Arctic Development

Estuarnine Fish Communities Of The Eastern James-hudson Bay Coast
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Estuarine fish communities of the eastern James-Hudson Bay coast

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Synopsis

Sampling in six estuaries of the east coast of James and Hudson Bays between 1973 and 1977 has revealed latitudinal differences in the composition of fish communities. Arctic and subarctic *marine* species are more prominent in estuaries of Hudson Bay. Fewer species are found northwards with 35 species in lower rivers and estuaries of James Bay and *only* 24 in those of Hudson Bay, for a total of 38 species. Climate, postglacial dispersion and restricted space are proposed as causes of the observed distribution of fishes.

Introduction

Until recently, biological surveys of the eastern James-Hudson Bay coast have not been numerous. Reviews of the literature on fish distributions in this region (Vladykov 1933, Dymond 1933, McAllister 1964, Hunter 1968) indicate that surveys also lacked detailed coverage of individual rivers and estuaries. In this decade, the hydroelectric development of James Bay rivers has initiated numerous surveys both within river bassins (Magnin 1977, Legenthe & Beauvais 1978), and along the coast. The purpose of the present study was to describe the composition of the ichthyofauna in estuaries along the eastern James-Hudson Bay coast. The processes which may have contributed to the observed geographical distribution of fish species are discussed.

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Methods

This study covers the estuaries of six rivers located along approximately 900 km of coastline and seven degrees of latitude (Fig. 1). General accounts of the climate of the region have been made by Thompson (1968) and Wilson (1971), of the geology by Lee (1968) and Pelletier et al. (1968), and of the vegetation by Rowe (1959) and Saville (1968). The physical

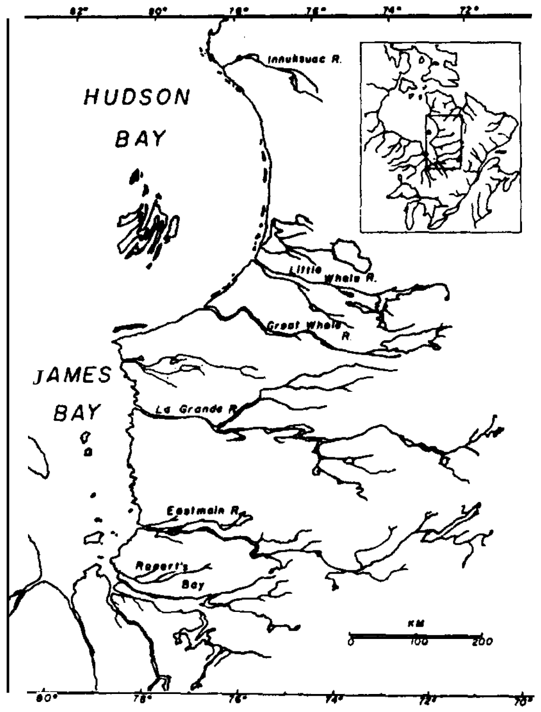

Fig. 1. The east coast of James *and* Hudson Bays, showing the rivers and estuaries studied. Rupert's Bay includes the rivers Nottaway, Broadback, Rupert and Pontax.

and biological oceanography of James and Hudson Bays have been treated by Dunbar (1958) and Barber (1968). Physical studies of estuaries have concentrated on Rupcrt's Biry and La Grande, the results of which are in numerous manuscript reports (see Cardinal & Caron 197 S). Table 1 presents key data for each river.

Diverse methods were employed to capture fish including gill nets, trap nets, seines, minnow traps, rotenone and trawls. Table 2 summarizes capture methods and frequency for each river. The predominance of gill-netting and seining indicates that sampling was most intense in the littoral zone. Since 1974, all gill-netting included the use of a standard 45 x 1.8 m gill net comprised of six panels graded in mesh size from 25 to 102 mm (stretched measure). The biological data collected varied slightly between surveys. In most cases, fish were analyzed for growth, maturity and diet.

In all of these surveys, the date, time, location and method of capture, and the number of each species captured were precisely recorded. Salinity measurements accompanied fish collections and enabled us to evaluate the presence of most species throughout the salinity gradient. The maximum salinity recorded for freshwater and diadromous species appears in Table 3. These observations were preferably taken from seines; however, in the case of gill-net collections maximum salinity is expressed as a range of lowest surface salinity to highest bottom salinity recorded between low and high tides respectively. These data are presented. as a modification of McHugh's (1967) ecological classification of estuarine fishes. We have classified *Acipenser fulvescens* and *Cottus ncei* according to the observations of Melville (1915) and Scott & Crossman (1973) respectively.

