Incidental catches of harbour porpoises (*Phocoena phocoena*) in the gillnet fishery of the Estuary and Gulf of St. Lawrence in 2000–2002

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ABSTRACT

Lesage, V., J. Keays, S. Turgeon, and S. Hurtubise. 2004. Incidental catches of harbour porpoises (*Phocoena phocoena*) in the gillnet fishery of the Estuary and Gulf of St. Lawrence in 2000–2002. Can. Tech. Rep. Fish. Aquat. Sci. 2552: 37 p.

The incidental catch of harbour porpoises in the gillnet fishery of the Estuary and Gulf of St. Lawrence was examined using 1) questionnaires mailed to fishermen and inquiring about bycatches in 2000 and 2001 (n = 2,277 or 44% of the fishermen with valid licenses) and 2) using data from the At-Sea Observer and Sentinel Fisheries programs of 2001 and 2002. The questionnaire survey had a low response rate (22%) and provided bycatch estimates of 2,215 (95% CI 1,151–3,662) and 2,394 (95% CI 1,440–3,348) porpoises in 2000 and 2001, respectively. The low number of hauls monitored by at-sea observers prevented the estimation of bycatch rates for several zones and the study area as a whole, and provided only imprecise estimates for all other zones. The results from questionnaires indicated a 24–63% reduction in bycatch rates since the late 1980s, whereas the At-Sea Observer program provided bycatch rates for 2001 and 2002 that were unreliable and underestimated, approaching one quarter of those documented in the late 1980s. Although both indices indicate a decrease in bycatch levels since the late 1980s, the magnitude of this change remains uncertain given the weaknesses associated with the two approaches. The results from the sentinel fisheries and from commercial fisheries subjected and not subjected to at-sea observations suggest that fine-scale temporal and spatial changes in fishing activities may greatly affect harbour porpoise bycatch rates.

RÉSUMÉ

Lesage, V., J. Keays, S. Turgeon, and S. Hurtubise. 2004. Incidental catches of harbour porpoises (*Phocoena phocoena*) in the gillnet fishery of the Estuary and Gulf of St. Lawrence in 2000–2002. Can. Tech. Rep. Fish. Aquat. Sci. 2552 : 37 p.

Les mortalités accidentelles de marsouins communs associées à la pêche au filet maillant de l'estuaire et du golfe du Saint-Laurent furent examinées à l'aide de 1) questionnaires distribués aux pêcheurs et questionnant sur le nombre de prises accidentelles au cours de 2000 et 2001 (n = 2277 ou 44 % des pêcheurs détenant une licence), et de 2) données provenant des programmes d'Observateurs en Mer et de Pêches Sentinelles de 2001 et 2002. Le recensement par questionnaires eut un faible taux de réponse (22 %) et fournit une estimation de 2,215 (95 % CI 1151–3662) et 2,409 (95 % CI 1440–3348) marsouins communs pris accidentellement en 2000 et 2001, respectivement. Le faible nombre de traits monitorés par les observateurs en mer en 2001 et 2002 n'a pas permis le calcul d'une estimation des prises accidentelles pour plusieurs zones et globalement pour l'aire d'étude, et a résulté en des estimations imprécises pour les autres zones. Les résultats des questionnaires ont indiqué une réduction de 24–63 % des prises accidentelles depuis la fin des années 1980, alors que ceux du programme d'Observateurs en Mer ont indiqué des taux non fiables et sous-estimés pour 2001 et 2002, approchant le quart de ceux observés à la fin des années 1980. Bien que les deux indices suggèrent une décroissance du nombre de prises accidentelles depuis la fin des années 1980, la magnitude de ce changement demeure incertaine compte tenu des faiblesses méthodologiques des deux approches. Les résultats des pêches sentinelles et des pêches commerciales sujettes ou non à l'observation en mer suggèrent que des changements spatiaux et temporels à fine échelle des activités de pêche peuvent influencer grandement les taux de prises accidentelles de marsouins communs.

INTRODUCTION

The harbour porpoise (*Phocoena phocoena*) is a species particularly vulnerable to incidental catches in fishing gear. A number of reviews have shown interactions between this species and fisheries throughout most of its range (Gaskin 1984; Jefferson and Curry 1994; Bjørge et al. 1994; Stenson 2003). Although several types of gear such as fish weirs and traps may be involved in these interactions, mortalities are most often associated with fisheries using pelagic or bottom set gillnets (Smith et al. 1983; Gaskin 1984; Lien et al. 1994; Fontaine et al. 1994a; Jefferson and Curry 1994; Stenson 2003).

Harbour porpoises are widely distributed in temperate coastal waters of the northern hemisphere (Gaskin 1984). The species occurs at least seasonally in the Estuary and Gulf of St. Lawrence (Laurin 1976; Fontaine et al. 1994a; Larrivée 1996; Kingsley and Reeves 1998). Analyses of genetics and contaminant profiles suggest that individuals from this region may constitute a distinct population, although the Laurentian Channel might act as a physical barrier, separating sub-populations in the Gulf of St. Lawrence (Gaskin 1984; Wang et al. 1996; Rosel et al. 1999; Westgate and Tolley 1999; Tolley et al. 2001; Anderson 2003; Read 2003). Sergeant et al. (1970) referred to harbour porpoises as being moderately common in the Estuary and Gulf of St. Lawrence. Aerial surveys conducted in the Gulf of St. Lawrence, which sampled a large portion of the Gulf in 1995 and its northern shelf in 1996, provided estimates (uncorrected for visibility biases) of 12,100 (CV 26%) and 21,720 (CV 38%) harbour porpoises in 1995 and 1996, respectively (Kingsley and Reeves 1998).

Laurin (1976) was the first to suggest that bycatch of harbour porpoises might represent a non-negligible source of mortality for this species in the Gulf of St. Lawrence. Studies conducted during the late 1980s and early 1990s indicated substantial bycatches of harbour porpoises in the groundfish gillnet fisheries of the Gulf of St. Lawrence (Fontaine et al. 1994a; Larrivée 1996). These mortalities were thought to approach or exceed levels sustainable by the population. Similar concerns were raised for harbour porpoises off Newfoundland and Labrador and for other populations in the northwest Atlantic, including West Greenland and the Bay of Fundy / Gulf of Maine (Gaskin 1984; Read and Gaskin 1988; Gaskin 1992; Bravington and Bisack 1996; Bisack 1997a; Caswell et al. 1998; Teilmann and Dietz 1998; DFO 2001).

During the early 1990s, several groundfish stocks collapsed in the northwest Atlantic, leading to substantial reductions and even complete moratoria of several fisheries. In the Gulf of St. Lawrence, the Atlantic cod fishery, which accounted for most of the harbour porpoise incidental catches in this area, was closed in 1993 (southern Gulf) and 1994 (northern Gulf). The fishery in the northern Gulf was reopened at a very low level in 1997, but was restricted to longlines for 1997 and 1998, and was closed again in 2003. In the southern Gulf, the gillnet fishery was reopened in 1997, and was closed again in 2003. These reductions in groundfish fishery activities were suspected to have had beneficial impacts on harbour porpoise populations by reducing incidental catches (DFO 2001). Reductions in bycatch levels were observed in the Bay of Fundy / Gulf of Maine following the reduction in fishing effort and implementation of the Take Reduction Plans (Waring et al. 2001). Assuming this trend also prevailed in the Gulf of St. Lawrence and Newfoundland, where no information on recent bycatch levels was available, the Committee on the Status of Endangered Wildlife in Canada revised in 2003 the status afforded to the species in eastern Canada in 1990, from *threatened* to *special concern* (COSEWIC 2003). Following the change in status, a reduction in bycatch rates of harbour porpoise during 1998–2001 was confirmed for the Bay of Fundy (Trippel and Shepherd 2004). However, bycatch rates

in Newfoundland waters in 2002 do not appear to be negligible, although confidence intervals around the estimates are large (Lawson et al. 2004).

The objective of this study was to describe the distribution and level of gillnet fishing activity in the Estuary and Gulf of St. Lawrence in 2000–2002 and to provide an estimate of incidental catches of harbour porpoises in this fishery. An approach similar to that used in the late 1980s and early 1990s, i.e., questionnaires sent to gillnet fishermen, was employed to allow comparisons between estimates from the two periods (Fontaine et al. 1994a; Larrivée 1996). Bycatch estimates obtained through questionnaires suffer from numerous problems, as they are based usually on a small number of respondents whose capacity of recollection of bycatch numbers varies depending on the number of incidents, motivation, time elapsed since the end of the fishing season, and their trust in the interviewer (Lien et al. 1994). Therefore, a theoretically more reliable technique using independent observers onboard fishing vessels was used to estimate incidental catches of harbour porpoises in the gillnet fishery in 2001 and 2002 (IWC 1994; 1997; Donovan and Bjørge 1995).

MATERIALS AND METHODS

The study area encompassed the Lower St. Lawrence Estuary and the entire Gulf of St. Lawrence, i.e., Northwest Atlantic Fisheries Organization (NAFO) Divisions 4R, 4S, and 4T. These divisions were partitioned further into five zones, based on the spatial distribution and intensity of fishing activities (see below; Figure 1). Information on the incidental catch of harbour porpoises in fishing gear was obtained using two different approaches: 1) questionnaires mailed to fishermen after the end of their fishing season and 2) data collected directly from fishing vessels, either by the fishermen themselves or by independent observers.

QUESTIONNAIRES

A list of the 5,137 fishermen from the Estuary or Gulf of St. Lawrence with valid groundfish, Atlantic herring (*Clupea harengus harengus*) or mackerel (*Scomber scombrus*) gillnet fishery licenses in 2000 was obtained from Fisheries and Oceans Canada, Division of Statistics and Data Processing. Fishermen that had valid licenses in 2000 were assumed to have maintained their licenses through 2001. Questionnaires were sent to a random sample of 2,277 or 44% of these fishermen during October-November 2001, inquiring as to fishing activities and marine mammal bycatches during the two preceding fishing seasons, i.e., 2000 and 2001. Fishermen were asked the same questions as those formulated by Fontaine et al. (1994a), i.e., the number of harbour porpoises caught during 2000 and 2001, month and location of capture, type of fishing gear. Fishermen were also asked to report observations of harbour porpoises, incidental catches of other marine mammals, damage to fishing gear, and their impressions on the trends of populations of harbour porpoises and pinnipeds. Only the information related to harbour porpoise bycatches will be presented in this report.

DATA OBTAINED DIRECTLY FROM FISHING VESSELS

At-Sea Observer program

An At-Sea Fisheries Observer program has been in place in the Gulf of St. Lawrence since the early 1980s. This program consists of having an independent observer onboard commercial fishing vessels to collect information on fishing activities, including fishing location, gear type, catches, and discards. Observers are not specifically dedicated to the collection of information on bycatches of marine mammals. However, in area 4R, datasheet coding for harbour porpoise bycatches has been in place since 1989, with bycatches of any landed marine mammal being collected routinely and consistently over the years (D. Kulka, DFO, St. John's, NL, pers. comm.). In areas other than 4R (i.e., 4S and 4T), observers also took note of catches and discards of fish and invertebrates. However, prior to 2001, marine mammal bycatch information was noted in the remarks section and was probably not noted systematically since observers were not instructed to pay attention to marine mammal bycatches *per se*. In 2001 and 2002, coding for each species of marine mammal was added to the datasheets, and the importance of noting marine mammal bycatches was emphasized by a DFO representative during the annual training sessions of observers. When not specified in the remarks section, the number of harbour porpoises incidentally taken during a haul was estimated from the reported mass, assuming a mean mass per individual of 50-60 kg (Read and Tolley 1997).

The At-Sea Observer program coverage varied with the type of fishery. According to conservation harvesting plans, coverage for the fixed gear Atlantic cod fishery should have been at least 5% for vessels less than 45 feet in length and at least 10% for larger vessels during both 2001 and 2002. Coverage should also have been at least 5% for the fixed gear Greenland halibut (*Reinhardtius hippoglossoides*) and winter flounder (*Pleuronectes americanus*) fisheries. No coverage was made of the fixed gear fishery for American plaice (*Hippoglosoides platessoides*) and witch flounder (*Glyptocephalus cynoglossus*).

Sentinel Fishery program

The Sentinel Fishery program for the Gulf of St. Lawrence was initiated in 1994. This program does not intend to monitor commercial fishing activities. Instead, its main objective is to obtain information on population trends of commercially valuable but non-abundant species using predefined scientific fishing protocols and gear types. Fishermen may be asked to deploy their fishing gear in non-traditional fishing areas during periods of low abundance or low density of the targeted fish species. Information collected in the context of Sentinel Fisheries is very similar to that collected during the At-Sea Observer program and includes records of marine mammal incidental catches and measurements or sampling of targeted species. In area 4T, every fixed gear sentinel fishing vessel has an observer present when catches are hauled on board. The observer handles the data collection and fish sampling. In areas 4R and 4S, information on catches and discards associated with the fixed gear fishery are noted by fishermen themselves since there are no observers dedicated to these vessels. During 2001 and 2002, Atlantic cod (*Gadus morhua*) was the only species targeted by the fixed gear Sentinel Fishery program in areas 4R, 4S, and 4T.

TOTAL FISHING EFFORT AND ESTIMATION OF BYCATCH RATES

An index of commercial fishing activities was obtained from the information on total landings of all fish species in terms of "live" kilograms of fish through purchase slips, logbooks, and dock-side monitoring. This database also provided information on target species and type of fishing gear, but incomplete information on fishing location, fishing gear, soak time, etc., since logbooks are not mandatory for smaller vessels and for some types of fisheries.

