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STRIPED BASS (Morone saxatilis) FROM THE GULF OF ST. LAWRENCE

by

G.J. Chaput and R.G. Randall
Science Branch, Gulf Region
Department of Fisheries & Oceans
P.O. Box 5030
Moncton, New Brunswick, E1C 9B6

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ABSTRACT

A review of striped bass biology and exploitation in the Gulf of St. Lawrence is presented. The southern Gulf of St. Lawrence represents the northern limit of its distribution. Striped bass have been reported from a large number of rivers and coastal areas throughout the southern Gulf as bycatch in gaspereau and smelt fisheries and in recreational fisheries. Spawning of striped bass has been documented in two New Brunswick rivers and bass overwinter in Gulf rivers. Annual harvest of striped bass in Atlantic Canada from commercial gear has generally been less than 20 tons; maximum reported harvest was in 1917 at 65 tons. Landings of striped bass from the southern Gulf have averaged 13 tons since 1968, ranging between 2 and 48 tons. Potential production of striped bass in the Gulf is unknown and the population appears to be sustained at a low level.

RÉSUMÉ

Ce document fait le bilan de la biologie et de l'exploitation du bar rayé dans le golfe du Saint-Laurent. Le sud du golfe représente la limite nord de la distribution du bar rayé. Des individus ont été retrouvés dans une quantité de rivières et zones côtières du golfe du Saint-Laurent, provenant de captures incidentes dans les pêcheries de gaspereau et de l'éperlan ainsi que dans les pêches sportives. Le frai s'effectue dans au moins deux rivières du Nouveau-Brunswick et ce poisson hiverne dans les rivières du golfe. Les prises annuelles canadiennes de l'atlantique ont généralement été inférieures à 20 tonnes après avoir atteintes 65 tonnes en 1917. Les débarquements annuels du sud du golfe, depuis 1968, se sont élevés à 13 tonnes en moyenne, sur un étendu de 2 à 48 tonnes. La production potentielle de cette espèce dans le golfe du Saint-Laurent est inconnue. La population semblerait se soutenir à un niveau peu élevé.

INTRODUCTION

This document presents a sumary of available data regarding striped bass biology and exploitation in the Gulf of St. lawrence. It has been prepared in response to a request for scientific advice on the status of the striped bass resource and the identification of benefits which may result from the introduction of regulations.

The current state of knowledge of the biology of striped bass from the Gulf of St. Lawrence has been reviewed in response to the following questions

1. What is the distribution of striped bass populations in the Maritime Provinces, including limitations by acid precipitation or other environmental restriction?

2. What is the optimum size/age composition, for harvesting striped bass and appropriate time of year?

3. What is the current stock status in relation to potential production and sustainability?

4.a) For areas identified as having a surplus to spawning requirements, what restrictions would be most effective in sustaining those populations?
   b) For areas identified as reduced or declining populations relative to potential, what would be the most effective means for conserving the remaining stocks and provide for rebuilding?

GENERAL BIOLOGY AND MANAGEMENT

The striped bass, Morone saxatilis has an Atlantic Coast distribution extending from the St. Lawrence R., throughout the southern Gulf of St. Lawrence, south to the St. John's R. in Northern Florida and several Gulf of Mexico coastal states (Setzler et al. 1980). It has been successfully introduced into numerous reservoirs and rivers throughout the United States as well as on the Pacific Coast where its present distribution extends from British Columbia to Mexico.

A summary of life history characteristics is presented below (from Setzler et al. 1980, Scott and Crossman 1973, Scott and Scott 1988).

Longevity: 29-31 years maximum, record weight 56.7 kg.
Generally less than 20 years of age in Canadian waters

Feeding: Voracious and opportunistic. Larvae consume zooplankton, juveniles consume small crustaceans and other invertebrates, adults consume fish and larger invertebrates. Not a steady feeder, frequently feeds in schools. Does not feed during spawning migration.

Reproduction: In Canadian waters, males mature at age 3 and 4, females at age 5 or older. Maturation rates are positively correlated with temperature. Iteroparous spawners but not necessarily consecutive.

Fecundity: 106 to 216 thousand eggs per kg of body weight. Eggs of three consecutive spawning seasons may be present in ovary.

Spawning: May to July, May in Kouchibouguac R. (Hogans and Melvin 1984), mid-May to mid-June in St. Lawrence R. (Beaulieu 1985). Occurs at or near surface, at head of tide or freshwater. Occurs during the day or night. Spawning peaks triggered by noticeable increase in water temperatures. Water temperatures ranging between 12 and 18°C.

Eggs: Nonadhesive, semi-buoyant.
Hatching time: 29 hours at 22°C
48 hours at 17.8-19.4°C, and
80 hours at 11°C.

A few points relative to its life history should be highlighted.

1. Freshwater/saltwater interface and estuaries are critical habitat areas of all life stages.
2. Older fish are predominantly female.
3. Females do not necessarily spawn every year after maturity (Scott and Crossman 1973).
4. In eastern US, it has been shown that immature females are more migratory than males (Kohlenstein 1981).

In terms of management, the following aspects have been highlighted:

1. Striped bass abundance is related to year-class dominance (Cooper and Polgar 1981, Rago and Dorazio 1989).
2. Recruitment appears most sensitive to density-independent factors in early larval stage (Goodyear 1980, Rago and Dorazio 1989, Uanowicz and Polgar 1980). Density dependent factors may also be important in regulating striped bass recruitment, however, such factors have not been demonstrated to date (Goodyear and Christensen 1984).

Factors hypothesized to have contributed to the production declines in eastern US stocks included (Rago and Dorazio 1989):

1. toxic contaminants,
2. starvation of larval fish,
3. overexploitation,
4. predation on fry,
5. occurrence of unfavourable climatic events,
6. modification of water practices,
7. competition with other species, and
8. reduced water quality.

Of the eight factors listed, seven would directly affect the survival of the early life stages (1,2,4,5,6,7,8), whereas only three would potentially affect juveniles and spawning stock (3,6,7). Tolerance and optimum levels of striped bass relative to several environmental factors are presented below (from Setzler et al. 1980).

Environmental factors (tolerance/optimum):

Temperature (°C)	Eggs	14-23 / 17-20
	Larvae (20mm or less)	12-23 / 16-19
	Young (20-50 mm)	10-27 / 16-19
	Young (50-100 mm)	?-30 / 18-23
pH	Eggs	?
	Larvae	6-9 / 7-8
	Young (20-50mm)	6-10 / 7-9
	Young (50-100mm)	6-10 / 7-9
Salinity (ppt)	Eggs	0-10 / 1.5-3
	Larvae	0-15 / 5-10
	Young (20-50mm)	0-20 / 6-12
	Young (50-100mm)	0-35 /10-20
Oxygen (mg/l)	Eggs	1.5- /
	Larvae	2-20 / 5-28
	Young (20-50mm)	3-20 / 6-12
	Young (50-100mm)	3-20 / 6-12
Flow rate(m/s)	Eggs	0.3-5.0/1.0-2.0
	Larvae	0-5 /0.3-1.0
	Young (20-50mm)	0-5 / 0-1
	Young (50-100mm)	0-5 / 0-1

Turbidity Adapted to silt-laden and turbid waters. Heavy sediment load (<1000 mg/l) does not adversely affect hatching.

Salinities of 5 ppt have provided a mitigative effect against pH and inorganic contaminant toxicity (Rago and Dorazio 1989). Overexploitation and unfavourable climatic conditions may also act in concert to reduce abundance:

> "If favourable conditions for survival occur infrequently and for short time periods ("windows") during the spawning season,...increased juvenile production requires an increase in the number of spawning females to ensure adequate egg production during the occurrence of favourable windows. This is particularly relevant for striped bass, which broadcasts large numbers of eggs that suffer high mortality even under optimal conditions" (Rago and Dorazio 1989:27).

RESULTS

Distribution and Abundance

Inferences of distribution and abundance of striped bass in the Gulf of St. Lawrence were obtained from landing statistics. Bass have been reported throughout most southern Gulf of St. Lawrence rivers from Margaree to Pokemouche River (Table 1). A substantial recreational fishery has existed at Bathurst Harbour as well as at Dalhousie NB and the Caraquet-Shippagan Channel (Bujold 1985, Madden 1984). Catches of striped bass at the salmon trapnet, Dalhousie NB, have however been minimal, total catch of bass between 1972 and 1980 was 10 (Table 2).

Bass are more abundant in the Southwest than the Northwest branch of the Miramichi (Fig. 1). The Southwest Miramichi attracts a larger proportion of spring fish than does the Northwest although bass are abundant in May and June in the Northwest Branch as evidenced by the high catch rates of bass in the gaspereau trapnets at Newcastle (Table 1).

Seasonal Timing

The daily counts at Millbank trapnet since 1976 demonstrate three main modes of bass occurrence in the Miramichi River between May and November (figs. 1, 2). A major mode occurs during May and June and is considered to represent the spawning migration. Secondary and tertiary modes in summer and fall represent feeding modes. Similar patterns of abundance were noted at the recapture traps in the two branches of the Miramichi River during 1985 to 1987 (Fig. 1).

