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Observations on interactions between seals and salmon in Newfoundland and Labrador Rivers

Observations sur les interactions entre les phoques et les saumons dans les cours d'eau de Terre-Neuve et du Labrador

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ABSTRACT

There are six species of seals present in Newfoundland and Labrador waters including harp, hooded, harbour, grey, ringed and bearded seals. All have been reported to opportunistically feed on salmon; however, only two incidences of salmon have been documented in the stomachs of harp seals and nothing for any other species (n=7,500 stomachs). Presently there is growing concern from resource users and the general public that seals may be a factor in the declining returns of salmon in many Newfoundland and Labrador rivers. To address this issue a questionnaire dealing with a wide range of seal/salmon concerns related to the commercial fishery in Labrador was conducted in 1997 (n=88 participants). In addition, a River Observation Program was conducted from 1999 - 2002 to identify which rivers have seal/salmon interactions and to document the frequency of occurrence and nature of the interactions. The occurrence of schooling bait fish (i.e. capelin, smelt or juvenile herring) in a river estuary during the smolt or adult salmon run appears to be an important factor in determining when and where seal/salmon interactions will occur (particularly in the case of harp seals). Whether the seal predator is a migratory or a more resident species also appears to influence the nature and frequency of occurrence of a predation incident. There is also evidence that recent warm winter temperatures have altered coastal ice coverage enough to allow seals access to river and estuarine habitats that were traditionally protected by ice during the early winter and spring. These findings provide direction for future research and emphasize the importance of having a good understanding of the ecological factors influencing the distribution, seasonal migration patterns and feeding behavior of the seal predator in question and its preferred prey.

RÉSUMÉ

Six espèces de phoque sont présentes dans les eaux de Terre-Neuve et du Labrador, à savoir le phoque du Groenland, le phoque à capuchon, le phoque commun, le phoque gris, le phoque annelé et le phoque barbu. Toutes ces espèces se nourrissent à l'occasion de saumon. Cependant, seulement deux cas documentés font état de la présence de saumon dans l'estomac de phoques du Groenland, alors qu'aucun cas n'a été documenté pour les autres espèces (n=7 500 estomacs). Les utilisateurs de la ressource et le public sont de plus en plus préoccupés par le fait que les phoques puissent être un des éléments responsables des déclins observés dans les remontes de saumon de nombreux cours d'eau de Terre-Neuve et du Labrador. En réponse à cette problématique, une enquête portant sur une gamme étendue d'inquiétudes au sujet des phoques/saumons relativement à la pêche commerciale au Labrador à été menée en 1997 (n=88 participants). De plus, un programme d'observation des cours d'eau a été mis en place de 1999 à 2002 afin de déterminer dans quels cours d'eau il y a des interactions entre les phoques et les saumons; ce programme, devait également permettre de documenter la fréquence et la nature de ces interactions. La présence de bancs de poissons-appâts (capelan, éperlan ou hareng juvénile) dans l'estuaire des cours d'eau au moment de la migration des saumoneaux ou des saumons adultes semble avoir un effet important sur le moment et le lieu où des interactions entre les phoques et les saumons se produisent (particulièrement dans le cas du phoque du Groenland). La nature et la fréquence des cas de prédation sur le saumon varient selon que le phoque prédateur appartient à une espèce migratrice ou à une espèce résidente. Il existe également des preuves à l'effet que les températures chaudes des derniers hivers ont modifié la couverture de glace en hiver et au début du printemps, ce qui fait que les phoques ont maintenant accès aux cours d'eau et aux estuaires. Ces observations ouvrent des pistes pour de nouvelles recherches et montrent combien il est important de bien connaître les facteurs écologiques qui influent sur la répartition, les habitudes de migration saisonnière et le comportement alimentaire des phoques prédateurs et de leurs proies préférées.