For the questionnaire survey, bycatch estimates of harbour porpoises were calculated using an active fisherman as the unit of effort, i.e., bycatch estimates were expressed as a number of bycaught porpoises per respondent (Fontaine et al. 1994a; Larrivée 1996). A fisherman was considered active if he had landed fish at least once during the fishing season. An estimate of the total number of harbour porpoise bycaught in the Estuary and Gulf of St. Lawrence during a given year was obtained by extrapolating the average bycatch rate to the total number of active gillnet fishermen during that year.

Total landings per haul was used as the unit of effort for the at-sea observers and sentinel fisheries. A haul was defined as the retrieval of a string of nets. Because there is no direct measure of hauls in the commercial fishing database, this measure of effort from the At-Sea Observer program was used to back-calculate total hauls from fish landings by the commercial fishery and estimate the number of bycatches for the entire fishing fleet. Given the low coverage by at-sea observers in several zones, mean landings per haul was calculated globally and not per zone for each target species and year.

STRATIFICATION SCHEME

Differences were expected 1) between years in fish and harbour porpoise abundance and distribution (Palka 1995; Trippel et al. 1999; Chouinard et al. 2001; 2002; Waring et al. 2001) and 2) between Sentinel Fishery and At-Sea Observer programs in fishing location and season (see above). Consequently, an initial stratification of the data was established, based on year and methodology of data collection (At-Sea Observer program vs Sentinel Fishery program vs questionnaires). Data were further stratified, based on the spatial distribution and intensity of fishing activities relative to NAFO areas, resulting in five zones: Northwestern Gulf, Miscou, Southern Gulf, North Shore, and 4R (Figures 1–4). The Greenland halibut and Atlantic cod fisheries were considered separately since the fishery for Greenland halibut typically occurred in deep waters of the channels in contrast to the Atlantic cod fishery, which mostly operated in shallower waters (Figures 1–4). The location of fishing activities shown in these figures provides an incomplete overview of the entire fishery for these species since fishing location information was obtained from only one of three possible sources of information in the commercial fishery database (i.e., logbooks), and logbooks are mandatory only for larger vessels in some NAFO areas (e.g., logbooks are not mandatory for vessels 45 feet or less in area 4T for the Greenland halibut fishery). The low levels of activity by at-sea observers precluded any seasonal stratification of the data.

The low response rate from questionnaires (see Results) also precluded any stratification of the data for the calculation of bycatch rates. Active fishermen in the different NAFO areas were assumed to have had an equal chance of receiving or completing and returning the questionnaire i.e., the number of answers that were received was considered proportional to the number of

active fishermen in each NAFO area. One way of verifying this assumption would have been to re-sample both respondents and non-respondents shortly after questionnaires were returned. However, this verification could not be done in a timely fashion following the reception of questionnaires.

Standard bootstrap techniques were used to calculate the 95% confidence interval associated with bycatch estimates.

RESULTS

Based on the bycatch information from the At-Sea Observers and Sentinel Fishery programs, gillnets were the only gear responsible for the incidental catch of harbour porpoises in this study (see below). Consequently, other types of gear (e.g., longlines) will not be dealt with further in this document.

FISHING ACTIVITIES IN 2001 AND 2002

A total of 786 and 882 bottom-set gillnet hauls were monitored by at-sea observers in 2001 and 2002, respectively. Fisheries targeted by the At-Sea Observer program were, in decreasing order of importance, Atlantic cod, Greenland halibut, winter flounder, and American plaice (Table 1). Fishing activities for Atlantic cod occurred mainly in the 4R and Miscou zones, whereas the Greenland halibut fishery occurred almost exclusively in the northern Gulf (i.e., Northwestern Gulf and North Shore zones) and along the west coast of Newfoundland (zone 4R) (Table 1; Figures 5–8). Fishing activities for Atlantic cod were at least twice as intense in zone 4R as they were in Miscou during both 2001 and 2002. However, the number of hauls monitored by at-sea observers in 4R was three to four times less than in Miscou, resulting in a stable coverage of about 9% in Miscou compared to less than 1% in 4R. While the intensity of cod fishing activities was comparable in the North Shore and Southern Gulf zones, coverage by at-sea observers was nearly null in the former and 6–35% in the latter. Similarly, coverage of the Greenland halibut fishery by at-sea observers was relatively high (7–17%) in the Northwestern Gulf but nearly null in the North Shore and 4R zones, where high levels of halibut fishing occurred during both years. The winter flounder fishery concentrated in 4R, Miscou, and Southern Gulf zones, whereas the American plaice fishery occurred almost exclusively in zone 4R. The commercial fishery and number of hauls observed for both these fisheries was relatively low in 2001 and 2002, resulting in variable percent coverage.

The at-sea observer activities followed relatively closely the seasonal activity of the commercial fishery for both Atlantic cod and Greenland halibut fisheries. Most of the at-sea observer effort for the cod fishery occurred early and late in the season (late July and late September) in the Southern Gulf, when most of the fishing activity occurred, whereas at-sea observer effort occurred mainly in July and early August in the more northerly areas of the Gulf (Figure 5). Similarly, the at-sea observer effort was the highest during periods when most of the commercial fishery for Greenland halibut took place in the Northwestern Gulf, 4R, and North Shore zones, i.e., mainly between early July and late September (Figure 6).

The Sentinel Fishery program was oriented exclusively towards Atlantic cod in 2001 and 2002 (Table 1). The spatial distribution of this fishery appeared to be independent of the

commercial fishery activities. Sentinel fishery activities were highest in the North Shore zone, with a steady 100 hauls per year, even though commercial fishing activity for Atlantic cod was low in this zone compared to Miscou and 4R. Similarly, substantial levels of sentinel fisheries occurred in the Southern Gulf in 2002 despite low activity in commercial fishing in this zone. Sentinel and commercial fishing activities were low during both years only for the Atlantic cod fishery of the Northwestern Gulf. In addition, and in contrast to the At-Sea Observer program, which peaked at the same period as the commercial fishery, sentinel fisheries remained highly active over extended periods and included areas and periods with little or no commercial fishing activities (Figure 5).

INCIDENTAL CATCHES OF HARBOUR PORPOISES IN 2000–2002

Questionnaires

Fifty-seven percent of the 2,277 questionnaires were mailed to fishermen who possessed either a groundfish gillnet fishery license (n = 230) or both a groundfish gillnet license and a herring or mackerel gillnet license (n = 1,064). The remaining 983 questionnaires (43%) were mailed to fishermen with only a herring or mackerel gillnet fishery license. Response rates from groundfish fishermen (57%) and those who possessed only a herring or mackerel gillnet license (43%) were proportional to the number of questionnaires assigned to each group. A total of 1,744 of 5,137 (i.e., 34%) of the holders of valid licenses were active in 2000 (Table 2). Assuming that the 2,277 questionnaires were sent randomly to active and inactive fishermen, an expected 774 questionnaires were received by active fishermen. Based on this assumption, return rates from active fishermen (n = 258) and active fishermen who provided useful information on bycatch levels (n = 173) were 33% and 22%, respectively (i.e., 258 and 173 of 774 active fishermen).

A total of 188 and 296 harbour porpoises were taken by 37 (24%) and 47 (27%) fishermen in 2000 and 2001, respectively (Table 2; Figure 9). These mortalities were reported from different zones of the Gulf of St. Lawrence (Figures 10 and 11). The 4R, Miscou, and North Shore zones were responsible for the largest bycatches, whereas the Northwestern Gulf, and particularly the St. Lawrence Estuary portion of this area, accounted for a relatively small number of incidental mortalities. The number of bycatches was highest in July and August during both 2000 and 2001, although they remained high during September in 2001 (Figure 12). Atlantic cod, herring, and mackerel were the species most often associated with bycatches of harbour porpoises during both 2000 and 2001 (Table 3).

These mortalities resulted in mean bycatch rates of 1.24 (SD = 4.9) and 1.71 (SD = 4.6) porpoises per reporting fisherman in 2000 and 2001, respectively. Mean catch rates did not differ significantly between years (t = -0.70, $p > 0.05$). Extrapolation of these bycatch rates to the entire active fishing fleet using bottom-set gillnets resulted in an estimated total bycatch of 2,215 (95% CI 1,151–3,662) and 2,394 (95% CI 1,440–3,348) porpoises for the Estuary and Gulf of St. Lawrence in 2000 and 2001, respectively. The use of a survey area similar to Fontaine et al. (1994a) provided estimates of 1,343 (95% CI 307–2,379) and 703 (95% CI 300–1,107) harbour porpoise bycatches in 2000 and 2001, respectively.

At-Sea Observer and Sentinel Fishery programs

A total of 10 harbour porpoise bycatches were reported by at-sea observers in 2001 (n = 4) and 2002 (n = 6) (Table 1). Atlantic cod and Greenland halibut bottom-set gillnet fisheries were responsible for seven and three of these catches, respectively. At least six of the seven harbour porpoises taken by the Atlantic cod fishery in the different zones of the Gulf were caught in late July, when most of the at-sea observer activities took place; the date of bycatch was unavailable for an animal taken in zone 4R. The three incidental mortalities associated with the Greenland halibut fishery occurred in the Northwestern Gulf in 2002 and were spread out in time between late July and early September (Figure 13a). Harbour porpoise bycatches associated with the Atlantic cod fishery occurred in waters less than 60 m deep, whereas at least two of the three captures associated with the Greenland halibut fishery occurred at deeper depths (Figure 14: NAFO areas 4Tq and 4To). The low number of hauls that were monitored by at-sea observers prevented the calculation of bycatch estimates for several zones and the study area as a whole, and provided only imprecise estimates (i.e., large CVs) for all other zones (Table 4). Using the upper confidence limits of mortality estimates and the information available for the different zones from both years, and assuming that harbour porpoise bycatch was proportional to fishing effort, total bycatch of harbour porpoises was probably on the order of 1000 individuals or fewer during both 2001 and 2002.

Sentinel Fishery activities resulted in 86 and 77 bycatches of harbour porpoise in 2001 and 2002, respectively (Tables 1 and 5). Depending on the year, incidental mortalities of harbour porpoises by this fishery peaked in late August or early September, even though the commercial fishery activity peaked earlier in the season, in late July in 2001 and late August 2002 (Figure 13b). Between 53 and 65% of these catches occurred in the Miscou zone. Most of the other mortalities occurred in the 4R and North Shore zones (Table 5).

Harbour porpoise bycatch levels associated with the Sentinel Fishery were higher than levels reported through the At-Sea Observer program (Tables 4 and 5). It is noteworthy that higher bycatch levels were associated with the Sentinel program whose activity occurred over a more extended period than the commercial or at-sea observer fishery and included areas where target species might have been less abundant. The larger number of bycatches (n = 31 for 14 hauls in 2001, n = 48 for 19 hauls in 2002) observed in the Sentinel Fishery on the Miscou Bank (NAFO area 4Tn) compared to bycatch numbers reported through the At-Sea Observer program (n = 0 in 313 and 212 hauls in 2001 and 2002, respectively) was puzzling. The vast majority (26 of 31 and 46 of 48) of the mortalities inflicted by the sentinel fishery occurred in late August and September, when activities by commercial cod fishery had decreased (Figure 5). Commercial fishery activities were nearly null and coverage by at-sea observers was non-existent during this period in 2002, which might explain why no harbour porpoises were reported for that year. During the same period in 2001, 37 hauls were subjected to at-sea observer monitoring and none were associated with bycatches. A comparison of different parameters related to operations, including fishing depth, number of gear, soak time, and fishing location, for periods when both types of activity occurred at the same period (August and early September) revealed significant differences in fishing characteristics between commercial fisheries, commercial fisheries with at-sea observers on board, and sentinel fisheries. Specifically, sentinel fisheries soaked nets of similar length (455 m) but of smaller mesh, at deeper depths, for longer periods, and for a lower quantity of landed fish than did the commercial fisheries with an observer on board (Table 6). Plotting the cod fishing locations in the Miscou zone (NAFO 4Tn) indicated that, at least for

August and early September 2001, there was no overlap in fishing location between the two fisheries. There was also no overlap between commercial fisheries with observers on board and commercial fisheries not subjected to at-sea observations (Figure 15). Commercial and sentinel fisheries generally followed the 60-m isobath, whereas fishing activities with at-sea observers on board occurred in shallower waters, inside the Miscou Bank. In 2002, periods of activity by at-sea observer and sentinel fisheries in area 4Tn did not overlap in time but did overlap spatially (Figure 16).

DISCUSSION

The At-Sea Observer program and the questionnaire survey provided inconsistent indices of harbour porpoise bycatch levels in the Estuary and Gulf of St. Lawrence. On the one hand, estimates made using at-sea observer data suggested that 1000 harbour porpoises or fewer were taken during 2001 or 2002, whereas questionnaires to fishermen estimated a total bycatch of twice as many (2,215 and 2,394) harbour porpoises in 2000 and 2001, respectively. The use of a survey area similar to Fontaine et al. (1994a) resulted in estimates from questionnaires of 1,343 and 703 harbour porpoises taken in 2000 and 2001, respectively. In comparison, Fontaine et al. (1994a) had estimated a total bycatch of 1,907 (95% CI 1,235–2,579) and 1,762 (95% CI 563–3,251) harbour porpoises in 1989 and 1990, respectively. In a similar study conducted over an undefined portion of the Gulf of St. Lawrence, but which included the Estuary and northern Gulf of St. Lawrence and the Îles-de-la-Madeleine, Larrivée (1996) estimated total bycatches of 1,493–5,806 and 1,657–5,642 harbour porpoises in 1992 and 1993, respectively (mean estimates of 3,650 in both years). However, these estimates were produced assuming that all fishermen with valid licenses had been actively fishing in each of these years, which might not have been the case (M. Larrivée, Centre spécialisé des pêches, C.P. 220, Grande-Rivière, Qc, pers. comm.). The comparison of our questionnaire survey data with the results from Fontaine et al. (1994a) would indicate a 24–63% reduction in the incidental catch of harbour porpoises since the late 1980s. Using at-sea observer data for an area similar to Fontaine et al. (1994a), the total bycatch in 2001 and 2002 would be on the order of 500 individuals or fewer, representing a reduction in bycatch levels of at least 72–75% compared to the late 1980s.