Harvest in most Gulf region districts is seasonal (Fig. 3) and the pattern can be summarized as follows:

1 - winter fisheries (Dec. to April) are prevalent in districts 75 to 77 only.

2 - spring fishery (May and June) prevalent in Miramichi River (districts 71 and 72) as well as districts 76 and 77.

3 - summer harvest (July and Aug.) smallest and prevalent in districts 66, 68, 70, 75 and 76.

4 - fall fisheries (Sept. to Nov.) are prevalent in districts 68, 70, 75 to 77.

Striped bass clearly overwinter in some Gulf of St. Lawrence rivers as evidenced by the harvest of bass during the winter months in districts 75, 76 and 77 (Fig. 3). The presence of bass at Millbank trapnet in late fall suggests that they would overwinter in the Miramichi system although the exact location is unknown. Anecdotal evidence that striped bass overwinter in the Miramichi system can be found in McKenzie's report (1959) where reference is made to the practice of sweeping around a large hole in the ice with a long-handle dipnet as a means of capturing bass. Bass were also reported as bycatch among tomcod during late autumn and early winter (McKenzie 1959). Coastal migrants ascended the Kouchibouguac River between September to December and overwintered in the freshwater portions of the river (Hogans and Melvin 1984).

Bass also spawn in Gulf New Brunswick rivers. Young-of-the-year (0+) bass have been collected from the Kouchibouguac and Tabusintac rivers (Hogans and Melvin 1984; Melvin 1978).

Size and Age Composition

Wide ranges in size and age of bass are encountered in Gulf rivers. Between 1975 and 1986, bass measured at the DFO Millbank trapnet ranged between 10 and 75 cm fork length, the most abundant size range was 30 to 50 cm (Table 4, Fig. 4). In 1986, bass captured between July and October at the recapture traps in both branches of the Miramichi River ranged between 18 and 57 cm in length (Table 3).

Overall, male bass were more abundant in the smaller length groups than female bass; the modal length for males was 37 cm in contrast to 47 cm for female bass (Fig. 4). The maximum length of male bass was 64 cm in contrast to female bass which ranged up to 75 cm fork length. In the recreational catch from Bathurst Harbour in 1984, modal length and age of males was 57 cm and 3 years whereas female modal length and age were 62 cm and 6 years (Bujold 1985). Male bass collected on the spawning grounds in Kouchibouguac River had a modal length of 42 cm and a modal age of 4 years whereas female bass modal length and age were 51 cm and 5 years (Hogans and Melvin 1984).

Size and age data for recreational fisheries from two areas in Gulf New Brunswick are summarized below:

	Age		Range	
Location	Range	Dominant	Length (cm)	Weight (kg)
Bathurst				
1978-1983	3-14	4	33-89	0.4-7.5
1984	2-13	6-7	31-94	0.5-8.6
1986	4-11	8-9	43-83	-
Newcastle				
1984	2- 9	N/A	24-69	0.1-4.5

Maximum age of bass, sampled from Kouchibouguac River in 1983-84 was 6 years (Hogans and Melvin 1984).

Size at age of striped bass from southern Gulf rivers is similar to size at age of bass from the Annapolis River, Nova Scotia but larger than bass from the St. Lawrence River (Table 4). Bass from Chesapeake Bay were larger at age than Gulf bass, especially for the older aged fish (8+ years). Based upon these size at age relationships, the bass measured at the DFO trapnets would not have been more than 10 years old (tables 3, 4).

Current Stock Status

Commercial harvest of striped bass along the Atlantic Coast (1930 to 1986) peaked at 6,344 t in 1973 but has since declined to less than 200 tons in 1986 (Table 6). Canadian harvest of striped bass has been insignificant during the past 57 years, having represented between 1 and 5% of total Atlantic commercial catch during three short time periods, 1931 to 1935, 1942 and 1981 to 1986 (Table 6).

Canadian commercial catch of striped bass from the coastal regions peaked in 1917 at 65 tons and was lowest in 1966 at approximately 1 ton (Table 7). Canadian catches have fluctuated in the past 70 years but have not followed the increasing then decreasing trend of the landings from the United States (Fig. 5; Table 6).

Catch from Prince Edward Island (PEI) is essentially non-existent. Catches from Nova Scotia (NS) have ranged between 0.5 and 22 t annually between 1917 and 1968 (Table 7). Between 1917 and 1934, landings from the coast of the Gulf of St. Lawrence were significant proportions of the sea fishing catch of Nova Scotia. Sea fisheries catches from New Brunswick (NB) peaked at 56 tons in 1917 declining to less than 0.5 t in 1934 and were not registered between 1935 and 1968 (Table 7). New Brunswick sea fisheries catches originated entirely from Gulf districts between 1917 and 1935. Quebec (PQ) sea fisheries catches were only recorded for the years 1949 to 1957 and ranged between 1.4 and 14.5 t (Table 7).

Inland (districts 55-58, 60, 61) fisheries harvest from Canada during 1917 to 1968 has ranged between 1.2 t and 61.8 t (Table 7). NB inland harvest increased from a low of 0.2 t in 1920 to 44.1 t in 1959 (Table 7). Quebec inland catch varied between 4.5 to 48.9 t during 1920 to 1950 but declined to negligible quantities in 1963 and has remained so (Beaulieu 1985).

Harvest in Gulf Region (NAFO Divisions 4R, 4S, 4T)

The Gulf Region catch has declined dramatically from a high of 61.5 t in 1917 to 0 reported catch in 1935 (Table 7). No harvest of striped bass from Gulf districts was registered between 1935 and 1968. Since 1968, reported harvest of striped bass has averaged 13.2 t, ranging between 2.3 in 1987 and 47.8 t in 1981 (Table 8). Landings have been almost exclusively from New Brunswick districts 70, 71, 72, 75 and 76 (Table 8). Maximum annual reported catch from an individual district, 18.8 t, occurred in 1981 (district 77). The most consistent catches have been reported from districts 70 and 75 (Table 8).

The harvest of striped bass in gaspereau trapnets is particularly high in the Northwest Miramichi at Newcastle NB (Table 1) as well as by anglers (Watling 1985). Catch rates (number per net day) in the Newcastle gaspereau nets are substantially higher than other areas in the Miramichi but have declined at all locations since 1981, including the DFO index trapnet at Millbank (Table 9).

In terms of total numbers counted at the Millbank trapnet, three peak years of abundance have been noted since 1968, namely 1968, 1974 and 1979 (Fig. 6). Catch in May and June has fluctuated in the last 22 years, ranging between 12 and 506 bass, with peak years occurring in 1970, 1972, 1977 and 1980 to 1983 (Fig. 6). Low counts of bass at Millbank have been encountered in the 1970's and recent low numbers do not necessarily infer continued low abundance or extinction.

Stock Composition

Tagging studies of striped bass undertaken in the St. Lawrence River and Kouchibouguac River, NB, suggest the existence of at least two population groups of striped bass within the Gulf of St. Lawrence watershed; one population group is limited to the St. Lawrence River and a second group has a wide distribution along the Gulf New Brunswick coast. All reported recaptures of bass tagged in the St. Lawrence River were from the immediate region (Beaulieu 1985). Of 39 bass tagged at Bathurst, NB, in 1986, 2 were recaptured in the Tabusintac River the same year, 1 from Bathurst and 1 from Miscou Island, midway between Bathurst and Tabusintac River (Meagher et al. 1987). Bass tagged in the Kouchibouguac River, NB, were recaptured from New Brunswick rivers both north and south of the Kouchibouguac River (Hogans and Melvin 1984). One recapture was also reported from Maryland USA (Hogans and Melvin 1984) (Rago and Dorazio (1989) reported two recaptures from the eastern US however, only one tag was reported by Hogans and Melvin). Three of seven helminth parasite species identified from a limited number (17) of bass from Kouchibouguac Park, NB, had never before been reported in any other fish from Canadian waters but had been identified in bass from the eastern US (Hogans 1984). The recapture from Maryland, US and the presence of common parasitic fauna suggest that migration of striped bass from the coastal United States into Gulf of St. Lawrence rivers occurs. Not all bass in the Gulf of St. Lawrence are of US origin since young-of-the-year bass have been captured in the Kouchibouguac River (Hogans and Melvin 1984) and in the Tabusintac River (Melvin 1978).

DISCUSSIONS

Limitations in the distribution of striped bass relative to environmental restrictions are probably minimal in the southern Gulf of St. Lawrence. Striped bass are tolerant of a wide range of environmental conditions. The large industrial base of the lower Miramichi River watershed and channel dredging projects undertaken in several New Brunswick rivers could intermittently have affected the movements of bass into these systems and the subsequent survival of eggs and larvae.

