DFO Atlantic Fisheries Research Document 95/119

MPO Pêches de l'Atlantique Document de recherche 95/ 119

Status of Striped Bass (*Morone saxatilis*) in the Gulf of St. Lawrence

by

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ABSTRACT / RÉSUMÉ

Striped bass (*Morone saxatilis*) abundance in the Gulf of St. Lawrence is highly variable. Bass are exploited primarily as by-catch in three fixed-gear commercial fisheries which occur seasonally in the estuaries. The decline in reported landings since 1993 is due in part to managment measures restricting the by-catch retention of striped bass. The present striped bass management plan gives priority to increased spawning escapement through protection of both adult and juvenile fish. The 1993 population of striped bass in the Miramichi was estimated at about 5000 fish but increased to between 40 and 60 thousand fish in 1994. The 1994 spawning population was highly dependent on the 1990 and 1991 year-classes. Males comprised more than 90% of all spawners in both years. Current production in the Gulf of St. Lawrence is dependent on spawning in the Miramichi River. Neither viable spawning aggregations nor juvenile production were observed outside of the Miramichi River. The average potential exploitation rate for adult striped bass in the gaspereau fishery was 25% in 1993 and 20% in 1994. Based on cumulative recapture rates of bass tagged at the onset of the fishery, the potential exploitation rate was closer to 35% in 1994. The autumn smelt fishery yielded the highest average CPUE's of the three fixed gear fisheries. Juvenile bass dominated the by-catch in this fishery and most of the by-catch of 0 group bass probably die because the catch is not culled immediately. Sex-differentiated growth and maturation occurs in Gulf of St. Lawrence striped bass. As a result, a higher proportion of female bass are expected to recruit to the spawning population of the Miramichi at ages 4 and 5 in 1995. Long-term prospects are considered to be improved. Year-classes are now more likely to have multiple opportunities to spawn under continued conservation management.

Les effectifs du bar rayé (*Morone saxatilis)* du golfe du Saint-Laurent varient fortement en abondance. Cette espèce est principalement exploitée dans les prises accessoires de trois pêches commerciales saisonnières à engins fixes dans les estuaires. La baisse notée dans les volumes déclarés des débarquements depuis 1993 est en partie attribuable aux mesures de gestion adoptées qui limitent la quantité de bar rayé qui peut être conservée dans les prises accessoires. L'actuel plan de gestion de cette espèce vise à accroître en priorité les échappées de géniteurs par la protection des adultes et des juvéniles tout à la fois. En 1993, on a évalué la population de bars rayés de la Miramichi à 5000 poissons, mais elle était passée entre 40 000 et 60 000 en 1994. Il existe une forte corrélation entre la population de géniteurs de 1994 et les classes d'âge de 1990 et de 1991. Les mâles constituaient plus de 90 % de tous les géniteurs ces deux années-là. Dans le golfe du Saint-Laurent, l'actuelle production dépend de la ponte dans la Miramichi. On n'a observé aucune concentration viable de géniteurs ni aucune production de juvéniles dans aucune autre rivière. Le taux d'exploitation potentiel moyen du bar rayé adulte à la pêche au gaspareau était de 25 % en 1993 et de 20 % en 1994. Compte tenu des taux cumulatifs de recapture de bars marqués au commencement de la pêche, il est estimé que le taux potentiel était plus près de 35 % en 1994. Des trois pêches à engins fixes, la pêche d'automne à l'éperlan est celle qui a obtenu le taux moyen le plus élevé de CPUE. Les juvéniles du bar rayé dominaient les prises accessoires de cette pêche; la majeure partie des bars rayés capturés qui ont moins d'un an meurent probablement parce que le tri des captures ne se fait pas immédiatement. La croissance et la maturation du bar rayé du golfe du Saint-Laurent diffèrent selon le sexe. C'est pourquoi on pense qu'une proportion supérieure de femelles sera recrutée dans la population des géniteurs de la Miramichi à 4 et 5 ans d'âge en 1995. On pense qu'à long terme, l'évolution démographique du bar rayé prend un tour plus positif. Grâce au maintien du régime de gestion axé sur la protection, les différentes classes d'âge auront de multiples occasions de frayer.

INTRODUCTION

Greater than 90% of all reported landings of striped bass in the Maritime Provinces occur in the Gulf of St. Lawrence as unregulated by-catch in the estuarine commercial fisheries of New Brunswick (Chaput and Randall 1990, Melvin 1991). Reported landings (Years: 1917-1968; Table 1) vary greatly among years suggesting that striped bass abundance in the Gulf of St. Lawrence is highly variable with time. Additional unregulated landings occur in recreational and aboriginal food fisheries (Chaput and Randall 1990) but these are not reported for the province on a regular basis. In 1990, Gulf of St. Lawrence striped bass were categorized as either reduced or declining (Chaput and Randall 1990). Conservation management was recommended. Measures designed to both arrest the decline in abundance and to increase spawning escapement through reduction of fishing mortality were introduced (Dept. of Fisheries and Oceans 1993).

Little information has been collected on annual changes to the size and age composition of striped bass; for fish intercepted either in directed and non-directed fisheries, or in Dept. of Fisheries and Oceans (DFO) index traps. Consequently, any relationship between variability in striped bass abundance and changes in either number of spawners or recruits cannot be identified. Furthermore, catchability of adult striped bass in gaspereau traps during their May-June spawning period (Bradford et al. 1995) is not known. This limits the usefulness of by-catch data reported in gaspereau logbooks as a measure of spawning stock.

Gulf of St. Lawrence striped bass are genetically distinct from Bay of Fundy fish (Wirgin et al. 1993), but stock structure within the Gulf is not known. Gulf of St. Lawrence striped bass are also thought to be highly migratory (Hogans and Melvin 1984), which could explain the high autumn-winter landings in southeast New Brunswick (Table 2) where spawning appears to have been infrequent over time. Knowledge of stock-structure and seasonal movements are essential for management of striped bass in the long term as these are likely to influence the total fishing mortality of a year-class.

We update the database in order to assess whether or not categorization of striped bass abundance as reduced or declining is justified. First estimates of adult population size are provided as a reference point for future assessments of the state of the resource. Estimates of adult bass catchability in gaspereau traps is presented as well as an assessment of the usefulness of bycatch statistics as a measure of abundance. We also report interim results from ongoing assessments of the life-history traits of these most northern populations of striped bass (Scott and Scott 1988). Results from migration studies, based on mark-recapture experiments, are summarized.

The principal study area is the Miramichi River estuary (Fig. 1), currently the only site where substantial bass spawning occurs (Bradford et al. 1995) and the location of well-developed fixed-gear commercial fisheries (Chaput 1995). Direct, systematic sampling of bycatch in these fisheries was initiated in 1991 (Hanson and Courtenay 1995). Sampling of the striped bass bycatch has continued through to December, 1994.

DESCRIPTION OF FISHERIES

Commercial

The only commercial fishing licenses designated for striped bass in the Gulf of St. Lawrence are sweep net licenses in district 76 (Fig. 2). These licenses, 13 in total in 1993, probably account for the reported landings of January to March in southeast New Brunswick (Table 2). In 1994, these 13 licenses were issued as recreational licenses and now conform to recreational fisheries regulations introduced in 1993.

Striped bass are exploited commercially as bycatch in three fixed gear commercial fisheries which occur seasonally in the estuaries. Gaspereau (alewife, *Alosa pseudoharengus* and blueback herring, *A. aestivalis*) are fished with box traps during May-June. Within the Miramichi estuary a portion of the fishery occurs at the same time, and partially within the same location, as striped bass spawning (Fig. 1). American eels (*Anguilla rostrata*) are fished with fyke nets during June to October. Rainbow smelt (*Osmerus mordax*), and a by- catch of Atlantic tomcod (*Microgadus tomcod*), are fished concurrently with either box or bag nets from October to March. Within the Miramichi River estuary eel and smelt fishing occurs within the known summer-autumn distribution of both young-of-the- year (Fig. 1) and older striped bass (Chaput and Randall 1990). Seasons, locations, mesh size of fishing gear and distribution of effort for each fishery are given in Table 3.

The decline in the reported landings since 1993 (Tables 1 and 2) is due in part to regulations that required striped bass ≥38 cm total length (TL) be released. Bass <38 cm TL could be retained and landed because these fish are considered difficult to cull from the catch.

Recreational

Prior to introduction in 1993 of bag limits and size restrictions, recreational fishing occurred throughout the Gulf of St. Lawrence. Timing of fishing was specific to location and appears to have been cued to specific and predictable life-history events. In Baie des Chaleurs, angling activity focussed on feeding migrants during July and August and was centred at Dalhousie, Bathurst Harbour, and the Caraquet-Shippagan Channel (Bujold 1985; Madden 1984). Similarly, angling success is reported to have been greatest during August-September in the Tabusintac (Madden 1984), Kouchibouguac, Richibucto, and Bouctouche Rivers (anecdotal information reported to R. Bradford). In contrast, peak angling at Newcastle (Miramichi) occurred during May-June (Watling 1985) when adult striped bass are known to spawn (Bradford et al. 1995).

Recreational fisheries regulations introduced in 1993 included season, bag limit and size restrictions:

- season from July 1 to October 31,
- bag limit of one fish per day, and
- a minimum keep size of 68 cm total length.

Recreational catch data have only been collected at Kouchibouguac National Park. Creel surveys were conducted at five locations used by anglers on the Kouchibouguac River and in the estuary of the Black River in 1992 to 1994. The surveys were conducted by Kouchibouguac National Park personnel from the end of April to early September with most of the fishing activity occurring from the end of April to mid-June. Catch data were compiled through field interviews and from a

telephone survey of all National Parks angling license holders who purchased licenses at the park. In 1992, 1419 bass were estimated to have been angled (kept) of which 92% were between 20 and 30 cm fork length (Table 4). There were no angling harvests in 1993 and 1994. Because of the minimum size restriction, there were no reported catches of bass >68 cm total length.

First Peoples Fisheries

Little is known about past utilization of striped bass by First Peoples and whether or not these fish were directly targeted. Data collected since the inception of Aboriginal Fishing Agreements with the DFO indicates that by-catches of bass are common in both gill nets and trap nets set to intercept Atlantic salmon in the Tabusintac, Miramichi, Richibucto, and Bouctouche River estuaries. A portion of this bycatch is consumed.

In 1994, First Peoples which had food fishery agreements with DFO were regulated as to harvests under similar regulations to the recreational fisheries. Harvest amounts were based on communal needs of individual First Nations.

TARGET

Conventional conservation targets based on a relationship between spawner population and recruitment may not be appropriate for striped bass. Research in the eastern United States indicates that density-independent factors affect recruitment to a greater extent than does spawning stock biomass (Rago and Goodyear 1987). Full protection of spawners and potential spawners is the interim target specified in the 1993 New Brunswick Striped Bass Management Plan. The major elements of the plan are:

- arrest the decline in abundance
- increase abundance
- and sustain abundance at levels correspondent to supporting habitat.

The management plan gives priority to increased spawning escapement through protection of both adult and juvenile fish from commercial, recreational and aboriginal food fishing interests.

FISHERY DATA

Two sources of fishery data are available, landings statistics and logbook reports. Purchase slip and supplementary 'B' data provide indications of the levels of catch by statistical district and month. Purchase slips are the record of the catch purchased by the buyer whereas supplementary 'B' slips are estimated by DFO Conservation and Protection personnel of the catch which is consumed or sold locally and which otherwise does not appear on purchase slips. These data, although generally felt to be deficient in reporting actual total harvests, provide an indication of the timing of fisheries geographically and are available for the period 1968 to 1994. The time series from 1968 to 1990 has been previously described (Chaput and Randall 1990; LeBlanc and Chaput 1991).

Bycatch of striped bass in three estuary fisheries (gaspereau, eels, smelt) was also documented through logbook programs and from directed monitoring of catches.

Gaspereau Fisheries

Logbooks completed by gaspereau fishers throughout Gulf New Brunswick provide an indication of the annual variability of bycatch. Gaspereau logbooks have fields for catches of species other than gaspereau - these fields are not completed by all fishers, nor does an individual fisher complete the fields every year. There is no distinction for size of bass on the logbook forms. Logbook reports are not completed every year by all individuals - except for the Miramichi River, the distribution of the logbooks by DFO Science Branch has been inconsistent over time.

Miramichi River Fisheries

In 1991 and 1992, striped bass were sampled as part of a broad multi-species study of bycatch in the gaspereau and smelt fisheries of the Miramichi River estuary. The sampling protocol, detailed in Hanson and Courtenay (1995), is similar to that of 1993 and 1994 (described below), with the following exceptions:

1) sample frequency was higher during 1993 and 1994 and
2) no tagging of striped bass was undertaken in 1991 and 1992.

Eel Fisheries

In 1993, eel logbooks were completed by 2 fishers who collectively fish about 70 percent of all fyke nets set within the Miramichi River estuary. The number of traps fished, hours fished, and the total catch of striped bass per day were recorded. Daily catch of juvenile (Ages 0^+ and 1^+) fish was reported separate from adolescent and adult fish (i.e., fish which could spawn during the following spring) by assigning striped bass to length categories either > or < about 17 cm TL. By-caught striped bass were also sampled directly from individual fyke nets set in the NW branch of the Miramichi River on four occasions between 2 August and 1 September. Eel fishers were not issued logbooks during 1994. However, estimates of bycatch in individual fyke nets were obtained on 5 occasions between 15 July and 30 September.