Introduction

Atlantic salmon, *Salmo salar,* in Newfoundland and Labrador has a long history of subsistence, commercial and recreational exploitation. Over the last several decades there has been increased concern over the declining abundance of many stocks (Parrish *et al.* 1998; Anon. 2002; Dempson *et al*. 2004). Numerous management initiatives have been put in place with the goal of increasing returns and escapements (Dempson *et al.* 1998, 2004). Some of these initiatives have resulted in closure of the commercial fishery in Newfoundland (1992) and in Labrador (1997), stricter angling regulations, river conservation closures and hook and release programs. Despite these measures many stocks have continued to decrease in Newfoundland and Labrador waters (Anon. 2002; Dempson *et al*. 2004) as well as in eastern North America (Parish *et al.* 1998; Cairns 2001; Hutchinson *et al.* 2002). The factors responsible for these declines are not known but several have been suggested including: the effects of aquaculture; habitat destruction and pollution; predation; unreported fishing and a changing ocean environment (Dempson *et al.* 1998; Cairns 2001; Hutchinson *et al*. 2002). The importance of seal predation on salmon in estuarine habitats has received considerable public as well as research attention. However, because of the logistic difficulty and the substantial resources needed to address the issue, it is not surprising that there are serious data gaps hampering our understanding of the potential problem (Harwood 1984; Cairns 2000; Cairns and Reddin 2000; Middlemas *et al.* 2003).

There are six species of seals present in Newfoundland and Labrador waters including harp, *Pagophilus groenlandicus*, hooded, *Cystophora cristata,* harbour, *Phoca vitulina,* grey, *Halichoerus grypus*, ringed, *Phoca hispida*, and bearded seals, *Erignathus barbatus*. With the exception of harp and hooded seals, relatively little is known about the habitat use and food habits of these species along the coast of Newfoundland and Labrador (e.g. Lawson *et al.* 1995; Anon. 2000a; Hammill and Stenson 2000). Currently there is little information to evaluate the importance of seal predation on salmon in either coastal areas or offshore (Hammill and Stenson 2000). The Marine Mammal Section of the Department of Fisheries and Oceans (DFO) has examined more than 7,500 food containing seal stomachs. There has been only two salmon found in the stomach of a harp seal and nothing for any other species. Despite this lack of quantitative evidence, anecdotal reports indicate that all seal species (with the possible exception of bearded seals) will opportunistically take salmon in Newfoundland and Labrador waters.

It is important to note that there are several shortcomings in the existing data set relative to seal/salmon issues. The biological sampling program was designed to collect harp and hooded seal stomachs for estimating diets in marine areas. Although nearshore waters were sampled, few seals were taken from river estuaries and none were likely taken from rivers. In general, species other than harp and hooded seals are under represented in the data base. In addition,

the most appropriate time to sample harp and hooded seals is during the late fall and winter and therefore the data base has relatively few spring, summer and early fall samples when evidence of salmon in the diet would be expected.

Given the growing concern that seal predation may be a factor in the declining returns of salmon in Newfoundland and Labrador, the following two programs were initiated. In 1997, commercial salmon fishermen in Labrador were asked to fill out a questionnaire addressing a range of industry issues including seal/salmon interactions, and from 1999 -2002, a River Observation Program was conducted on several salmon assessment rivers in Newfoundland and Labrador. The general objective of the questionnaire was to document the importance fishermen placed on predator/salmon fisheries interactions relative to other challenges they faced in the industry. The objectives of the Observation Program were to identify which rivers had seal/salmon interactions, document the frequency of occurrence and nature of the interactions, and to consider potential mitigation actions where problems may exist. The results of both programs are presented and discussed from the perspective of future research recommendations.

