



Fisheries and Oceans  
Canada

Pêches et Océans  
Canada

Ecosystems and  
Oceans Science

Sciences des écosystèmes  
et des océans

## **Canadian Science Advisory Secretariat (CSAS)**

---

**Research Document 2017/043**

**Quebec Region**

### **Pup production of Northwest Atlantic grey seals in the Gulf of St. Lawrence**

M.O. Hammill<sup>1</sup>, J-F Gosselin<sup>1</sup> and G.B. Stenson<sup>2</sup>

<sup>1</sup>Maurice Lamontagne Institute  
Fisheries and Oceans Canada  
850 route de la mer, P.O. Box 1000  
Mont Joli, QC G5H 3Z4

<sup>2</sup>North Atlantic Fisheries Centre  
Fisheries and Oceans Canada  
80 East White Hills Road  
St. John's, Newfoundland and Labrador  
A1C 5X1

---

## Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

### Published by:

Fisheries and Oceans Canada  
Canadian Science Advisory Secretariat  
200 Kent Street  
Ottawa ON K1A 0E6

[http://www.dfo-mpo.gc.ca/csas-sccs/  
csas-sccs@dfo-mpo.gc.ca](http://www.dfo-mpo.gc.ca/csas-sccs/csas-sccs@dfo-mpo.gc.ca)



© Her Majesty the Queen in Right of Canada, 2017  
ISSN 1919-5044

### Correct citation for this publication:

Hammill, M.O., Gosselin, J-F., and Stenson, G.B. 2017. Pup production of Northwest Atlantic grey seals in the Gulf of St. Lawrence. DFO Can. Sci. Advis. Sec. Res. Doc. 2017/043. iv + 14 p.

---

---

## **ABSTRACT**

Pup production in the Gulf of St. Lawrence was estimated in 2016 using multiple methods including visual and photographic estimates. Reconnaissance flights were also carried out to determine if any pupping occurred along the south and southwest coasts of Newfoundland and Anticosti Island. A small number of pups were found on Anticosti while no pupping occurred along the Newfoundland coast. In 2016 there was very little ice. Over 95% of the pups were born on land. Where possible, counts were corrected for the proportion of pupping completed when the survey was completed. Total pup production is estimated to be 10,500 (SE=800 rounded to the nearest 100) animals.

---

## **La production de jeunes phoques gris de l'Atlantique Nord-Ouest dans le golfe du Saint Laurent**

### **RÉSUMÉ**

La production de jeunes phoques dans le golfe du Saint-Laurent a été estimée en 2016 en utilisant de nombreuses méthodes, y compris des estimations visuelles et photographiques. Des vols de reconnaissance ont également été effectués pour déterminer si des événements de mise bas se sont produits le long des côtes sud et sud-ouest de Terre-Neuve et de l'île d'Anticosti. Un petit nombre de jeunes phoques ont été trouvés sur Anticosti alors qu'aucune mises bas n'a eu lieu le long des côtes de Terre-Neuve. En 2016, il y avait très peu de glace. Plus de 95 % des phoques sont nés sur terre. Dans la mesure du possible, les chiffres ont été corrigés pour la proportion de mises bas complétée lorsque le relevé a été terminé. La production totale de jeunes phoques est estimée à 10 500 (SE = 800 arrondi à la centaine la plus proche).

---

## INTRODUCTION

The grey seal (*Halichoerus grypus*) is distributed throughout the North Atlantic extending from the northeastern United States to Labrador in the west, and from the United Kingdom to the Murmansk region in Russia and south throughout the Baltic Sea and along the coast of France in the east. Recently there have been reports of sightings in Greenland (Härkönen et al. 2007; Rosing-Asvid et al. 2010). Grey seals were abundant throughout their range historically, but underwent significant declines in some areas as early as the 2<sup>nd</sup> Century. Since the middle of the 20<sup>th</sup> Century, most populations have shown signs of recovery (Härkönen et al. 2007; Lavigueur and Hammill 1993; Hammill et al. 2007; Thomas et al. 2007).

The northwest Atlantic grey seal is considered to form a single population (Boskovic et al. 1996), but within Canadian waters, grey seals are subdivided into three components for management considerations: Sable Island, Gulf of St. Lawrence (Gulf), and Coast of Nova Scotia (Fig. 1). The three regions have had very different population trajectories. Sable Island, Nova Scotia, is a sand island located approximately 300 km east of Halifax (44.8 N, 60.8 W) and is home to the largest breeding colony of grey seals in the world (Bowen et al. 2007). Using pup production as an index of population size and trends, pup production on Sable Island has increased rapidly since the 1970's, from less than 2,000 animals in 1975 to over 25,000 pups in 1997 (Bowen et al. 2003) for an annual rate of increase of 12.8%. More recently, estimates of pup production, indicated that numbers had continued to increase (41,500 (SE=4,381) in 2004 and 54,482 (SE=1288) in 2007), but that the rate of increase had declined (Bowen et al. 2007; Thomas et al. 2007).

