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Homing of Alewives (Alosa pseudoharengus) and Blueback Herring (A. aestivalis) to and within the Saint John River, New Brunswick, as indicated by Tagging Data

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HOMING OF ALEWIVES (*Alosa pseudoharengus*) AND BLUEBACK HERRING (*A. aestivalis*) TO AND WITHIN THE SAINT JOHN RIVER, NEW BRUNSWICK, AS INDICATED BY TAGGING DATA

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Results of a series of tagging studies conducted in the Saint John River, New Brunswick, indicate that alewives and blueback herring return with accuracy not only to the home river but also to natal areas within the river. Straying by upstream-destined migrants was most pronounced in downstream areas. Tag recovery rates declined with time. Most tagged fish were recaptured within three years after release but a few were caught after five years. Some adult alewives migrate annually as far south as North Carolina at mean rates of 17 $km \cdot day^{-1}$. Within-river migration rates were estimated at 8-21 $km \cdot day^{-1}$. Where geographically separated populations exist, such as in the Saint John River, alewives and blueback herring are best managed on a population-specific basis rather than on a mixed stock basis.

Résumé

Jessop, B. M. 1994. Homing of alewives (Alosa pseudoharengus) and blueback herring (A. aestivalis) to and within the Saint John River, New Brunswick, as indicated by tagging data. Canadian Tech. Rep. Fish. Aquat. Sci. No. 2015: 22p.

Les résultats d'une série d'opérations de marquage réalisées dans la rivière Saint-Jean, au Nouveau-Brunswick, reflètent assez fidèlement les montaisons de gaspareaux et d'aloses d'été, non seulement dans leur rivière d'origine, mais aussi dans la partie de la rivière où ils ont vu le jour. Dans leur remontée vers l'amont, les poissons avaient plus tendance à s'égarer dans la partie aval de la rivière. Le taux de récupération des étiquettes a diminué avec le temps. La plupart des poissons marqués ont été repris dans les trois ans de leur remise à l'eau, quoique certains l'ont été au bout de cinq ans. Certains gaspareaux adultes migrent chaque année jusqu'en Caroline du Nord, parcourant 17 $km/jour^{-1}$ en moyenne. Au sein de la rivière, on estimait la vitesse de migration à 8-21 $km/jour^{-1}$. Là où ils constituent des populations géographiquement distinctes, comme c'est le cas dans la rivière Saint-Jean, il est plus efficace de gérer les gaspareaux et les aloses d'été en fonction de chaque population plutôt que comme un stock mixte.

INTRODUCTION

Extensive commercial fisheries for alewives (Alosa pseudoharengus) and blueback herring (A. aestivalis) exist in the major tributaries of the Saint John River downstream of the Mactaquac Dam and at the Mactaquac Dam (Fig. 1). The Saint John River has historically supported the most productive fishery in the Maritime Provinces for these closely related species (Department of Fisheries and Oceans, Statistics Division, Scotia-Fundy Region). The average annual commercial harvest was 2,480 t. between 1950 and 1993.

Alewives and blueback herring are similar in appearance. Even experienced fishermen, who recognize the existence of separate species, cannot reliably distinguish them and commonly and collectively refer to them as "gaspereau" in the Maritime Provinces and "river herring" in the United States. Commercial landing statistics make no species distinction and record only alewives, yet blueback herring may comprise as much as 30-40% of the "alewife" landings in the Saint John River (Jessop et al. 1983). Species distinctions were not made in the studies reported here, and the collective term gaspereau will be used unless a specific species is named.

Fishery management options based on the stock concept vary depending upon the extent to which homing occurs and on the resultant match between the management unit (stock) and the biological unit (population). The ability of salmonids to home to a parent stream and even to a natal tributary is well documented (reviews by Leggett (1977a) and Hasler and Scholz (1983)). Amongst the anadromous clupeids, American shad (Alosa sapidissima) have been shown capable of returning to a home stream and to a natal tributary (Walburg and Nichols 1967; Carscadden and Leggett 1975; Melvin et al. 1986). That alewives home can be inferred from the numerous successful restockings of barren streams (Rounsefell and Stringer 1943), and by studies of interpopulation variation in morphometrics and meristics (Messieh 1977); homing by alewives is a widely accepted concept (Loesch 1987). Olfaction is important in the stream selection process for salmonids (Hasler and Scholz 1983) and American shad (Dodson and Leggett 1974); Thunberg (1971) has demonstrated that alewives can select a "home" water when given a choice.

The annual spawning migration of alewives to the Saint John River begins about mid-late April, followed two to three weeks later by blueback herring. Runs peak during mid-late May or early June, depending upon the species and distance migrated upriver, and end in mid-late June. Most spent fish rapidly return to the sea.

Homing by anadromous fishes may be defined as the return to a natal river for spawning, whether just once by species which spawn then die, e.g., Pacific salmon, or in successive years by species which may spawn in successive years, e.g., gaspereau. In large rivers, homing by species such as Atlantic (Salmo salar) and Pacific salmon (Onchorhynchus spp.) may involve return to a natal tributary or reach within the larger home river. Adult, not juvenile, fish were tagged in this study thus preventing a conclusive demonstration that a fish returns to its natal area. Homing is defined here as the return in succeeding years of sexually ripening adult fish to the area of first capture. This area is, presumably, the spawning area, although the capture of some fish in transit to other spawning areas occurs. The commercial fisheries of the lower Saint John River are distributed along paths to spawning areas and within spawning areas.

Between 1973 and 1983, 53,000 tags were applied in five tagging experiments conducted in the lower Saint John River to examine stock relationships and migratory patterns of alewives and blueback herring. This study examines the evidence for homing by gaspereau to, and to natal regions within, the Saint John River, their coastal and instream migration patterns and rates, and the implications of homing on stock definition and fishery management.

MATERIALS AND METHODS

Tagged gaspereau from five experiments were released at a variety of sites in the lower Saint John River (Table 1, Fig. 1). Not all experiments were designed with the same purpose in mind, but all provide information on the homing behaviour of anadromous gaspereau. Fish were obtained in 1973 and 1977 from the Mactaquac Dam fish-collection facilities and tank-trucked to a nearby site on the headpond (Mactaquac Lake) where they were tagged and released. In 1974, fish were trucked to Brown's Flats, about 113 km downstream from the Mactaquac Dam, prior to tagging and release. In 1981 and 1983, fish were obtained from commercial trap(pound)-nets then tagged and released at the capture sites. Normal fishing activities occurred at all net sites on the day following tagging except in 1983 when no fishing activity occurred for the remainder of the week in upper Washademoak Lake. All fish tagged were sexually ripening, unspent adults.

Two types of Floy anchor tags were used: FD-67 "flag" tags (with a rectangular portion at the external end of the tag) of various colors and FD-68B "spaghetti" tags which were labelled with individual numbers and a Department of Fisheries and Oceans return address. The use of similarly colored flag tags (yellow in 1973, 1974, 1977; red in 1973, 1977) in each of the Mactaquac Dam experiments has created uncertainty in interpretation of the results. The yellow tags used in 1973 and found on fish returning in 1974 were separated from those applied in 1974 by the presence of marine algal growth on the tag. In 1975 and 1976, all yellow tags were assumed to be from the 1974 release. One yellow tag recaptured after 1974 might be from the 1973 tagging based on the proportions of yellow tags used in 1973 and 1974 and on the rate of decline in tag recoveries after tagging. From 1977 onwards, all red and yellow tags were assumed to be from the 1977 release; no marine algal growth was found on tags of these colors recovered in 1977. The error involved in these assumptions is believed minimal. The 1981 and 1983 releases used individually numbered tags.

Commercial gaspereau fishermen in the Saint John River were alerted to check their catches for the presence of tags. By agreement with the Queens-Sunbury Gaspereau Trap-Netter's Association, no reward was paid for tag returns during 1981 because many were expected to be caught shortly after release. In later years, a reward ($3.00) was paid for each tag returned with information on the date and location of capture and gear used. There is an anecdotal report that some tags were retained by fishers in Saint John harbour but no reports of such activity elsewhere and the fishers in the tributary lakes seemed cooperative, although the possibility that some tags were unreported always exists. Tag returns may underestimate tag recoveries but there is no method to adjust for misreporting.

