Geographic and temporal variations in levels of anisakid nematode larvae among fishes in the Gulf of St. Lawrence, eastern Canada

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GEOGRAPHIC AND TEMPORAL VARIATIONS IN LEVELS OF ANISAKID NEMATODE LARVAE AMONG FISHES IN THE GULF OF ST. LAWRENCE, EASTERN CANADA

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Marcogliese, D. J. 1995. Geographic and temporal variations in levels of anisakid nematode larvae among fishes in the Gulf of St. Lawrence, eastern Canada. Can. Tech. Rep. Fish. Aquat. Sci. 2029: viii + 16 p.

A total of 3441 fish belonging to 35 species collected from the Gulf of St. Lawrence, eastern Canada, in 1990 and 1992 were examined for anisakid nematodes. *Pseudoterranova decipiens*, found in 13 species, was most prevalent in the southern Gulf, reflecting the distribution of the main definitive host, the grey seal (*Halichoerus grypus*), and warmer temperatures. Shorthorn sculpin (*Myoxocephalus scorpius*), longhorn sculpin (*M. octodecemspinosus*) and ocean pout (*Macrozoarces americanus*) were among the most heavily infected hosts. *Anisakis simplex*, found in 17 species, was most prevalent in the northern Gulf, reflecting the distribution of cetaceans in the Gulf of St. Lawrence. Shorthorn sculpin, Atlantic herring (*Clupea harengus*) and marlin-spike (*Nezumia bairdi*) were among the species most heavily infected. *Contracaecum osculatum* and/or *Phocascaris* sp. were found in 13 species, being most abundant in shorthorn sculpin from the northern Gulf of St. Lawrence. Contracaecines are generally more abundant at northern latitudes. Abundances of *P. decipiens* and contracaecines in white hake (*Urophycis tenuis*) and longhorn sculpin from St. Georges Bay were significantly higher in 1990 compared to 1992. Of the fishes examined herein, herring and capelin (*Mallotus villosus*) are probably the most important in transmitting *A. simplex* to the cetacean hosts, whereas all species are probably of secondary importance in transmitting *P. decipiens* and contracaecines to the phocid hosts.

RÉSUMÉ

Marcogliese, D. J. 1995. Geographic and temporal variations in levels of anisakid nematode larvae among fishes in the Gulf of St. Lawrence, eastern Canada. Can. Tech. Rep. Fish. Aquat. Sci. 2029: viii + 16 p.

Un total de 3341 poissons appartenant à 35 espèces, capturés dans le golfe du Saint-Laurent en 1990 et 1992 ont été examinés pour trouver les nématodes anisakidés. La prévalence de *Pseudoterranova decipiens*, retrouvé chez 13 espèces, était plus élevée dans le sud du golfe, reflétant ainsi la distribution de l'hôte définitif principal, le phoque gris (*Halichoerus grypus*), et les températures plus chaudes. Le chaboisseau à épines courtes (*Myoxocephalus scorpius*), le chaboisseau à dix-huit épines (*M. octodecemspinosus*) et la loquette d'Amérique (*Macrozoarces americanus*) étaient parmi les hôtes les plus fortement infectés. La prévalence d'*Anisakis simplex*, retrouvé chez 17 espèces, était plus élevée dans le nord du golfe, reflétant la distribution des cétacés dans le golfe du St. Laurent. Le chaboisseau à épines courtes, le hareng atlantique (*Cuplea harengus*) et le grenadier du Grand Banc (*Nezumia bairdi*) étaient parmi les hôtes les plus infectés. *Contracaecum osculatum* et/ou *Phocascaris* sp., retrouvés chez 13 espèces, étaient plus abondants chez le chaboisseau à épines courtes du nord du golfe du Saint-Laurent. Les contracaecinés sont généralement plus abondants aux latitudes nordiques. L'abondance de *P. decipiens* et des contracaecinés infectant la merluche blanche (*Urophycis tenuis*) et le chaboisseau à dix-huit épines de baie Saint-Georges était significativement plus élevée en 1990 qu'en 1992. Parmi tous les poissons examinés, le hareng et le capelan (*Mallotus villosus*) sont probablement les plus importants dans la transmission d'*A. simplex* aux cétacés, tandis que toutes ces espèces jouent vraisemblablement un rôle secondaire dans la transmission de *P. decipiens* et des contracaecinés aux phoques.