A relatively small number of animals breed on isolated islands along the Nova Scotia Eastern shore (Mansfield and Beck 1977). Significant culling efforts, particularly in the Basque Island area limited pup production in this area to the low 100's. The Basque Islands no longer exist due to the effects of erosion, but pupping continues on Bowen's Ledge and White Islands. A new colony was discovered on Hay Island in 1993 by J. Conway (Pers. comm. DFO, Halifax) (Fig. 1) and pup production has increased in this area from a few hundred to about 2,700 in 2007 (Hammill et al. 2007). Additional pupping occurs on Bowen's Ledge and White Island (N=113 in 2007) and in the last few years, small colonies have also appeared along the southwestern shore of Nova Scotia on Flat and Noddy Islands (N=204; Hammill et al. 2007). Combining the estimates from the southwestern shore colonies and the Eastern Shore, results in a total estimate of approximately 3,000 animals in 2007.

In the Gulf of St. Lawrence, grey seals have traditionally had their young on the pack-ice located between Prince Edward Island and Cape Breton, or on beaches and/or small islands in the Northumberland Strait, western Nova Scotia, and Deadman Island in the central Gulf. Recently, a small number of pups have been observed on Anticosti Island in the northern Gulf (Fig. 1). The trajectory of pup production in the Gulf has been much more variable than on Sable Island due to culling and scientific harvests (Stobo and Zwanenburg 1990; Hammill et al. 1998), and higher mortality rates associated with pupping on the pack-ice (Hammill et al. 2007; Thomas et al. 2007). Pup production estimates for the Gulf component was 5,436 (SE=672) in 1984 and rose to 10,700 (SE=1,300) by 1996. However, subsequent surveys indicated that pup production has varied from a low of 5,300 (SE=900) in 2000 to a high of 14,200 (SE=1,200) in 2004. In 2007, pup production was estimated to be 11,400 (SE=1100) (Hammill et al. 2007).

---

Here we provide new estimates of grey seal pup production in the Gulf and northern portion of the Eastern Shore based upon aerial surveys and island counts completed in January-February 2016.

## MATERIALS AND METHODS

### RECONNAISSANCE SURVEYS

Pupping grey seals were located during reconnaissance aerial surveys flown in the southern Gulf and along the Nova Scotia Eastern Shore during January and February 2016. Flights were made at an altitude of 152 m using a Bell 429 helicopter. Additional low-altitude flights were made during January in the southern Gulf by enforcement personnel using the DFO Conservation and Protection (C&P) Super King Air fixed wing aircraft. Additional flights with science personnel on board were flown along the south and west coast of Newfoundland and the coast of Anticosti Island.

### COUNTS

There was very little ice present in the southern Gulf of St. Lawrence during the winter of 2016. A small group of seals was observed on the ice in Northumberland Strait, but numbers were too few to carry out a strip transect survey. Instead the group was treated as a small group and an estimate of the total number of pups present was made.

In 2016, nearly all pups were born on islands. Several different techniques were used to obtain a total count. Where visual counts were recorded, animals were counted by two observers seated on the left side of the helicopter from the air at 60 m and moving along the beach about 30 m offshore. Counts were averaged between observers. If possible, oblique photographs were also taken. Additional counts were obtained from some islands using photographs taken using a large format camera and an Unmanned Aerial Vehicle (see Hammill et al. 2017 and den Heyer et al. 2017 for details). Photographs were counted at least twice, and the results from the two counts were averaged. For Anticosti and Margaree Islands, only one estimate is available. Counts were made by a single observer flying in a King Air. A comparison among the methods can be found in Hammill et al. (2017)

### TEMPORAL DISTRIBUTION OF BIRTHS

Non-Sable Island Northwest Atlantic grey seals begin pupping on the islands in December and births continue until early February. The majority of births, particularly of ice pupping animals, occur in January. Aerial survey and island estimates were corrected to account for births that occurred after counts were completed by modelling the distribution of births over the period of the survey. The model uses the change in the proportion of pups of different ages as the season advances to develop the birthing ogive (details described in den Heyer et al. 2017). Estimates of the number of pups in each concentration can then be corrected for pups born after the survey was flown by:

$$N_i = N_{uncor} / P_i \tag{1}$$

where:

$N_{uncor}$  = the uncorrected estimate for survey  $i$ ;

$P_i$  = the proportion estimated to have been born prior to survey  $i$ .

---

The estimates of  $N_{uncor}$  and  $P_i$  are independent and therefore the error variance of the quotient is given by (Mood et al. 1974):

$$V_i = N_{uncor}^2 \times V_p / P_i^4 + V_n / P_i^2 \quad (2)$$

where:

$V_p$  = the variance in the proportion estimated to have been present prior to survey  $i$ ;

$V_n$  = the variance in the uncorrected estimate for survey  $i$ .

The stage surveys were conducted by walking through the colony from one end to the other, or by flying over the colony at low altitude and assigning pups to developmental stages. Pups were assigned to one of five distinct age-related categories based on a combination of morphometric and pelage features to model the distribution of births (Bowen et al. 2003). New data resulted in some changes to the stage duration data used in previous surveys, (W.D. Bowen, DFO, Dartmouth, N.S. pers. comm.; Hammill et al. 2007) and these were used to correct the survey counts.