When incomplete or suspect information on tagged fish was received, I attempted to complete or confirm the information. Many tags were returned from fish processing plants and from fishermen who had purchased bait from these plants. Often the origin of the catch containing tagged fish could not be verified because of inadequate plant records and the habit of some fishermen, particularly those from Washademoak and Grand lakes, to mix catches from different areas when hauling fish to the processing plants. Only verified information has been used in this analysis because any misidentification of the origin of fish increases the estimated degree of straying.

Some fishermen were less cooperative than were others in the diligence with which they examined their catches for tagged fish and provided complete recovery information. The areas most thoroughly and reliably reported were Washademoak Lake, the upper portion of Grand Lake, and the Oromocto River. The Mactaquac Dam fish collection facility was operated by Department of Fisheries and Oceans staff, and the tag count there is assumed accurate.

Most tag recoveries occurred at the Mactaquac Dam fish collection facility and in the commercial trap-net fisheries of the lower Saint John River. Few tags were expected from the Kennebecasis and Belleisle bays because of the relatively limited fishing activity occurring in those areas. Few tags came from the main stem of the river because little fishing activity occurred there.

Tag returns are best interpreted relative to fishing effort. About 100 trap-nets were distributed as follows: Oromocto River - 17 nets; Grand, French, Indian and Maquapit lakes - 47 nets; Washademoak Lake - 28 nets; Belleisle and Kennebecasis bays - 8 nets. Surface areas of the tributary fishing areas are: Washademoak Lake - 37.0 km^2; Oromocto Lake (with downstream tributary lakes) - about 45 km^2; Grand, Maquapit, French and Indian lakes - combined total 197 km^2. Fishing effort can be estimated from the number of trap-nets per 100 km^2 of water surface area, which increased from about 24 in Grand Lake, to 38 in the Oromocto River system, and to 76 in Washademoak Lake. Catch-per-unit-of-effort (CPUE, $kg \cdot hr^{-1}$) estimates available from fisher logbooks for the years 1980-1983, by geographic region, provide an alternative, better adjustment for the recapture rate of tagged fish in different regions of the lower Saint John River (Table 2).

The degree of homing was estimated by the percent recovery of tags (all releases pooled by site) at the site of origin relative to the other sites. Daily migration rates ($km \cdot day^{-1}$) were estimated from the most direct distance between release and recapture sites and the number of days at large.

RESULTS

The drop-back downstream of the Mactaquac Dam of tagged fish following their release into Mactaquac Lake in 1973 and 1977 at a site about 0.5 km upriver of the dam was minor, as indicated by the few (<0.1%) fish recaptured in the fish collection facility during the spring of release (Table 3). Eleven tagged fish were observed in 1973 at Beechwood Dam, 142 km upriver of the Mactaquac Dam. The mean rate of travel was estimated at 20.9 $km \cdot day^{-1}$. Fish of Mactaquac Dam origin released downriver at Brown's Flats on Long Reach in 1974, were recaptured in almost equal numbers that year in Washademoak Lake and at Mactaquac Dam (Table 3). Fish returning to Mactaquac Dam (N=75) averaged 8.1 km day^{-1}, if it is assumed that upstream progress is continuous and that no delay occurred in entering the fishway. Delay of fish entering the fishway is known to occur. When gaspereau abundance is high, the limited fishway capacity results in delay in movement through the fishway and obvious backup. An ultrasonic tracking study of Atlantic salmon released downstream of the Mactaquac Dam indicated that salmon could remain in the vicinity of the fishway for between 3 and 11 days before entering (Jessop, unpublished data). The 148 km between river mouth and Mactaquac Dam are likely traversed in 18 or fewer days.

Recaptures of flag-tagged fish occurred up to five years after tagging. Total recaptures of flag-tagged fish amounted to 2.3% of the 1973-1977 releases. Subsequent to the initial year of tagging, 97% of recaptures (271 of 279 recaptures; Table 3) of Mactaquac-origin, flag-tagged fish occurred at the Mactaquac Dam.

In some years, the often substantial numbers of flag tags obtained from fish processing plants could not be attributed to a definite recapture site. Many tags unattributable to a specific recapture site are believed to have originated from the commercial fishery at Mactaquac Dam, particularly in 1978 with fish from the 1977 release. Double counting and an apparent reduction in return rate to the Mactaquac Dam would result if fish recaptured in the fishery at the dam were also recorded at the fish-lift. Tags observed at Mactaquac Dam were not removed from either the commercial catch or the spawning escapement because of the difficulty in doing so.

Recoveries of flag tags from coastal regions included seven from the gill-net fishery in Saint John Harbour (some fishers indicated that more tags were recovered there than were reported), two from the mouth of the Magaguadavic River, New Brunswick, southwest of the Saint John River, and nine from trap-nets at Pembroke, Maine. No flag tags were recovered from within rivers other than the Saint John.

The majority of the recaptures (usually >70%) of number-tagged gaspereau released in 1981 and 1983 occurred in the release area in all years (Table 4; Figs. 4 to 7). The percentage of total tags recovered was highest (51%) in Washademoak Lake, where fishing effort was highest (76 nets$\cdot$100 km^{-2} of water surface), giving a tag recovery rate of 0.049 tag$\cdot$net$\cdot$100 km^{-2}. In the Oromocto River and Grand Lake systems, tag recovery rates were similar, relative to fishing effort, and about one-third of the recovery rate in Washademoak Lake (0.015 tag$\cdot$net$\cdot$100 km^{-2}). The high recovery rate of numbered tags in Washademoak Lake in the year of release (1981), relative to a CPUE in the trap-net fishery about half of that for Grand Lake and the Oromocto River (21 versus 34-38 kg$\cdot hr^{-1}$) suggests that gaspereau entering Washademoak Lake tended to remain there and to be caught by the high fishing effort. About 94% of total recaptures of number-tagged gaspereau occurred during the year of release, then declined sharply in succeeding years, but continued to occur up to three years after marking. Total recoveries of numbered tags amounted to 5.6% of the initial release. After the year of tagging, 63% (40 of 63 recaptures; Table 4) of number-tagged gaspereau were recaptured at the site of original tagging, 35% were recaptured at downstream sites, and 2% were recaptured at upstream sites. As noted previously, the number and percentage of recaptures at individual release sites are probably higher than indicated because about 7% (78 of 1,131 tags) of the recovered tags, all from fish processing plants, could not be assigned to a specific recapture site.

The frequency of recapture decreased with distance from the tagging site. Gaspereau released at either the upper or lower Washademoak Lake sites were caught almost equally at both sites, indicating a widespread movement of fish throughout the lake. Fish tagged at the lower Washademoak Lake site were about five times as likely (41 versus 9 recaptures) to exit the lake and be recaptured at locations outside of Washademoak Lake than were those tagged at the upper Washademoak Lake site. The most frequent recapture locations were the nearby Grand (primarily lower portion), Maquapit and French lakes. In Grand Lake, which is almost five times as large as Washademoak Lake, fish released at the lower site were recaptured there about eight times more frequently (66 versus 8 recaptures) than at the upper site while fish released at the upper site were about 13 times more frequently caught (103 versus 8 recoveries) there than at lower Grand Lake. Releases at the lower Grand Lake site were about five times (22 versus 4 recoveries) as likely to be recaught at sites other than Grand Lake, particularly the nearby locations of French, Maquapit and Washademoak lakes, than were releases from upper Grand Lake. Evidently, some gaspereau move rather directly through lower Grand Lake towards the entrance to Maquapit, French and Indian lakes. Other than French Lake itself, nearby Maquapit Lake was the most common recapture site for fish tagged in French Lake, but a few fish were also caught in lower Grand and Washademoak lakes. All Oromocto River fish were recaptured there except one which was recaptured in lower Grand Lake in late June, presumably while migrating downstream after spawning. All fish released in Kennebecasis Bay were recaptured there except for one which moved upstream to lower Washademoak Lake.