1.0 INTRODUCTION

Anisakid nematodes infect a wide variety of fishes throughout the world. Certain species (e.g. *Pseudoterranova decipiens, Anisakis simplex*) pose problems for commercial fisheries in that they can be found in the flesh of fish and may infect humans. While records are extensive, usually surveys of these parasites have concentrated on the most important commercial fish species, notably Atlantic cod (*Gadus morhua*) (Scott and Martin 1957, 1959; Templeman *et al.* 1957; Wiles 1968; Young 1972; Platt 1975; Grabda 1976; Wootten and Waddell 1977; McClelland *et al.* 1983a, b, 1985) and Atlantic herring (*Clupea harengus*) (van Banning and Becker 1978; McGladdery 1986; Lang *et al.* 1990) in the North Atlantic Ocean. Multi-species surveys of anisakids in fish are usually directed at commercial fishes to document potential health hazards to consumers (Torres *et al.* 1978, 1983; Huang 1988; Orecchia *et al.* 1989; Sanmartin Duran *et al.* 1989; Caracappa *et al.* 1990; Kardousha 1992; Pacini *et al.* 1993; Petersen *et al.* 1993).

Few surveys of anisakids in noncommercial fish species exist (McClelland *et al.* 1990; Jensen *et al.* 1994). However, to fully comprehend the dynamics of anisakid nematodes, it is necessary to determine levels of infection in all prey species of the marine mammals which serve as definitive hosts. Thus, surveys of parasites in unexploited and underexploited fishes are also required. This report presents results from a survey of more than 30 species of fish from the Gulf of St. Lawrence in eastern Canada, the site of large populations of seal and whale definitive hosts. Infection levels in Atlantic cod and American plaice (*Hippoglossoides platessoides*) are presented elsewhere (Boily and Marcogliese 1995).

2.0 MATERIALS AND METHODS

Fish were collected with otter trawls in 1990 and 1992 from various areas in the Gulf of St. Lawrence using research and commercial vessels (Fig. 1). In 1990, samples were collected from St. Georges Bay and Anticosti Island in September on the *CSS E. E. Prince*. In 1992, samples were collected from southwestern Newfoundland (May), Anticosti Island (May, October), St. Georges Bay (September), and Bradelle Bank (September) on the *CSS Alfred Needler*. Flatfish samples from southern Gaspé (July), northern Gaspé (August), and the north shore (August-September) were collected by commercial vessels. Fish collected by research vessels were frozen at sea, while those taken by commercial vessels were stored on ice until transport to the fish plant, where they were frozen. Fish were stored at -20°C until necropsy. All fish were thawed, measured to the nearest mm, weighed to the nearest g, gutted, identified to sex and filleted. The fillets and flaps were inspected for nematodes by systematic destruction of the flesh (Power 1961). The viscera were inspected with the aid of a magnifying lens. Nematodes were identified as in McClelland *et al.* (1983a). *Contracaecum osculatum* and *Phocascaris* sp. are combined under the sub-family Contracaecinea, as it is not possible to distinguish between third-stage larvae of these two species with certainty (Berland 1961; Fagerholm 1988; Likely and Burt 1992). A total of 3441 fish was examined, of which 3134 belonging to 28 species are listed in Table 1.

When sample sizes permitted, fish were divided into size-classes as in McClelland *et al.* (1990), to facilitate comparisons with infection levels in other parts of Atlantic Canada. Only data for certain species, white hake (*Urophycis tenuis*), shorthorn sculpin (*Myoxocephalus* *scorpius*), and longhorn sculpin (*M. octodecemspinosus*), were subjected to statistical analysis, based on adequate sample sizes and distribution of samples in both the northern and southern Gulf of St. Lawrence. Prior to statistical analysis, worm counts were transformed for each parasite using a $\log_{10}(x+1)$ transformation to approximate normality (McClelland *et al.* 1983a, b, 1985, 1987). Variations in abundance of larval anisakines with host length and geographic location were analyzed using a Type III ANOVA (SAS PROC GLM) with a level of significance set at $P<0.05$. Prevalence is the proportion of fish in a sample infected with a particular parasite, expressed as a percentage; abundance is the mean number of parasites of a given species per fish, infected and uninfected; and density is the number of parasites of a given species per kg fish body weight (Margolis *et al.* 1982).

3.0 RESULTS

Thirteen species were infected with *P. decipiens*. Data for 10 species from various sites in the Gulf of St. Lawrence are presented in Table 2. In addition, small samples ($n<10$) of Greenland cod (*Gadus ogac*), sea raven (*Hemitripterus americanus*) and monkfish (*Lophius americanus*) contained infected fish. Short- and longhorn sculpin, and ocean pout (*Macrozoarces americanus*) were most heavily infected (Table 2). With the exception of the Anticosti sample in 1990, abundance and prevalence were higher in all species from the southern Gulf than in their counterparts from the northern Gulf. Within sites, abundance and prevalence were also higher in 1990 as compared to 1992. Among shorthorn sculpin, sealworm abundance was highest (14.83/fish) at Anticosti in 1990 ($P<0.0001$), and among longhorn sculpin and white hake, highest (6.40 and 0.13/fish, respectively) in St. Georges Bay in 1990 ($P<0.001$ and $P<0.05$, respectively).

