



STOCK ASSESSMENT OF NORTHWEST ATLANTIC GREY SEALS (*Halichoerus grypus*)

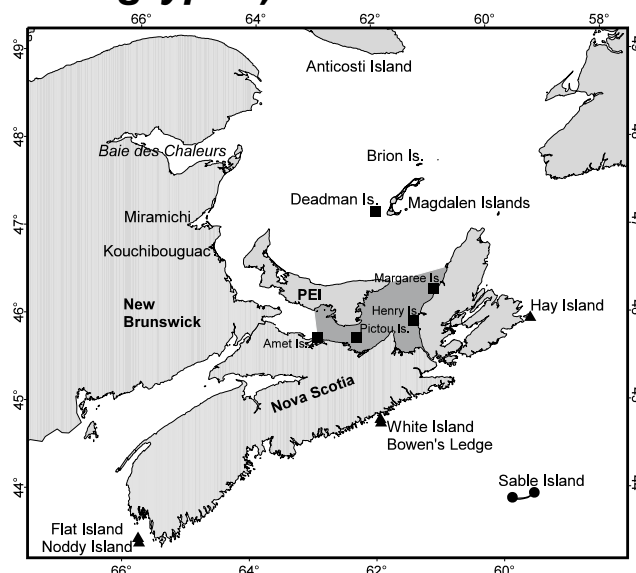


Figure 1: Southern gulf of St Lawrence and Scotian Shelf showing location of Sable Island (•), Eastern Shore (▲), Gulf (■) grey seal colonies and general location of ice-breeding animals (dark grey area). The Eastern Shore encompasses the east coast of Nova Scotia, from approximately Noddy Island to Hay Island

Context :

Seals in Atlantic Canada are managed under the Objective Based Fisheries Management (OBFM) approach, which was implemented in 2003. Under this approach, populations are classified as 'Data Rich' or 'Data Poor' depending on certain data criteria. For populations classified as Data Poor, a more risk-adverse approach is used when establishing harvest quotas. Under OBFM, grey seals are considered as 'Data Poor'.

The grey seal is a large and abundant species found throughout the North Atlantic. The Northwestern Atlantic population forms a single genetic population. However, they are divided into three components for management purposes, based on the location of the main breeding concentrations. Breeding occurs during December to February on Sable Island (Sable Island herd), on small islands along the eastern shore of coastal Nova Scotia (the Eastern shore herd) and on drifting pack ice and small islands in the Gulf of St. Lawrence (Gulf herd). Grey seals are largely a continental shelf species, preferring areas with water depths less than 200 m deep. There is a small commercial hunt for grey seals in the Gulf of St. Lawrence and along the Eastern Shore. Grey seals on Sable Island are currently protected. Grey seals are perceived as a nuisance to commercial fisheries and some are killed under a nuisance seal permit. They are an important host for the seal/cod worm (*Pseudoterranova decipiens*), which also infect many groundfish species, and must be removed during processing. Grey seals are also considered by industry to be affecting the recovery of some depleted fish stocks, and to damage fishing gear. Evidence of the impact of grey seal predation on depleted stocks is inconclusive and there is no current information on the extent of gear damage caused by seals.

This review was undertaken to examine the results from a recent pup abundance survey and population modelling, to evaluate current population size and trends, which will provide a scientific basis for setting harvest levels and to determine if grey seals could be moved from the Data Poor to Data Rich category.