There are several caveats associated with the two approaches that were used in this study to estimate bycatch levels. In contrast to the study by Fontaine et al. (1994a), which surveyed all active fishermen, our study questioned 44% of the fishermen with licences and an estimated 34% of active fishermen. The estimation of total bycatch in our study assumed that the random sample of fishermen who received a questionnaire was distributed in the different zones of the study area proportionally to the level of fishing activity in each zone. Return rates of questionnaires in the study by Fontaine et al. (1994a) were 33% and 18% for 1989 and 1990, respectively. In this study, the return rate from fishermen who provided useful information on bycatch was 22%. Return rates of this magnitude were considered low and their reliability in providing bycatch estimates questioned by participants at a workshop (Palka 1994). Our study and others of the same type are subject to diverse biases associated with the willingness of fishermen to transmit information that might impede their future fishing activities. Surveys also suffer from the capacity of fishermen to recall events that took place weeks or months earlier (Lien et al. 1994). Questionnaires in this study were distributed shortly after the end of the fishing season, which helped reduce the latter bias. While fishermen were asked to provide

information on harbour porpoises taken incidentally over the past two seasons, those bycatch estimates from the fishing season just preceding the distribution of questionnaires (2001) were considered the most reliable.

There are several lines of evidence indicating that bycatch rates might have been underestimated by the At-Sea Observer program. The zones identified as being associated with high levels of bycatch differed between the two sources of information used in this study (questionnaires to fishermen; At-Sea Observer and Sentinel Fishery programs). Fontaine et al. (1994a) and Larrivée (1996) had both identified the Gaspé Peninsula (NAFO areas 4Tn and 4To), and the Lower North Shore (areas 4Sv and 4Sw) as important areas of bycatch of harbour porpoises. The Sentinel Fishery program and the questionnaires, but not the at-sea observer data, confirmed the importance of these areas for incidental mortalities of harbour porpoises (Figures 10 and 11; Table 1). The absence or low coverage of the Atlantic cod fishery by at-sea observers in the North Shore zone, and to a lesser extent in area 4To, may in part explain the absence of reported bycatches in these sectors.

The use of an independent observer, ideally dedicated to marine mammal research (so-called "on-watch"), is recognized as being the most desirable approach for obtaining information on bycatch levels of marine mammals (Perrin et al. 1994; Trippel et al. 1996; Bisack 1997a; DFO 2001). However, the amount and distribution of observer coverage must be adjusted so as to ensure the detection of a reasonably high number of events and thereby achieve an acceptable coefficient of variation (Bisack 1997b). As stated by Wade (1999), "a five percent observer coverage may be sufficient for a very large fishery, but may be grossly inadequate for a smaller fishery." In this study, the number of hauls monitored by observers was low throughout the Estuary and Gulf of St. Lawrence and for all groundfish fisheries with the exception of the Greenland halibut fishery in the Northwestern Gulf and the Atlantic cod fishery in the Miscou zone (Table 1). In addition, the observers on Sentinel Fishery or At-Sea Observer vessels were not entirely dedicated to marine mammal watch, thereby causing an underestimation of incidental mortalities of harbour porpoises in fisheries. Studies that have compared mortalities reported by at-sea observers while they were "on-watch" and "off-watch" for marine mammals, i.e., while they were or were not actively watching for harbour porpoises in nets being hauled, indicated that a non-negligible (about 18–37%) proportion of bycaught harbour porpoises fall out of the net before being brought on deck (Palka 1994; Bravington and Bisack 1996).

The Miscou zone (NAFO area 4Tn) was identified as one of the most problematic areas for bycatches of harbour porpoises in the Gulf of St. Lawrence by both Fontaine et al. (1994a) and Larrivée (1996). This one sector contributed 13% and 18% of all the bycatches reported by fishermen through questionnaires in 2000 and 2001, respectively, and 62–65% of incidental mortalities reported by the Sentinel Fishery program in 2001 and 2002. However, no harbour porpoise bycatches were detected by at-sea observers in 2001 and 2002 in spite of the high number of monitored hauls (Table 1). Inconsistencies in data collection between observers are unlikely to be the reason for this discrepancy since the same individuals served as observers onboard sentinel or at-sea observer fishery vessels (M. Jean, Biorex Inc., Caraquet, N.B., pers. comm.). An experimental study conducted by Larrivée (1996) between May and August 1992 in this area (4Tn) indicated a mean bycatch rate of 3.85 harbour porpoises per landed metric ton of fish. Applying this rate to the landings reported in this area in 2001 (705 t) and 2002 (496 t) would have yielded estimated bycatches of 2,714 and 1,910 harbour porpoises, respectively, for area 4Tn alone. The bycatch rate obtained by Larrivée (1996) is likely unrealistic for the 2001

and 2002 situation in area 4Tn given the profound changes observed in the fishing season and number of operating vessels. However, the results from this simple calculation suggest that a meticulous examination of the data available for this area is warranted.

The comparison of fishing location and timing between sentinel fisheries and commercial fisheries subjected and not subjected to at-sea observation indicated that fine-scale differences in the temporal and spatial distribution of fisheries may greatly influence rates of harbour porpoise bycatch. Fisheries that occurred later in the season (late August and September) and closer to the 60 m isobath appeared more susceptible to cause incidental mortality of harbour porpoises (Figures 13 and 15). Larrivée (1996) obtained similar results in a controlled fishing experiment between the 36 m and 55 m isobath of the Miscou Bank (area 4Tn) during the period 19 August to 29 September 1994. She observed a decline in cod landings with date and soaking depth, and a parallel increase in harbour porpoise bycatches. Consequently, a larger effort by at-sea observers, closer to the 60 m isobath where most of the commercial fisheries activity occurred, might have revealed higher bycatch estimates in 4Tn. The difference that was observed in 2001 in the spatial distribution between commercial fisheries subjected and not subjected to observer monitoring suggests that fishermen may distribute their fishing effort differently in the presence and absence of at-sea observers. This pattern was not observed in 2002.

Significant differences in the characteristics of hauls were also observed between the sentinel and at-sea observer fisheries (Table 6). One striking difference was the short soak time (median = 7.3 h; range 2.5–18 h) of the commercial fishery subjected to at-sea observation compared to sentinel fisheries (median = 19.7 h; range 17.8–24 h). This difference suggests a deployment and retrieval of nets in the same day by the fisheries subjected to at-sea observations, compared to an overnight deployment by the sentinel fisheries. The effect of soak time on bycatch rate is unclear, with some studies indicating an increase in capture rate per haul with the amount of time nets are left in the water (Vinther 1999) and other studies showing a reversed trend or unclear patterns (Palka 1994; Larrivée 1996; Hood 2001; DFO 2001). A positive correlation between soak time and harbour porpoise bycatch, if it was to occur, might represent a plausible explanation for the higher bycatch rates observed in the sentinel fisheries.

The increase in harbour porpoise bycatches in late summer could be related to an influx of harbour porpoises inshore in response to an increase in the abundance of Atlantic herring in coastal waters of the Baie des Chaleurs (LeBlanc et al. 2001; 2002). This species, which spawns in the spring and autumn, represented an important prey of harbour porpoises in the Miscou zone both in the late 1980s and in 2001–2002 (Fontaine et al. 1994b; Guimont 2003). This species is also regularly associated with bycatches of harbour porpoises in eastern Canada (Fontaine et al. 1994a; Trippel et al. 1999; Hood 2001; this study). The distribution of Atlantic herring closely follows the 60 m isobath in the Miscou Bank area and likely overlaps to some extent the distribution of Atlantic cod (LeBlanc et al. 2001; 2002; Figures 15 and 16). Therefore, harbour porpoises might have sought this abundant and rich food resource during late summer in the vicinity of the Miscou Bank, making them vulnerable to incidental mortalities in Atlantic cod fisheries. Two studies that were conducted in the Bay of Fundy and Newfoundland indicated a close relationship between harbour porpoise and Atlantic herring catch rates and support this hypothesis (Trippel et al. 1999; Hood 2001).

In conclusion, bycatch estimates obtained through questionnaires and the At-Sea Observer program, although imprecise, indicate that the incidental mortality of harbour porpoises in the gillnet fishery of the Estuary and Gulf of St. Lawrence has remained non-negligible in

2000–2002, in spite of a reduction in groundfish fishery activities. Both indices suggest that harbour porpoise bycatch levels likely decreased since the late 1980s, but the magnitude of this change remains uncertain. Although results from questionnaires suffer from a number of weaknesses associated with the method, the consistency in the areas identified as the most problematic for harbour porpoise bycatches between this study and two similar surveys conducted in the late 1980s and early 1990s lends confidence to the general trend observed since the late 1980s. The 24–63% reduction in bycatch levels obtained through the questionnaire survey is probably more realistic than the 72–75% reduction suggested by the at-sea observer program, given the incomplete and generally low coverage of the fishery by the latter program. The striking differences in bycatch rates that were observed between the sentinel fisheries and commercial fisheries subjected to at-sea observations in NAFO area 4Tn indicate that slight changes in the spatial and temporal distribution of fishing activities might result in substantial changes in the incidental mortalities of harbour porpoises. These results also highlight the sensitivity of bycatch estimates to the spatial and temporal distribution of the effort by at-sea observers. Clearly, the seasonal and fine-scale spatial distribution of harbour porpoise bycatch should be investigated further by intensifying at-sea observer monitoring in areas of the Gulf of St. Lawrence where harbour porpoises are known to be present, such as the Lower North Shore and area 4R, where much of the Atlantic cod fishery takes place. A better understanding of these factors would help mitigate the impacts of the commercial groundfish fisheries on this harbour porpoise population.

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Table 1. Distribution of at-sea observer and sentinel fishery efforts (number of hauls) relative to fishery activities in the different zones and types of sink gillnet fishery in 2001 and 2002.

Target species	Zone	N Commercial hauls		N Observed hauls		Observer coverage (%)		N Sentinel hauls		N Harbour porpoises (N hauls)			
										Observers		Sentinels	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Atlantic cod	NW Gulf	9	60	1	1	10.9	1.0	22	12	0	0	0	0
	North Shore	1428	2529	1	17	0.1	1.0	539	457	0	1 (1)	26 (14)	14 (7)
	4R	8814	9404	70	80	0.8	0.9	512	403	1 (1)	0	11 (6)	13 (7)
	Miscou	3887	2522	362	232	9.3	9.2	195	329	0	2 (2)	46 (27)	50 (21)
	Southern Gulf	1116	139	67	48	6.0	34.5	135	233	3 (3)	0	3 (2)	0
Greenland halibut	NW Gulf	2686	2835	190	468	7.1	16.5	0	0	0	3 (3)	-	-
	North Shore	475	328[a]	4	0	0.8	0	0	0	0	-	-	-
	4R	4716	4047	16	19	0.3	0.5	0	0	0	0	-	-
	Miscou	61[a]	31[a]	0	0	0	0	0	0	-	-	-	-
	Southern Gulf	0	0	-	-	-	-	-	-	-	-	-	-
Winter flounder	NW Gulf	0	0	-	-	-	-	-	-	-	-	-	-
	North Shore	0	0	-	-	-	-	-	-	-	-	-	-
	4R	115	48	0	1	0	2.0	0	0	-	0	-	-
	Miscou	376	76[a]	14	0	3.7	0	0	0	0	-	-	-
	Southern Gulf	389	5	12	4	3.1	77.8	0	0	0	0	-	-
American plaice	NW Gulf	0	0	-	-	-	-	-	-	-	-	-	-
	North Shore	0	0	-	-	-	-	-	-	-	-	-	-
	4R	816	115	41	12	5.0	10.4	0	0	0	0	-	-
	Miscou	9	7[a]	8	0	84.4	8.0	0	0	0	-	-	-
	Southern Gulf	0	0	-	-	-	-	-	-	-	-	-	-

[a] Estimation based on species' annual mean landing per haul

Table 2. Estimates of harbour porpoise bycatches during 2000 and 2001 and associated coefficient of variation (CV) calculated from a questionnaire survey of fishermen from the Estuary or Gulf of St. Lawrence with valid groundfish, Atlantic herring, or mackerel gillnet fishery licenses in 2000. Confidence intervals (CI) were estimated using standard bootstrap techniques.

	N (in %)	Estuary and Gulf of St. Lawrence		Area similar to Fontaine et al. 1994a	
		2000	2001	2000	2001
Fishermen with valid licences in 2000	5137				
Questionnaires sent to fishermen with valid licenses in 2000	2,277 (44%)				
Questionnaires returned	294 (13%)				
Questionnaires returned by inactive fishermen	36				
Questionnaires returned by active fishermen unwilling to participate	35				
Active fishermen willing to participate	223 (10%)				
Questionnaires with information on harbour porpoise bycatches		152	173	78	89
Fishermen who caught harbour porpoises (in %)		37 (24.3)	47 (27.2)	19 (24.3)	21 (23.6)
Total number of harbour porpoise bycatches[a]		188	296	133	132
Mean number of bycaught harbour porpoises per fisherman (CV); [95% CI]		1.27 (352%)[b] [0.66–2.10]	1.70 (267%)[b] [1.02–2.38]	1.72 (348%) [0.39–3.05]	1.49 (276%) [0.63-2.35]
Active gillnet fishermen in the fishing fleet		1,744	1,408	781	472
Extrapolation of the number of bycatches to the fishing fleet (95% CI)		2,215 (1,151–3,662)	2,394 (1,440–3,348)	1,343 (307-2,379)	703 (300-1,107)

[a] Assuming a bycatch of one harbour porpoise for fishermen who indicated "some bycatches"
[b] Between-year differences were not significant (*t*-tests, $p > 0.05$)

Table 3. Species associated with incidental catches of harbour porpoises during 2000 and 2001, as indicated by a questionnaire survey of fishermen from the Estuary and Gulf of St. Lawrence with valid groundfish, herring, or mackerel gillnet licenses in 2000.

