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Short communication

Relationship between cod fishery activities and the population of herring gulls on the North Shore of the Gulf of St Lawrence, Québec, Canada

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The history of herring gull (*Larus argentatus*) populations nesting along the North Shore of the Gulf of St Lawrence and the commercial fishing activities there are closely related. Coastal cod (*Gadus morhua*) supply the main fishery in this part of the Gulf and traditionally have resulted in significant amounts of fish offal being discarded at sea and in fishing ports. Using commercial catch data of cod landings, and information from herring gull surveys conducted in the migratory bird sanctuaries on the North Shore from 1925 to 1993, the relationship between the cod fishery and herring gull populations was investigated. Between 1925 and 1975 the fisheries harvested a mean of 5 234 t of cod annually, with high and low catches of 11 000 and 1 700 t, respectively. During the same period, the herring gull population in the sanctuaries increased from 650 to 8 000 pairs. After 1975, and until 1993, the annual mean harvest was 5771 t peaking in 1983 at 11 500 t. There was then a steady decline until a complete fishery collapse in 1993. During the same period, the herring gull population increased from 8 000 pairs in 1975 to 14 000 pairs in 1988, but then dropped dramatically in most sanctuaries and was estimated at only 3000 pairs in 1993. This general decline of gulls appears to be related to the decrease in commercial fishing activities in the region, but not uniformly so.

Key words: cod fishery, Gulf of St Lawrence, herring gull.

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Introduction

Quinquennial censuses of the migratory bird sanctuaries of the North Shore of the Gulf of St Lawrence show that herring gull (*Larus argentatus*) populations, after reaching their highest numbers in the 1980s, declined sharply between 1988 and 1993 (Fig. 1). Field observations suggest poor reproductive success since 1990 in some of the sanctuaries. Parallel to this, the cod (*Gadus morhua*) fishery, by far the most important fishery on the North Shore, with over 90% of groundfish landings, rapidly declined after 1983 until a moratorium on fishing was imposed in 1994. The scavenging behaviour of seabirds behind fishing vessels is well known (e.g. Hudson and Furness, 1989), and several authors have attributed the growth of many seabird populations to their utilization of discarded fish and offal (e.g. Nisbet, 1978; Oro *et al.*, 1995).

We hypothesize that fish offal (livers and intestines) and discarded fish obtained by scavenging herring gulls following commercial fishing boats contributed to the support of large populations of herring gulls, and that the collapse of cod fishing activities triggered the recent decline of the herring gull on the North Shore. In this paper we check for a correlation between the size of herring gull populations and the size of cod fishery landings in this region.

Methods

The Canadian Wildlife Service has censused seabird populations in the migratory bird sanctuaries of the

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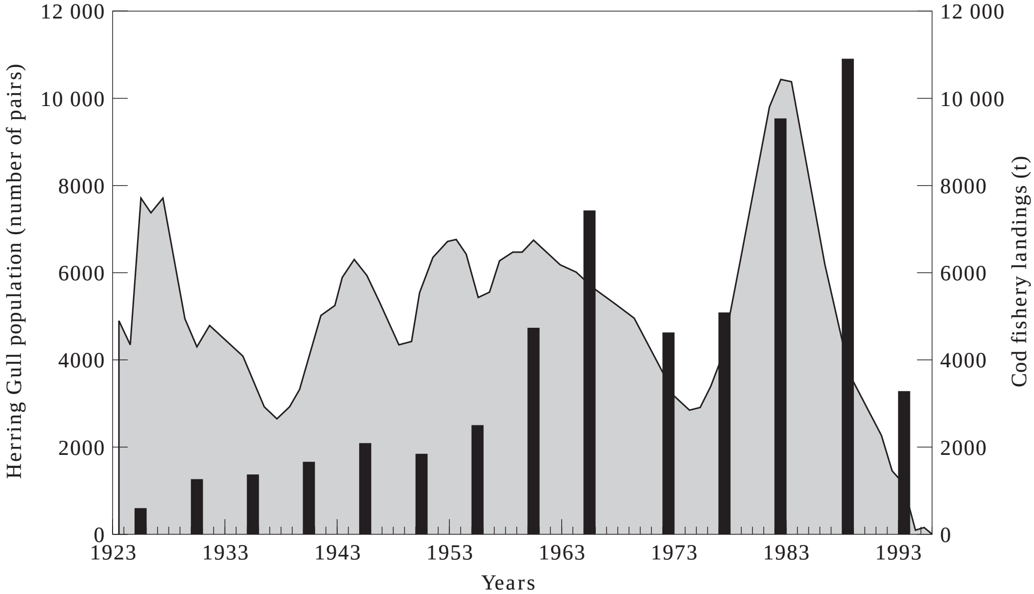