Methods

The River Observation Program was conducted from 1999 - 2002 and principally involved Department of Fisheries and Oceans (DFO) technical and scientific staff working at fish counting facilities throughout the Province of Newfoundland and Labrador (Fig. 1). Participants recorded the date, location, time and activities of all piscivarious mammals and birds observed in the vicinity of the counting facility. The identity and general hunting behavior of potential predators in the area was noted and if feeding was observed the species and size of prey was documented whenever possible. Participants were asked to document their sighting effort by indicating the amount of time they spent observing a section of the river. In some cases it was possible for observations to be made for periods > 1 h, in other situations observations were of shorter duration often made on route to the counting facility either on foot or by boat. Whenever possible, participants were requested to develop consistent sighting protocols for the facility based on daily viewing opportunities. They were also asked to indicate clearly whether sightings were made of one individual for an extended period of time, or of many individuals with no possibility of double counting, or in a situation where it was not possible to keep track of individuals. The opportunistic observation protocols at the various river sites limited the comprehensiveness and type of data collected as well as curtailed detailed statistical analyses. However, given the exploratory nature of the project and the general research objectives, it was possible to take these limitations into consideration when data were interpreted and discussed. This manuscript focuses primarily on seal observations. The term ‘seal/salmon fisheries interaction’ is used generally to include foraging behavior as well as observations

of direct and indirect predation (e.g. damage to fishing gear and loss or damage of catch).

In addition to the logbook information collected for a few rivers (n=7), there has also been an effort to interview DFO personnel (n=10) who have spent significant amounts of time on salmon rivers. The objective was to collect and synthesize their existing knowledge of salmonid predation. Questions focused on whether there was a potential predation problem on the river based on their observation and experience. If there was, personnel were then asked to comment on the following: 1) what predators were involved; 2) the frequency of occurrence and seasonal timing of the interaction: and, 3) the nature and details of the interaction (e.g. direct predation/foraging behavior, gear damage or catch/angling loss). When possible, substantive reports of seal/salmon fisheries interactions from the public, conservation groups and anglers were investigated with follow-up phone calls to confirm the details of the sighting.

Commercial salmon fishermen along the Labrador coast were requested by Fisheries Management Branch, DFO Newfoundland and Labrador Region to voluntarily fill out a general questionnaire in 1997. It dealt with a range of salmon fishery issues including when and where seal related problems occurred, the nature of the problems (e.g. predation or gear damage), and which predator species were involved. All commercial license holders were asked to participate (n=137) and a total of 88 individuals returned at least a partially completed questionnaire. Questions pertaining to the ecological aspects of predator/salmon fisheries interactions were developed by DFO salmonid research personnel. It was hoped that some of the participants in the project would agree to keep an observation logbook on a longer-term basis. However, the commercial fishery was closed at the end of the 1997 season and there was no project follow – up; regardless of this, much of the information collected is still relevant to current seal/salmon interaction issues.

Results

Comments on Specific Rivers Based on Logbook Data and Interviews:

Logbook information was collected from 7 rivers including: Campbellton River 2001; Northeast Brook 1999-2002; Rocky River 2000-2001; Northeast River 1999; Bishops Falls Fishway 2000-2001; Paradise River 1999 and 2001; and English River 1999-2002. The longest series of data with consistent sighting effort are from Northeast Brook and English River (Fig. 1; Table 1).

Observations of Northeast Brook were made from a bridge crossing the river on route to the counting fence and provided information on predators frequenting the mouth of the river. The observation period covered the smolt and adult salmon run from 28 April – 17 September during the years 1999 - 2002.

The peak of the smolt run is usually mid May while peak adult and kelt returns occur during August. At Northeast Brook the majority of seals sighted were harbour seals; 87.5% (1999), 80.0% (2000) and 77.4% (2001) of seals were observed feeding actively in the mouth of the river during late August and early September. In 2002 there were no seals observed. In two of the four years seal foraging activity over lapped with a run of juvenile herring, *Clupea harengus*, and the presence of mackerel, *Scomber scombrus*, in the estuary. There were also two harbour porpoise, *Phocoena phocoena*, seen actively feeding in the mouth of the river on 2 September 2001 when herring were present.

