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Status of Striped Bass (*Morone saxatilis*) in the Gulf of St. Lawrence in 1996 and Revised Estimates of Spawner Abundance for 1994 and 1995

by

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ABSTRACT / RÉSUMÉ

Spawner abundance for 1996 was estimated to be 8,090 fish (5,097 female; 2,993 males). This represents a precipitous decline from a year earlier when spawners were estimated to be 50,000 fish. Removals of adults through unregulated, direct commercial fishing activities between May 1995 and March, 1996 were estimated to be about 30,000 fish. The 1991 year-class remains the largest single component of the spawning population, a consequence of a poorer than expected contribution to spawning by the 1992 year-class and a year-class failure in 1993. The decline in female abundance is expected to continue into 1997. Female spawners (63%) outnumbered male spawners (37%) for the first time since sampling was initiated in 1993, but a re-distribution of the sex ratio is expected in 1997 upon the recruitment of age 3 males from the 1994 year-class. The juvenile abundance index obtained by sampling of the bycatch in the autumn smelt fishery was the highest observed since monitoring of this fishery was initiated in 1991. However, the average body size of the year-class is small and the prospects for winter survival are probably poor. Production of Miramichi striped bass is likely to remain heavily dependent on the spawners of the 1991 year-class through to 1998 or 1999. Spawning site fidelity continues to be 100% for Miramichi striped bass. Estimates of spawner abundance are now revised to 29,000 fish in 1994 and 50,000 fish in 1995. These estimates replace those reported in earlier assessment documents.

Le nombre de géniteurs de bar rayé en 1996 a été estimé à environ 8 090 poissons (5 097 femelles, 2 993 mâles). Ce niveau représente une chute précipiteuse du 50 000 poissons estimés l'année précédente. Les pêches commerciales non-limitées visant le bar rayé depuis mai 1955 à mars 1996 ont prélevé envrion 30 000 poissons. La cohorte de 1991 était toujours dominante en conséquence d'un recrutement plus faible que prévu de la cohorte de 1992 et une presque faillite de la cohorte de 1993. Une diminution additionelle d'abondance de femelles est prévue pour 1997. Les femelles composaient 63% des géniteurs en 1996. C'est la première fois que les femelles étaient plus abondantes que les mâles depuis le début des recherches en 1993, mais le ratio devrait s'équilibrer en 1997 avec le recrutement des mâles agés de trois ans (chohorte de 1994). L'indice d'abondance des juvéniles provenant des captures dans les filets d'éperlan de la pêche d'automne était le plus élevé depuis le début de la série en 1991. Cependant, les juvéniles étaient de petite taille et leur taux de survie durant l'hiver est prévu être faible. La production ultérieure du bar rayéde la Miramichi va dépendre principalement de la cohorte de 1991 jusqu'au moins 1998 ou même 1999. Les géniteurs de la Miramichi démontre une fidèlité parfaite à leur site de frai. Les estimations de l'abondance de géniteurs pour 1994 et 1995 ont été révisées à 29 000 poissons et 50 000 poissons, respectivement. Ces nouvelles estimations remplacent celles présentées antérieurement.

INTRODUCTION

The southern Gulf of St. Lawrence (Fig.1) is currently the principle area of wild striped bass (*Morone saxatilis*) production in New Brunswick (Bradford et al. 1995a,b; Anon. 1996). Gulf striped bass are genetically distinct from Bay of Fundy fish (Wirgin et al. 1993) and are considered to comprise a single biological unit (Bradford and Chaput 1996). Southern Gulf of St. Lawrence striped bass, which spawn predominantly in the Northwest Miramichi River estuary, are also highly migratory (Bradford and Chaput 1996; Hogans and Melvin 1984). The known summer range of Miramichi spawning fish extends from Percé, Québec to Margaree River, Nova Scotia (Bradford and Chaput 1996).

The 1996 assessment represents the first census of spawner abundance since the permanent closure of the commercial fishery in March, 1996. As such, current levels of spawner abundance will provide the basis for monitoring the response of this population to conservation management and the development of the recreational fishery. Since 1990, southern Gulf of St. Lawrence striped bass have been categorized as either reduced or declining (Chaput and Randall 1990). In 1993, a mark-recapture experiment estimated spawner abundance to be about 5,500 fish. Signs of recovery were evident in 1994 with recruitment of the 1991 year-class. Resumption of harvesting as bycatch in commercial fisheries in July 1994 reduced spawner abundance below the level of returns that were anticipated for 1995 (Bradford and Chaput 1996). However, high abundance of young-of-the-year bass in the fall open-water smelt fishery of the inner Miramichi Bay supported the view of a greater overall egg production in the Miramichi in 1995 relative to the two previous years.

Further reductions in spawner abundance were anticipated for 1996 given that commercial fishing targeted spawners during 1995 and into the first quarter of 1996 (Bradford and Chaput 1996).

Forecasts for 1996 included:
1) spawning potential for the Northwest Miramichi was to remain above the 1993 level,
2) poor recruitment from the 1993 year-class, and
3) possible extension of the known geographic range of migrant Miramichi striped bass.

In this assessment we report on the accuracy of the above forecasts. We also suggest suitable sampling protocols for estimating spawner abundance in the Northwest Miramichi and update the data base regarding stock structure, spawner abundance and spawner success. The estimates of spawner abundance for 1994 and 1995 are revised based on the results of the 1996 experimental design. The previously calculated estimates of spawner abundance for 1994 and 1995 were not stable over the duration of the experiment (declined; Bradford and Chaput 1996) which introduced uncertainty into the assessment of stock status. Spawner abundance was estimated to be 40 to 60 thousand fish in both 1994 and 1995 but in neither case was a converged estimate obtained at the end of the mark-recapture experiment (Bradford et al. 1995a; Bradford and Chaput 1996).

The study area during 1993 to 1996 was the Miramichi River estuary (Fig.1) which remains the principle site of spawning for striped bass within the southern Gulf (Bradford and Chaput 1996) and which is 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) and has continued through to November, 1996. A summary of the science workshop held on December 9, 1996 to gather additional information from user groups and other government agencies regarding striped bass from the southern Gulf is presented in Appendix 1.

DESCRIPTION OF FISHERIES

Commercial

Commercial fisheries for striped bass were permanently closed in March 1996 through an amendment of the Canada Fisheries Act. The sale of wild-caught striped bass is no longer permitted. Commercial fishers are required to release all striped bass that are intercepted in commercial fishing gear that targets other species (i.e., a bycatch). An exception (through condition of license) has been made for gaspereau and smelt fisheries where a bycatch tolerance for fish <35 cm total length (TL) is in effect. The bycatch tolerance in these fisheries recognizes the difficulty of sorting bass less than 35 cm TL from large quantities of similar-sized fish.

Season: None
Harvest: None
Size Restriction: Striped bass <35cm TL captured in gaspereau and smelt fishing gear may be retained but not sold.

The final summary of the commercial harvest, by statistical district and by month for the years 1917 to 1995, was presented by Bradford and Chaput (1996).

Recreational

Recreational angling data are not collected on a regular basis. There is no new information to report beyond that summarized in Bradford et al. (1995a) and Bradford and Chaput (1996). Recreational fisheries regulations as of May 1996 were as follows:

Season: 1 May to 31 October
Bag Limit: hook and release only
Size Restriction: no fish may be kept

First Nation Fisheries

First Nations harvest striped bass for food, social and ceremonial purposes. Harvest levels are based on communal needs. Prior to 1996, harvests were restricted to striped bass larger than 68cm TL. However, size restrictions have proven to be impractical because gillnets, a common food fishing gear, also intercept smaller sized bass which could not always be released alive. Therefore, the size restrictions were lifted for 1996 and the harvest managed on the basis of total catch.

Season: July 1 - October 31
Harvest: based on communal needs of individual first nations
Size Restriction: none

CONSERVATION REQUIREMENTS

Data compiled on southern Gulf striped bass since 1993 indicate that production of viable year-classes depends upon spawner abundance above a minimum threshold (see Management Considerations below). However, there are insufficient data to determine the precise relationship (if any) between spawner abundance and recruitment. Protection of both spawners and potential spawners is the interim target specified in the 1993 New Brunswick Striped Bass Management Plan (Dept. of Fisheries and Oceans 1993), of which the major elements are:

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

The goal of the management plan is to increase spawning escapement through reductions in fishing-induced mortality of adult and juvenile fish in commercial, recreational and aboriginal food fisheries.

FISHERY DATA

Commercial fisheries for striped bass in the Maritimes are closed. Virtually all data pertaining to the bycatch of striped bass in gaspereau and smelt fisheries is obtained by direct sampling of the catch.

Bycatch Fisheries in the Miramichi River Estuary

Direct sampling of striped bass catches in the gaspereau and smelt fisheries of the Miramichi River estuary has occurred every year since 1991. Sampling protocols have been described previously (Bradford et al 1995a,b; Bradford and Chaput 1996). Changes in 1996 to the sampling protocols are summarized below in the section "Estimation of Stock Parameters". There was no direct sampling of the eel fishery in 1996. Sampling of the smelt fisheries is described in the section "Spawner Success".