Species associated with harbour porpoise bycatches	2000		2001	
	N of respondents	%	N of respondents	%
Atlantic cod	14	41	18	40
Atlantic herring	12	35	18	40
Atlantic mackerel	15	44	17	38
Capelin	5	15	9	20
Flounder	3	9	3	7
Greenland halibut	1	3	1	2
Hake	1	3	1	2
Lumpfish	3	9	3	7
Undetermined	7	21	8	13

Table 4. Estimates of incidental catches of harbour porpoises in the bottom-set gillnet fishery in the Estuary and Gulf of St. Lawrence using information obtained from the At-Sea Observer program. The coefficient of variation (CV) and 95% confidence intervals (CI) were estimated using standard bootstrap techniques.

Year	Targeted species	Zone	N of bycatch per haul (N of observed hauls)	N commercial hauls	Estimated mortalities	CV (%)	95% CI
2001	Atlantic cod	NW Gulf	-[a]	9	-[a]	-[a]	-[a]
		North Shore	-[a]	1428	-[a]	-[a]	-[a]
		4R	0.0143 (70)	8814	126	99	0–378
		Miscou	0 (362)	3887	0		
		Southern Gulf	0.04478 (67)	1116	50	53	0–100
	Greenland halibut	NW Gulf	0 (190)	2686	0	-	-
		North Shore	-[a]	475	-[a]	-[a]	-[a]
		4R	0 (16)	4716	0	-	-
		Miscou	-[a]	61	-[a]	-[a]	-[a]
		Southern Gulf	-	0	-	-	-
2002	Atlantic cod	NW Gulf	-[a]	60	-[a]	-[a]	-[a]
		North Shore	0.05882 (17)	2529	149	98	0–446
		4R	0 (80)	9404	0	-	-
		Miscou	0.0086 (232)	2522	22	74	0–54
		Southern Gulf	0 (48)	139	0	-	-
	Greenland halibut	NW Gulf	0.0064 (468)	2835	18	57	0–42
		North Shore	-[a]	328	-[a]	-[a]	-[a]
		4R	0 (19)	4047	0	-	-
		Miscou	-[a]	31	-[a]	-[a]	-[a]
		Southern Gulf	-	0	-	-	-

[a]The At-Sea Observer coverage was too low to estimate harbour porpoise bycatch rates

Table 5. Bycatch rates and total number of harbour porpoise incidentally taken in the bottom-set sentinel gillnet fishery for Atlantic cod operating in the Estuary and Gulf of St. Lawrence in 2001 and 2002.

Year	Zone	N of bycatch per haul (n hauls)	Total n of bycatches
2001	NW Gulf	0 (22)	0
	North Shore	0.048 (539)	26
	4R	0.021 (512)	11
	Miscou	0.236 (195)	46
	Southern Gulf	0.222 (135)	3
	Total:		**86**
2002	NW Gulf	0 (12)	0
	North Shore	0.031 (457)	14
	4R	0.032 (403)	13
	Miscou	0.152 (329)	50
	Southern Gulf	0 (233)	0
	Total:		**77**

Table 6. Comparisons of median values and the 10th and 90th percentiles (P10-P90) of different parameters of Atlantic cod fishing operations between sentinel fisheries (Sentinels) and commercial fisheries conducted under the At-Sea Observer program (Observers) in area 4Tn during August and early September 2001.

Parameter	Sentinels (N = 51) Median (P10-P90)	Observers (N = 188) Median (P10-P90)	$F_{\text{Anova on ranks}}$	$P > F$
Depth (m)	44 (35–96)	40 (34–56)	14.6	0.0002
Soak time (h)	19.7 (17.8–24)	7.3 (2.5–18)	178.7	0.0001
Mesh (mm)	145 (140–146)	145 (140–152)	10.5	0.001
Landings (kg)	11 (0–377)	134 (30–409)	4.3	0.040

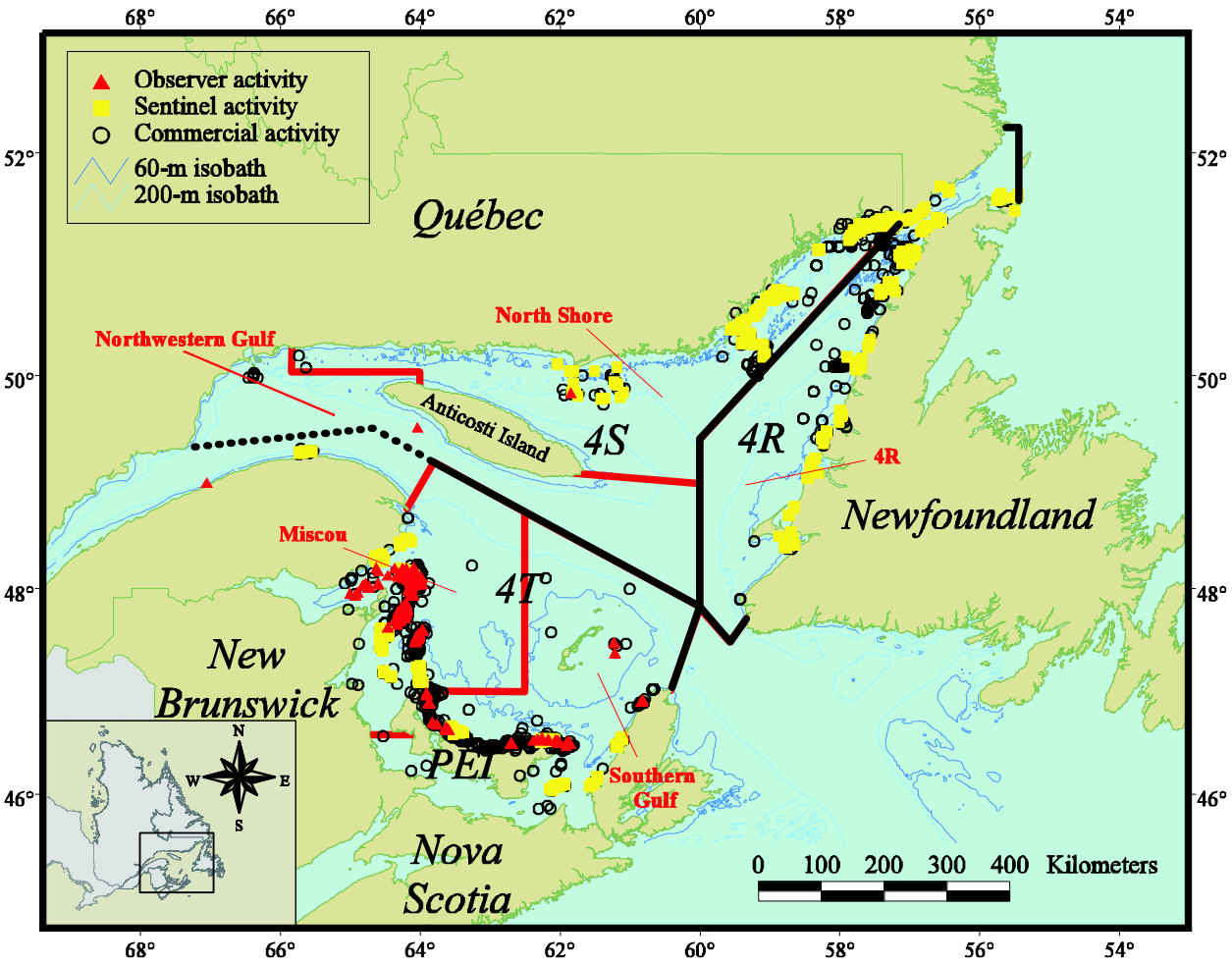

Figure 1. Distribution of Atlantic cod fishing activities using bottom set-gillnets in the study area in 2001. Information on fishing location was unavailable for most (94%) fishing activities in zone 4R. The black lines (plain and dotted) indicate the limits between NAFO zones 4R, 4S and 4T, whereas the plain red lines delimit the five zones referred to in the document (red text).

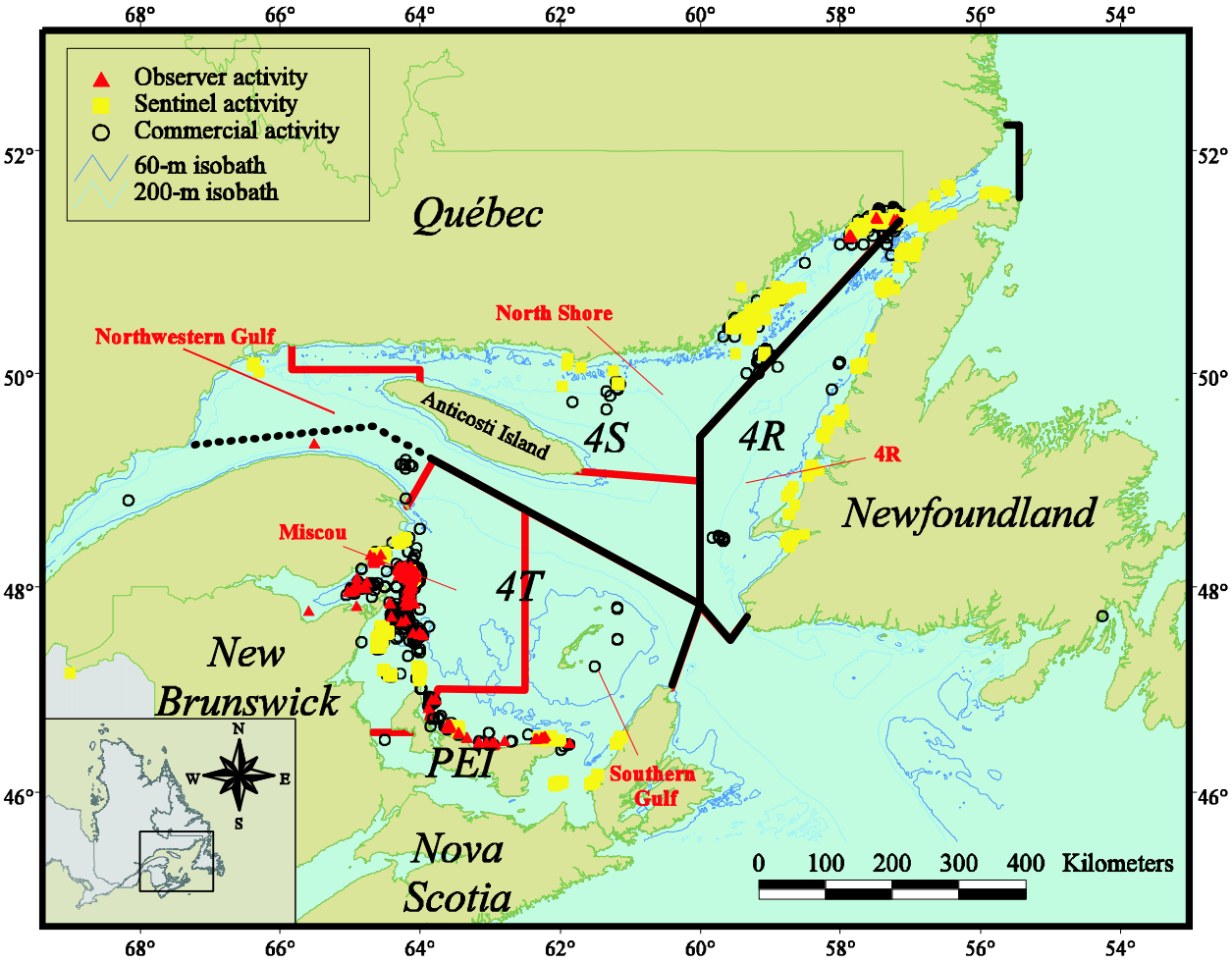

Figure 2. Distribution of Atlantic cod fishing activities using bottom set-gillnets in the different zones of the study area in 2002. Information on fishing location was unavailable for most (99%) fishing activities in zone 4R. The black lines (solid and dotted) indicate the limits between NAFO zones 4R, 4S and 4T, whereas the solid red lines delimit the five zones referred to in the document (red text).

