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**Quebec and Maritimes Region**

**Canadian Science Advisory Secretariat**
**Science Advisory Report 2013/008**

# STOCK ASSESSMENT OF NORTHWEST ATLANTIC GREY SEALS *(HALICHOERUS GRYPUS)*

*Photograph by W. D. Bowen*

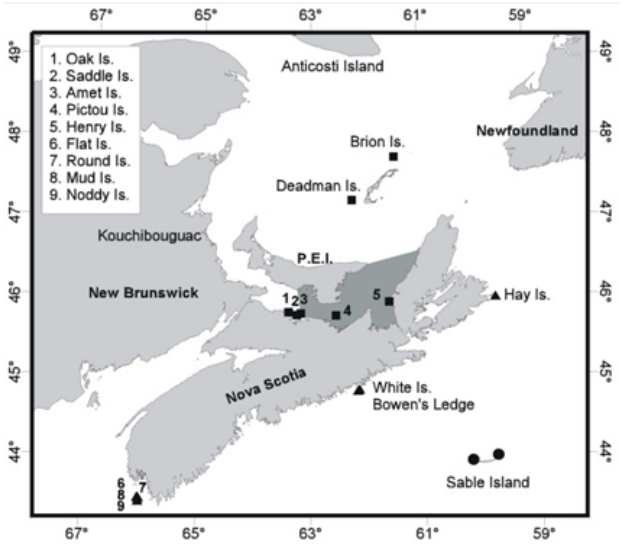



*Figure 1. Southern gulf of St Lawrence and Scotian Shelf showing location of Sable Island (●), coast of Nova Scotia (▲), Gulf (■) grey seal colonies and general location of ice-breeding animals (dark grey area).*

## Context

*There is a small commercial hunt for grey seals in the Gulf of St. Lawrence and along the coast of Nova Scotia. Grey seals are managed under the Atlantic seal management strategy, a precautionary approach for Atlantic seals which was implemented in 2003. The management objective is to maintain an 80% probability (L20) that the population will remain above 70% (N70) of the largest estimated population size. N30, corresponding to 30% of the maximum population size, is the population level below which all harvesting should cease.*

*The interaction between a growing grey seal population and fish stocks on the Atlantic Coast has become an issue of considerable interest, as Atlantic cod stocks, in particular, are depleted and some continue to decline. Fisheries on these stocks have become severely restricted or closed altogether. In a recent review, it was concluded that of the hypotheses for which there were data, predation by grey seals was the most likely reason for the lack of recovery of southern Gulf of St. Lawrence cod (NAFO fishing zone 4T).*

*Given interest in commercial hunting and the potential for population management of grey seals, advice is needed on the impact of harvest age composition and level on future population size of grey seals. For each age class scenario (#1: age composition comprised of 97% young of the year, 3% animals aged 1+ years, and #2: 50% young of the year, and 50% animals aged 1+ years), what is the maximum harvest that could be taken from the grey seal population with probabilities of 0, 5, 10 and 15% of falling below the limit reference point (LRP is roughly equivalent to current N30).*

## SUMMARY


- Grey seals form a single genetic population that is 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 of St. Lawrence and 4% are born along the coast of Nova Scotia. This distribution has changed over time, with a decline in the fraction of the population born in the Gulf.
- A population model incorporating estimates of reproductive rates up to 2011 was fitted to pup production estimates up to 2010 to describe the dynamics of the grey seal population in Atlantic Canada. Combining all three herds, the model estimated a total 2012 grey seal pup production in Atlantic Canada of 76,200 (95% CI=60,000-105,000) animals, with an associated total population of 331,000 (95% CI=263,000-458,000). Population size in all three management areas appears to be leveling off.
- The current estimate of population size is slightly lower than what was presented in 2010 due to differences between the types of models used in the assessment. The difference does not represent a change in abundance but rather a change in methods used to estimate abundance.
- Removals from the population during the last five years include animals taken in the commercial harvest, for scientific collections, nuisance seals (seals removed for damaging gear and catches), and incidental catches in commercial fisheries. Estimates of the number of seals killed as nuisance seals are incomplete. There is no data available on incidental catches, but the numbers are thought to be small.
- Projections from the population dynamics model were used to investigate the consequences of a range of harvest strategies. Harvests of 36,700 animals (97% Young of the Year) would maintain an 80% probability of staying above N70 and a 95% probability of staying above N30. Higher harvest levels would be possible, but with lower probabilities of remaining above N70 and N30.
- If the proportion of Young of the Year in the catch declines to 50%, then harvests of 19,900 animals (97% Young of the Year) would maintain an 80% probability of staying above N70 and a 95% probability of staying above N30. Higher harvest levels would reduce the probabilities of remaining above N70 and N30.