ESTIMATION OF STOCK PARAMETERS

1996 Spawner Abundance

Mark-Recapture

The 1996 estimate of spawner abundance was obtained by separating the marking and recapture sites both in time and in location. Logbook data returned by gaspereau fishers in previous years (Bradford et al. 1995a) indicated that adult striped bass were available for capture in the Napan River one to two weeks before their arrival on the spawning grounds in the Northwest Miramichi. Therefore, a tagging operation was initiated in the Napan River (Fig. 1) prior to the opening of the gaspereau fishery. Early marking was expected to provide precise, stable-with-time estimates of spawner abundance.

Recaptures in the Northwest Miramichi of fish tagged in Napan River would be possible from the day of arrival of fish in the Northwest Miramichi River. There would also be less need to tag continuously through the season in order to secure a sufficient pool of marked fish.

Two gaspereau fishers were contracted to operate three traps set on the Napan River between May 15 and May 25 (before the June 1 opening date for gaspereau fishing on this river). The trapnets, which operated continuously over this time period, were fished every 48h. The total catch of striped bass was counted, measured to length (fork length, (FL) and total length, (TL) to the nearest 0.1cm) and scale sampled for later aging. Fish ≥35 cm TL were tagged with individually numbered, yellow T-bar tags (length 3.2 cm) inserted between the first two spines of the anterior dorsal fin, and then released. Recaptured fish carrying current year tags were noted and released. Fish carrying tags applied in previous years were noted and added to the marked pool for 1996.

The recapture phase of the experiment began with the first day of commercial gaspereau fishing on the Northwest Miramichi River (20 May) with traps located on this river used as recapture sites for tags applied to striped bass in the Napan River. Two to six gaspereau traps were visited daily during the fishing season (May 20 to June 19). A total of 13 traps are fished within this section of the river, but not all are necessarily fished every day. Therefore, the total number of traps operated on any given day of sampling was also recorded. The total catch of striped bass was counted, measured to length and scale sampled for later aging. Marked fish recaptured when the sampler was present were released after first recording the tag number and date of capture. Fishers whose traps were not sampled kept recaptured tags separated for each day fished. For the purposes of the mark-recapture experiment these tags were subtracted from the total pool of tags available for recapture in subsequent days.

A Bayesian estimator (Gazey and Staley 1986) was used to calculate total returns of striped bass ≥35 cm TL, both sequentially for each day of fishing and as a single census estimate for the season. The most probable population size given R recaptures out of M marks placed in a sampled catch of C was calculated over a range of possible population sizes. The 1996 mark-recapture experiment differs from those in previous years in that only tags applied to striped bass captured in the Napan River between May 15 and 25, before the gaspereau fishery started in the Northwest Miramichi, were used. Tag loss was assumed to be negligible. The reporting rate for recaptures from the gaspereau fishery was assumed to be 100% (daily contact with fishers in the Northwest Miramichi). Estimates of marked fish available per day were corrected for removals reported from the previous day of fishing.

The day for termination of the recapture phase of the experiment was defined on the basis of change with time in 1) the catch rate, 2) the reproductive state of intercepted fish, and 3) the cumulative recapture profiles on the Northwest Miramichi (Fig. 1) of striped bass tagged in Napan River. Inspection of the cumulative recapture profiles suggested that spawning fish were in the Northwest Miramichi up to June 10 but left the area after that time (Fig. 2). Direct observations of spent females indicated that a major spawning event occurred between June 1 and 3. Declines in the catch-per-unit-effort (CPUE) from the gaspereau traps after June 10 provide additional evidence of a movement of bass out of the Northwest Miramichi (Table 1; Fig. 3). A 53 cm striped bass, suspected to be a female, tagged on May 31, 1996 was recovered in the estuary of the Grand Cascapedia in Chaleur Bay on June 23, 1996 (Fig. 1) (G. Landry, Québec MEF pers. comm.). Prior to June 11, the exploitation rate in the gaspereau traps of the Northwest Miramichi was estimated at 0.8% per day, with the total cumulative exploitation rate of 15% over the duration of the gaspereau fishery. These values are not unlike those estimated for 1994 and 1995 (Fig. 2).

Revisions to estimates of spawner abundance for 1994 and 1995

The sampling protocols established for 1996 were based on the expectation that stable sequential Bayesian estimates of spawner abundance could be obtained by utilizing a single pool of fish marked early in the spawning run which could then be followed through to spawning. Population estimates in previous years had relied on continuous marking of fish throughout the experiment. Therefore spawner abundance for both 1994 and 1995 has been re-estimated following similar protocols to 1996.

<u>1994</u>

In 1994, 529 striped bass were tagged on May 24 and 26 (Fig. 2). Some of these fish were recovered downstream from the Northwest Miramichi soon after tagging but a large proportion were recovered in the Northwest Miramichi from June 2 to the end of the season on June 18. The cumulative recapture profiles for these two tagging groups were similar and provided daily exploitation rate estimates of 0.9% and 1.1% in the Northwest Miramichi. Directly sampled recaptures from these tagging groups were more infrequent after about June 12. For this reason, the mark and recapture experiment encompassed the period June 1 to June 12. We considered the initial marked population (M) for this experiment to be 485 fish (after adjusting for removals in downstream fisheries). Only directly observed recaptures (R) and directly sampled catch (C) for successive fishing days starting June 1 were used. Marks available for each day of sampling were corrected for total removals (observed and reported) from the previous days fishing.

A single census estimate of spawner abundance was obtained by pooling both the observed catch (n = 1806) and observed recaptures (n = 28) for the June 1 to 12 time period. The number of marks available for recapture was reduced to 430 from 485 to account for removals reported by other fishers.

<u>1995</u>

Revised 1995 estimates were obtained in a similar fashion to 1994. Marks from the May 24 to 28 tagging groups were pooled (M = 289). The cumulative recapture profile of the May 28 group (the largest with 252 fish tagged) indicated that the interception rate in the Northwest Miramichi gaspereau fishery was constant at 1.2% per day from May 30 to June 9 with fewer fish recaptured after that date (Fig. 2). We concluded that after June 9, bass left the Northwest Miramichi. This conclusion was supported by the field observation that spent fish became the dominant component of the catch after June 9. The catch rates declined after that date (Fig. 3). The sequential Bayesian population estimate was obtained from catch and recapture data for the June 1 to 9 period. Inputs for the single census estimate were M = 275 (obtained as for 1994 above), C = 1049, and R = 6.

<u>Indices of Abundance - CPUE</u>

Stratified mean catch of striped bass (fish•trap^{-1}•day^{-1}) was calculated following Cochran (1977) and as detailed in Bradford and Chaput (1996). These data provide an index of year-to-year change in average catch for the duration of the gaspereau fishery in the Northwest Miramichi; i.e., the catch of mature, spawning and spent fish and therefore is not necessarily a precise measure of spawner abundance. Geometric mean CPUE and median CPUE for 1993 to 1996 were also calculated as additional indicators of change in abundance among years.

Bycatch of striped bass, by either size or age group, in the gaspereau and open-water smelt fisheries was standardized to catch per effort units of number of fish•net^{-1}•24h^{-1}. For summary purposes, the bycatch data for all years were separated into juvenile and adult components. All fish were assigned an arbitrary birth date of 1 January. With this convention, all fish showing 2 annuli or less on the scales and sampled before 15 May were considered to be juveniles. All fish with more than two annuli and sampled before 15 May are considered adults. The minimum observed age at first maturity has been two years, but greater than 99% of all mature fish have been three years of age or older (Bradford et al. 1995a).

Spawner Success

In 1996, smelt fishers operating in the vicinity of Loggieville (Fig. 1) were visited twice weekly between 15 October and 26 November. During each visit striped bass were sorted from two smelt nets, usually a shallow set (depth <5m) and a deep set (depth >5m). Generally, one crate of catch (about 58 kg all species) was sampled from each net. The total number of bass in the net was obtained by scaling the number of bass from the sampled crate to the total number of crates of catch from the net. Striped bass less than 18cm FL were considered to be young-of-the-year (age-0) and their count was used to estimate spawner success in 1996.

Juvenile Mortality

Studies on smallmouth bass (*Micropterus dolomieui;* Shuter et al. 1980, Shuter and Post 1990), yellow perch (*Perca flavescens*; Shuter and Post 1990) and white perch (*Morone americana*; Johnson and Evans 1990) have shown that survival during the first winter is size dependent. Large fish can withstand winter starvation more successfully than small fish because the ratio of energy stored to metabolic rate increases with body size (Shuter et al. 1980). This may also be the case for Miramichi striped bass, which are subject to both a short growing season (June to September) and a much longer winter season (October to April).

