Reference 2000

THE EFFECTS OF HABITAT AVAILABILITY AND DISTURBANCE ON THE DISTRIBUTION AND MOVEMENTS OF GREATER SNOW GEESE IN SOUTHERN QUEBEC

A progress report submitted to the

Institute for Wetland and Waterfowl Research
and
Canadian Wildlife Service

by

Arnaud Béchet, Jonathan Olson, Jean-François Giroux
Université du Québec à Montréal

and

Gilles Gauthier
Université Laval

Correspondance: Jean-François Giroux, Département des sciences biologiques, Université du Québec à Montréal, C.P. 8888, Succursale Centre-ville, Montréal, QC, H3C 3P8. Phone: (514) 987-3000 (ext. 3353#). Fax: (514) 987-4647. E-mail: giroux.jean-francois@uqam.ca

February 2000

SUMMARY

The Greater Snow Goose population has increased considerably in the last 30 years reaching more than 800,000 birds in the spring of 1999 with consequences on natural habitats and crop depredation problems. Moreover, geese have started to bypass the traditional stopover areas of the St. Lawrence estuary in fall for the corn-growing areas of SW Quebec and northern United States (Vermont, New York). This results in reduced opportunities for goose hunting and observation along the St. Lawrence estuary, which have not been compensated by additional opportunities in SW Quebec. A spring conservation hunt was established for the first time in 1999 to reduce the population increase and to limit crop depredation. The consequences of this conservation hunt on the pattern of spring and fall migrations are unknown. Moreover, the effects of habitat availability on the distribution of the birds should also be evaluated in order to suggest management strategies based on habitat manipulation that would enhance hunting success and reduce crop depredation. The aims of our research programme are therefore to 1) evaluate the effect of habitat availability and disturbance, including scaring and hunting activities (spring and fall), on the migratory behavior of snow geese in Quebec, 2) experiment management techniques to reduce crop depredation along the estuary by establishing alternate feeding sites, and 3) experiment the use of lure crops to increase hunting success in fall. The effects of the management actions on goose dispersal and length of stay in an area are evaluated by 1) regular counts of geese in the experimental sites and in night roosts along the St. Lawrence river, and 2) tracking of radio-marked geese and observation of neck-collared geese.

Regional censuses in spring 1999 showed that a large number of geese used the SW region (west of Quebec City) until the end of the season. In 1998 and 1999 geese started to use newly sown corn fields in the SW causing severe local depredation problems. Multi-strata capture-recapture models suggest that reverse migration (from east to west) occurred in 1999 compared to previous years, a change in behavior that could explain the higher use of the SW in late spring. This is believed to be related to the disturbance induced by the spring hunt along the estuary. Increases in disturbance rates in 1999 were responsible for a decrease in the length of feeding bouts in fields of the lower estuary region, resulting in less depredation. Alternate feeding sites are used by geese in spring and could be a good strategy to reduce local problems. However, their establishment is costly and will never support the entire population of geese.

Condition of geese upon departure for the Arctic was very low in 1999. Compared to data collected in previous years, geese had 30 to 50% less body fat at the end of spring staging. This poor condition may have been a leading cause of the very poor breeding success experienced by the birds in summer 1999 with a concomitant low hunting success in fall.

In fall, between 20 and 40% of the geese fly directly to the USA without stopping in Quebec. Although most of those that stop are still using the middle estuary, there is an increasing proportion using SW Quebec. The total average length of stay of geese in southern Quebec is therefore increasing compared to the mid eighties. However, innovative hunting techniques must be implemented to take advantage of this situation and to increase the total harvest. Lure crops are effective in attracting geese and increasing hunting success when the production of juveniles is high but not when there are few young in the flock.

Field work will be conducted in the spring and fall of 2000. This will allow us to confirm the different trends presented in this progress report and to assess the effectiveness of the management options chosen.

INTRODUCTION

Waterfowl managers have become concerned about the dramatic increases of some populations of North American Arctic nesting geese. The basis of their concerns is the widespread habitat degradation that is occurring in many Arctic-nesting colonies and staging areas (Abraham and Jefferies 1997). The spring population of the Greater Snow Goose has increased from less than 50,000 birds in the late 60s to more than 800,000 in the spring 1999. A recent study on Bylot Island, the main nesting colony, has shown that geese were at about half the carrying capacity of their breeding habitat (Massé 1998). This level is considered to be an ideal and long term sustainable level.

In spring, the number of Greater Snow Geese has exceeded the carrying capacity of the natural marshes and the birds started to use the surrounding farmlands in the mid 70s. Traditionally limited to the middle estuary, their regional distribution has also expanded towards the lower estuary and southwestern Quebec. Crop depredation by geese occurs in these three regions but the extent depends on the type of crops and timing of migration. At the beginning of the staging period in southwestern Quebec, the geese mainly rely upon waste grain in stubble and plowed cornfields. This feeding activity does not result in damage complaints. Later in spring, however, some geese feed on early growth of newly sown cereals including corn, a foraging behavior that can cause severe local damage. Along the middle and lower estuary, geese feeding in hayfields can reduce forage production by up to 25% at the first cut. This has constituted the most important irritant to farmers during the last fifteen years and represents approximately 1 million dollars in annual losses.

In the mid 80s, Maisonneuve and Bédard (1992) used repeated sightings of neck-collared birds to establish that 80 - 89 % of the population stopped in southern Quebec in fall while the remainder flew directly to their US wintering areas. They also estimated that the average fall staging period of a goose in the estuary varied between 16 and 19 days. Preliminary observations of radio-marked birds in 1995 revealed that the percentage of birds flying directly to the US had increased and that the staging period in the estuary had shortened (J.-F Giroux and G. Gauthier, unpubl. data). The decreased use of the estuary in fall is also obvious at the Cap Tourmente National Wildlife Area, a traditional staging ground where the number of goose-days has decreased steadily from 2.0 million in 1985 to 0.8 million in 1996, despite the increase in population size (A. Reed, pers. comm.). This change in the migration pattern is a real concern for those benefiting from the presence of greater snow geese in the estuary (outfitters, hunters, bird-watchers and the general public). There is a strong tradition of goose hunting along the estuary and the hunt is generally easier there than in southwestern Quebec. The corn-growing area of southwestern Quebec has been increasingly used in recent years by snow geese in fall but this has not resulted in a concurrent increase of the harvest due to lack of proper management.

In 1999, a spring conservation hunt was established for the first time in Quebec following the recommendations of Giroux *et al.* (1998). Hunting started on 15 April throughout southern Quebec. Its main objective was to increase the total harvest in order to stop the growth of the population. A secondary objective was to reduce the use of vulnerable hayfields by allowing hunters to approach flocks of feeding birds. The effects of disturbance due to hunting activities on the regional distribution of geese are unknown and could alter the risks of crop damage in different regions.

The Arctic Goose Habitat Working Group also recommended that habitat management be implemented to reduce crop depredation and increase hunting opportunities by promoting movements of birds both at a regional and local scale. In 1997, the Canadian Wildlife Service initiated a pilot project in the Montmagny area that consists in the creation of five alternate feeding sites. These areas located near marshes were designed to attract geese during the spring staging period to reduce crop depredation in nearby vulnerable hayfields. Finally, a series of lure crops (corn and small cereals cut and left on the grounds) were established at Isle-aux-Oyes in the fall 1998 and 1999 to test their effectiveness in improving hunting success.

OBJECTIVES

Our first objective is to describe the patterns of habitat use by geese in three main spring staging regions. We also want to evaluate changes in disturbance rate as related to the establishment of the spring conservation hunt. To prevent and minimize crop depredation, managers are usually interested in absolute and relative numbers of goose-days in each sensitive region. As a managing tool, it will be extremely useful to know more precisely the pattern of birds' movements throughout the season. In particular, as the middle and lower estuary are sensitive regions, we are therefore interested in the timing of variations of the probabilities of movements from and to these regions. Besides, as the southwestern region is a less sensitive region until the last two weeks of the season, it is important to determine factors (habitat availability, disturbance) that induce departure of the birds towards eastern regions. Timing of changes in movement probabilities is crucial to assess risks in crop damage and could provide insights to assess optimal date of hunting opening.

The second objective of our research is to determine the proportion of birds that passed through in fall without staging in southern Quebec and the length of stay of the other birds in each region. We are particularly interested in determining if the same birds are overflying southern Quebec each year and in explaining the individual variation of the length of stay. In addition to the status of the geese, we want to determine the effects of disturbance on the movements of geese in fall. We also explore the possibility that disturbance associated with the spring hunt may incite the birds to pass through or to stay for shorter periods in fall.

Finally, we want to determine if the creation of alternate feeding areas and the establishment of lure crops could influence the local distribution of birds.

