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Assessment of the Margaree River gaspereau fishery, 1995 and 1996

G. Chaput, P. LeBlanc and R. Crawford[2]

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

[2]Nova Scotia Dept. of Fisheries
Nova Scotia

ABSTRACT

The harvests of gaspereau from the Margaree River have undergone large annual variations between 1950 and 1996. Harvests in 1996 of 94 t were the second lowest in the time series and follow an almost continuous decline from the peak historic catch of 1,912 t in 1988. The alewife (*Alosa pseudoharengus)* harvests in 1995 and 1996 were dominated by first time spawners, similar to previous years. The 1991 year-class, based exclusively on catches, has been the weakest observed to date. The fishing mortality rates between 1983 and 1994 were in excess of F_{OPT} (F = 0.4). There was a greater than 99% chance that the fishing mortality rate in 1995 exceeded F_{opt}. There was less chance (60%) that F in the 1996 fishery exceeded the target level. The large oscillations observed in the landings are in part due to overexploitation. That overexploitation has occurred is evident from the large dependence of the runs on first time spawners and the high proportion of the cohorts which are harvested before ever having spawned. The management plan in 1996 which included a full three days closure and the reduced number of licenses actively fished resulted in lower exploitation rates from those of the previous five years and close to the target.

RESUME

Des grandes fluctuations annuelles caratérisent les débarquements de gaspareau de la rivière Margaree depuis 1950. Le débarquement en 1996 de 94 t était le deuxième plus faible depuis 1950 et correspond à une tendance décroissante continue du maximum de 1 912 t enrégistrées en 1988. Les captures de gaspareau (*Alosa pseudoharengus*) en 1995 et 1996 comprenaient majoritairement des poissons de premier frai, tout comme dans les années précédentes. Par rapport uniquement aux captures, la cohorte de 1991 est la plus faible jusqu'à date. Les taux de mortalité de pêche entre 1983 et 1994 dépassaient le taux optimal (F_{OPT}, F = 0.4). En 1995, il était fort probable (99% de chance) que le taux de mortalité de pêche dépassait F_{OPT}. En 1996, il était moins probable (60%) que le taux de pêche fut excessif. Les grandes fluctuations des débarquements sont en parti attribuables à une sur-pêche. Il est évident que le stock a été sur-pêché : forte dépendence des captures sur les poissons de premier frai, proportion élevée de poissons récoltés avant avoir frayer une fois. Le plan de gestion mis en place en 1996 comprenait une fermeture complète de trois jours par semaine. Cette gestion et le nombre réduit de trappes pêchées ont contribué à la réduction du taux d'exploitation des cinq années précédentes et à un rapprochement au niveau de pêche cible.

Introduction

The Margaree River gaspereau fishery is prosecuted in-river, above head of tide along a 20 km stretch between the estuary and the main spawning area in Lake Ainslie (Fig. 1). Tip-traps are installed from the bank and generally filter half of the river, from the bank outward. Alewife (*Alosa pseudoharengus*) are the dominant component of the harvests, blueback herring (*Alosa aestivalis*) are less abundant and migrate into the river later (in early June) than alewife. Alewife have returned to the river as early as mid-April but the major run occurs in the second to fourth weeks of May. Crawford (1986) has shown that spawning occurs throughout Lake Ainslie but tended to be concentrated in the shallower Loch Ban portion of the lake (Fig. 1). Juvenile gaspereau leave the lake in late summer and throughout the fall and return to spawn at age three and four years. Adults feed in the southern Gulf of St. Lawrence after spawning and overwinter outside the Gulf of St. Lawrence, along the Atlantic coast of Nova Scotia (Crawford and Tully 1989).

There are no quotas on the river but control of exploitation rates in recent years has relied on closures to reduce effort and allow escapement into Lake Ainslie. The majority of gaspereau harvested is salted on site and processed by individual fishers. Fishing practices have evolved with mechanical tip-traps adopted by almost all fishers by the early 1980's.

The Margaree River has been formally assessed since 1983 (Alexander 1984, Alexander and Vromans 1985, 1986, 1987, 1988; Chaput 1993; Chaput and LeBlanc 1988, 1989; Chaput et al. 1991; Claytor et al. 1995). Other information related to migrations, age structure and physiology were prepared by O'Neil (1980) and Crawford (1988).

The objectives of this assessment are to evaluate the exploitation rates in the 1995 and 1996 fisheries relative to target reference levels.

Fisheries Management and Landings

Prior to 1984, there were no within season closed periods for fishing gaspereau on the Margaree River. The fishing season opened March 31 and closed June 30. In 1984, weekend closures were introduced following the assessment that exploitation rates were excessive. The weekend closures consisted of a 18:00 Friday to 8:00 Sunday closure for the river situated below the Highway 19 bridge (about midway between the estuary and Lake Ainslie) and the 18:00 Saturday to 8:00 AM Monday closure for the fishers above the bridge (Fig. 1). This management measure had the effect of reducing the potential fishing time (traditionally sunrise to sunset) by 20% (Table 1). In response to concerns by fishers that a chance occurrence of the major run on a weekend closed period could impact on their harvests, an alternative management plan was proposed by the fishers and adopted for the 1992 to 1995 fishery. The alternative managment plan, described by Chaput (1992) and Claytor et al. (1995) resulted in a slight decrease in potential fishing time from the 1984 to 1991 period (6%) but a 25% reduction relative to the pre-1984 situation (Table 1, 2). Under this management plan, traps could be fished in both zones seven days per week. After the 1995 fishery, it was evident that the stock had severely declined (see subsequent sections) and in response, additional closure periods were introduced to the 1996 season: complete closure for three days of the week and half day fishing periods for two of the four fishing days (Table 2). This management regime resulted in a 57% reduction in potential fishing from the pre-1984 period, a 46% reduction from the 1984 to 1991 period and a 43% reduction from the 1992 to 1995 period (Table 1).

Regulations require that traps plus leaders and all walkways or other conveyances over the river allow one-half the width of the river to remain open at all times. Additionally, the combined length of trap and leader may not be more than 15 m and no trap may be set within 55 m of another trap.

Potential licensed effort increased from the 21 licenses in 1971, peaked in 1980 at 82 licenses and has stabilized at about 60 licenses since 1989 (Table 3). The fishery is currently restricted by a freeze on new entrants and license or site transfers are permitted only to immediate family members. Active licenses have tended to be substantially less than the potential licenses on the river. The decline in active licenses in 1992 was the result of a

change in the fisheries inspection regulations which required that all gaspereau destined for human consumption must be cured and processed in a certified building. Several fishers were able to accommodate the inspection regulations in 1993 and active effort increased. The decline in active licenses in 1996 was the result of the management plan.

The Statistical District 2 landings have undergone large annual variations between 1950 and 1996 (Fig. 2). The harvests of gaspereau from the Margaree River have represented important proportions of the Gulf Nova Scotia harvests (38% to 90%) since 1978 (Table 4). Estimated landings in 1996 were the second lowest in the time series and follow an almost continuous decline from the peak historic catch of 1,912 t in 1988. High harvest levels were generally short-lived, lasting no more than two years in succesion followed by a dramatic decline in the subsequent year (Fig. 2). Relative to the southern Gulf gaspereau fisheries, the harvests from the Margaree River have represented 6% to 36% of the total with the lowest percentages in the 1991 to 1996 time period.

Conservation and Management Objectives

Fisheries Management Objective

In past assessments, the status of the gaspereau stock was evaluated relative to the management objective of $F_{0.1}$. Estimation of the fishing mortality for $F_{0.1}$ was based on yield per recruit analysis method of Thompson and Bell as described in Rivard (1982) under the assumptions of a Type I fishery (natural mortality occurs at a time of year different from the fishing mortality) because the fishery occurs over a period of about four weeks during the year (Chaput and LeBlanc MS1989). The estimation of $F_{0.1}$ is sensitive to the assumed natural mortality rate (M) for the species.

Parameters used in the yield per recruit analysis (Chaput and LeBlanc MS 1989)

Age	Weight (kg)	Patial Recruitment
3	0.213	0.60
4	0.267	0.99
5	0.312	1.00
6	0.351	1.00
7	0.394	1.00
8	0.415	1.00
9	0.441	1.00
10	0.500	1.00
11	0.500	1.00

M	$F_{0.1}$
0.2	0.32
0.4	0.60
0.5	0.78
0.6	1.00

An analysis of the population of alewife from South River (Gulf of St. Lawrence shore, Nova Scotia) indicated that the natural mortality of alewife was high (M = 0.44 equivalent to 36% mortality for the year) and increased for previous spawners (M = 1.05 equivalent to 65% mortality for the year) (Chaput and Alexander MS1989). These values are much higher than the assumed natural mortality of 0.2 for Atlantic herring (18% annual mortality). Higher natural mortality for gaspereau relative to herring would be expected because of the freshwater spawning migration which gaspereau undertake. At a maximum spawning age of eleven years for gaspereau from the southern Gulf, the empirical relationship derived by Hoening (1981) indicated that M was in the order of 0.4. Jensen (1996) reviewed three life history relations called the Beverton and Holt invariants, one of which provides an indication of the natural mortality on the basis of the age at maturity (M x m = C1; where M = natural mortality, m =

age at maturity, and C1 = 1.65 or 2). The age at maturity of alewife in the Margaree River (based on the proportion of the recruitment to the river which matures at age 3 years versus 4 years) was 3.36 years. This gives an estimate of M = 0.49.

Based on the estimated mortality rates from the South River alewife population, $F_{0.1}$ was estimated at F = 1.05 (exploitation rate of 0.65) (Chaput and LeBlanc 1989). At M = 0.4, the target fishing mortality at $F_{0.1}$ declines to 0.6 (exploitation rate of 0.33) while at M = 0.5, the target fishing mortality would be 0.8 (exploitation rate of 0.55). Walters and Pearse (1996) suggest that F_{opt} (defined as the optimum fishing rate based on the long-term objective of maximizing a logarithmically risk-averse function of catch) is less than two-thirds $F_{0.1}$ of harvestable fish. It has also been suggested that given the uncertainty of estimating and forecasting stock size, the fishing mortality should remain below M (Walters and Maguire 1996). For the gaspereau stock of the Margaree River, the target F should therefore not exceed 0.4, which is equivalent to about two-thirds $F_{0.1}$..

Assessment Data

The data used in the assessment of the Margaree River gaspereau fishery include logbook reports from individual fishers, two-stage stratified sampling for age composition and derivation of the catch at age, and estimation of the harvests by telephone survey.

Fishery logbooks are used to make inferences on timing of the catch and in the past have been used as an abundance index in cohort analysis (Chaput et al. MS1991) and in a depletion estimation procedure (Leslie) to estimate exploitation rates in the current year (Claytor et al. MS1995). Logbook contributions in 1996 declined from previous years (30% of active licenses returned logbooks) with the highest returns in 1988 (92% participation). Logbook reported harvests in 1996 represented 21% of the estimated harvests.