The relationship between size going into the first winter and size of survivors was examined by comparing the observed pre-winter body length frequency distribution with the back-calculated age-1 length frequency distribution of survivors of the same year-class at age-2. The lengths at age-1 were obtained by back-calculation using the scale proportion hypothesis detailed in Francis (1990). This method had been previously used to calculate size-at-age of striped bass from the Miramichi (Chaput and Robichaud 1995). Briefly, annuli recorded in body scales are used to estimate (back-calculate) their corresponding length at that age based on the distance from the focus to the annulus relative to the length and scale radius of the fish at the time (age) of sampling. All age-2 fish used in the analysis were collected either during late May or early June, before somatic growth occurred for the year of sampling; i.e. no 'plus' growth. Comparisons of the observed pre-winter lengths and the estimated length at age-1 of the survivors were used to estimate the change in body size composition of the 1991, 1992 and 1993 year-classes (Bernier 1996).

Coastal Migrations

Bass captured in DFO index traps and native food fishery traps in the Northwest and Southwest Miramichi rivers were examined for tags. Some bass were also tagged prior to release using similar tags and methods described in the previous section. Striped bass sampled as a bycatch from the Richibucto and Bouctouche gaspereau fisheries (May-June) were also examined for tags. 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 were summarized for the years 1991 to 1995 by Bradford and Chaput (1996). Recapture histories for bass tagged prior to 1991 in Kouchibouguac National Park were summarized by Bradford et al. (1995b).

ASSESSMENT RESULTS

Spawner Abundance Estimates

1996

Based on the sequential Bayesian estimates of population size, the 1996 spawner abundance in the Northwest Miramichi was initially about 2,500 fish on May 29 and increased to a stable level of between 5,000 and 8,000 fish during the remainder of the experiment (Fig. 4). These estimates are consistent with the observed changes in CPUE, which increased from 3.8 on May 29 to 22.2 on May 31 (Table 1; Fig. 3). The CPUE varied between 9.2 and 16.3 from June 3 to 10 (Table 1). The decline in CPUE from 22.2 on May 31 to 5.0 on June 1 followed by an increased CPUE of 12.7 on June 3 is of considerable interest. During this time (May 31 to June 3), the reproductive state of the females progressed from mature to ripe and running to spent (R.G. Bradford personal observation). Furthermore, it was during this period of time that angler success declined at Strawberry Marsh (near the confluence of the Northwest and Southwest Miramichi rivers) and increased in the vicinity of the mouth of the Northwest Millstream, a tributary of the Northwest Miramichi several kilometres upstream from the gaspereau trapnets (Mr. Brian Donovan, Miramichi, N.B. personal communication). Collectively these data indicated that in 1996 the gaspereau traps intercepted adult striped bass as they ascended the estuary to spawn and then intercepted spent fish on their downstream migration. If this was the case then the data indicated that the population estimates obtained during the fishes ascent and descent of the river are comparable.

The final sequential estimate of 8,090 fish obtained on 10 June, was identical to the estimate of 8,050 fish calculated using the single census method (Table 2;Fig. 4).

1994

The revised estimates for 1994 were 27,775 and 29,000 fish using the single and sequential estimation procedures, respectively (Table 2; Fig. 4). These values were less than the 40 to 60 thousand fish reported previously by Bradford et al. (1995a). The revised estimates are not necessarily an improvement on previous efforts since the sequential estimates continued to decline over the duration of the experiment (Fig. 4). Furthermore, the low revised estimates were inconsistent with the fact that the catch rates (stratified mean catch, median and geometric mean CPUE) in 1994 were the highest during 1993 to 1996 (Table 3; Fig. 3). The higher catch rates in 1994 relative to the estimated spawner abundance cannot be explained on the basis of an extended residence time and a correspondingly higher incidence of recapture of previously released fish (1994 was one year in which all bass >38 cm TL were released by commercial fishers).

1995

The revised 1995 sequential estimates, in contrast to the 1994 estimates, were stable with time and converged on 50,000 fish by the end of the experiment on June 9 (Fig. 4). This compared favourably with the single census population estimate of 47,800 fish (Table 2; Fig. 4). This estimate represents an improvement, in both reliability and precision, over the previous 1995 estimate of 40 to 60 thousand fish. which was the most likely abundance estimate which could be drawn from a suite of estimates which ranged from about 100 thousand fish at the onset of sampling to 38 thousand fish at the end of sampling on 19 June (Bradford and Chaput 1996).

Trends in Spawner Abundance

Spawner abundance for 1996 was estimated at just over 8,000 fish (Table 2). This represents a precipitous decline from 1995 levels of 50,000 fish. The estimated decline in spawner abundance between 1995 and 1996 was corroborated by the observed declines in catch rates which fell from 36.83 fish•trap^{-1}•day^{-1} to 8.85 (stratified mean catch) (Table 3; Fig. 3).

The male and female constituents of the spawning population in 1996 were estimated to be 2,993 and 5,097 fish, respectively (Table 3). Identifiable males (ripe and running) comprised 37% of the sampled catch between 24 May and 10 June. We assumed that all other fish ≥35cm FL were females.

Unregulated and directed commercial fishing prior to March 1996 appears to have been the principle contributing factor to the reduction of spawner abundance during 1995 to 1996. Landings within the Miramichi system alone during 1995 were estimated at about12,300 fish (Table 3). A further 18,800 (17.3 t at 0.92kg per fish; Bradford and Chaput 1996) were reported as landed and sold in districts other than those of the Miramichi River (Bradford and Chaput 1996). Total removals of spawners between May 1995 and May 1996 in the southern Gulf of St. Lawrence were therefore, in excess of 30,000 fish, or more than half the 1995 spawning stock. Striped bass of Gulf origin were readily available in local fish markets during the summer and autumn of 1995 and the winter of 1995/1996 (Mr. Fred Wheaton, New Brunswick Wildlife Federation, personal communication).

Year-Class Composition and Sex Ratio

The 1996 spawning population was again dominated by the 1991 year-class (Fig. 5; length range 45-60cm) as has been the case since 1994. The contribution of the 1992 year-class was lower than anticipated given that:

1) in 1995, age 3 male fish of this year-class were well represented in the spawner population (Fig. 5), and

2) recruitment of 4 year old females was anticipated in 1996.

The 1993 year class, as forecast in the 1995 assessment, was virtually absent from the gaspereau catches (Fig. 5). The lack of recruiting male striped bass partially accounted for the complete reversal of the sex ratio from 1995 when males comprised 63% of the sampled catch to the 63% female composition in 1996 (Table 3). Removals of male spawners both at age 3 (in 1994 about 513 fish were removed) and age 4 (in 1995 about 6,000 fish were removed based on 63% of the 9,576 total bass removed) was also a contributing factor to the decline of male spawners relative to female spawners (Table 3).

Spawner Success

Indices of juvenile abundance reported here differ from those reported in previous assessments, because only the data obtained from the fishery in the Loggieville sector of the river are reported. Abundance estimates reported in previous years also included samples from upstream sites (Chatham area), but these were not sampled in 1996. Median CPUE is used as opposed to the arithmetic mean CPUE reported in previous documents because there are fewer samples available from Loggieville than for the fall fishery as a whole.

The median CPUE of young-of-the-year (age-0+) striped bass in the 1996 open-water smelt fishery of the Miramichi was 452 fish, the highest recorded since sampling of the fishery was initiated in 1991(Table 4; Fig. 6). The CPUE of age-0 bass was high in both 1995 and 1996 and more than ten times those observed for 1992 to 1994 (Fig. 6). The high abundance of age-0 bass in 1995 and 1996 was consistent with the increased abundance of female bass in the spawning population of the Northwest Miramichi (Table 3).

Juvenile Mortality

Striped bass which enter their first winter at a fork length ≤10cm are less likely to survive the winter than those which are > 10cm (Fig. 7) (Bernier 1996). The variability among years in the average pre-winter lengths of young bass combined with differences in spawner success will profoundly affect the recruitment to the spawning population. For example, the 1991 year-class which currently supports most of the egg production on the Miramichi was large bodied entering their first winter (13 cm on average) (Fig. 8). In 1993 the young-of-the-year were smaller on average (10 cm on average) and survivorship was only about 50% (Bernier 1996). This year-class will fail to contribute in any substantive way to spawner production for this population; i.e., a year-class failure has occurred.

Similarly, the lower than anticipated recruitment of the 1992 year-class in 1996 (see Year-Class Composition and Sex Ratio above) can be attributed in part to relatively poor spawner success (Table 4), poor Age 0+ growth (Fig. 8) and subsequent poor first-winter survival (Fig. 7).

Stock Structure

Few recaptures were reported for locations outside of the Miramichi estuary in 1996. This was probably a consequence of the migratory population being numerically reduced relative to previous years, as well as tag loss. Based on tag recoveries in 1996, the spawning site fidelity of Miramichi striped bass was estimated at 100%, for the third consecutive year.

Sources of Uncertainty

The selection of the day for termination of the mark-recapture experiment depends upon the cumulative recapture profiles and observations of spawning state of striped bass during the gaspereau fishery. The sampling protocols adopted for 1996 made estimates of population size possible from the first day of sampling and this clearly benefitted the experiment when comparisons are drawn with the results obtained in previous years. The good coherence between the sequential estimates and the traits of the sampled catch (CPUE, maturity, sex ratio etc.) provided additional support for terminating the experiment on June 10 in 1996. Further improvements to the methodology may be realized by including a rate-of-change factor into the decision process for termination of the experiment.