## INTRODUCTION

### Background

The current status of the Canadian Atlantic grey seal population was re-assessed. The dynamics of the population were described using an age-structured model that incorporates data on reproductive rates, removals and estimates of ice-related mortality updated to 2011. Canadian Atlantic grey seals have been managed under the Atlantic Seal Management Strategy. As a data-rich population, the management objective has been to maintain an 80 % probability that the population remains above a precautionary reference level (N70) which is defined to be 70 % of the maximum estimated population size.

### Species Biology

The grey seal is a member of the family Phocidae. In Canada, they are sometimes referred to as horse-head seals owing to the elongated snout of adult males. Males 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 250 kg. Breeding occurs on islands, isolated beaches or on the pack ice. Females nurse a single pup for about 17 days. Mating occurs during late lactation after which adults return to sea to feed. The pup, known as a whitecoat, moults its white fur at approximately three weeks of age after which it is referred to as a beater. There is a single population of grey seals in the Northwest Atlantic that is divided into three components, Sable Island, Gulf of St Lawrence and Coastal Nova Scotia, for management considerations based on the locations of the major pupping concentrations. Grey seals are a coastal or continental shelf species. They haul out on exposed reefs or on beaches of undisturbed islands.

## Human Induced Mortality

There is a small commercial harvest for grey seals (Table 1). Harvests occur in the Gulf of St. Lawrence and along the Eastern Shore of Nova Scotia. Animals are also taken under scientific permit, under a nuisance seal permit provision of the Marine Mammal Regulations, and as incidental catch in commercial fisheries. There is limited information on the magnitude of this latter mortality. Nuisance seal licenses are issued to fishermen that report seals causing damage to fishing gear or catches. They are required to report the number of seals they have removed, but not all fishermen do provide this information.

*Table 1. Reported removals from the NW Atlantic grey seal population over the last years. 1 the nuisance seal estimate is based on the number of seals reported removed, divided by the reporting rate*

| | **2007** | **2008** | **2009** | **2010** | **2011** | **2012** |
|---|---|---|---|---|---|---|
| **Commercial harvest 1+** | 1747 | 1471 | 263 | 58 | 215 | 200 |
| **Science collections** | 87 | 0 | 0 | 0 | 320 | 90 |
| **Nuisance seals[1]** | 3373 | 3334 | 3381 | 2933 | 2076 | 3000 |

# ASSESSMENT

A mark-resighting analysis of branded females was used to estimate i) juvenile survival (weaning to age 4), ii) adult survival and iii) sighting probabilities (ages 4 to 14), which can be used as a proxy for average birth rate. Two groups of cohorts (1985-89 and 1998-2002) were analyzed separately to test for temporal changes in vital rates. Sightings from 1987 to 1999 of the 1980s cohorts and from 2000 to 2012 of the recent cohorts provided estimates of juvenile survival and average age first birth. The estimates of capture probability (p) from the mark-recapture model provide a lower bound for average birth rates at 53 to 78 %. Reduced reproductive rates were observed from 1992-1995, reaching a minimum of 53%. For the 1998-2002 cohorts, reproductive rates were high (~ 78%), with a slight decline observed in 2006 to around 73%. Estimated apparent survival rates of adult females averaged 0.95 and 0.97 for the 1980s and the 1998-2002 cohorts, respectively. Estimated probabilities of average age of first birth (over ages 4 to 14 yr) did not change over time. However, apparent juvenile survival decreased significantly from 0.78 in the 1980s cohorts to 0.33 in the recent cohorts.