Optimum size/age composition for harvesting striped bass has been the subject of intense study by U.S.A. biologists. In response to indications of declining stocks, minimum size limits, which have changed annually in many regions, were imposed in an attempt to protect the 1982 and subsequent year classes (Rago and Dorazio 1989). Yield per recruit analysis of Chesapeake Bay bass was maximum when minimum legal limit ranged from 80 to 90 cm total length (Goodyear 1984). Bass of that length would be between 8 and 10 years of age (Setzler et al. 1980), ages and sizes rarely encountered in the angling fisheries of New Brunswick nor the Millbank trapnet. In addition, size-at-age data suggest that striped bass from the Gulf region grow more slowly than Chesapeake Bay bass (Table 4) thus the maximum yield per recruit would be obtained at a smaller size. The imposition of minimum size regulations increases the potential egg production and since recruitment of striped bass is considered density-independent, (Cooper and Polgar 1981), the increased egg production would potentially result in increased recruitment. Other models, predicting the fishing mortality (F) which would produce stock collapse under various minimum length regulations, arrived at a minimum length of 61 cm (24 in.) at which F increased dramatically and would have to exceed 1.38 to 2.02 for stock collapse to occur (Rago and Dorazio 1989). These estimates were based upon an estimated natural mortality equal to 0.2, and non-catch mortality of sublegals equal to 20% of F.

The present management strategies for striped bass in the eastern United States as summarized by Rago and Dorazio (1989) provide a combination of size and season restrictions (Table 5). In several regions, exploitation is closed during the winter months and into May to protect spawners.

Harvest of large bass only, which are predominantly females would have certain advantages. Successful spawning requires a disproportionate male to female ratio which can be as high as 50:1 (Setzler et al. 1980); male:female ratio at spawning time in the Kouchibouguac River was 7.2:1 (Hogans and Melvin 1984). Organochloride levels have been shown to increase with fish size and these toxicants may contribute to reduced egg and larval survival (Jessop 1980). Minimum size restrictions would consequently release smaller mature females which may be less burdened with toxicants and consequently generate eggs and larvae with higher survival rates.

The recreational fishery at Bathurst Harbour harvests the greatest quantity of fish during July and August whereas the Tabusintac fishery is best in Sept.-Oct. (Madden 1984, Bujold 1985), a time when large bass undertake coastal feeding migrations (Hogans and Melvin 1984). The Newcastle (Miramichi R.) peak angling period is reported to be May-June (Madden 1984). The gaspereau fisheries in Gulf New Brunswick, between May and June, capture a substantial quantity of bass, some of which are discarded back to the river. The survival rate of these discards is unknown.

Harvest of bass during the spawning period should be minimized to permit maximum egg production. Bycatch in gear set for gaspereau, especially in Gulf New Brunswick rivers cannot be eliminated, however, it has been reported that in some eastern US areas, gaspereau nets are equipped with an opening at the bottom of the net which allows small bass to escape while minimizing losses of gaspereau which seek escape near the surface (Watling 1985).

Given that the striped bass has practically disappeared from the St. Lawrence River, it has been proposed that the striped bass be declared an endangered species in the province of Quebec (Beaulieu 1985). In the Gulf maritime region, the potential production of striped bass is unknown. Bass populations appear to be sustained at low levels, it probably has never been an abundant species in the Gulf of St. Lawrence. Fishing mortality and habitat degradation, acting in concert, are undoubtedly the greatest threat to sustained populations in the Gulf region.

No areas can presently be identified as having a surplus to spawning requirements. Spawning stock size in all river systems in the Gulf of St. Lawrence has not been determined. In spite of exhaustive research in the eastern U.S., spawning requirements have not been established given that density-independent factors have been more strongly correlated with recruitment than spawning stock size.

The Gulf of St. Lawrence rivers would be more wisely considered as having reduced or declining populations relative to potential. Under such a categorization, conservative management is recommended.

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Table 1. Numbers of striped bass captured in gaspereau gear as recorded in logbook reports. Not all logbook reports contained bycatch estimates and the absence of catch numbers in a given year does not necessarily indicate the absence of striped bass in the river system. Place names indicated in figure 7.

	Year								
River	1981	1982	1983	1984	1985	1986	1987	1988	1989
Margaree	-	-	-	-	-	-	-	1	1
Wallace	-	-	-	11	10	-	-	-	-
Bouctouche	-	-	-	2	-	-	-	-	-
Richibucto	-	-	78	219	8	18	-	-	131
Kouchibouguac	-	-	143	-	-	-	-	-	2
Black	-	-	15	-	-	-	-	-	-
Napan	65	2710	611	2065	26	18	-	-	-
Miramichi	-	-	-	-	-	-	-	-	-
Loggieville	376	401	971	41	52	283	26	-	19
Chatham	3248	3473	2338	849	1253	393	149	135	169
Newcastle	21861	10679	2082	-	3863	873	414	759	261
Tabusintac	-	-	5	45	-	-	-	-	-
Tracadie	-	-	-	-	139	-	-	-	-
Pokemouche	-	-	-	-	-	-	-	3	-

Table 2. Catch of striped bass in the salmon trap at Dalhousie, NB. See figure 7 for location of Dalhousie in the Gulf of St. Lawrence.

Year	Fishing Period			Catch data	
	Start		End	Date	Number
1972	May 30	to	Aug. 25	July 8	1
				July 11	1
				July 18	1
1973	May 14	to	Sept. 28	June 15	1
				Aug. 6	1
1974	May 18	to	Oct. 31	July 12	1
				Aug. 26	1
1975	May 14	to	Aug. 25		0
1976	May 14	to	Aug. 29	June 7	1
				Aug. 4	1
1977	May 13	to	Aug. 31		0
1978	May 12	to	Aug. 31		0
1979	May 12	to	Aug. 31	July 16	1
1980	May 12	to	Aug. 31		0
1989	June 27	to	July 22		0

Table 3. Fork length (cm) of striped bass from three locations on the Miramichi River, NB.

Location	Year	Month	Fork Length (cm) Mean	Min.	Max.	N
Millbank	1975	May	51	34	68	4
		June	60	53	67	3
	1976	May	41	34	66	31
		June	48	48	48	1
		Sept.	52	42	66	4
	1977	May	40	33	71	59
		June	36	24	53	34
	1978	May	49	34	64	9
		June	44	33	54	8
	1979	May	45	34	71	24
		June	51	46	54	5
	1980	May	41	10	75	21
		June	52	51	53	2
	1981	May	41	23	52	12
	1982	May	43	31	54	21
		June	39	33	45	2
	1986	May	45	38	55	12
		June	47	34	54	3
		Aug.	19	19	19	1
		Sept.	41	33	49	5
		Oct.	51	43	59	2
Northwest Branch	1986	July	28	27	30	3
		Aug.	27	19	34	25
		Sept.	34	23	45	2
		Oct.	38	31	50	3
Southwest Branch	1986	July	30	28	33	2
		Aug.	25	18	43	55
		Sept.	28	23	47	5
		Oct.	41	32	57	7

Table 4. Comparative length (cm) at age of striped bass. Locations are indicated in figures 7 and 8.

	Bathurst		Newcastle	Kouchibouguac	Annapolis	St. Lawrence	Chesapeake
Age	1979-83a	1984b	1984c	1983d	1978e	f	g
1						19.6	11.0
2		39.0	31.5	22.2		31.4	23.2
3	35.0	38.5	37.3	37.5		36.5	34.0
4	42.9	45.7	40.6	41.6	42.0	41.1	43.7
5	51.6	51.5	53.1	47.7	49.0	45.8	52.5
6	59.9	57.4	57.9	51.8	63.7	50.6	60.3
7	64.3	60.9	56.6		67.8	55.3	67.2
8	69.1	63.7	61.0		71.2	58.4	73.5
9	72.1	70.8	68.8		75.0	60.1	79.1
10	73.2	83.4			78.3		84.1
11	81.5	72.1			78.4	68.4	88.6
12	86.9				82.6		92.6
13	88.4	93.5			90.1	76.0	96.3
14	78.7				93.8		99.5
15					95.5	82.9	102.4
16					97.5	74.1	105.0
17					101.3		107.3
18						88.2	109.4
19					103.5		111.2
20					105.0		112.9

Data sources:

- a Madden 1984
- b Bujold 1985
- c Watling 1985
- d Hogans and Melvin 1984
- e Jessop 1980
- f Magnin and Beaulieu 1967
- g Goodyear 1984

Table 5. Fisheries regulations currently enforced in US Atlantic waters relative to striped bass (from Rago and Dorazio 1989).

Table 14. State regulations in place as of 13 January 1989 that affect fishing for striped bass

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

[1] Catch and possession

[2] Potomac River Fisheries Commission

Table 6. Commercial catch (metric tons) of striped bass from the Atlantic coast, 1930 to 1987. NAFO divisions are illustrated in figure 7.