**Stage 1-** animals very thin, movements uncoordinated, and the fur has a yellowish hue from the placental fluids (Mean duration in days: 3.0, SE=0.59);

**Stage 2-** animals are thin, although they are beginning to show signs of fattening, a distinct neck is still visible, movements are more coordinated and the pelage no longer has a yellowish hue (Mean=3.1, SE=0.62)

**Stage 3-** the fur is white in colour and the animals have become so fat that a distinct neck is no longer discernable; no sign of moult (Mean=11.9, SE=2.4).

**Stage 4-** the fur has become discoloured, assuming a grey tinge, and lanugo is lost, beginning around the head and flippers. When the amount of fur loss exceeds approximately the equivalent of 1 hand on the back, or has progressed beyond the head, the animal is considered a stage 4. (Mean duration=5.3, SE=1.07)

**Stage 5-** the final stage, all lanugo has been lost. Animals begin leaving the colony during this stage.

## RESULTS

### RECONNAISSANCE SURVEYS

The areas where pupping is known to occur in Northumberland Strait, and around Cape Breton Island were searched and assessed frequently during January and February. The King Air operated by the Conservation and Protection Branch within DFO completed surveys along the south and west coasts of Newfoundland in late January, but no animals were seen.

### ICE

In the Gulf, grey seals pup on the drifting pack ice in Northumberland Strait. Concentrations are found when ice is present between Prince Edward Island and Nova Scotia, to the east of Amet Island. Normally larger concentrations are detected near Pictou Island. This ice drifts in an easterly direction and depending on wind and tide moves into St George's Bay and towards Port Hawkesbury or towards Hendry Island and north along the west coast of Cape Breton Island. In 2016, ice cover was among the lowest ever recorded for this time of the year and very few pups were seen (Fig. 2).

---

## Total pup counts

The number of pups counted on the islands in the Gulf are listed in Table 1. Pups were also observed along the edge of drifting pack ice near Point Prim, located at the southeastern tip of Hillsborough Bay, Prince Edward Island, but numbers were too few to set up a transect survey. Therefore, an estimate of animals hauled out on the ice was made (N=500). No new colonies were located in the Gulf. No pups were observed along the shoreline of the Kouchibouguac National Park, nor at Oak Island. Seals were observed at Saddle, Pictou, Henry, Margaree, Deadman (Île de corp morts), Brion and Anticosti Islands.

## Stage surveys

Stage surveys were flown over the larger island breeding colonies (Table 2). The adjustments to the survey counts were significant for Pictou Island, but were negligible for Saddle, Amet and Henry Islands. At Pictou Island, the most complete coverage of the island was carried out with the large-format camera on 15 January. The stage surveys indicated that only about 41% (SE=9.5) of the births had been completed at this time. The adjusted count for Pictou Island from the large format camera was 5089 (Se=1174), which is slightly higher, but not significantly different from the count from the UAV survey which is carried out later (N=4436, SE=814) (Table 3). The large format camera estimate was retained because it was obtained from complete coverage of the island, whereas the UAV only covered animals around the coast and did not include a small group at the western end of the island.

Total estimated grey seal pup production in the Gulf was 10,500 (SE=800, rounded to the nearest 100) animals (Table 3). There have been no changes in Gulf pup production since 2004, but there has been a decline in the proportion of the herd pupping on the ice, with the proportion of pups born on the ice declining considerably from nearly 100% up to 1996 to 1% in 2016 (Table 4, Fig. 3).

## DISCUSSION

The method used to evaluate the pup production of Gulf grey seals has evolved over time since assessments began in the early 1980s. Early studies used mark-recapture methods based on live recaptures at Sable Island of marked animals in the year of their birth, or by the recovery, or resighting, of marked animals from shot samples in the same or subsequent years to marking (Myers et al. 1997; Hammill et al. 1998). Aerial survey techniques, similar to the approaches used to assess harp seals (Stenson et al. 2003), where extensive reconnaissance is carried out to detect all concentrations, systematic surveys are flown to estimate the number of animals present on the ice, and multiple surveys to work out the proportion of pupping that has occurred since the counting survey was flown, were initiated in 1996 (Hammill et al. 2007). Within the time series there are also estimates of pup production available for the Gulf of St. Lawrence from 1966 and 1975, but the methods used to obtain these estimates, particularly for pups born on the ice are poorly described and are likely to be underestimates (Table 4).

Grey seals in the Gulf of St Lawrence have traditionally been considered to be ice-breeding, with less than 1% of the pups born on land, (Fig. 1). However, since the early 1990s ice cover has become more variable (Bajzak et al 2011; Johnston et al. 2005), making it more difficult to find ice suitable for pupping in the Northumberland Strait or western Nova Scotia area (Table 4; Figs. 2, 3).