Commercial sampling followed a similar procedure to that used since 1989 (Chaput MS1993). Sampling was conducted daily in each of the fishing zones (lower and upper). The objective was to measure 200 to 250 fish from each zone, preferrably from one trap site but several trap sites were visited to obtain the complete length sample when catch rates were low. Detailed samples for species identification, length, weight, sex, maturity and ovary weight were collected by retaining 3 fish for every 5 mm fork length group up to 280 mm and 5 fish for every 5 mm group for fish longer than 280 mm. When detailed samples were frozen prior to analysis, fresh fish lengths were estimated from frozen lengths using the following relationship (Chaput MS1993):

adjusted length (mm) = 1.0143 X frozen length (mm) + 4.557

Scales for age determination were collected preferentially from the left side, midway between the dorsal fin and the ventral scutes. Species (alewife, *Alosa pseudoharengus*; blueback herring, *Alosa aestivalis*) were identified on the basis of the external appearance and the peritoneum colour (Scott and Crossman 1973). The peritoneal lining of alewife tends to be pale to dusky whereas the lining of the body cavity of blueback herring is sooty to black.

The catch-at-age of alewife and blueback herring was derived from age-length keys (Table 5) applied to length sampling vectors. Length vectors within each group were weighted by the reported logbook catch for that period. Catch-at-age was first derived for the total logbook catches and then adjusted for the total harvests from the river using the proportion of the total harvests reported in the logbooks.

The total harvests from the Margaree River were obtained from a telephone survey conducted during January to March of each year. Fishers were asked for bait sale amounts as well as the total number of pails of cured gaspereau packed. A 50 lb pail of cured gaspereau was assumed to represent 70 lbs of fresh fish (30 lb pail of cured fish = 42 lbs of fresh fish) (Alexander and Vromans MS1988). Estimates of bait sales were obtained in 1995 by Conservation and Protection Branch field staff. No fishers reported selling bait in 1996.

Continuous (1 to 1.5 hour intervals) water temperature recorders were installed in Loch Ban (Lake Ainslie) and at the Environment Canada water gauging station in the upper part of the Southwest Margaree.

Estimation of Stock Parameters

The timing of the 1995 fishery was the latest observed since monitoring began in 1983 (Table 6). The 50% cumulative catch occurred on June 6 with the 10% cumulative catch on May 25 and the maximum catch on June 10 (Fig. 3). Timing of the harvests in 1996 was earlier than observed during 1990 to 1995 (Table 6). The 50% cumulative harvests reported from the logbooks occurred on May 23, the same day as the maximum reported harvest. Prior to 1990, the 50% cumulative catch occurred between May 17 and May 23, with the exception to 1985. The first report of gaspereau in 1996 was May 3; the first report in 1995 was May 8. The Southwest Margaree water temperatures in 1995 were cool; mean daily temperatures did not stay above 10 C until May 21 and above 15 C until June 16. In 1996, mean daily temperatures exceeded and remained above 10 C by May 18 and above 15 C by June 3 (Fig. 3).

Approximately 500 thousand gaspereau (alewife and blueback herring) were harvested in 1996 compared to over 800 thousand in 1995 (Table 7). These harvests are the lowest during the 1983 to 1994 period when harvests ranged between 1.9 million and 6.7 million fish (Tables 7 and 8). The alewife harvests in 1995 and 1996 were dominated by first time spawners, similar to previous years. Previous-spawners comprised 28% by number of the 1996 alewife catches but the percent previous-spawners in 1995 was among the highest in the time series at 42%. The 1990 year-class was the dominant component of the 1993 and 1994 fisheries whereas the 1992 year-class has been the dominant cohort in the 1995 and 1996 fisheries (Table 7). The 1991 year-class, based exclusively on catches, has been the weakest observed to date. The first blueback was observed in samples collected on May 23, 1996 and June 8, 1995. The much later arrival of blueback herring into the fishery in 1995 corresponds to the later migration of alewife into the river that year. Blueback herring made up a higher proportion of the overall harvest in 1995 (9.0% by number) compared to previous years (range 0.1% to 5.7%).

The total returns and spawning escapements to Lake Ainslie were estimated direclty from the catch-at-age matrix by cohort summation, under different assumptions for natural mortality (M): M = 0 (provides estimates of maximum exploitation rate), and mortality rates of 0.4, 0.5 and age-stratified as described by Chaput and Alexander (MS1989). The number of females escaping to Lake Ainslie was estimated using the proportion female by age group and spawning history (Table 9). The total ovarian material brought into Lake Ainslie was estimated as the product of the number of females at age escaping to Lake Ainslie and the age-specific gonad weight at age of females (Table 9). Alewife recruiting to the spawning stock at age 3 tend to be mostly males whereas those recruiting at age 4 and 5 tend to be mostly females.

The exploitation rates between 1983 and 1994 are equal to or in excess of target exploitation rates at F_{OPT} under the assumed natural mortality rate of M = 0.4 (Fig. 4). The high exploitation rates in the 1991 to 1994 fisheries were previously estimated using a depletion estimator applied to logbook catch rates (Claytor et al. MS1995). As the total stock abundance declined (based on estimated runs to the river), the exploitation rates increased. The increased exploitation rate on the smaller run is consistent with the observed behaviour of gasperau during the migration and the placement of the fishing gear. At low abundance, gaspereau travel in small schools close to the river banks. At very high abundance, gaspereau schools spread across the entire river. Since the commercial traps are installed from the bank towards the middle of the river, at low abundance, each trap exploits a greater proportion of the run than at high abundance.

Exploitation rates of the 1995 and 1996 fisheries cannot be estimated by backward summation because insufficient proportions of the 1992 and 1993 cohorts have been seen. A Leslie depletion estimate for these two years was attempted following the procedure outlined by Claytor et al. (MS1995). No significant fits ($P > 0.20$) were obtained from the Leslie depletion analysis of the logbook catch and effort data. There were insufficient numbers of logbooks returned in 1996.

Alternate estimates of escapement

Sampling for gaspereau larvae in Lake Ainslie (the main spawning area for the Margaree River stock) has been conducted in nine years since 1983 (Crawford 1996). Sampling was conducted weekly from the latter part of May until early July. A five minute surface tow with a half metre plankton net (mesh 500 μm) was conducted at four fixed stations within the lake. Mean larval abundance was calculated for the entire sampling season from the

individual weekly observations. There was a strong positive association between the estimates of escapement (male and female number from cohort summation and M = 0.4) and mean larval abundance (Fig. 5). The associations were weaker for female spawners and for total gonad weight variables. Total spawning escapement estimates adjusted for natural mortalities of 0.5, 0.6 and age-stratified resulted in associations of similar strength to M = 0.4.

Our interest was in estimating the exploitation rate (harvest divided by total return) in 1995 and 1996. A Bayesian approach was used to describe the probabilities of alternate spawning escapement levels and exploitation rates in 1995 and 1996 (Hilborn and Walters 1992). Spawning escapement estimates were obtained from the backward cohort summation for the 1983 to 1994 spawning escapements. A total of seven spawner / larval index annual estimates were available (1983 to 1985, 1989 to 1991, 1994). Uninformative prior probabilities (uniform distribution) were used for the slope and intercept parameters of the linear association between larval index and total spawning escapement. The likelihoods of each slope and intercept combination were determined from the normal distribution. The 1995 spawning escapement was estimated using the 1995 larval abundance index of 120.6 larvae (prolarvae and postlarvae) per 100 m^3. The 1996 spawning escapement was estimated in a similar fashion based on the mean index of 280.5 larvae per 100 m^3 (Crawford 1996).

There was a very high probability that the fishing mortality rate in 1995 exceeded the target level at F_{opt} (the F_{opt} level = two-thirds $F_{0.1}$) (Fig. 6). At M = 0.4, there was a greater than 90% chance that the fishing mortality rate exceeded the target level. Even under the age-stratified-M assumptions, the fishing mortality rate in 1995 had a 60% chance of exceeding F = 0.5.

There was less chance that F in the 1996 fishery exceeded the target level (Fig. 6). At M = 0.4 assumption, there was a 60% chance that F exceeded 0.4 whereas under M = 0.5 assumption, there was less than 20% chance that the F exceeded the target level of 0.5. Under the age-stratified-M assumption, it was very probable that the F was below the target level.

Other indicators of exploitation levels

Claytor et al. (MS1995) used logbook data and the Leslie depletion estimator to derive exploitation rates for the 1991 to 1994 fisheries. The depletion estimates derived by Claytor et al. (MS1995) and the exploitation rates estimated by backward cohort summation indicate that exploitation rates during 1991 to 1994 were in excess of 0.75.

	1991	1992	1993	1994
Depletion estimate	0.87	0.89	0.85 to 0.96	0.73
	Backward cohort summation			
M = 0.4	0.79	0.80	0.80	0.77
M = 0.5	0.76	0.78	0.77	0.75
M = stratified	0.70	0.73	0.72	0.71

Additional evidence of the high exploitation level in this fishery is provided by the counts of gaspereau passing through a counting fence to Lake Ainslie in 1979 relative to the harvest of gaspereau in the same year. The counting fence was installed above the last commercial trap in the Southwest Margaree, just below the outlet of the lake. The daily counts of gaspereau are summarized in Figure 7. A total of 3,367,944 gaspereau were counted through the fence between May 2 and June 3, 1979. The fishery harvested 1,776 tons. Based on average weights of 0.225 kg to 0.276 kg per gaspereau (1983 to 1994 values), the 1979 harvest would have represented between 0.66 and 0.70 of the total run of between 9.8 and 11.3 million fish. The 1987 spawning migration to the Southwest Margaree was estimated to have been as high as 11.9 million fish in 1987 and 11.5 million fish in 1988 (assuming the age-stratified natural mortalities of 0.44 and 1.05) yielding a harvest of 1259 t in 1987 and 1,666 t in 1988.

A counting fence was also operated in 1983 but because of operational difficulties, the escapement of gaspereau to Lake Ainslie was estimated to have been at least twice the count of gaspereau (148,000 fish), i.e. 300,000 fish (Alexander MS1984). Backward cohort summation suggests that the minimum escapement to the lake in 1983 was 644 thousand fish. The 1983 harvest of gaspereau was 2.1 million alewife. The maximum exploitation rate

for the 1983 fishery, based on backward summation, was estimated at 0.77. At an escapement of 300 thousand gaspereau, the exploitation rate would have been 0.88. Both of these are in excess of the target fishing exploitation rates.

The combination of methods used to estimate the total annual returns to the river provide a clear indication of depressed returns to the Margaree River since 1991 (Fig. 8). The largest return was estimated in 1979 (based on counting fence data) while the lowest returns to date were estimated for 1996 based on the larval index / spawning escapement relationship. The cohort larval index method generally encompasses the cohort summation estimate; this is not surprising since the cohort summation is used to estimate the spawning escapement for the larvae / spawner relationship. The Leslie depletion estimates are very close to the cohort summation estimates. In a fishery where generally 75% of the population is removed in a given year, the estimates of returns are less sensitive to losses from natural mortality. In the Margaree River fishery, 62% to 95% of the 1980 to 1990 cohorts were harvested before they had a chance to spawn once (Table 10).

A plot of the estimated recruitment (to the river as first time spawners) relative to the estimated spawning stock (from cohort summation assuming M = 0.4) indicates that an important part of the decreased abundance of the 1991 and 1992 year-classes (returns in 1994 to 1996) was the result of low spawning escapement (Fig. 9). There was large variability in the recruit to spawner relationship, but escapements of less than 1 million fish (males and females) to Lake Ainslie have produced less than 2 million recruits (to age 3 and 4) in two of three years. When escapement has exceeded 1 million spawners, recruitment has exceeded 2 million fish in 5 of 7 years (Fig. 9).