ECOLOGICAL CONSIDERATIONS

Conservation Requirements

The improved estimates of spawner abundance for the years 1993 to 1996 provide a basis for an initial examination of the spawning requirements for the Miramichi River stock. Estimates of female abundance are sequentially 330, 2320, 18500, and 5097 fish for the years 1993 to 1996 (Table 3). The corresponding indices of spawner success (median CPUE of age-0 striped bass in the fall smelt fishery) were 17, 7, 255, and 452 (Table 4). The trends do not correspond well except that several thousand females appear to be required to produce high abundance of age-0 bass. The decline in female abundance between 1995 and 1996 is inconsistent with the 177% increase in juvenile production for 1996. This discrepancy cannot be satisfactorily explained by higher absolute fecundities (eggs per female) of females in 1996. Fecundity data reported by Hogans and Melvin (1984) indicate that fecundity of a 44 cm bass (median size at age 4; 1995, Fig. 5) was about 53,000 eggs and for a 52.5 cm fish (median size at age 5 in 1996, Fig. 5) was about 126,000 eggs, 238% higher. Factoring these values into the spawner estimates for 1995 and 1996 indicates that egg production in 1995 would have been 50% higher than in 1996. After accounting for possible removals of female bass before spawning in 1995 (total female removals = 9576 bass X 37% female = 3543 females), the egg production in 1995 would still have been 14% higher than in 1996. The fecundity estimates may be inadequate as they were obtained from only 8 fish. More comprehensive fecundity data are required.

Possible environmental effects on egg/larval survival could well have contributed to inter-year variability in juvenile abundance. Nonetheless, there are obvious benefits accrued to the population when female spawner abundances are higher than the 1993 level (330 females). The age-0 index, the age-2 index (Table 4), and the low abundance of mature age-3 males in the 1996 spawner population (Fig. 5) indicate a year-class failure in 1993. This situation has probably been exacerbated by a low average pre-winter body size (Fig. 8) and consequently, poor winter survival (Fig. 7). The several fold increase in median age 0^{+} CPUE in 1995 and 1996 over previous years indicates that this population benefits when spawning females number more than 5000 fish.

Interpretation of Revised Estimates

The use of marks applied early in the spawning season improved the estimates for 1995 and 1996 but not 1994. This difference for 1994 may have been a consequence of differences in spawning stock composition (1994; 92% male; 1995, 63% male, 1996, 37% male). Abundance estimates of spawners on spawning grounds obtained using mark-recapture experiments may be sensitive to spawning-associated behaviour, for example, the likelihood that individual fish will locate a spawning partner. This may be the basis for the lower-than-anticipated contribution of the 1992 year-class to spawning in 1996. Age 3 males dominated the catch in 1995 after spawning (June 9) was observed to have occurred (R.G. Bradford personal observation), and thereby may have been over-represented in the sampling relative to their actual contribution to spawning.

The validity of the 1994 estimate may be uncertain but we were able to obtain a robust estimate of spawner abundance for a year (1995) which coincides with the recruitment of both sexes from the dominant year-class (1991) to the spawning population. This provides a basis for monitoring the survival of the year-class which will sustain egg production for the next year and possibly two years. Changes in abundance of males and females, separately, can also be examined and this offers a basis for deriving conservation spawning requirements for this resource.

FORECAST/PROSPECTS

The 1990 categorization (Chaput and Randall 1990) of the stock as reduced or declining remains appropriate. There are no indications that females of the 1992 and 1993 year-classes will contribute substantively to the spawning in 1997 and therefore, egg production will continue to depend on spawners of the 1991 year-class. There are estimated to be less than 10,000 fish of the 1991 year-class, of which fewer than 6,000 are females. A forecast of possible egg production in 1997 is not possible because of the absence of reliable fecundity data for northern striped bass.

Female abundance is likely to decline further in 1997 as a consequence of pressures exerted on the population since the end of the census in June, 1996. Mortality can be expected to have occurred as a consequence of natural factors, illegal harvest, removals in native food fisheries as well as the hook and release angling fishery. However, a re-balancing of the sex ratio of spawners is anticipated for 1997 through recruitment of age-3 males (1994 year-class).

The 1995 recommendation (Bradford and Chaput 1996) that a future change in the status of southern Gulf striped bass be based on increases in both spawner abundance and spawner success remains valid. However, and as shown in this document, spawner success may not directly translate into recruitment to the spawning stock. First winter survival is an important determining factor of year-class strength and also needs to be integrated into the assessment of stock status.

The prospects for a recovery of this resource in the short term are poor. A spawning population of at least 50,000 fish (i.e., the maximum observed to date) in which both males and females are well represented is unlikely either in 1997 or 1998. The abundance estimate for the apparently strong 1995 year-class which will be obtained from the spring 1997 Northwest Miramichi gaspereau fishery (at age

2^{+}) should provide an indication of whether or not recovery of this population in 1999-2000 remains a realistic expectation.

MANAGEMENT CONSIDERATIONS

The abundance of female spawners is at risk of a continued decline through to May 1998. Measures to deter illegal harvests and to further reduce and eliminate fisheries induced mortality are to be encouraged. Conscientious angling practices (hook and release techniques) should be promoted throughout the southern Gulf of St. Lawrence. Current status of stocks information should be communicated to all parties (First Nations, commercial fishers, recreational anglers) for improved collaboration towards effective conservation measures.

RESEARCH RECOMMENDATIONS FOR 1997

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

Objectives:
1) establish baseline spawner abundance for regulation and development of recreational fishery and for development of conservation requirements,
2) confirm the hypothesis of a year-class failure in 1992 and 1993,
3) estimate the abundance of the female component of the spawning population, and
4) extend migration/stock structure studies to 1997.

Sample Miramichi Smelt Bycatch: October-December, 1997
Objectives:
1) assess striped bass spawning success in the Miramichi in 1997 given the expectation that female abundance has declined since June 1996 and
2) assess the relationship between pre-winter abundance, pre-winter body size and post-winter survival.

Size-dependent Winter Survival
Objectives:
1) Extend the back-calculation analysis to the 1994 to 1996 year-classes to confirm the observed relationship for the 1991 to 1993

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 Eel Ground First Nation is greatly appreciated. Reneé Bernier, Scott Douglas, John Hayward, and Dave Moore, provided greatly needed assistance in the field. Peter Cronin (NB Dept. of Natural Resources and Energy) and Brian Jessop (DFO Science) provided critical review of this document.

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Table 1. Summary of the catch per individual trap per 24h and the mean ± 1 standard deviation (SD catch of striped bass for each day that the 1996 gaspereau fishery on the Northwest Miramichi River wa sampled for bycatch.

Date	Traps Fished	Traps Sampled	Catch per Trap per 24h 1	2	3	4	5	6	Mean	SD
24-May-96	2	2	1.3	0.8					1.0	0.3
29-May-96	4	4	6.0	2.0	5.0	2.0			3.8	1.8
31-May-96	11	5	11.5	6.5	14.0	57.0	22.0		22.2	18.1
01-Jun-96	13	4	7.0	5.0	6.0	2.0			5.0	1.9
03-Jun-96	13	3	4.0	14.0	20.0				12.7	6.6
05-Jun-96	13	5	11.0	18.0	11.5	29.0	9.0		15.7	7.3
06-Jun-96	13	6	13.0	16.0	27.0	8.0	12.0	9.0	14.2	6.3
09-Jun-96	13	4	8.0	3.0	34.0	20.0			16.3	12.0
10-Jun-96	13	5	4.0	5.0	14.0	12.0	11.0		9.2	4.0
11-Jun-96	13	3	3.0	6.0	16.0				8.3	5.6
12-Jun-96	13	4	2.0	3.0	25.0	6.0			9.0	9.4
13-Jun-96	13	3	2.0	14.0	7.0				7.7	4.9
14-Jun-96	13	6	0.0	6.0	6.0	7.0	5.0	1.0	4.2	2.7
15-Jun-96	13	3	8.0	8.0	3.0				6.3	2.4
16-Jun-96	13	3	3.0	6.0	0.0				3.0	2.4
17-Jun-96	13	3	7.0	5.0	5.0				5.7	0.9
18-Jun-96	13	5	1.0	5.0	4.0	6.0	1.0		3.4	2.1
19-Jun-96	13	4	1.0	7.0	0.0	7.0			3.8	3.3

Table 2. Summary of sequential and single census spawner population size in 1996, and revised spawner abundances for 1994 and 1995. The mode and 95% confidence intervals are also shown.

				Number of Spawners		
Year	**Duration**	**Model**	**Marks**	**Mode**	**95% Confidence Interval**	
1994	1 June - 12 June	Single	430	27,775	21,475	40,550
		Sequential	485	29,000	23,000	47,000
1995	1 June - 9 June	Single	275	47,800	31,000	138,100
		Sequential	289	50,000	35,000	175,000
1996	29 May - 10 June	Single	417	8,050	6,150	12,000
		Sequential	452	8,090	6,275	13,370

Table 3. Summary of catch statistics and spawner abundance for 1993 to 1996.