---

As pupping on the ice declined, new colonies have appeared on islands throughout the Gulf and including Henry Island (1997), Oak Island (2007), Pictou Island (2007 assessment, but reports of some pupping since 1997), Kouchibouguac National Park (2007), Anticosti Island (2007), Brion Island (2010) and Saddle Island (2010). The presence of even a small number of pups at Anticosti Island is particularly surprising, since conditions were considered to be unfavourable in the northern Gulf and along eastern New Brunswick for pup survival, and animals were thought to leave the northern Gulf during winter (Hansen and Lavigne 1997; Goulet et al. 2001). However, if mild winters continue, then expansion may be expected in areas where there is little disturbance. So far no pupping has been observed around Newfoundland although a number of suitable isolated beaches are present along the south coast and on Miquelon, and seals use these areas during the non-pupping periods.

Compared to harp seal visual surveys, grey seal surveys are less precise in spite of animals being larger and occurring in a smaller area. The CVs of the estimates have fallen in the range of 7-57% for grey seals, compared to 8-10% for harps. A number of biological and habitat differences contribute to complicate survey efforts for grey seals including an extended pupping season, clumped distribution and variable ice quality. Grey seals pup over a 6 week period in the southern Gulf. They form relatively small patches of animals that are unevenly dispersed across the survey area. In poor ice years, the extended pupping season means that patches forming early in the season might be lost before being surveyed, as seen in 2010. However, the main challenge is organizing survey logistics to be able to complete systematic surveys when ice conditions are good, or setting up island surveys, in years where ice is very limited and animals have moved ashore. Ideally, the large format photographic planes could be used for both, but the extended pupping season makes this an expensive option for surveying grey seals. An alternative which offers considerable potential is to use a UAV platform or to install a camera system in a helicopter which combines the lower expense of accessing a helicopter locally, the larger autonomy of the helicopter and the photographic benefits, normally found in the large format camera (Hammill et al. 2017).

The grey seal is the only species that regularly breeds on both land and on ice. The appearance of new colonies underlines how adaptable this species appears to be. On the small islands in the area, the colonies are relatively isolated and little disturbed. However, other colonies such as Oak Island are easily accessible and ease of access for all-terrain vehicles and snowmobiles may account for why this colony was only used in a single year. In subsequent surveys, no pups were found on Oak Island. However, it is possible that animals found on nearby Saddle Island in 2010 and 2016, may be animals that have pupped on Oak Island and possibly Amet Island.

Overall, there has been a declining trend in ice cover of the southern Gulf of St Lawrence (Bajzak et al. 2011). This has led to a shift in the breeding habitat of grey seals in this area from one where animals pupped primarily on the ice to one where the pups are born primarily on islands. This switch does not appear to have been proportional to the amount of ice. Instead animals appear to have continued to prefer the ice habitat until several years of poor ice cover encouraged animals to move to land (Fig. 3).

In this study we have tried to adjust for the proportion of animals that are born after the survey has been flown. However, we have not adjusted our estimates for the proportion of pups that have left the colony before the survey has been completed. After weaning at an age of approximately 17 days, grey seal pups fast for an average of 21 days before leaving and feeding on their own. There is, however, considerable variability in fasting duration (9- >21 days) (Noren et al. 2008) and since the pupping season of grey seals

---

extends over a period of 6 weeks, it is possible that some pups may have been missed if they have left the pupping site prior to being surveyed. It is also possible that some pups may have been born and then died prior to being surveyed. We observed approximately 500 pups on thin ice outside of Hillsborough Bay. However, when we revisited the area in the following days, the ice had broken up and no pups could be found. Mortality of pups born on poor ice has also been seen among harp seals, particularly in recent years (e.g. Stenson and Hammill 2014)

Estimates of pup production in the Gulf of St. Lawrence are imprecise and quite variable. This is associated with the variable distribution of small concentrations or groups of pups on the ice and likely elevated mortality related to poor ice conditions. When ice is present, improving survey coverage by reducing the spacing between survey lines, increasing strip width, or repeated surveys of the same patch would contribute to improving survey precision. However, in recent years ice cover has been limited, and animals have responded by pupping on islands in the southern Gulf. This requires a different survey strategy of total counts of these island areas. Moving to a helicopter or UAV photographic system are two methods that might improve estimates of pups born in these areas.

### ACKNOWLEDGEMENTS

We would like to thank P. Wyatt for getting us onsite and home in the evening. We also thank Jean Leblanc (C&P-Gulf Region), who provided seal observations from their enforcement flights and arranged the flights around Anticosti Island, and L. Sheppard and B. Stockwood for surveying the Newfoundland coast. This project was supported by the Department of Fisheries and Oceans, survey fund under the Centre of Expertise in Marine Mammalogy (CEMAM).