The upstream extent of sampling was defined by the first impassable fish barrier, the distance of which varied according to the river (Table 2). The downstream extent of sampling was limited to a zone up to 10 km offshore of the rivers' mouths. The full seaward extent of fish movements has not been determined.

The mean total catch of all fish species in each estuary was calculated from experimental gill nets of graded meshes. Due to heteroscedacity in catch data (Bartlett's Test for homogeneity of variances, $P < 0.05$), differences in mean catches were tested by a Kruskal-Wallis one-way analysis of variance (Siegel 1956). The relative abundance of fish species in each estuary was determined from the percentage of each

Table 1. The major physical characteristics of the rivers studied. Mean breakup date is taken from Wilson (1971).

River	Latitude	Drainage area (km' x 1000)	Mean annual flow (m' s-')	Mean date of breakup
Rupcrt's thy	s 1° 40'	138.0	2549	May 1
Eastmain	52" 15'	46.4	603	May 10
La Grande	53" 50'	97.6	1700	May 20
Great Whale	S5° 17'	4?,7	612	May 20
Little Whale	56" 00'	15.8	167	June 1
Innuksuac	58° 26'	1t.4	101	June 20

Table 2. A summary of the sampling undertaken in each river and the responsible organisations. GIROQ- Groupe Interuniversitaire de Recherches Océanographiques du Québec. Université Laval, Québec. Centreau- Centre de rechcrches sur l'eau, Université Laval, Québec. DFO- Department of Fisheries and Oceans, Arctic Biological Station, Ste. Anne de Bellevue, Québec. CEN- Centre d'Etudes Nordiques, Université Laval, Québec. SEBJ- Société d'Energie de la Baie James, Montréal.

River	Sampling dates	Upriver extent of sampling (km)	Sampling frequency Gill nets	Seines	Others	Responsible organisation
Rupert's Bay	June-Aug 1977	4-18	82		2	GIROQ
	June 1977					Centreau
Eastmain	July, Scpt 1973	27	132	19		DFO
	Aug-Nov 1974					DFO
	Feb, June-Oct 1975					DFO
La Grande	July -Dec 1973	37	256	22	39	DFO
	Mar. JulyOct. Dcc 1974					DFO, SEBJ
	Feb, June, July, Oct 1975					DFO
Great Whale	Aug, Scpt 1973	13	72	6	6	DFO
	Aug, Scpt 1976					GIROQ
	July, Aug 1977					GIROQ, CEN
Little Whale	July, Aug 1977	7	24	10		GIROQ
Innuksuac	July -Scpt 1977	3	28	8	6	CEN

Table 3. Species composition and relative abundance in the six rivers and estuaries studied. The relative abundance of fish in each estuary is based on the percentage of total catch from gill nets. Asterisks indicate the presence of species only, as revealed by all other sampling methods. Maximum salinity observations are presented for freshwater and diadromous species. For gill nets, maximum salinity is expressed as a range of lowest surface salinity to highest bottom salinity recorded between low and high tides respectively. Hyphens indicate species which were captured in brackish water, but for which salinity measurements were not available.