Year	1993	1994	1995	1996
CATCH DATA				
Stratum (Days)	16	19	20	18
Traps per Stratum	13	13	13	13
Traps Sampled	46	50	64	72
Total Trap Days	208	247	260	212
Stratified Mean Catch/Trap/Day	3.6	68.7	36.8	8.9
Standard Deviation	0.25	17.44	5.01	0.64
POPULATION ESTIMATES (BAYESIAN)	**1993**	**1994**	**1995**	**1996**
All Spawners				
Iterations	1	7	6	6
Estimated Number of Spawners (mode)	5,500	29,000	50,000	8,090
0.025 quantile	4,550	23,000	35,000	6,275
0.975 quantile	7,300	47,000	175,000	13,370
By Sex				
Proportion (Mature Males)	0.94	0.92	0.63	0.37
Mature Males	5,170	26,680	31,500	2,993
Mature Females (maximum)	330	2,320	18,500	5,097
INTERCEPTION / EXPLOITATION	**1993**	**1994**	**1995**	**1996**
Northwest Miramichi				
Number of Intercepted Spawners	745	16,966	9,576	1,876
Standard Deviation	52	4,308	1,303	136
Number of Spawners Removed (n)	51	4513	9576	19
Biomass of Spawners Removed (t)	<0.1	1.8	8.8	<0.1
other than Northwest Miramichi				
Number of Spawners Removed (n)	65	5,808	12,324	24
Biomass of Spawners Removed (t)	<0.1	2.3	11.3	<0.1

Table 4. Summary of abundance indices expressed as the catch of fish per net per day of fishing effort (median, 5th to 95th percentiles) by age class for striped bass from the Miramichi River estuary. Age-0 and age-1 bass adundance estimates are from sampling the bycatch in the October to November open water smelt fishery. The age-2 and spawners abundance estimates are from sampling the bycatch in the May and June gaspereau fishery of the Northwest Miramichi. NS means not sampled.

	Median	5th ; 95th percentiles	Median	5th ; 95th percentiles	Sample size
Abundance indices from the open-water smelt fishery (downstream traps only)					
	Age-0		Age-1		
1991	18	[15 ; 227]	0	[0 ; 3]	3
1992	50	[0 ; 191]	0	[0 ; 0]	16
1993	17	[2 ; 62]	0.1	[0 ; 18]	8
1994	7	[2 ; 21]	0	[0 ; 0]	10
1995	255	[132 ; 671]	0	[0 ; 0]	11
1996	452	[159 ; 2964]	NS		11
Abundance indices from the gaspereau fishery in the Northwest Miramichi (stratified mean and standard deviation)					
	Age-2		Spawners		
1991	0.02		1.5		23
1992					NS
1993	5.6	0.3	3.6	0.25	46
1994	8.0	3.2	68.7	17.4	50
1995	0.3	0.01	36.8	5.0	64
1996	5.8	0.5	8.8	0.6	72

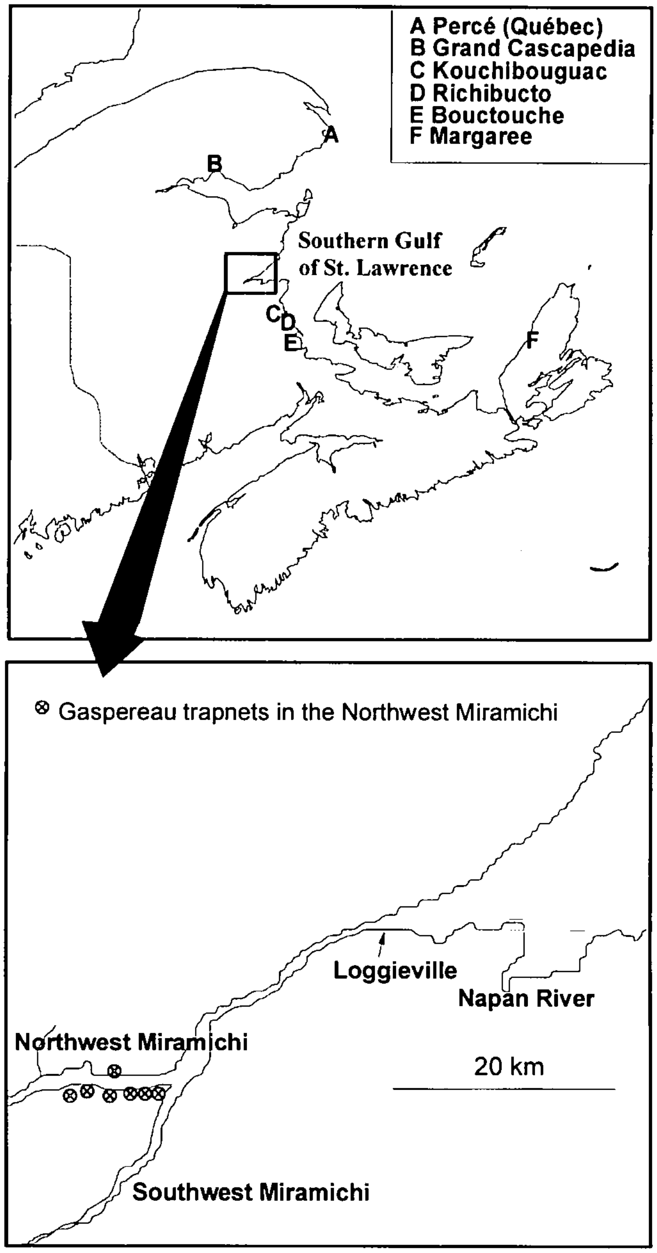
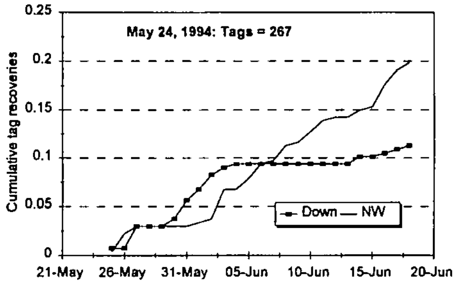
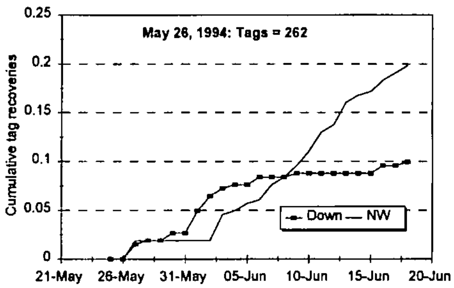


Figure 1. Place names and locations sampled for assessing the status of the striped bass stock of the southern Gulf of St. Lawrence.



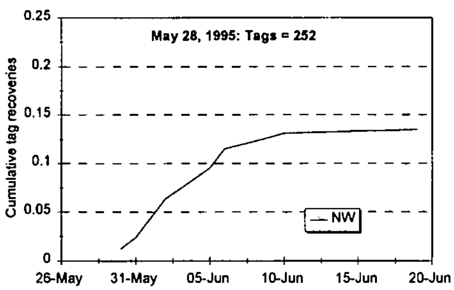
Starting June 2, 1994

NW	Regression output:	
Constant	-0.028	
Std Err of Y Est	0.007	
R^2	0.976	
No. of Observations	17	
Degrees of Freedom	15	
X Coefficient(s)		0.009
Std Err of Coef.	0.000	



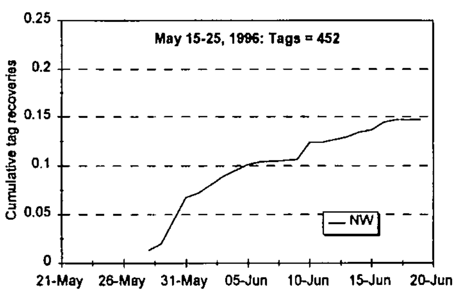
Starting June 2, 1994

NW	Regression output:	
Constant	-0.079	
Std Err of Y Est	0.007	
R^2	0.988	
No. of Observations	17	
Degrees of Freedom	15	
X Coefficient(s)		0.011
Std Err of Coef.	0.000	



May 30 to June 9, 1995

NW	Regression output:	
Constant	-0.005	
Std Err of Y Est	0.009	
R^2	0.966	
No. of Observations	8	
Degrees of Freedom	6	
X Coefficient(s)		0.012
Std Err of Coef.	0.001	

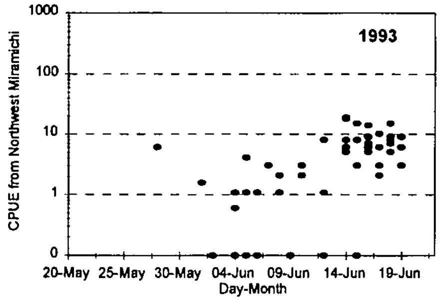


May 28 to June 10, 1996

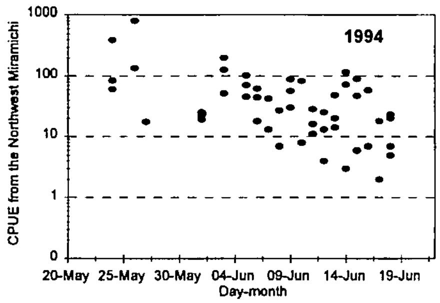
NW	Regression output:	
Constant	0.021	
Std Err of Y Est	0.015	
R^2	0.873	
No. of Observations	9	
Degrees of Freedom	7	
X Coefficient(s)		0.008
Std Err of Coef.	0.001	

Figure 2. Cumulative recaptures by individual tag groups of bass tagged in the Northwest Miramichi and rcovered in either the Northwest Miramichi (Northwest) gaspereau fishery or from downstream traps (Down) during 1994 to 1996.