### LITERATURE CITED

- Bajzak, C. M.O., Hammill, G.B. Stenson and S. Prinsenber. 2011. Drifting away: implications of changes in ice conditions for a pack ice-breeding phocid, the harp seal (*Pagophilus groenlandicus*). *Can. J. Zool.* 89:1050-1062.
- Boskovic, R., Kovacs, K.M., and Hammill, M.O. 1996. Geographic distribution of mitochondrial DNA haplotypes in grey seals *Halichoerus grypus*. *Can. J. Zool.* 74:1787-1796.
- Bowen, W.D., McMillan, J., and Mohn, R. 2003. Sustained exponential population growth of grey seals at Sable Island, Nova Scotia *ICES J. Mar. Sci.* 60:1265-1274.
- Bowen, W.D., McMillan, J.I., and Blanchard, W. 2007. Reduced Population Growth Of Gray Seals At Sable Island: Evidence From Pup Production And Age Of Primiparity. *Mar. Mamm. Sci.*, 23(1): 48–64.
- den Heyer, C.E., Lang, S.L.C., Bowen, W.D., and Hammill, M.O. 2017. [Pup Production at Scotian Shelf Grey Seal \(\*Halichoerus grypus\*\) Colonies in 2016](#). DFO Can. Sci. Advis. Sec. Res. Doc. 2017/056. v + 35 p.
- Goulet, A.-M., Hammill, M.O. and Barrette, C. 2001. Movements and diving activities of grey seal females (*Halichoerus grypus*) in the Gulf of St Lawrence, Canada. *Polar Biol.* 24:432-439.

- 
- Hammill, M.O., Stenson, G.B., Myers, R.A., and Stobo, W.T. 1998. Pup production and population trends of the grey seal (*Halichoerus grypus*) in the Gulf of St Lawrence. *Can. J. Fish. Aquat. Sci.* 55:423-430.
- Hammill, M.O., Gosselin, J.F., and Stenson, G.B. 2007. Changes in abundance of grey seals in the NW Atlantic. *NAMMCO Sci. Publ.* 6:99-115.
- Hammill, M.O., Dale, Stenson, G.B., den Heyer, C., Gosselin, J.-F., Leblanc, P., and Johnston, D. W. 2017. Comparison of methods to estimate grey seal pup production at different colonies. *DFO Can. Sci. Advis. Sec. Res. Doc.* 2017/041. iv + 19 p
- Hansen, S., and Lavigne, D.M. 1997. Temperature effects on the breeding distribution of grey seals (*Halichoerus grypus*). *Physiol. Zool.* 70: 436-443.
- Härkönen, T., Brasseur, S., Teilmann, T., Vincent, C., Dietz, R., Abt, K and Reijnders, P. 2007. Status of grey seals along mainland Europe from the Southwestern Baltic to France. *NAMMCO Sci. Pub.* 6:57-68.
- Johnston, DW, Friedlaender, AS, Torres, L.G., Lavigne, D.M. 2005. Variation in sea ice cover on the east coast of Canada from 1969 to 2002: climate variability and implications for harp and hooded seals. *Clim. Res.* 29:209-222.
- Lavigueur, L., and Hammill, M.O. 1993. Distribution and seasonal movements of grey seals, *Halichoerus grypus*, in the Gulf of St. Lawrence. *Can. Field Nat.* 107:329-340.
- Mansfield, A.W. 1966. The grey seal in Eastern Canadian Waters. *Canadian Audubon Magazine* Nov-Dec 1966. pp 160-165.
- Mansfield, A.W. and Beck, B. 1977. The grey seal in eastern Canada. *Dept. Environ., Fish. and Mar. Serv. Tech. Rep. No. 704.* 81 pp.
- Mood, A. M., Graybill, F. A., and Boes, D. C. 1974. *Introduction to the Theory of Statistics*, 3<sup>rd</sup> Ed. McGraw-Hill, Toronto. Xvi, 564p.
- Myers, R.A., Hammill, M.O., and Stenson, G.B. 1997. Using mark-recapture to estimate the numbers of a migrating population. *Can. J. Fish. Aquat. Sci.* 54:2097-2104.
- Noren, S.R., Boness, D.J., Iverson, S.J., McMillan, J., and Bowen, W.D. 2008. Body Condition at Weaning Affects the Duration of the Postweaning Fast in Gray Seal Pups (*Halichoerus grypus*) *Physiol. Biochem. Zool.* 81(3):269–277.
- Rosing-Asvid, A., Teilmann, J., Dietz, R., and Olsen, M. T. 2010. First Confirmed Record of Grey Seals in Greenland. *Arctic* 63(4): 471–473.
- Stenson, G.B., and Hammill, M.O. 2014. Can ice breeding seals adapt to habitat loss in a time of climate change? *ICES J. Mar. Sci.* 71:1977-1986.
- Stenson, G.B., Rivest, L.-P., Hammill, M.O., Gosselin, J.-F., and Sjare, B. 2003. Estimating Pup Production of Harp Seals, *Phoca groenlandica*, in the Northwest Atlantic. *Mar. Mamm. Sci.* 19:141-160.
- Stobo, W.T., and Zwanenburg, K.C.T. 1990. Grey seal (*Halichoerus grypus*) pup production on Sable Island and estimates of recent production in the Northwest Atlantic. *Can. Bull. Fish. Aquat. Sci.* 222:171-184.
- Thomas, L, Hammill, M.O., and Bowen, W.D. 2007. [Estimated size of the Northwest Atlantic grey seal population 1977-2007](#). *DFO Can. Sci. Advis. Sec. Res. Doc.* 2007/082.

---

## TABLES

Table 1. Estimates of pup production on islands/small ice patches.