	Canada *				USA Atlantic *			**
	4T	4X	Total	% of Atlantic	SA 5	SA 6	Total	Total SA 5&6
1930			5	0.5				1090
1931			10	1.3				757
1932			11	1.4				739
1933			6	1.5				424
1934			5	1.0				456
1935			8	1.3				629
1936			6	0.4				1442
1937			6	0.3				2080
1938			7	0.4				1816
1939			6	0.4				1707
1940			4	0.3				1320
1941			5	0.5				947
1942			5	0.3				1780
1943			14	4.0				332
1944			12	0.5				2579
1945			8	0.3				2437
1946			4	0.2				2077
1947								2085
1948			3	0.1				2727
1949			15	0.6				2543
1950			13	0.4				3490
1951			7	0.3				2762
1952			12	0.5				2445
1953			8	0.4				2304
1954			20	0.9				2268
1955			15	0.7	44			2194
1956			10	0.5	32			2032
1957			7	0.4	35			1890
1958			7	0.2	42			2763
1959			3	0.1	46			3712
1960			10	0.3	89			3878
1961			11	0.3				4291
1962			15	0.4				3906
1963			7	0.2	246	3955	4201	4213
1964			5	0.1	53	3006	3059	3881
1965			2	0.1	216	3205	3421	3497
1966		1	1	0.0	372	3733	4105	4116
1967	2	3	5	0.1	358	4308	4666	4749
1968	6	7	13	0.3	428	4590	5018	4835
1969	9	14	23	0.4	532	5086	5618	5623
1970	11	4	15	0.3	681	4350	5031	5051
1971	13	7	20	0.6	412	3078	3490	3548
1972	9	3	12	0.3	120	3723	3843	4584
1973	6	3	9	0.1	169	5167	5336	6335
1974	5	5	10	0.2	137	4108	4245	4997
1975	7	1	8	0.2	716	3135	3851	
1976	7	2	9	0.2	498	2464	2962	
1977	5	3	8	0.2	469	1858	2327	
1978	5	4	9	0.2	398	1606	2004	
1979	7	2	9	0.6	450	1045	1495	1572
1980	15	3	18	0.8	378	1691	2069	2114
1981	48		48	2.4	439	1479	1918	1937
1982	32		32	2.8	377	679	1056	1104
1983	23	2	25	3.1	192	728	920	780
1984	12	1	13	1.0	74	1231	1305	1333
1985	19		19	3.3	82	472	554	560
1986	10		10	6.1	50	104	154	153
1987								196

* Canada : Total 1930 to 1954 from Fisheries Statistics of Canada.
Total 1955 to 1986 from NAFO Statistical Bulletin.
USA : Total 1955 to 1986 from NAFO Statistical Bulletin.

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

Table 7. Canadian landings (tons) of striped bass, 1917 to 1968. Sea refers to landings from coastal areas, Inland refers to landings within the freshwater region. Gulf refers to landings from the Gulf of St. Lawrence districts of Canada and the Atlantic provinces.

	CANADA			PEI	NS		NB			QUEBEC	
	Sea	Inland	GULF	Sea	Sea	GULF	Sea	Inland	GULF	Sea	Inland
1917	65.3	17.4	61.5	0.0	9.3	5.5	56.0	1.7	56.0	0.0	15.7
1918	57.8	4.0	54.5	0.2	22.0	18.9	35.6	1.1	35.6	0.0	2.9
1919	35.0	1.2	33.8	0.0	1.8	0.5	33.2	0.7	33.2	0.0	0.5
1920	28.8	16.4	28.4	0.0	1.0	0.5	27.8	0.2	27.8	0.0	16.1
1921	17.1	11.7	16.0	0.0	1.5	0.3	15.7	0.3	15.7	0.0	11.4
1922	20.7	9.2	19.1	0.0	1.8	0.2	18.9	0.3	18.9	0.0	8.9
1923	27.5	6.0	25.5	0.0	2.7	0.7	24.8	0.8	24.8	0.0	5.2
1924	41.5	11.1	39.8	0.0	2.1	0.4	39.5	0.8	39.5	0.0	10.3
1925	24.2	10.7	22.1	0.0	2.5	0.5	21.7	0.3	21.7	0.0	10.4
1926	21.4	31.1	20.0	0.0	2.0	0.7	19.4	9.6	19.4	0.0	21.5
1927	24.8	17.0	22.8	0.0	2.9	0.9	21.9	0.5	21.9	0.0	16.4
1928	12.2	25.3	10.3	0.0	2.9	0.9	9.4	0.5	9.4	0.0	24.8
1929	8.1	32.4	5.8	0.0	2.3	0.0	5.8	0.4	5.8	0.0	32.0
1930	5.4	28.4	4.0	0.0	1.4	0.0	4.0	0.3	4.0	0.0	28.0
1931	9.6	30.4	3.2	0.0	6.4	0.0	3.2	2.3	3.2	0.0	28.0
1932	10.6	33.0	3.9	0.0	6.7	0.0	3.9	3.9	3.9	0.0	29.2
1933	6.3	30.7	0.7	0.0	5.5	0.0	0.7	1.3	0.7	0.0	29.4
1934	4.8	30.6	0.4	0.0	4.5	0.0	0.4	5.2	0.4	0.0	25.4
1935	8.1	31.5	0.0	0.0	8.1	0.0	0.0	4.3	0.0	0.0	27.2
1936	6.0	27.9	0.0	0.0	6.0	0.0	0.0	1.5	0.0	0.0	26.3
1937	6.4	17.7	0.0	0.0	6.4	0.0	0.0	3.6	0.0	0.0	14.1
1938	7.4	22.0	0.0	0.0	7.4	0.0	0.0	3.6	0.0	0.0	18.4
1939	6.3	18.3	0.0	0.0	6.3	0.0	0.0	2.6	0.0	0.0	15.7
1940	4.2	50.3	0.0	0.0	4.2	0.0	0.0	1.5	0.0	0.0	48.9
1941	5.0	40.2	0.0	0.0	5.0	0.0	0.0	0.4	0.0	0.0	39.8
1942	4.6	43.9	0.0	0.0	4.6	0.0	0.0	4.4	0.0	0.0	39.5
1943	13.8	61.8	0.0	0.0	13.8	0.0	0.0	8.9	0.0	0.0	53.0
1944	12.5	33.1	0.0	0.0	12.5	0.0	0.0	5.8	0.0	0.0	27.3
1945	7.8	5.7	0.0	0.0	7.7	0.0	0.1	1.1	0.0	0.0	4.6
1946	3.8	12.5	0.0	0.0	3.8	0.0	0.0	3.4	0.0	0.0	9.1
1947					0.5			3.6		0.0	4.5
1948	3.2	14.5	0.0	0.0	3.2	0.0	0.0	0.5	0.0	0.0	14.1
1949	15.0	9.1	0.0	0.0	9.5	0.0	0.0	0.9	0.0	5.5	8.2
1950	13.2	22.7	0.0	0.0	6.8	0.0	0.0	3.2	0.0	6.4	19.5
1951	7.3	23.6	0.0	0.0	5.9	0.0	0.0	1.8	0.0	1.4	21.8
1952	12.3	23.6	0.0	0.0	5.9	0.0	0.0	7.7	0.0	6.4	15.9
1953	8.2	17.3	0.0	0.0	5.9	0.0	0.0	5.9	0.0	2.3	11.4
1954	20.0	5.0	0.0	0.0	5.5	0.0	0.0	2.3	0.0	14.5	2.7
1955	14.5	5.9	0.0	0.0	7.7	0.0	0.0	4.1	0.0	6.8	1.8
1956	10.5	3.2	0.0	0.0	3.6	0.0	0.0	1.4	0.0	6.8	1.8
1957	6.8	5.9	0.0	0.0	6.8	0.0	0.0	2.7	0.0	0.0	3.2
1958	6.8	22.3	0.0	0.0	6.8	0.0	0.0	20.0	0.0	0.0	2.3
1959	3.2	45.5	0.0	0.0	3.2	0.0	0.0	44.1	0.0	0.0	1.4
1960	10.5	8.2	0.0	0.0	10.5	0.0	0.0	5.0	0.0	0.0	3.2
1961	11.4	2.7	0.0	0.0	11.4	0.0	0.0	0.9	0.0	0.0	1.8
1962	15.0	8.2	0.0	0.0	15.0	0.0	0.0	5.5	0.0	0.0	2.7
1963	6.8	3.6	0.0	0.0	6.8	0.0	0.0	2.7	0.0	0.0	0.9
1964	5.5	5.9	0.0	0.0	5.5	0.0	0.0	5.9	0.0	0.0	0.0
1965	2.3	1.4	0.0	0.0	2.3	0.0	0.0	0.9	0.0	0.0	0.5
1966	0.9	21.4	0.0	0.0	0.9	0.0	0.0	21.4	0.0	0.0	0.0
1967	1.8	8.6	0.0	0.0	1.8	0.0	0.0	8.6	0.0	0.0	0.0
1968	8.2	4.1	0.0	0.0	8.2	0.0	0.0	4.1	0.0	0.0	0.0

Source: 1917 to 1947, Fisheries Statistics of Canada.
1948 to 1968, Fisheries Statistics New Brunswick, Nova Scotai, Prince Edward Island, Quebec.