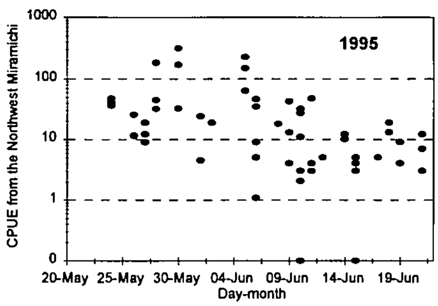
CPUE



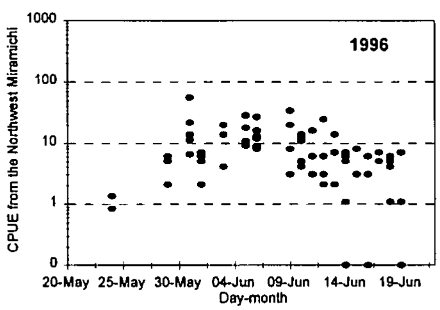
Stratified arithmetic mean		3.5
Geometric mean		0.5
Median		3.0
Number of observations with no bass catch	11 of 56	



Stratified arithmetic mean		68.7
Geometric mean		30.3
Median		27.5
Number of observations with no bass catch	0 of 50	



Stratified arithmetic mean		36.8
Geometric mean		11.7
Median		12.0
Number of observations with no bass catch	2 of 56	



Stratified arithmetic mean		8.8
Geometric mean		4.0
Median		6.0
Number of observations with no bass catch	3 of 71	

Figure 3. Catch per unit of effort (bass per trapnet per 24 hr period) of striped bass greater than 38 cm fork length from the Northwest Miramichi gaspereau fishery, 1993 to 1996. Individual points may represent several observations.

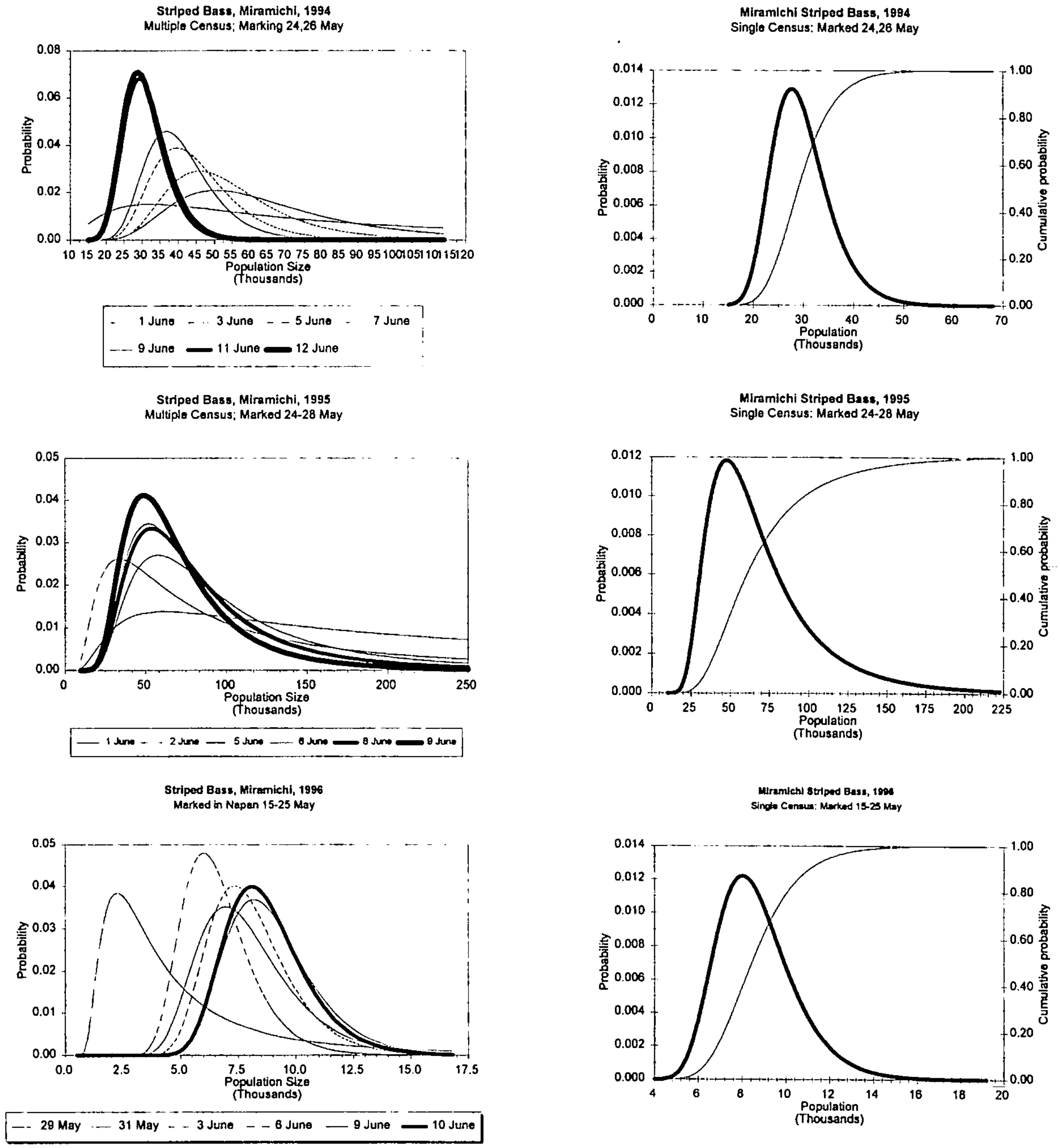


Figure 4. Multiple and single census Bayesian estimates of spawner abundance for years 1994 to 1996. The 1994 and 1995 estimates have been revised from the estimates reported previously. Individual estimates used in the multiple census approach are shown for each day of sampling. The cumulative distribution of estimates obtained for the single census is shown for each year. Final estimates obtained using the sequential Bayesian algorithm are shown as heavy lines.