The estimated escapement in 1992 to 1996 (based on Leslie depletion estimates for 1991 to 1994 and larval indices for 1995 and 1996) have been less than 1 million spawners (Fig. 10). Recruitments of more than 3 or 4 million spawners are not expected for the next five years.

Management Considerations

1) Are the exploitation rates in 1995 and 1996 greater than the target levels?

The target exploitation rates suggested for the Margaree fishery are based on levels equivalent to at most F = 0.5 (two-thirds $F_{0.1}$ or F <=M) (Walters and Pearse 1996). The estimated exploitation rates are greater than the rates at F_{opt} for all assumed M in 1995. The 1996 exploitation rates are closer to F_{opt} at the high M assumptions but there was a high probability (60%) that the exploitation rates were in excess of F_{opt} if M = 0.4.

2) Was the 1996 management plan effective?

There are strong indications that the management plan in 1996 reduced the exploitation rates from those of the previous five years to a level which corresponded to the target. The estimated migration in 1996 was less than the 1995 value but the larval abundance increased, as a direct result of increased escapement directly related to the lower exploitation rate. The consecutive three day closure was initiated to reduce exploitation and to allow gaspereau to migrate freely from the estuary to the lake. Alexander and Vromans (1989) indicated that in 1988, gaspereau required, on average, 148 hours (6 days) to pass through the 20 km fishing zone. Fishers of the Margaree River feel that gaspereau can ascend to the lake within one to two days based on the synchrony of catches between lower and upper traps. Gaspereau can ascend the river more quickly if there are no traps in the river and no fishing activity to deter their upstream migrations.

3) What is the conservation definition for gaspereau?

Minimum spawning stock biomass as a conservation definition for the Margaree River gaspereau has not been defined. There are indications from estimates of escapements and returns in previous years that escapements to the lake less than one million fish result in a high probability of producing recruitments less than two million fish. Recruitment to the river from combined year-classes has frequently exceeded 10 million fish. Year-class production can attain 8 to 10 million fish. One threshold reference point (conservation) has been defined as the spawning stock which produces less than half of maximum recruitment (Mace 1994). A conservation limit of one million fish would not be an unreasonable threshold level.

Fixed harvest rates have been suggested as more appropriate for ensuring the sustainability of fisheries (Hilborn and Walters 1992; Walters and Pearse 1996). For the Margaree gaspereau fishery, an exploitation rate of 0.32 to 0.4 would be appropriate. A fixed harvest rate strategy would take advantage of large recruitments and increase the spawning escapement. Harvests would also increase when recruiment is large but the challenge is to ensure that exploitaiton rates on low runs to the river do not exceed the levels defined under F_{opt}.

4) What is the prognosis for 1997 to 2000?

Reduced escapements in 1991 to 1996 are not expected to produce any large recruitment over the next five years. There is always a chance that a large year-class may result from a low spawning escapement as was observed for the 1990 year-class.

5) What are the harvest expectations for this stock?

Had the stock been exploited at the F_{opt} level of 0.4 between 1983 and 1995, harvests would have been reduced by half. The large oscillations observed in the landings are in part due to overexploitation. That overexploitation has occurred is evident from the large dependence of the runs on first time spawners and the high proportion of the cohorts which are harvested before ever having spawned. If recruitments observed in the last 14 years are an indication of the levels in the future, harvests as high as 800 t would be expected. This harvest level could be achieved by fewer fishers fishing fewer days per week as in 1996.

6) What is required to improve the assessment of this stock?

Estimates of returns and escapements are based on cohort summation, depletion estimates from logbook catch rates and an associaton between spawning escapement (from cohort summations) and a larval index. An independent estimate of the spawning escapement for the current year would be used to verify the appropriateness of the larval survey as an index of escapement and to directly estimate the exploitation rate in the fishery. A counting fence was successfully operated in 1979 but not so in 1983. Mark and recapture estimates could be considered to estimate the escapement into the lake. The estimates of escapement should be combined with the larval survey and sampling of the commercial catches.

References

Alexander, D.R. MS1984. Status of the Margaree River gaspereau fishery (1983). CAFSAC Res. Doc. 84/17. 14p.

Alexander, D.R. and A.H. Vromans. MS1985. Status of the Margaree River gaspereau fishery (1984). CAFSAC Res. Doc. 85/91. 17p.

Alexander, D.R. and A.H. Vromans. MS1986. Status of the Margaree River gaspereau fishery (1985). CAFSAC Res. Doc. 86/31. 17p.

Alexander, D.R. and A.H. Vromans. MS1987. Status of the Margaree River gaspereau fishery (1986). CAFSAC Res. Doc. 87/18. 17p.

Alexander, D.R. and A.H. Vromans. MS1988. Status of the Margaree River alewife (*Alosa pseudoharengus*) fishery 1987. CAFSAC Res. Doc. 88/25. 25p.

Chaput, G.J. MS1993. Assessment of the Margaree River gaspereau fisheries, 1991 and 1992. DFO Atlantic Fisheries Res. Doc. 93/19.

Chaput, G.J. and D.R. Alexander. MS1989. Mortality rates of alewife in the southern Gulf of St. Lawrence. CAFSAC Res. Doc. 89/38.

Chaput, G.J. and C.H. LeBlanc. MS1989. Assessment of the Margaree River gaspereau fishery, 1988. CAFSAC Res. Doc. 89/29.

Chaput, G.J. and C.H. LeBlanc. MS1990. Assessment of the Margaree River gaspereau fishery, 1989. CAFSAC Res. Doc. 90/33.

Chaput, G.J., C.H. LeBlanc, and G. Nielsen. MS1991. Assessment of the Margaree River gaspereau fishery, 1990. CAFSAC Res. Doc. 91/12.

Claytor, R.R., P. LeBlanc, R. Jones, and G. Chaput. MS1995. Status of gaspereau in the Margaree River 1993 and 1994. DFO Atlantic Fisheries Res. Doc. 95/64.

Crawford. R.H. 1983. The gaspereau fishery of the S.W. Margaree River, 1983. Nova Scotia Department of Fisheries. 16p.

Crawford, R.H. 1986. Larval gaspereau abundance in Lake Ainslie and the recruitment process. Nova Scotia Department of Fisheries. 20p.

Crawford, R. 1996. Status of larval gaspereau abundance in Lake Ainslie 1983-1996. Nova Scotia Department of Fisheries.

Crawford, R. and D. Tully. 1989. The biology of gaspereau from Pictou Harbour, Nova Scotia. Marine Resource Division, Nova Scotia Department of Fisheries. 41p.

Hilborn, R. and C.J. Walters. 1992. Quantitative Fisheries Stock Assessment: choice dynamics, and uncertainty. Chapman and Hall.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. U.S. Vol. 81:898-902.

Jensen, A.L. 1996. Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Can. J. Fish. Aquat. Sci. 53: 820-822.

Mace. P.M. 1994. Relationships between common biological reference points used as thresholds and targets of fisheries management strategies. Can. J. Fish. Aquat. Sci. 51:110-122.

O'Neil, J.T. 1980. Aspects of the life histories of anadromous alewife *Alosa pseudoharengus* (Wilson), and the blueback herring, *A. aestivalis* (Mitchell) in the Southwest Margaree River and Lake Ainslie, Nova Scotia, 1978-1979. M.Sc. Thesis, Acadia University, Wolfville, Nova Scotia.

Rivard, D. 1982. APL programs for stock assessment. Can. Tech. Rep. Fish. Aquat. Sci. No. 1091. 146 p.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Bull. Fish. Res. Board Can. No. 184. 966p.

Walters, C. and J.-J. Maguire. 1996. Lessons for stock assessment from the northern cod collapse. Reveiws in Fish Biology and Fisheries 6: 125-137.

Walters, C. and P.H. Pearse. 1996. Stock information requirements for quota management systems in commercial fisheries. Reviews in Fish Biology and Fisheries 6:21-42.

Table 1. Potential effort (hours) by a single trap in the lower zone and in the upper zone for the AM (500 to 1200) and PM periods (1200 to 2200) relative to the management plans.

	Lower		Upper		
	AM	PM	AM	PM	Total
Pre-1984					
Monday	7	10	7	10	
Tuesday	7	10	7	10	
Wednesday	7	10	7	10	
Thursday	7	10	7	10	
Friday	7	10	7	10	
Saturday	7	10	7	10	
Sunday	7	10	7	10	
					238
1984 to 1991					
Monday	7	10	4	10	
Tuesday	7	10	7	10	
Wednesday	7	10	7	10	
Thursday	7	10	7	10	
Friday	7	6	7	10	
Saturday	0	0	7	6	
Sunday	4	10	0	0	
					190
1992 to 1995					
Monday	0	9	7	10	
Tuesday	7	10	7	1	
Wednesday	7	1	7	10	
Thursday	7	10	0	9	
Friday	0	9	7	10	
Saturday	7	10	7	1	
Sunday	7	1	7	10	
					178
1996					
Monday	0	0	0	0	
Tuesday	0	0	0	0	
Wednesday	0	0	0	0	
Thursday	7	1	7	10	
Friday	7	10	0	9	
Saturday	0	9	7	10	
Sunday	7	10	7	1	
					102

Table 2. Margaree River, N.S. gaspereau fishery fishing schedule for the 1995 and 1996 season. AM fisheries open at sunrise and close at 13:00 the same day. PM fisheries open at 13:00 and close at dusk. Full day fisheries are open from sunrise to dusk. During the 1996 season each the lower and upper zone were closed from sunrise to dusk for three consecutive days.

		1996		1995	
	Week	Lower	Upper	Lower	Upper
May 1	1	AM	Full	AM	Full
2	1	Full	PM	Full	PM
3	1	PM	Full	PM	Full
4	1	Full	AM	Full	AM
5	1	Closed	Closed	AM	Full
6	1	Closed	Closed	Full	PM
7	1	Closed	Closed	PM	Full
8	2	PM	Full	Full	AM
9	2	Full	AM	AM	Full
10	2	AM	Full	Full	PM
11	2	Full	PM	PM	Full
12	2	Closed	Closed	Full	AM
13	2	Closed	Closed	AM	Full
14	2	Closed	Closed	Full	PM
15	3	Full	AM	PM	Full
16	3	AM	Full	Full	AM
17	3	Full	PM	AM	Full
18	3	PM	Full	Full	PM
19	3	Closed	Closed	PM	Full
20	3	Closed	Closed	Full	AM
21	3	Closed	Closed	AM	Full
22	4	Full	PM	Full	PM
23	4	PM	Full	PM	Full
24	4	Full	AM	Full	AM
25	4	AM	Full	AM	Full
26	4	Closed	Closed	Full	PM
27	4	Closed	Closed	PM	Full
28	4	Closed	Closed	Full	AM
29	5	AM	Full	AM	Full
30	5	Full	PM	Full	PM
31	5	PM	Full	PM	Full

		1996		1995	
	Week	Lower	Upper	Lower	Upper
June 1	5	Full	AM	Full	AM
2	5	Closed	Closed	AM	Full
3	5	Closed	Closed	Full	PM
4	5	Closed	Closed	PM	Full
5	6	PM	Full	Full	AM
6	6	Full	AM	AM	Full
7	6	AM	Full	Full	PM
8	6	Full	PM	PM	Full
9	6	Closed	Closed	Full	AM
10	6	Closed	Closed	AM	Full
11	6	Closed	Closed	Full	PM
12	7	Full	AM	PM	Full
13	7	AM	Full	Full	AM
14	7	Full	PM	AM	Full
15	7	PM	Full	Full	PM
16	7	Closed	Closed	PM	Full
17	7	Closed	Closed	Full	AM
18	7	Closed	Closed	AM	Full
19	8	Full	PM	Full	PM
20	8	PM	Full	PM	Full
21	8	Full	AM	Full	AM
22	8	AM	Full	AM	Full
23	8	Closed	Closed	Full	PM
24	8	Closed	Closed	PM	Full
25	8	Closed	Closed	Full	AM
26	9	AM	Full	AM	Full
27	9	Full	PM	Full	PM
28	9	PM	Full	PM	Full
29	9	Full	AM	Full	AM
30	9	Closed	Closed	AM	Full

Table 3. Historic harvests of gaspereau from Statistical District 2, from the Margaree River and total licenses and active licenses.