Annual recoveries of tags from the Mactaquac Dam fish collection facility occurred between early May when the fishway commenced operation and late June or early July when the gaspereau run ceased. Tag recoveries from the downstream commercial fisheries occurred mostly between late April and late June (the commercial fishery ceased on June 30 by regulation) which covers the duration of the main gaspereau spawning migration to the Saint John River.

Some gaspereau evidently undertake lengthy annual migrations along the Atlantic coast (Table 5). About 12% of the fish recaptured from the 1981 tagging (1,131) were recaptured away from the release sites, mostly at other sites within the Saint John River. About 1% of total recaptures were obtained from coastal locations, including 0.2% from North Carolina. When tag recoveries away from the release site are used as the calculation base, 9% of tags were recovered in coastal locations, of which 1.5% were from North Carolina. In addition, a gaspereau (believed to be an alewife based on the date of tagging and the species composition of the run) from the St. Croix River, New Brunswick, tagged in the spring of 1981 for another project (personal communication, J.R. Semple, Department of Fisheries and Oceans, Halifax, Nova Scotia) was recaptured by gill-net on March 30 - April 1, 1982, in the Pamlico Sound-Hatteras area of North Carolina. If alewives are assumed to arrive at their Saint John River spawning area by June 1, then the estimated rate of travel of fish returning from the Albemarle Sound Region of North Carolina (March 15 departure) is about 17 $km \cdot day^{-1}$.

By early May, northward migrating alewives have reached Rhode Island; others were caught off Pembroke, Maine, in late April. By late April, the earliest migrants from the Bay of Fundy (and fish that have overwintered in the lower river) have already moved up the Saint John River to Washademoak and Grand lakes and to the Oromocto River. They reach Mactaquac Dam by early May. The Saint John River is unusual in that a run of large (26-27 cm mean fork length) alewives enters the lower river after late November and overwinter under the ice. These fish are harvested between mid-January and mid-March, depending upon ice conditions, by a winter gill-net fishery at several sites in the lower river, including Long Reach and the upper end of Kennebecasis Bay.

DISCUSSION

Gaspereau home to the Saint John River and, evidently, to presumed natal areas within the river system with moderate to high (63-97%) fidelity. No similar tagging studies using gaspereau are known to exist with which to compare this study but, on the basis of an analysis of meristic characteristics, Messieh (1977) concluded that, while alewives return to the Saint John River, they "are probably not as specific as American shad or Atlantic salmon in homing to specific areas or tributaries". The technical difficulties of marking premigratory, underyearling alewives and blueback herring have, to date, prevented a proper study of homing by these species. Rates of straying by Atlantic salmon migrating within the Miramichi River system (17%; Stasko et al. 1973) and by Pacific salmon (2-17%; Shapovalov and Taft 1954; Quinn and Fresh 1984) are comparable to those shown by gaspereau in this study.

If the geographic areas of tagging are presumed to be natal, the frequencies and locations of recaptured fish reflect, amongst other factors, the homing ability of the gaspereau, the geographic distribution of fishing effort, the number and survival rate of fish released in the area, and the geographic relationship between release and recovery sites. Recovery of tags is difficult from recaptures of relatively small fish, such as alewives, in high volume fisheries where fish are handled in bulk rather than individually. The scarcity of coastal and offshore fisheries that either target gaspereau or have appreciable bycatch minimizes the potential for documenting the marine migration of specific alewife stocks. The observed low recapture rate (2.3-5.6%) for tagged gaspereau is typical of that for tagged fish even when fishing activity is high (Quinn and Fresh 1984; Wheeler and Winters 1984). Low recapture rates can be offset somewhat by larger numbers of tagged fish.

Fish of various geographic origins evidently strayed more often to lower Washademoak and Grand lakes than to other locations. The recapture, outside and upstream of Washademoak Lake, of a higher proportion of fish that were tagged and released in lower, as compared to upper, Washademoak Lake implies that a higher proportion of fish entering lower Washademoak Lake were strays destined for other upstream locations. Strays tended to remain in the lower portion of these lakes although some fish tagged in each lake became well mixed. Strays caught in a non-natal area would, presumably, have resumed migration towards their natal area if they were not caught. Some Pacific salmon that have strayed are known to have returned to their natal river to spawn (Ricker and Robertson 1935) yet some also spawn in non-natal streams (Quinn and Fresh 1984). American shad may meander, hold, and even migrate downstream while enroute to their spawning area (Dodson and Leggett 1973) and gaspereau may behave similarly.

No estimate is available of the homing success of strays. Washademoak Lake seems to get more strays of upriver origin than does Grand Lake possibly because its entrance is longer and more strategically sited in relation to the main river current flows than is the entrance to Grand Lake. A high fishing effort and, perhaps, more reliable reporting of tag recaptures might also have contributed more tags. The observation that strays from upriver sites tended to be caught downriver yet strays from downriver sites were infrequently caught upriver is consistent with the olfactory theory of instream homing (Hasler and Scholz 1983) because both Washademoak and Grand lakes often experience inflows of water from the main stem due to tidal and/or Mactaquac Dam hydroelectric generation cycle effects. Whether fish enter with the inflow or against the outflow is unknown.

Although tagged fish were recaptured as much as five years after initial release, the sharp decline in the rate of recapture with each year following release and negligible recapture rate after the third year is similar to results reported by Nakashima and Winters (1984). Anchor tags similar to those used in this study are suitable for migration and stock delineation studies because of their efficiency of application and the high survival of tagged fish (Nakashima and Winters 1984). The apparent high mortality rate of tagged fish can be attributed both to tag and handling induced mortality and to the shedding of tags over time, which leads to overestimation of mortality. Minimial fish handling and release immediately after tagging in this study may have reduced mortalities (Winters 1977). Little could be done to reduce tag shedding, which increases with time (Hay 1981).

Alewives and blueback herring are known to undertake seasonal inshore and offshore migrations, generally remaining inside the 200-m depth contour of the continental shelf (Stone and Jessop 1992), as do American shad (Neves 1981). The extent of migration by fish from specific river systems is virtually unknown. Some gaspereau annually migrate during summer to the Bay of Fundy from rivers along the Atlantic coast and return south, accompanied by gaspereau from northern, e.g., Bay of Fundy, rivers during autumn and winter, as do American shad (Dadswell et al. 1987). Gaspereau from two Bay of Fundy rivers (Saint John, St. Croix) have been recaptured along the Atlantic coast as far south as North Carolina, as have river herring of mixed origin tagged in Minas Basin in the upper Bay of Fundy (Rulifson et al. 1987). A single river herring from Maine has been recovered from both Massachussetts and Virginia (Richkus and DiNardo 1984).

The rate of coastal migration estimated for alewives (17 $km \cdot day^{-1}$) is comparable to that for American shad (21 $km \cdot day^{-1}$, Leggett 1977; 30±14 $km \cdot day^{2}$, Dadswell et al. 1987) but within-river migration rates were faster (8-21 $km \cdot day^{-1}$ for gaspereau vs 1.6-3.1 $km \cdot day^{-1}$ for shad; Leggett 1976).

The timing and extent of seasonal migration becomes evident when coastal and inland recaptures are combined and integrated with other field observations. Most of the gaspereau spawning run occurs between late April and late June, with alewives preceeding blueback herring by about three weeks and with the runs peaking progressively later as the distance upstream increases. Spent alewives begin moving downstream from Mactaquac Dam in late June and a bit earlier from the lower lake system. By late August and through

September they are moving south along the New Brunswick shore of the Bay of Fundy and some have reached southern Maine by early October. By March of the following year, Albemarle Sound, North Carolina, has been reached, which may be the southern limit of migration by alewife and blueback herring of northern origin. The capture of small quantities of yearling alewives and blueback herring in Washademoak and Grand lakes during July and August and of large numbers of two and occasionally three-year-old fish there during June implies that some younger, immature fish remain relatively near their natal river and do not undertake the extensive coastal migrations of adult fish. Immature alewives may remain in inshore waters for one or two years (Milstein 1981; Walton 1981). The proportion of adult fish that participate in extensive migrations is unknown, but coastal fisheries in Canada and the United States probably harvest fish of mixed national origins.