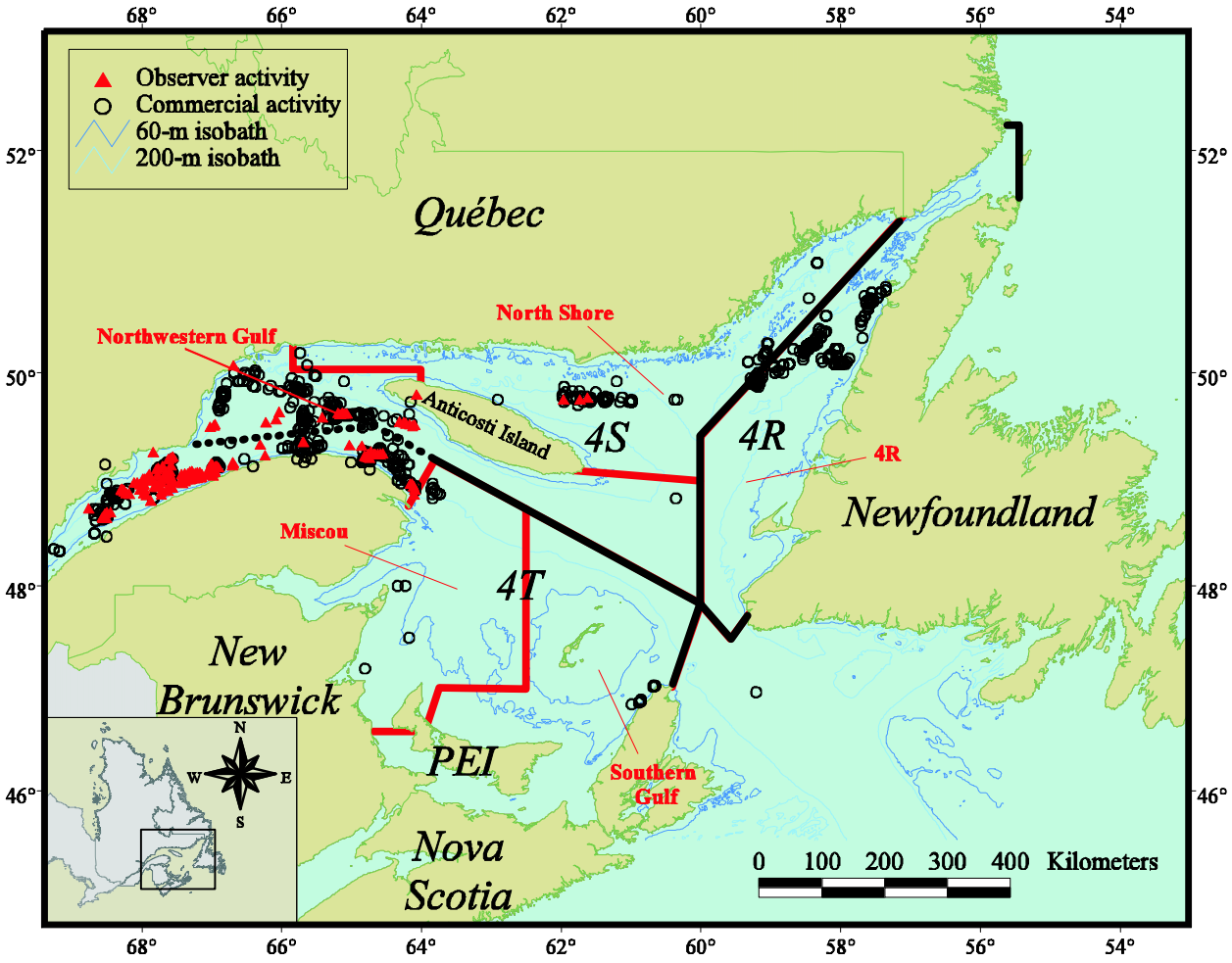

Figure 3. Distribution of Greenland halibut fishing activities using bottom-set gillnets in the different zones of the study area in 2001. Information on fishing location was unavailable for a large fraction of the commercial fishery activities in zone 4R. The black lines (solid and dotted) indicate the limits between NAFO zones 4R, 4S and 4T, whereas the solid red lines delimit the five zones referred to in the document (red text).

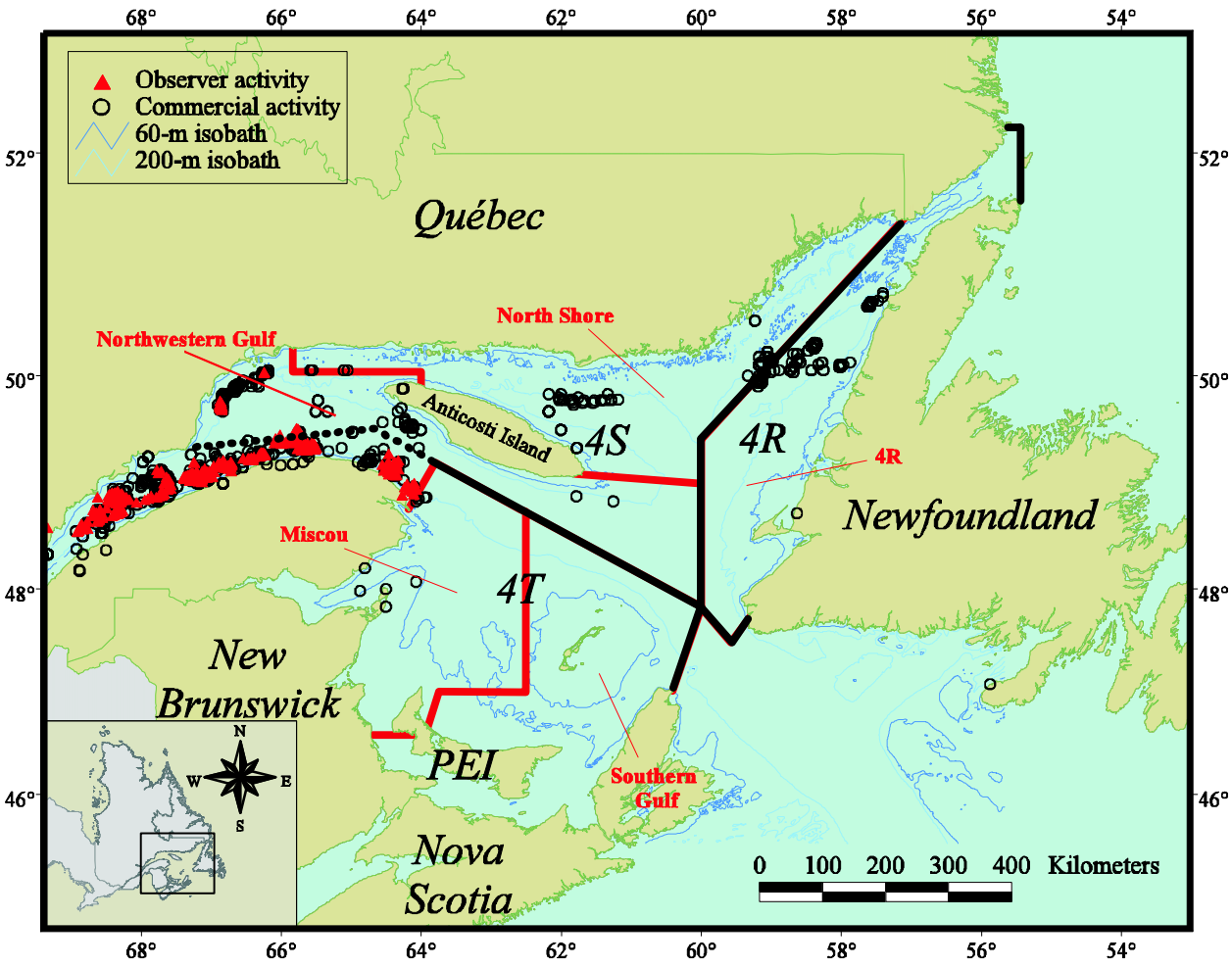

Figure 4. Distribution of Greenland halibut fishing activities using bottom-set gillnets in the different zones of the study area in 2002. Information on fishing location was unavailable for most (93%) fishing activities in zone 4R. The black lines (solid and dotted) indicate the limits between NAFO zones 4R, 4S and 4T, whereas the solid red lines delimit the five zones referred to in the document (red text).

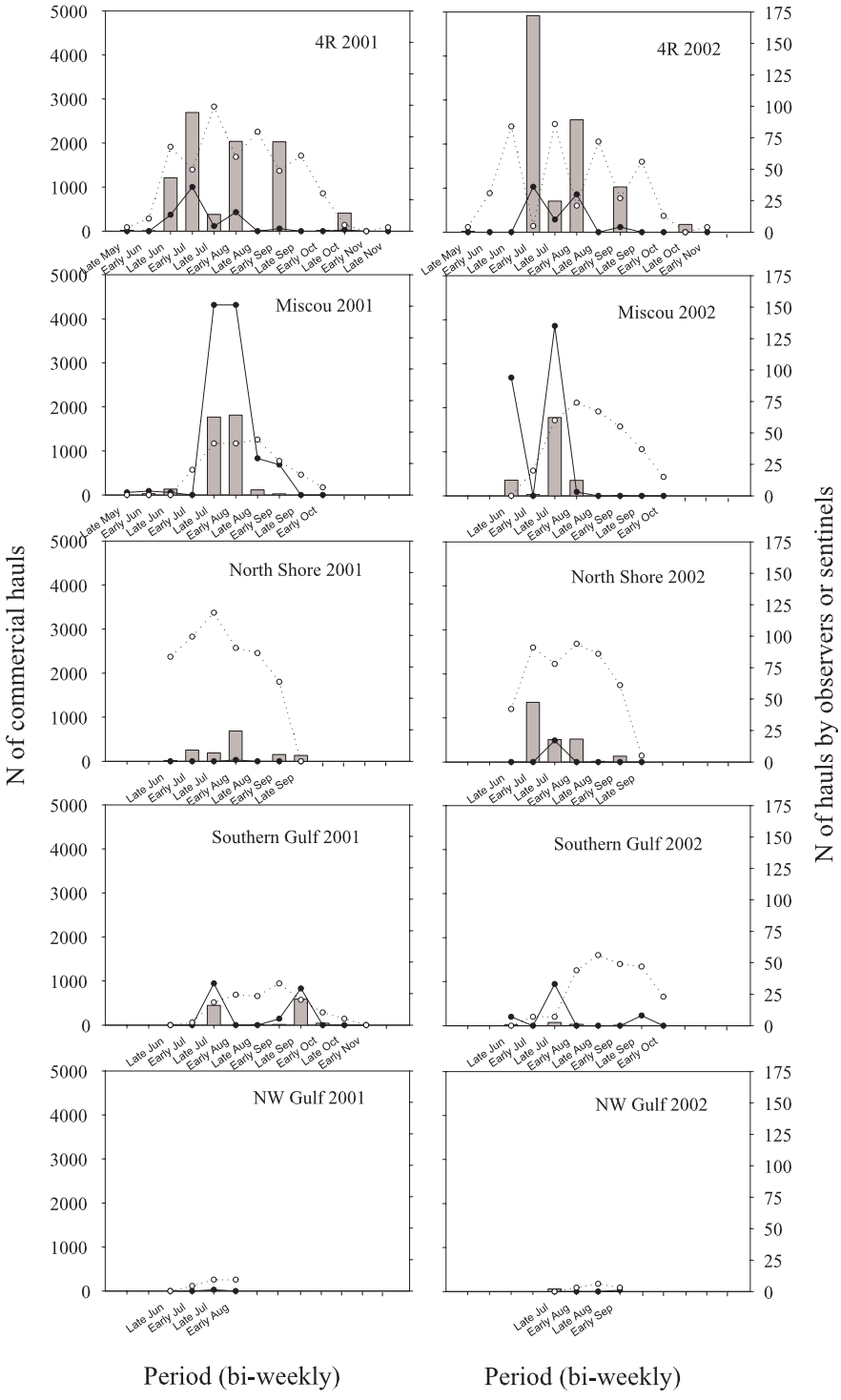

Figure 5. Seasonal distribution and level of commercial fishing activities (bars), at-sea observer activities (solid lines), and sentinel fisheries (dotted lines) for Atlantic cod in five zones of the Estuary and Gulf of St. Lawrence in 2001 and 2002.

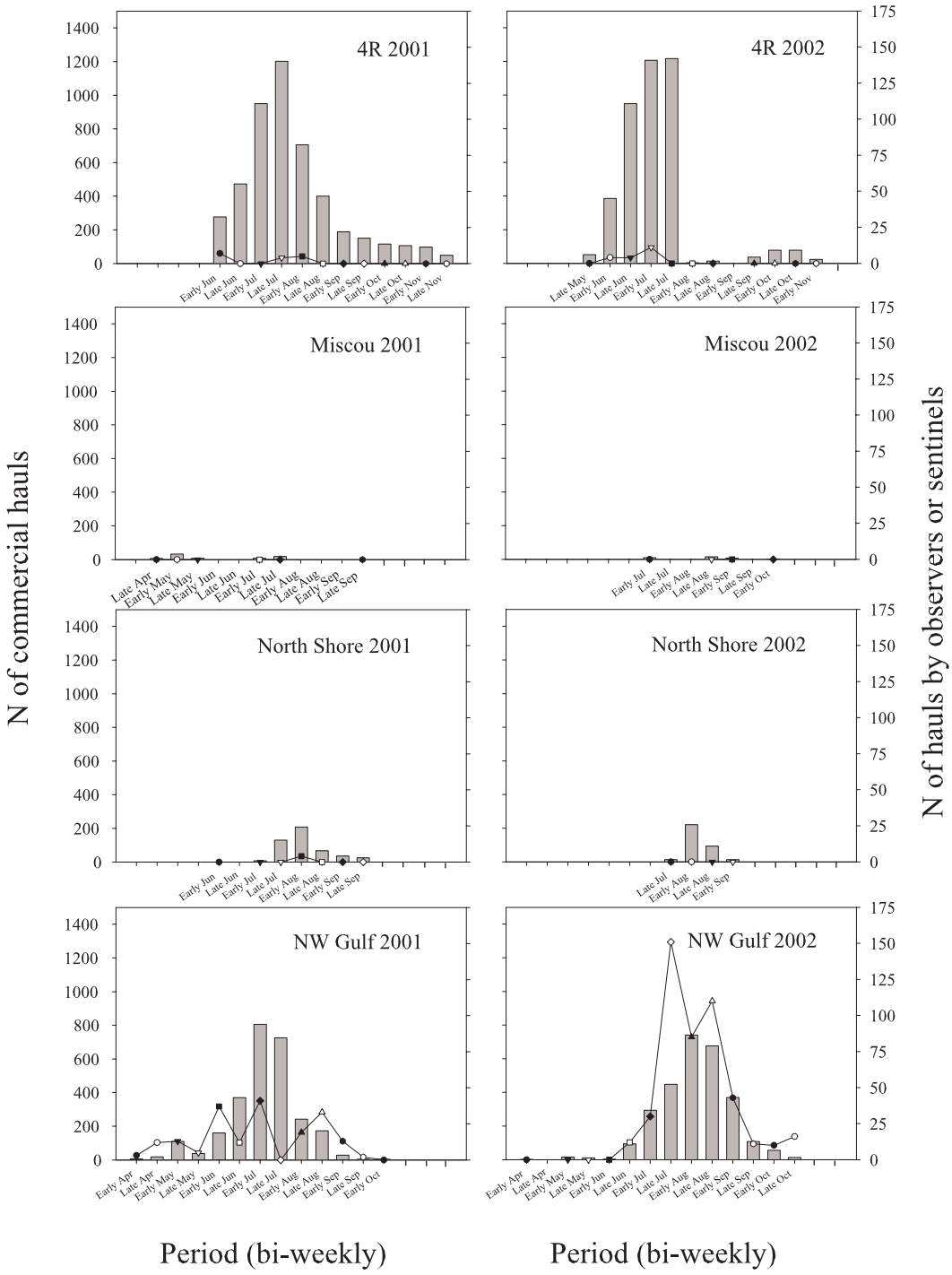

Figure 6. Seasonal distribution and level of commercial fishing activities (bars) and at-sea observer activities (solid lines) for Greenland halibut in the four zones of the Estuary and Gulf of St. Lawrence, where some fishing occurred during 2001 and 2002.