SUMMARY

- Grey seals form a single genetic population that can be divided into three groups for management purposes based on the location of breeding sites. Most pups (81%) are born on Sable Island, 15% are born in the Gulf and 4% are born along the Eastern Shore of Nova Scotia. This distribution has changed over time, with a decline in the fraction of the population born on the ice compared to on small islands, and an increase in the proportion of animals born on the Eastern Shore, compared to the Gulf.
- Using aerial surveys, total production of Northwest Atlantic grey seals in 2007 was 67,500 (SE=1,400). This includes 54,500 (SE=1,300) pups born on Sable Island, 3,000 (SE=40) along the eastern shore of Nova Scotia, and 9,900 (SE=600) in the Gulf of St. Lawrence.
- Pup production on Sable Island increased at an exponential rate of 12.8% per year between the 1970s and 1997. However, since then surveys indicate that there has been a decline in the rate of increase to about 7% per year. Pup production in the eastern Shore component has also increased from a few hundred in the early 1990s to over 3,000 in 2007. Pup production in the Gulf has been more variable. It has increased from roughly 7,000 animals in 1984 to 11,000 in 1996, but has fluctuated between 6,100 and 15,600 since then.
- On Sable Island there has been a significant increase in the age at first birth over the last decade. The proportion of animals aged 5 years old appearing for the first time with a pup has declined from 30% during the period 1985-1989 to 12% during 1998-2002. In the non-Sable Island component of the population, the mean age at first birth is 5 years old. This has not changed since the late 1960s, nor have changes been observed over time in age specific pregnancy rates.
- The reproductive data used in the population model were obtained from animals shot in the Gulf of St. Lawrence. The presence of mid- to late-term fetuses is used to estimate age-specific birth rates. These data will slightly overestimate actual birth rates as some pregnancies will not be carried to term.
- Removals from the population during the last five years include animals taken in the commercial harvest, scientific collections, nuisance seal removals and incidental catches in commercial fisheries. No information is available on incidental catches, and data on number of seals killed as nuisance seals are limited.
- Pup surveys completed approximately every 4 years combined with estimates of age-specific reproductive rates and removals are incorporated into a population model to determine total abundance. The variability associated with model parameters, as well as potential changes in natural mortality rates due to environmental conditions add uncertainty to the non-Sable Island population estimates. Additional uncertainty is associated with the application of reproductive rate data from the Gulf to the Sable Island component of the population.
- With the completion of the 2007 survey, there are now three surveys in the last 15 years. This along with the reproductive data means that the grey seal assessment should now be considered as Data Rich.

INTRODUCTION

Background

Seals in Atlantic Canada are managed under the Objective Based Fisheries Management (OBFM) approach, which was implemented in 2003. Under this approach, populations that have been surveyed at least three times over a 15 year period, with the last survey less than five years old, and having current data on reproduction or mortality (≤ 5 years old) are considered 'Data Rich'. Harvest levels for Data Rich populations are to be set to maintain the population above 70% of the maximum observed population size. Populations that do not satisfy these criteria are considered 'Data Poor' which requires a more risk-adverse approach to setting harvest levels. Under OBFM, grey seals were considered 'Data Poor'.

Species Biology

The grey seal is a member of the family Phocidae that was first described by Fabricius (1791). Its name *Halichoerus* comes from the Greek meaning "sea pig", and *grypus* from the Latin meaning hook-nosed. In Canada, they are sometimes referred to as horse-head seals owing to the elongated snout of adult males. Males tend to be darker than females, in some cases almost black. They may reach a length of 231 cm, and weigh as much as 350 kg. Females are smaller, reaching 201 cm in length and weigh up to 227 kg. Breeding occurs on islands, isolated beaches or on the pack ice. Pups are born with a white lanugo, which they begin to shed approximately 15 days after birth and is completely replaced with a black spotted, silver coat by the time pups are 25 days old.

An examination of mitochondrial DNA variation in samples from Canada, Norway and the Baltic Sea supports the hypothesis that seals from these areas represent three distinct populations. Eastern and western Atlantic grey seals diverged first, possibly 1.0 - 1.2 million years ago, while the Baltic Sea animals diverged much later. The Northwest Atlantic population is often divided into two components (Gulf and Sable Island), for management considerations based on the locations of the major pupping concentrations. However, recent increases in coastal colonies indicate that this could be further separated into animals born in the Gulf of St. Lawrence (Gulf), Sable Island and Eastern Shore the latter including colonies mainly along the eastern shore of Nova Scotia.

Grey seals are considered to be a coastal or continental shelf species. They haul out on exposed reefs or on beaches of undisturbed islands. These concentrations of animals are typically quite noisy, and are associated with vocalizations resembling growls and roars. These noises sometimes resemble the calling of a wolf, and this may be the source of the general French term "loups marins or sea wolves".