The existence of different populations of gaspereau defined by their ability to home to a natal stream and, probably, to an natal area within a larger river system complicates the task of fishery management. Fisheries which exploit mixed stocks during marine, estuarine or main stem river fisheries could subject some populations to excessive fishing mortality. Elimination of a minor substock from the management unit is possible even when an overall quota sufficient to maintain the stock complex as a whole is not exceeded (Sinclair et al. 1985). Once severely reduced, a population may not recover quickly because a substantial degree of homing to geographically separated natal spawning areas could restrict the ability of another spawning population to repopulate nearby overfished spawning areas. Management policies for alewives and blueback herring should be based on fisheries that harvest spawning, rather than mixed, stocks.

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Table 1. Details of gaspereau tagging studies, Saint John River, 1973-1983.

Date	Tagging Site	Release	Tag Type[a]	Color	Number Tagged
1973					
May 24-31	Mactaquac	Mactaquac	FD-67	blue	1,000
Jun 4- 8	Mactaquac	Mactaquac	FD-67	red	1,480
Jun 12-15	Mactaquac	Mactaquac	FD-67	yellow	1,975
Jun 19-21	Mactaquac	Mactaquac	FD-67	green	2,000
Jun 26-28	Mactaquac	Mactaquac	FD-67	orange	1,775
					8,230
1974					
May 23- Jun 6	Mactaquac	Brown's Flat	FD-67	yellow	9,527
1977					
May 30- Jun 4	Mactaquac	Mactaquac	FD-67	yellow	7,500
				red	7,500
					15,000
1981					
May 2- 9	U. Washademoak L.[b]	U. Wash. L.	FD-68	yellow	2,467
May 9	Oromocto R.	Oromocto R.	FD-68	yellow	2,496
May 11	U. Grand L.	U. Grand L.	FD-68	yellow	2,489
May 16-22	L. Washademoak L.	L. Wash. L.	FD-68	yellow	2,418
May 23-30	Kennebecasis Bay	Kennebec. B.	FD-68	yellow	2,497
May 30	L. Grand L.	L. Grand L.	FD-68	yellow	2,496
Jun 5	French L.	French L.	FD-68	yellow	2,499
Jun 13	U. Washademoak L.	U. Wash. L.	FD-68	yellow	1,349
					18,711
1983					
Apr 14	U. Washademoak L.	Same	FD-68	yellow	1,427

[a] FD-67 tags are unnumbered, flag-type with no return address; FD-68 tags are numbered, spaghetti-type with return address.

[b] U = upper portion of lake; L = lower portion of lake.

Table 2. Annual mean catch rate (CPUE), by year and location, of gaspereau in the trap-net fishery of the lower Saint John River, 1980-1983.

	CPUE ($kg \cdot hr^{-1}$)				
Region	1980	1981	1982	1983	Mean
Kennebecasis/ Belleisle bays	8.2	6.0	6.2	9.0	7.4
Washademoak L.	10.8	21.2	19.2	25.3	19.1
Grand L.	30.6	38.4	38.0	42.3	37.3
Oromocto R.	46.1	34.4	36.6	23.4	35.1

Table 3. Summary of the number and percent recovery, by year and location, of gaspereau, from the Mactaquac Dam, Saint John River.

Year tagged	Number tagged	Year recovered	Number recovered	Percent recovered by location				
				Mactaquac	Tributaries	Main stem	Fish[a] plant	Coastal[b]
1973	8,230	1973	13	15[c]	0	0	0	0
		1974	30	70	3	3	23	0
		1975	8	50	0	13	38	13
		1976	1	100	0	0	0	0
		1977	1	100	0	0	0	0
		1978	1	100	0	0	0	0
1974	9,527	1974	143	52	47	0	0	1
		1975	71	65	6	0	13	17
		1976	8	100	0	0	0	0
1977	15,000	1977	11	100	0	0	0	0
		1978	471	39	0	0	60	1
		1979	4	0	0	0	100	0
		1980	5	100	0	0	0	0

[a]Tags recovered in fish plants could seldom be attributed to a particular catch site; many are believed to come from the Mactaquac Dam commercial fishery and may include some of those already included in the dam recoveries.

[b]Includes Saint John Harbour (below Reversing Falls).

[c]The remaining fish were recovered upriver at the Beechwood Dam.

Table 4. Summary of the number and percent recovery, by year and location, of gaspereau tagged at sites in the lower Saint John River.

Year tagged	Site and date tagged	Number tagged	Year recovered	Number recovered	Percent recovered by location[a]									
					MD	O	F	M	G	W	K	R	C	FP
1981	Washademoak L.	6,234	1981	546	<1	<1	1	2	6	82	0	<1	<1	8
	May 2, 16, 22		1982	31	0	0	0	0	3	94	0	0	3	0
	June 13		1983	3	0	0	0	0	0	67	0	0	33	0
	Grand L.	4,985	1981	242	0	0	2	4	77	5	0	<1	<1	12
	May 11, 30		1982	11	0	0	0	0	0	91	0	0	9	0
			1983	2	0	0	0	0	0	50	50	0	0	0
	French L	2,499	1981	155	0	1	70	19	5	2	0	<0	<3	1
	June 5		1982	3	0	0	0	0	0	67	0	0	33	0
			1983	2	0	0	0	0	0	0	0	100	0	0
	Oromocto R.	2,496	1981	121	0	97	0	0	<1	0	0	0	<1	2
	May 9		1982	3	0	67	0	0	0	0	0	0	33	0
	Kennebecasis Bay May 23	2,497	1981	4	0	0	0	0	0	25	75	0	0	0
1983	Washademoak L.	1,427	1983	1	0	100	0	0	0	0	0	0	0	0
	April 14		1984	7	0	0	4	0	0	57	0	29	14	0

[a] Location codes:

MD = Mactaquac Dam
O = Oromocto R.
F = French L.
M = Maquapit L.
G = Grand L.
W = Washademoak L.
K = Kennebecasis Bay
R = main stem of river and associated small lakes
C = coastal
FP = fish plant, i.e., could not be attributed to a within-river site

Table 5. Recoveries along the Atlantic coast of tagged gaspereau from the Saint John River, New Brunswick.

Tag number	Release Site	Release Date	Recovery Site	Recovery Date	Recovery Gear
00425	Oromocto R.	9-05-81	Deadmans Hbr., N.B.	18-08-81	weir
05883	Grand L.	11-05-81	Campobello I.	26-08-81	weir
09205	Washademoak L.	22-05-81	Deadmans Hbr., N.B.	18-08-81	weir
08975	Washademoak L.	22-05-81	Reid St. Park, Me.	5-09-81	seine
16664	French L.	5-06-81	Deadmans Hbr., N.B.	18-08-81	weir
16445	French L.	5-06-81	Seely Cove, N.B.	-08-81	weir
17153	French L.	5-06-81	Reid St. Park, Me.	5-09-81	seine
16566	French L.	5-06-81	Reid St. Park, Me.	5-09-81	seine
18175	Washademoak L.	13-06-81	Deadmans Hbr., N.B.	18-08-81	weir
18027	Washademoak L.	13-06-81	Red Head, N.B.	-09-81	weir
03936	Washademoak L.	2-05-81	Albemarle Sd., N.C.	8-03-82	unknown[c]
01884	Oromocto R.	9-05-81	Albemarle Sd., N.C.	-05-82[b]	unknown[c]
13058	Grand L.	30-05-81	Block I., R.I.	2-05-82	trawler
FRB264375[a]	Grand Manan	28-08-78	Washademoak L.	12-06-81	trap-net
FRB177665	Grand Manan	24-09-79	Washademoak L.	12-06-81	trap-net
FRB178264	Grand Manan	24-09-79	Washademoak L.	12-06-81	trap-net
FRB189492	Grand Manan	1-10-79	Washademoak L.	12-06-84	trap-net

[a]Gaspereau tagged by Dept. Fisheries and Oceans, St. Andrews, N.B., while mixed with herring.