Seventeen species were infected with *A. simplex*. Data for 12 species from various sites in the Gulf are presented in Table 3. In addition, small samples ($n<10$) of silver hake (*Merluccius bilinearis*), pollock (*Pollachius virens*), eelpout (*Lycodes* sp.), Greenland cod, and sea raven contained fish infected with whaleworm. For most fish hosts, abundance and prevalence were higher in the northern Gulf than in the southern Gulf. Among shorthorn sculpin, abundance was highest (2.83/fish) at Anticosti ($P<0.005$), and the interaction between sample and host length was also significant ($P<0.05$). Among longhorn sculpin ($P<0.005$) and Atlantic herring abundance was highest (0.41 and 4.51/fish, respectively) in collections from southwest Newfoundland. The fish most heavily infected with *A. simplex* include shorthorn sculpin, Atlantic herring, and marlin-spike (*Nezumia bairdi*) (1.03/fish) (Table 3).

Thirteen species were infected with larval Contracaecinea (*C. osculatum* and/or *Phocascaris* sp.). Data for 11 species are presented in Table 4. In addition, small samples ($n<10$) of lumpfish (*Cyclopterus lumpus*) and Greenland cod contained infected fish. Among shorthorn sculpin, abundance was highest (2.58/fish) at Anticosti in 1990 ($P<0.05$), while for white hake and longhorn sculpin it was higher in St. Georges Bay in 1990 compared to 1992 ($P<0.005$ in both cases).

Sealworm infections are often presented in terms of density, or number per unit weight. Highest densities (20.7/kg and 37.3/kg) were found in short- and longhorn sculpin, respectively

(Table 5). Densities were also high in ocean pout (1.8-2.5/kg) and medium-sized yellowtail flounder (*Pleuronectes ferrugineus*) (2.7/kg). Among fish from small samples ($n < 10$), densities were high in sea raven (73.5/kg) and monkfish (15.3/kg) from St. Georges Bay in 1990 and 1992 respectively.

Anisakids were not found in 10 Atlantic argentine (*Argentina silus*), 12 white barracudina (*Notolepis rissoi*), 35 cusk (*Brosme brosme*), 41 fourbeard rockling (*Enchelyopus cimbrius*), 3 threespine stickleback (*Gasterosteus aculeatus*), 37 fourlined snakeblenny (*Eumesogrammus praecisus*), 132 moustache sculpin (*Triglops murrayi*), 27 assorted small sculpins (*Artediellus atlanticus, Cottunculus microps, C. thomsoni, Gymnocanthus tricuspis, Icelus bicornis, I. spatula*), 24 Atlantic poacher (*Agonus decagonus*), 13 alligatorfish (*Aspidophoroides monopterygius*), 10 sea tadpole (*Careproctus reinhardti*), 40 Atlantic spiny lumpsucker (*Eumicrotremus spinosus*), or 57 snailfish (*Liparis* spp.).

4.0 DISCUSSION

Previous surveys of sealworm in the Gulf of St. Lawrence focused on Atlantic cod, flatfish and rainbow smelt (*Osmerus mordax*) (Scott and Martin 1957, 1959; Templeman *et al.* 1957; Wiles 1968; McClelland *et al.* 1983a, 1985, 1987; Landry 1990; Landry and Hare 1990; Boily and Marcogliese 1995). Of those fishes, witch flounder (*Glyptocephalus cynoglossus*) examined in 1980-81 from the southern Gulf (McClelland *et al.* 1983a) were infected with sealworm at levels comparable to those from St. Georges Bay in 1992. Higher sealworm prevalence and abundance in hosts from the southern Gulf compared to those from the north as found in this study were also observed in Atlantic cod and American plaice (McClelland *et al.* 1985, 1987; Boily and Marcogliese 1995). This geographic difference is most likely attributable to the high density of breeding grey seals (*Halichoerus grypus*) (Stobo and Zwanenburg 1990), the main definitive host for sealworm (McClelland 1980; Brattey and Stenson 1993), and the comparatively warm temperatures found in the southeastern Gulf (Petrie 1990).

High prevalence, abundance and density of sealworm in long- and shorthorn sculpin occur on the Scotian Shelf off Nova Scotia (McClelland *et al.* 1990), and in shallow Norwegian waters (Jensen *et al.* 1994). Sculpin, however, are not a major component of grey seal diet in the Gulf of St. Lawrence (Benoit and Bowen 1990; Murie and Lavigne 1992), and it is questionable whether they are important in transmission of sealworm to seals. The diet of grey seal in the Gulf of St. Lawrence is composed primarily of cod, capelin and herring (Benoit and Bowen 1990; Murie and Lavigne 1992). Thus, those infected species surveyed herein are probably only of secondary importance in transmitting sealworm to seals.