STUDY AREA AND METHODS

The Greater Snow Goose spring staging area can be divided into three large regions with homogeneous characteristics. In southwestern Quebec (SWQ - from Lac Champlain to Quebec City including the Lake St. Pierre area), cornfields are abundant and waste grain corn is the main food resource for the species. In this region, resting areas consist of managed flooded fields (Baie-du-Febvre, St. Barthélémy) and rivers (Richelieu, St. Lawrence) (Figure 1). In the middle estuary (MEST - from Quebec City to St. Jean-Port-Joli), *Scirpus* marshes are traditionally used as resting and feeding areas (Gauthier *et al.* 1988). In the late 70s, geese started to use the adjacent hayfields and now they also fly to the Beauce region where stubble cornfields are abundant. Finally, in the lower estuary (LEST), *Spartina* marshes are used for resting and for a limited amount of feeding. Only hayfields and stubble cereals (first year hayfields) are available as agricultural food resource because of the low number of degree-days that prevents corn growing in this region. In fall, geese concentrate their activities in the middle estuary (MEST) and southwestern Quebec (SWQ). At Isle-aux-Oyes, a total of 53.6 ha of cereals and corn were planted on the 190 ha of agricultural lands that cover the island. These crops were cut regularly throughout the fall and left in the fields.

A total of 292 different female Greater Snow Geese have been radio-tagged between 1996 and 1999. We were able to replace 17 of these radio-transmitters, which permitted to accurately track some birds during two successive years. Birds were captured when molting in August in small family groups on Bylot Island. During the following fall and spring, radio-tagged birds were tracked daily from the start of the staging period until the final departure of the birds. Six crews covered the entire staging area and carried out daily censuses in the different resting sites from Lac Champlain to Matane in spring and from La Pocatière to Lac Champlain in fall. Birds were also counted daily in the Montmagny alternate feeding areas in spring. Every week, aerial surveys were conducted to localize missing radio-tagged birds. Daily tracking of radio-tagged geese included assessment of the status (paired or alone, with or without young), daily foraging trip distances, habitat use and disturbance rate.

In spring, the proportion of time spent in the different habitats was corrected by the average percentage of time spent by geese feeding in each habitat. Censuses and radio-tagged bird resightings were pooled into 5-day periods. We estimated seasonal movements of marked female using multi-strata models and program MARK (White *et al.* 1996). The three parameters used in this type of models include the survival probability (S), the capture probability (p) and the transition probability (ψ).

In fall, we will use the same approach but the analyses have not been completed. We therefore computed the length of stay for each bird based on the first and last day that the signal was picked up. A bird was considered to have passed through Quebec if only one signal was received or if no signal at all was obtained. In the last case, the bird had to be located the following spring with a functioning radio to be considered as a bird that flew directly to the US.

The effectiveness of the lure crops was established by comparing hunting success (n geese shot/n hunter-days) before and during the establishment of the lure crops at Isle-aux-Oyes. We also obtained similar data for other nearby hunting sites in order to compare the effect of lure crops on hunting success.

RESULTS

SPRING MIGRATION

A higher number of geese were present after April 15 (6th period) in the SWQ region in 1999 than in 1998 and 1997 (Figures 2 - 4). Although less birds were present at Baie-du-Febvre in 1999 after April 15, a greater use of the area between Trois-Rivières and Quebec City (included in the SW) was observed. In 1999, the relative number of goose-days in LEST was lower than in 1998 contributing to an increase in the relative use of SWQ.

Respectively 657, 682 and 478 hours of tracking were used to asses habitat use based on 42, 74 and 56 radio-tagged birds in 1997, 1998 and 1999. In SWQ overall corn use (stubble plus ploughed fields) represents up to 70% of the habitat use for the three years (Figures 5 - 7). Variations in stubble corn use (36.3% in 1997, 51.4% in 1998 and 41.4% in 1999) may reflect variations in availability due to ploughing in fall. In 1998 and 1999, geese started to feed on newly sown corn at the end of the season. Overall, hayfield and stubble cereal use in this region was always lower than in the other two regions but reached 30% in 1999. In the MEST region, we suspect that habitat use was biased in 1997 with an overestimate of marsh use and concomitant underestimate of hayfields. The use of *Scirpus* marshes was similar in 1998 and 1999 with 42% while hayfield use decreased from 35.6% to 26.7% in 1999. On the other hand, the use of stubble cereals (first-year hayfields) increased from 9.2 to 17.8% resulting in a combined use of these 2 types of agricultural habitats similar in both years (44.8%). Use of corn fields, mainly found in the Beauce area of the MEST region, remained constant over the years and relatively low (less than 15%). In conclusion, habitat use in MEST remained similar despite the establishment of a conservation hunt in 1999. In LEST, however, important changes occurred in 1999 when hunting activities started. The increased use of *Spartina* marshes (more than 35%) can be related to a decrease in time spent in hayfields (Figure 7).

In agricultural habitats there was no difference in disturbance rate between years within each region. Therefore we pooled together the three years and did not detect any differences among regions. In 1999, however, disturbance due to hunting represented respectively 21% and 31 % of the overall disturbance rate in the MEST and LEST region (Figure 8). In the marsh habitats, the disturbance rate were relatively low compared to the agricultural ones. Hunting in adjacent hayfields lead to few disturbances in marshes in 1999 (Figure 9). Consequently, in the agricultural habitats of the LEST region, mean time elapsed between the beginning of an observation bout and the time that the geese were disturbed dropped from 35 min in 1997 to 18 min in 1999 (Figure 10). This type of disturbance discourage the geese from feeding in hayfields resulting in a decreased use of this habitat (Figure 7). Indeed, preliminary assessment by the Régie de l'Assurance Agricole du Québec (RAAQ) shows a decrease in depredation on hayfields in LEST in 1999. This could have also important behavioral consequences at a regional scale.

Because too few radio-tagged geese were tracked in 1997 (35 birds), only 1998 (70 birds) and 1999 (63 birds) data permitted to perform modeling. Our probability of capture (*p*) was not constant among sites and during the season because of the large area covered. Thus, contrary to most studies of capture-recapture (Nichols *et al.* 1997, Lindberg & Sedinger 1998), we chose to reduce *S* before reducing *p*. We fixed *S* constant among periods and sites but we could not fix it to 1 because of radio transmitter failure during the season and bird mortality (especially in 1999 when hunting mortality occurred). A reduced model with survival constant among sites and periods of time and with the probability of capture site and time dependent was preferred for both years. Because the use of the three regions is a dynamic process that follows the progression of snow melt in spring and because no geese are present in MEST and LEST in the first period of the season, we then constrained p to 1 (p_1) for these periods.

The most parsimonious model for 1998 was a model where movement probability depended on site (s) and time (t), S p_{1s*t} ψ_{s*t} (AICc=1049.59; number of parameters=82). In 1999, movement probabilities only depended on the departure site (d) and time, S p_{1s*t} ψ_{d*t} (AICc=1035.68; number of parameters=55). This is an important difference in the pattern of regional movements during these two years. It implies that in 1999 geese were equally prompt to move eastward than westward from any of the regions along the St. Lawrence river. Estimates of movement probabilities clearly show these differences (Figures 11-13). In 1999, geese leaving the SWQ region moved with an equal probability to MEST and LEST whereas in 1998 they primarily moved to MEST (Figure 11). A very high probability of moving out of SWQ (almost 100%) coincided with the period when the spring hunt started. However, a large proportion of geese had left Baie-du-Febvre, the most important staging area, few days before the opening day on April 15 (Figure 4). In 1998, the pattern of regional use appears to be a directional process, and probabilities of movement from MEST to LEST were higher than from MEST to SWQ. In 1999, birds from MEST were equally prone to move towards SWQ than toward LEST (Figure 12). In the LEST region, the annual differences in estimates of movement probabilities are striking (Fig. 13). In 1998, birds hardly moved once arrived in LEST whereas in 1999, they had a high probability of going back toward MEST and SWQ. The use of newly sown corn at the end of the season in SWQ may be partly related to geese returning to SWQ. More information is needed to confirm this pattern.

Condition of snow geese was also monitored in spring 1999. We cannon-netted geese toward the end of their staging period at 3 sites along the St. Lawrence river, Baie-du-Febvre (SWQ, 19 April), Isle-aux-Oyes (MEST, 11 May) and Isle-Verte (LEST, 14 May) using the methods of Gauthier at al. (1992). A sample of adult females were killed and their abdominal fat mass, an excellent index of body condition (Gauthier and Bédard 1985), was weighed. When we compared the fattening of geese in 1999 to similar data collected at various times in the past 2 decades (Gauthier et al. 1984, 1992), we found a striking difference. Upon departure for the Arctic in mid-May, fat reserves of geese were 30 to 50% lower in 1999 compared to any values recorded in the past (Figure 14). In the Arctic, Gauthier et al. (1999) also reported a very poor breeding success in 1999: the proportion of geese that attempted to breed was low, egg-laying was late, clutch size was the lowest ever recorded and nest predation rate was very high. Poor body condition may have been an important factor involved in this breeding failure because spring temperatures were normal and snow-melt was only marginally delayed on Bylot Island this year.

The alternate feeding sites have been used by geese in all years since their creation in 1997. More detailed analyses of bird use compared to the overall regional population are being completed.