Observations in the vicinity of the English River, Labrador were made during a 20-minute boat ride to and from the community of Postville to the fence site and provided information on predators frequenting the river estuary. The observation period from mid June to mid September during the years 1999 - 2002 covered the adult salmon run which usually peaked from mid July to mid August. Both ringed and harp seals were observed but most sightings (67.0 – 88.0%) were of harp seals (Table 2). In the English River Estuary 77.0%, 73.0% and 88.8% of the seal sightings were made prior to mid July in 1999, 2000 and 2001 respectively. In 2002, 85.0% of the seal sightings occurred between 7 August and 4 September. The high observation rate of harp seals in 2001 was concurrent with the presence of capelin, *Mallotus villosus*, in the estuary.

Based on limited logbook data only 2 seals were seen in the Campbellton River estuary in 2001. Sightings were made on 8.7% of the observation days and the effort was 0.18 seals/hr. This differed from the previous year when a ‘pulse’ of harp seals entered the estuary when capelin were present and were observed to forage in the estuary. Several seals were shot and at least one had consumed two adult salmon (D. Reddin, Salmonids, DFO pers. comm.). Unfortunately details of this incident and sighting effort are limited because there was no logbook being kept at the time.

There were no seal sightings reported in the logbooks for the Bishops Falls Fishway, a counting facility on a tributary of the Gander River, during the spring, summer or early fall. However, since 1995 seals have been reported to frequent areas along the Gander River approximately 5 km down-river from the Fishway during December and January (W. Penney, Marine Mammals, DFO pers. comm.). Animals have been observed hauling out near a causeway at the mouth of the river as well as swimming up-river for several kilometers. Discussions with DFO personnel, residents and anglers indicated that access to the mouth of the river is dependent on ice conditions in Gander Bay. These reports noted that in cold years the entire Bay freezes and harp seals use only the distant ice-edge when present in the area. In warmer years, the Bay is almost ice free, or it breaks-up more frequently in storms allowing harp seals access to the river. Long-term residents and anglers in the area are of the opinion that winter ice conditions have become lighter and more variable during the last 10 – 15 years.

Logbook observations indicated no seal sightings at either Northeast River or Rocky River during the study period. However, seals were observed at the mouth of the Colinet River which is approximately 1Km to the east of the Rocky River during a late winter warm spell in 2000. Several harp seals gained access to a small area of open water at the mouth of the river where sea run brown trout, *Salmo trutta,* overwinter. Chasing behavior and feeding activity were observed by local residents who reported that during cold winters, seals were usually restricted to the ice-edge farther out in the Bay.

The Paradise River in central Labrador has a resident population of harbour seals with a known pupping area located in the upper reaches of the river. The size of the population is unknown, but local fishermen estimate that there may be as many as 100 animals (D. Redding pers. comm.). In addition to harbour seals, ringed, harp, and grey are commonly seen and bearded seals frequent the area occasionally. Personnel working at fish counting facilities along the river see harbour seals daily at known haul-out sites and at predictable foraging sites. However, due to the relatively high number of observers travelling and working on the river throughout the day for variable lengths of time, calculating sighting effort is difficult and not consistent with data from the other monitored rivers. These data are interesting but require a different analysis approach and modified observation protocols for future studies.

Information on the occurrence of seal/salmon fisheries interactions based on interviews with DFO personnel who have long-term experience at fish counting facilities throughout the Province are presented in Table 2. All rivers where a salmon assessment is conducted are included; this provides a broader geographic perspective on the issue than the Logbook Program. Seal/salmon fisheries interactions were observed more frequently in rivers along the NE Coast of Newfoundland and parts of the Avalon Peninsula more often than the West Coast (harp seals in the former and harbour seals in the later area). In addition to the rivers with DFO supported fish counting facilities, the interview data suggested that there are several other rivers with potential seal/salmon interaction problems requiring attention in the future (eg. the Little Salmonier and Flat Bay River in Newfoundland and the Pinnware River in Labrador).