Infections with sealworm are generally lower in the Gulf of St. Lawrence than on the Scotian Shelf for white hake, ocean pout, and witch flounder (McClelland *et al.* 1990). Densities of sealworm are lower in the Gulf than on the Scotian Shelf for white hake >30 cm, ocean pout <50cm, witch flounder >30 cm, and yellowtail flounder. Cusk and redfish (*Sebastes* spp.) were not infected in the Gulf in this study, but are infected on the Scotian Shelf. The higher infection rates on the Scotian Shelf are most likely due to the proximity of Scotian Shelf fish to Sable Island (McClelland *et al.* 1983b; Marcogliese and McClelland 1992), site of the largest breeding colony of grey seals in the northwestern Atlantic Ocean. In Norwegian waters, cusk and fourbeard rockling, but not witch flounder, are infected with sealworm (Jensen *et al.* 1994).

Previous surveys of whaleworm in the Gulf of St. Lawrence have been restricted to Atlantic cod, flatfish and Atlantic herring (Scott and Martin 1957, 1959; Templeman *et al.* 1957; McClelland *et al.* 1983a, 1985; McGladdery 1986; Boily and Marcogliese 1995), and the earliest surveys in the 1950s were confined to cod fillets only. In this study, infections were high in pelagic fish such as Atlantic herring, and lower in demersal species, with some exceptions, such as shorthorn sculpin.

In the few surveys which examined whole fish from both the northern and southern Gulf, *A. simplex* was more abundant in the north (McClelland *et al.* 1985; Boily and Marcogliese 1995). The geographic distribution of whaleworm among the fish hosts reflects the abundance of toothed and baleen whales which frequent the northern Gulf of St. Lawrence (Prescott and Richard 1982; Reeves and Mitchell 1987). Capelin (*Mallotus villosus*), Atlantic herring and redfish dominate the diet of harbour porpoise (*Phocoena phocoena*) in the Gulf of St. Lawrence (Fontaine *et al.* 1994). Thus, given the infection levels in Gulf fishes, and that harbour porpoise consume ten times as much capelin as Atlantic herring (Fontaine *et al.* 1994), capelin and Atlantic herring are probably responsible for most of the transmission of whaleworm to these and possibly other whales.

Haddock (*Melanogrammus aeglefinus*), skates, cusk and argentine were not infected with whaleworm in the Gulf, but were on the Scotian Shelf, while the reverse was true for ocean pout, witch flounder, and yellowtail flounder (McClelland *et al.* 1990). Infections were higher in white hake and redfish on the Scotian Shelf, but were comparable for Atlantic herring (McClelland *et al.* 1990). In general, infection levels were low in these hosts in both locations, and differences are probably due to chance. The one exception is the high levels observed in cusk on the Scotian Shelf, but the differences are probably due to the fact that large (>61 cm) cusk were examined in McClelland *et al.*'s (1990) samples, whereas only small (<27 cm) cusk were examined from the Gulf of St. Lawrence.

Surveys of larval *Contracaecum osculatum* and *Phocascaris* spp. are rare, and the only studies documenting their abundance in fish from the Gulf of St. Lawrence are those of McClelland *et al.* (1983a, 1985) and Boily and Marcogliese (1995) in Atlantic cod and flatfish. In this study, infections were moderate to low in all species except shorthorn sculpin collected at Anticosti in 1990. Grey seals and especially harp seals (*Phoca groenlandica*) are the main hosts for *C. osculatum* (Brattey and Ni 1992; Brattey and Stenson 1993). The contracaecines tend to be more abundant in seals from higher latitudes (Brattey and Stenson 1993), which may account for their higher abundance in fish from the northern Gulf of St. Lawrence. Sand lance (*Ammodytes* spp.) and Atlantic cod dominate the fish component of the harp seal diet in the Gulf (Beck *et al.* 1993). Given infection levels of fishes in the Gulf (Boily and Marcogliese 1995; this study) and what is known about the diets of harp and grey seals in the Gulf (Benoit and Bowen 1990; Murie and Lavigne 1992; Beck *et al.* 1993), cod are probably the most important hosts transmitting contracaecines to both harp seals and grey seals in the Gulf of St. Lawrence, and the species examined herein are of secondary importance. Sand lance may also be important, but no data exist on infection levels of contracaecines. They are heavily infected with *A. simplex* on the Scotian Shelf (McClelland *et al.* 1990).

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Table 1. Number of each species of fish examined for anisakid nematodes, arranged by size, site, and date. Only samples where n ≥ 10 are included.