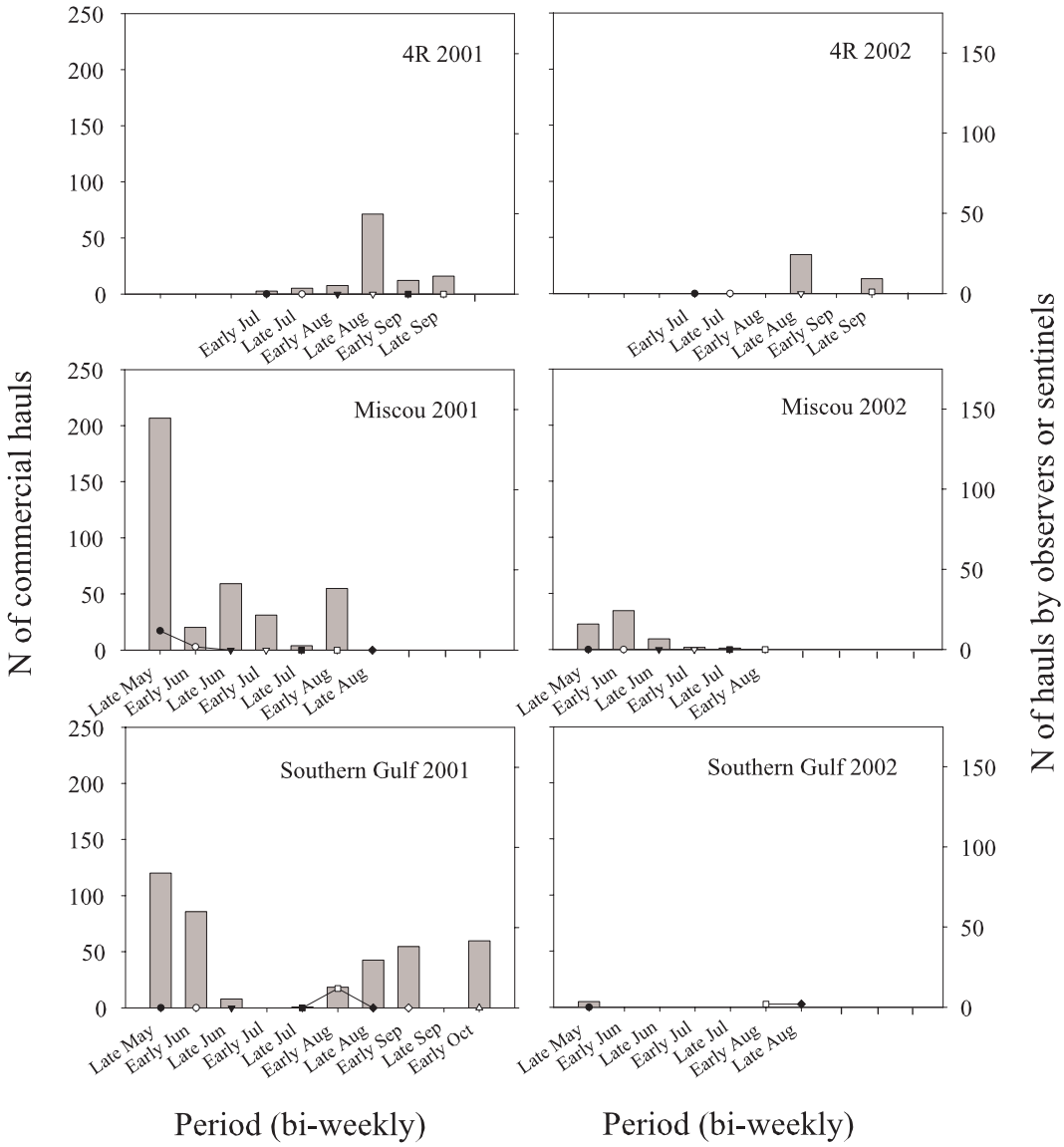

Figure 7. Seasonal distribution and level of commercial fishing activities (bars) and at-sea observer activities (solid lines) for winter flounder in the three zones of the Estuary and Gulf of St. Lawrence, where some fishing occurred during 2001 and 2002.

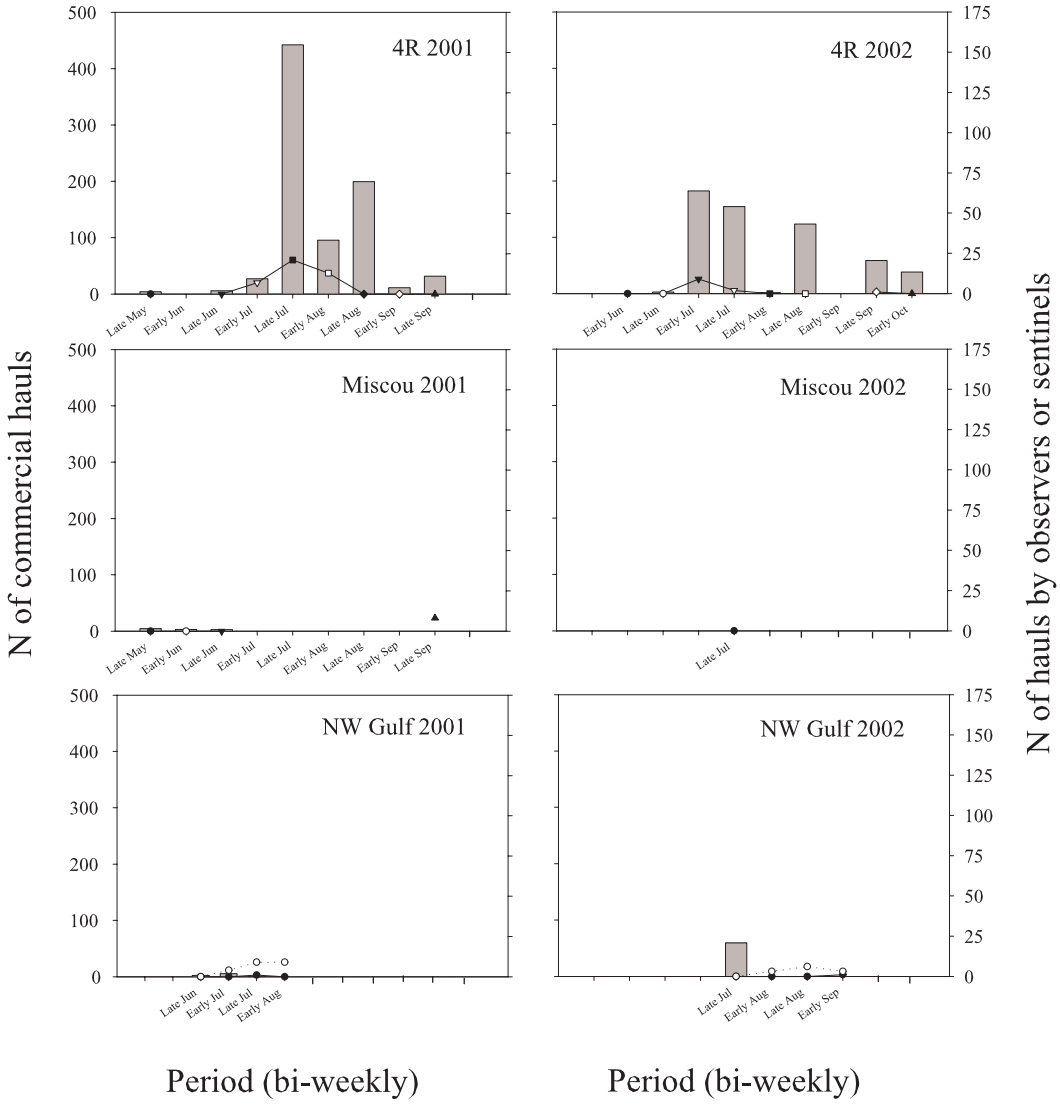

Figure 8. Seasonal distribution and level of commercial fishing activities (bars) and at-sea observer activities (solid lines) for American plaice in the three zones of the Estuary and Gulf of St. Lawrence, where some fishing occurred during 2001 and 2002.

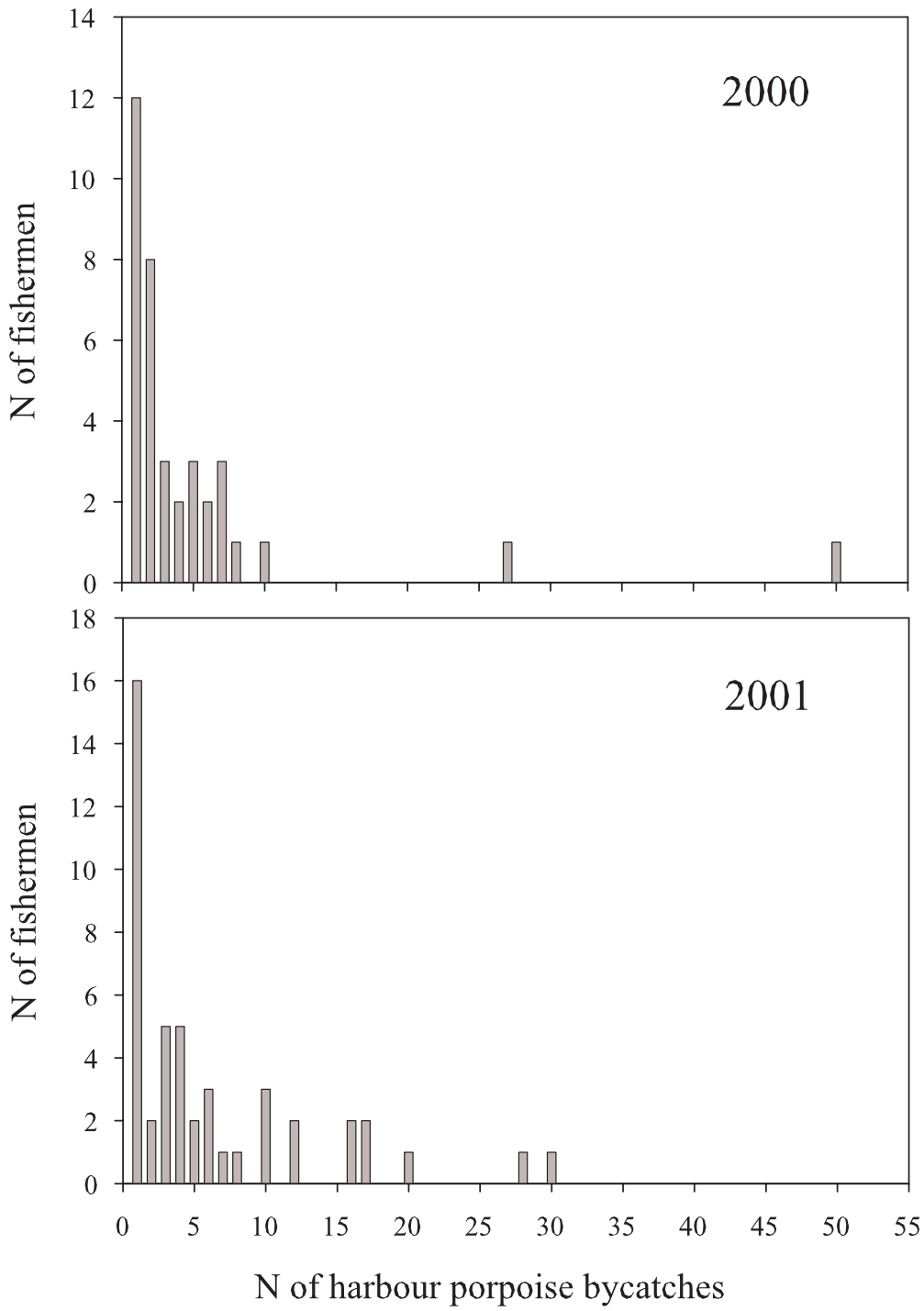

Figure 9. Frequency distribution of the number of harbour porpoise bycatches per gillnet fisherman in the Estuary and Gulf of St. Lawrence in 2000 (n = 37) and 2001 (n = 47).