Grey seals were at one time very abundant, and widely distributed along the Canadian east coast, and in the Gulf of St Lawrence where they were first hunted by Amerindians. Extensive hunting by Europeans, particularly after the disappearance of the Walrus (*Odobenus rosmarus*) in the Gulf and on Sable Island, resulted in the depletion of the grey seal population by the mid-1800's. Up to the 1950's, the grey seal was considered uncommon or rare, but they continued to be hunted. Some grey seals were taken in a bounty program focused on harbour seals (*Phoca vitulina*). A grey seal culling program at the breeding sites in the Gulf of St. Lawrence and along the Eastern Shore occurred between 1967 and 1984, removing from 114 to 2,375 animals per year. From 1978 until 1990, a bounty was paid to licenced fishermen who submitted lower jaws from grey seals, and information on date and location of capture. A total of

4,379 individuals was taken during this program. Captures were initially quite high, but with the exception of a large number of returns in 1987 (753), they declined steadily until 1990, when only 79 returns were received.

Human Induced Mortality

There is a small commercial harvest for grey seals (Table 1). Over the last five years, an average of 655 animals have been removed per year. Harvests occur in the Gulf of St. Lawrence and along the Eastern Shore. Grey seals are protected on Sable Island. Some grey seals have been killed under a Nuisance seal permit provision of the Marine Mammal Regulations. A total of 484 nuisance seal permits was issued in 2007, with 99% of these issued in Nova Scotia (the Maritimes Region). Only 91 seals have been reported killed, but statistics are incomplete. Some animals are removed as part of Department of Fisheries and Oceans scientific sampling programs to study diet, growth and reproductive rates. This program has removed 347 seals in the last 5 years. Grey seals may also be taken as incidental catch in commercial fisheries, but no data are available on the magnitude of this mortality.

Table 1. Reported removals from the NW Atlantic grey seal population over the last five years.

	2003	2004	2005	2006	2007
Commercial harvest	6	0	579	1804	887
Science collections	85	199	15	22	26
Nuisance seals	No Data	No Data	No Data	No Data	91
Incidental catch	No Data	No Data	No Data	No Data	No Data

ASSESSMENT

The total number of grey seals in the northwest Atlantic cannot be counted directly. Surveys of the total population are impractical because animals are distributed widely across the Atlantic seaboard during the summer and, even though they congregate during the whelping and moulting periods, not all of the population is present at the surface at any one time and place. However, the number of seal pups born in a year can be estimated from aerial surveys conducted, when females give birth and nurse their pups. Estimates of total population are based on a population model that incorporates independent estimates of pup production with data on reproductive rates (female age at first birth and age specific pregnancy rates), mortality rates and catches including struck and lost.

2007 Pup Production

The Gulf and Eastern Shore components of the Northwest Atlantic grey seal population give birth on the pack ice in the Gulf of St. Lawrence as well as on small islands in the Gulf and along the east coast of Nova Scotia. Visual strip transect surveys were flown over the whelping patches on the ice in the Gulf of St. Lawrence and multiple counts were completed at islands in

the Gulf and along the Eastern Shore. Where possible, counts were corrected for the proportion of pupping completed when the survey was completed. Pup production along the eastern shore of Cape Breton Island and Nova Scotia was 3,000 (SE=40). Pup production in the Gulf of St. Lawrence was 9,900 (SE=600). Total pup production of the non-Sable Island herd is estimated to be 13,000 (SE=600) animals. Pup production in the non-Sable Island component of the population increased from the early 1980s until the mid 1990s, but has been quite variable since then (Table 2). Prior to 1996, 95% of the non-Sable Island pups were born on the ice, while the remainder were born on islands within and outside of the Gulf of St. Lawrence. Due to a series of winters with poor ice conditions, particularly since 1997, the proportion of pups born on the ice declined to approximately 80% of production during the assessments of 1997, 2000, and 2004, then declined further to approximately 30% of total non-Sable Island production in 2007. Pup production along the Eastern Shore accounted for approximately 23% of the non-Sable Island pup production in 2007.