		Landings (metric tons)				Total	Active	Logbooks
	Year	District 2		Margaree River		Licenses	Licenses	Returned
	1950	713						
	1951	755						
	1952	964						
	1953	638						
	1954	1,275						
	1955	1,163						
	1956	859						
	1957	58						
	1958	395						
	1959	496						
	1960	531						
	1961	423						
	1962	558						
	1963	551						
	1964	640						
	1965	875						
	1966	320						
	1967	185						
	1968	188						
	1969	251						
	1970	408						
	1971	620				21		
	1972	965				25		
	1973	1,113				27		
	1974	1,681				37		
	1975	1,238				61		
	1976	497				44		
	1977	1,202				39		
	1978	1,713				62		
	1979	1,776				81		
	1980	1,069				82		
	1981	1,369				75		
	1982	1,445				67		
	1983	580				69	44	9
	1984	883	*	883	*	68	45	42
	1985	1,223	*	1,223	*	68	25	18
	1986	623	*	545	*	68	33	13
	1987	1,259	*	1,259	*	68	33	23
0.871339	1988	1,912		1,666	*	69	38	35
0.745684	1989	1,506		1,123	*	59	41	32
1	1990	1,016	*	1,016	*	62	41	30
0.702028	1991	641		450	*	62	32	20
0.896272	1992	617		553	*	62	27	14
0.917706	1993	802		736	*	60	37	17
1	1994	498	*	498	*	59	36	18
1	1995	217	*	217	*	59	33	13
0.895238	1996	105	*	94	*	59	24	7

* Estimates from Science Branch

Table 4. Gaspereau landings from Margaree River, Nova Scotia (NS), New Brunswick (NB), and Prince Edward Island (PEI) statistical districts from 1978 to 1996. Data are summarized from purchase slip and supplementary "B" slips compiled by Statistics Branch. Asterisk indicate values compiled by Science Branch.

		Nova Scotia Statistical Districts										
Year	Margaree	2	3	11	12	13	45	46	NS	NB	PEI	Gulf
1978		1713	5	36	7	32	118	0	1911	3084	104	5099
1979		1776	0	114	9	49	74	0	2024	4409	405	6837
1980		1069	0	910	21	80	76	12	2167	4676	253	7097
1981		1369	1	61	13	78	103	30	1653	2708	259	4620
1982		1446	0	29	18	34	115	21	1664	1994	133	3790
1983		580	0	144	27	16	10	3	780	1901	36	2717
1984	883*	883	0	78	7	85	0	0	1052	1717	88	2857
1985	1,223*	1223	0	0	1854	100	26	0	3203	3569	238	7011
1986	545*	623	0	161	32	236	0	0	1052	2261	464	3699
1987	1,259*	1259	0	848	59	128	122	144	2559	4419	364	7342
1988	1,911*	1912	-	570	120	225	-	8	2835	3714	233	6782
1989	1,506*	1506	-	245	148	130	75	12	2116	3681	133	5929
1990	1,016*	1016	-	226	1	202	33	26	1504	3196	84	4784
1991	450*	641	0	218	60	110	1	40	1070	3554	87	4711
1992	553*	617	-	101	20	23	-	11	772	3454	318	4544
1993	736*	802	-	73	40	24	0	12	951	3573	198	4722
1994	498*	498	-	77	21	10	-	11	617	3246	95	3958
1995	217*	217	-	25	7	7	58	55	368	3230	34	3632
1996	94*	105	-	1	4	7	99	49	265	1828	53	2051

Table 5. Dates, sites, periods and numbers of fish sampled in 1995 and 1996 for the Margaree River, N.S. gaspereau fishery. Boxes define sample groupings for age-length keys.

		1995						1996					
		Lower			Upper			Lower			Upper		
		Site	Period	No.	Site	Period	No.	Site	Period	No.	Site	Period	No.
May	11												
	12												
	13												
	14												
	15												
	16												
	17								12 PM	45			
	18												
	19												
	20												
	21												
	22	5,12 AM		200	41 PM		69		12,26 AM	229			
	23	2 PM		239	38 AM		20		26 PM	261	37 AM		279
	24	17 PM		239	41,49 AM		247		12 PM	272			
	25	26 AM		259	38,52,60 PM		238						
	26				38 PM		93						
	27	5 PM		65	33 PM		189						
	28	15 AM		250									
	29	2,5 AM		230	49 AM		114		5 AM	67			
	30	17,26 PM		216	33 PM		98						
	31	1 PM		242	41,52,60 AM		208						
June	1	1 PM		238	37 AM		229	June	1	26 PM	311		
	2	26 AM		231	41,49 AM		234		2				
	3	1,2 AM		230					3				
	4	8 PM		130	60 PM		31		4				
	5	1 AM		222	41,52,60 AM		74		5	2 PM	633	35,38 AM,PM	450
	6	26 AM		268	35,41 AM		146		6				
	7	5 PM		258	37 PM		52		7				
	8	26 PM		287	52 PM		262		8	2,5 AM	218		
	9	12 AM		240	38,52,60 AM		133		9				
	10	26 AM		210	41 PM		257		10				
	11	1 PM		254	41,49 PM		149		11				
	12	1 PM		199	35,52 PM		227		12				
	13	12 AM		33	41 AM		99		13				
	14	17 AM		18					14				
	15								15				
	16	2 PM		234					16				
	17	12 AM		85					17				
	18	17 AM		195					18				
	19				41 PM		131		19				
				5272			3300			2162			729

Table 6. Dates of maximum and cumulative landings for the Margaree River, N.S. during 1983 - 1996.

Year	Maximum Catch	Cumulative 10%	Cumulative 50%	Cumulative 90%	Total Days For 10% to 90%	Logbook Catch (mt)	Estimated Landings (mt)
1983	May 17	May 10	May 17	May 24	15	113	579
1984	May 17	May 16	May 21	May 28	12	637	883
1985	May 30	May 21	May 28	June 02	12	506	1223
1986	May 17	May 09	May 17	May 26	15	213	545
1987	May 13	May 12	May 16	May 26	15	882	1259
1988	May 22	May 17	May 23	May 29	13	1375	1666
1989	May 18	May14	May 19	May 23	10	973	1123
1990	June 04	May 13	May 29	June 04	22	780	1016
1991	May 31	May 18	May 28	May 31	13	208	450
1992	June 02	May 24	June 01	June 04	12	359	553
1993	May 23	May 18	May 27	June 05	19	439	736
1994	May 19	May 19	May 29	June 05	18	273	498
1995	June 10	May 25	June 06	June 12	19	83	217
1996	May 23	May 23	May 23	June 06	15	20	94

Table 7. Alewife catch-at-age for the Margaree River, N.S. gaspereau fishery. First number in age indicates total age, second number indicates age at first spawning. Numbers are in 1000s of fish. PS=Previous spawners; YC=year-class.

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
2.2	0	0	25	2	0	0	1	0	6	5	0	0	0	1
3.3	713	2601	447	1262	4400	2479	120	2806	422	1774	2460	19	345	73
3.2	2	0	107	16	0	0	0	0	0	3	0	2	0	0
Total 3	715	2601	554	1278	4400	2479	120	2806	422	1776	2460	20	345	73
4.4	371	428	3070	235	434	1431	2444	281	1283	188	565	1448	115	243
4.3	397	258	920	159	429	2355	1236	54	41	133	151	240	31	86
4.2	0	0	0	0	10	0	0	0	0	0	6	0	0	0
Total 4	768	687	3990	394	873	3786	3680	335	1324	321	722	1688	146	329
5.5	0	0	0	0	0	0	1	36	35	0	8	17	8	6
5.4	157	35	205	372	131	267	186	628	56	47	40	63	209	13
5.3	334	185	41	129	19	160	181	244	55	97	21	82	89	3
Total 5	491	221	245	501	149	428	368	908	146	144	69	162	306	22
6.6	0	0	0	0	0	0	0	0	0	0	0	0	0	1
6.5	5	1	1	7	0	0	0	1	0	0	0	1	3	0
6.4	45	20	6	11	181	0	11	23	19	1	7	7	5	13
6.3	52	4	27	6	5	7	6	55	20	2	7	4	0	7
Total 6	103	26	34	23	186	7	17	79	39	3	14	11	8	21
7.5	0	0	0	0	0	0	0	0	1	0	0	0	0	1
7.4	0	4	0	4	0	0	0	4	1	0	0	0	0	1
7.3	18	1	3	0	0	0	0	3	1	0	0	0	0	0
Total 7	18	5	3	4	0	0	0	7	3	0	0	0	0	1
8.4	3	4	1	0	0	0	0	0	0	0	0	0	0	0
8.3	3	1	0	0	0	0	0	0	0	0	0	0	0	0
Total 8	5	5	1	0	0	0	0	0	0	0	0	0	0	0
9.4	0	43	0	0	0	0	0	0	0	0	0	0	0	0
9.3	5	0	0	0	0	0	0	0	0	0	0	0	0	0
Total 9	5	43	0	0	0	0	0	0	0	0	0	0	0	0
Total	2105	3588	4852	2202	5608	6700	4186	4135	1940	2249	3265	1881	805	447
% PS	49	15	27	32	14	42	39	24	10	13	7	21	42	28
Major YC	79	81	81	83	84	84	85	87	87	89	90	90	92	92
% of Total	36	72	82	58	78	57	88	68	68	79	75	90	18	74
Landings (t)	580	883	1223	545	1259	1666	1123	1016	450	553	736	498	217	94
Weight (kg) perfish	0.276	0.246	0.252	0.248	0.225	0.249	0.268	0.246	0.232	0.246	0.225	0.265	0.270	0.210

Table 8. Blueback catch-at-age for the Margaree River, N.S. gaspereau fishery. First number in age indicates total age, second number indicates age at first spawning,. Numbers are in 1000s of fish. PS=Previous spawners; YC=year-class.