Smelt Fisheries

The smelt fishery is conducted during two distinct seasons, an open water fishery from 15 October until freezing (usually early December) and a winter fishery conducted through the ice from about 1 January until February 28 or early March (closure is subject to variation orders). In 1993 fishers were visited weekly during autumn and bi-weekly during winter. Striped bass could not be completely sorted from the catch either on the fishing boats or on the ice. Therefore, number of nets fished and hours fished was recorded, total catch of striped bass was counted, and length frequencies of the bass catch were obtained. Sampling of bycatch in the 1994 open water smelt fishery proceeded as in 1993. Coverage was not extended to the winter fishery.

Bycatch by either age or size group for the three fixed gear fisheries was standardized to a catch per unit effort (CPUE±standard deviation (SD)) of number of fish·net^{-1}·day^{-1}. For summary purposes, the bycatch data for all years was separated into its juvenile and adult components. Because all fish were assigned an arbitrary birth date of January 1, the convention established was as follows:

juvenile	- $\leq 1^+$ years of age if sampled before January 1
	- ≤ 3 years of age if sampled after January 1
adult	- >2 years of age if sampled before January 1
	- >3 years of age if sampled after January 1

This convention will designate juveniles older than age 2 as adults. Therefore, adult assignments outside the May-June spawning period are best considered as a combined estimate of spawners and potential spawners as all fish will be at least as old as the minimum observed age at first spawning of 3 years.

RESEARCH DATA

A long time series of counts of striped bass at the Millbank trapnet is available for the period 1975 to 1992. Opportunistic sampling of bass from the Millbank trapnet (length, weight, scales and sex) was undertaken for years 1975 to 1982. Lengths of bass (total for each year) are summarized in Figure 2. Ageing of many of these scales has been completed and back-calculated length-at-age determined from these samples (Chaput and Robichaud 1995). A length-weight regression from these data has also been calculated.

For the Miramichi River, counts of bass are also available from trapnets operated upstream of the confluence of the Northwest and Southwest Miramichi for 1985 to 1987 and 1992 to 1994. Length and scale samples were collected opportunistically at the index trapnets in 1994 over the whole season.

For the Kouchibouguac River, striped bass have been monitored using several gears from early spring until freeze-up. A counting fence was operated in the Black River from 1984 to 1992. Counts of striped bass during that time period have varied from 0 (5 of 9 years) to a high of 29 in 1992 (Delaney et al. 1993). Most of the striped bass between 1989 and 1992 were in the 10 to 20 cm length range (Table 4). A gaspereau trapnet, in the Kouchibouguac River was also operated from early May until freeze-up in 1990 to 1994 (Table 5). In the spring of 1993, a washout occurred and the trap was not fished afterwards. It was replaced for the fall season by a smelt box net at the same location. In the fall of 1994, the gaspereau net was replaced by the smelt box net. Catches are summarized by size-group (Table 4) and season (Table 5). An eel trapnet (fyke net) has also been fished in the Kouchibouguac River in the spring from 1992 to 1994. Catches were highest in 1992, all bass less than 20 cm length, and none were caught in 1994 (Table 4).

Counts and lengths of striped bass were also obtained from the catches in the estuary food fishery trapnets in the Bouctouche River in 1993 and the Tabusintac River in 1994.

ESTIMATION OF STOCK PARAMETERS

Population estimates were obtained using mark and recapture experiments.

1993

During May-June, 1993, one to six gaspereau traps in the Northwest (NW) Miramichi River estuary (Fig. 1) were visited daily. Because fishers were permitted to keep striped bass smaller than 38 cm TL, live striped bass were measured to length (0.1 cm) and samples were separated into 2 size groups; i.e., < 38 cm and >38 cm. Striped bass >38 cm were tagged and released in order to estimate potential exploitation rates on this size group in an unregulated bycatch fishery. Individually numbered, fluorescent orange T-bar tags (length 8.9 cm) were inserted between the first two spines of the anterior dorsal fin (Dunning et al. 1987). Marked fish that were recaptured when the sampler was present were returned to the water after first recording the tag number and date of capture. Recaptures were not weighted by fishing effort and the potential exploitation rate for adult striped bass captured in gaspereau traps was estimated as u =recaptures ÷ marks (Ricker 1975).

The population size was estimated using a pooled sample of marks, recaptures and observed catch (Peterson estimate, Ricker 1975). The inputs were: number of fish marked and released in the first trapping event (M), number of fish in the second trapping event which were marked in the first trapping event (R), and number of fish in the second event which were not previously marked (U).The simplest estimator of the population size is:

$$\hat{N} = \frac{M}{R} * (R+U)$$

Assuming that the three inputs are known without error, then the confidence interval for N was obtained from the Bayes algorithm (Gazey and Staley 1986).

$$P(N_i \mid R) = \frac{P(N_i)\ P(R \mid N_i)}{\sum_{i=1}^{K} P(N_i)\ P(R \mid N_i)}$$

In the case of 1993, K = 1.

1994

In 1994 sampling of gaspereau traps was largely restricted to 2 traps located in the Northwest Miramichi. Sampling protocols established during 1993 for individual trap assessments were otherwise followed.

The population size in 1994 was based on a sequential Bayes algorithm extended to multiple mark and recapture events.

$$P_{t+1}(N_i) = \frac{P(R_{t+1} \mid N_i)\ P_t(N_t)}{\sum_{i=1}^{K} P(R_{t+1} \mid N_i)\ P_t(N_t)}$$

where t = marking and recapture events.

The change in the estimated population distribution from one sequence to the other is a measure of the information added by the sample. Also, a continuous trend towards larger or smaller population size is strong evidence that the population is not closed, either increasing or decreasing over the period of study (Gazey and Staley 1986). A total of 18 recapture events were used in 1994 to estimate the population size and the change in population over time.

Coastal Migrations

Bass caught during May-June in traps nets operated by the Department of Fisheries and Oceans at Eel Ground (Fig. 1) were examined for tags and marked as described above. Between May-November 1994, food fishery traps located in the Nepisiguit, Tabusintac, Miramichi, and Bouctouche River estuaries were used as both tagging and recapture sites (recapture sites only during 1993). Striped bass were also tagged opportunistically during May-June, 1994 while sampling bycatch from the Pokemouche, Richibucto, and Bouctouche gaspereau fisheries. A $5.00 reward was offered for each tag returned with information on date and location of capture. Each tag carried the address of the Gulf Fisheries Centre in Moncton.

Bass were also marked in the Kouchibouguac River estuary using the same technique as in the Miramichi River. Seasonal and annual movements of striped bass marked in the Kouchibouguac River estuary are summarized for years 1991-present. Recaptures in the Miramichi between 1983-1984 (i.e., Hogans and Melvin 1984) are also summarized.

ASSESSMENT RESULTS

State of the Stock

The 1993 estimated total catch of bass ≥38 cm TL was 1354 fish which in combination with the recapture of 64 of 259 marked bass yields a population estimate of about 5000 adults. Estimated population size increased about 10 fold in 1994 to between 40 thousand - 60 thousand fish but sequential solutions of the Bayes algorithm suggested a steady decline in abundance with time during 1994 (Fig. 3). The decline in abundance corresponded with the decline in CPUE (Fig. 4), suggesting that bycatch estimates from gaspereau fisheries were indicative of spawner abundance.

The 1990 categorization (Chaput and Randall 1990) of the stock as reduced or declining was supported by subsequent direct sampling of by-caught striped bass in the gaspereau fishery. Average adult CPUE during 1991 was less than 2 (Table 6) with a maximum CPUE of about 10 (Fig. 5). The 1993 average CPUE was similar (Table 6) but with a maximum CPUE of about 75 (Fig. 5). Observed potential catch was less than the average landed catch (5099± 7113 fish; Years 1981-1989) and an order of magnitude lower than the maximum catch (21861 fish; Year 1981) reported in gaspereau logbooks (Chaput and Randall 1990). Estimates of population size (mark-recapture) in combination with CPUE data suggest that Miramichi spawner abundance is reduced when fish number 5000 or less.

The 1994 Miramichi spawning was highly dependent on the 1990 and 1991 year-classes, i.e. recruits. Greater than 90% of all adult bass sampled during May-June 1994 were between 33 to 52 cm TL (Fig. 6). Approximate observed ranges in length for age 3 and age 4 striped bass are 33 to 45 cm and 38 to 55 cm respectively (Fig. 7). Estimates of the relative contribution of the two year-classes to the spawner population is pending verification of age determinations which are in progress.

Sequential estimates of the 1993 adult population size were not calculated because there is reason to doubt the usefulness of the mark-recapture data. No relationship was apparent between proportion of fish recaptured with time (Fig. 8). In contrast, the 1994 relation between proportion recaptured and time was strong and highly predictable (r^2 =0.84; Fig. 8). Differences between years in the number of tags available per day (i.e., 1 to 58 in 1993 as compared to 7 to 288 in 1994) appears to be the basis for the presence of a relationship.

The strong 1991 year-class appears to be restricted to the Miramichi estuary since few adult fish where sampled elsewhere during May-June, 1994; Tracadie River (CPUE <1; Table 6) Richibucto and Bouctouche combined (CPUE =3; Table 6, maximum CPUE <50; Fig. 5). Juveniles the 1990 and 1991 year-classes were captured in relatively high numbers in the Kouchibouguac River (Years 1992, 1993; Table 4) but these were not reflected in spring 1994 counts of bass in the experimental gaspereau trap although they were observed in the fall of 1994 (Tables 4 and 5).

Sources of Uncertainty

Sex Ratio of Spawners

Males comprised >90% of all spawner striped bass sampled from gaspereau traps during both 1993 and 1994. The remainder were either spawning females or immature males and females. Growth traits of Gulf of St. Lawrence male and female striped bass differ beyond age 3 (Fig. 9) which suggests that age at first maturity may also differ (Chaput and Robichaud 1995). Differential age at first maturity could be the basis for dominance of male fish over the past two spawning seasons. Verification of sex-differentiated age at maturation is necessary. Otherwise one cannot assume equal catchability for male and female bass in gaspereau traps (i.e., spawning season) which in turn raises questions as to the validity of bycatch-based indices of abundance.

Growth studies on the May-June 1995 bass bycatch in Miramichi gaspereau traps has the potential to resolve this issue because 1) the male component of the dominant, recruit year-classes to the spawning population is already known and 2) opportunistic sampling at DFO Index traps in past years indicates that a significant proportion of the female component of a year-class will recruit to the spawning population between ages 4 and 5 (Chaput and Robichaud 1995).

ECOLOGICAL CONSIDERATIONS

Stock Structure

Production of Gulf of St. Lawrence striped bass is presently dependent on spawning in the Miramichi River estuary, even though spawning has occurred in the Nepisiguit, Tabusintac, Kouchibouguac and Richibucto Rivers in past years. Neither viable spawning aggregations (Table 6;

Fig. 5) nor juvenile production (Table 6) were obvious outside of the Miramichi region during a year (1994) when recovery was inferred in the Miramichi. In addition, all May-June 1994 recaptures of fish marked in the Miramichi during the previous spring occurred in the Miramichi (Fig 10). Furthermore, all May-June recaptures for fish tagged during summer-autumn (Years 1991-1993) in the Kouchibouguac River have occurred in the Miramichi (Fig. 11). Age 2^{+} juveniles tagged in Kouchibouguac have been recaptured as adults in Miramichi (Table 7), a result consistent with observed high counts of juveniles (Years 1992-1993) but not adults (Year 1994) in Kouchibouguac (Table 4).

Stock structure of Gulf of St. Lawrence striped bass remains an open question. It remains to be seen whether or not any of the remaining 1700 marked bass still at large at the end of the 1994 Miramichi gaspereau fishery will be recaptured during May-June 1995, in spawning condition elsewhere in the Gulf; i.e., geographic expansion of spawning effort. However, earlier mark-recapture studies suggest striped bass exhibit a degree of spawning site fidelity. Adult bass tagged, in a spawning area and during the spawning season (Kouchibouguac; April 1983), have been recaptured elsewhere (Miramichi) that same season as spawners (Table 7).

Seasonal Occurrence: Miramichi

The time series of striped bass counts at DFO Index traps (Years 1976-1994) indicate that most years of inferred high spawner abundance (i.e., high counts for up to June 30; Fig. 12) are also years of high annual counts (Fig. 11). However, summary of the longest continuous time series (Millbank; Fig. 13) shows that abundance is not uniform for the spring, summer, and autumn seasons. Highest fish counts occur during the May-June spawning season. Bass are present during the summer feeding period but in low numbers. A secondary peak in bass counts occurs throughout late summer and autumn (Weeks 33-40) with a subsequent decline thereafter (Fig. 13). The peak in autumn counts may reflect pre-winter migrations of striped bass back into freshwater (Hogans and Melvin 1984; Bradford et al. 1995). Bass can be captured through the ice in the Miramichi and these individuals marked after capture during winter have been recaptured in the Miramichi gaspereau fishery the next spring (R.G. Bradford unpublished data).

Fishery Interactions

Gaspereau

Mark-recapture experiments indicated that the average potential exploitation rate for adult striped bass intercepted in gaspereau traps were 25% (64 returns from 259 tags) and 20% (355 returns from 1748 tags) during 1993 and 1994, respectively. Cumulative recapture data for bass marked at the onset of the 1994 gaspereau season indicated that the actual potential exploitation rate, over the entire gaspereau season, was closer to 35% (Fig. 8). This assumed that the decline in CPUE as the gaspereau fishery progresses with time (Fig. 4) resulted from dispersal of fish throughout the estuary and not emigration out of the estuary.