Comments on the 1997 Commercial Salmon Questionnaire

When Labrador commercial fishermen were asked to identify the most significant challenge they faced during the season (n=88), 46.7% reported that seal/salmon interactions were the major problem (i.e. usually a combination of gear damage, direct predation, and catch loss). Other major concerns included the occurrence of dirty water (23.8%), the presence of ice (13.6%), the presence of sea gulls (7.9%), regulatory issues (4.5%) and the weather in general (3.5%). When fishermen were asked specifically if predation by seals or other species was a problem (n=88), 95.0% indicated that it was and, of those respondents, 93.0% identified seals as the top predator while 7.0% indicated gulls were a more

serious problem. Of those fishermen identifying seals as the top predators (n=78), 50.6% indicated that gulls were the next most serious problem, 35.4% indicated that there were no other serious predators other than seals, and 7.6% reported otters. The remaining 6.4% of fishermen noted whales, sea birds other than gulls, mink and polar bears as other predators in their area.

When fishermen (n=83) were asked to list which species of seals caused problems in their area 61.4% listed both grey and harp seals, 49.4% identified harbour seals, and 32.5% identified ringed seals. Hooded seals (9.6%) and bearded (3.6%) seals were less of a concern. Unfortunately, this question did not ask fishermen to identify the *most* problematic species in their area; therefore, respondents listed more than one species. However, geographic differences could still be detected in the fisherman's responses (Table 3). Those setting nets along more exposed coastlines (Black Tickle, Charlottetown and Mary's Harbour) tended to have problems with highly migratory seal species such as harp seals while nets set in protected bays (Makkovik, Rigolet and Cartwright) were frequented by more sedentary species like harbour and grey seals.

A total of 90.0% of fishermen felt that the number of seals had increased in their area over the last five years while 10% were of the opinion that seal numbers had remained stable, and no one thought numbers had decreased (n=88). The fishermen indicating that seal numbers were stable in their area were those who did not experience seal related fish loss or net damage. When fisherman (n=75) were asked whether or not seals had changed their general behavior in the last five years the most common observations could be summarized as follows: 1) seals were bolder and/or smarter in terms of approaching nets and evading hunters (29.3%), 2) seals were present in an area for longer periods of time (20.0%), 3) increased numbers have been seen upriver and inland (16.0%), 4) they have become more habituated to human disturbance (13.3%); 5) they appeared to be hungrier and in some cases appeared to be in poor condition (10.7%), and 6) seals seemed to be more attracted to nets (10.7%).

Discussion

The River Observation Program has been a useful research approach to assess the potential for seal/salmon fisheries interactions in Newfoundland and Labrador Rivers. Information from interviews and logbooks has identified rivers with higher levels of reported seal/salmon interactions, helped determine which seal species are involved, provided an indication of the seasonal and yearly variability associated with the occurrence of these interactions, as well as provided some evidence to support or disclaim concerns of significant seal predation in specific rivers. Although these data are descriptive and it is not possible to address the possible impact of seal predation on various salmonid

stocks with the information collected, recommendations for future research as well as comments on mitigative measures can be made.

The migratory behavior and general habitat preferences of each seal species can partially explain the geographic variation in the occurrence of seal/salmon interactions and the involvement of different seal species. Exposed rivers and estuaries along coastal Labrador and the Northeast coast of Newfoundland adjacent to traditional harp seal migration routes (Sergeant 1991; Stenson and Kavanagh 1993; Stenson and Sjare 1997; Lacoste and Stenson 2000) tended to have higher incidents of interactions involving this species. Sheltered bays and large estuaries more removed from these core migration areas tended to have a higher number of observations involving harbour seals and grey seals (and along the coast of Labrador, ringed and possibly bearded seals; Mansfield and Beck 1977; Boulva and McLaren 1979). From an ecological perspective this is not surprising. However, it is important because many people in Newfoundland and Labrador do not distinguish between seal species and they consider any seal in coastal waters a 'problem seal'. In recent years, this view has hampered our understanding of the scope and the nature of potential predation problems as well as stalled meaningful discussions on possible mitigation plans. The potential fisheries interaction problems associated with a highly migratory species like the harp seal are different from those created by a resident species such as the harbour seal. Therefore, any mitigative plan of action to address seal/salmon interactions must be evaluated from this perspective if it is to be cost effect and efficient (e.g. Middlemas *et al.* 2003). In this regard, data collected during the River Observation Program and from the questionnaire completed by commercial salmon fishers, will be useful as a future educational and management tool.