Age	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
1.1	0	0	0	0	0	0	0	0	0	0	0	0		
3.3	0	0	0	0	1	2	0	13	49	94	40	0		
3.2	0	1	1	0	0	0	0	0	0	0	0	0		
Total 3	0	1	2	0	1	2	0	13	49	94	40	0		
4.4	0	0	7	1	2	25	5	0	39	12	3	3		
4.3	0	4	11	0	0	5	0	0	10	0	5	4		
4.2	0	1	3	0	0	0	0	0	0	0	0	0		
Total 4	0	5	21	1	2	30	6	0	50	12	8	7		
5.5	0	0	0	0	0	0	14	1	10	0	0	5		
5.4	0	0	2	1	0	2	35	46	0	1	1	5		
5.3	0	3	4	0	0	0	1	1	0	2	0	0		
5.2	0	1	0	0	0	0	0	0	0	0	0	0		
Total 5	0	4	5	2	0	2	50	47	10	3	1	9		
6.5	0	0	0	0	0	0	1	2	0	0	0	0		
6.4	6	0	7	1	2	0	1	4	6	0	0	0		
6.3	6	2	0	1	0	0	0	0	0	0	0	0		
Total 6	13	2	7	1	2	0	2	5	6	0	0	0		
7.5	0	0	0	0	0	0	0	0	1	0	0	0		
7.4	0	0	0	0	0	0	0	1	2	0	0	0		
7.3	0	0	0	0	1	0	0	0	0	0	0	0		
Total 7	0	0	0	0	1	0	0	1	3	0	0	0		
8.4	0	0	0	0	1	0	0	0	0	0	0	0		
8.3	0	0	1	0	0	0	0	0	0	0	0	0		
Total 8	0	0	1	0	1	0	0	0	0	0	0	0		
9.4	0	0	0	0	0	0	0	0	0	0	0	0		
10.4	0	0	0	0	0	0	0	0	0	0	0	0		
Total	13	12	37	4	6	34	57	67	118	109	49	16	79	16
% PS	99	94	80	81	55	21	66	79	16	3	11	52	.	.
Major YC	79	81	81	83	84	84	85	87	87	89	90	90	.	.
% of Total	97	42	57	40	33	89	87	71	42	86	81	58	.	.

Table 9. Percent female at age and mean ovary weight of migrating alewife in the Margaree River, 1995 and 1996.

Age		Percent female			
		1995		1996	
Total	FSP	female	N	female	N
2	2			20.0%	5
3	3	30.1%	528	26.1%	111
4	3	22.2%	45	29.1%	55
5	3	55.2%	145	0.0%	1
6	3			37.5%	8
4	4	60.7%	140	68.9%	180
5	4	69.5%	370	72.7%	11
6	4	85.7%	14	66.7%	15
7	4	100.0%	1	100.0%	1
5	5	75.0%	12	83.3%	6
6	5	85.7%	7		
7	5			100.0%	1
6	6			100.0%	2

Age	Ovary Weight			
	1995		1996	
Total	Grams	N	Grams	N
2			23.7	5
3	31.8	161	35.6	107
4	44.4	95	46.9	234
5	61.3	348	54.5	17
6	59.6	18	69.6	25
7	75.5	1	70.1	2

Table 10. Exploitation histories of the 1979 to 1993 year-classes in the Margaree River gaspereau fishery. Percentage of the year-class harvested as first time spawners (new recruitment) is based on summation of the catch-at-age matrix and therefore reresents a maximum value. No adjustments are made for natural mortality.

YEAR CLASS		3 Year Olds	4 Year Olds	5 Year Olds	6 Year Olds	7 Year Olds		% Harvest as New Recruitment
	Year							
		1982	1983	1984	1985	1986	SUM	% New Recruitment
1979	Catch (1000's)	?	768	221	34	4	1027	> 36
	New recruitment	?	371	0	0	0	371	
		1983	1984	1985	1986	1987	SUM	% New Recruitment
1980	Catch (1000's)	715	687	245	23	0	1670	68
	New recruitment	713	428	0	0	0	1141	
		1984	1985	1986	1987	1988	SUM	% New Recruitment
1981	Catch (1000's)	2601	3990	501	186	0	7278	78
	New recruitment	2601	3070	0	0	0	5671	
		1985	1986	1987	1988	1989	SUM	% New Recruitment
1982	Catch (1000's)	554	394	149	7	0	1104	62
	New recruitment	447	235	0	0	0	682	
		1986	1987	1988	1989	1990	SUM	% New Recruitment
1983	Catch (1000's)	1278	873	428	17	7	2596	65
	New recruitment	1262	434	0	0	0	1696	
		1987	1988	1989	1990	1991	SUM	% New Recruitment
1984	Catch (1000's)	4400	3786	368	79	3	8633	68
	New recruitment	4400	1431	1	1	1	5833	
		1988	1989	1990	1991	1992	SUM	% New Recruitment
1985	Catch (1000's)	2479	3680	908	39	0	7106	70
	New recruitment	2479	2444	36	0	0	4959	
		1989	1990	1991	1992	1993	SUM	% New Recruitment
1986	Catch (1000's)	120	335	146	3	0	604	72
	New recruitment	120	281	35	0	0	436	
		1990	1991	1992	1993	1994	SUM	% New Recruitment
1987	Catch (1000's)	2806	1324	144	14	0	4288	95
	New recruitment	2806	1283	0	0	0	4089	
		1991	1992	1993	1994	1995	SUM	% New Recruitment
1988	Catch (1000's)	422	321	69	11	0	823	75
	New recruitment	422	188	8	1	0	619	
		1992	1993	1994	1995	1996	SUM	% New Recruitment
1989	Catch (1000's)	1776	722	162	8	1	2669	88
	New recruitment	1774	564	17	0	0	2355	
		1993	1994	1995	1996		SUM	% New Recruitment
1990	Catch (1000's)	2460	1688	306	21		4475	88
	New recruitment	2460	1448	8	1		3917	
		1994	1995	1996			SUM	% New Recruitment
1991	Catch (1000's)	20	146	22			188	74
	New recruitment	19	115	6			140	
1992		1995	1996				SUM	% New Recruitment
	Catch (1000's)	345	329				674	87
	New recruitment	345	243				588	
1993		1996					SUM	% New Recruitment
	Catch (1000's)	73					73	100
	New recruitment	73					73	

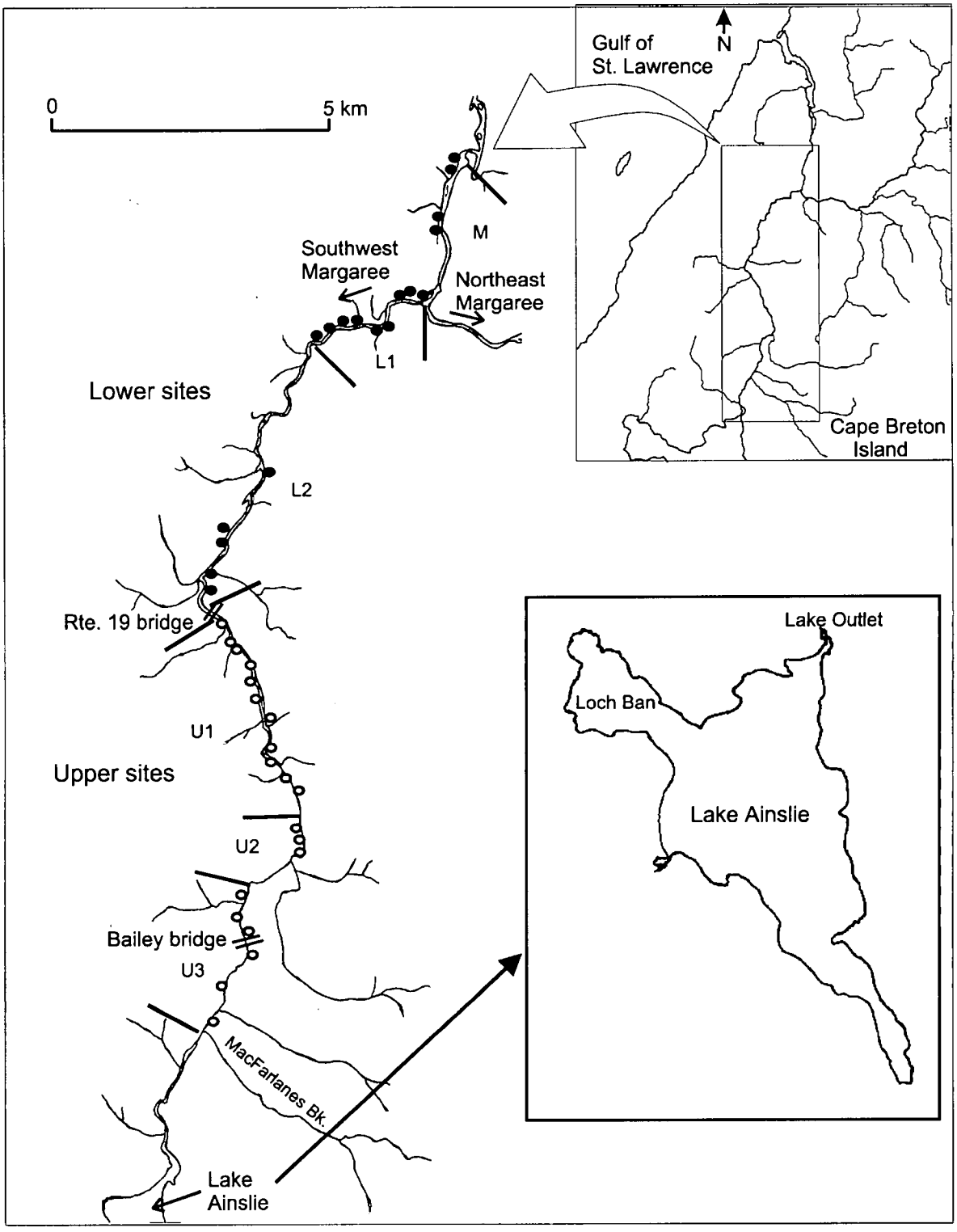


Figure 1. Gaspereau trap sites of the Margaree River and Lake Ainslie.