[b]The tag was returned in May; it is believed to have been caught earlier.

[c]Believed to be gill-net.

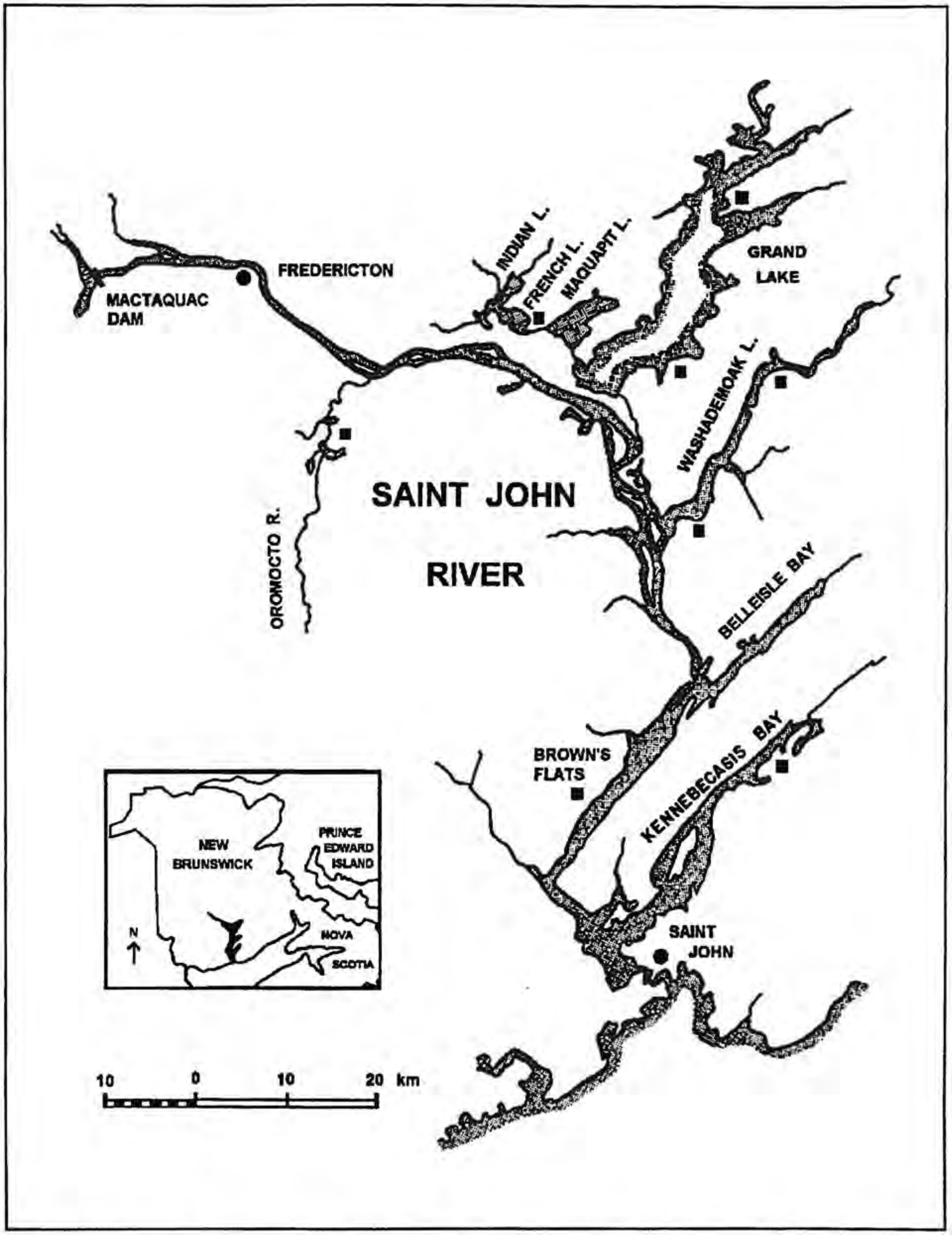

Fig. 1. Map of the lower Saint John River. Solid squares indicate release sites for tagged fish.

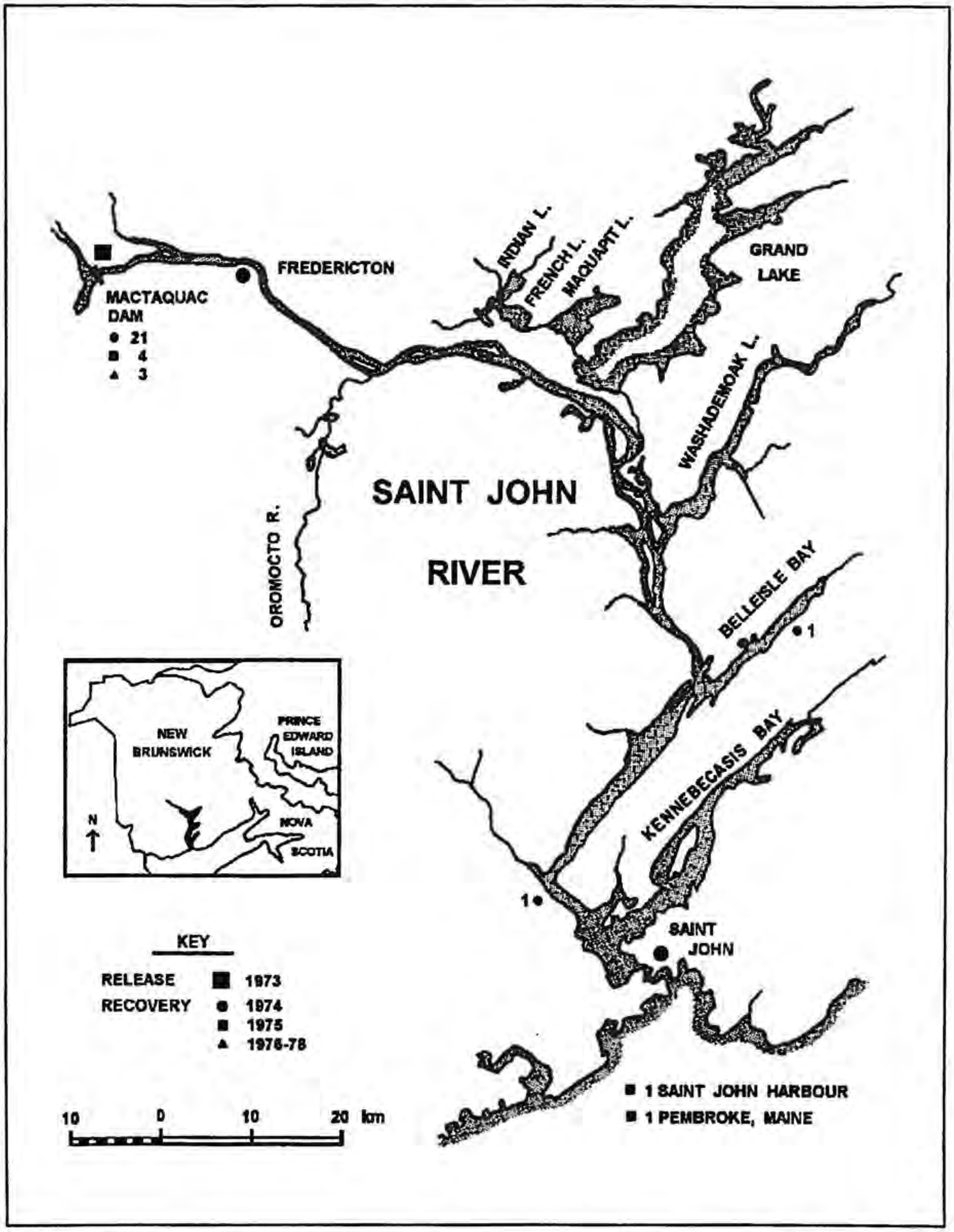

Fig. 2. Number of recoveries, by year, of gaspereau tagged and released at the Mactaquac Dam in 1973 (N = 8,230). Not included are tags from fish processing plants that could not be attributed to a specific recovery site (1974: N = 7; 1975: N = 2).