FALL MIGRATION

Between 20 and 40% of the geese passed directly to the US in 1996 - 1998 (Table 1). Results from 1999 are not yet available because we need to confirm the status of the transmitters this coming spring. The majority that stopped were still staging in the estuary region. However, the proportion that staged in southwestern Quebec doubled during the four years reaching more than 60% in 1999. The length of stay of geese in Québec varied considerably between individuals, from one to more than sixty days. In the middle estuary of the St. Lawrence river, their traditional area, the average length of stay of the geese has remained fairly constant during the study (Table 2). Preliminary estimates based on the 1995-97 data had yielded 11 and 12 days (Giroux, unpubl. data). However, these estimates included geese located only once, which are now considered to have passed directly to the US. Using a different method based on resightings of neck-collared geese, Maisonneuve and Bédard (1992) estimated an average length of stay of 15 -17 days in the mid eighties. Their data are presently being reanalyzed using modern capture-mark-recapture (CMR) techniques. The overall length of stay of geese in the province has increased in the last few years (Table 2). This is related to the increased use of southwestern Quebec. In the middle estuary, both agricultural fields and tidal marshes are used for feeding while agricultural lands are exclusively used in the southwestern part of the province.

Table 1. Percentage of geese overflying southern Quebec and the percentage staging in different regions for the birds that stopped for at least one day in fall 1996-1999.

		% of geese		
Year	N geese tracked	overflying Quebec	staging in the estuary	staging in the Southwest
1996	61	21	100	27
1997	90	40	96	41
1998	93	30	94	45
1999	83	n/a[1]	95	63

[1] Will be available in spring 2000.

Table 2. Mean length of stay of greater snow geese in the middle estuary and in southern Quebec (middle estuary plus southwestern Quebec) for birds that staged at least one day in fall 1996-1999.

Year	Middle estuary (N geese)	Quebec (N geese)
1996	13.0 ± 1.2 (48)	15.5 ± 1.4 (48)
1997	14.7 ± 1.7 (52)	18.8 ± 1.9 (54)
1998	17.5 ± 1.8 (61)	22.4 ± 1.9 (65)
1999	15.9 ± 1.3 (69)	23.7 ± 1.7 (74)

Over the years, we tracked 83 females during two consecutive falls and found no correlation in the length of stay between the first and second year ($r = 0.18$, $P = 0.096$). One problem encountered is the difficulty to obtain the status of the geese (presence/absence of a mate and juveniles) in both years specially for birds overflying Quebec or with a short length of stay. We are still exploring these data.

We found that the disturbance rates associated with hunting activities were higher in fall 1999 than in the two previous years (Figure 15). We believe that this may have been caused by changes in hunting regulations in 1999 which allowed hunters to approach the geese (i.e. sneak-hunting). In previous years, hunters had been restricted to hunting from fixed blinds using decoys. We also observed a greater rate of disturbance from other causes which might indicate that the birds were more nervous and more prone to take off regardless of the type of disturbance.

Hunting success depends greatly on the proportion of juveniles in the fall flock (Figure 16). In 1993, with nearly 50% of juveniles, success was good at all sites. At the traditional Cap Tourmente guided hunt, the density of hunters is low and many of them bag their limits when there is above average production. Considering that bag limits have been increased in recent years, the number of geese shot per hunter per day has also therefore increased (Figure 15). At Isle-aux-Oyes, success was low before the establishment of the lure crops in 1998 when a record number of geese were shot. The best site for comparison is Montmagny where the increase in 1998 was not as high as at Isle-aux-Oyes. In 1999, when production of juveniles was among the lowest recorded during the last 25 years, success was low at all sites including Cap Tourmente. The lure crops at Isle-aux-Oyes did attract the geese a few times but did not improve the overall hunting success. A conclusive evaluation of lure crops to enhance the harvest of geese will be possible only once they are tested under various levels of juvenile production.

DISCUSSION

In spring, preliminary results indicate that the migration pattern was extremely different in 1999 compared to 1998. During the conservation hunt, geese moved back from LEST to SWQ, a phenomenon that lead to an increase in the number of goose-days for this region. This higher number of goose-days at the end of the season could have also been the cause of severe damage to early growth of corn in SWQ as reported by a preliminary report of the Régie de l'Assurance Agricole du Québec (RAAQ, unpublished sources).

Several factors may affect the distribution and movements of geese during the spring staging season. First, the abundance of food resources might influence the decision that a goose takes when leaving a region for another. It is very difficult to obtain accurate sampling of the resource because of the huge territory used by geese for feeding. Abundance of crucial food resources such as waste grain in cornfields may be extremely variable but mainly depends on the availability of stubble cornfield in spring, which in turns is related to the weather prevailing during the preceding fall. If the winter is late, most cornfields will be ploughed to accelerate farming operations in the following spring and to prevent the survival of pest insects (corn borer) in the stubble. Furthermore, stubble cornfields can be ploughed as early as the 10th of April depending on climatic conditions. Thus, availability of waste corn grain will decrease as stubble cornfields progressively disappear during the season. This man-induced depletion of corn added to the goose-induced depletion considerably reduces the availability of this highly energetic food resource by the beginning of May. An indirect assessment of agricultural habitat availability is provided by the habitat use data.

Disturbance is another factor that may influence goose movements. Bélanger & Bédard (1990) showed that disturbance could be extremely costly. Hunting disturbance appears to have reduced the time geese spent in the fields and therefore could have a direct influence on the regional probabilities of movement. The spring 2000 season will allow us to confirm these preliminary results. In addition to increasing the harvest and promoting local movements (specially from vulnerable hayfields), we believe that the spring conservation hunt should also be considered as a tool to influence the regional distribution of geese in southern Quebec. A judicious timing of the hunting period in different regions may allow the birds to remain in a region (ex. SW Quebec) when the potential for crop depredation is the lowest and to open hunting when vulnerable crops appear.

Finally, further analysis will be carried out to determine the exact costs of hunting disturbance in terms of reduction of foraging time on highly energetic food resources as well as on regional movements. We aim to be able to correlate changes in movement probabilities with disturbance rates and resource depletion. This could offer an important managing tool to foresee the optimal date of hunting opening and to minimize goose damage to agricultural crops.

We are also interested in determining how food availability and disturbance might influence the condition of the birds and subsequent reproductive output. The proportion of juveniles in the fall of 1999 was the lowest ever recorded (2%) with a resulting poor harvest and a general disappointment among hunters. We should not try to solve the problem of crop depredation in spring by creating a new problem in fall, i.e. the gradual disengagement of hunters attributed to poor harvest. Results from the next field season will be useful in establishing the links among these different factors.

In fall, our preliminary results support the idea that a greater proportion of birds are flying directly to the US. However, the total use of southern Quebec appears to be compensated by an increasing proportion of birds that use southwestern Quebec and by longer staging periods in that area. We are pursuing our analyses to determine the absolute use (number of goose-days) of each area in relation to habitat availability and disturbance rates.

Hunting is more difficult in southwestern Quebec and the greater use of that area may not result in a proportional increase of harvest. One solution may be the use of lure crops but their effectiveness as a hunting technique may be limited to years when the more vulnerable juveniles are present in the population. Delaying ploughing of stubble corn fields could also be an alternative technique to attract geese in fall to enhance hunting success. We still have to convince the farmers of this technique and a more agronomic justification (soil and water conservation issues) might be an alternative approach.

PLANS FOR 2000

The same protocol is planned for 2000. Ninety birds were marked in August 1999 at Bylot Island and we will be searching for approximately 120 radio-marked geese this coming spring. Arnaud Béchet, Ph.D. candidate will complete his field work with two years before and two years since the establishment of the spring conservation hunt. He will then complete his analyses, write papers for his thesis and presents his results at conferences.

It is still unknown if geese will be marked with radio-transmitters this summer. However, if the spring hunt is extended to spring 2001, monitoring of birds movements and habitat use in 2001 absolutely requires that new birds are marked with radio-transmitters in summer 2000. Regardless, the birds marked in 1999 and tracked during the spring will be monitored in fall 2000. Jonathan Olson will use data for the fall 1996-1999 to complete his M.Sc. thesis. The analyses are underway and he should complete the writing of his thesis by the end of the summer. The additional results obtained in 2000 will be subsequently added to his paper. Detailed monitoring of the alternate feeding areas is complete but the number of geese in the Montmagny area where they are located will still be estimated on a daily basis this spring. Finally, hunting success will be evaluated in fall at Isle-aux-Oyes where lure crops should again be implemented.

LITERATURE CITED

Abraham, K. F. and Jefferies, J. L. 1997. Pp 7-72 *in* Batt, B.D.J. ed. Arctic ecosystems in Peril: Report of the Arctic Goose Habitat Working Group. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Akaike, H. 1973. Information theory and an extension of the maximum likelihood principles. Pp 267-281 *in* Petran, B. N. and Csaki, F. International symposium on information theory. Akademiai Kiado. Budapest. Hungary..

Bélanger, L. & Bédard, J. 1990. Energetic cost of man-induced disturbance to staging Snow geese. Journal of Wildlife Management 54: 36-41.

Burnham, K. P. & Anderson, D. R. 1998. Model selection and inference: A practical Information-Theoretic Approach. Springer-Verlag, New York. 353p.

Gauthier, G. and J. Bédard. 1985. Fat reserves and condition indices in greater snow geese. Canadian Journal of Zoology 63:331-333.

Gauthier, G., J. Bédard, J. Huot and Y. Bédard. 1984. Spring accumulation of fat by greater snow geese in two staging habitats. Condor 86:192-199.