Given the overwhelming dominance of recruit males in the catch for both years there is the possibility that an unregulated bycatch fishery could alter the sex ratio in later years. Any potential effect on spawning stock composition remains to be determined pending verification of age at recruitment for female bass. Sex ratios skewed in favour of males are common in successfully reproducing eastern U.S. populations (Setzler et al. 1980; Rago and Goodyear 1987).

Although mortality of adult striped bass landed, sorted and released by gaspereau fishers has not been determined, high recapture rates of marked fish and a consistent rate of recapture with time (1.3% per day; Fig. 7) indicate that handling has a benign short-term effect on the fish.

Prohibition on retention of by-caught striped bass ≥38 cm TL meant that about 3% during 1993 and 12% during 1994 of adult fish could be legally retained by gaspereau fishers, the majority of which were males.

Eel

Direct sampling of bycatch and logbook data (Table 6) both indicate that the Miramichi eel fishery has had little impact on striped bass abundance. This may reflect the small volume of water fished by traps relative to the overall size of the estuary and the extensive dispersal of striped bass during the summer months. Consequently, the data may not reflect impact of eel trap bycatch on striped bass in smaller estuaries of the Gulf of St. Lawrence.

Smelt

Sampling of the autumn smelt fishery yielded the highest average CPUE's (up to 380) of the three fixed-gear fisheries (Table 6). Juvenile striped bass dominated the bycatch during each of the four years of sampling (Years 1991-1994; Table 6). Highest average CPUE was observed during 1990 but this may not be indicative of the average for this fishery as there were only 6 days of observation during November. Subsequent sampling shows substantial variability in CPUE within season (Fig. 14). CPUE's for 0 group fish were consistently the greatest over the four years of sampling. Observed CPUE's in excess of 100 were common for all years. Adult CPUE's were always less than 10 with 0 the most frequent (Fig. 14).

Most 0 group bass captured in the autumn smelt fishery probably die because fishers do not always cull these fish from their catch. A complete cull is impractical because these small bass are mixed in a catch dominated by other fish species of similar size. Estimated 0 group bycatch in 1993 was 50 thousand fish (Bradford et al. 1995). Whether or not high estimated total catches and high CPUE's (Fig. 14) contribute to total mortality in the first year remains an open question. The exploitation rate for striped bass in autumn-set smelt nets is not known.

The winter smelt fishery is likely to have little impact on striped bass abundance in view of the very low CPUE's for bass of any age (Table 6).

Other Fisheries

Despite restrictions detailed in the 1993 management plan (Dept. Fisheries and Oceans 1993), sales of striped bass ≥38 cm TL have continued through to autumn, 1994 (Mr. Fred Wheaton, New Brunswick Wildlife Federation; personal communication). The origin and method of capture of these fish is not precisely known. The availability of freshly caught bass throughout the summer-early autumn indicates that feeding migrant bass were being intercepted. If so, interception of virgin female bass was likely to have occurred. Impact on future composition of spawning populations cannot be determined.

Density-Independent Factors

Density independent factors acting during the egg, larval and early juvenile stages are known to influence recruitment for eastern U.S. striped bass populations (Setzler et al. 1980; Ulanowicz and Polgar 1980; Rago and Goodyear 1987). Similar factors may act within the Miramichi system as well; i.e., variable spawner abundance among years but similar CPUE's for correspondent 0 group in smelt traps (Years: 1990-1994, Fig. 14). The 0 group length frequency distributions (Years 1993, 1994; Fig. 15) are composed of several modes. These could result from discontinuous spawning, disruption of spawning or mortality of eggs and larvae during freshets, or perhaps differential mortality at a later stage of development.

Condition Indices

Of further interest are differences among years in average 0 group pre-winter lengths of up to 3 cm (Years 1990-1994; Fig. 16) and a suggested link to subsequent abundance at age 2. The strong 1991 year-class has the largest observed pre-winter lengths (median =13 cm; Fig. 16). Median length is 10 cm for both the 1992 and 1993 year classes (Fig. 16). These year-classes are less well-represented (Fig. 6) in either the 1994 gaspereau bycatch (1992 year-class) or the fall run of bass into the Tabusintac River (1993 year-class).

Year-class size and even population viability at the limits of distribution of other temperate percid species is dependent on the ability of young-of-the-year to complete a minimum amount of growth before winter starvation (Shuter and Post 1990). Briefly, large fish withstand winter starvation better than small fish because the ratio of energy stored to metabolic rate is an increasing function of body size (Shuter and Post 1990).

FORECAST/PROSPECTS

Higher Spawning Potential for Miramichi; May-June, 1995

The available data indicate that sex-differentiated growth and maturation occurs in Gulf of St. Lawrence striped bass. Therefore, a higher proportion of female bass are expected to recruit at ages 4 and 5 to the Miramichi spawning population in May-June, 1995. However, probable removal of migrant, virgin females creates uncertainty regarding the number of females still alive in the 1990 and 1991 year-classes. Unequivocal statements regarding prospects for recovery/decline are premature.

Reduced Recruitment of Spawners From 1992 Year-class in 1995

Low CPUE at age 2^+ in 1993 gaspereau fishery (Fig. 6), poor representation at age 2^+ in fall-run of bass into the Tabusintac River (Fig. 6), and low pre-winter average lengths at age 0^+ (Fig. 16) suggest the contribution of the 1992 year-class to the 1995 spawning population will be less than for the 1991 year-class in the 1994 spawning population.

Low CPUE for Age 2^+ Striped Bass in May-June 1995

Similarly, poor representation at age 1^+ in fall-run of bass into the Tabusintac River (Fig. 6), and low pre-winter average lengths at age 0^+ (Fig. 16) suggest the 1993 year-class will be poorly represented as a bycatch in the 1995 Miramichi gaspereau fishery.

Mark-Recapture: Repeat Spawning, Return of Migrants to Miramichi

Bass marked on the Miramichi spawning grounds during May-June 1993 were recaptured one year later in the same location (Fig. 10). Repeat spawning is expected to be observed during 1995 as well.

May-June recaptures are anticipated in the Miramichi during 1995 of striped bass marked during summer-autumn in either Kouchibouguac (Years 1991-1994) or Tabusintac (Year 1994).

MANAGEMENT CONSIDERATIONS

Exploitation Opportunities and Strategies

Long term prospects for the striped bass population of the Miramichi river are considered to be improved. Year-classes are now more likely to have multiple opportunities to spawn under conservation management. Increased 0 group production is likely to occur under a combination of repeat spawning and appropriate environmental conditions.

Migration studies indicate that Gulf of St. Lawrence recreational and aboriginal food fisheries intercept migrant fish from the Miramichi. Removals of striped bass during summer-autumn need to be reported accurately in order to obtain annual total fishing mortality estimates for striped bass. These data are of particularly high value during this period of apparent increasing abundance.

Future restoration of viable spawning activity to its known historical range (Nepisiguit south to Richibucto) would raise fundamental management questions. Would spawning outside of the Miramichi estuary be sustainable in the long term under new management provisions? Could the communal needs of First Peoples outside of the Miramichi estuary be met by striped bass produced in situ; i.e., reduce current reliance on migrant fish? Could recreational fisheries, currently active for a brief time each year, depending on location, be extended to the entire ice free season?

Within-Season Forecasting

Observed length frequency distributions during autumn from aboriginal food fishery traps appear to forecast the composition of the bycatch (gaspereau fishery) near spawning grounds the following spring (Fig. 6). The dominance of the 1991 year-class is reflected sequentially in the length frequency distributions from May-June 1993 through to November 1994 (Fig. 6).

Therefore, compilation of catch data from commercial and aboriginal food fisheries shows promise as a means to track individual year-classes and to develop indices of abundance `within season'. These data would be of value for the development and regulation of future effort in both the recreational and aboriginal food fisheries.

RESEARCH RECOMMENDATIONS FOR 1995

Repeat Miramichi Sampling, Mark-Recapture Experiments: May-June

Objectives:

1) verify presence of virgin female spawners,
2) estimate abundance of female component of spawning population,
3) document sex-differentiated growth histories of adults by age class, and
4) extend migration/stock structure studies to 1995.

Sample Miramichi Smelt Bycatch: October-December, 1995

Objectives:

1) assess spawning success in Miramichi 1995 given expectation of detectable numbers of mature females during May-June 1995 and
2) determine pre-winter abundance and body size.

Dedicated Sampling, Mark-Recapture: Richibucto, Bouctouche

Objectives:

1) sample gaspereau bycatch: evaluate potential spawning activity, determine biological traits, assess intra-river spawning by fish known (marked) to spawn in previous years in Miramichi and
2) mark gaspereau bycatch: assess adult population size, augment assessment of migration/stock structure.

Back-Calculate Somatic Growth of 1990-1994 Year-classes: Miramichi

Objective:

1) verify size-dependent winter mortality of 0 group: compare observed pre-winter length with back-calculated length at age 1,

Initiate Year-Round Collection of Water Temperature: Miramichi

Objective:

1) develop environmental indices potentially relevant to spawning success and recruitment.

ACKNOWLEDGEMENTS

We thank the commercial fishers of the Miramichi River estuary for their co-operation during the course of this study and for sharing in their knowledge of the river and its fisheries. The interest shown and effort expended in sampling by the Pabineau, Burnt Church, Eel Ground and Bouctouche First Nations is greatly appreciated. We also thank Kevin Davidson (DFO, Gulf Region, Moncton, N.B.) and Mark Hambrook (DFO) and the additional staff of the Miramichi Fish Culture Station,

Newcastle, N.B. for logistic support. We thank Mr. Bob Carrol (deceased), Mr. Fred Wheaton and Mr. Hal Wood of the New Brunswick Wildlife Federation (NBWF) as well as Simon Courtenay, Dave Dunn and Victor Gionet of (DFO Moncton) for their support and encouragement. Andy Bahm, Marc-Andre Bernard, John Hambrook, and Luiz Mello provided assistance in the field. G. Delaney, F. LeBlanc, L. LeBlanc and M. Savoie of the Kouchibouguac National Park were involved in the studies on the Kouchibouguac River. Portions of this study were funded through the Canada-New Brunswick Co-operative Agreement on Recreational Fisheries Development administered through the NBWF.

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STOCK STATUS WORKSHOP NOTES

New Brunswick Striped Bass

Wharf Inn, Newcastle
January 17, 1995

Participants:

Normand Allain	Gaspereau Trapnetter
Henry Allain	Gaspereau Trapnetter
Eugène Richard	Gaspereau Trapnetter
Edmond Drysdale	U.P.M.
Gerald Dutcher	Gaspereau Trapnetter
Gaetan Landry	M.P.A. - Caraquet
Florence Albert	M.P.O. - Tracadie-Sheila
Bernard Dubee	N.B.D.N.R.E. - Newcastle
R.J. Allain	D.F.O. - Tracadie-Sheila
Marc Gallant	Gaspereau Trapnetter
Michel Savoie	Parc National Kouchibouguac
Léophane LeBlanc	Parc National Kouchibouguac
Ross Claytor	DFO - Science
Tim Lutzac	DFO - Science
Rod Bradford	NB Wildlife Federation
Gérald Chaput	DFO - Science

Landings:

- Striped Bass angling catches are not collected on an annual basis. The only catch statistics would be available from the national survey done every 5 years.

- A system for collecting recreational angling statistics should be implemented.

- Commercial landings are available only from Statistics Branch purchase slip files, these do not appear to accurately reflect numbers landed. These landings for 1993 appear to be well below the landings estimated by research on the Miramichi River.

- First Nations catches were not available.

- Improved landing statistics will be important to manage this fishery.

Research Data:

- Population estimates and exploitation rates for 1993 and 1994 in the Miramichi River were obtained from a tagging experiment which used gaspereau traps as mark and recapture sites.

- By-catch in eel, smelt, and gaspereau traps were also monitored.

- Migration of striped bass was also studied through the mark and recapture research utilizing commercial and First Nation food fishery and assessment traps as marking and recapture sites.

- Data from Kouchibouguac Park were also available on abundance at the Black River counting fence, and gaspereau and recreational fisheries on the Kouchibouquac River.

Abundance:

- The population estimate for Miramichi Striped Bass in 1993 was 5,000 and for 1994 was 40,000 to 60,000.

- Exploitation rates in the fishery based on tag returns was about 20% in both years.

- Counts at the Black River counting fence show an increase from 1992 to 1994 but counts were not made in 1993.

- Exploitation rates in the Kouchibouquac River gaspereau fishery were estimated at 20%. Angling exploitation rates before the imposition of the 68 cm size limit was twice this level. In 1993 and 1994 angling exploitation rate was 0% because of the size restriction.

- Logbook data from selected gaspereau trapnetters also shows an increase in catch rates from 1993 to 1994 on the Miramichi River.

- Returns in 1994 come from a spawning population that was thought to be low.

Recommendations:

- Establish systems for collecting accurate annual landing statistics in all fisheries.

- Identify spawning populations.

Table 1. Purchase slip and supplementary 'B' landings (t) of striped bass from the Gulf New Brunswick statistical districts, 1917 to 1994. Statistical districts are shown in Figure 2. Data for 1917 to 1988 are from LeBlanc and Chaput (1991). Data for 1989 to 1994 are from Statistics Branch, DFO. A period means no landings were registered, a value of 0.0 means landings were less than 50 kg.