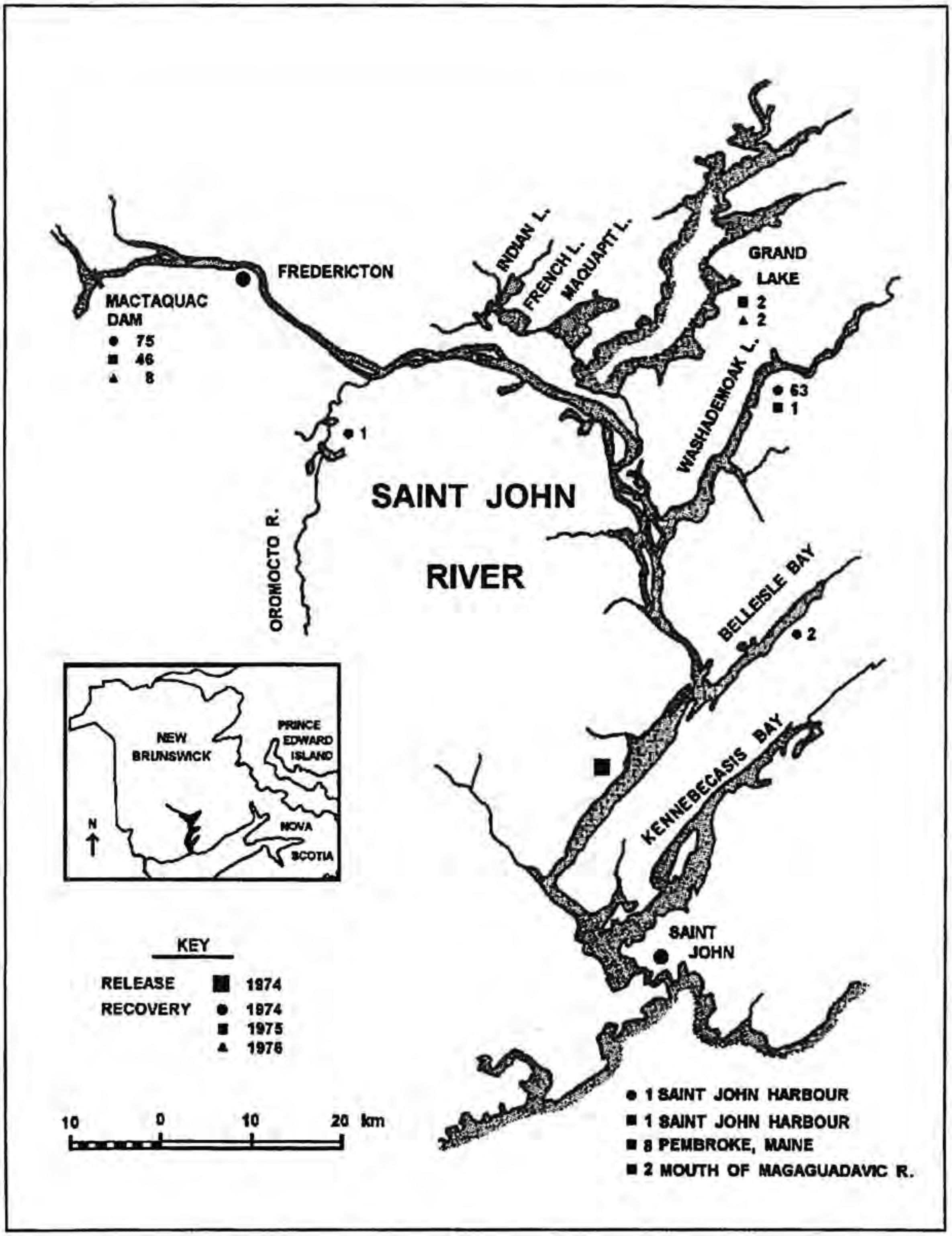

Fig. 3. Number of recoveries, by year, of gaspereau from the Mactaquac Dam tagged and released at Brown's Flats in 1974 (N = 9,527). Not included are tags from fish processing plants that could not be attributed to a specific recovery site (1974: N = 13; 1975: N = 9).

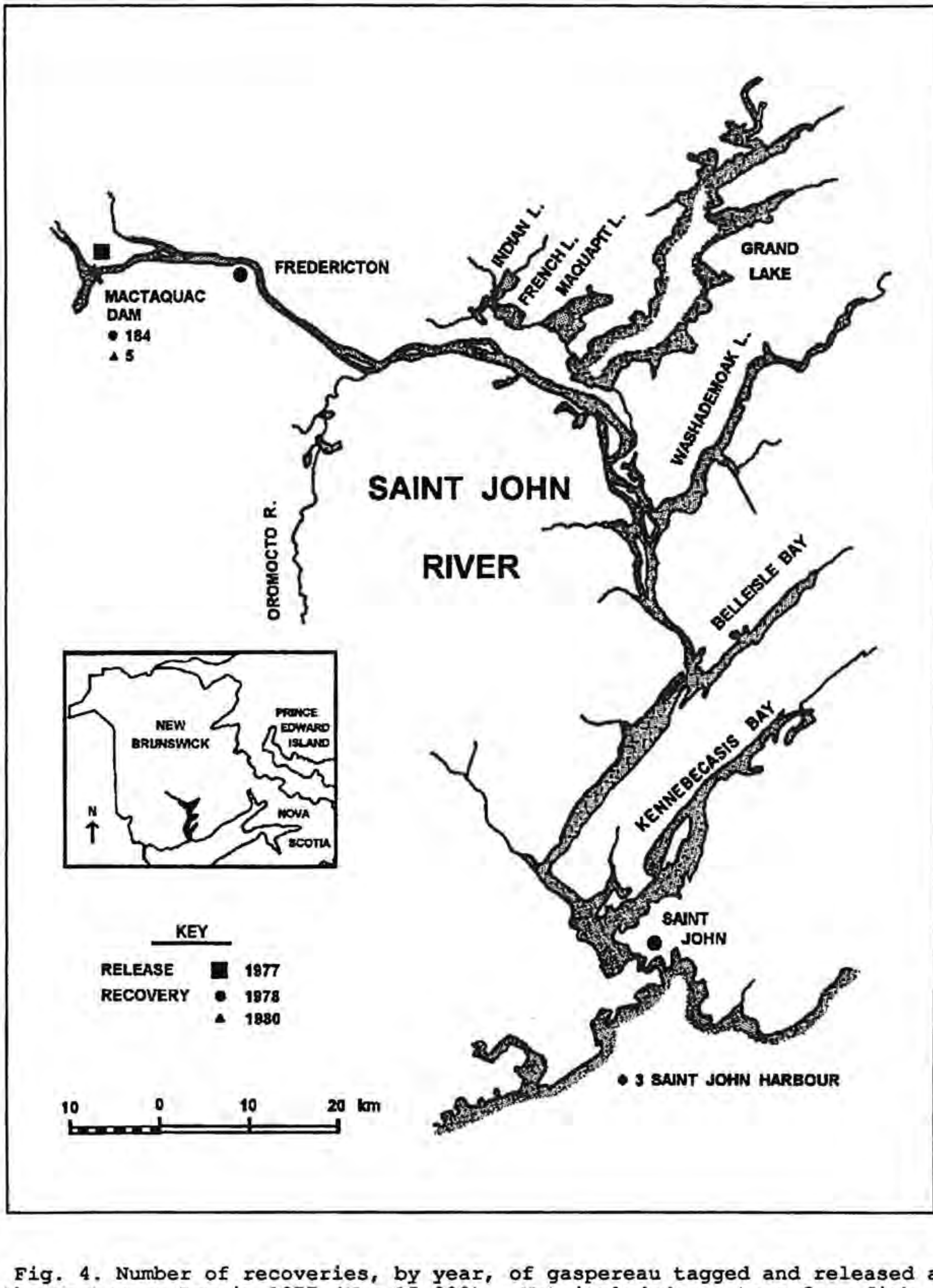

Fig. 4. Number of recoveries, by year, of gaspereau tagged and released at the Mactaquac Dam in 1977 (N = 15,000). Not included are tags from fish processing plants that could not be attributed to a specific recovery site (1978: N = 284; 1979: N = 4).