The seasonal (pulses) and yearly variation in the occurrence of seal/salmon interactions exhibited by several of the monitored rivers appeared to have been influenced by the movement of pelagic bait fish into the estuaries. Energy rich capelin, herring, and to a lesser degree, Arctic cod, *Boreogadus saida,* are key components of the harp seal diet and are also consumed by other seals as well (Lawson *et. al.* 1995; Lawson *et al.* 1998; Hammill and Stenson 2000). Information from the logbooks and interviews suggests that if the presence of pelagic bait fish in a river or estuary overlaps with the run time for smolt or adult salmon, then seal/salmon interactions are more likely to occur. Therefore, any changes in the timing of pelagic fish movements may shift or change seal predation pressure on salmon. Chaput (1995) has noted that in the Miramichi River runs of schooling, non-salmonid fishes such as smelts attracted predators into the area.

To evaluate the importance of this relationship, both historic and current information on the timing of pelagic fish movements and the presence of seal predators on a relatively fine geographic scale are needed to determine if significant changes have occurred. Capelin spawning times for some major beaches are generally known, but for many others there is no information (Anon.

2000b; B. Nakashima Pelagic Fish, DFO pers. comm.). The situation is even more problematic for herring, and smelt, *Osmerus mordax*, given the paucity of published information for specific rivers and estuaries (J. Wheeler, Pelagic Fish, DFO pers. comm.). In the case of capelin, in the early 1990s the seasonal distribution and abundance became increasingly variable and spawning times were significantly delayed. In many areas, spawning was approximately 1.5 months late or did not occur at all (Anon. 2000b; Carscadden *et al*. 1997; Carscadden *et al*. 2001). A shift in spawning times of this magnitude, for example, could shift potential predation pressure from the end of a smolt run to the adult salmon run given if seals were present at the time (the latter is an important point discussed below). The biological consequences of this from a salmon survival perspective could be significant. This delayed spawning phenomenon in capelin is thought to be a response to colder than normal water temperatures from 1989 – 1996 (Drinkwater 1996, 1997; Carscadden *et al*. 2001). Although temperatures returned to the 20-year norm by approximately 1997, many aspects of capelin reproductive biology have not (Anon. 2000b; Carscadden *et al.* 2001; Parsons and Lear 2001). Much less is known about how other pelagic fish species responded to ecosystem changes during the 1990s (Lilley and Carscadden 2002).

Comments from participants in the Observation Program as well as reports from anglers, hunters and the general public to the Department's Marine Mammal Section suggest that seal/salmon interactions may have increased in some river systems during the 1990s compared to the 1980s (W. Penney pers. comm.). However, evaluating whether these interactions might have occurred because of increasing seal abundance or more from changes in seal distribution and/or foraging behavior is difficult due to a paucity of data. With the exception of harp seals, relatively little is known about the detailed seasonal distribution, foraging behavior and abundance of any seal species in Newfoundland and Labrador nearshore waters.

In the case of harbour seals, little is known about the current distribution or abundance of this species. Although seal numbers may have increased since the 1970s (Boulva and McLaren 1979; Hammill and Stenson 2000), densities are very low compared to other seal species in Newfoundland and Labrador. Historical references indicate that harbour seals have always been present in eastern North American rivers and estuaries and they were known to prey on salmonids (Boulva and McLaren 1979; Baum 1997). Thus, there is very limited corroborating data to indicate that increased predation of salmon by harbour seals may have occurred in recent years. Grey Seals have historically frequented the region during the summer (Mansfield and Beck 1977), but there are no survey data on the distribution and abundance of the species in Newfoundland and Labrador waters. However, in recent years there have been reports to the Department from anglers indicating an increased number of grey seals in some rivers and coastal areas. Marine Mammal personnel have tried to verify some of these reports but have found no evidence of a significant increase in grey seal abundance or a significant change in seasonal distribution for most

areas. However, there is a need for more detailed observations from several rivers in southern Labrador and the south coast of Newfoundland. There are no abundance estimates or recent seasonal distribution data for either ringed or bearded seals in Newfoundland and Labrador to suggest increased interactions with salmonids.