Location	Date	Numbers of pups (SE)
Hillsborough Bay/Pt Prim (Ice)**	28-01-2016	500
Kouchibouguac park	22-01-2016	0
<i>Gulf Islands</i>		
Saddle Island*	25-01-2016	2370 (46)
Oak Island	22-01-2016	0
Amet Island*	21-01-2016	123 (5.7)
Pictou Island*	15-01-2016	2095 (0.7)
Henry Island*	01-02-2016	748 (25.7)
Margaree Island	16-01-2016	16
Deadman Island*	02-02-2016	90 (0)
Brion Island**	02-02-2016	1498
Anticosti Island**	25-01-2016	40

\*2 counts

\*\* estimate

Table 2. Number of grey seal pups in different age-related developmental stages.

	Stage					Total
	1	2	3	4	5	
<b>Saddle Island</b>						
22 January	9	70	137	2	2	220
26 January	0	26	302	59	19	406
30 January	0	4	350	65	20	439
<b>Amet Island</b>						
22 January	0	13	29	23	6	71
26 January	0	5	16	38	28	87
30 January	0	0	11	21	30	62
<b>Pictou Island</b>						
22 January	28	328	261	14	2	633
26 January	14	293	397	78	18	800
30 January	7	25	577	43	32	684
8 february	4	20	222	148	81	475
<b>Henry Island</b>						
23 January	6	76	156	15	1	254
26 January	3	50	202	38	7	300
1 February	2	24	102	52	27	207

Table 3. Total pup production in the Gulf of St. Lawrence after correcting for births.

Location	Date	Count (SE)	Proportion Births	Adjusted count
Hillsborough Bay/Pt Prim (Ice)	28-01-2016	500	-	500
Kouchibouguac park	22-01-2016	0	-	0
Cape St George	01-02-2016	4	-	4
<i>Gulf Islands</i>				
Saddle Island	25-01-2016	2370 (46)	0.99 (0.01)	2381 (13.6)
Oak Island	22-01-2016	0	-	0
Amet Island	21-01-2016	123 (5.7)	1	123 (5.7)
Pictou Island	15-01-2016	2095 (0.7)	0.41 (0.095)	5089 (1174)
Henry Island	01-02-2016	748 (25.7)	0.99 (0.01)	756 (27.4)
Margaree Island	16-01-2016	16	-	16
Deadman Island*	02-02-2016	90	-	90
Brion island	02-02-2016	1498	-	1498
Anticosti Island	25-01-2016	40	-	40
Total				10,497 (815)

Table 4. Estimates of Gulf grey seal pup production (with standard errors), from mark-recapture (M-R) and aerial surveys, with estimates separated into ice and island estimates where possible, rounded to the nearest 100.

Year	Ice		Island		Estimate	Total		Born on Ice (%)
	Estimate	SE	Estimate	SE		SE	CV	
1966 <sup>5</sup>	900	-	-	-	900	-	-	-
1975 <sup>4</sup>	3,300	-	500	-	3,800	-	-	-
1984 <sup>1</sup>	7,169	911	-	-	7,169	911	12.7	99
1985 <sup>1</sup>	6,706	795	-	-	6,706	795	11.8	99
1986 <sup>1</sup>	5,588	679	-	-	5,588	679	12.2	99
1989 <sup>1,2</sup>	9,352	1,756	-	-	9,352	1,756	18.8	99
1990 <sup>1,2</sup>	9,176	649	-	-	9,176	649	7.1	99
1996 <sup>3</sup>	10,691	1,306	26	-	10,717	1,306	12.2	99
1997 <sup>3</sup>	5,810	780	1,029	30	6,839	800	11.7	85
2000 <sup>3</sup>	4,850	910	410	-	5,260	910	17.3	92
2004 <sup>3</sup>	13,473	1,216	737	65	14,210	1,200	8.4	95
2007 <sup>3</sup>	4,615	940	6,798	526	11,413	1,077	9.4	40
2010 <sup>3</sup>	4,585	6,435	6,643	291	11,228	6,442	57.4	41
2016	500	-	9,997	814.6	10,497	815	7.3	5

<sup>1</sup> Hammill et al. 1998

<sup>2</sup> Myers et al. 1997, Several estimates available from 1 and 2 for 1989, 1990. These were averaged.

<sup>3</sup> Hammill et al. 2007, and current study.

<sup>4</sup> Mansfield and Beck 1977 assuming 500 pups born on Amet and Deadman Is.

<sup>5</sup> Mansfield 1966, estimated by subtracting 500 pups from estimates of pup production on Sable and Basque Island.