	Statistical Districts								
Year	64	68	70	71	72	73	75	76	Gulf NB
1917	1.2	8.2	.	4.0	0.4	1.5		35.7	61.4
1918	0.9	7.2	.	1.1	4.5	1.5		16.6	54.4
1919	.	4.1	0.5	1.2	2.3	3.6	15.4	2.3	33.7
1920	.	17.3	.	2.2	0.5	4.2	0.9	2.7	28.3
1921	.	1.1	.	1.5	.	2.7		7.4	15.9
1922	.	1.4	.	1.2	.	.		16.3	19.1
1923	.	0.9	.	0.2	.	5.4		18.0	25.5
1924	.	.	.	0.9	7.2	.		30.6	39.8
1925	.	0.9	.	0.7	0.4	4.1			22.1
1926	.	.	.	1.9	0.4	.		14.6	20.0
1927	.	.	.	.	.	6.5		15.4	22.8
1928	.	.	.	0.2	.	3.7	5.4		10.3
1929	.	.	.	.	.	1.7	3.0	0.9	5.8
1930	.	.	.	0.5	0.5	0.9	0.4	1.8	4.0
1931	.	.	.	.	0.5	0.9		1.8	3.2
1932	.	.	0.8	.	0.5	1.1		1.5	3.9
1933	.	.	0.2	.	0.1	.		0.4	0.7
1934	.	.	.	.	0.3	.		0.0	0.4
.									
1968	.	.	0.4	1.8	1.1	0.1	1.2	3.6	8.2
1969	.	.	0.1	0.4	1.6	0.1	4.8	2.4	9.4
1970	.	0.1	2.6	0.9	3.4	0.4	2.7	0.6	10.6
1971	.	.	0.7	1.4	8.5	0.4	2.0	0.4	13.3
1972	.	.	0.1	1.8	3.4	0.5	3.1		8.8
1973	.	.	0.2	0.1	3.8	.	2.0	0.0	6.1
1974	.	0.1	.	0.3	3.6	.	1.5		5.4
1975	.	0.7	3.2	1.0	.	.	2.2		7.2
1976	0.1	0.1	1.9	1.6	3.1	.	1.9		8.6
1977	.	.	0.9	1.2	.	.	3.0		5.1
1978	.	.	1.5	.	.	.	3.2		5.1
1979	.	0.1	2.2	1.2	.	.	3.3		6.8
1980	0.2	0.1	9.7	2.9	.	.	2.2		15.3
1981	0.2	0.9	5.5	4.7	.	.	1.2	16.4	47.8
1982	.	1.0	3.8	2.4	.	.	1.9	17.4	32.4
1983	.	2.0	3.0	6.9	.	0.1	4.7	3.6	23.4
1984	.	0.1	9.9	2.2	.	.	0.3	43.0	17.3
1985	.	0.8	2.3	8.0	.	.	0.0	9.7	22.0
1986	1.0	2.2	3.5	.	.	.		5.5	12.5
1987	.	.	0.6	.	.	0.1	1.0	0.6	2.3
1988	.	0.1	2.0	0.9	.	.	1.0	0.2	4.1
1989	.	.	.	0.1	.	.		3.8	4.0
1990	.	.	.	0.0	.	.		0.8	1.0
1991	.	.	.	0.0	.	.	0.2	1.1	1.3
1992	.	.	.	0.2	.	.	0.3	8.4	8.9
1993	.	.	.	0.0	.	.	0.0	0.6	0.6
1994	.	.	.	.	.	.	.	1.0	1.0
Average 89-93	0.0	0.0	0.0	0.1	0.0	0.0	0.2	2.9	3.2

Table 2. Striped bass landings (t) from Gulf New Brunswick statistical districts by season, 1968 to 1994. Data sources as in Table 1. Statistical districts are shown in Fig. 2. A period means no landing registered. A value of 0.0 means landings were less than 50 kg.

	Year	January to March	April to June	July to September	October to December	Total
Northeast NB Districts 65-68	1975	.	.	0.7	0.1	0.8
	1976	.	.	0.2	.	0.2
	1980	.	.	0.3	0.2	0.5
	1981	.	.	1.0	0.2	1.2
	1982	.	0.2	0.5	0.3	1.0
	1983	.	.	0.0	1.9	1.9
	1984	.	.	0.5	0.2	0.7
	1985	.	.	1.4	0.4	1.8
	1986	.	.	1.8	1.7	3.5
	1988	.	.	0.1	.	0.1
Central NB Districts 71-73	1968	.	3.0	0.3	0.1	3.4
	1969	.	2.0	0.1	.	2.1
	1970	.	4.8	2.5	0.1	7.4
	1971	.	10.3	0.7	.	11.0
	1972	.	5.7	.	.	5.7
	1973	.	4.1	.	.	4.1
	1974	.	3.9	.	.	3.9
	1975	.	1.0	2.7	0.5	4.2
	1976	.	4.7	1.9	.	6.6
	1977	.	1.2	0.7	0.2	2.1
	1978	.	.	0.9	0.5	1.4
	1979	.	1.4	1.8	0.2	3.4
	1980	.	3.1	9.3	0.1	12.5
	1981	.	4.8	5.3	0.1	10.2
	1982	.	2.4	2.7	1.0	6.1
	1983	.	6.9	1.5	1.5	9.9
	1984	.	2.3	3.1	6.6	12.0
	1985	.	8.4	0.8	1.2	10.4
	1986	.	.	3.5	.	3.5
	1987	.	.	0.6	.	0.6
	1988	.	0.9	1.4	0.6	2.9
	1989	.	0.1	.	.	0.1
	1990	.	.	.	.	0.0
	1991	.	.	.	.	0.0
	1992	.	0.2	.	.	0.2
	1993	.	.	.	.	0.0
	1994	.	.	.	.	0.0
Southeast NB Districts 75-80	1968	3.0	0.3	.	1.5	4.8
	1969	5.3	0.2	.	1.8	7.3
	1970	2.5	0.3	.	0.5	3.3
	1971	2.2	.	.	0.2	2.4
	1972	2.6	0.2	.	0.3	3.1
	1973	1.1	1.0	.	.	2.1
	1974	0.7	0.1	.	0.7	1.5
	1975	1.7	.	.	0.5	2.2
	1976	1.6	.	.	0.3	1.9
	1977	1.5	.	0.7	0.8	3.0
	1978	2.0	.	0.7	0.6	3.3
	1979	2.0	.	0.7	0.5	3.2
	1980	1.6	.	0.6	.	2.2
	1981	1.1	29.2	2.0	4.0	36.3
	1982	2.3	16.7	2.2	4.0	25.2
	1983	2.5	7.0	0.6	1.1	11.2
	1984	.	3.1	0.4	1.1	4.6
	1985	.	3.1	4.1	2.6	9.8
	1986	0.1	2.5	2.1	0.8	5.5
	1987	0.1	1.3	0.3	.	1.7
	1988	.	1.1	.	.	1.1
	1989	.	.	1.9	1.9	3.8
	1990	.	0.4	0.3	.	0.7
	1991	1.2	0.0	.	0.0	1.2
	1992	0.1	8.0	.	0.5	8.6
	1993	0.5	.	0.0	0.1	0.6
	1994	0.2	0.8	.	.	1.0

Table 3. Seasons, location, and gear number, type and mesh size (cm) for fixed-gear commercial fisheries of the Miramichi River estuary.

Fishery	Duration	Location	Gear	Nets	Mesh Size (cm)
Gaspereau	15 May to 15 June	NW Miramichi Chatham Loggieville Napan River	Box	13 11 6 6	3.1
Eel	No Closure	NW Miramichi Loggieville Napan River	Fyke	44 15 24	2.4
Smelt	15 October to December	Chatham to Napan River	Bag	21	2.4
	January to March	Miramichi Bay	Bag Box	>300	2.4

Table 4. Summary of number and size of striped bass from research gear and sport creel survey, Kouchibouguac National Park, 1989 to 1994.

		Length group					
Gear	Year	0-10 cm	10-20 cm	20-30 cm	30-40 cm	40+ cm	Total
Black River counting fence	1989	0	0	0	0	0	0
	1990	0	2	0	0	0	2
	1991	0	1	0	0	0	1
	1992	2	16	1	0	0	19
	1994[1]	0	154	0	9	19	182
Gaspereau trap	1990	0	558	3	0	1	562
	1991	0	339	16	2	0	367
	1992	0	736	13	21	0	770
	1993[2]	0	0	62	64	5	131
	1994	0	0	33	39	3	75
	1994[2]	0	35	2	51	24	112
Eel trap	1992	31	54	0	0	0	85
	1993	2	0	0	0	0	2
	1994	0	0	0	0	0	0
Sport fishing creel	1992	0	0	1302	113	4	1419
	1993	0	0	10[3]	0	0	10[3]
	1994	0	0	0	0	0	0

[1] Smelt box net used instead of counting fence in 1994. The net was set below counting fence site and blocked the entire river.
[2] Smelt box net used instead of gaspereau trap in the fall of 1993 and 1994
[3] Striped bass (estimated length) seized by Park Wardens from anglers within Black River

Table 5. Summary of catches of bass and effort in research gears from the Kouchibouguac National Park, 1989 to 1994.

Gear type	Year	Dates	Effort (days)	Catch of bass
Black River counting fence	1984	May - Nov.		0
	1985	May - Nov.		0
	1986	May - Nov.		0
	1987	May - Nov.		0
	1988	May - July		10
		Aug. - Oct.		0
	1989	May - Nov.		0
	1990	May - July		0
		Sept. - Oct.		2
	1991	May - July		0
		Sept. - Oct.		1
	1992	May - July		0
		Sept. - Oct.		19
	1994[1]	Sept. - Nov.		182
Gaspereau trapnet	1990	Sept. 20-Nov. 1	25	562
	1991	May 23 - June 25	17	21
		Sept. 24 - Nov. 22	26	336
	1992	May 29 - June 30	14	139
		Sept. 15 - Nov. 13	37	631
	1993	June 19 - 22 (washout)	4	0
	[2]	Sept. 30 - Nov. 17	26	131
	1994	June 7 - July 8	20	75
	[2]	Sept. 1 - Nov. 8	36	110
American eel trap	1992	Aug. 26 - October	42	53
		Oct. 6 - Nov. 12	20	32
	1993	June 1 - July	13	2
	1994	June 1 - July 3	34	0

[1] Smelt box net used instead of counting fence in 1994. The net was set below counting fence site and blocked the entire river.
[2] Smelt box net used instead of gaspereau trap in the fall of 1993 and 1994

Table 6. Arithemetic mean(±1standard devidation) of CPUE (fish·net^{-1}·24h^{-1}) and net days of observation for striped bass by fishery, location, and year of sampling. Data for Miramichi smelt fishery are divided into the autumn and winter components (L =logbook).

			CPUE (fish·net^{-1}·24h^{-1})	
Location	Year	Net-days	Adult	Juvenile
Gaspereau fishery				
Miramichi	1991	23	1.5 ± 2.0	0.2 ± 0.6
	1993	73	2.0 ± 2.3	3.8 ± 5.1
	1994	51	82.9 ± 137.6	4.5 ± 7.1
Kent County	1994	31	3.1 ± 4.3	5.6 ± 5.4
Tracadie	1994	85	0.2 ± 0.5	0.0 ± 0.2
Eel fishery				
Miramichi	1993 (L)	2200	0.0 ± 0.2	0.1 ± 0.2
	1993	176	0.0 ± 0.1	0.5 ± 0.2
	1994	172	0.0 ± 0.3	0.5 ± 1.2
Kent County	1994	128	0.0 ± 0.2	0.0 ± 0.0
Smelt fishery (Miramichi)				
Autumn	1991[1]	21	0.0 ± 0.1	380.1 ± 726.6
	1992	23	0.0 ± 0.1	62.6 ± 75.9
	1993	135	0.5 ± 0.9	8.8 ± 29.0
	1994	66	0.1 ± 0.2	98.3 ± 233.7
Winter	1991	59	0.0 ± 0.0	3.8 ± 4.8
	1992	47	0.0 ± 0.0	0.6 ± 1.6
	1993	113	0.0 ± 0.1	0.0 ± 0.1

[1] Sampled during November only

Table 7. Summary of recaptures in the Miramichi River estuary of striped bass marked in the Kouchibouguac River estuary (Type =life-history stage when marked, Season-Yr = season and year of marking, n =number of recaptures, Date =month and year of recapture, NWM =Northwest Miramichi River estuary, MRE =Miramichi River estuary). Recaptures were from gaspereau traps, smelt traps, anglers or unknown.

