goals. Examine all aspects including economic costs and potential.

CULTURE

It appears that the culture potential exists for stock restoration with a minimal amount of spawning effort using the Schubenacadie River stocks in Nova Scotia. Based on the management decisions determined above, and assuming stock identification is what is desired, it would be simple to establish a portable hatchery on the river. Whether this population is desirable for stocking in the St. Lawrence estuary remains to be determined, even if it is for commercial cage culture.

A tremendous number of questions need to be answered concerning the genetics, physiology, growth potential, and economics of producing the fish for stock restoration or commercial culture. If the broodstock are available, the fry can be produced. Rearing the fry to a suitable fingerling size will require either ponds and/or intensive culture set-up. Water temperature would need to be between 16 and 23°C to rear them in ponds up to 30-50 mm in 45-60 d. At that time they could be stocked in either river systems or cages for continued growth. They could also be stocked in ponds.

The length of the outdoor growing season will have to be determined to evaluate economic potential for commercial culture. If the fish are cultured indoors, the costs associated with production also have to be figured in to determine economic viability. As I stated in the meeting, "can I grow fish here in Canada" is not the right question. I can grow fish anywhere given the right facilities. "Can I grow fish in Canada and make money" is the right question.

The cage culture potential in the Northumberland Strait sounds very interesting. How long the water temperature is elevated, how cold the water gets during the winter, will it be necessary to remove the fish from the cages and move them indoors, all have to be answered.

The use of existing pond facilities in Quebec would be a major plus for the culture of fingerlings for stocking into the St. Lawrence. I would highly encourage the consideration of use of existing facilities before investing in construction of new ones. A pilot study with existing ponds should be satisfactory to evaluate if the fish can be reared in the region.

STRIPED BASS CULTURE ON PRINCE EDWARD ISLAND?

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SUMMARY

Finfish culture on Price Edward Island is concentrated around fresh water reserves with the majority of facilities utilizing surface water, ground water or blended mixtures of pumped sea water and ground water. Seapen salmonid culture is limited by lethal water temperatures in the winter months (-0°C to -2°C) and marginal water temperatures during the summer months (20°C). However, our estuaries are well sheltered systems and possess good water quality for shellfish and seaplant culture. Our abundant ground water reserves, mainly fresh water but with some brackish sources in selected coastal areas, are a constant 7°C-8°C and are the backbone of our hatchery programs. Our hatchery capacity and summer seawater temperatures offer potential for striped bass as a culture species on P.E.I.

Although found only in limited numbers, striped bass are indigenous to Island waters. It is anticipated that culture can be initiated by drawing on the local natural stock as a source of eggs. By employing indigenous stock, no threat will be imposed on the natural gene pool through possible escapement during culture trials. The hatchery technology has been employed for salmonids for several years with P.E.I. maintaining five certified disease free hatcheries. Several Island salmonid culture operators are enthusiastic and optimistic about the potential for striped bass culture. The following development scenario will be evaluated commencing with striped bass eggs in May/June of 1991:

1) Either adult bass will be captured under DFO scientific permit and spawned in captivity or eggs will be acquired from the wild under DFO scientific permit.

2) Eggs will be hatched and fry reared on a heated ground water source.

3) Fish will be reared to fingerlings on controlled ground water/surface water sources to maximize temperature.

4) Fingerlings will be placed in cages in estuaries in the following spring and retrieved in the fall. Fish will either be marketed, if market size is achieved in one grow-out season, or wintered in land-based tanks on ground water and recaged in estuaries a second season for the production of larger market fish.

The economic viability of striped bass culture on P.E.I. will remain obscure until the development culture is evaluated. It is anticipated that striped bass culture may be reasonably assessed by the fall of 1993 for the production of fish with one-season cage culture.