Gauthier, G., Giroux, J.-F. and J. Bédard. 1992. Dynamics of fat and protein reserves during winter and spring migration in greater snow geese. Canadian Journal of Zoology 70:2077-2087.

Gauthier, G., A. Reed, L. Rochefort, J.-F. Giroux and E. Lévesque. 1999. Population study of greater snow geese on Bylot Island (Nunavut) in 1999: a progress report. Université Laval, unpublished report.

Gauthier, G., Bédard, Y. and Bédard, J. 1988. Habitat use and activity budgets of greater snow geese in spring. Journal of Wildlife Management 52: 191-201.

Giroux, J.F., Batt, B., Brault, S., Costanzo, G., Filion, B., Gauthier, G., Luszcz, D. and Reed, A. 1998. Conclusions and management recommendation. Pp 81-88 *in* B.D.J. Batt, ed. The greater snow Goose Habitat Working Group. Arctic Goose Joint venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario.

Lebreton, J. D., Burnham, K. P., Clobert, J. and Anderson, D. R. 1992. Modeling survival and testing biological hypotheses using marked animals : a unified approach with case studies. Ecological Monograph 62: 67-118.

Lindberg, M. S. and Sedinger, J. S. 1998. Ecological significance of brood-site fidelity in Black Brant: Spatial, annual, and age-related variation. Auk 115:436-446.

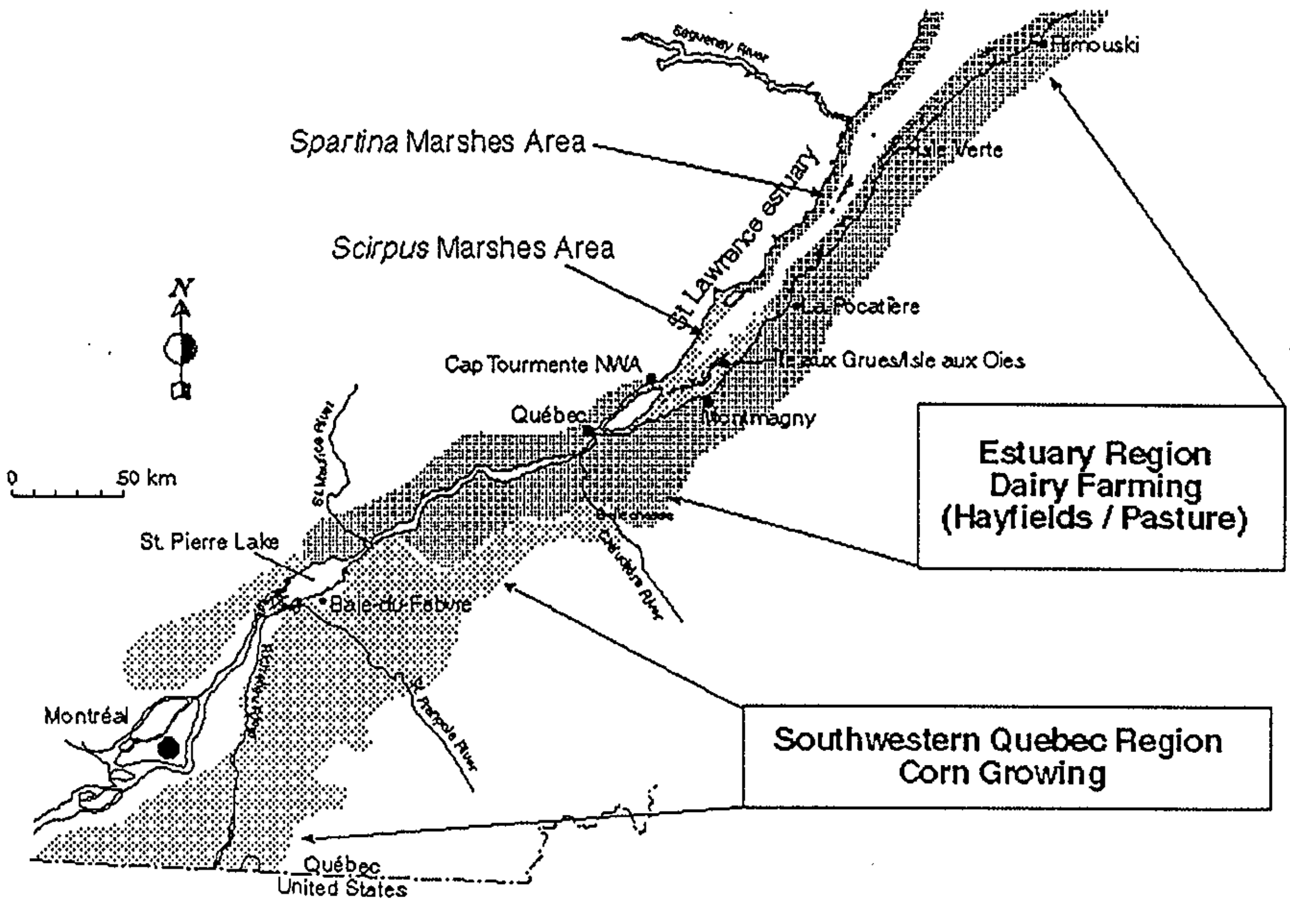
Maisonneuve, C. & Bédard, J. 1992. Chronology of autumn migration by greater snow geese. Journal of Wildlife Management 56: 55-62.

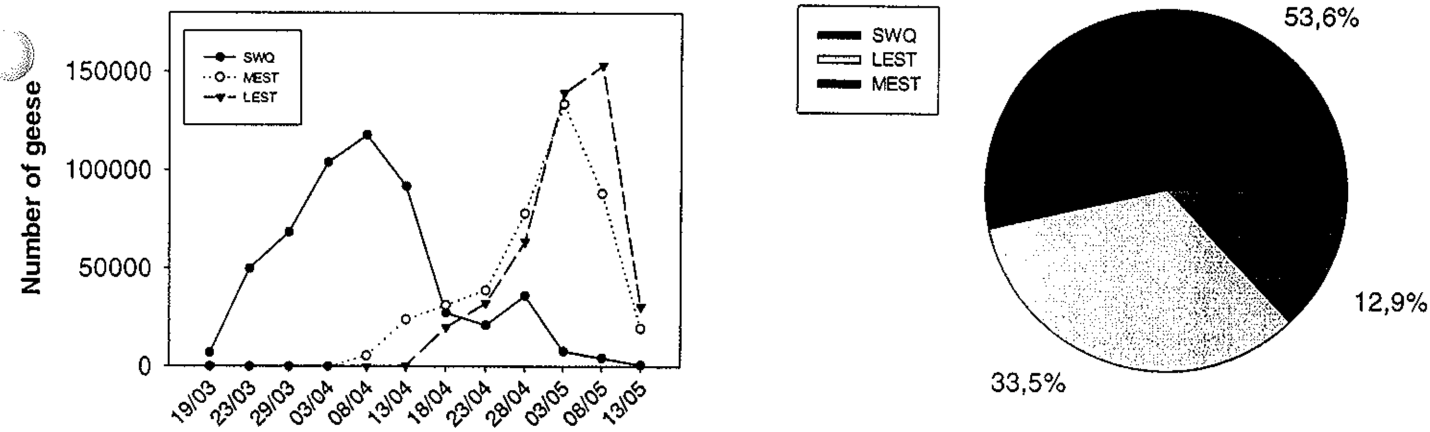
Nichols, J. D., Hines, J. E. and Blums, P. 1997. Tests for senescent decline in annual survival probabilities of common pochards, *Athya ferina*. Ecology 78: 1009-1018.

White, G. C.1996. Program MARK. Colorado State University.

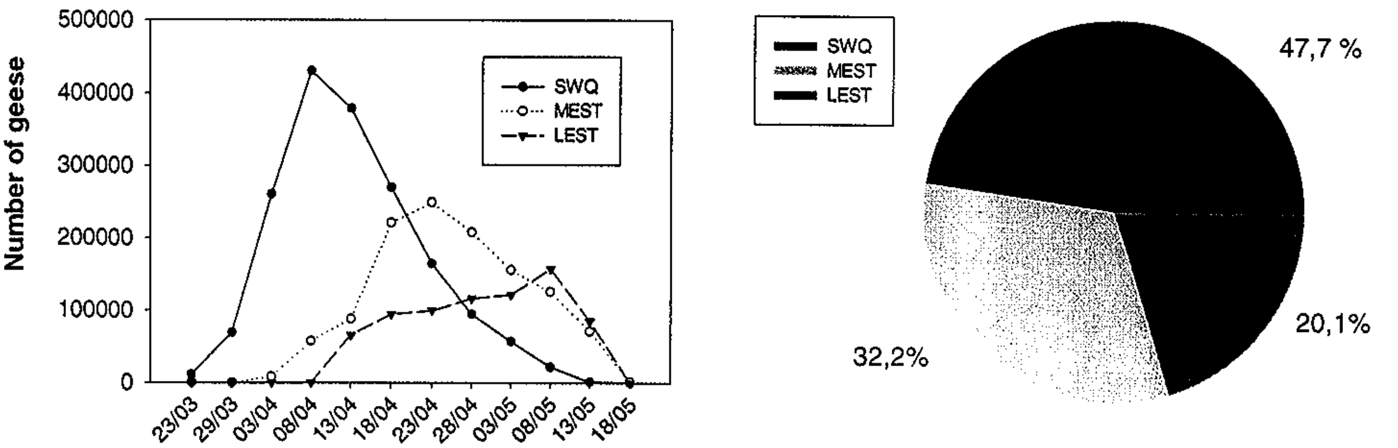
Massé, H. 1998. Estimation de la capacité de support des différents écosystèmes humides utilisés par la grande oie des neiges nichant à l'Île Bylot (TNO, Canada). MSc thesis, dépt. phytologie, Univ. Laval.