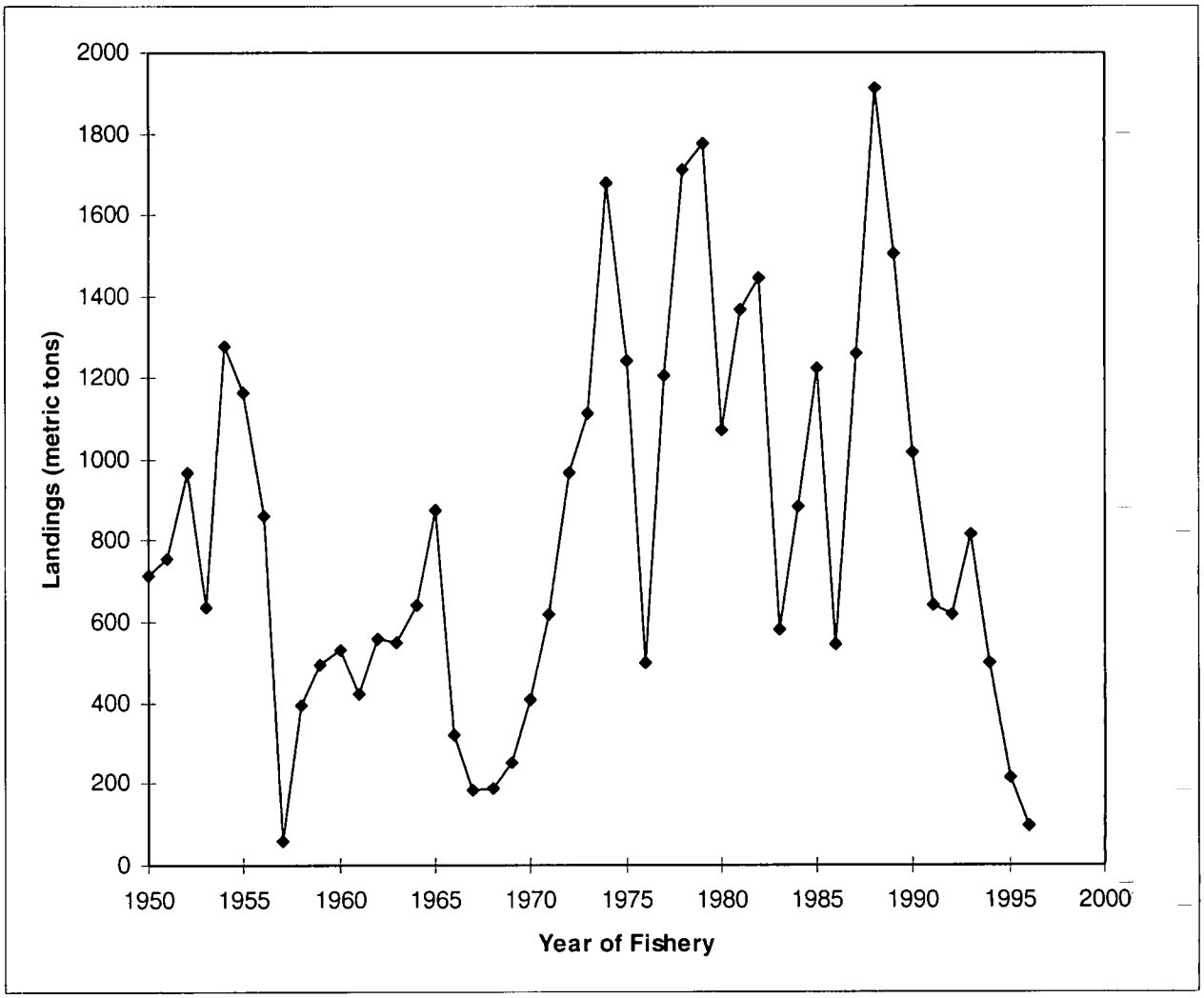


Figure 2. Historic landings (metric tons) of the District 2 gaspereau fishery, 1950 to 1996. The Margaree River fishery has represented between 70% and 100% of the District 2 landingsof gaspereau.

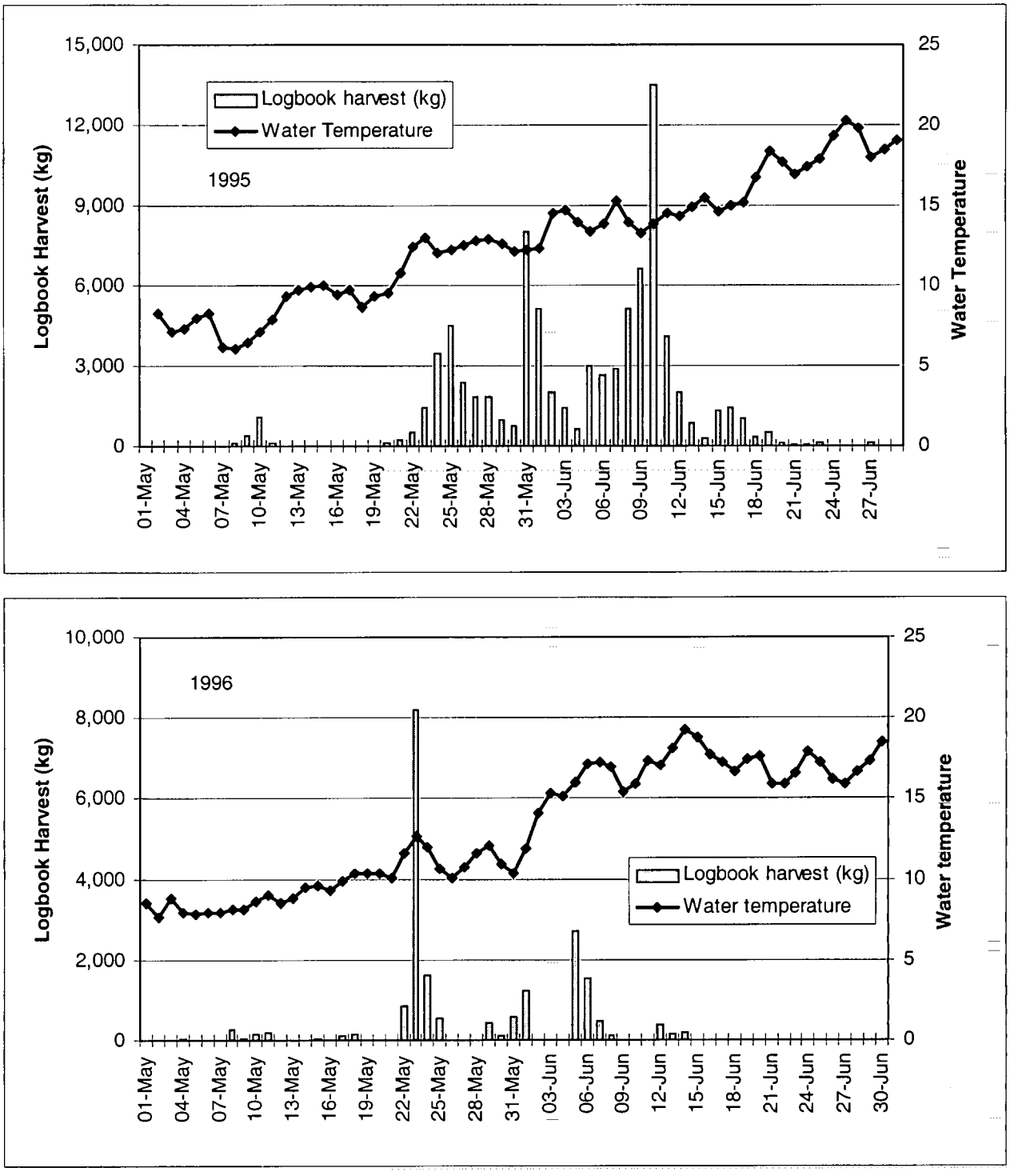


Figure 3. Daily harvests (kg) of gaspereau from the Margaree River as reported in logbooks during 1995 (upper) and 1996 (lower). Mean daily water temperatures from Loch Ban are also shown.

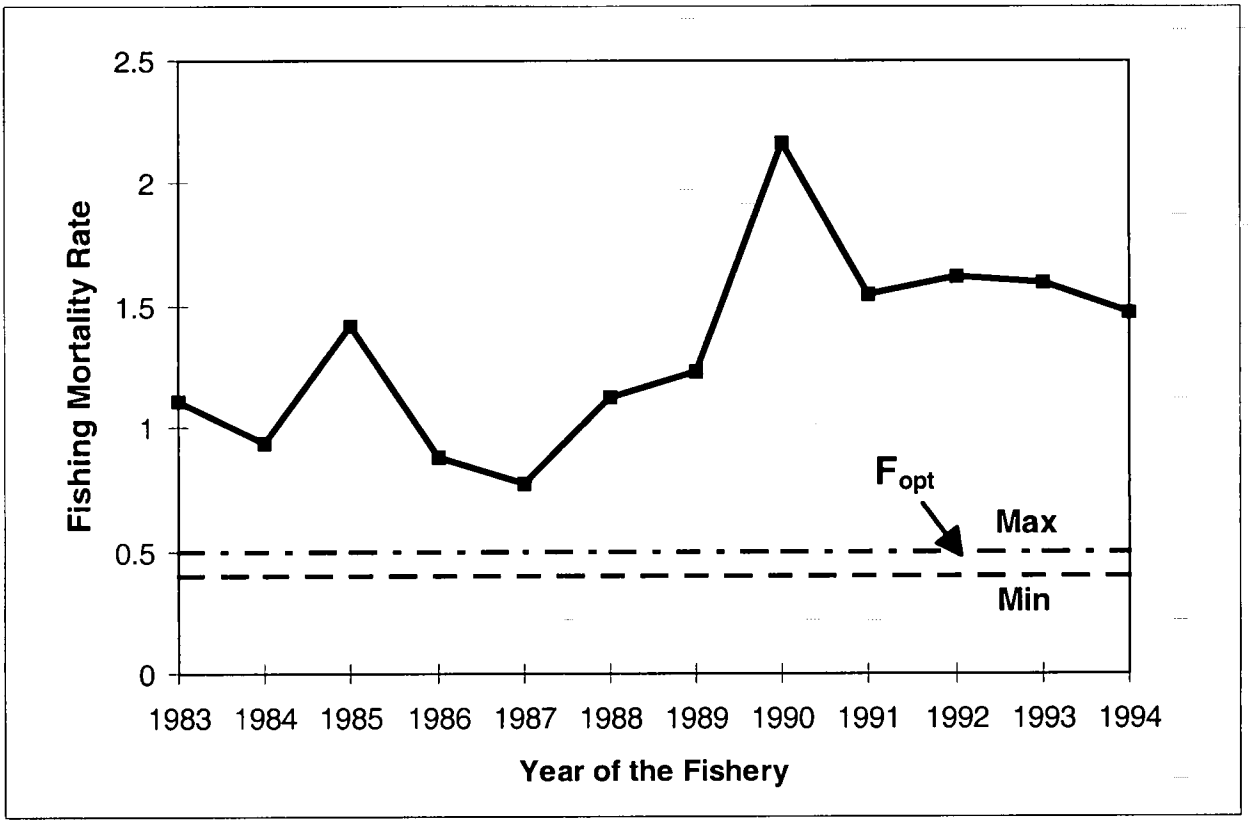
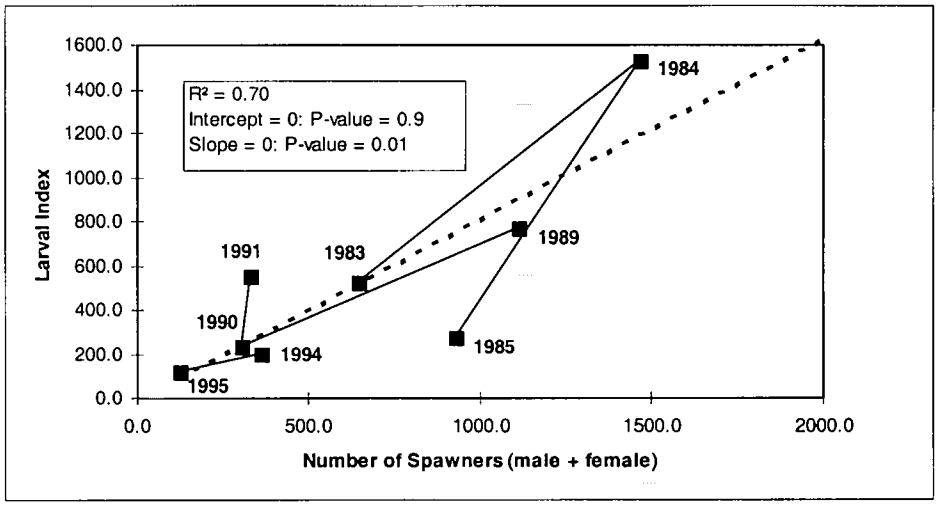
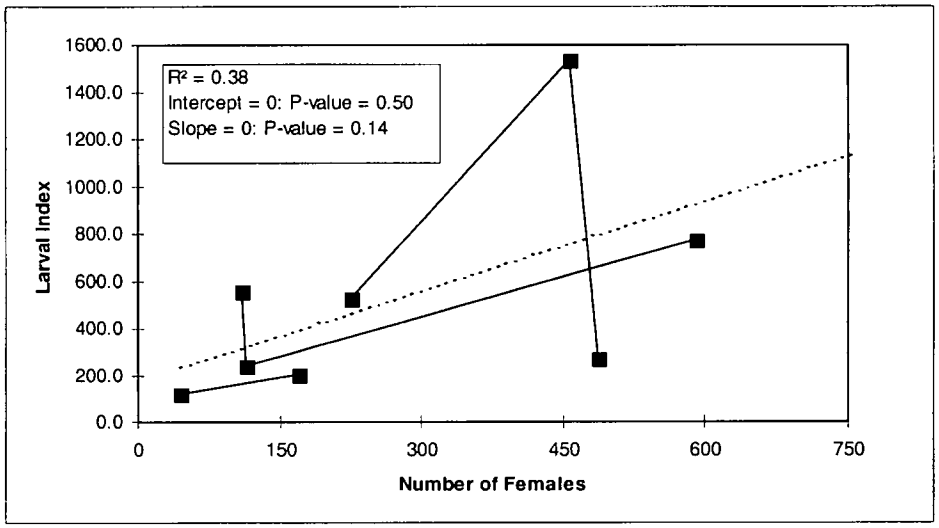