In the case of harp seals, population abundance has changed significantly since the late 1980s and is currently at a high of 5.2 million animals (Anon. 2000a; Hammill and Stenson 2000; Healey and Stenson 2000; Stenson *et al.* 2003). In addition, the Department has received reports from fishermen and hunters since the early 1990s indicating that the distribution, habitat use and timing of migration have also changed (W. Penney pers. comm.). During this period seals have been observed frequenting nearshore habitats never used before in the late spring, summer and early fall. For some coastal areas during the mid 1990s there have been reports of harp seals remaining in the area all year round. This contrasts historical information that indicates most seals migrate north to Arctic waters to feed for the summer and early fall (Sergeant 1991). These data and observations do provide corroborating evidence to substantiate that harp seal/salmon interactions may have increased in some rivers during recent years. Observations and comments made by commercial salmon fishermen along the coast of Labrador as well as some of the participants in the Logbook Program are also consistent with this information. These reported changes in the distribution, habitat use and timing of migration of harp seals are likely a response to changing prey distribution and abundance, particularly capelin, Arctic cod, and herring during the 1990s (Anon. 2000a; Hammill and Stenson 2000; Lilley and Simpson 2000; Carscadden *et al.* 2001) and could have inadvertently affected salmon survival in some nearshore areas.

Given the seasonal presence of both landfast ice and pack ice in Newfoundland and Labrador waters, it is surprising that so little is known about the influence of ice on the ecology of many fish and marine mammal species in the region (Drinkwater 2000; Parsons and Lear 2001; G. Lilley, Groundfish DFO pers. comm). The potential link between decreased ice cover and increased seal access to salmonid over wintering habitat is interesting from this perspective as well as from the perspective of continuing ocean basin climate change and increasing variable regional ice conditions (e.g. Colbourne *et al*. 1994; Drinkwater 1996, 1997). It is likely that the occurrence of seal/salmon interactions resulting from changing coastal ice conditions will continue to be influenced by regional climatic trends in the future. Therefore, knowledge of the historic, current and anticipated ice chronology of key salmonid rivers and estuaries may be very useful for evaluating possible changes in seal predation pressure in the past as well as predicting future ‘trouble spots’.

There are two other noteworthy observations from this study that highlight future research initiatives. First, man-made structures such as bridges, causeways or large culverts may exacerbate the effects of declining or variable ice cover by creating year-round pockets of open water that delay freeze-up

and/or accelerate break-up times in the area. The causeway on the Gander River and a bridge near the mouth of Colinet River are partially responsible for maintaining open water areas that attract seals and make the area accessible to them. Secondly, salmonids are probably not the only fish species to benefit from a relatively protected, ice-covered winter habitat that inhibits seal movements. Aggregations of northern cod, *Gadus morhua*, as well as other groundfish and pelagic species, frequenting bays that are traditionally frozen for much of the winter may also experience increased predation pressure by seals. Given the mobility, migratory behavior and distribution of harp seals, this species is the most likely to move quickly into nearshore habitats that become available due to changing ice conditions.

In conclusion, the combination of information collected from the River Observation Program, interviews with DFO personnel and local knowledge from fishermen/anglers has provided a fresh look at seal/salmon interactions. Future research should evaluate whether a better understanding of changing inshore pelagic fish distribution and variable ice conditions could be useful for predicting the occurrence and perhaps seriousness of seal/salmon interactions in various river systems. It is also important to consider these findings and research recommendations from a climate change perspective. There is relatively little known about the vulnerability and adaptive capacity of any one species to climate variability let alone an understanding of how predator/prey relationships between two or more species may be influenced.