Figure 1. Relationship between cod fishery landings and the population of herring gulls in the sanctuaries of the North Shore, 1923–1995.

North Shore (Fig. 2) nearly every five years since 1925 (Chapdelaine, 1995). Data on fishery landings have been gathered annually for each fishery district of the North Shore (Fig. 2) since 1917 by Fisheries and Oceans (Canada). The herring gull population in each sanctuary was related to the cod fishery landings of the corresponding district. Brador Bay sanctuary was excluded from the analysis because of its small number of breeding gulls. The link between the total herring gull population of all sanctuaries and the sum of cod fishery landings of districts 19, 21, 22, and 23 was also investigated.

The correlation (Pearson product-moment) between the number of breeding pairs of herring gulls and the number of tonnes of cod landed in the corresponding fishery district for the same years was tested. Howes and Montevecchi (1993) observed a 6-year lag between the highest levels of fish landings and the highest gull populations in Gros Morne National Park, Newfoundland, and considered that this was consistent with the 5 to 7-year recruitment period for herring gulls in North America (Kadlec and Drury, 1968). Accordingly, we also tested if the gull population responded with a lag time of 1 to 9 years. The same tests were used with 5-year means of fishery landings to counter large annual fluctuations. As the number of correlation tests was very high, Bonferroni-corrected significance levels were used. All analyses were made for the 1925–1993 period, but because the Corossol sanctuary had been censused on a regular basis since 1940 we present the results for the 1940–1993 period only.

Results

Table 1 shows the relative importance of cod landings by district and the importance of the herring gull population of the sanctuaries for the 1940–1993 period. It is worth noting that sanctuaries are not present in all fisheries districts and some important herring gull colonies are located outside the sanctuaries, so the total population is not representative of the whole North Shore population.

In general, gull populations were more closely correlated with 5-year means of fishery landings than with annual landings. The herring gull population in the Corossol sanctuary was significantly ($p<0.05$) correlated with cod fishery landings in district 19 (Fig. 3) with lags of 0 to 3 years (Table 2). Gull numbers from St Augustine were also related to cod landings in district 23, but with lags of 5 to 9 years. However, gull populations from Betchouane, Watshishou, Fog Island, Wolf Bay and St Mary's Islands were not significantly correlated with cod landings in their respective fishery districts. Finally, the whole population of herring gulls in the North Shore sanctuaries was correlated with the sum of cod landings in districts 19, 21, 22, and 23 and for every lag time tested. The relationship appeared strongest with lags of 5–6 years (Table 2). Using Bonferroni corrections, only two