Species	Length range (cm)	St Georges Bay, 1990	St Georges Bay, 1992	Bradelle Bank, 1992	Anticosti 1990	Anticosti May, 1992	Anticosti Oct., 1992	SW Nfld. 1992	Gaspé south 1992	Gaspé north 1992	North shore 1992
Skates (*Raja* spp.)	5-41	-	-	-	92	85	-	16	-	-	-
Atlantic herring, (*Clupea harengus*)	≤ 30	-	-	-	-	50	-	66	-	-	-
	≥ 31	-	-	-	-	16	-	35	-	-	-
Capelin (*Mallotus villosus*)	9-17	-	-	-	116	21	54	22	-	-	-
Atlantic argentine (*Argentina silus*)	29-40	-	-	-	-	-	-	10	-	-	-
White barracudina (*Notolepis rissoi*)	13-26	-	-	-	-	12	-	-	-	-	-
Cusk (*Brosme brosme*)	11-27	-	-	-	-	-	29	-	-	-	-
Fourbeard rockling (*Enchelyopus cimbrius*)	4-24	-	-	-	-	24	11	-	-	-	-
Haddock (*Melanogrammus aeglefinus*)	17-59	-	-	-	-	-	-	14	-	-	-
Longfin hake (*Urophycis chesteri*)	10-22	-	-	-	-	-	-	26	-	-	-
White hake (*Urophycis tenuis*)	≤ 30	31	-	-	-	-	18	-	-	-	-
	31-50	52	73	-	-	-	58	-	-	-	-
	≥ 51	-	28	-	-	-	-	-	-	-	-
Marlin-spike (*Nezumia bairdi*)	2-25	-	-	-	-	36	-	-	-	-	-
Cunner (*Tautogolabrus adspersus*)	11-32	22	-	-	-	-	-	-	-	-	-
Eelpouts (*Lycodes* spp.)	≤ 40	-	-	36	-	30	77	15	-	-	-
	≥ 41	-	-	26	-	-	-	-	-	-	-
Ocean pout (*Macrozoarces americanus*)	≤ 50	-	21	-	-	-	-	-	-	-	-
	≥ 51	-	14	-	-	-	-	-	-	-	-
Fourlined snakeblenny (*Eumesogrammus praecisus*)	14-39	-	-	-	-	-	-	19	-	-	-
Atlantic wolffish (*Anarhichas lupus*)	32-51	-	-	14	-	-	-	-	-	-	-
Redfishes (*Sebastes* spp.)	≤ 20	-	-	-	-	60	-	61	-	-	-
	≥ 21	-	-	-	-	25	-	21	-	-	-

Table 1 (cont.).

Species	Length range (cm)	St Georges Bay, 1990	St Georges Bay, 1992	Bradelle Bank, 1992	Anticosti 1990	Anticosti May, 1992	Anticosti Oct., 1992	SW Nfld. 1992	Gaspé south 1992	Gaspé north 1992	North shore 1992
Atlantic hookear sculpin (*Artediellus atlanticus*)	6-7	-	-	10	-	-	-	-	-	-	-
Longhorn sculpin (*Myoxocephalus octodecemspinosus*)	≤ 30	28	27	-	-	-	-	17	-	-	-
Shorthorn sculpin (*Myoxocephalus scorpius*)	≤ 30	13	-	-	14	45	32	-	-	-	-
	≥ 31	-	-	-	12	22	27	-	-	-	-
Moustache sculpin (*Triglops murrayi*)	5-16	-	-	77	-	14	22	19	-	-	-
Atlantic poacher (*Agonus decagonus*)	11-23	-	-	-	-	12	-	-	-	-	-
Atlantic spiny lumpsucker (*Eumicrotremus spinosus*)	3-12	-	-	-	-	20	13	-	-	-	-
Snailfishes (*Liparis* spp.)	6-23	-	-	-	-	21	-	24	-	-	-
Witch flounder (*Glyptocephalus cynoglossus*)	≤ 30	-	-	20	26	47	40	10	-	78	32
	≥ 31	-	10	50	24	26	42	-	-	-	49
Winter flounder (*Pleuronectes americanus*)	16-44	96	-	-	-	-	-	41	60	-	63
Yellowtail flounder (*Pleuronectes ferrugineus*)	≤ 20	-	-	-	-	-	-	22	-	-	-
	21-30	29	21	-	-	-	-	42	-	-	-
	31-40	16	23	-	-	-	-	38	-	-	-
Greenland halibut (*Reinhardtius hippoglossoides*)	≤ 30	-	-	-	14	20	65	-	-	-	-
	31-50	-	-	19	25	41	96	16	-	-	-
	≥ 51	-	-	-	-	-	28	-	-	-	-

Table 2. Prevalence (P) and abundance (A) of sealworm, *Pseudoterranova decipiens*, in various fishes from the Gulf of St. Lawrence in 1990 and 1992. Only infected species from Table 1 are included. Sample sizes are provided in Table 1.