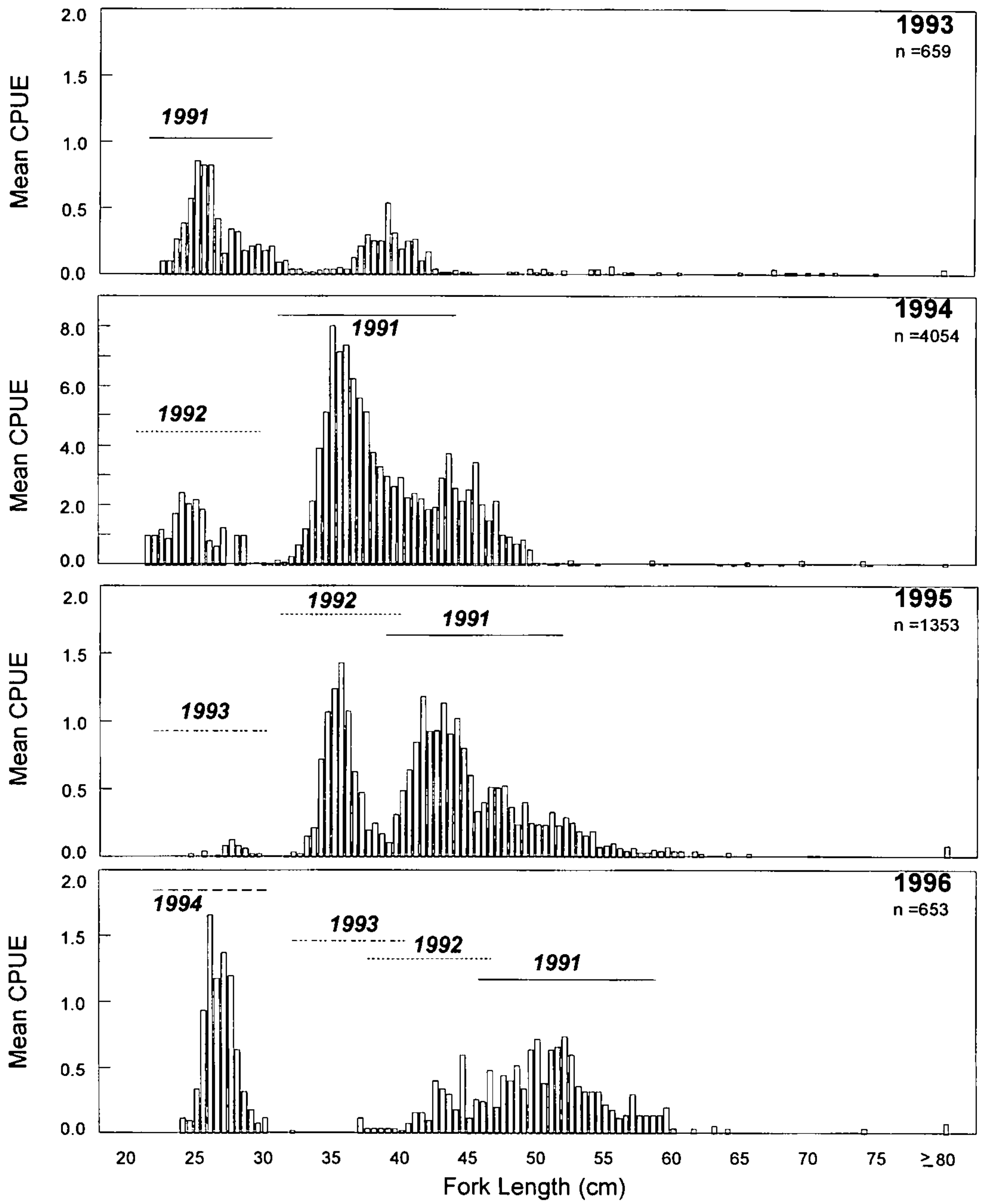


Figure 5. Length frequencies expressed as the mean catch per unit of effort (CPUE) of striped bass from the gaspereau fishery of the Northwest Miramichi during May and June 1993 to 1996. Lines of different style beneath years (in bold,italic) represent the length range of the associated year-classes in the population.

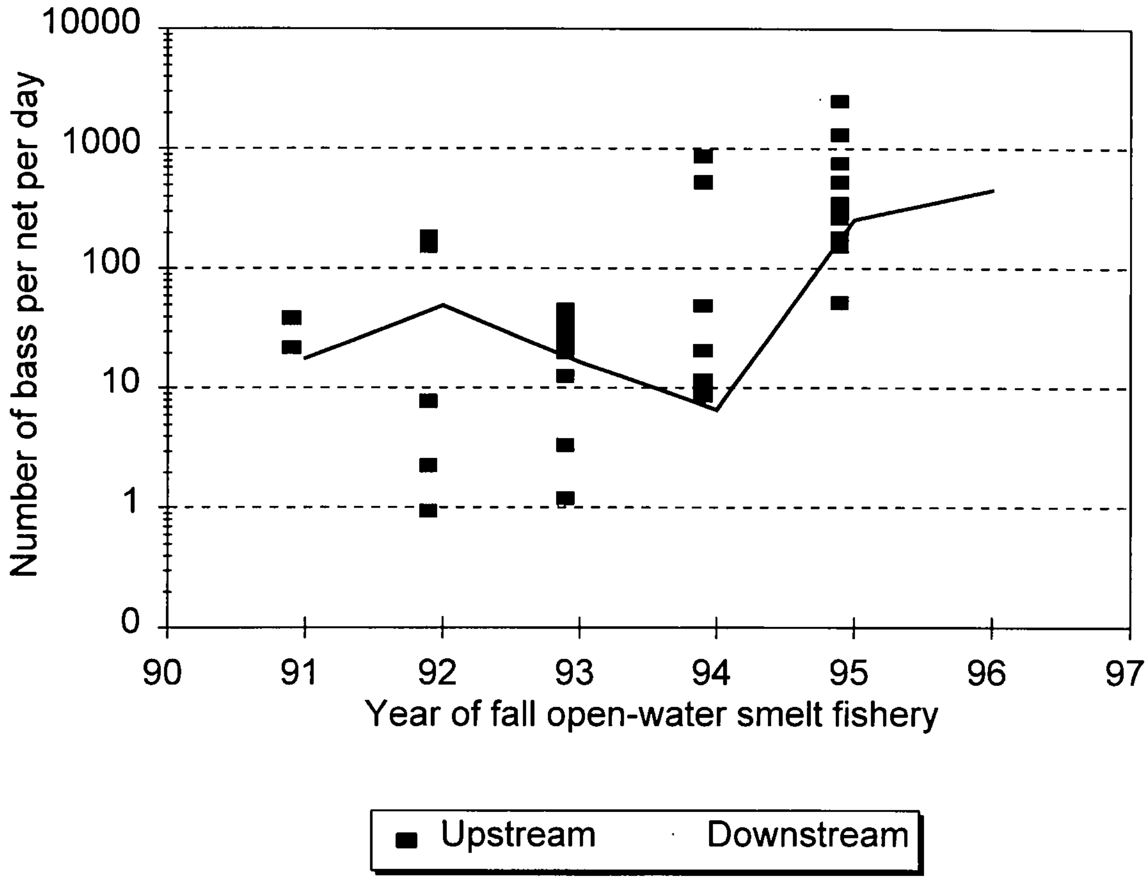


Figure 6. Catch per unit effort (fish per net per 24 hr period) of striped bass in the open water smelt fishery of the Miramichi River at upstream (Chatham) and downstream (Loggieville) locations, 1991 to 1996. Solid line is the median catch per unit effort at the downstream sampling location. Individual points may represent several observations.

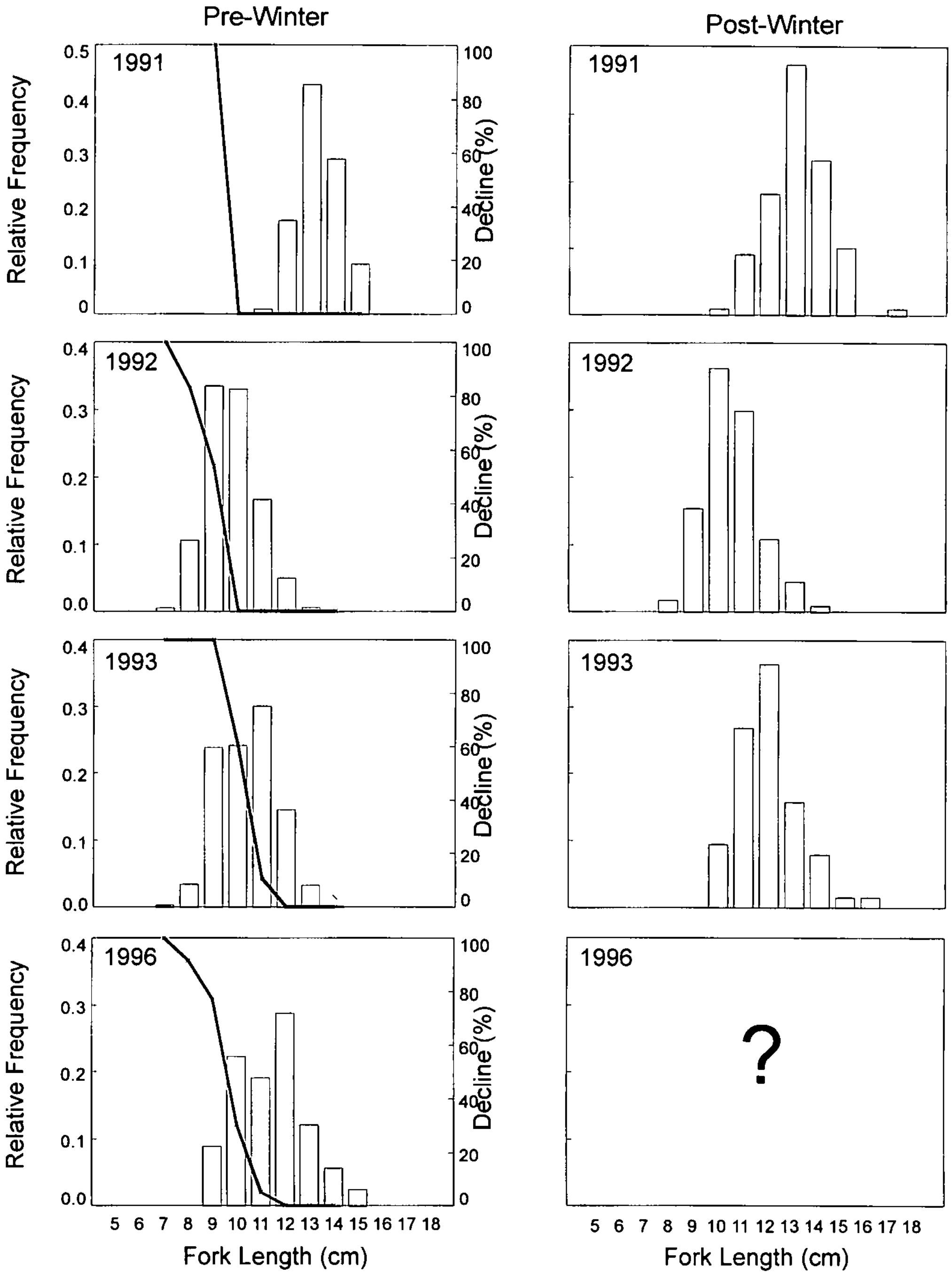


Figure 7. Pre-winter length frequency distribution compared to post-winter length frequency distribution estimated from back-calculation of length from scales of 2-year old bass for the 1991 to 1993 year-classes. The solid line represents the relative decrease in abundance of the particular length class from the pre-winter to the post-winter. The 1996 line represents the average of the three previous years.