Table 8. Landings (metric tons) of striped bass from Gulf Region districts, 1968 to 1988. Statistical districts are illustrated in figure 7.

	Statistical Districts																	
	Nova Scotia		New Brunswick													PEI		
Year	13	45	65	66	67	68	70	71	72	73	75	76	77	78	80	83	88	Gulf
1968	0.00	0.00	0.00	0.00	0.00	0.00	0.44	1.80	1.08	0.08	1.21	3.60	0.00	0.00	0.00	0.00	0.00	8.20
1969	0.00	0.00	0.00	0.01	0.00	0.00	0.10	0.37	1.57	0.11	4.80	2.44	0.01	0.00	0.00	0.00	0.00	9.39
1970	0.00	0.00	0.00	0.00	0.00	0.02	2.64	0.89	3.39	0.44	2.70	0.57	0.00	0.00	0.00	0.00	0.00	10.64
1971	0.00	0.00	0.00	0.00	0.00	0.00	0.67	1.40	8.46	0.43	1.99	0.36	0.00	0.00	0.00	0.00	0.04	13.33
1972	0.00	0.00	0.00	0.00	0.00	0.00	0.06	1.81	3.41	0.49	3.08	0.00	0.00	0.00	0.00	0.00	0.00	8.84
1973	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.05	3.82	0.00	1.96	0.05	0.00	0.00	0.00	0.00	0.01	6.10
1974	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.28	3.63	0.00	1.45	0.00	0.00	0.00	0.00	0.00	0.06	5.43
1975	0.00	0.11	0.00	0.00	0.00	0.73	3.19	1.00	0.00	0.00	2.18	0.00	0.00	0.00	0.00	0.00	0.00	7.21
1976	0.00	0.00	0.09	0.00	0.00	0.09	1.86	1.62	3.06	0.00	1.89	0.00	0.00	0.00	0.00	0.00	0.00	8.60
1977	0.00	0.00	0.00	0.00	0.00	0.00	1.77	2.46	0.00	0.00	5.93	0.00	0.00	0.00	0.00	0.00	0.00	10.16
1978	0.00	0.00	0.00	0.00	0.00	0.00	1.47	0.00	0.00	0.00	3.19	0.00	0.00	0.00	0.00	0.48	0.00	5.14
1979	0.00	0.07	0.00	0.00	0.00	0.02	2.22	1.21	0.00	0.00	3.26	0.00	0.00	0.00	0.00	0.00	0.00	6.79
1980	0.00	0.00	0.20	0.13	0.08	0.12	9.69	2.88	0.00	0.00	2.22	0.00	0.00	0.00	0.00	0.00	0.00	15.32
1981	0.00	0.00	0.16	0.00	0.07	0.93	5.53	4.73	0.00	0.00	1.18	16.37	18.75	0.01	0.04	0.00	0.00	47.78
1982	0.00	0.00	0.00	0.00	0.00	1.00	3.76	2.42	0.00	0.00	1.94	17.44	5.84	0.00	0.00	0.00	0.00	32.39
1983	0.30	0.00	0.00	0.00	0.00	1.96	3.03	6.91	0.00	0.02	4.73	3.58	2.82	0.00	0.00	0.00	0.00	23.35
1984	0.00	0.00	0.03	0.51	0.00	0.12	9.91	2.19	0.00	0.00	0.30	4.29	0.00	0.00	0.00	0.00	0.00	17.33
1985	0.00	0.00	0.00	0.97	0.00	0.83	2.33	8.05	0.00	0.00	0.04	9.72	0.05	0.00	0.00	0.00	0.00	22.00
1986	0.00	0.00	0.98	0.34	0.00	2.21	3.46	0.00	0.00	0.00	0.00	5.48	0.00	0.00	0.00	0.00	0.00	12.47
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.02	0.95	0.63	0.11	0.00	0.00	0.00	0.00	2.34
1988	0.00	0.00	0.00	0.00	0.00	0.06	2.00	0.91	0.00	0.00	1.00	0.15	0.00	0.00	0.00	0.00	0.00	4.13
Mean	0.01	0.01	0.07	0.09	0.01	0.39	2.62	1.95	1.35	0.08	2.19	3.08	1.31	0.00	0.00	0.02	0.01	13.19
Std Dev.	-	0.03	0.21	0.23	0.02	0.64	2.72	2.13	2.15	0.16	1.53	5.11	4.13	-	-	-	0.01	10.50
Mininum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.34
Maximum	0.30	0.11	0.98	0.97	0.08	2.21	9.91	8.05	8.46	0.49	5.93	17.44	18.75	0.01	0.04	0.48	0.06	47.78

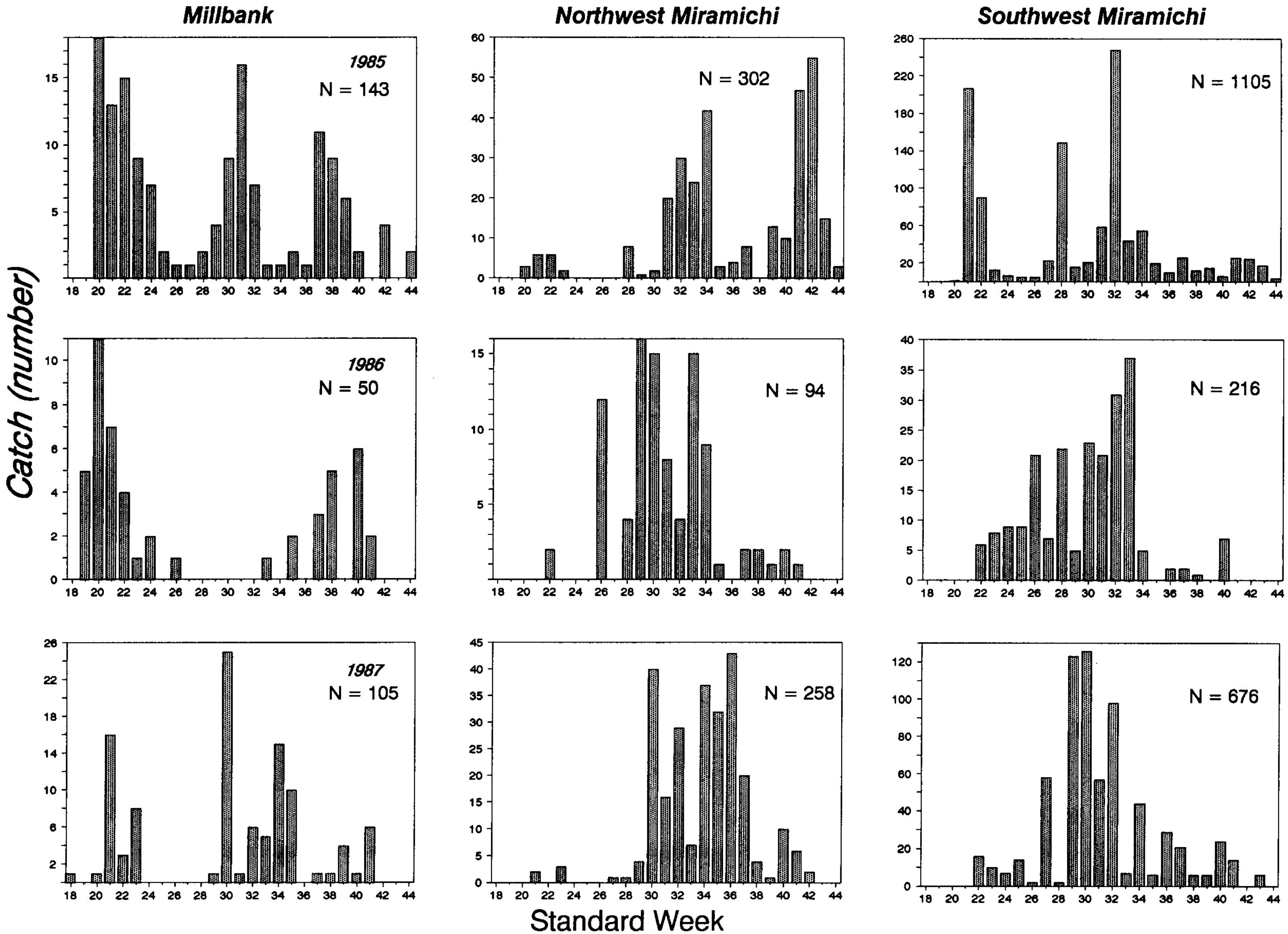

Figure 1. Counts of striped bass, by standard week, at Millbank trapnet and at the recapture trapnets in the Northwest and Southwest branches of the Miramichi River, 1985 to 1987. Standard week examples: week 18 = April 30 to May 6, week 30 = July 23 - 29, week 42 = October 15 - 21.