Marked in Kouchibouguac		Recaptured in Miramichi			
Type	Season-Yr	n	Date	Location	Remarks
Adult[1]	Spring 1983	2	June 1983	NWM-Gaspereau	Marked-recaptured: 2 spawning areas
		2	May & June 1983	MRE-Gaspereau	Marked in spawning area
		7	May & June 1983	MRE-Unknown	Marked in spawning area
		2	June 1983	MRE-Angled	Marked in spawning area
		1	September 1983	MRE-Unknown	Marked in spawning area
		1	February 1984	MRE-Unknown	Marked in spawning area: overwinter MRE
Juvenile[2]	Autumn 1991	1	June 1993	NWM-Gaspereau	Recaptured as adult
		1	November 1991	MRE-Smelt	Recaptured as juvenile
	Autumn 1992	1	May 1993	NWM-Gaspereau	Recaptured as juvenile?
		1	October 1992	MRE-Smelt	Within-season migration to MRE
		1	January 1994	MRE-Smelt	Overwintering in MRE

[1] Reference: Hogans and Melvin 1984
[2] Reference: Bradford et al. 1995

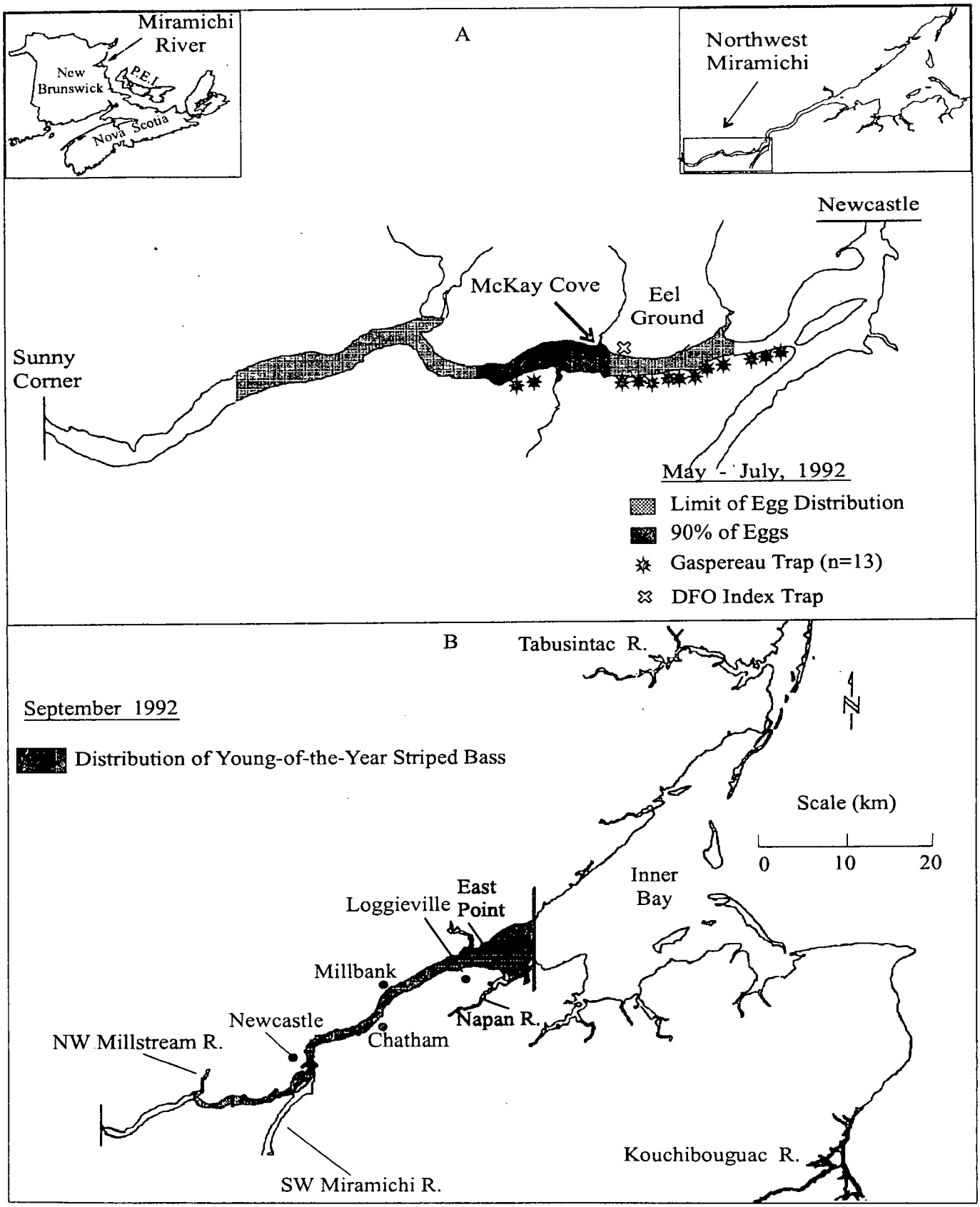


Figure 1. Map of study area with place names used in the text; a) distribution of striped bass eggs (shaded) and gaspereau traps in Northwest Miramichi River estuary, b) distribution of young-of-the-year striped bass during September. The limits of sampling are denoted by solid vertical lines.

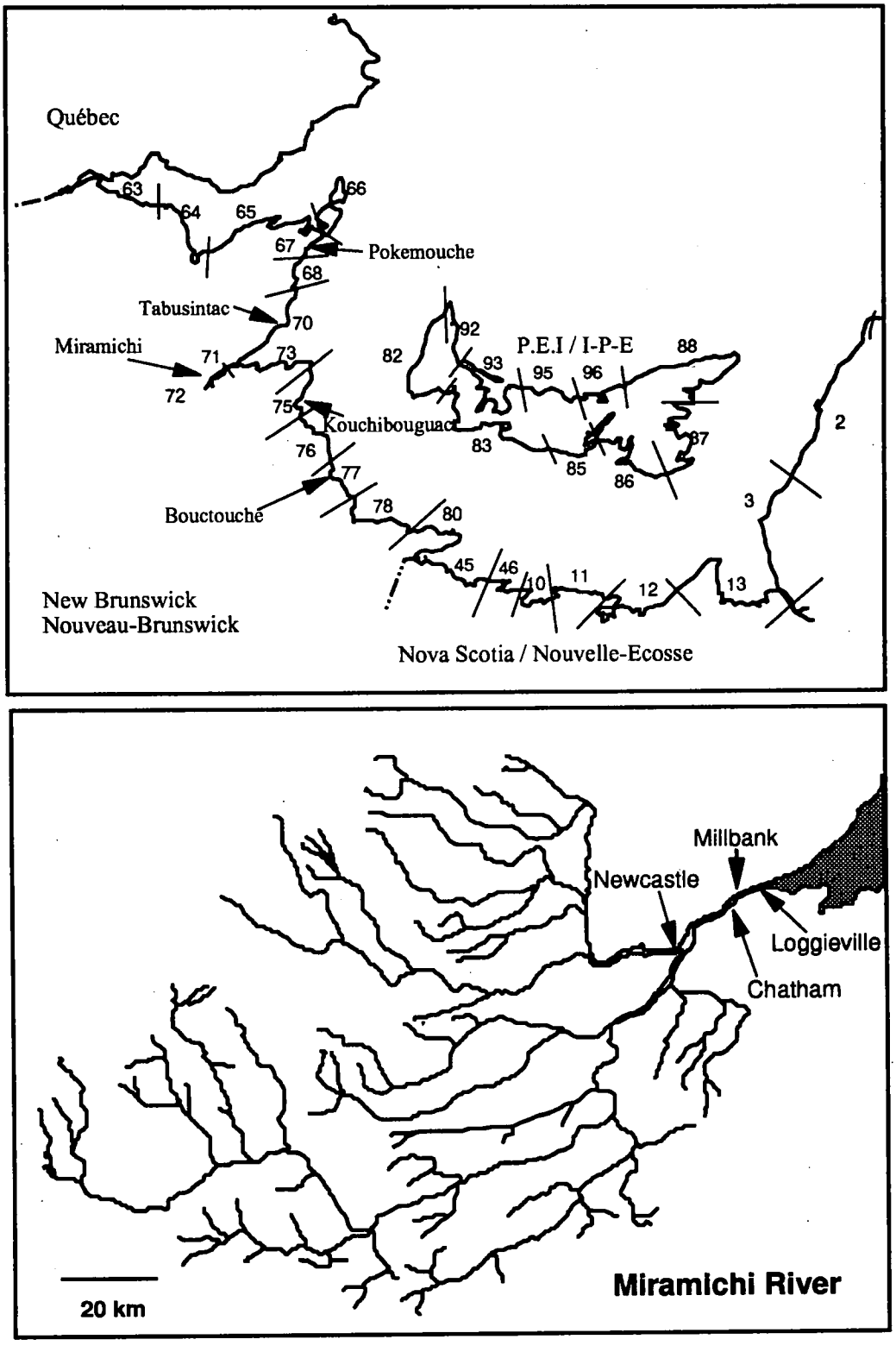


Figure 2. Statistical districts and locations referred to in the document.

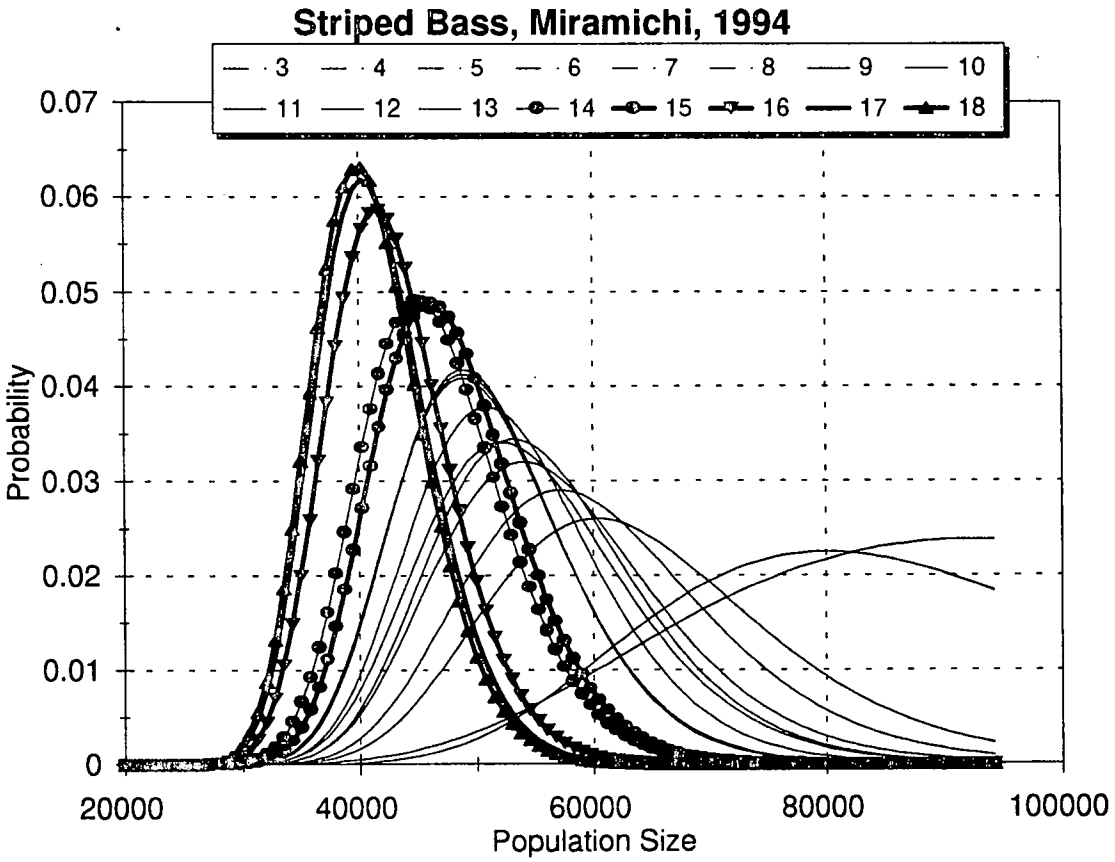


Fig. 3. Estimated population size of striped bass greater than and equal to 38 cm total length in the Miramichi River, 1994.

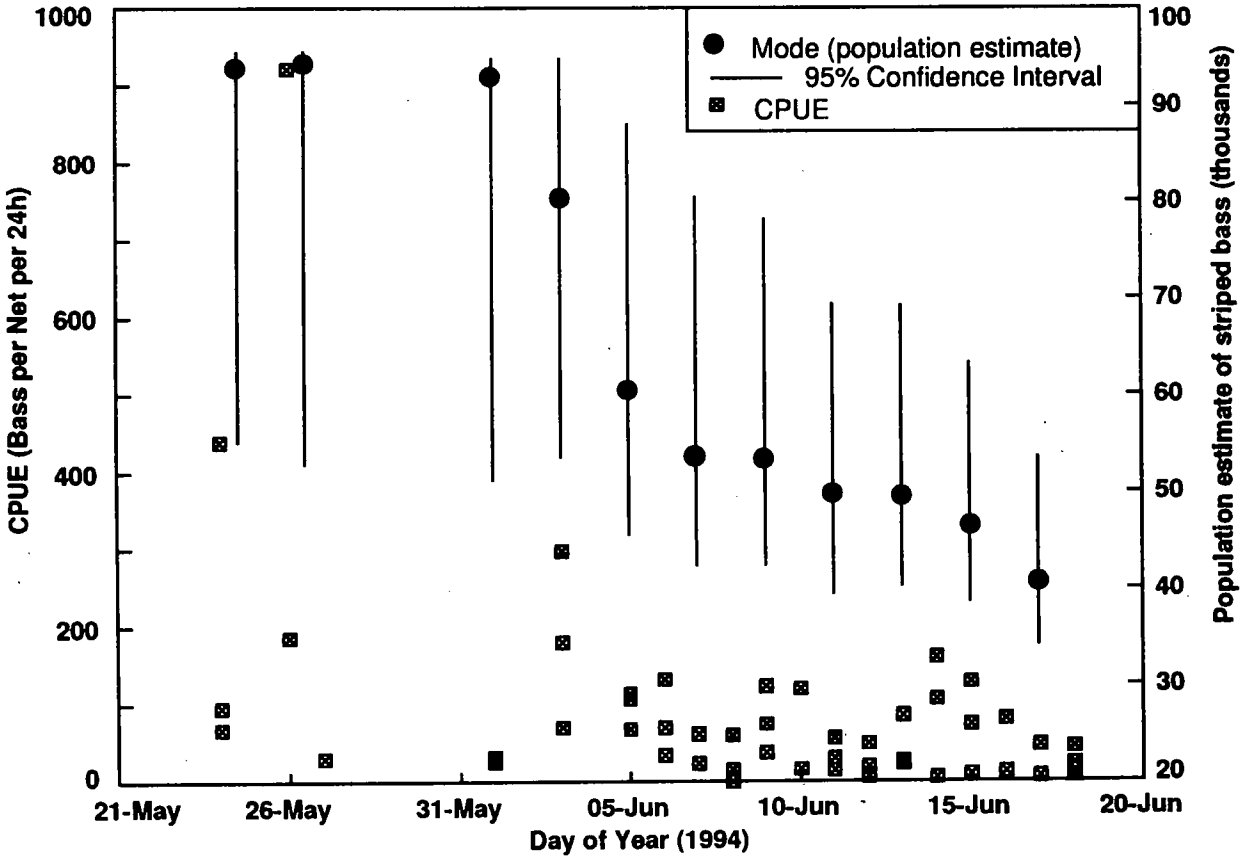


Figure 4. CPUE of striped bass in the 1994 gaspereau fishery, mode and confidence intervals of the sequential population estimates of the spawning population of striped bass versus time in 1994.