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Table 1. Seal Observations for Northeast Brook and English River. In both study areas the field seasons were approximately 70 – 90 days.

	Obs. Hours	Total Seals	Sighting Effort	% of Days with a sighting	Species (%)
Northeast Brook					
1999	~30.0	16	0.53/hr	17.5	harbour
2000	~30.0	21	0.70/hr	20.2	harbour
2001	~30.0	25	0.83/hr	21.2	harbour
2002	~30.0	none			
English River					
1999	83.0	43	0.52/hr	23.3	26 ringed; 67 harp
2000	70.8	26	0.37/hr	16.3	19 ringed; 69 harp
2001	78.0	89	1.14/hr	20.0	8 ringed; 88 harp
2002	46.0	20	0.43/hr	13.0	7 ringed; 13 harp

Table 2. Overview of seal/salmon fisheries interactions in Newfoundland and Labrador. Information based on informal Interviews with DFO personnel. Occasional = seals observed 5 – 10 times/year; Common = seals observed weekly for a significant portion of the year (e.g. during the smolt or adult salmon run). (a) adult run; (s) smolt run and (o) at other times of the year. Pg=harp seal; Pv=harbour seal; Ph=ringed seal; Hg=grey seal; Eb=bearded seal; Cc=hooded seal.

Location	Seal/Salmon Interactions			Perceived Importance of Predation	Comments
	Rare	***Occasional***	***Common***		
1. Exploits River		Pg;+(s,a,o)		Low	-importance of bait fish & ice in the estuary
2. Campbellton River		?	Pg; +(s)	Moderate	-more data needed; bait fish important
3. Gander River			Pg, Pv;+(a,o)	High	-bait fish & no ice in early winter important
4. Middle Brook				Low	
5. Northwest River				Low	
6. Northeast Brook			Pv; +(s)	Moderate	-bait fish important
7. Rocky River	+			Low	
8. Northeast River	+			Low	
9. Conne River	+			Low	- lack of seals interesting given aquaculture
10. Highlands	+			Very Low	
11. Crabbes River	+			Very Low	
12. M. Barachois River	+			Very Low	
13. Robinson's River	+			Very Low	
14. Fischells River	+			Very Low	
15. Flat Bay Brook	+			Very Low	
16. Harry's River	+			Low	-harbour seals in the area
17. Lomand River	+			Very Low	
18. Deer Arm Brook	+			Very Low	
19. Torrent River	+			Very Low	
20. Western Arm Brook	+			Very Low	
21. Paradise River			All; +(s,a,o)	High	-all seal species except hooded seals
22. English		Pg, Ph; +(s)		Moderate	-importance of migration timing & bait fish

Table 3. The species composition of seals considered problematic by commercial salmon fisherman along the coast of Labrador (n=83). B. Tickle = Black Tickle; Chartown = Charlottetown; Mary's H. = Mary's Harbour. Nets set in the Makkovik, Rigolet and Cartwright areas tended to be in more protected inland waters.

Species	**Makkovik % (n=10)**	**Rigolet % (n=9)**	**Cartwright % (n=18)**	**B. Tickle % (n=7)**	**Chartown % (n=17)**	**Mary's H. % (n=22)**
Harp	**30.0***	**44.4**	**33.3**	**71.4**	**64.7**	**100.0**
Hooded	10.0	11.1	11.1	0	11.8	9.1
(highly migratory)						
Grey	**55.6**	**88.9**	**88.9**	**14.3**	**52.9**	**54.5**
Ringed	30.0	0	50.0	28.6	35.3	31.8
Bearded	100.0	0	5.6	0	0	4.5
(seasonally sedentary)						
Harbour	**50.0**	**100.0**	**72.2**	**28.6**	**35.3**	**27.3**
(resident)						

* Indicates that 3/10 respondents from Makkovik considered harp seals problematic to their fishing operation.

Figure 1. Maps of the study area showing locations of salmon rivers where counting facilities exist. Number labels correspond with Table 1.