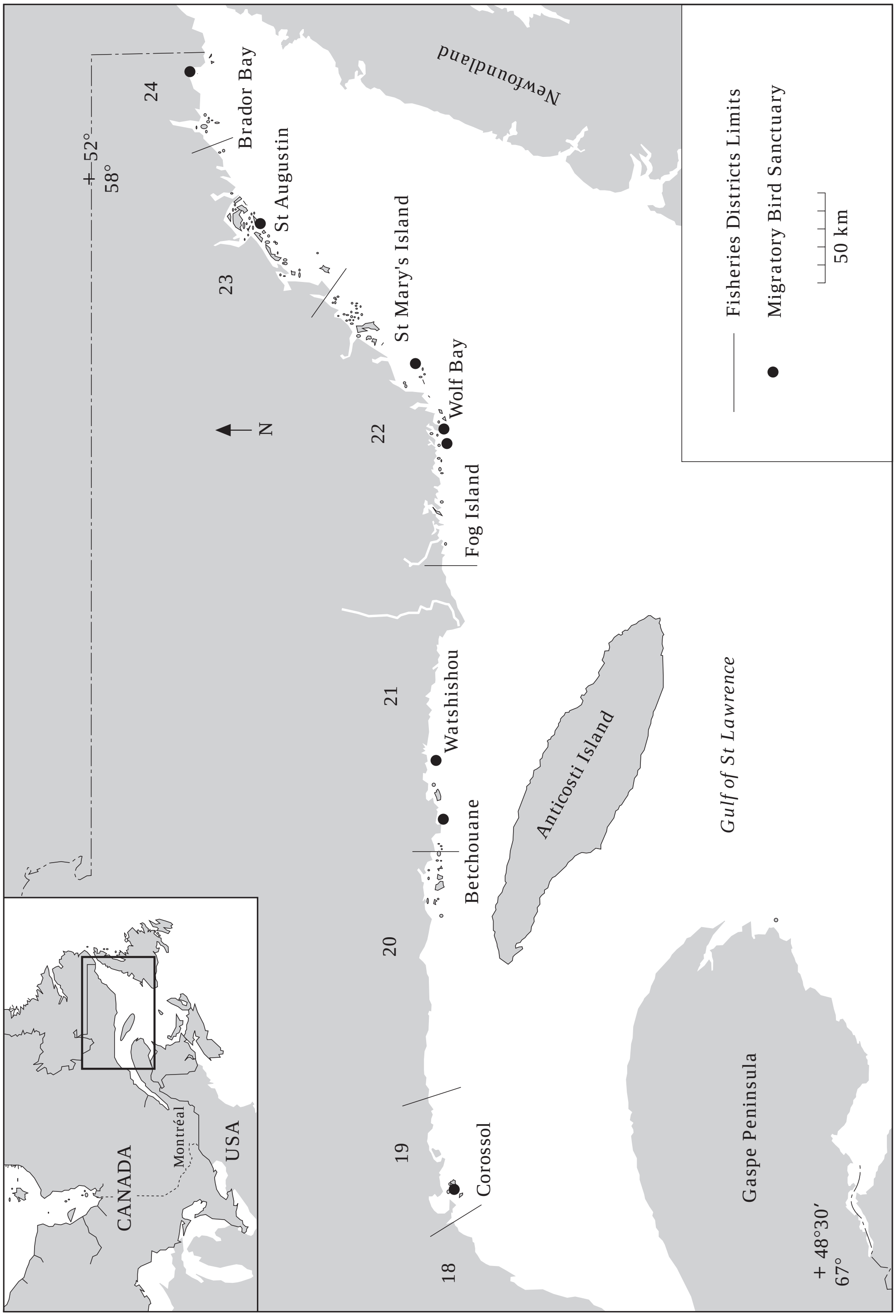

Figure 2. Fisheries districts and Migratory Bird Sanctuaries on the North Shore of the Gulf of St Lawrence, Québec, Canada.

Table 1. Average annual cod landings (by district) and breeding populations of herring gulls (by sanctuary), on the North Shore, for the period 1940–1995.