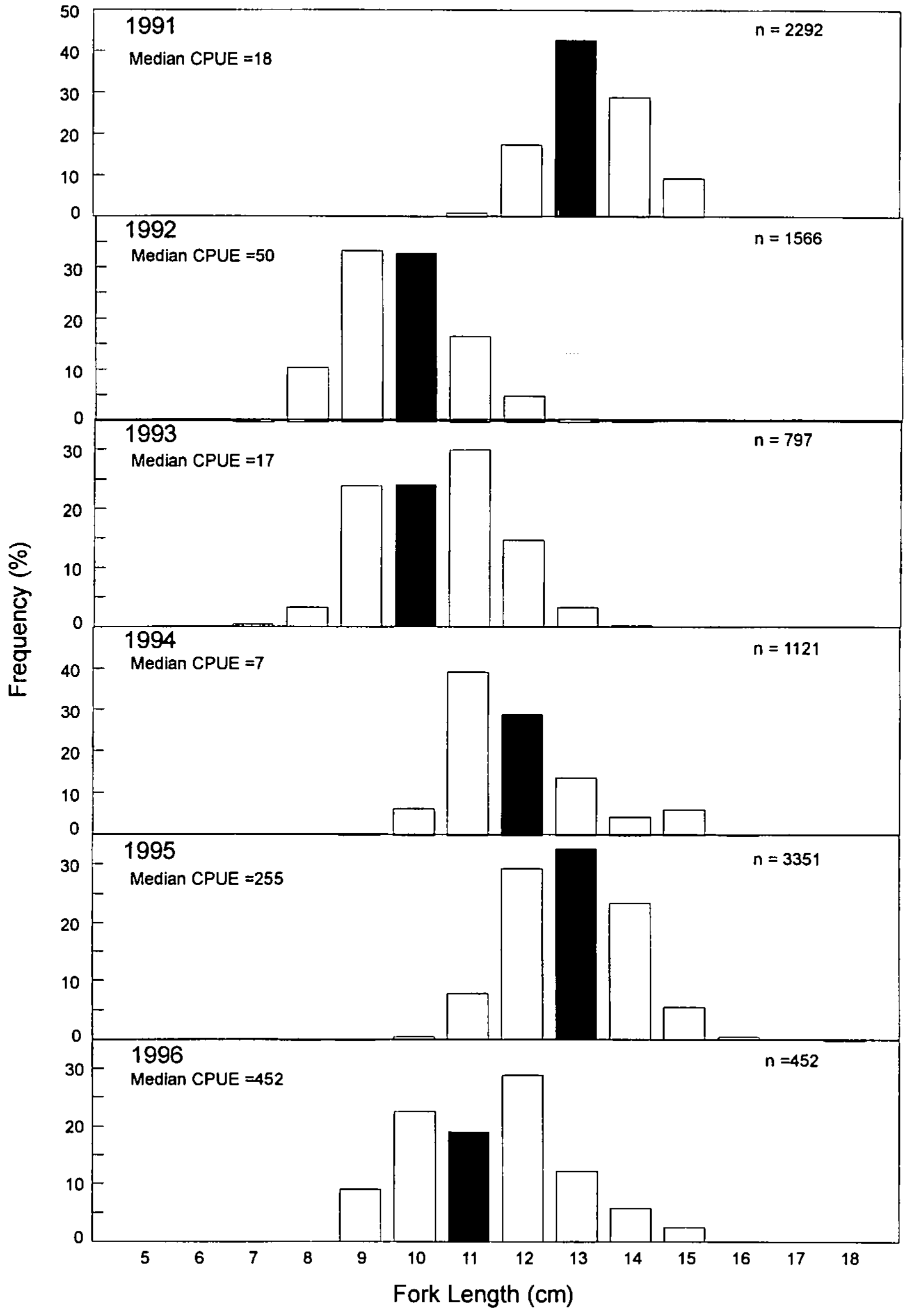


Figure 8. Length frequency distributions of age-0 striped bass sampled from the fall smelt fishery (October and November) in the Miramichi estuary. The median length interval is shown as the shaded bar.

Appendix 1. Record of Science consultation for striped bass for 1996.

1. SPECIES / STOCK:
- Striped bass Miramichi River/Southern Gulf of St. Lawrence

2. ARRANGEMENTS:
   DATE: Dec. 9, 1996
   TIME: 13:00 to 16:30
   LOCATION: Dept. of Natural Resources and Energy, Newcastle, New Brunswick

3. FORM OF CONSULTATION (Science Workshop, ZMAC, ETC..)
- Science Workshop

4. PARTICIPANTS (Name and Affiliation)
- Normand Allain, Gaspereau fisher (Northwest Miramichi), Richibouctou Village
- Robert Allain, DFO, Area Manager, Tracadie-Sheila
- Don Archibald, MREAC, Miramichi
- Jean-Claude Babineau, Southeast Anglers Association, Bouctouche, N.B.
- Rod Bradford, Rod Bradford & Associates, Mt. Uniacke, N.S.
- Gerald Chaput, DFO Science, Moncton, N.B.
- Harry Collins, MREAC, Chatham, N.B.
- Gilles Cormier, Southeast Anglers Association, Bouctouche, N.B.
- Gaëtan J. Couturier, DFO, Tracadie-Sheila, N.B.
- Junior Denny, Fisheries Coordinator, Eel Ground First Nation, Miramichi
- Brian Donovan, Angler, Miramichi, N.B.
- Bernard L. Dubee, DNRE, Miramichi, N.B.
- David Dunn, DFO Fisheries Management, Moncton, N.B.
- Gerald Dutcher, Gaspereau fisher, Loggieville, N.B.
- Clifford Ginnish, Fishery Supervisor, Eel Ground First Nation, Miramichi
- Mark Hambrook, DFO Science, Miramichi, N.B.
- John Hayward, DFO Science, Miramichi, N.B.
- Firmin LeBlanc, Kouchibouguac National Park, Kouchibouguac, N.B.
- Léophane LeBlanc, Kouchibouguac National Park, Kouchibouguac, N.B.
- Tim Lutzac, DFO Science, Moncton, N.B.
- Alan Madden, DNRE, Campbellton, N.B.
- Marie-Josée Maillet, Southeast Anglers Association, Bouctouche, N.B.
- Eugène Richard, Gaspereau fisher (Northwest Miramichi), Richibouctou Village
- Joe Richard, Gaspereau fisher (Northwest Miramichi), Richibouctou Village
- Daryl Trevors, commercial fisher, Miramichi, N.B.
- Fred Wheaton, New Brunswick Wildlife Federation, Moncton, N.B.

5. NEW INFORMATION BROUGHT FORWARD (what? by who?)-*(Only a brief description is required)*
- angling success very good in the fall in Bathurst Harbour for the third year in a row (A. Madden, DNRE)
- rumors of sales of bass prevalent in some areas, especially Richibucto area (J.C. Babineau)
- egg and larval survey in Kouchibouguac did not find bass in 1996 but juveniles were seined in late summer (L. LeBlanc, Kouchibouguac Park)

6. CONCERNS RAISED BY CLIENTS (include concerns, plus follow-up action/response made or committed). - *(Only a brief description is required)*
- questions regarding whether angling should be allowed during the spawning season (was to be considered for preparation of management plan)
- was the impact of seals on striped bass being considered? Seal abundance is increasing everywhere (N.

Allain). No plans to undertake seal predator studies specific to striped bass. The impact of seals on various fish resources is being studied by others.

- still do not know what the impact of the fall openwater fishery has on the young-of-the-year bass. Is it a small proportion of the total population - if so, may not be a major concern.
- very little is known of the importance of forage species abundance on striped bass, including smelt, sand lance, and invertebrates. No plans to undertake feeding studies of striped bass.

7. RECOMMENDATIONS: *(Only a brief description is required)*

a.) Pertaining to Assessment

- **The use of gaspereau traps in the Northwest Miramichi to estimate spawner abundance may be compromised by variations in season openings and effort. The use of alternate sources of data such as the Eel Ground food fishery trapnets should be considered to provide a more consistent measure of abundance (based on catch per unit of effort)**

b.) Pertaining to next year's workplans

- **continue estimation of spawner abundance and YOY index in openwater fishery to determine the extended contribution of the 1991 year-class**
- **with the collaboration of user-groups in other estuaries (Richibucto, Kouchibouguac) assess through tagging and monitoring of spawners in the spring whether spawning does occur and in a consistent manner in estuaries other than the Miramichi**
- **impact of hook and release angling on striped bass should be studied - first through a literature review of studies from the USA and through research initiatives during derbies (should these be developed)**

Rod Bradford	Gérald Chaput
NAME OF PRESENTOR	NAME OF RAPPORTEUR