Figure 1. St Lawrence river staging region with main stopover sites.

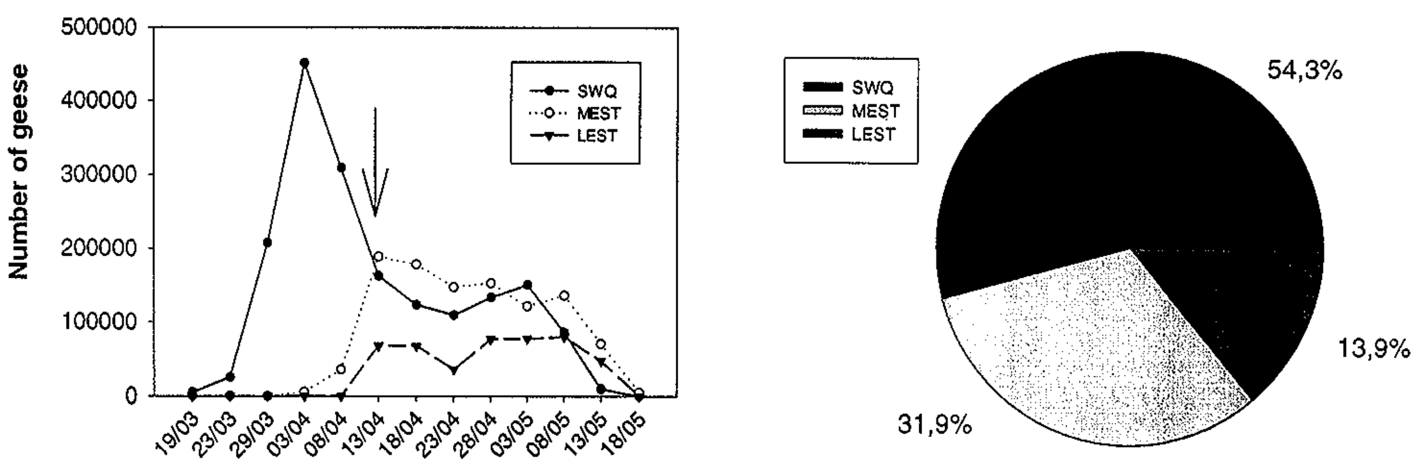




Figures 2. 5-days period pooled regional census and relative number of goose-days for the three regions in spring 1997.



Figures 3. 5-days period pooled regional census and relative number of goose-days for the three regions in spring 1998.



Figures 4. 5-days period pooled regional census and relative number of goose-days for the three regions in spring 1999.
The arrow indicates the beginning of the hunting season.
Dates are for the beginning of each 5-days period.

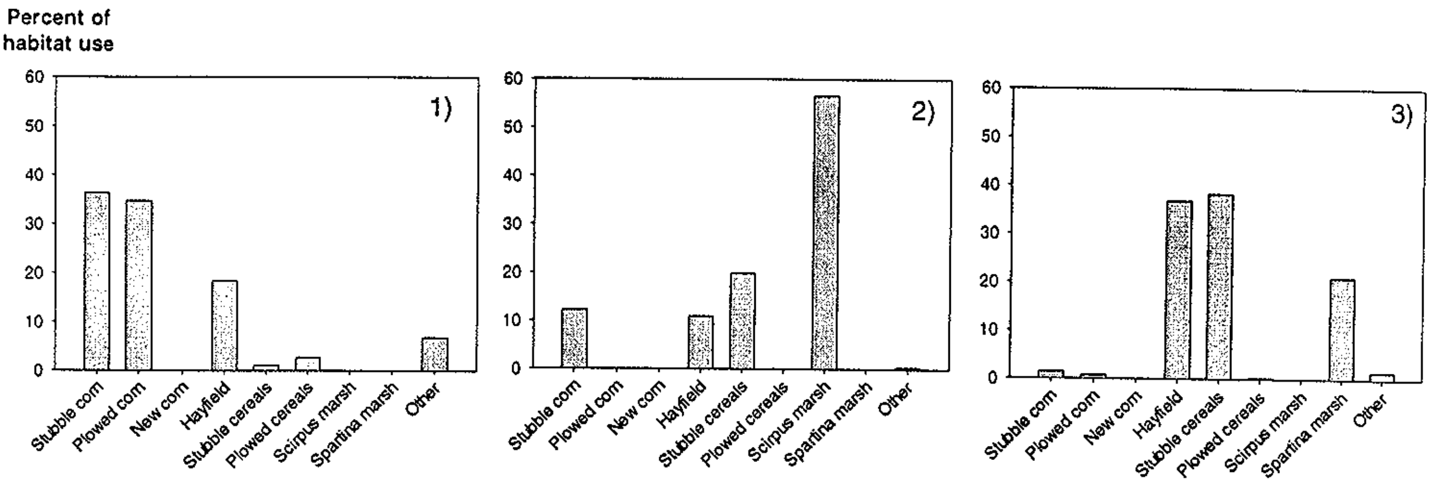


Figure 5. Percent of habitat use in spring 1997. 1) in SWQ, 2) in MEST, 3) in LEST

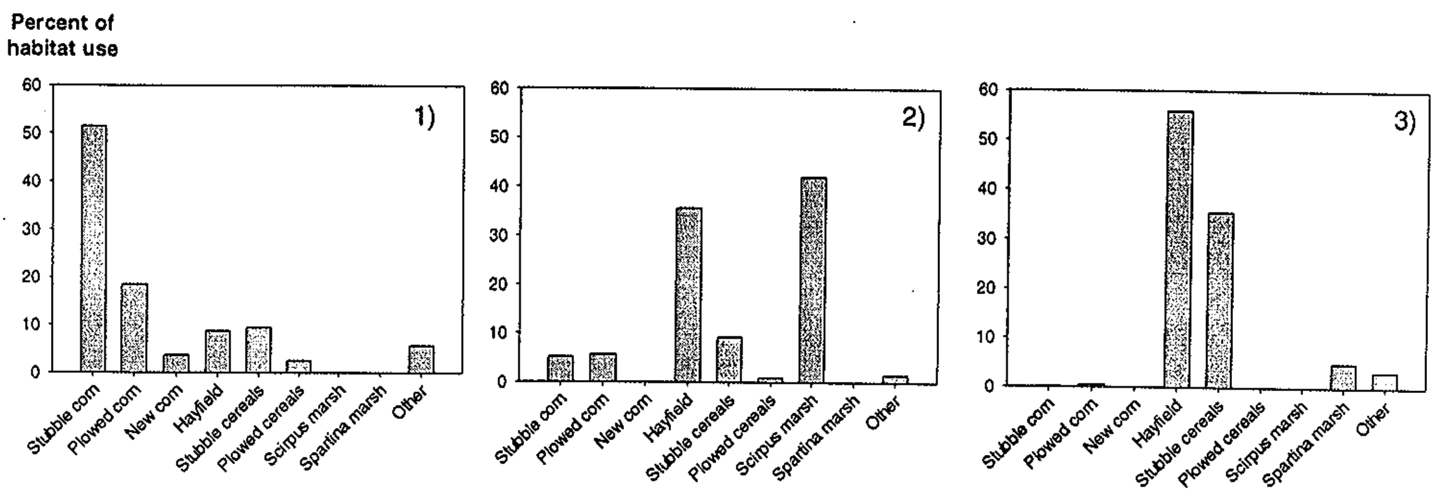


Figure 6. Percent of habitat use in spring 1998. 1) in SWQ, 2) in MEST, 3) in LEST