Fishery district	District 19	District 20	District 21		District 22			District 23	District 24	Total
Average cod landings per year (t)	190	634	323		596			1482	2048	4950
(mean annual percentage of the total)	(4.2%)	(11.1%)	(5.1%)		(12.4%)			(28.8%)	(38.5%)	(100%)
Sanctuary	Corossol		Betchouane	Watchichou	Fog Island	Wolf Bay	St Mary's	St Augustine	Brador Bay	Total
Average gull population per census (pairs)	1492		339	117	83	280	535	1148	5	3999
(mean annual percentage of the total)	(29.4%)		(11.3%)	(5.2%)	(3.5%)	(8.7%)	(17.6%)	(24.0%)	(0.2%)	(100%)

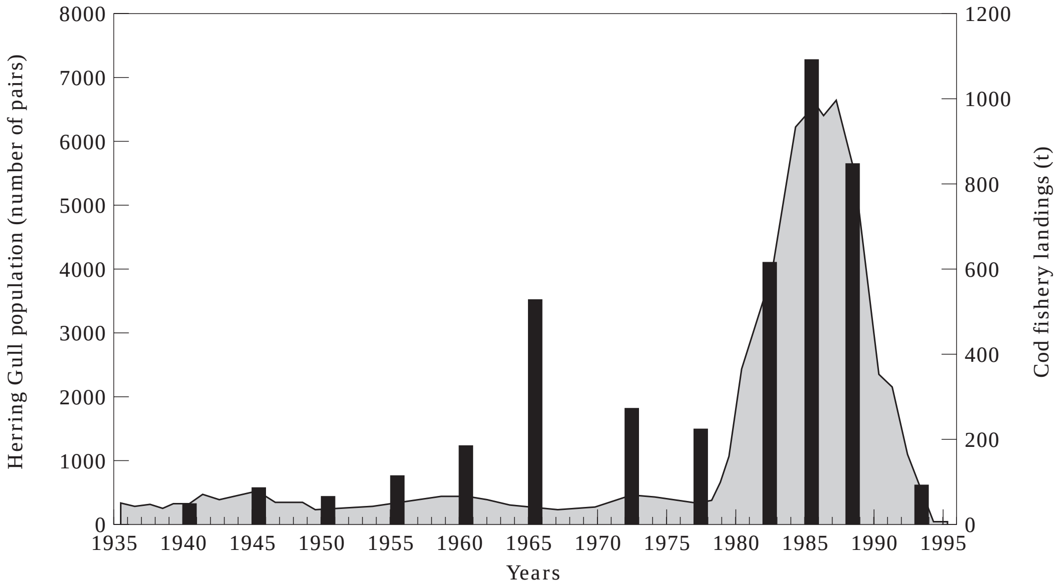

Figure 3. Relationship between the population of herring gulls on Corossol Island and cod fishery landings in district 19, 1935–1995.

correlations out of 80 tests were significant ($p<0.0006$). However, this method is rather conservative when the number of correlation tests is high. Usually the error rate is much less than $p<0.05$ and consequently the power of individual tests is reduced (Milliken and Johnson, 1992).

Discussion

For several decades, gull (*Larus* sp.) populations have been increasing world-wide. Seabird biologists have shown that this success may be attributed partly to the gulls' opportunistic ability to obtain food (fish offal and discarded fish) by following fishing boats (Oro, *et al.*, 1995; Furness, *et al.*, 1992). However, caution is required when generalizing this to the herring gull population of the North Shore of the Gulf of St Lawrence.

The total population of gulls in the sanctuaries appeared to be related to total cod landings on the North Shore. At a smaller scale, however, gull populations of only two sanctuaries out of seven showed strong correlations. It is worth noting that these were the sanctuaries with the largest numbers of herring gulls. Although we were expecting a 5 to 7-year lag between the highest levels of fish landings and the highest gull populations (based on the 5 to 7-year recruitment period for herring gulls in North America; see Howes and Montevecchi, 1993), gull populations of Corossol and St Augustine sanctuaries were better correlated with cod landings at lags of 0 to 3 years and 5 to 9-years respectively. Many factors may influence the relationship between gull numbers and fish landings. For example, the gull population in a sanctuary does not necessarily represent the total gull population of a fishery district. Gull populations outside sanctuaries are poorly surveyed and may have been responding differently. In addition, emigration and immigration from and to the sanctuaries are likely to occur. Finally, the quantity of fish offal available to seabirds per tonne of cod landings could be very different among districts, depending on how and where the fish is processed. The distance between the colonies and the sites where offal is available (e.g. Castilla and Pérez, 1995), and whether fish offal is mostly discarded at sea or at a fish plant, can influence the behaviour of gulls and, consequently, their breeding success and numbers (e.g. Arcos and Oro, 1996).