Host	Length range (cm)	St Georges Bay, 1990		St Georges Bay, 1992		Bradelle Bank, 1992		Anticosti 1990		Anticosti May, 1992		Anticosti Oct., 1992		SW Nfld. 1992		Gaspé south 1992		Gaspé north 1992		North shore 1992	
		P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A
White hake	≤ 30	9.7	0.10	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-
	31-50	7.0	0.13	4.1	0.04	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-
	≥ 51	-	-	3.6	0.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cunner	11-32	9.1	0.14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Eelpouts	≤ 40	-	-	-	-	0	0	-	-	0	0	0	0	0	0	-	-	-	-	-	-
	≥ 41	-	-	-	-	7.7	0.19	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ocean pout	≤ 50	-	-	47.6	1.00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	≥ 51	-	-	42.9	1.71	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Longhorn sculpin	≤ 30	50.0	6.40	11.1	0.22	-	-	-	-	-	-	-	-	5.9	0.12	-	-	-	-	-	-
Shorthorn sculpin	≤ 30	42.9	1.43	-	-	-	-	64.3	6.21	17.8	0.60	12.5	0.22	-	-	-	-	-	-	-	-
	≥ 31	-	-	-	-	-	-	66.7	14.83	0	0	14.8	0.41	-	-	-	-	-	-	-	-
Witch flounder	≤ 30	-	-	-	-	5.0	0.10	0	0	0	0	0	0	0	0	-	-	-	-	0	0
	≥ 31	-	-	30.0	0.40	8.0	0.24	0	0	3.8	0.04	2.4	0.02	-	-	-	-	9.0	0.12	0	0
Winter flounder	16-44	3.1	0.06	-	-	-	-	-	-	-	-	-	-	0	0	0	0	-	-	0	0
Yellowtail flounder	≤ 20	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
	21-30	41.4	0.52	0	0	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
	31-40	25.0	0.31	0	0	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
Greenland halibut	≤ 30	-	-	-	-	-	-	0	0	0	0	0	0	-	-	-	-	-	-	-	-
	31-50	-	-	-	-	21.1	0.32	20.0	0.28	0	0	2.1	0.02	0	0	-	-	-	-	-	-
	≥ 51	-	-	-	-	-	-	-	-	-	-	3.6	0.11	-	-	-	-	-	-	-	-

Table 3. Prevalence (P) and abundance (A) of whaleworm, *Anisakis simplex*, in various fishes from the Gulf of St. Lawrence in 1990 and 1992. Only infected species from Table 1 are included. Sample sizes are provided in Table 1.

Host	Length range (cm)	St Georges Bay, 1990		St Georges Bay, 1992		Bradelle Bank, 1992		Anticosti 1990		Anticosti May, 1992		Anticosti Oct., 1992		SW Nfld. 1992		Gaspé south 1992		Gaspé north 1992		North shore 1992	
		P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A
Atlantic herring	≤ 30	-	-	-	-	-	-	-	-	6.0	0.10	-	-	20.0	0.36	-	-	-	-	-	-
	≥ 31	-	-	-	-	-	-	-	-	25.0	0.38	-	-	54.3	4.51	-	-	-	-	-	-
Capelin	9-17	-	-	-	-	-	-	19.0	0.21	9.5	0.10	0	0	18.2	0.23	-	-	-	-	-	-
White hake	≤ 30	6.5	0.06	0	0	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-
	31-50	3.8	0.10	1.4	0.01	-	-	-	-	-	-	6.9	0.10	-	-	-	-	-	-	-	-
	≥ 51	-	-	32.1	0.64	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marlin-spike	2-25	-	-	-	-	-	-	-	-	58.3	1.03	-	-	-	-	-	-	-	-	-	-
Ocean pout	≤ 50	-	-	4.8	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	≥ 51	-	-	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Redfishes	≤ 20	-	-	-	-	-	-	-	-	0	0	-	-	0	0	-	-	-	-	-	-
	≥ 21	-	-	-	-	-	-	-	-	20.0	0.20	-	-	0	0	-	-	-	-	-	-
Longhorn sculpin	≤ 30	3.6	0.04	0	0	-	-	-	-	-	-	-	-	29.4	0.41	-	-	-	-	-	-
Shorthorn sculpin	≤ 30	14.3	0.29	-	-	-	-	42.9	1.14	26.7	0.36	28.1	0.56	-	-	-	-	-	-	-	-
	≥ 31	0	0	-	-	-	-	58.3	2.83	9.1	0.14	63.0	1.96	-	-	-	-	-	-	-	-
Witch flounder	≤ 30	-	-	-	-	0	0	0	0	0	0	2.5	0.05	0	0	-	-	-	-	0	0
	≥ 31	-	-	0	0	2.0	0.02	4.2	0.08	23.1	0.35	0	0	-	-	-	-	5.1	0.08	0	0
Winter flounder	16-44	0	0	-	-	-	-	-	-	-	-	-	-	0	0	1.7	0.03	-	-	14.3	0.17
Yellowtail flounder	≤ 20	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
	21-30	6.9	0.14	0	0	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
	31-40	6.3	0.13	0	0	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
Greenland halibut	≤ 30	-	-	-	-	-	-	21.4	0.50	0	0	0	0	-	-	-	-	-	-	-	-
	31-50	-	-	-	-	0	0	24.0	0.36	4.9	0.05	5.2	0.07	0	0	-	-	-	-	-	-
	≥ 51	-	-	-	-	-	-	-	-	-	-	32.1	0.93	-	-	-	-	-	-	-	-

Table 4. Prevalence (P) and abundance (A) of Contracaecinea in various fishes from the Gulf of St. Lawrence in 1990 and 1992. Only infected species from Table 1 are included. Sample sizes are provided in Table 1.