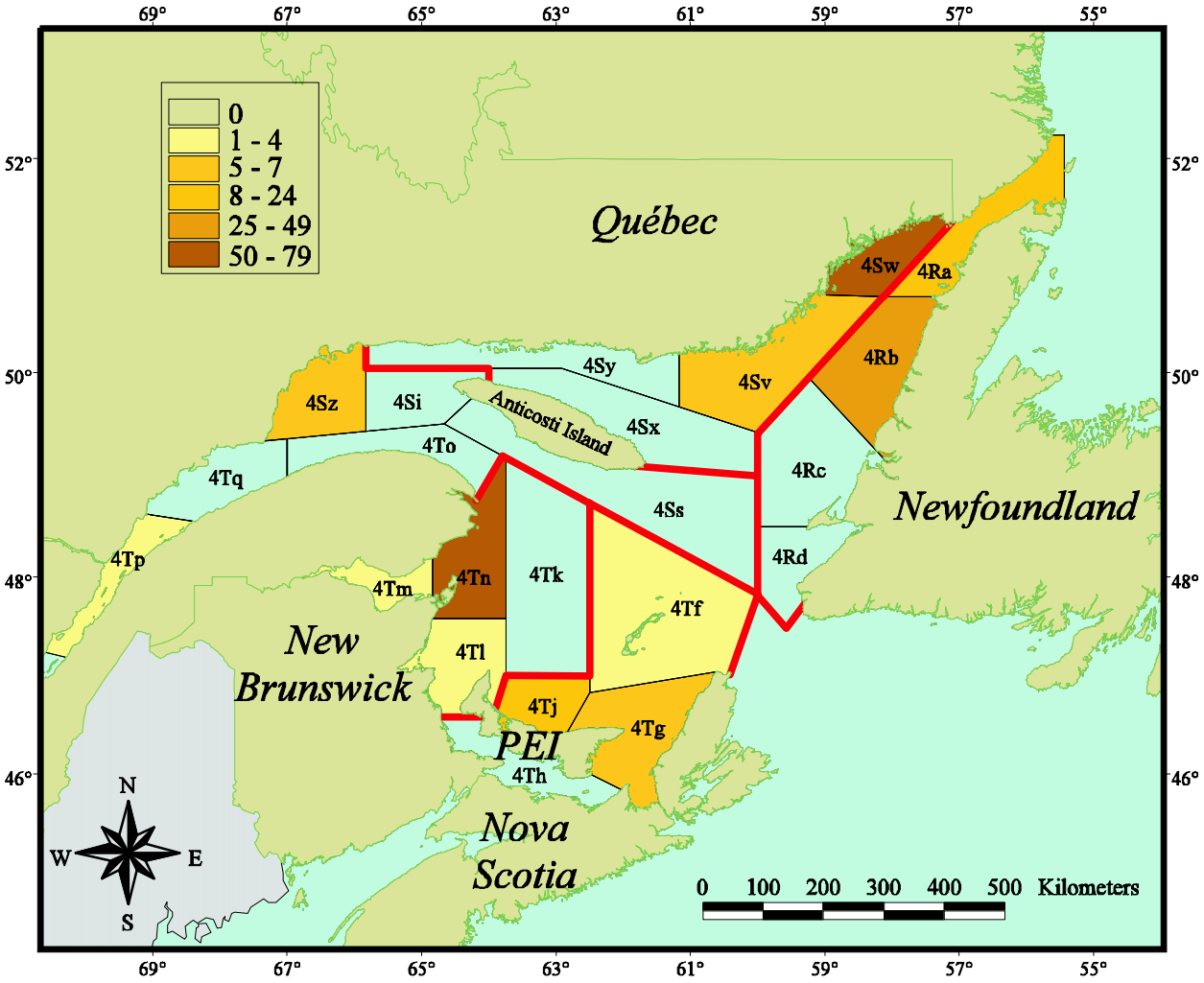

Figure 10. Distribution of the 178 harbour porpoises bycaught in the gillnet fishery in 2000 as indicated by questionnaires mailed to a sample of fishermen active during the 2000 fishing season. Ten harbour porpoises were caught in undetermined locations. The red lines delimit the five zones referred to in the document (see figures 1–4).

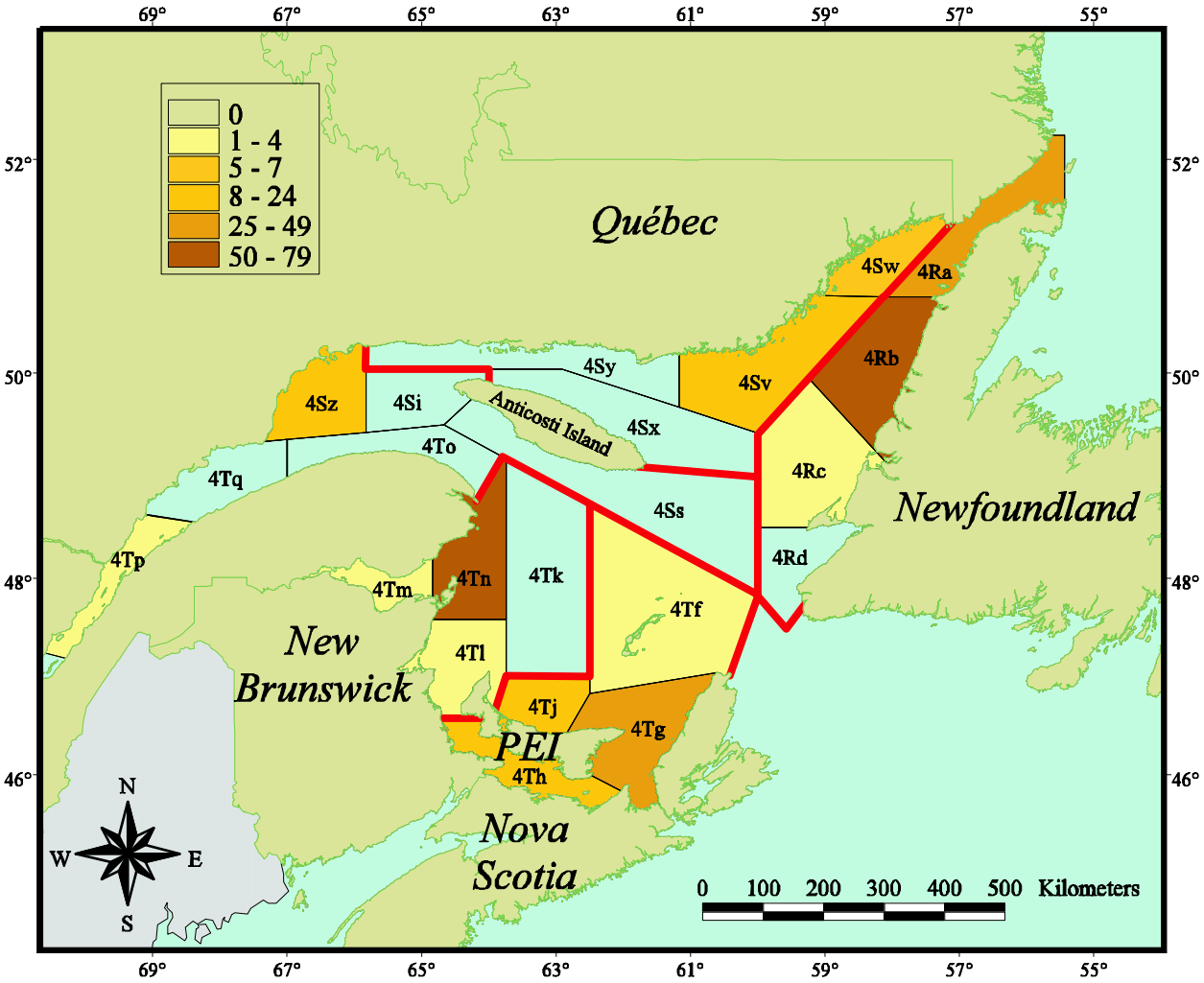

Figure 11. Distribution of the 281 harbour porpoises bycaught in the gillnet fishery in 2001 as indicated by questionnaires mailed to a sample of fishermen active during the 2001 fishing season. Fifteen harbour porpoises were caught in undetermined locations. The red lines delimit the five zones referred to in the document (see figures 1–4).

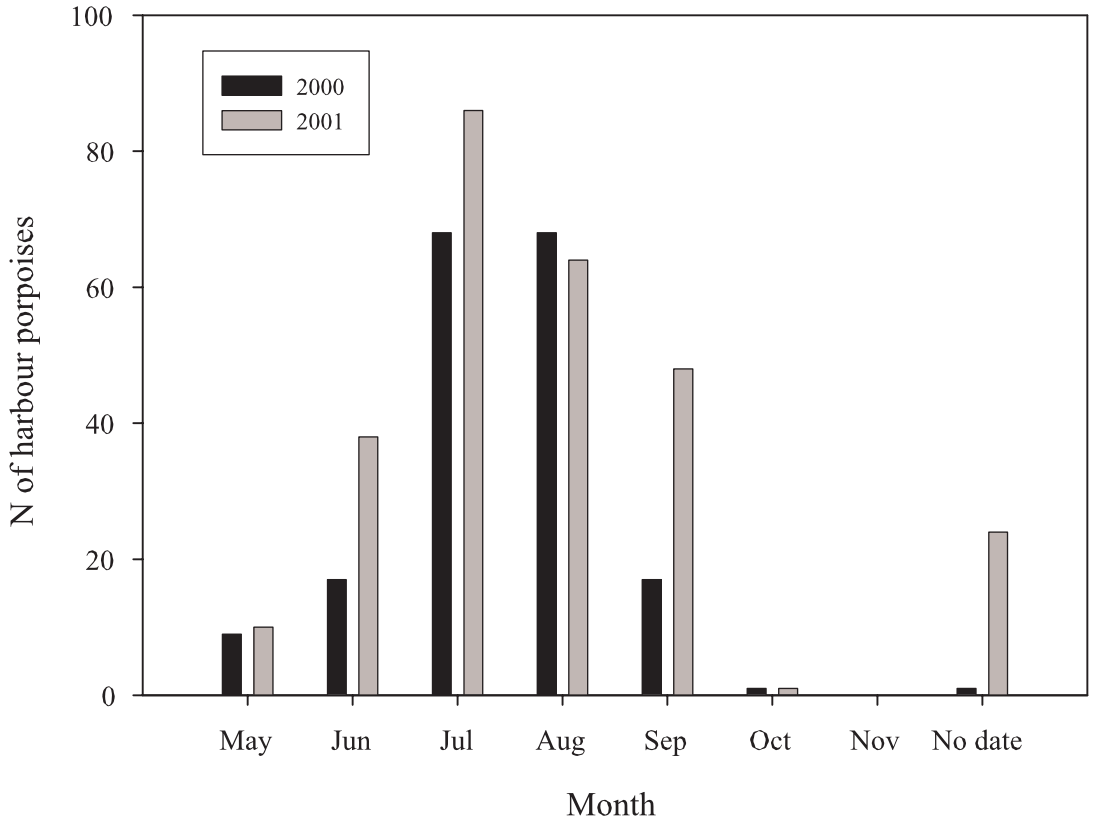

Figure 12. Monthly distribution of incidental mortalities of harbour porpoises in 2000 and 2001 as indicated by questionnaires to gillnet fishermen. "No date" represents bycatches with no known date.

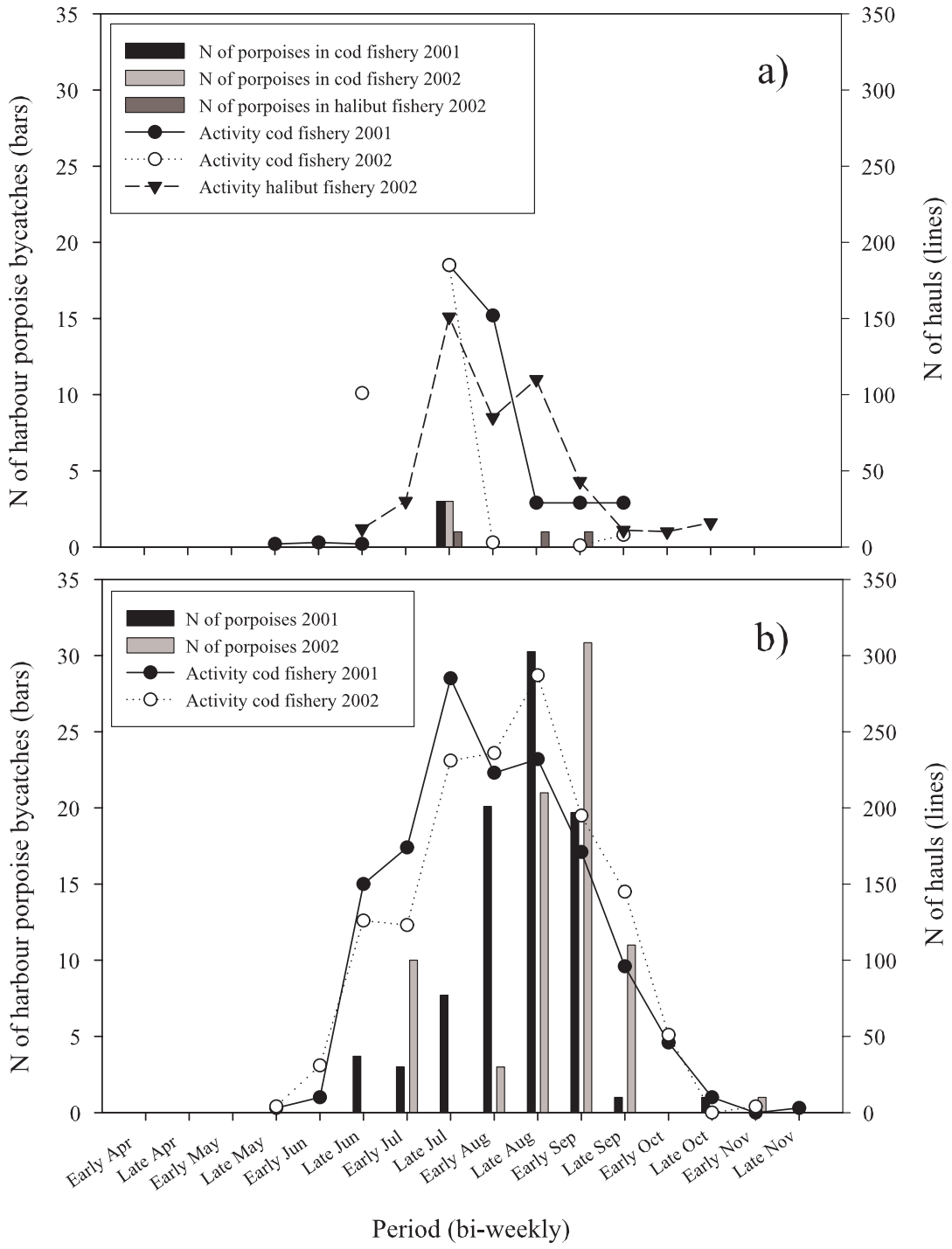

Figure 13. Monthly distribution of activities (lines) by a) at-sea observers and b) sentinel fisheries, and incidental mortalities reported by these two groups (bars) in 2000 and 2001.