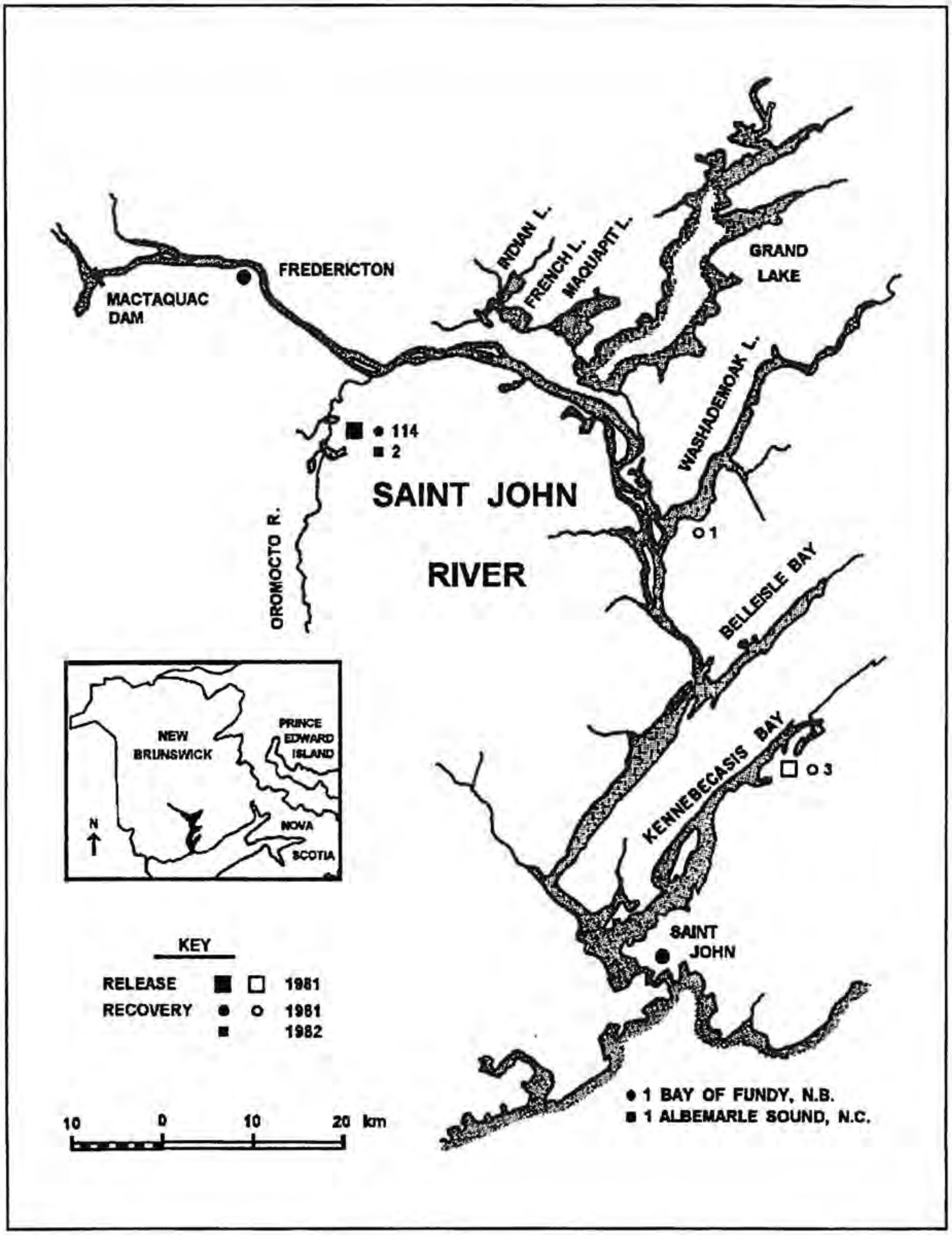

Fig. 5. Number of recoveries, by year, of gaspereau tagged and released in 1981 in the Oromocto River (N = 2,496) and in Kennebecasis Bay (N = 2,497).

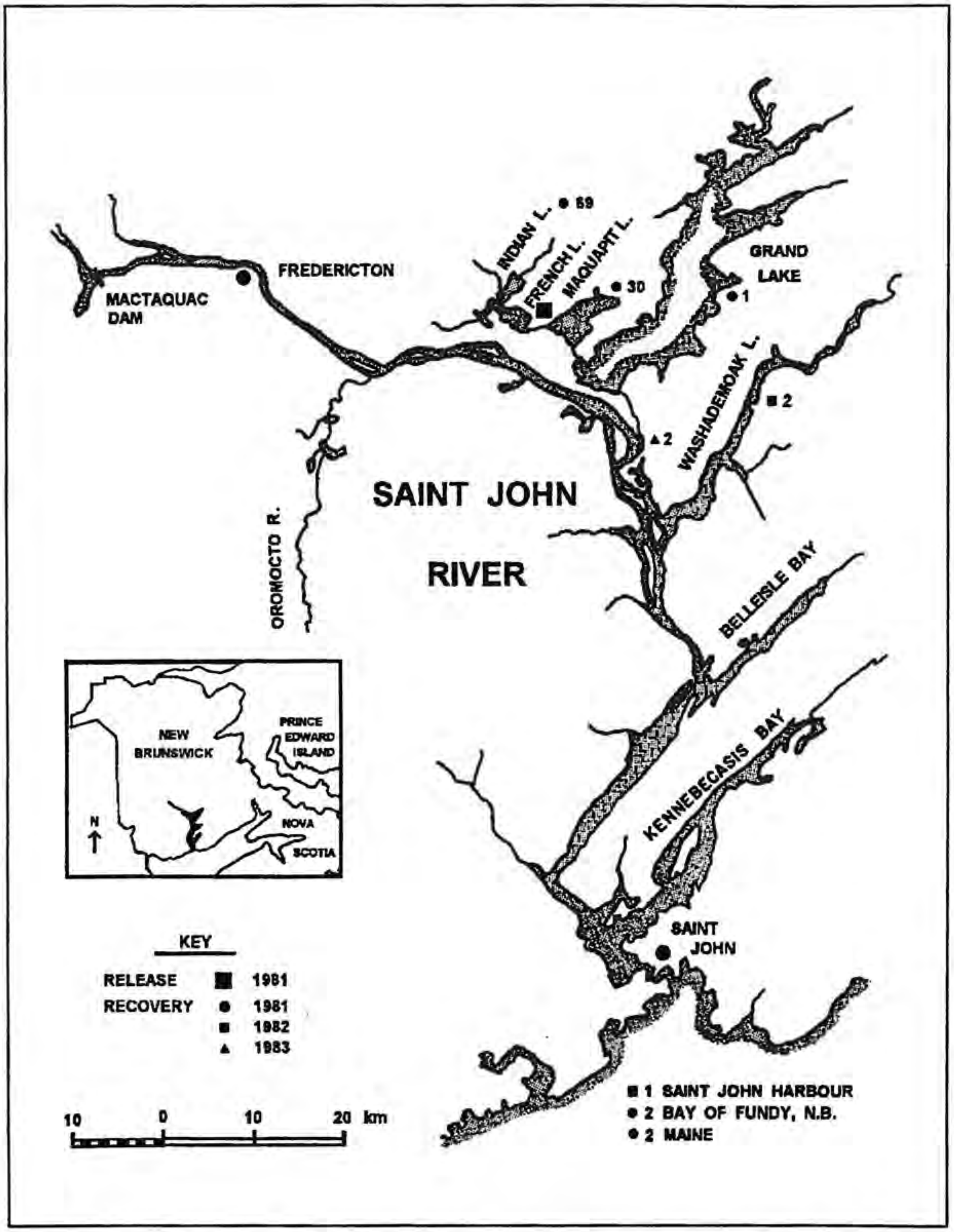

Fig. 6. Number of recoveries, by year, of gaspereau tagged and released in French Lake, 1981 (N = 2,499).