Host	Length range (cm)	St Georges Bay, 1990		St Georges Bay, 1992		Bradelle Bank, 1992		Anticosti 1990		Anticosti May, 1992		Anticosti Oct., 1992		SW Nfld. 1992		Gaspé south 1992		Gaspé north 1992		North shore 1992	
		P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A	P(%)	A
Skates	5-41	-	-	-	-	-	-	1.1	0.02	0	0	-	-	0	0	-	-	-	-	-	-
Capelin	9-17	-	-	-	-	-	-	19.0	0.25	0	0	0	0	0	0	-	-	-	-	-	-
Haddock	17-59	-	-	-	-	-	-	-	-	-	-	-	-	14.3	0.14	-	-	-	-	-	-
White hake	≤ 30	19.4	0.29	-	-	-	-	-	-	-	-	16.7	0.28	-	-	-	-	-	-	-	-
	31-50	25.0	0.38	6.8	0.12	-	-	-	-	-	-	5.2	0.09	-	-	-	-	-	-	-	-
	≥ 51	-	-	17.9	0.29	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marlin-spike	2-25	-	-	-	-	-	-	-	-	8.3	0.14	-	-	-	-	-	-	-	-	-	-
Longhorn sculpin	≤ 30	32.1	0.68	0	0	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
Shorthorn sculpin	≤ 30	0	0	-	-	-	-	28.6	1.00	15.6	0.62	18.8	0.22	-	-	-	-	-	-	-	-
	≥ 31	-	-	-	-	-	-	50.0	2.58	4.5	0.05	14.8	0.33	-	-	-	-	-	-	-	-
Witch flounder	≤ 20	-	-	-	-	0	0	0	0	0	0	0	0	0	0	-	-	-	-	0	0
	≥ 31	0	0	0	0	0	0	0	0	7.7	0.08	0	0	-	-	-	-	6.4	0.16	0	0
Winter flounder	16-44	2.1	0.03	-	-	-	-	-	-	-	-	-	-	0	0	0	0	-	-	0	0
Yellowtail flounder	≤ 20	-	-	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
	21-30	3.4	0.03	0	0	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
	31-40	6.3	0.06	0	0	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-
Greenland halibut	≤ 30	-	-	-	-	-	-	0	0	0	0	0	0	-	-	-	-	-	-	-	-
	31-50	-	-	-	-	0	0	12.0	0.16	2.4	0.02	0	0	0	0	-	-	-	-	-	-
	≥ 50	-	-	-	-	-	-	-	-	-	-	0	0	-	-	-	-	-	-	-	-

Table 5. Density (number/kg round weight) of sealworm, *Pseudoterranova decipiens*, in various fishes from the Gulf of St. Lawrence in 1990 and 1992.

Host	Length range (cm)	St Georges Bay, 1990	St Georges Bay, 1992	Bradelle Bank, 1992	Anticosti 1990	Anticosti May, 1992	Anticosti Oct., 1992	SW Nfld. 1992	Gaspé south 1992	Gaspé north 1992	North shore 1992
White hake	≤ 30	0.7	-	-	-	-	0	-	-	-	-
	31-50	0.3	0.1	0	-	-	0	-	-	-	-
	≥ 51	-	0.2	-	-	-	-	-	-	-	-
Cunner	11-32	0.4	-	-	-	-	-	-	-	-	-
Eelpouts	≤ 40	-	-	0	-	0	0	0	-	-	-
	≥ 41	-	-	0.2	-	-	-	-	-	-	-
Ocean pout	≤ 50	-	2.5	-	-	-	-	-	-	-	-
	≥ 51	-	1.8	-	-	-	-	-	-	-	-
Longhorn sculpin	≤ 30	37.3	1.2	-	-	-	-	0.6	-	-	-
Shorthorn sculpin	≤ 30	2.6	-	-	20.7	2.5	0.6	-	-	-	-
	≥ 31	-	-	-	20.0	0	0.7	-	-	-	-
Witch flounder	≤ 30	-	-	0	0	0	0	0	-	-	0
	≥ 31	-	0.4	0.4	0	0.1	0.1	-	-	0.2	0
Winter flounder	16-44	0.1	-	-	-	-	-	0	0	-	0
Yellowtail flounder	≤ 20	-	-	-	-	-	-	0	-	-	-
	21-30	2.7	0	-	-	-	-	0	-	-	-
	31-40	0.7	0	-	-	-	-	0	-	-	-
Greenland halibut	≤ 30	-	-	-	0	0	0	-	-	-	-
	31-50	-	-	0.9	0.6	0	<0.1	0	-	-	-
	≥ 51	-	-	-	-	-	0.1	-	-	-	-