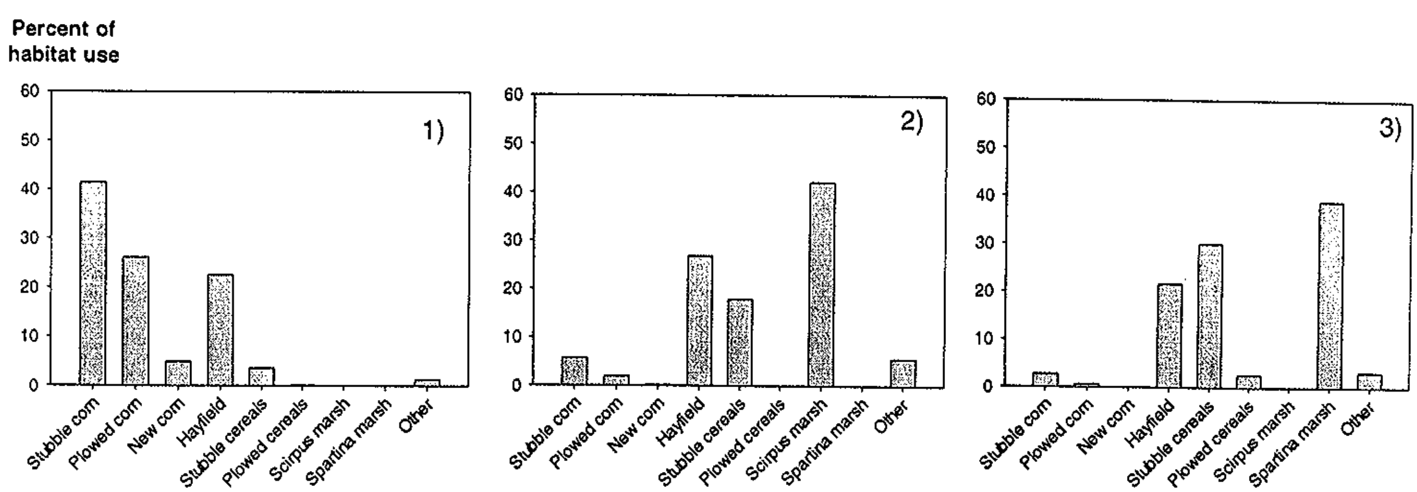


Figure 7. Percent of habitat use in spring 1999. 1) in SWQ, 2) in MEST, 3) in LEST

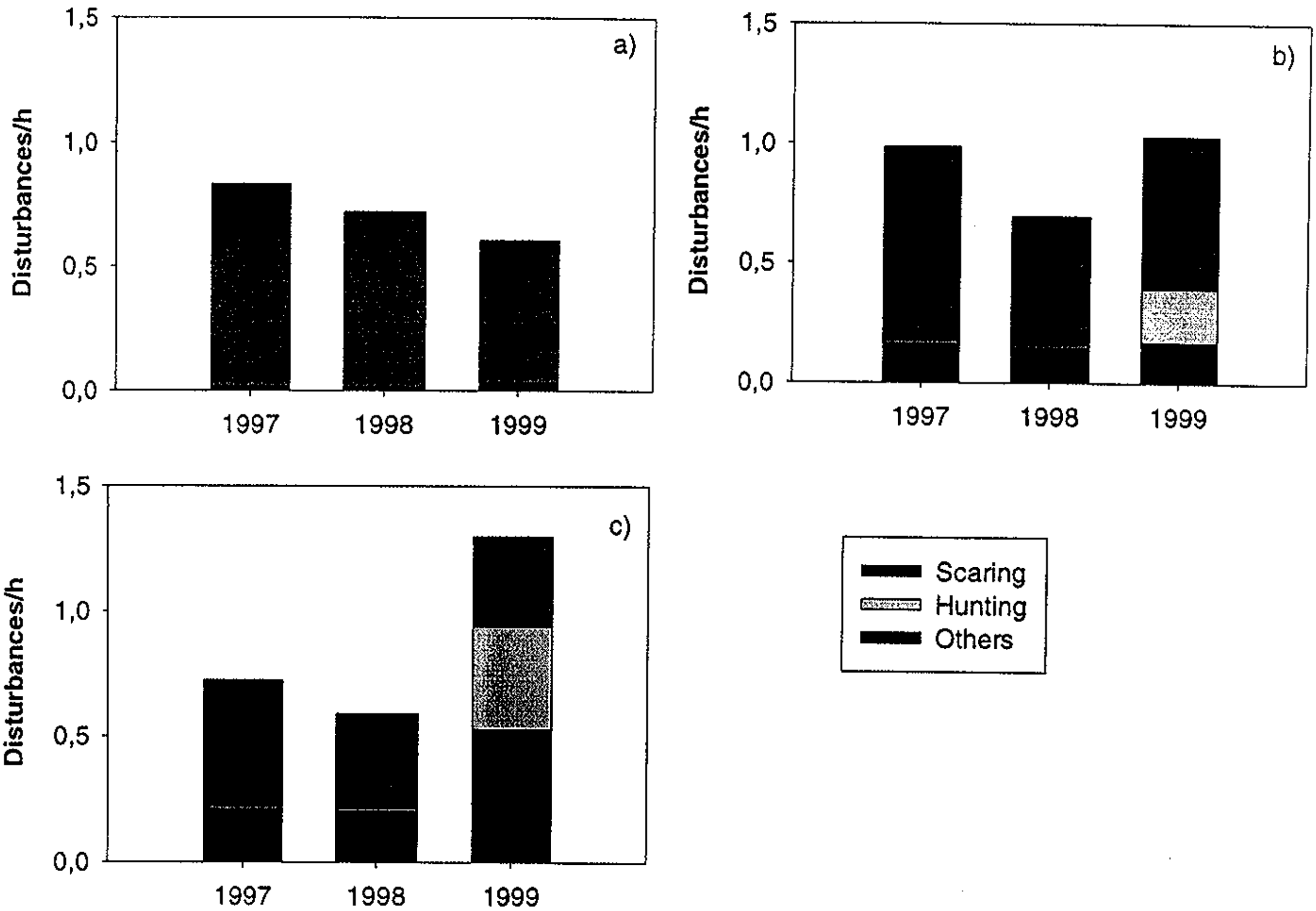


Figure 8. Disturbance rates in agricultural habitats in spring. a) in the SWQ region. b) in the MEST region. c) in the LEST region.

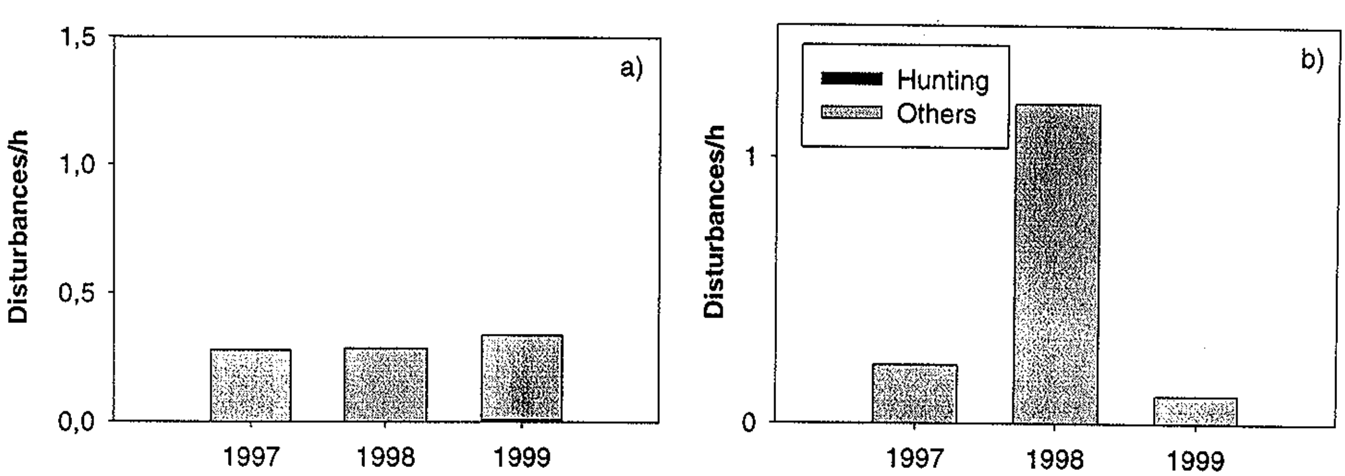


Figure 9. Disturbance rates in marsh habitats in spring. a) in the MEST region. b) in the LEST region.