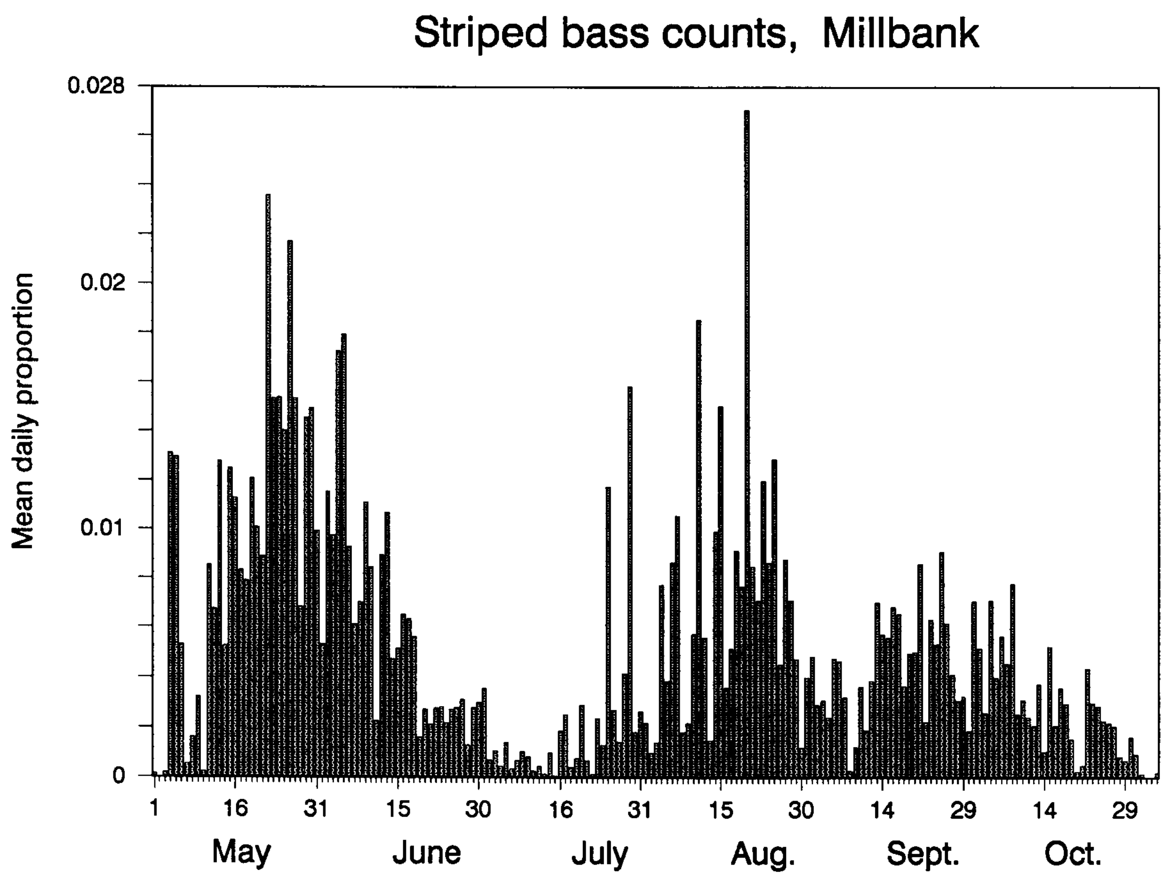

Figure 2. Mean daily proportion of total annual striped bass counts (1976-1989) at Millbank trapnet. Mean daily proportion calculated using daily proportion of annual count, then averaged over 14 years.

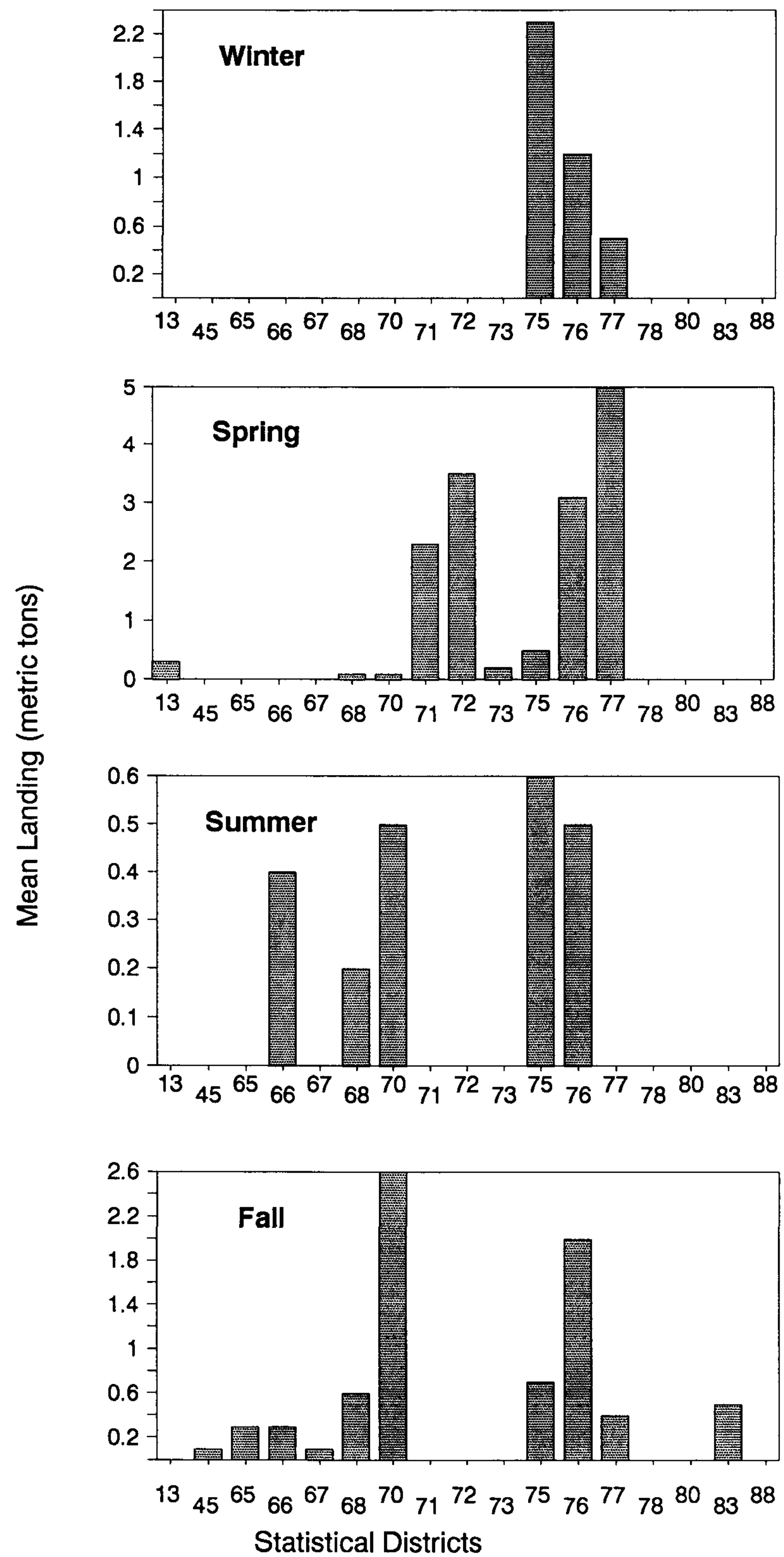

Figure 3. Mean landing (metric tons) of striped bass reported from Gulf districts for winter (December to April), spring (May, June), summer (July, August) and fall (September to November), 1968 to 1988. Statistical districts are shown in Figure 8.