## FIGURES

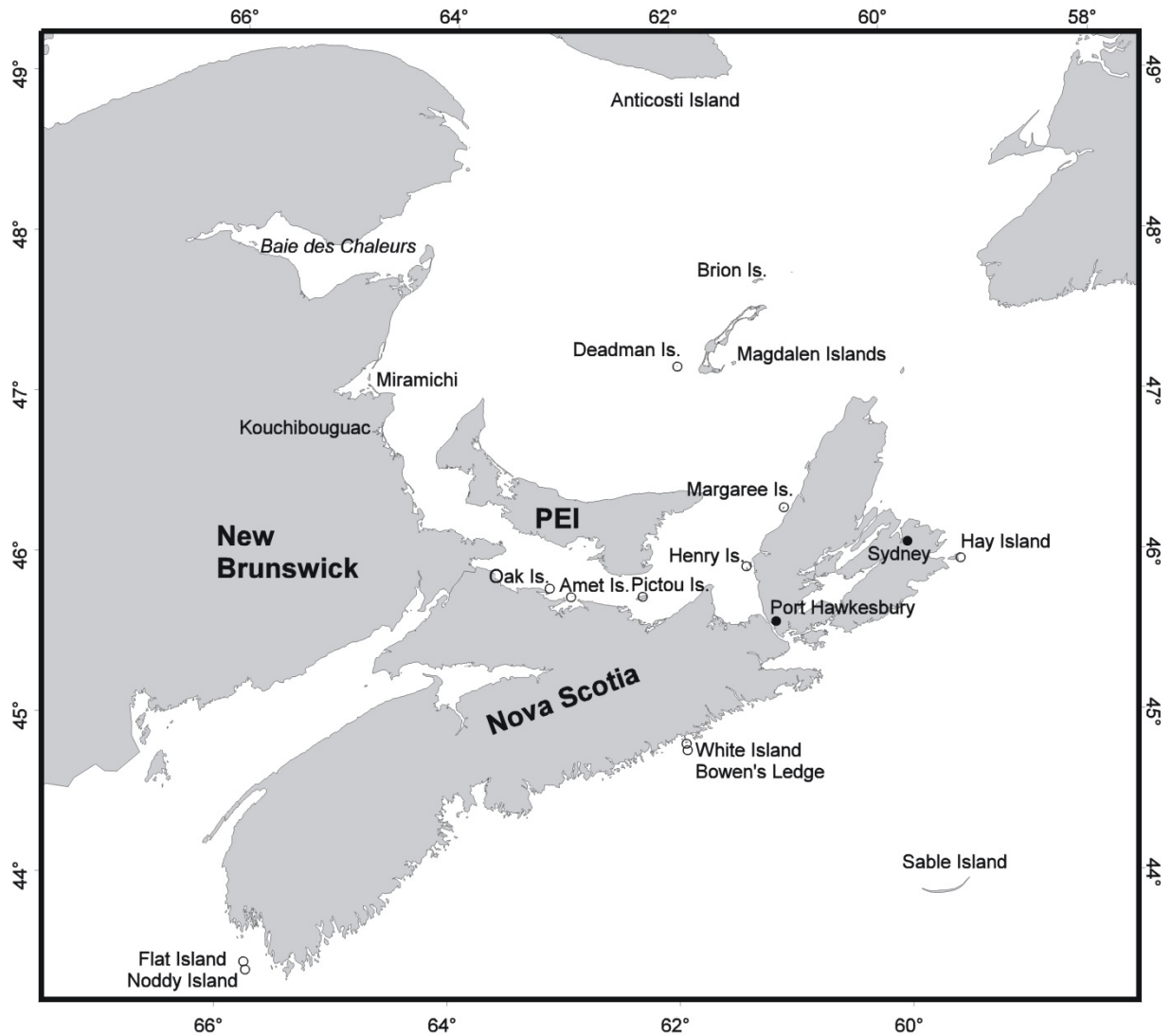


Figure 1. Map of study area. PEI is short for Prince Edward Island. Hillsborough Bay is the large bay, just underneath the "I" in PEI. Saddle Island is located just to the west of Amet Island.