Table 2. Estimates of Non-Sable grey seal pup production, from mark-recapture (M-R) and aerial surveys, rounded to the nearest 100. The mark-recapture method was replaced after 1990 by aerial survey methods. Standard errors are in brackets.

Year	Mark-recapture estimates	Aerial survey estimates
1984	7,200 (900)	
1985	6,700 (800)	
1986	5,600 (700)	
1989	9,700 (900)	
1990	9,000 (600)	
1996		11,100 (1,300)
1997		7,300 (800)
2000		6,100 (900)
2004		15,600 (1,200)
2007		13,000 (600)

On Sable Island, the numbers of pups born were assessed using an aerial digital-photographic survey. A total of 48,000 pups was counted on the digital imagery. Given the high quality of the imagery, no correction for missed pups was necessary after analysis of ground truthing plots. Correction for proportion of pups that died prior to the survey and the proportion of pups born before the survey, estimated total pup production was 54,500 (SE=1,300). The 2007 estimate indicates that pup production on Sable Island has continued to increase, but that the rate of increase has declined over two successive surveys (Table 3). The proportion of females recruited to the breeding colony at ages 4-7 year, from the 1998-2002 cohorts, were significantly lower than those in the mid-late 1980s. The new estimate of pup production and observed changes in age of first birth provide further indication of changes in vital rates of this population.

Table 3. Estimates of Sable grey seal pup production, total count and aerial surveys. Standard errors are in brackets.

Year	Total counts	Aerial survey estimates
1984	5,900 (300)	
1985	5,600 (300)	
1986	6,300 (300)	
1987	7,400 (300)	
1988	8,600 (300)	
1989	9,700 (400)	
1990	10,500 (600)	
1993		15,500 (463)
1997		25,400 (750)
2004		41,500 (4,381)
2007		54,500 (1,288)

Combining estimates from the Sable and non-Sable Island components of the population, total production of Northwest Atlantic grey seals was (67,500) (SE=1,400). This includes 54,500 (SE=1,300 pups born on Sable Island, 3,000 (SE=40) along the eastern shore of Cape Breton Island and Nova Scotia, and 9,900 (SE=600) in the Gulf of St. Lawrence. Approximately 81% of pups are born on Sable Island, 15% are born in the Gulf and 4% are born along the Eastern Shore.

Population Model

A Bayesian model was constructed and fit to available pup production data from 1977-2007, to examine the dynamics of the Northwest Atlantic grey seal population. A Bayesian approach offers a more rigorous framework to incorporate uncertainty into the assessment of changes in the size of the grey seal population. The population was divided into three breeding regions: Sable Island, Gulf of St Lawrence, and Eastern Shore of Nova Scotia. The model assumes that fecundity rates are age-dependent, but are constant over time, that adult survival rates are constant, and that pup survival is density dependent. Females are allowed to move from their natal area to a new region to breed, but once they start breeding they do not move. A Bayesian computer-intensive method was used to fit the model, with informative priors on model parameters. The posterior estimates for some parameters were close to their priors indicating that there was little information about these parameters in the pup production data. Other parameters were far from the prior: in particular the posterior estimates of carrying capacity were far higher than the prior values, indicating little evidence of density-dependent population regulation at current levels of pup production.

The total estimated population size at the end of the 2007 breeding season (i.e., including pups) was 304,000 (95% Credibility interval=242,000-371,000)(Fig. 2). This is seven times higher than the estimate for 1977 of 41,000 (95% Credibility Interval=31,000-51,000). Average annual rates of population increase are estimated to be 4% in the 1980s (lower due to greater harvests in the Gulf), 9% in the 1990s and 8% in the 2000s.