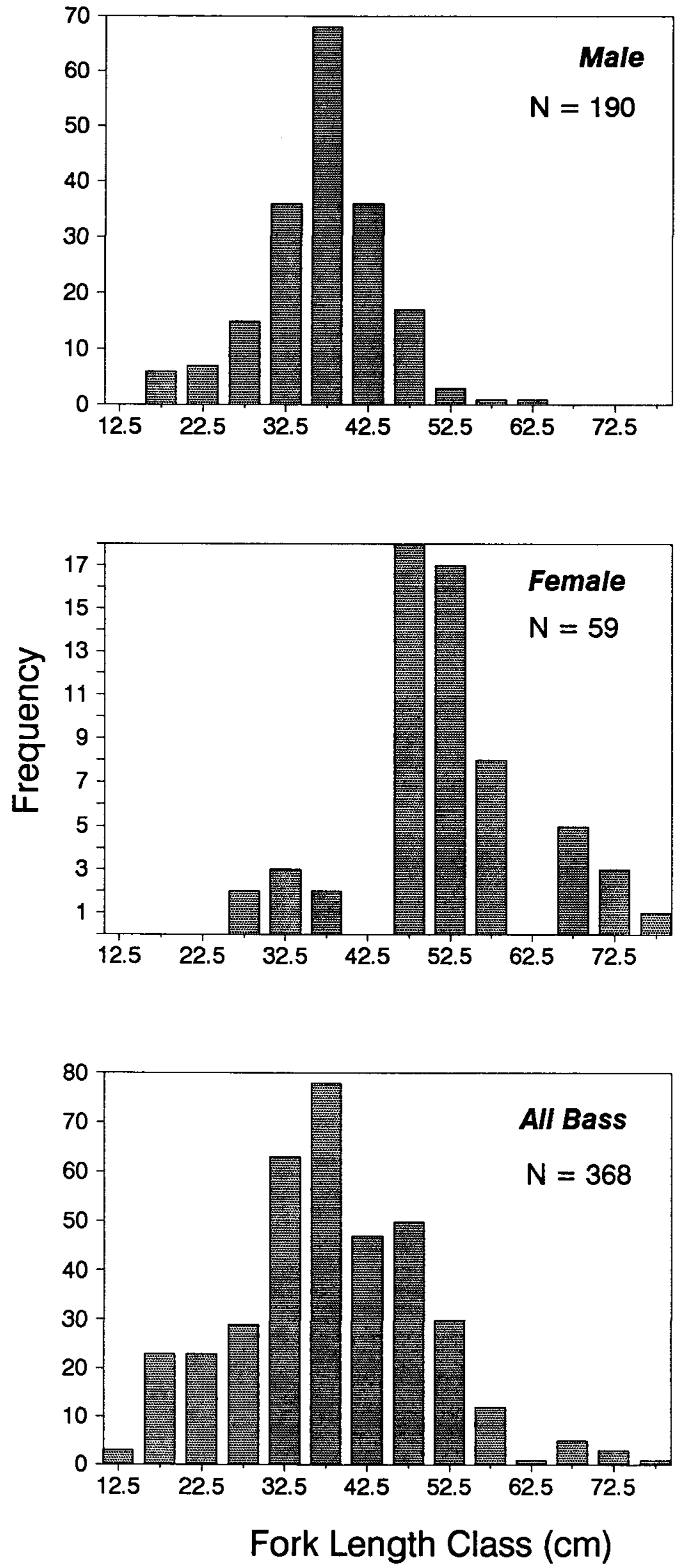

Figure 4. Length frequency distribution, by sex, of striped bass sampled from the Miramichi River, 1976 to 1986.

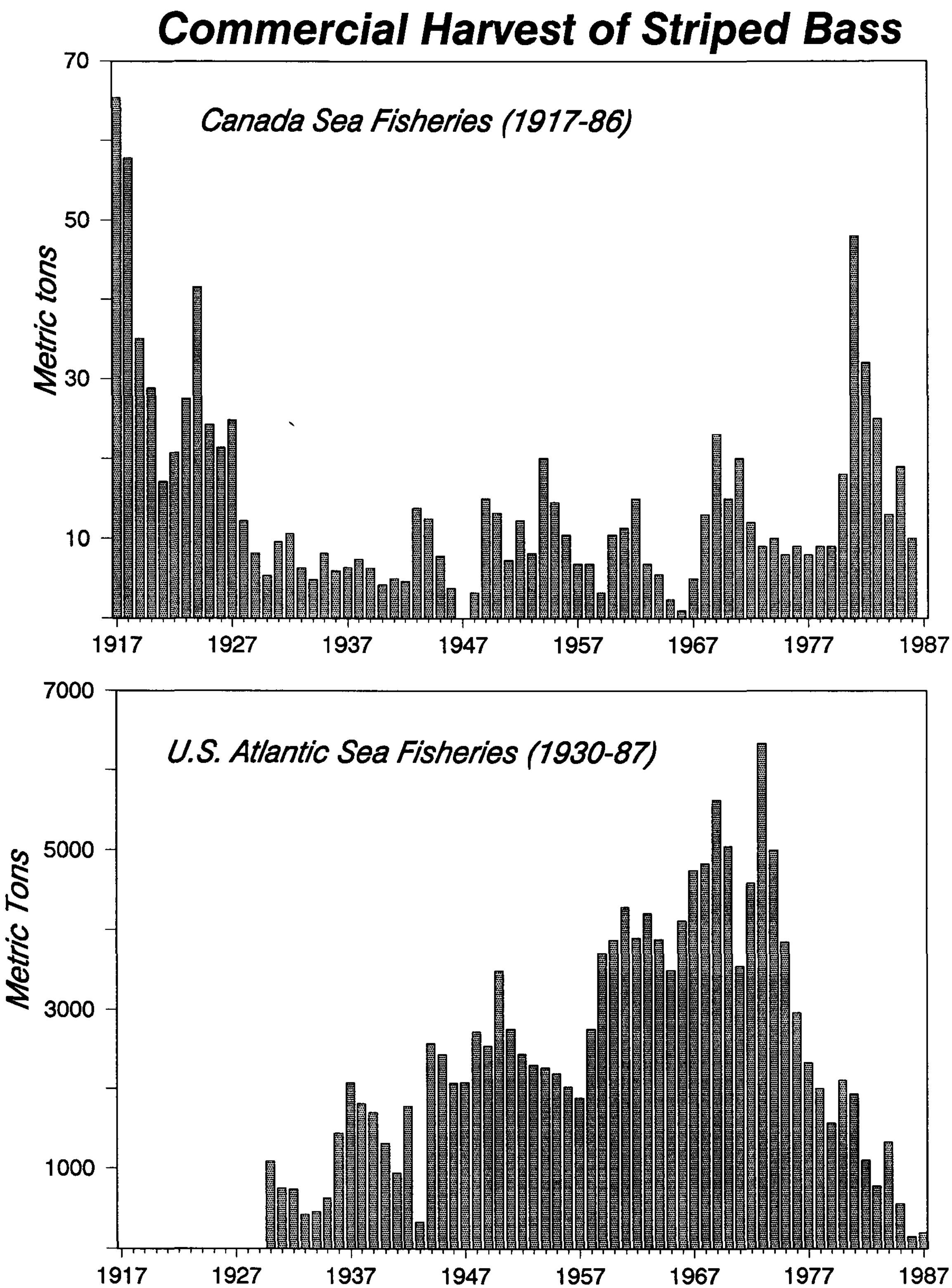

Figure 5. Commercial harvest of striped bass in the sea fisheries of Canada and US Atlantic, 1917 to 1987.

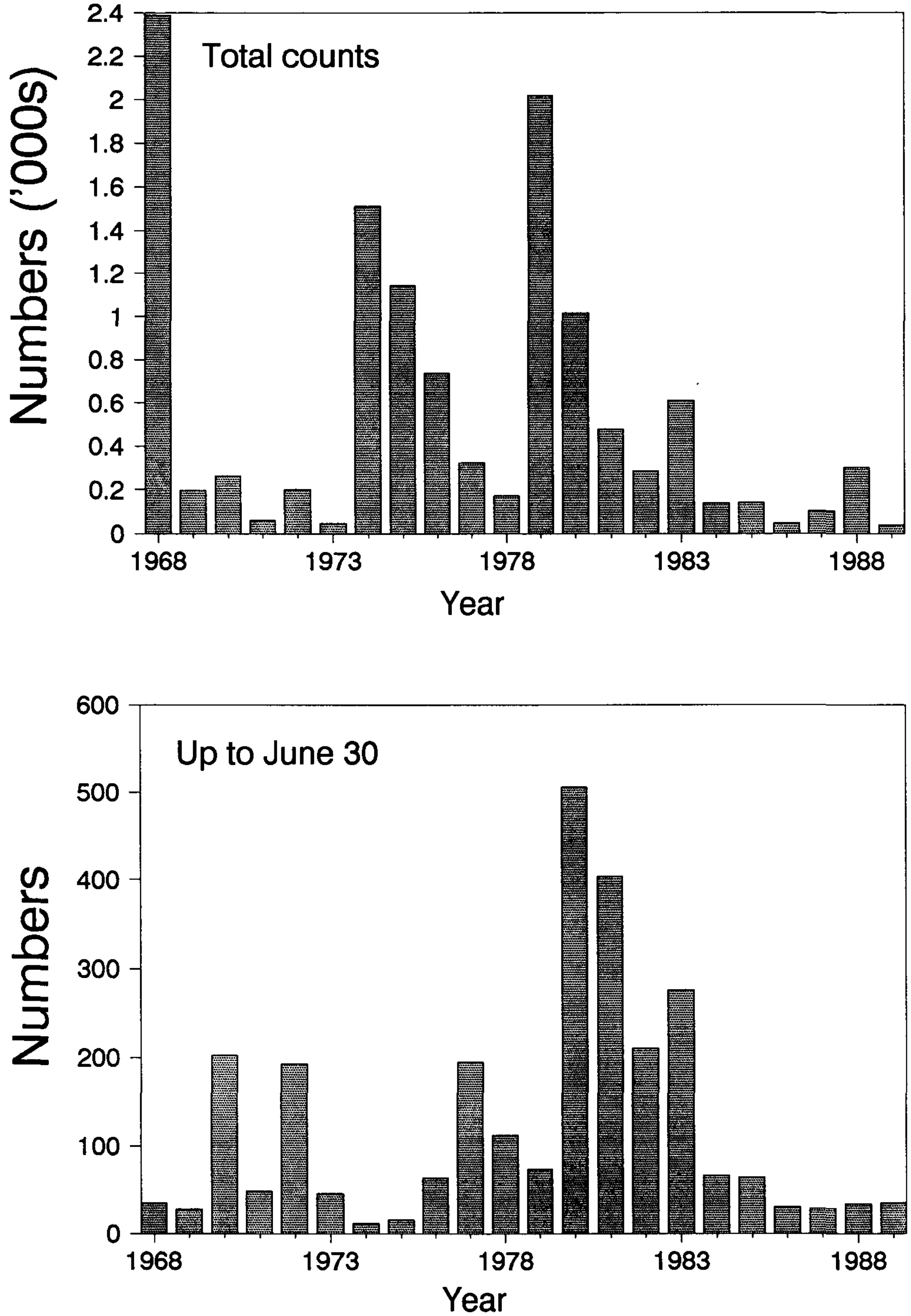

Figure 6. Total annual counts and counts up to June 30 of striped bass at Millbank trapnet, 1968 to 1989.