In conclusion, the artificial food source derived from the cod fishery did not appear to influence herring gull populations uniformly among the North Shore sanctuaries. We suggest that it would be useful to acquire more details of the availability of fishery wastes by district, or to explore directly the relationship between herring gull diet (including the importance of fish offal and discards) and breeding success of the species.

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Table 2. Correlations between populations of herring gull in the North Shore sanctuaries and cod landings in the corresponding fishery districts, with 0 to 9 year lags for the period of 1940–1993.

Time lag (years)	Corossol Island vs. district 19 (n = 12*)		Betchouane vs. district 21 (n = 13)		Watchichou vs. district 21 (n = 11)		Fog Island vs. district 22 (n = 11)	
	r	p	r	p	r	p	r	p
0	0.9202	†0.0001	− 0.3633	0.2224	− 0.0807	0.8136	0.0915	0.7890
1	0.8920	†0.0001	− 0.1256	0.6827	− 0.1516	0.6564	0.1788	0.5989
2	0.8245	‡0.0010	0.1446	0.6374	− 0.1811	0.5940	0.2171	0.5213
3	0.7042	‡0.0106	0.2738	0.3654	− 0.2134	0.5286	0.3098	0.3538
4	0.5236	0.0806	0.3852	0.1937	− 0.2767	0.4101	0.3052	0.3614
5	0.3209	0.3092	0.4716	0.1037	− 0.2395	0.4782	0.3474	0.2952
6	0.0749	0.8170	0.5168	0.0706	− 0.0206	0.9520	0.2494	0.4596
7	− 0.0153	0.9625	0.4990	0.0826	0.2412	0.4748	0.0071	0.9836
8	− 0.0745	0.8180	0.4751	0.1009	0.3383	0.3089	− 0.1513	0.6570
9	− 0.1652	0.6079	0.4710	0.1042	0.4838	0.1317	− 0.1906	0.5746

Time lag (years)	Wolf Bay vs. district 22 (n = 11)		St Mary's Islands vs. district 22 (n = 12)		St Augustine vs. district 23 (n = 9)		Total sanctuaries vs. districts (n = 9)	
	r	p	r	p	r	p	r	p
0	0.3974	0.2261	0.4202	0.1738	0.3028	0.4284	0.6668	‡0.0498
1	0.2414	0.4745	0.3432	0.2748	0.2905	0.4482	0.6981	‡0.0365
2	0.0608	0.8591	0.1787	0.5784	0.3558	0.3473	0.7429	‡0.0218
3	0.0699	0.8382	0.2213	0.4894	0.5058	0.1648	0.7843	‡0.0123
4	− 0.0183	0.9574	0.0911	0.7783	0.6118	0.0800	0.8043	‡0.0090
5	− 0.0163	0.9621	0.0446	0.8904	0.7099	‡0.0321	0.8425	‡0.0044
6	0.1080	0.7520	0.0408	0.8998	0.7678	‡0.0157	0.8291	‡0.0057
7	0.1106	0.7461	0.0142	0.9651	0.7962	‡0.0102	0.8114	‡0.0079
8	0.0332	0.9227	− 0.0534	0.8692	0.8121	‡0.0078	0.7653	‡0.0163
9	0.0144	0.9666	− 0.0260	0.9362	0.7655	‡0.0162	0.6981	‡0.0365

*Number of censuses in the sanctuary since 1940.
†Bonferroni test, α/k, significant correlation ($p < 0.0006$).
‡Significant correlation ($p < 0.05$).

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