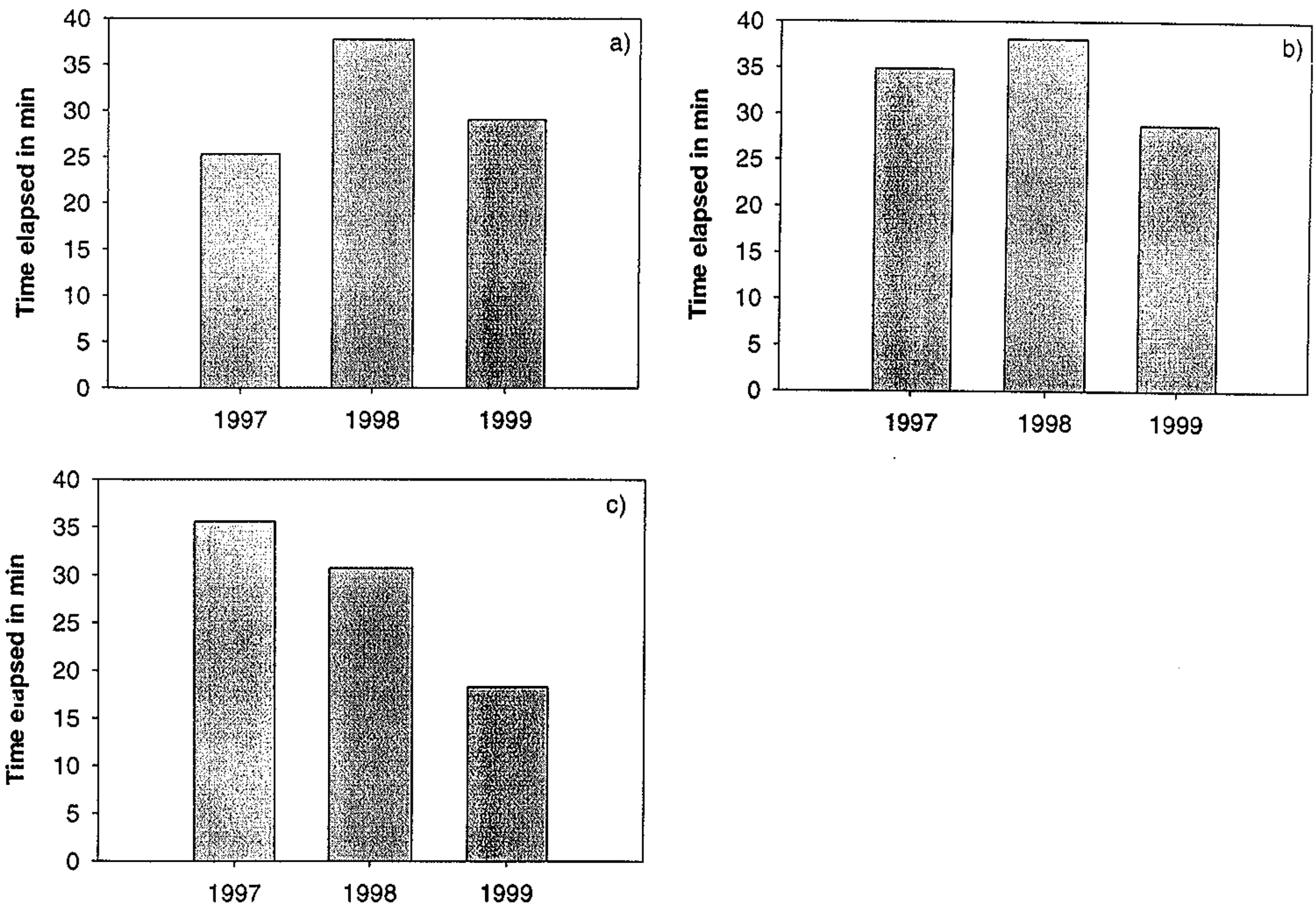


Figure 10. Time elapsed between the beginning of observation and a disturbance event in agricultural habitats in spring. a) in the SWQ region. b) in the MEST region. c) in the LEST region.

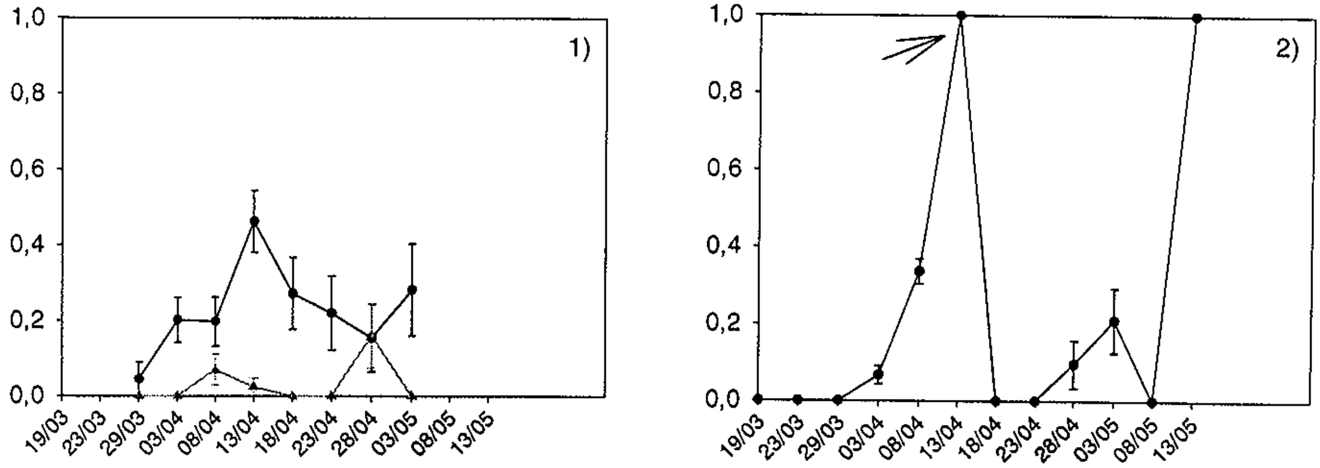


Figure 11. Movement probabilities in spring from SWQ : 1) in 1998 : —●— From SWQ to MEST. —▲— From SWQ to LEST
2) in 1999 : —●— From SWQ to MEST/LEST

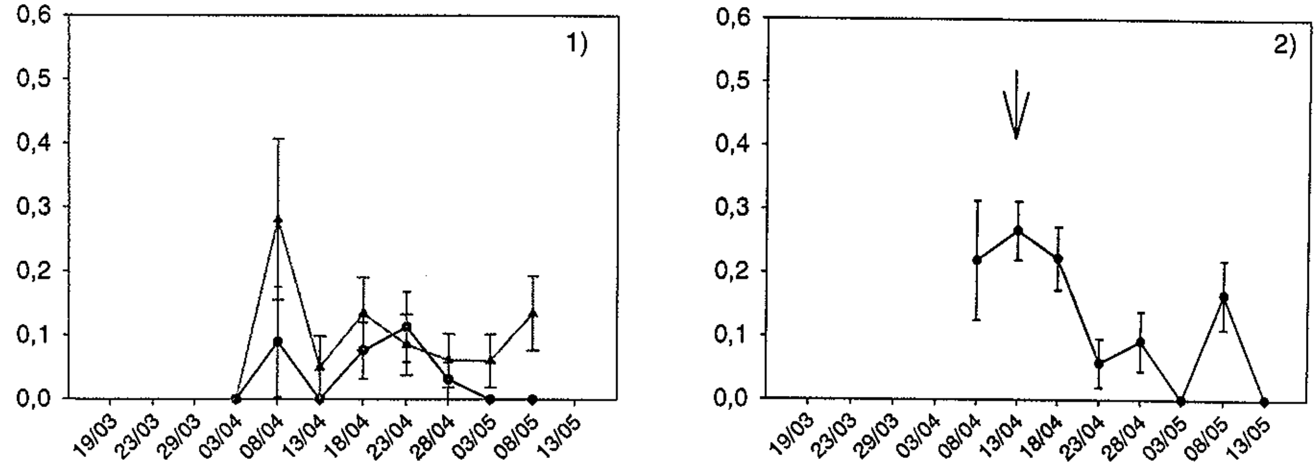


Figure 12. Movement probabilities in spring from MEST : 1) in 1998 : —●— From MEST to SWQ. —▲— From MEST to LEST
2) in 1999 : —●— From MEST to SWQ/LEST

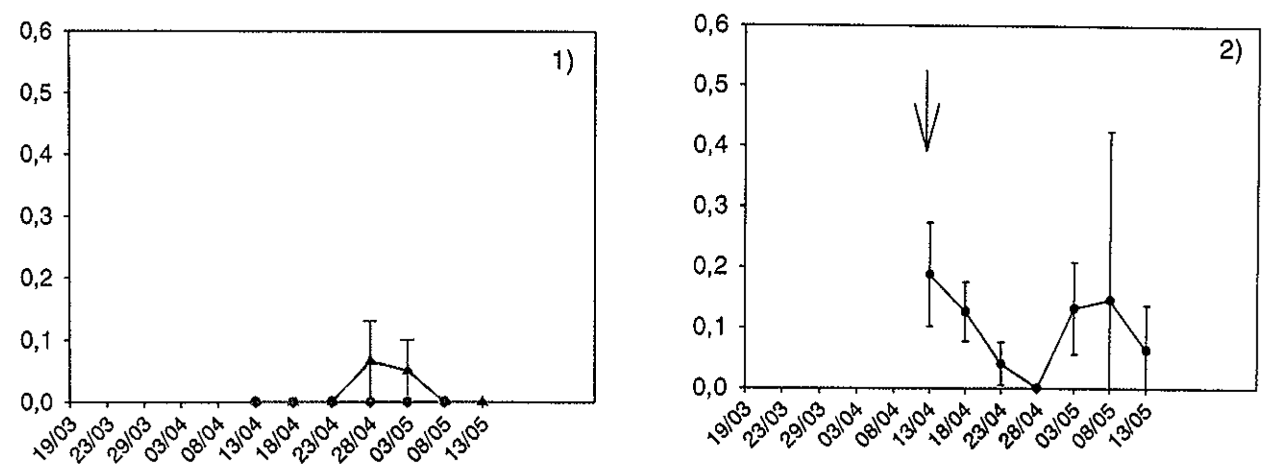


Figure 13. Movement probabilities in spring from LEST : 1) in 1998 : —●— From LEST to SWQ. —▲— From LEST to MEST
2) in 1999 : —●— From LEST to SWQ/MEST

Dates are the beginning of the 5 days periods.
Arrows indicate the beginning of the hunting season.