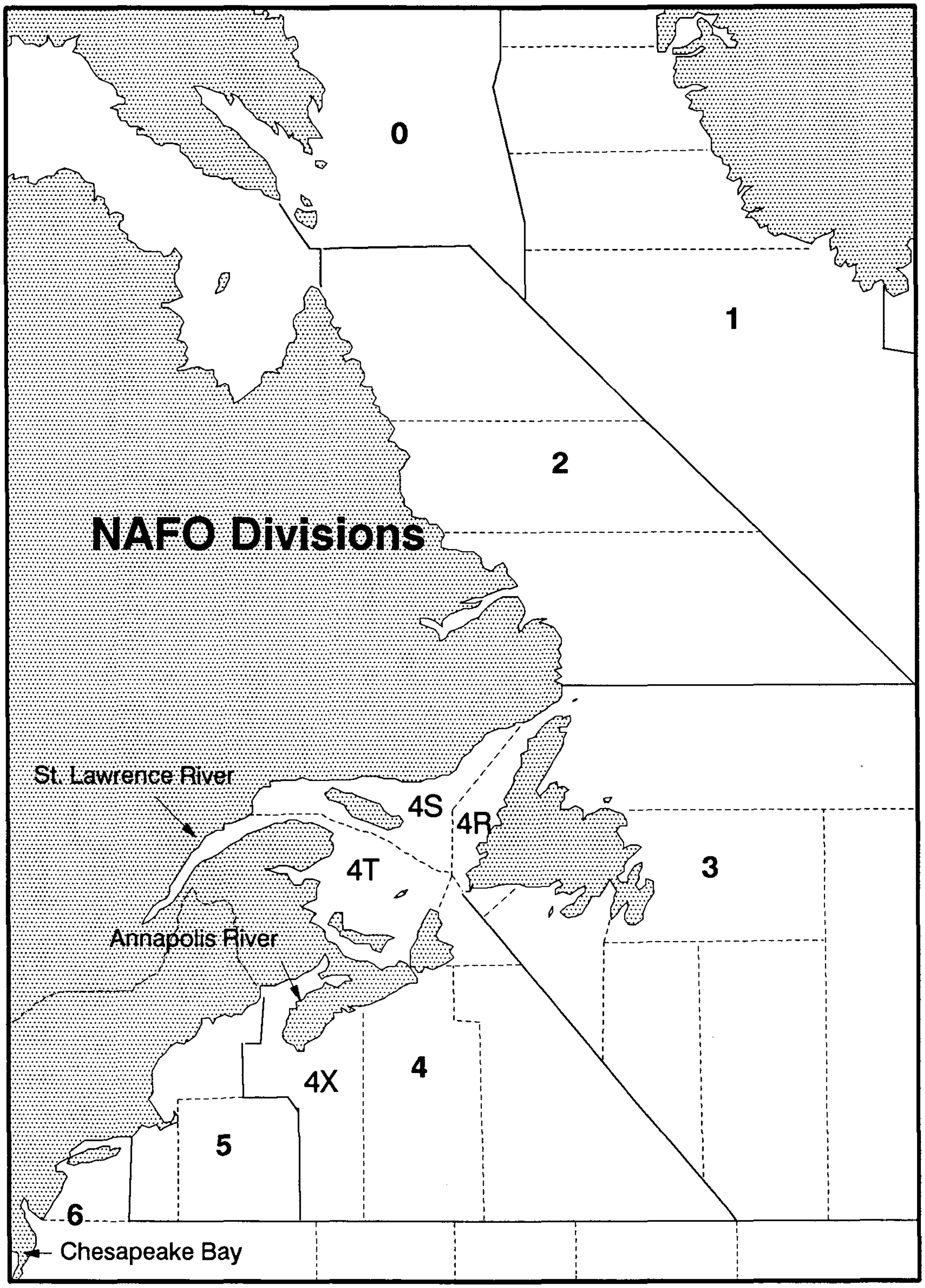

Figure 7. NAFO Divisions of the northwest Atlantic.

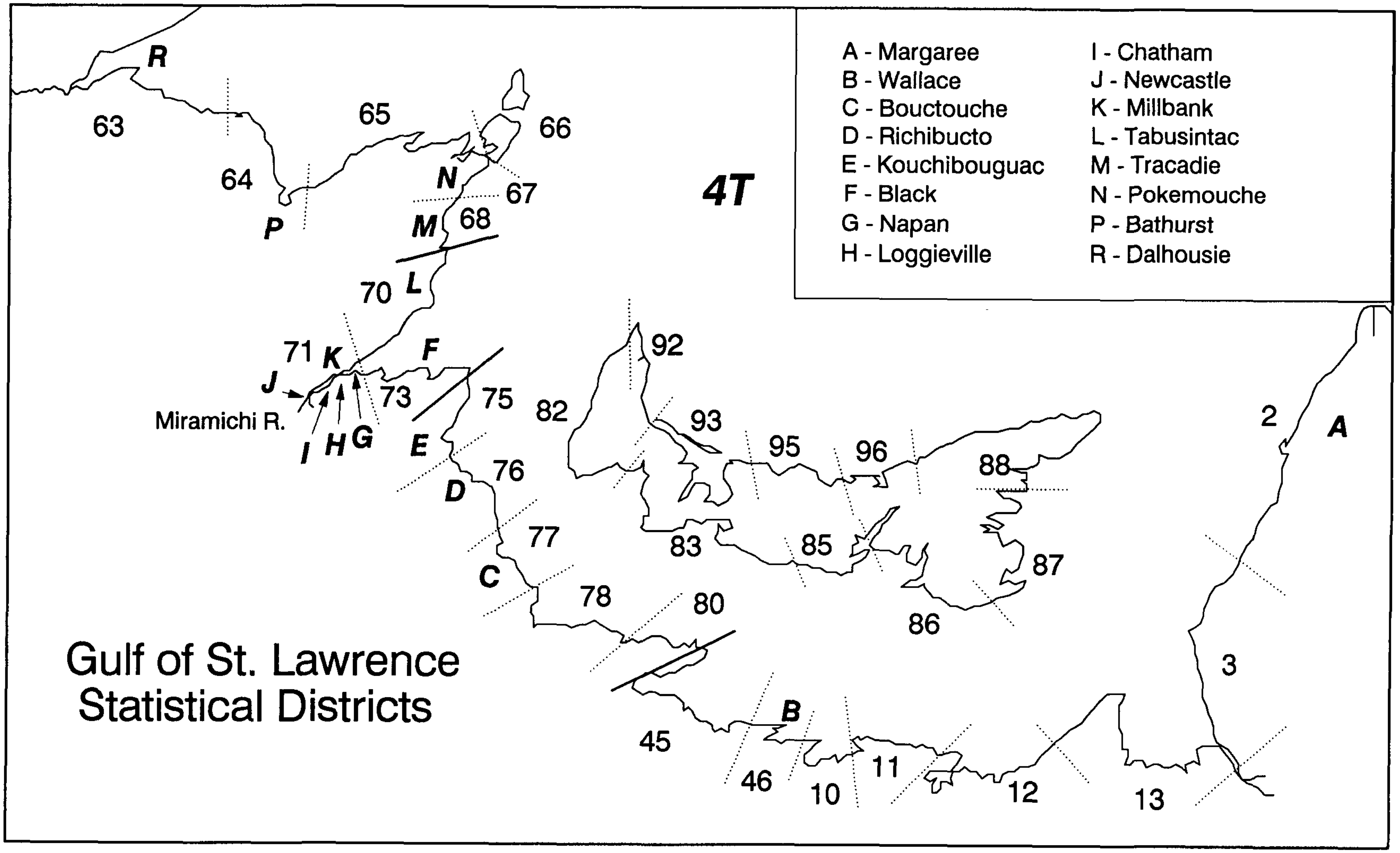

Figure 8. Gulf of St. Lawrence statistical districts and place names referred to in text.