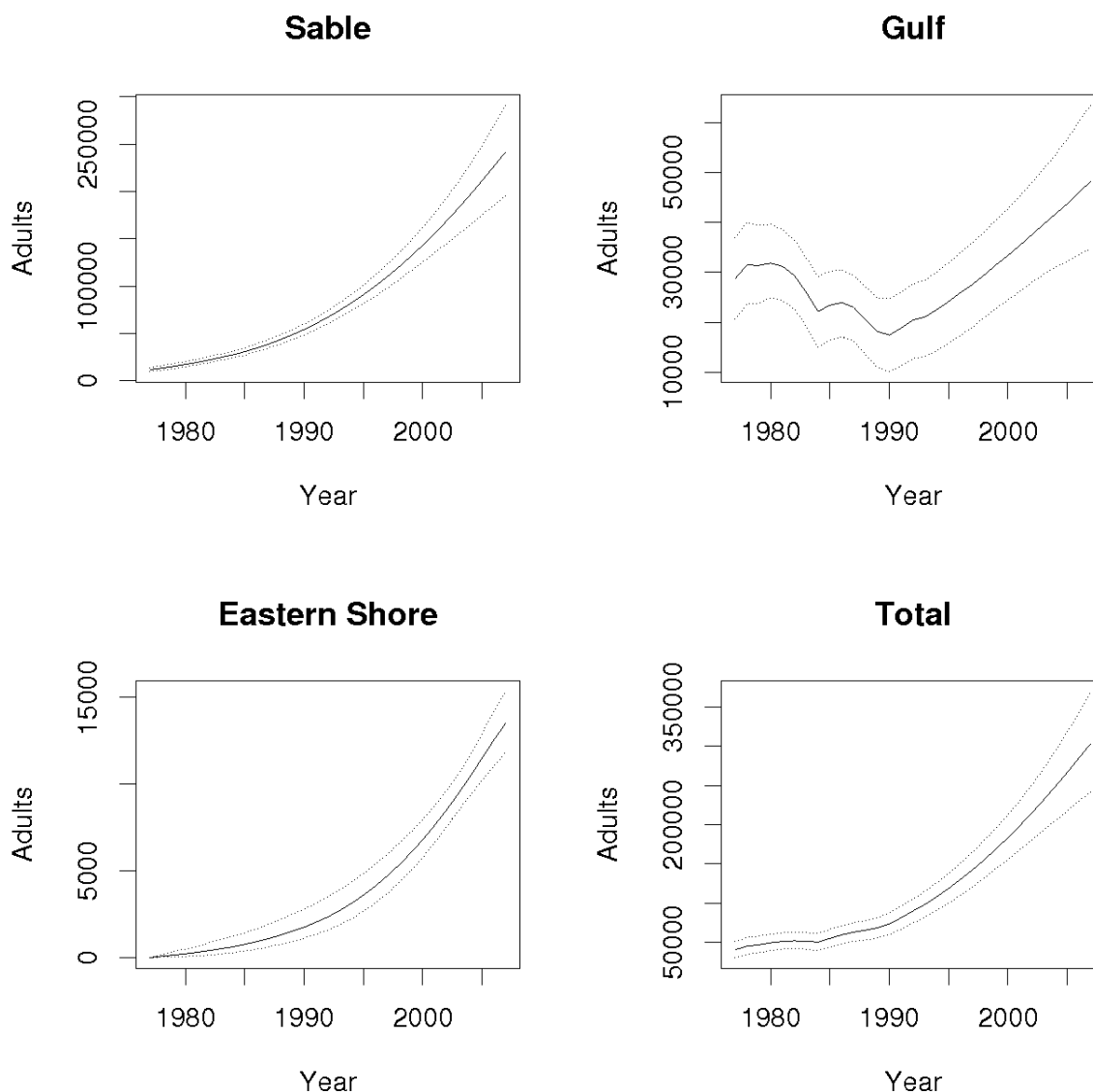


Figure 2. Estimated trajectories of the different herds and the total Northwest Atlantic grey seal population.