Species	Maximum salinity ‰	Estuary					
		Rupert Bay	Eastmain	La Grande	Great Whale	Little Whale	Innuksuac
Acipenseridae							
Acipenser fulvescens	–	< 1.0	< 1.0	<1.0			
Clupeidae							
Clupea harengus							<1.0
Salmonidae							
Salmo salar	--						<1.0
Salvelinus alpinus	6.8-25.0						2.7
Salvelinus fontinalis	19.2	< 1.0	2.4	1.8	18.0	28.0	10.2
Salvelinus namaycush	2.2-19.2					< 1.0	2.4
Coregonus artedii	19.2	6.3	42.1	25.1	6.0	4.1	< 1.0
Coregonus clupeaformis	20.5	7.1	15.8	8.4	5.6	15.9	34.1
Prosopium cylindraceum	2.2-19.2		*	6.4	3.5	2.6	3.0
Osmeridae							
Mallotus villosus		*	< 1.0	17.2	1.2	19.7	3.3
Ammodytidae							
Ammodytes hexapterus		*	*	*	*	*	*
Ammodytes dubius					<1.0	<1.0	
Stichaeidae							
Lumpenus fabricii			*	*	*	*	
Hiodontidae							
Hiodon tergisus	0	< 1.0					
Esocidae							
Esox lucius		<1.0	4.2	<1.0	< 1.0	< 1.0	
Cyprinidae							
Couesius plumbeus	0.4	*	< 1.0	< 1.0	?.9	1.2	
Notropis atherinoides	0	*	*	*			
Notropis hudsonius	0		*	*			
Rhinichthys cataractae	0						
Semotilus corporalis	0	*	< 1.0	*			
Semotilus margarita	0						
Catostomidae							
Catostomus catostomus	0.4-12.0	52.6	12.6	27.4	27.3	15.4	
Catostomus commersoni	0.9-1.8	6.0	1.4	1.0	1.0		1.5
Gadidae							
Gadus ogac		*	< 1.0	< 1.0	4.6	1.2	25.4
Lota lota			< 1.0	<1.0	<1.0	<1.0	1.4
Gasterosteidae							
Culaea inconstans	0			*			
Gasterosteus aculeatus	11.0	< 1.0	*	*	*	*	*
Pungitius pungitius	11.0		*	*	*	*	*
Percopsidae							
Percopsis omiscomaycus	0.4	< 1.0	< 1.0	<1.0			

Species	Maximum salinity ‰	Estuary					
		Rupert's Bay	Eastmain	La Grande	Great Whale	Little Whale	Innuksuac
Percidae							
Perca flavescens	0	*	< 1.0				
Stizostedion canadense	0						
Stizostedion vitreum	5.3	24.8	10.4	< 1.0			
Cottidae							
Cottus bairdi			•				
Cottus cognatus	1°0		*	*			*
Cottus ricei	0	< 1.0					
Myoxocephalus quadricornis		1.2	7.0	8.2	16.4	3.3	11.4
Myoxocephalus scorpioides			c 1.0	<1.0		<1.0	
Myoxocephalus scorpius			<1.0	1.5	25	6.4	35
Total of species		20	27	27	18	19	18
Total of families		13	13	13	11	11	9

species in the overall catch from gill nets. Species not captured in gill nets were excluded from the calculation of relative abundance because of the disparity of fishing efforts between gear.

Results

Table 3 provides a resumé of the species composition in the rivers and estuaries studied. Fifteen families and.. 38 species were found over the entire range of sites. Estuaries of the James Bay coast contain more faniilies and species. The Acipenseridae, most Cyprinidae, the Hiodontidae, Percopsidae, Percidae and two species of the freshwater Cottidae were found in rivers and estuaries of lower James Bay. Only two families, the Clupeidae and part of the Salmonidae, were restricted to the north. Thirty five species were found in rivers and estuaries of James Bay, whereas only 24 species appear in those of Hudson Bay. Ten species were present along the entire range.

The relative abundance of fish species is presented in Table 3. The Kruskal-Wallis one-way analysis of variance of the mean total catches in estuaries (Table 4) indicated significant differences between estuaries ($P < 0.05$). Thus, comparing relative species abundance as calculated in Table 3 between estuaries is not valid because of significant differences in the densities of fish, Table 3 indicates, however, patterns of species dominance. Salmonidae, Catostornidae and Cottidae were dominant in most rivers and estuaries. *Catostomus catostomus*, absent from the Innuksuac River, is the dominant species in gill nets at three of the remaining five sites. *Coregonus artedii* and *C. cZupeaformis* are important species in all of the rivers and estuaries sampled. At the northern and southern limits of the range *Gadus ogac* and *Stizostedion vitreum* are dominant predators respectively.

Table 5 presents an ecological classification of estuarine fish based on McHugh's (1967) system. The category of obligate freshwater species has been added to account for species that were never found in brackish water. The second group includes the remaining freshwater species that are usually considered as stenohaline but which were occasionally found at the mouths of rivers and in brackish water, in some cases feeding upon marine organisms. Diadromous species migrate between the sea and freshwater (Harden Jones 1968).