Figure 4. Estimates of the fishing mortality rate as calculated from backward summation of the catch at age matrix assuming M = 0.4. F_{opt} is defined as being equal to M (minimum F_{opt} = 0.4, maximum F_{opt} = 0.5).





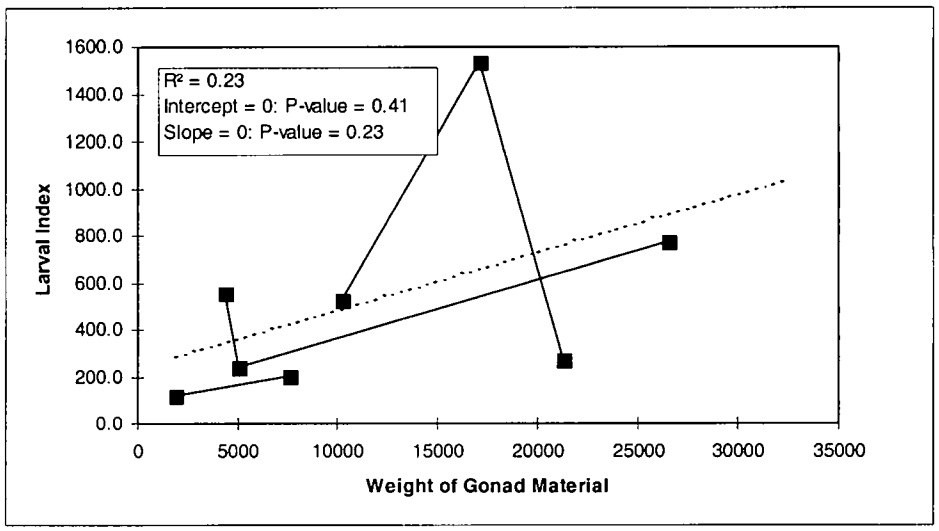


Figure 5. Relationship between larval index (number per 100 m3) in Lake Ainslie and spawning escapement for 1983 to 1985, 1989 to 1991, and 1994 to 1995.

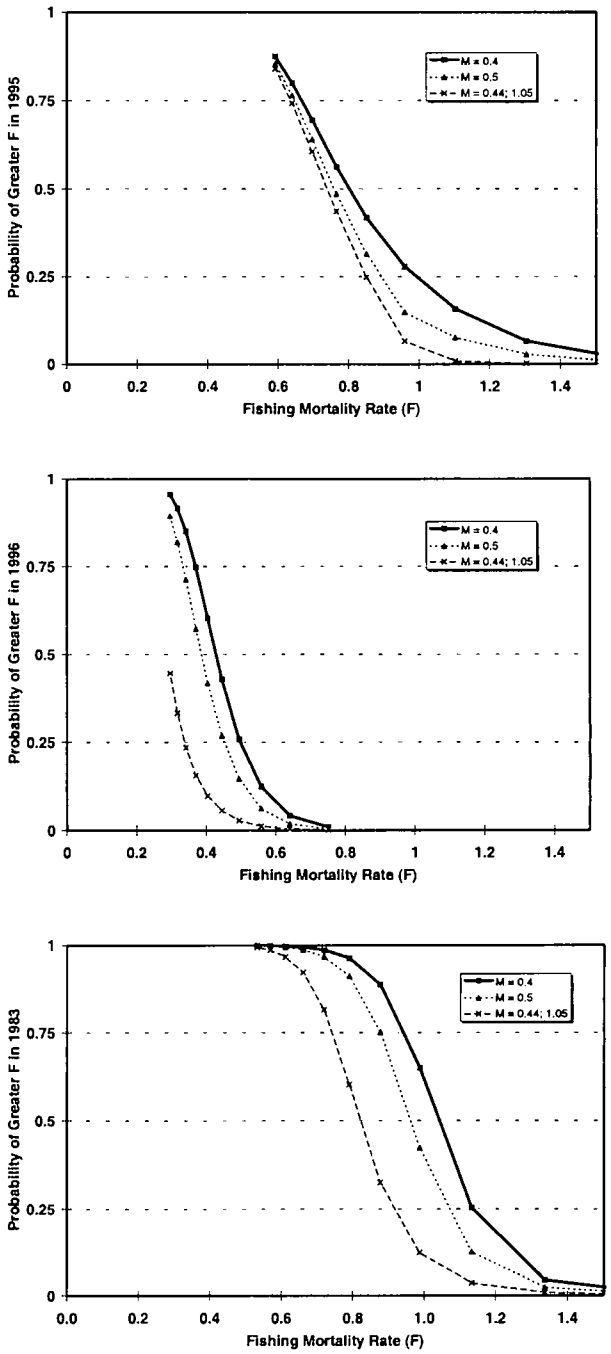


Figure 6. Bayes probability summaries of exploitation rates in the 1995, 1996 and for comparative purposes, the 1983 returns of gaspereau to the Margaree River. The spawning escapement was estimated by applying the relationship between spawners (from cohort summation) and the larval index for 1983 to 1985, 1989 to 1991, and 1994 to the larval index values for 1995 and 1996. The 1983 spawning escapement was estimated by excluding 1983 from the linear fit.

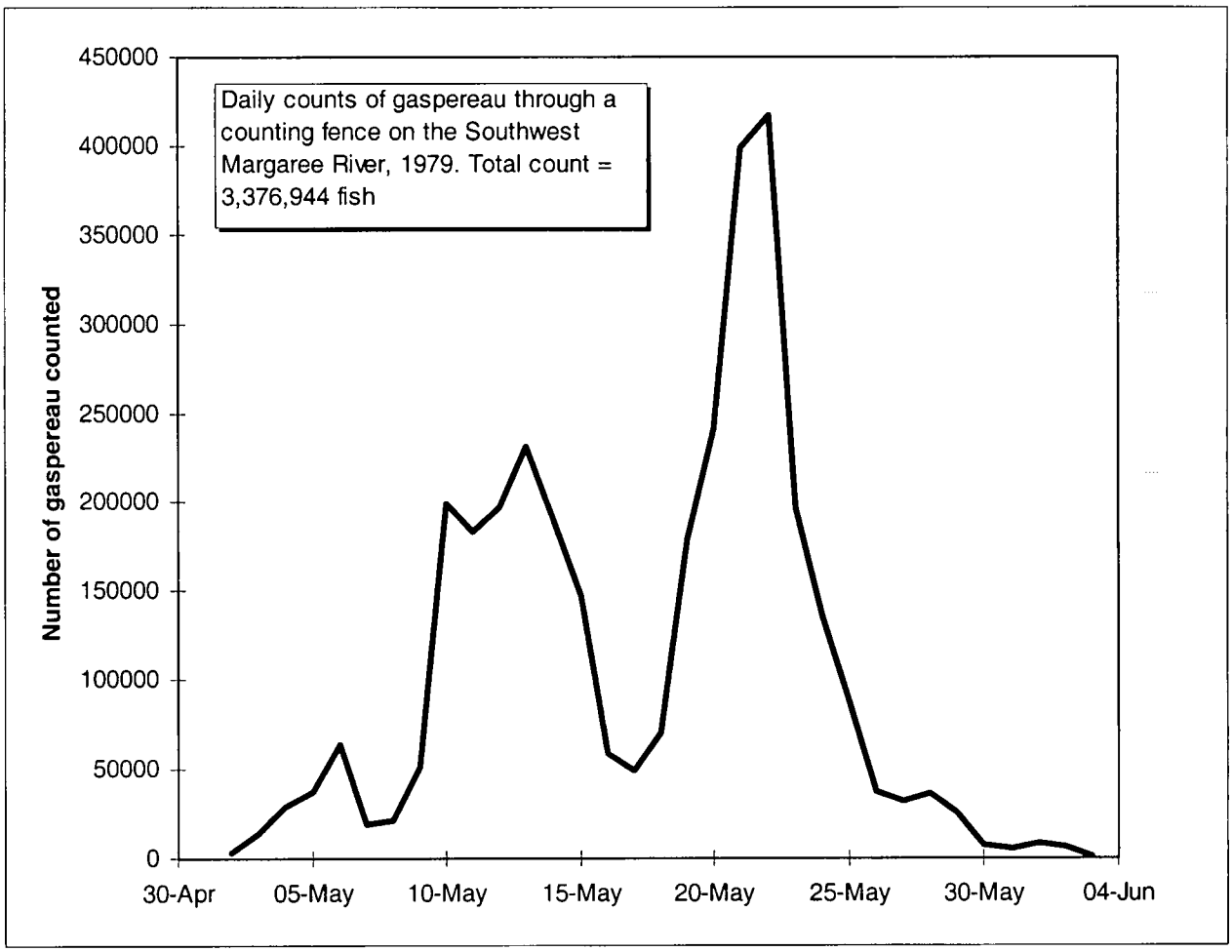


Figure 7. Daily counts of gaspereau through a counting fence at the outlet to Lake Ainslie, Margaree River, 1979. Data are from D. Morantz memo June 21, 1979 to B. Jessop.