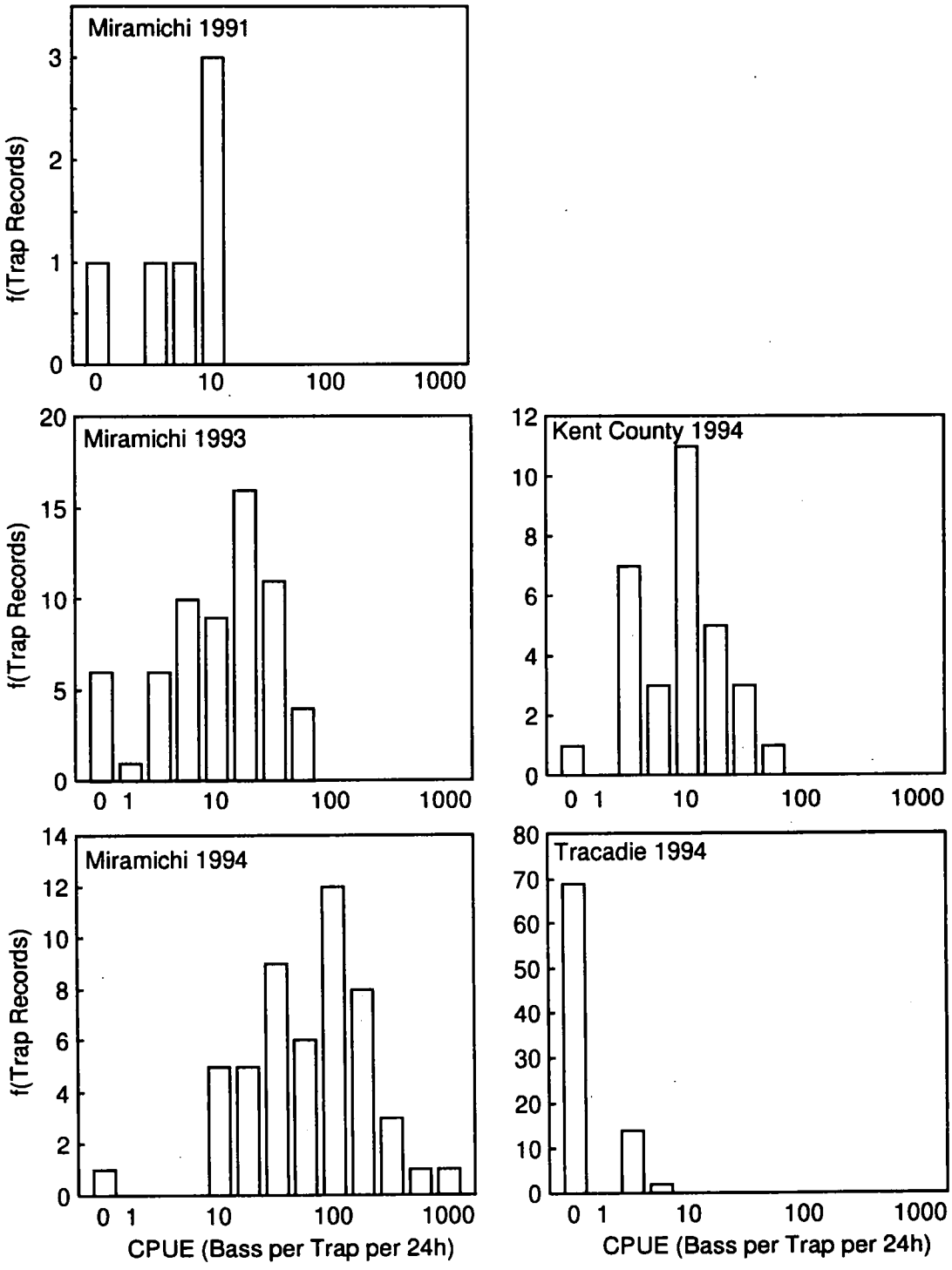


Figure 5. CPUE frequency distribution for Miramichi (1991, 1993 and 1994), Tracadie (1994), and Kent County (1994) gaspereau fisheries during May and June.

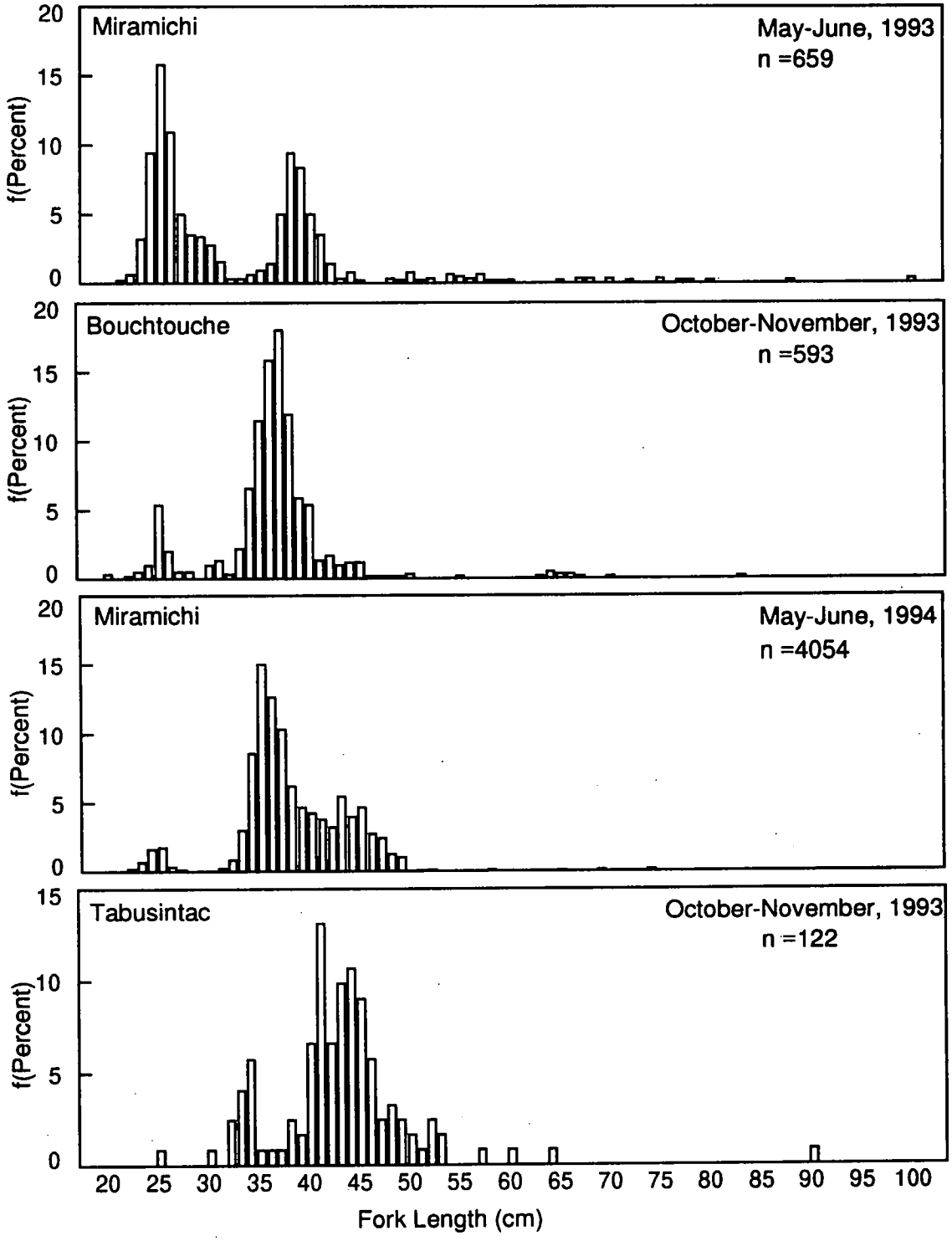
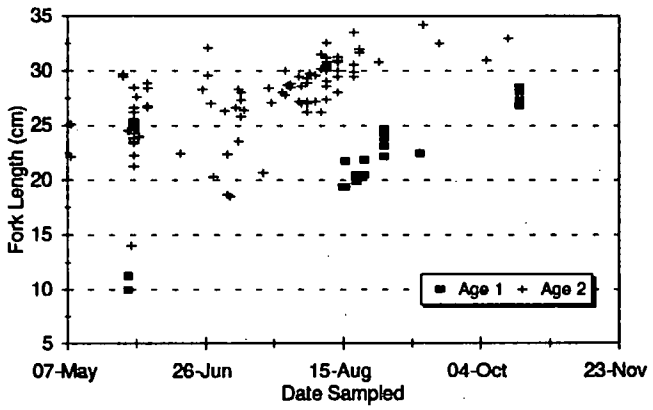
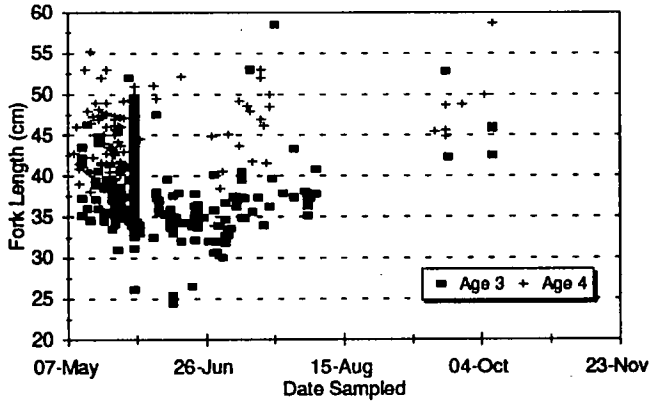


Figure 6. Length frequency distributions of striped bass in spring and autumn, 1993 and 1994.





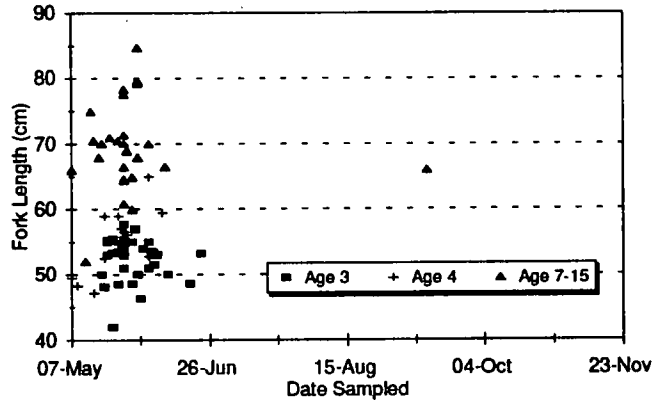


Figure 7. Length-at-age over the year of striped bass from the Miramichi River. Samples were obtained from Millbank, 1975 to 1992 and from sampling at gaspereau trapnets and smelt nets in the Miramichi, 1991 to 1994.