Category four of Table 5 comprises the marine species that spawn and live in the estuary. *Myoxocep-*

Table 4, **Mean total catch per unit of effort (fish captured per 24 hours experimental gill-net set) in the six estuaries studies. N- number of gill-net sets.**

Estuary	Year	Catch per effort	N
Rupert's Bay	1975	32.9	16
Eastmain	1974	22.3	10
La Grande	1974	29.5	46
	1975	37.0	28
Great Whale	1976	27.6	13
Little Whale	1977	15.6	12
Innuksuac	1977	13.7	13

Table 5. A classification of estuarine fishes, adapted from McHugh (1967). The presence of each species is indicated for the estuaries of James Bay and Hudson Bay.

Category and species	*Region* James Bay	Hudson Bay
1. Obligate freshwater species		
Hiodon tergisus	x	
Notrrtpis hudsoniux	x	
Notropis atherinoides	x	
Semotilus corporals	x	
Rhinichthys cataractae	x	
Semotilus margarita	x	
Perca flavescens	x	
Stizostedion canadense	x	
Cottus bairdi	x	x
2. Freshwater species that occasionally enter brackish waters		
Esox lucius	x	x
Couesius plumbeus	x	x
Catosromus catostomus	x	x
Catostomus commersoni	x	x
Culaea inconstans	x	
Percopsis omiscomaycus	x	
Stizostedon vitreum	x	
Cottus cognatus	x	x
Cottus ricei	x	
3. Diadromous species		
Acipenser fulvescens	x	
Salvelinus alpinus		x
Salvelinus namaycush		x
Salvelinus fontinalis	x	x
Salmo salar		x
Coregonus artedii	x	x
COre.genus clupeaformis	x	x
Prosopium cvlindraceum	x	x
Lota iota	x	x
Gasterosteus aculeatus	x	x
Pungitius pungitius	x	x
4. Truly estuarine species which spend their entire lives in the estuary		
Myoxocephalus quadricornis	x	x
5. Marine species which use the estuary primarily as a nursery ground, usually spawning and spending much of their adult life at sea, but often returning seasonally to the estuary		
Mallotus villosus	x	x
Ammodytes hexapterus	x	x
Ammodytes dubius		x
Lumpenus fabricii	x	x
Gadus ogac	x	x
Myoxocephalus scorpius	x	x
Myoxocephalus scorpioides	x	x
6. Adventitious visitrrrs which appear irregularly in the estuary		
Clupea harengus		x

halus quadricornis is a probable estuarine spawner. It is caught at all times of the year in the estuary, frequently in the mature stirtc. The remaining marine species spawn at sea, usually feeding seasonally in the estuarine zone. Species such as *Ammodytes dubius*, *I.umpenus fabricii* and *Myoxocephalus scorpioides* have marginal occurrence in the estuary and appeared rarely in our sampling. The presence of *C7upea harengus* in the Innuksuac River is adventitious, the species having never been recorded in Hudson Bay,

Faunal differences between coastal Hudson Bay and James Bay consist, in part, of a reduction in the number of freshwater species towards the north, favoring species that are more strongly euryhaline (Table 5). This is made evident by comparing the Eastmain and Innuksuac Rivers, the two extremities of the range for which sampling is adequate. In the lower Innuksuac River there are no stenohaline freshwater species, although there are more diadromous species than in the Eastmain River. Predatory niches are filled by *Stizostedion vitreum* and *Esox lucius* in the Eastmain river and estuary, replaced by *Gadus ogac* and *Salvelinus fontinalis* in the Innuksuac.

Discussion

Fish surveys of coastal James-Hudson Bay have been restricted to sampling techniques which vary in their selectivity and efficiency. In general, species smaller than 15 cm in total length are poorly represented by gill nets, whereas larger fish tend to avoid active gear, such as seines. Such problems are not uncommon in estuarine research (McHugh 1967, Haedrich & Hall 1976) which frequently necessitates quantitative srsmpling of the community. Our results from gill-net catches indicate that catostomids and salmonids are dominant groups in most estuaries, along with estuanne cottids. The analysis of predator stomachs and results from seines, trawls and other methods indicate that *Mallotus villosus*, *Ammodytes hexapterus* and *Gasterosteus aculeatus* are key forage species and are probably abundant in all estuaries.

In spite of the diversity of sampling techniques, species lists are probably complete for all the rivers and estuaries studied, other than Rupert's Bay where sampling was restricted to gill nets alone. There is no apparent relationship between the intensity of gill-netting (Table 2) and the number of species captured by gill net (Table 3), nor between the remaining species and sampling techniques.