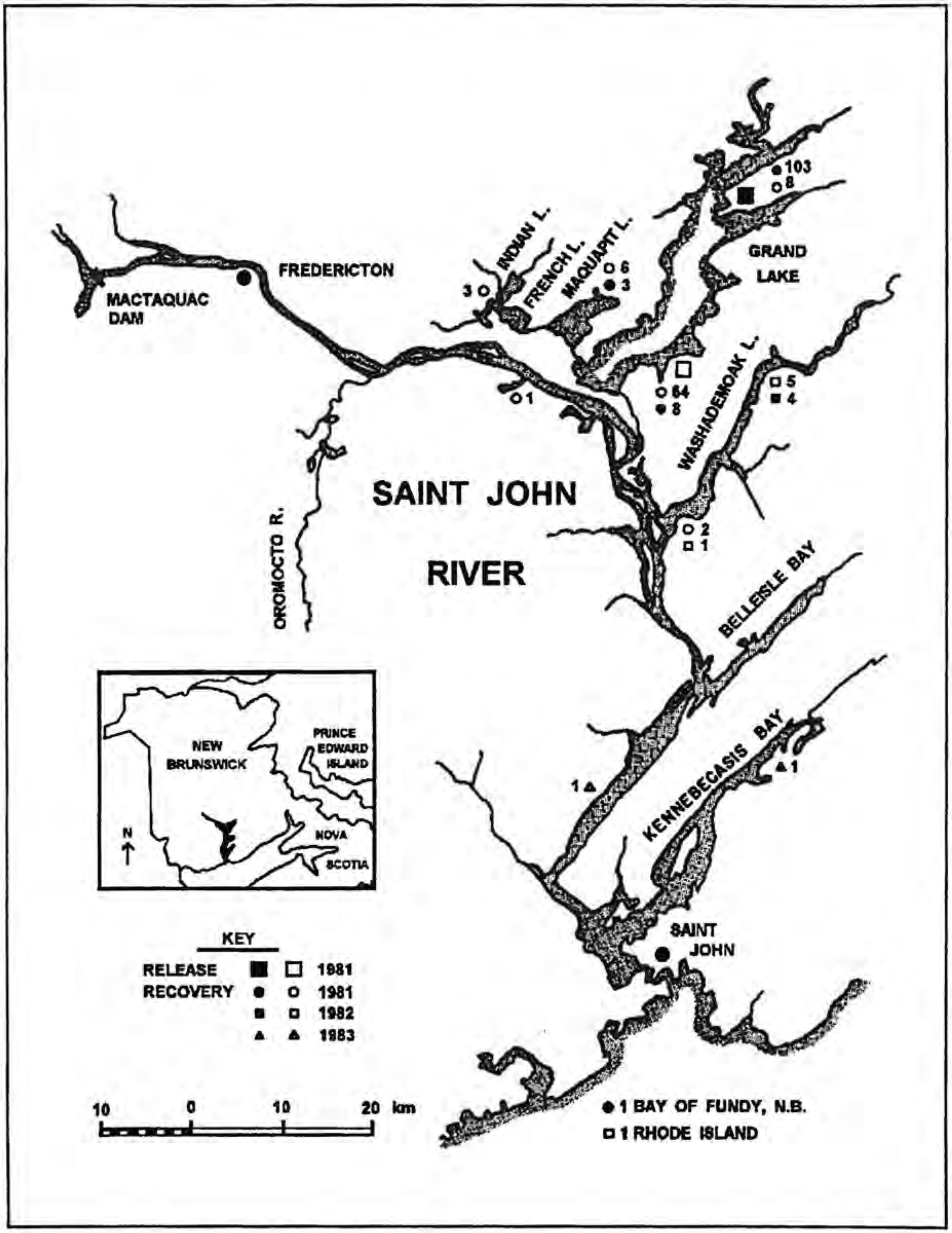

Fig. 7. Number of recoveries, by year, of gaspereau tagged and released in Grand Lake, 1981 (N = 2,489 at lower site, 2,496 at upper site).

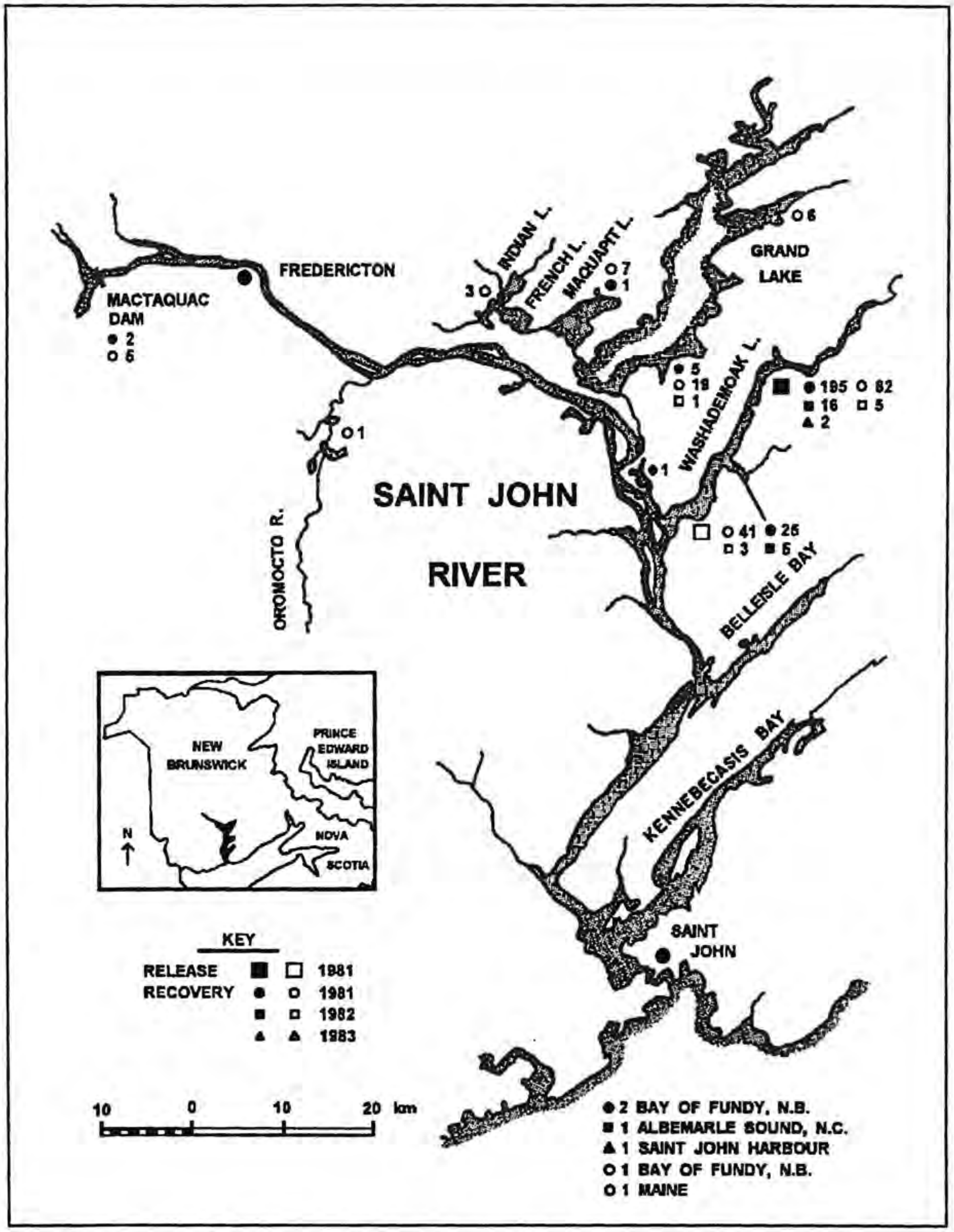

Fig. 8. Number of recoveries, by year, of gaspereau tagged and released in Washademoak Lake, 1981 (N = 2,418 at lower site, 3,816 at upper site).