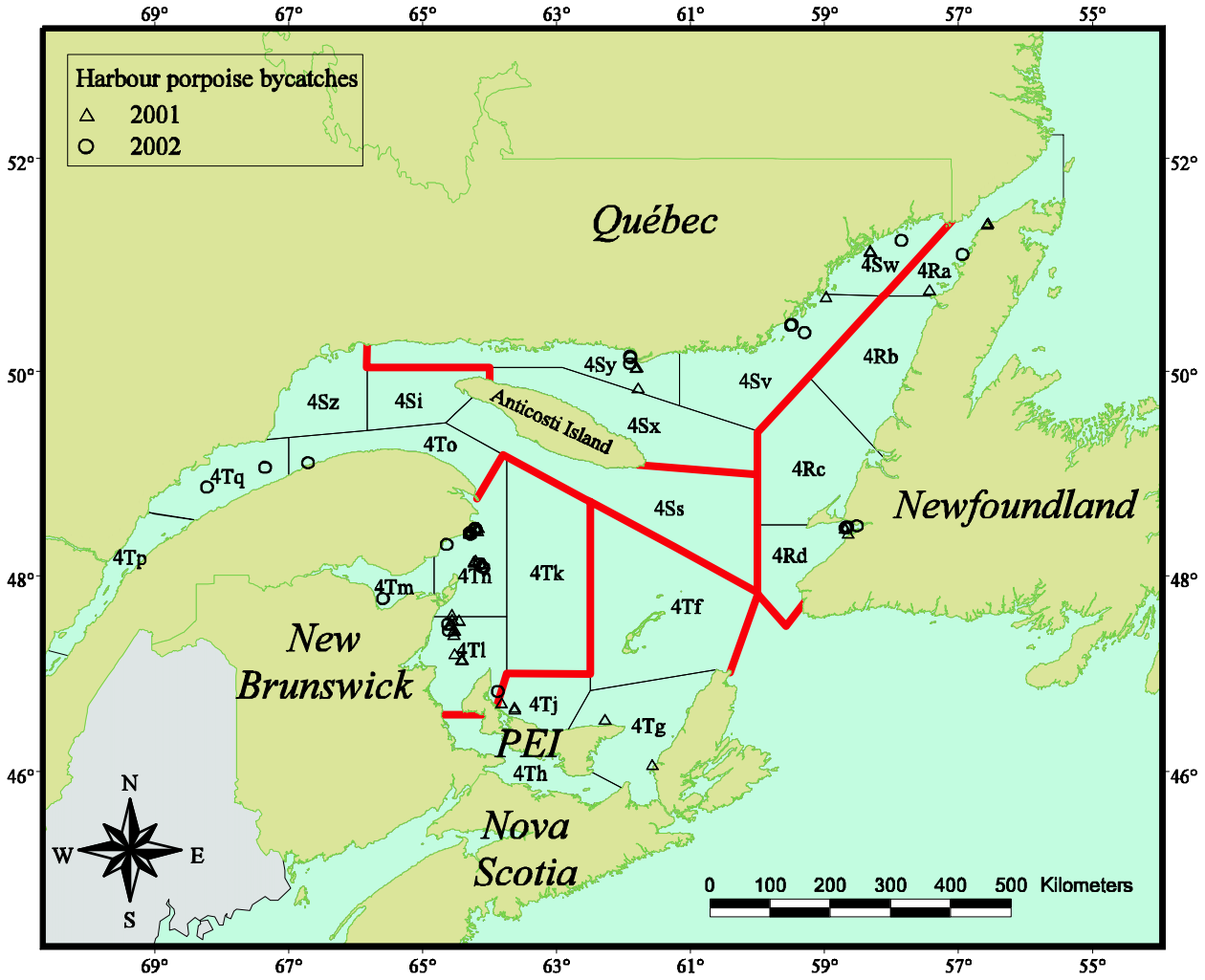

Figure 14. Spatial distribution of harbour porpoise bycatches reported by the At-Sea Observer and Sentinel Fishery programs in the different zones of the study area (red lines) in 2001 and 2002.

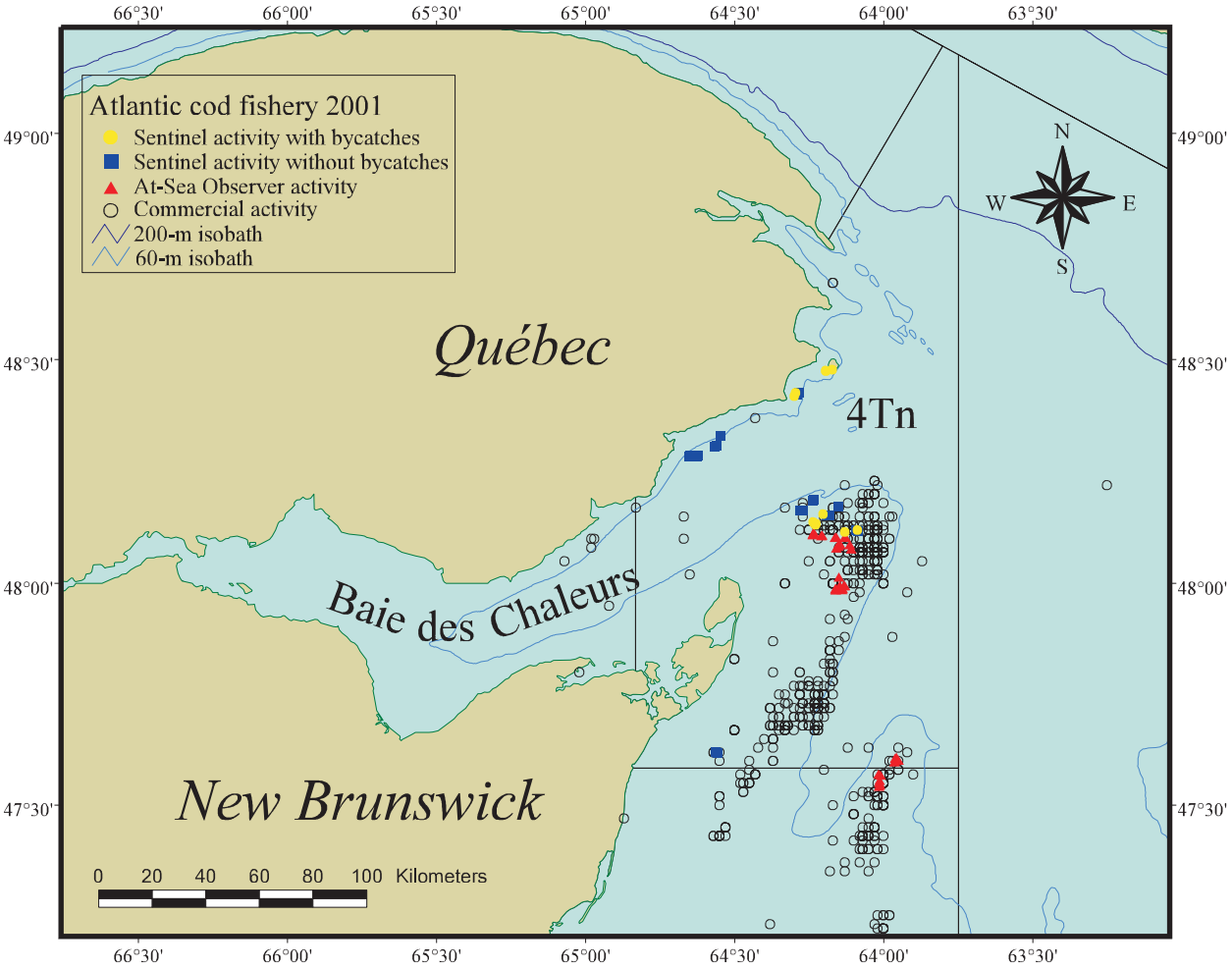

Figure 15. Spatial distribution of commercial cod fishery activities with and without at-sea observers on board and of sentinel fisheries that did or did not report bycatches of harbour porpoises. Fishing activities illustrated on this figure all took place in August and early September 2001 in NAFO Area 4Tn.

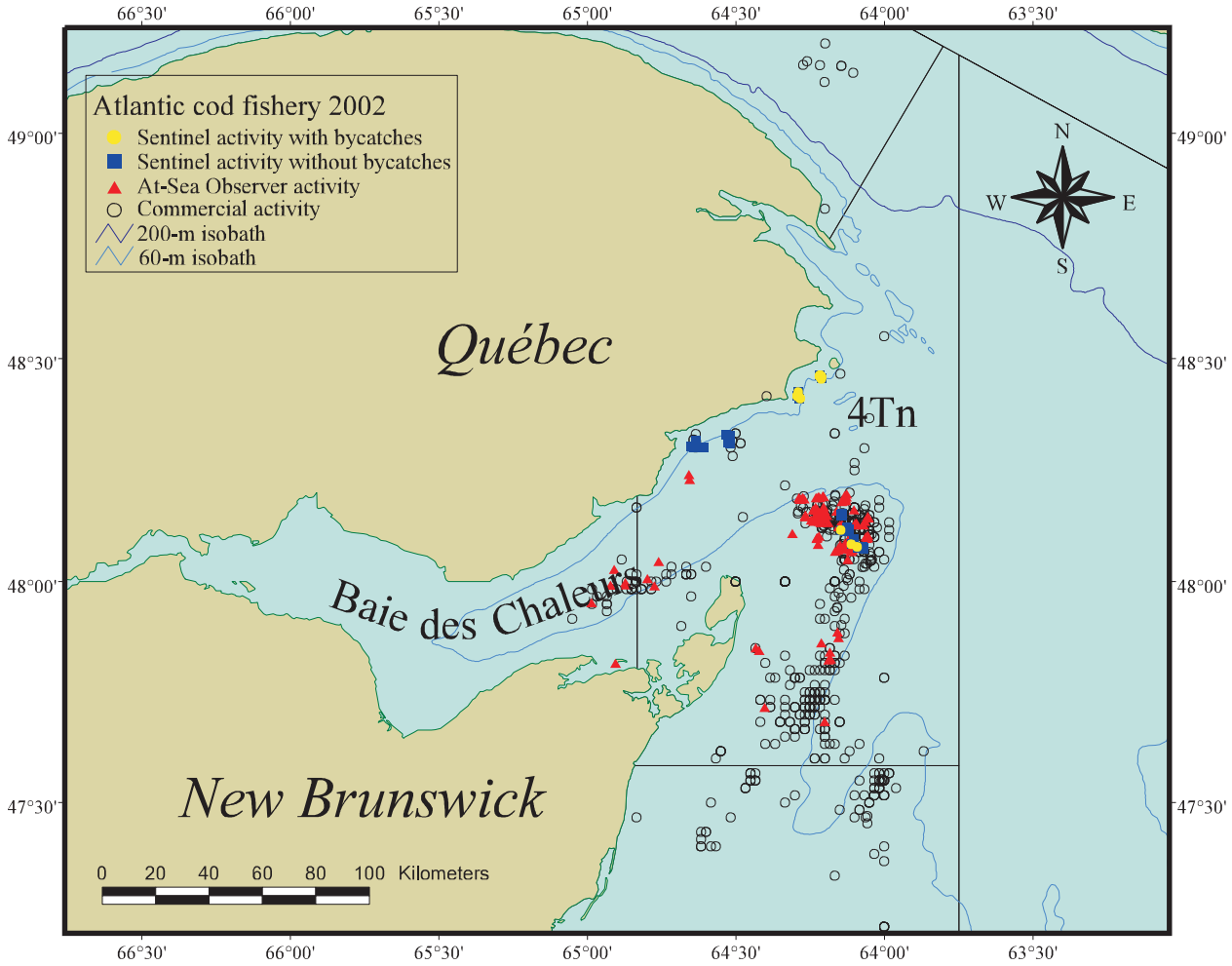

Figure 16. Spatial distribution of commercial cod fishery activities with and without at-sea observers on board and of sentinel fisheries that did or did not report bycatches of harbour porpoises. At-Sea Observer activities presented in this figure occurred between late July and early August and did not overlap temporally with activities by Sentinel Fisheries, which occurred in late August and September in 2002.