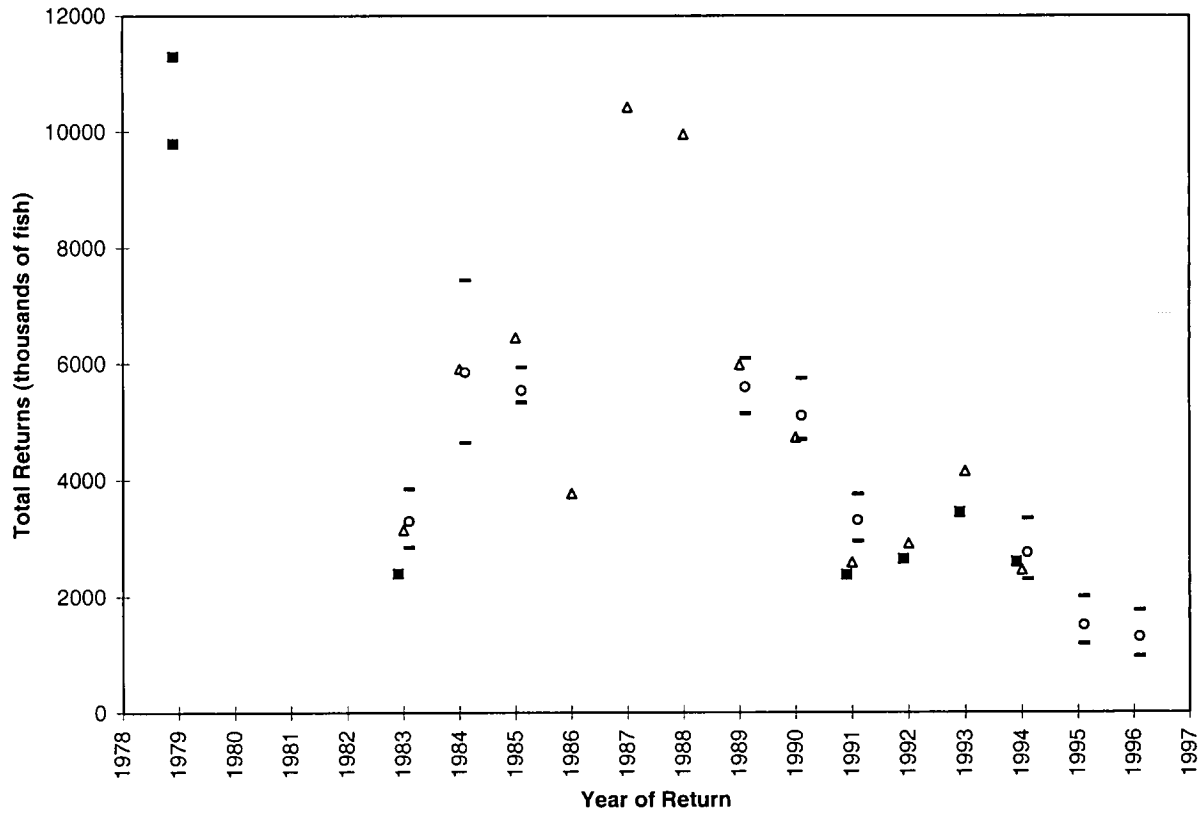
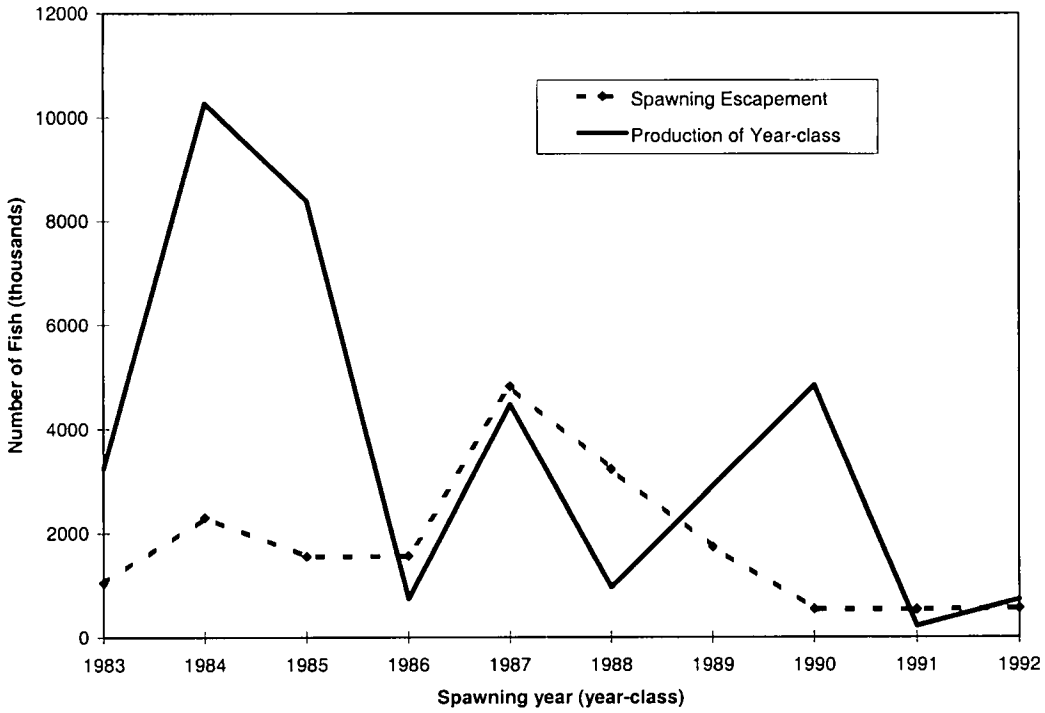


Figure 8. Estimated total returns of gaspereau to the Margaree River for 1979, 1983 to 1996. Methods used for estimation include: counting fence for 1979 and 1983 (squares), Leslie depletion estimates for 1991 to 1994 from Claytor et al. (1995) (squares), cohort summation at M = 0.4 for 1983 to 1994 (open triangles), and Bayes estimates of returns on the cohort summation of spawners relative to larval index for 1983 to 1985, 1989 to 1991, 1994 to 1996 (open circles = median, dashes ae the 5th to 95th percentiles from Bayes).



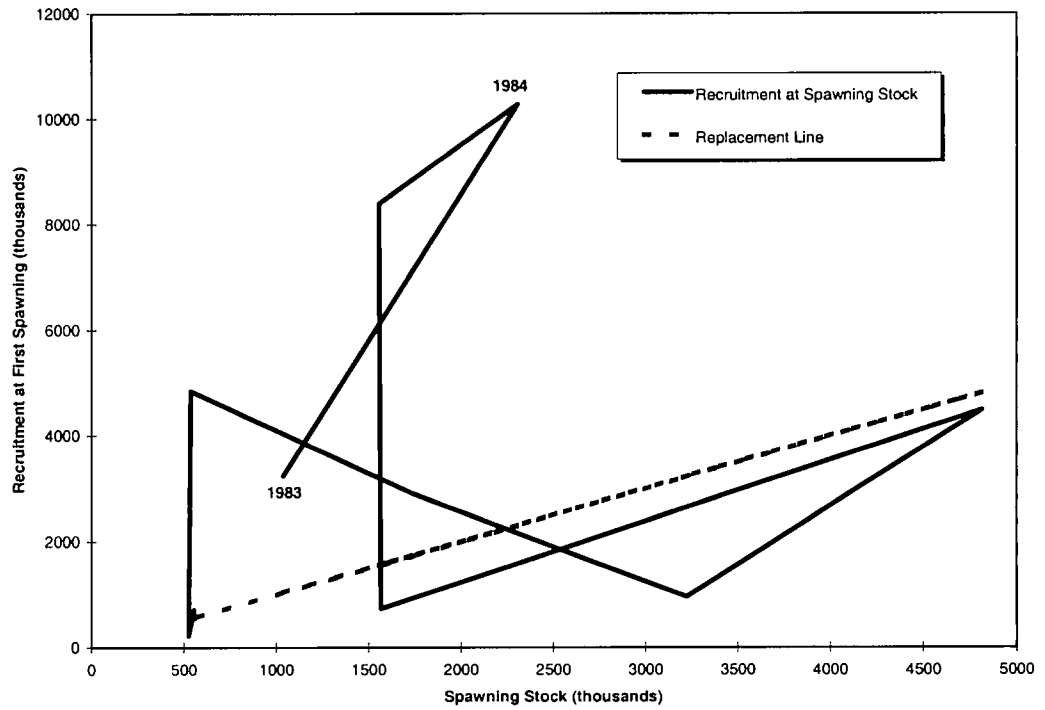


Figure 9. Recruitment at spawning stock for gaspereau from the Margaree River. Estimates of spawning stock and recruitment were obtained from cohort summation assuming M = 0.4.

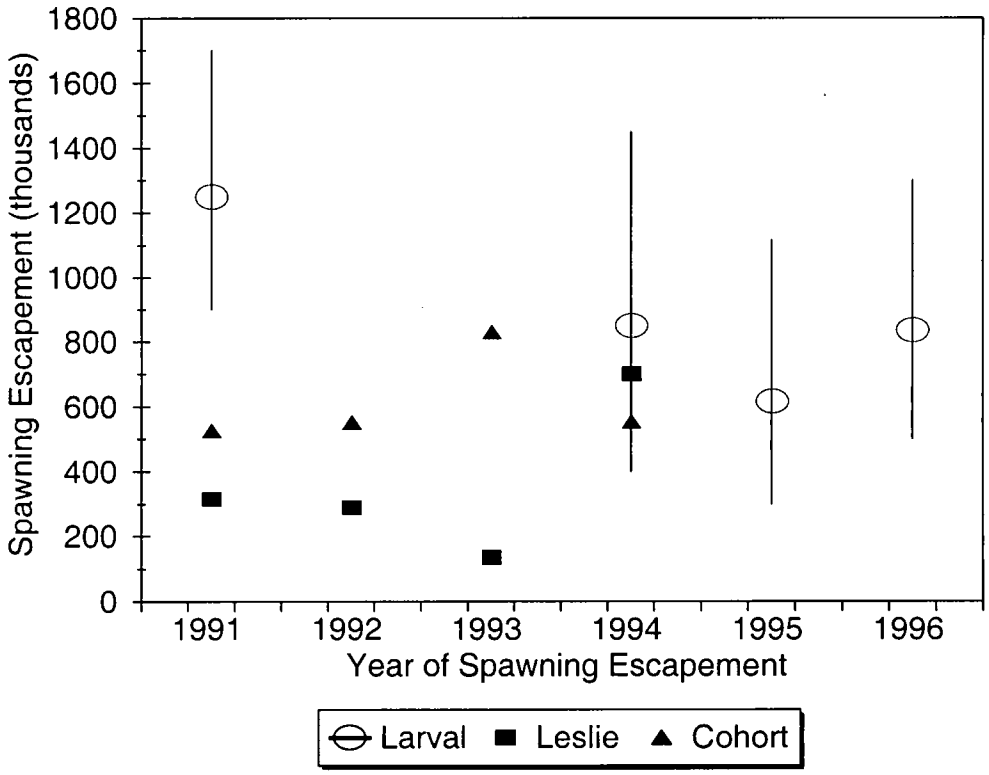


Figure 10. Estimated spawning escapement to Lake Ainslie (Margaree River) for 1991 to 1996. The vertical line in the open circles defines the 5th to 95th percentile range from Bayes analysis. Other symbols are similar to Figure 8.