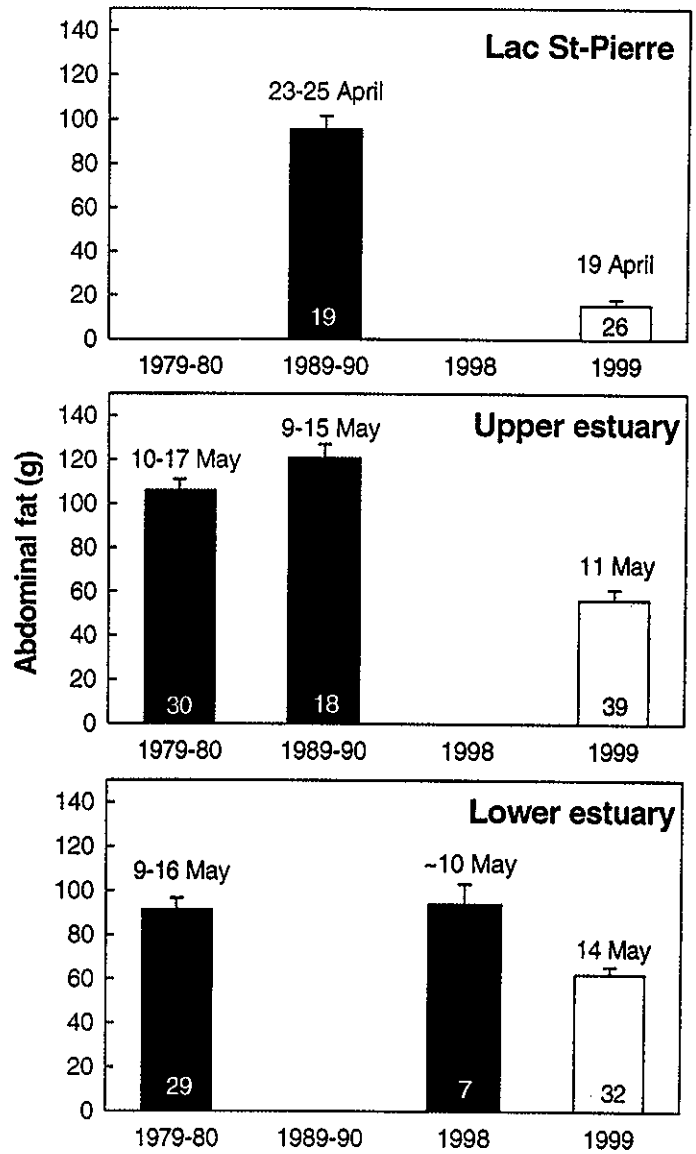


Figure 14. Abdominal fat mass of female greater snow geese upon departure from various spring staging areas along the St. Lawrence River. Geese were collected only in some years during the period 1979 to 1999. Numbers within bars are sample sizes and dates are sampling dates. Geese leaving Lac St-Pierre continue their fattening in the estuary area but geese leaving from the two estuary sites depart for the Arctic. Body fat was significantly lower in 1999 compared to any other years at all sites.

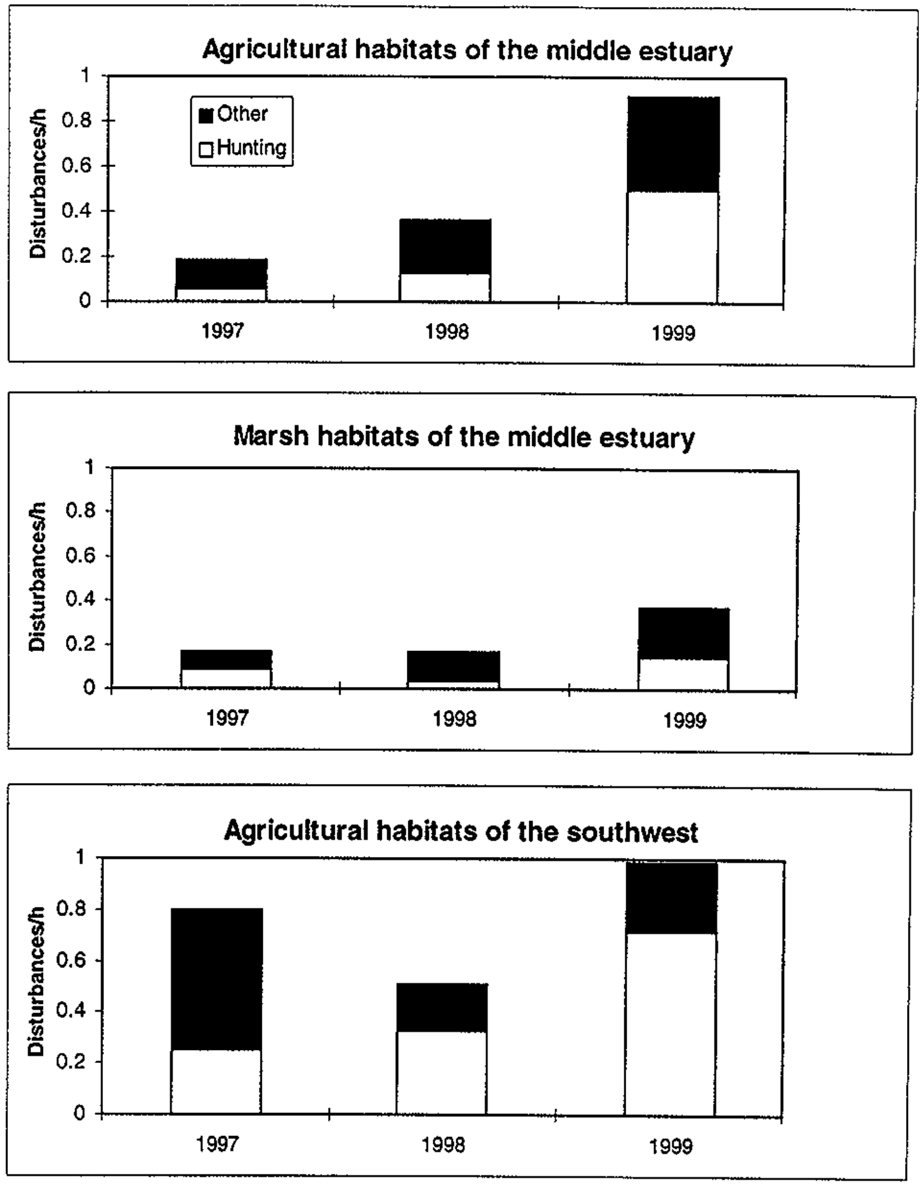


Figure 15. Disturbance rates in agricultural habitats and marshes in the middle estuary and southwestern Quebec during the fall staging period, 1997-1999.

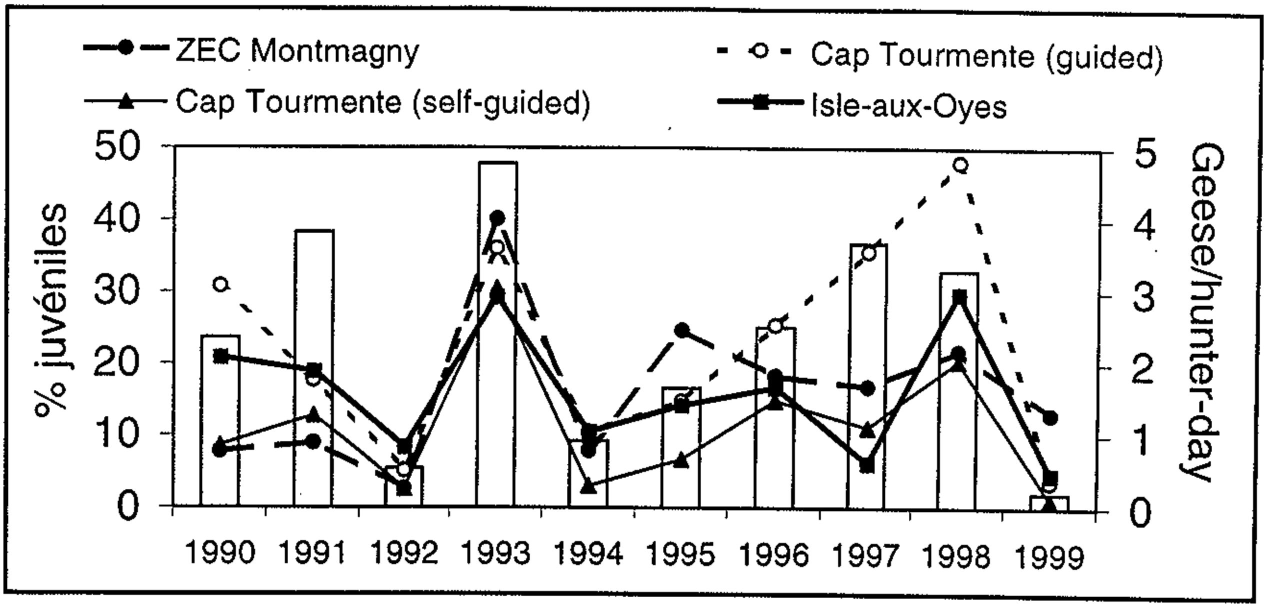


Figure 16. Number of geese/hunter-day harvested at Cap Tourmente, Montmagny and Isle-aux-Oyes in the falls 1990-1999. The lure crops were established in 1998 and 1999 at Isle-aux-Oyes. The percentage of juveniles is recorded in fall along the estuary by A. Reed (CWS).