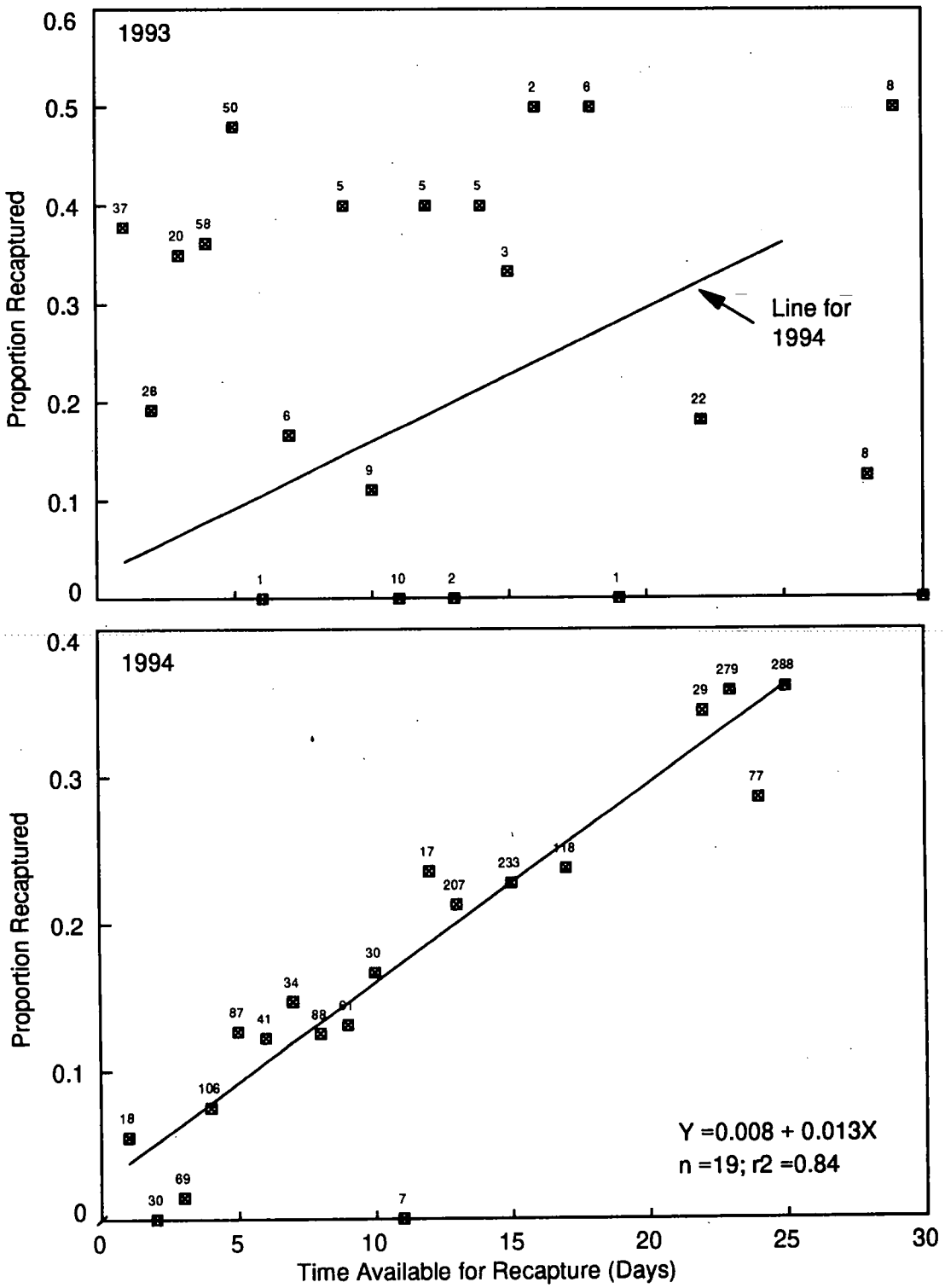


Figure 8. Proportion of marks from each day of tagging recaptured during the total time available for 1993 and 1994 gaspereau seasons. Numbers above squares are number of tags applied on individual days.

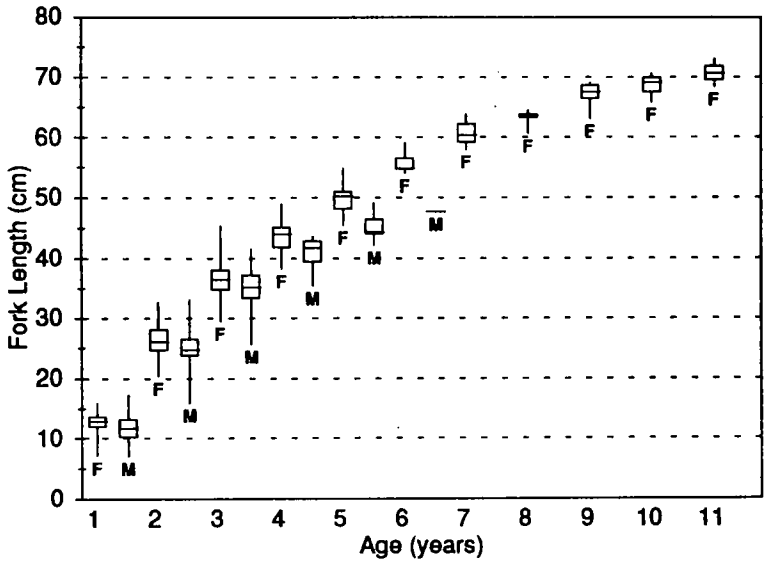


Figure 9. Back-calculated fork length-at-age of male and female striped bass from the Miramichi River as determined from samples collected between 1975 and 1986. Vertical lines represent the 5th and 95th percentile ranges, rectangles are the interquartile ranges, and the horizontal lines are the medians. 'M' = males and 'F' = females. Data from Chaput and Robichaud (1995).

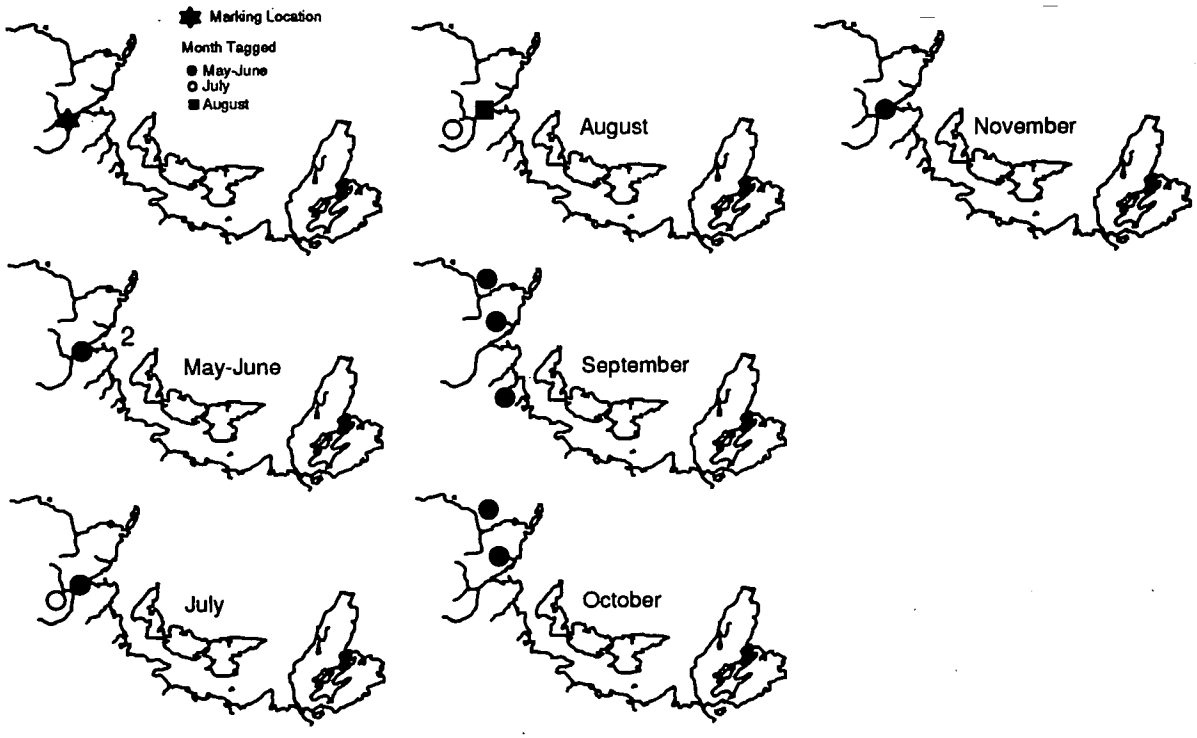


Figure 10. Recaptures by month for striped bass marked in the Miramichi during May-June, July, and August of 1993 and 1994. The '2' in the May-June recapture period shows that bass were recaptured on the spawning ground during 1994 after one year at large.

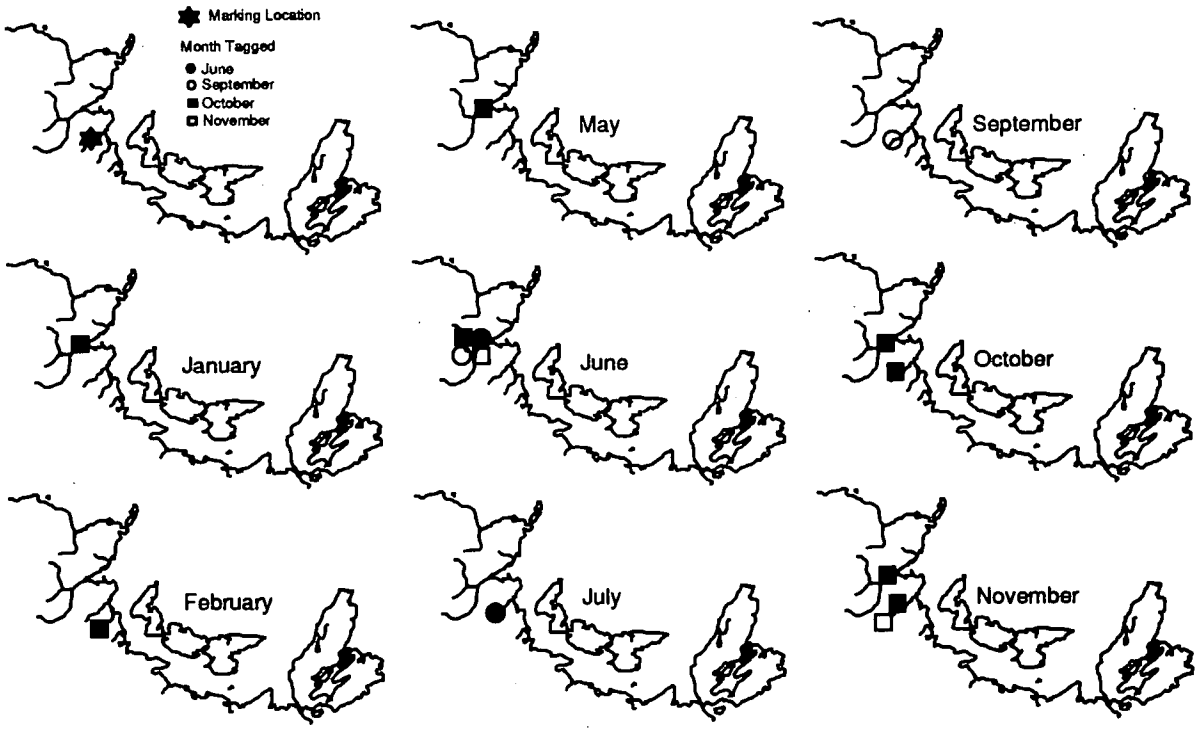


Figure 11. Recaptures by month for striped bass marked in Kouchibouguac during June, September, October, and November for 1991 to 1994.

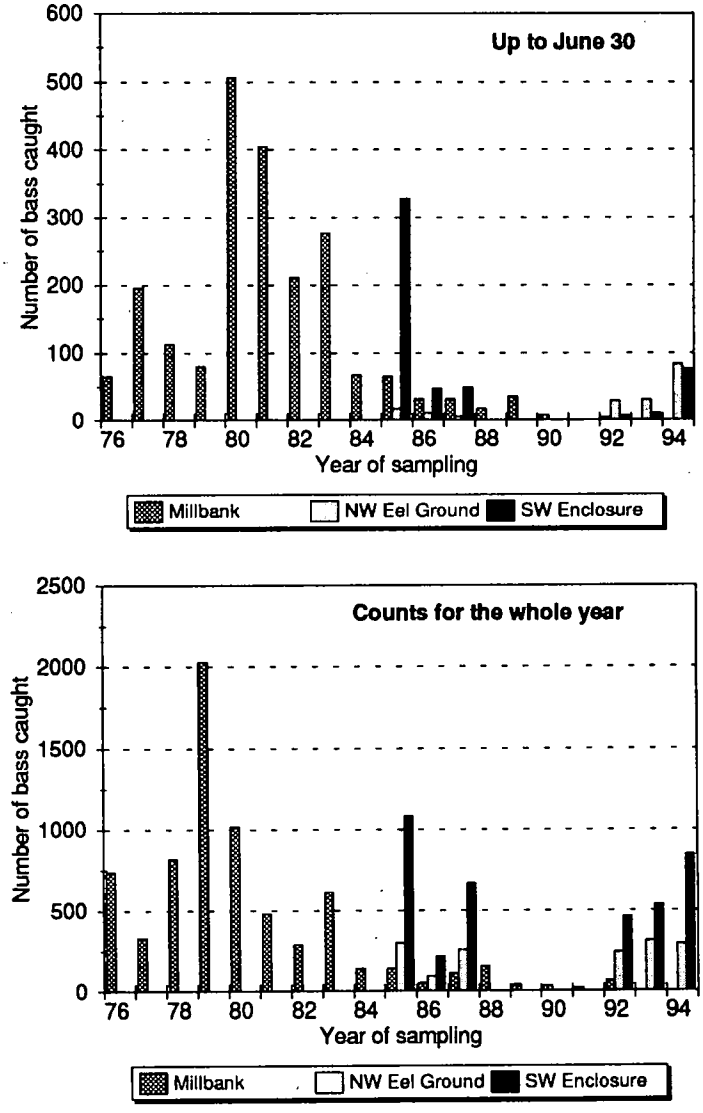


Figure 12. Counts of striped bass at the DFO index trapnets for the period up to June 30 (upper) and for the whole year (lower), 1976 to 1994.