Hunter (1968) reported 12 families and 31 species of marine fishes in the whole of James and Hudson Bays, which in combination with our results amounts to 22 families and 61 species. An additional five families and 16 species have been accounted for in Ungava Bay by Dunbar and Hildebrand (1952). Comparisons with other temperate estuaries indicate the relative paucity of species in the Hudson Bay region. Srivastava (1971) reported 151 fish species from the Gulf of St. Lawrence, of which 21 families and 50 species occur in the Saguenay fjord (Drainville 1970). McKenzie (1959) found 38 families and 69 species in the Miramichi River estuary of New Brunswick.

The marine fauna of James and Hudson Bays reflects combined arctic and atlantic influences. Throughout most of the year, both bays are stratified by warm, low salinity water of land origin overlying cold, moderately saline water (0° C, 32–34‰) derived predominantly from the arctic Sea (Dunbar 1958). Grainger (1963) and Grainger & McSween (1976) consider certain calenoid copepods, present in James Bay, to be indicators of the arctic current. Accounts of the marine fish fauna (Vladykov 1933, Dunbar & Hildebrand 1952, Hunter 1968) include a majority of arctic and subarctic species originating either from the Arctic or north Atlantic Seas. Many of these species are restricted to northern Hudson Bay and the Hudson Strait.

Marine species account for less than one third of the species which use the inshore estuary. Of the nine species, ***Gadus ogac, Myoxocephalus quadricornis, M. scorpioides,*** and ***Lumpenus fabricii*** are arctic species. ***Ammodytes*** and ***M. scorpius*** are subarctic. Dunbar (1975) attributed the presence of *Mallotus villosus*, a subarctic-boreal species, in Hudson Bay to its use of the warmer upper layer. As water temperature rises and salinity decreases towards the south of James Bay (Grainger & McSween 1976), it may be expected that arctic marine species will have limited occurrence. Our data (Table 3) indicate this for arctic and subarctic species such as *Salvelinus alpinus, G. ogac* and *M. scorpius* which are absent or rare in estuaries of southern James Bay.

Our results show that the freshwater component of the lower river and estuarine fauna is subject to change over the range of sites. Such changes may be induced by a generally more rigorous climate towards the north (Pianka 1978). Major climatic differences along the James-Hudson Bay coast appear to be associated with the onset of spring, as shown by the average dates of river breakup in Table 1. Towards the north, the winter duration is longer, river breakup is later, growing season is shorter and mean daily temperatures in April are lower (Wilson 1971). In addition, the predictability of the spring onset is variable throughout the region (Thompson 1968). Such factors may be crucial to the larval development and yearclass strength of many species. They may also limit the growing season of certain fishes accounting, in part, for the decline of freshwater species in northern estuaries.

Another important influence on the distribution of freshwater species along the James-Hudson Bay coast is the nature of postglacial dispersion into the region. Almost all of these freshwater and anadromous species have postglacial origins in the Mississippi and Atlantic refugia (Power 1975, Magnin 1977). The rate and extent of dispersion may have varied according to the salinity and temperature tolerances of each species and the routes taken. Species which reentered the territory by inland routes may have been delayed by adverse climate and the slow retreat of ice towards central Québec. Euryhaline species may have had a more rapid and extensive colonization of northern rivers and estuaries, due to a coastal route of dispersion (Power 1975). Such colonization may be responsible for the observation that predatory niches in estuaries of James Bay are filled by freshwater species such as S. ***vitreum,*** whereas similar niches in Hudson Bay are occupied by marine and more euryhaline species such as G. *ogac* and S. *fontinalis* respectively. Thus, it is possible that the absence of several freshwater species from northern coastal sites is the result of their failure to penetrate beyond certain watersheds.

A third factor influencing the number of freshwater species is the extent of the freshwater zone associated with each estuary. As shown in Table 2, the distance from the river mouth to the first impassable fish barrier is greatest in rivers of James Bay. In the smaller rivers of Hudson Bay, stenohaline freshwater species may be absent because of a lack of adequate habitat, or through competition with diadromous species. Talbot & Lejeune (1976) reported the absence of four freshwater species from the lower Great whale River that are present in the river above the first rapids. The increased number of species in the lower rivers and estuaries of James Bay may be due to the increased space and habitat afforded to stenohaline freshwater species.

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