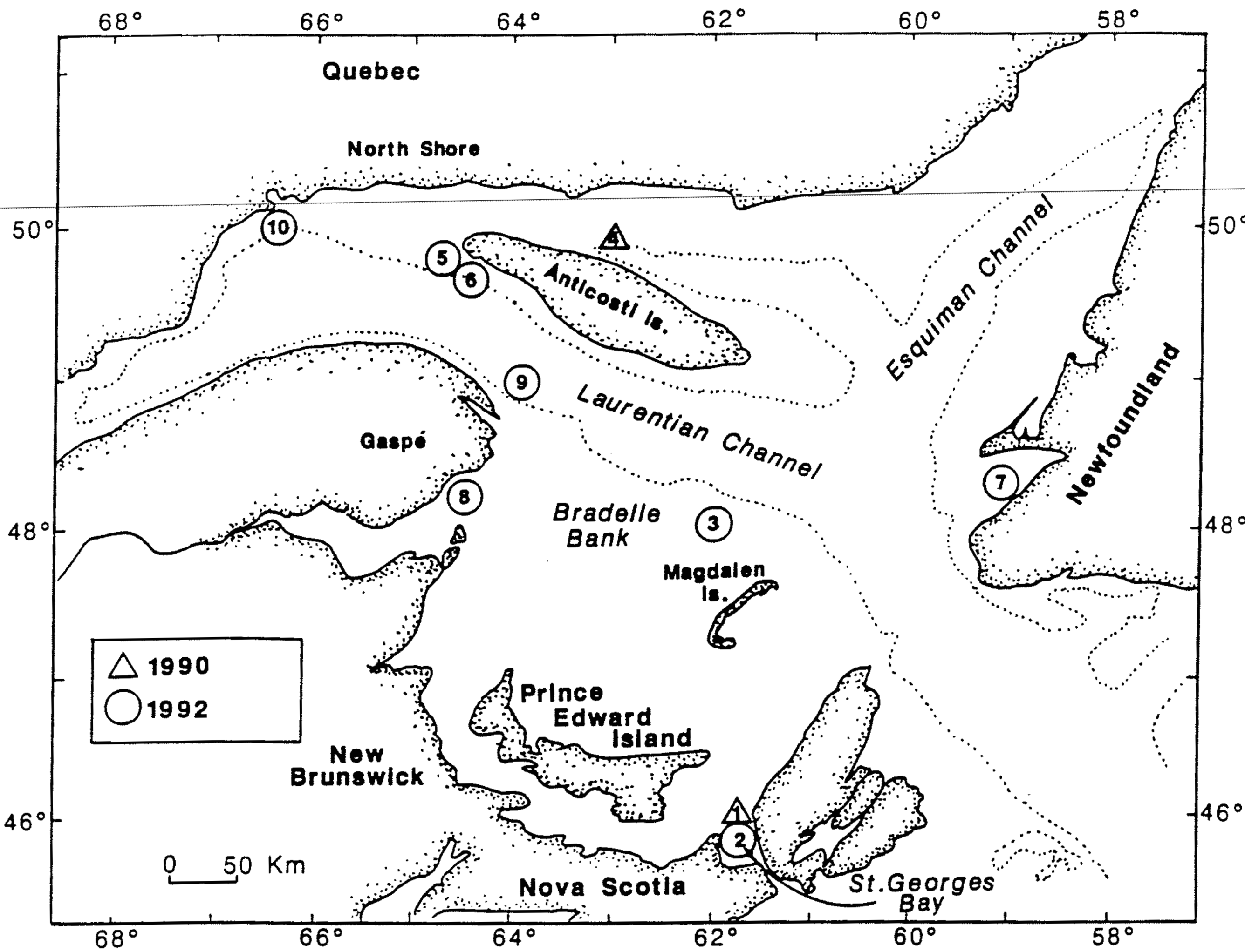

Fig. 1. Map of the Gulf of St. Lawrence showing sampling sites for fish collected in 1990 and 1992. Sample sites are: 1) St. Georges Bay, September 1990, 2) St. Georges Bay, September 1992, 3) Bradelle Bank, September 1992, 4) Anticosti, September 1990, 5) Anticosti, May 1992, 6) Anticosti, October 1992, 7) southwest Newfoundland, May 1992, 8) Gaspé south, July 1992, 9) Gaspé north, August 1992, and 10) north shore, August and September 1992.