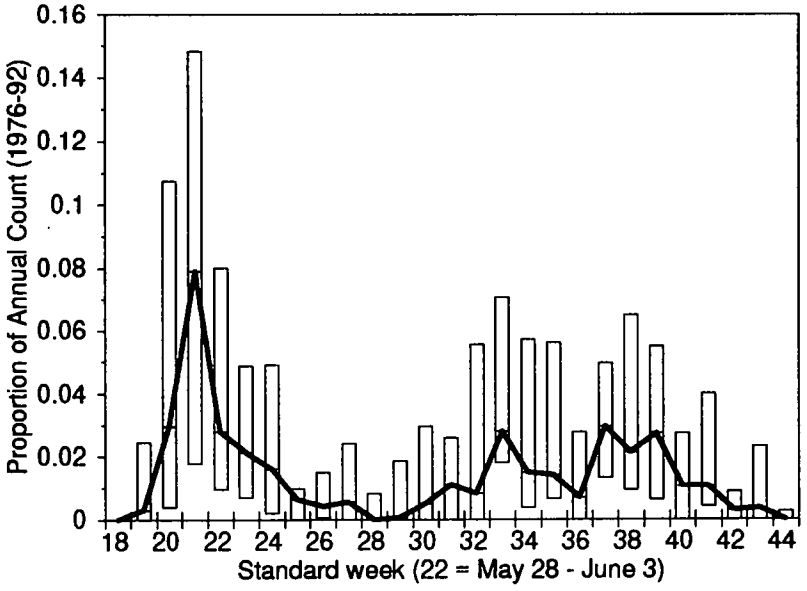


Figure 13. Seasonal occurence of striped bass in the Miramichi River estuary as observed at Millbank, 1976 to 1992. Recatangle represents interquartile range of the proportion of the total annual run in a given week, dark solid line joins the median values for a given week.

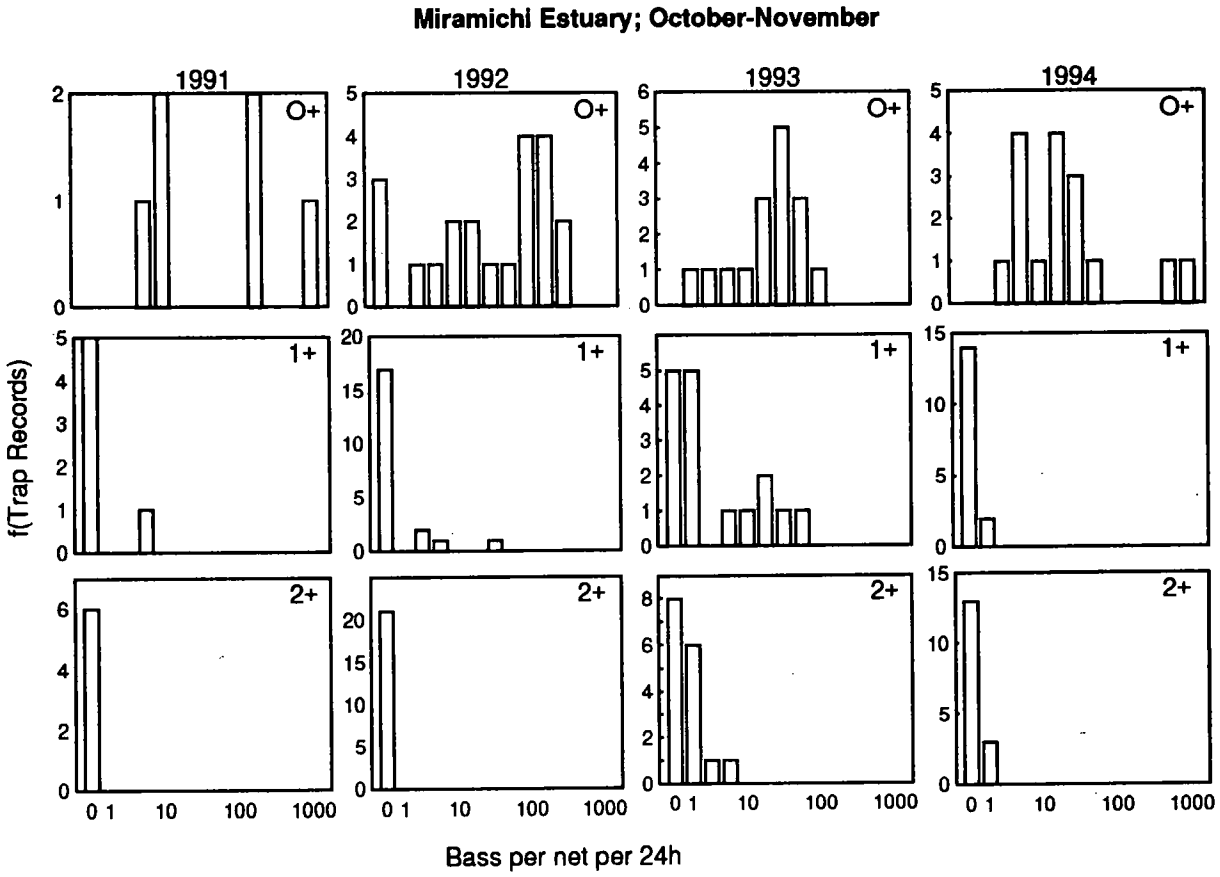


Figure 14. CPUE by age group and by year for by-catch of striped bass in the autumn smelt fishery of the Miramichi estuary. X-axis is log scale.

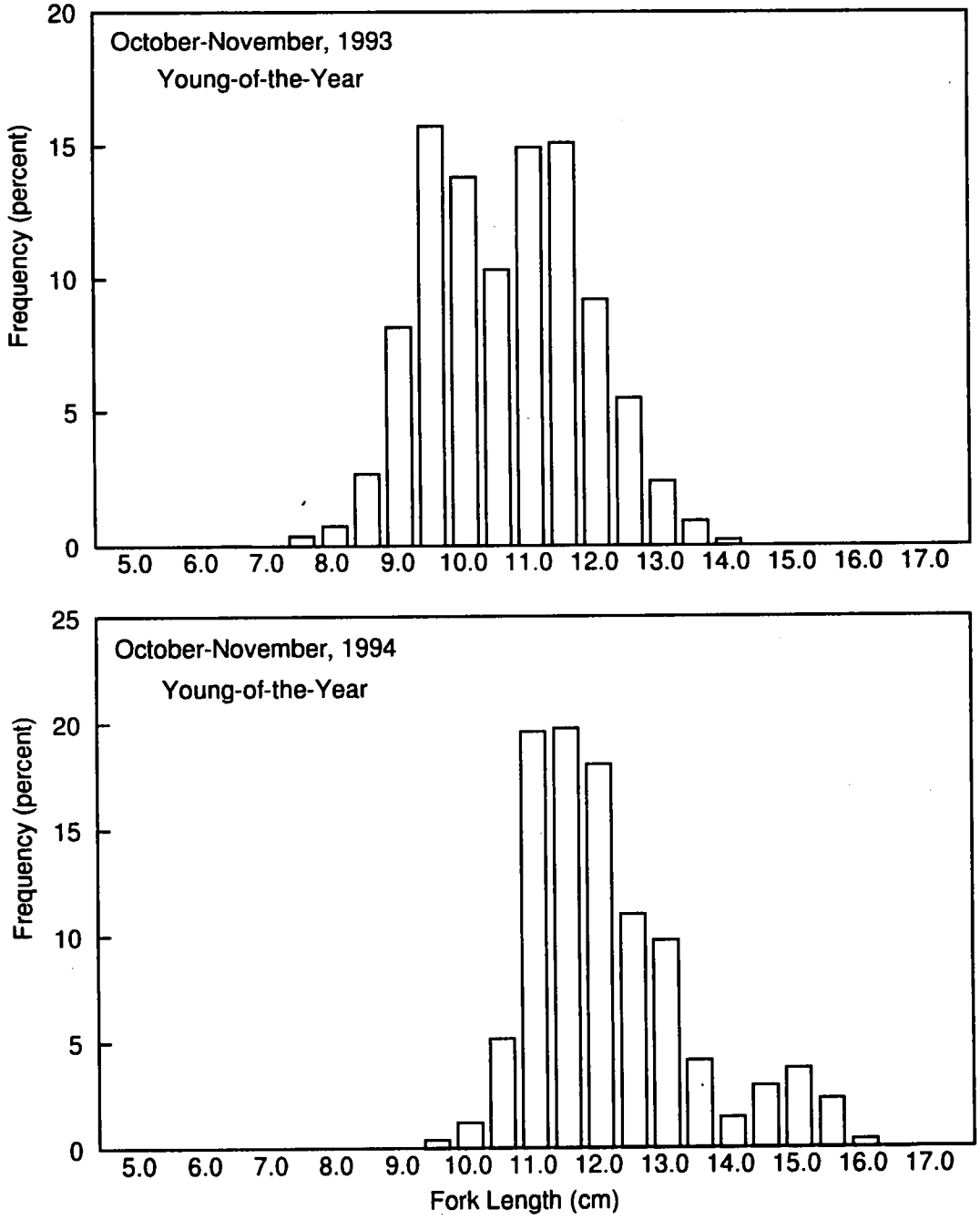


Figure 15. Length frequency distribution (by 0.5 cm groups) of young-of-the-year striped bass captured in the autumn smelt fishery of the Miramichi estuary.

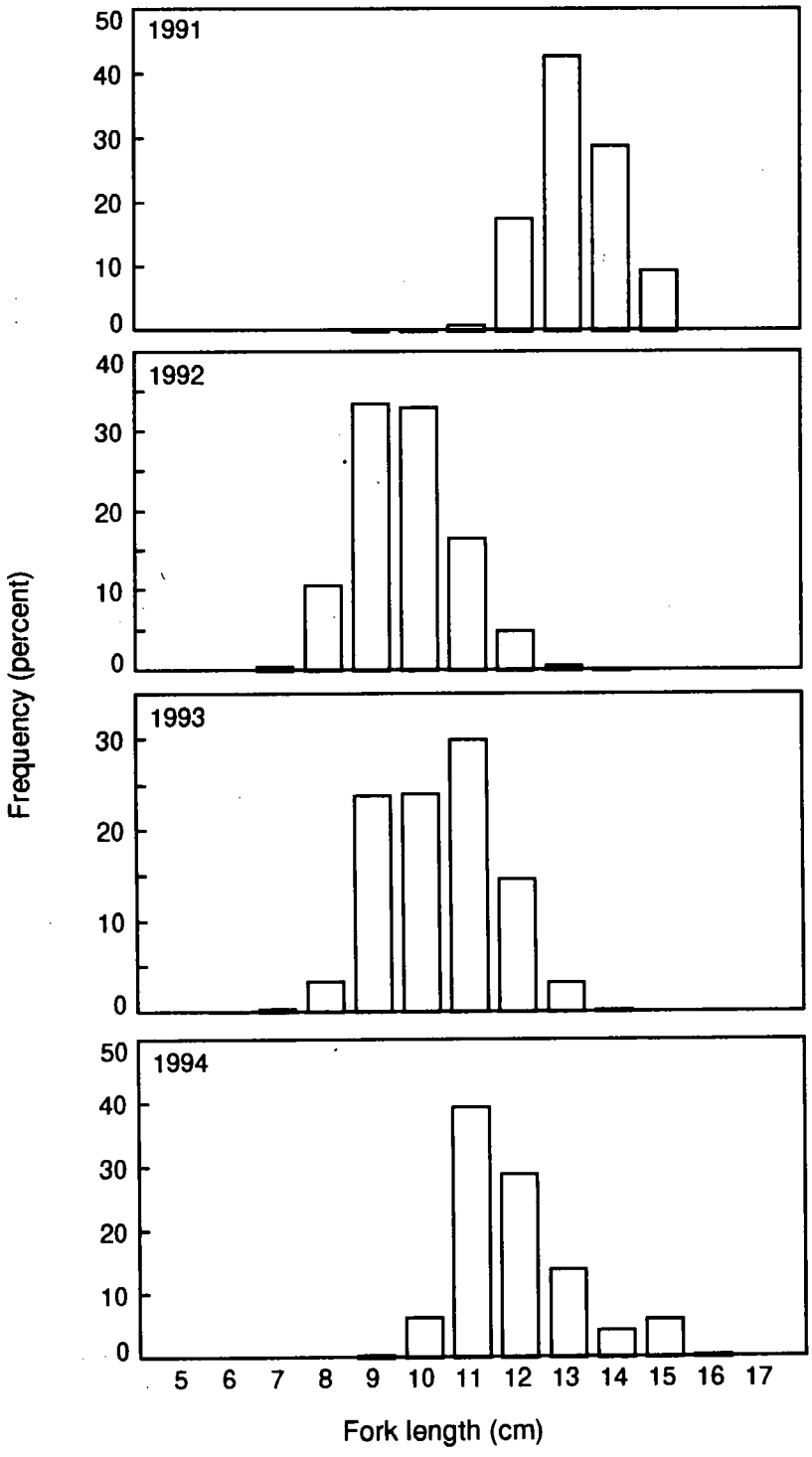


Figure 16. Length frequency distribution of young-of-the-year striped bass captured in the autumn smelt fisheries of the Miramichi estuary, 1990 to 1994.