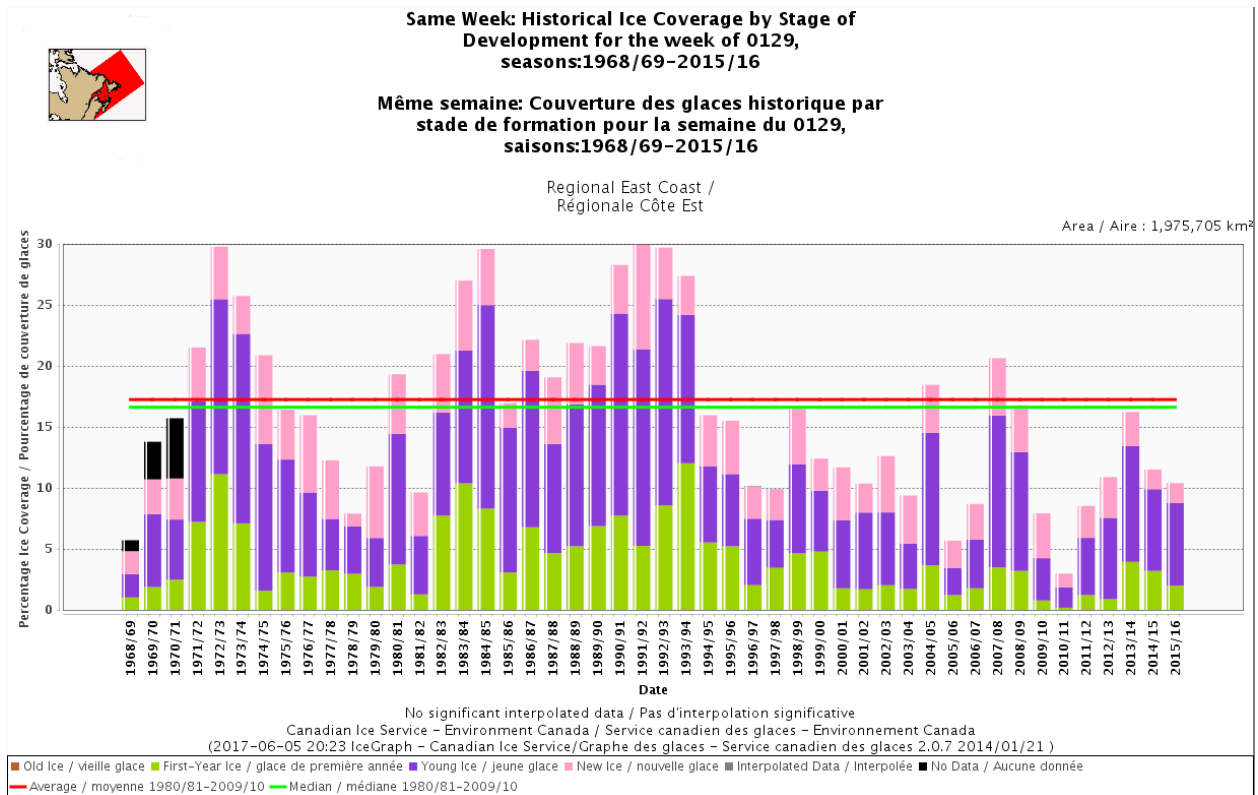


Figure 2. Ice cover in the Gulf of St Lawrence on 29 January from 1969-2016 (From Environment Canada), where new ice is <10 cm, young ice is <30 cm and first-year ice is 30 cm thick.

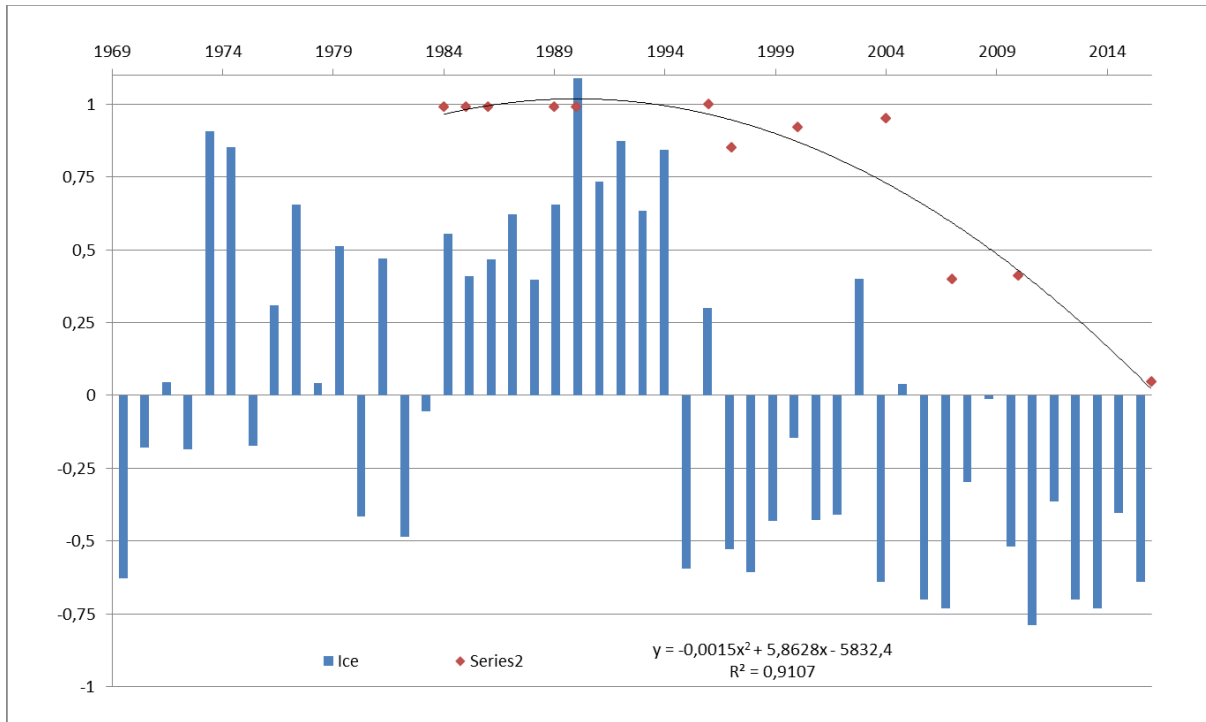


Figure 3. Proportion of pups born on the ice in the Gulf of St Lawrence by year (top x-axis), and the deviation in total ice cover in the Gulf of St Lawrence, from the mean (1969-1996), ice cover on 29 January, estimated as  $([Ice\ cover - mean\ ice\ cover] / mean\ ice\ cover)$ . Ice data are from [Environment Canada](#).