Sources of Uncertainty

The non-Sable island component of the population breeds on small islands and on the pack ice in the Gulf of St. Lawrence. Considerable variability in pup production has been observed, particularly over the last decade and overall, estimates of pup production are likely conservative (Table 2). This may be related to changes in ice conditions, resulting in high pup mortality or the displacement of animals to other sites prior to completion of counts. Further analyses should consider ice cover as a co-variate when examining this variability. Changes in ice conditions have resulted in new colonies forming in the Gulf of St. Lawrence and along the Eastern Shore. Extensive reconnaissance has detected these colonies, but in cases such as Anticosti Island, this new colony was detected late in the season and a proper assessment of animals on the island was not possible. Where possible, survey count data were corrected for pups born after a survey was flown. These corrections assume that the distribution of births can be described by a Normal distribution, and that the durations of age-specific pup stages are known. On Sable

Island, a change in the duration of the age-specific stages was observed between data collected in 1997 and again in 2007. It is more difficult to collect these stage data for the non-Sable Island component of the population, so stage duration values were used from both the 1997 and 2007 experiments on Sable Island. The use of Sable Island estimates is not expected to result in significant bias. Estimates using both stage duration data sets (1997 and 2007) were averaged to obtain a final non-Sable Island pup production estimate. Among the island colonies, where multiple counts were possible, good agreement was observed between visits, when counts were corrected for pupping, suggesting that the assumption that births were normally distributed was a reasonable approximation.

The population model did not find any evidence of density-dependent changes in pup production. This is because the reproductive rate data incorporated into the model were from animals sampled in the Gulf of St. Lawrence. This does not agree with published evidence that changes are occurring in the age at first birth in the Sable Island component of the population. The impacts of these changes need to be investigated, but it is likely that our estimate of total population size is conservative as a result. The fit of the model to the Gulf and Eastern Shore pup production data is poor, possibly because of uncertainty associated with the effects of variable ice conditions on Gulf pup production and the limited survey information available for the Eastern Shore colonies. Currently, harvesting is directed towards the Eastern Shore and Gulf components of the population, while the Sable Island herd is protected. The available reproductive data used in the model are for the Gulf and Eastern Shore components of the population, which are also the targeted groups for the commercial harvest. Although large numbers of nuisance seal licences have been issued, with the exception of 2007, there is no information available concerning the number of animals removed under the nuisance seal permit program. Almost all of these licences have been issued in Nova Scotia. Finally, the commercial harvest is supposedly directed against young of the year, but some recent incidents have determined that large numbers of adults are being killed as well. The age composition of the commercial harvest as well as the nuisance seal harvest need to be clarified.

ADDITIONAL STAKEHOLDER PERSPECTIVES

Grey seals are considered by the commercial fishing industry as an important factor limiting the recovery of groundfish stocks in eastern Canada. Grey seals are also important hosts for the nematode parasite, *Pseudoterranova decipiens* which must be removed from filets of some commercial fish species during processing. Although not toxic the worms are a cosmetic nuisance and increase costs associated with processing of fish. High worm burdens will reduce the quality rating of the filet, reducing the added on value. Grey seals also take baits from lobster traps and fish from gill nets and longlines and are known to break fishing gear. The value of this damage throughout Atlantic Canada has not been quantified in recent years.

CONCLUSIONS AND ADVICE

In 2007, a new assessment was completed, which enabled moving grey seals from the Data Poor to a Data Rich category. Under OBFM, harvest levels for Data Rich populations are to be set to maintain the population above 70% of the observed maximum population size.

The development of a Bayesian model to examine the dynamics of this population offers a more rigorous framework to incorporate uncertainty into the assessment of changes in the size of the grey seal population. Overall, the Northwest Atlantic grey seal population continues to grow, driven by increases in the component of the population breeding on Sable Island. However, harvesting is directed towards the Eastern Shore and Gulf components of the herd, where there is much less certainty associated with the dynamics of these components of the population. It will be important to better understand factors affecting pup production in the gulf, rates of movement among the three components of the population and improved reproductive rate data for the Sable and non-Sable Island herds. More information is needed on where animals are actually harvested and the age composition of this harvest. There are a number of nuisance seal permits that have been issued in Nova Scotia. The numbers of animals killed under this permit system needs to be determined and taken into consideration when setting harvest levels.

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