The total number of grey seals in the northwest Atlantic cannot be counted directly. The number of seal pups born is estimated from aerial surveys and ground counts conducted at pupping colonies. Estimates of total population are based on a population model that incorporates estimates of pup production with data on reproductive rates (age-specific pregnancy rates), mortality rates, and removals, including seals struck and lost.

Overall, reproductive rates were high among Gulf of St Lawrence animals throughout most of the time-series. There appears to have been a decline in reproductive rates in the early 2000s

that lasted for 2-3 years, then a return to high rates from 2004 until 2009. Since 2009, there has been a decline in reproductive rates across all age-classes, but samples sizes are small for age classes 4-7 years old. The recent decline has not been observed at Sable Island, possibly due to differing ecosystem conditions between the Scotian shelf and the Gulf of St. Lawrence.

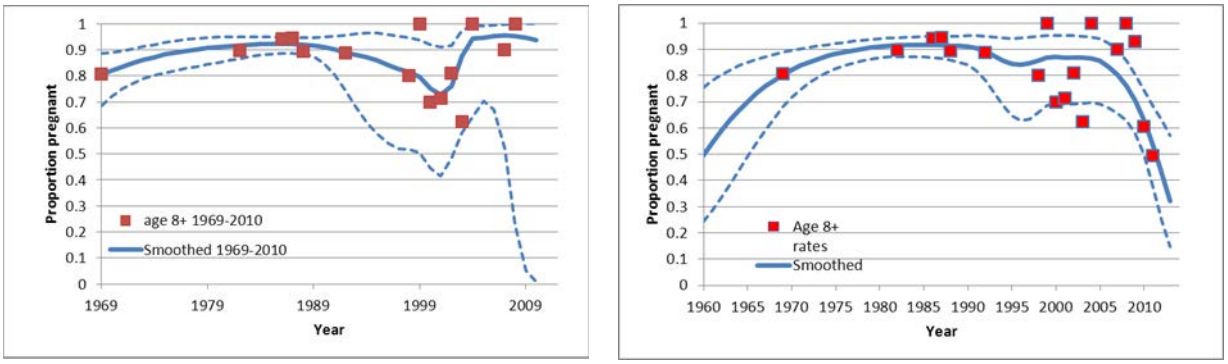



*Figure 2. Age specific reproductive rates and non-parametric smoothed rates for animals aged 8+ years for the period 1969-2008 (left) and the period 1969-2011 (right). Dotted lines represent 95% CI.*

## Pup Production

The Northwest Atlantic grey seal population gives birth on Sable Island, on the pack ice in the Gulf of St. Lawrence and on small islands in the Gulf and along the east coast of Nova Scotia.

Total pup production of Northwest Atlantic grey seals in 2010 was estimated to be 76,300 (SE=6,500). This includes 62,000 (SE=600) pups born on Sable Island, 3,000 (SE=100) along the coast of Nova Scotia, and 11,300 (SE=6,400) in the Gulf of St. Lawrence. Most pups (81%) are born on Sable Island, 15% are born in the Gulf and 4% are born along the coast 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 coast of Nova Scotia, compared to the Gulf.

## Population Model

A new model, based on the model formulation used to describe the dynamics of the Northwest Atlantic harp seal population was used in this assessment. The age-structured model incorporates information on age-specific reproductive rates, removal information and is fitted to the time series of estimated pup production by adjusting the model estimates of initial population size, adult mortality rate, and environmental carrying capacity. This model differs from the previous model by fitting to each grey seal herd separately, in the way that the reproductive data are incorporated into the model, and the treatment of variability in environmental conditions. Currently, the reproductive rate inputs into the model are based on samples taken from the Gulf of St. Lawrence.

When the model was fitted to the pup production estimates from all three herds using the reproductive data up to 2011, it predicted that pup production peaked in 2010 and declined significantly thereafter. However, field observations as well as birth rate information obtained from the mark-recapture experiment on Sable Island indicate that pup production and reproductive rates in that herd have remained high. Less than 12% of satellite tagged females from Sable Island forage in the Gulf of St. Lawrence. Also, as ecosystem conditions differ between the Gulf and the Scotian Shelf, it was deemed inappropriate to apply the reproductive rate samples obtained from 2009-2012 from the Gulf of St. Lawrence to the Sable Island and

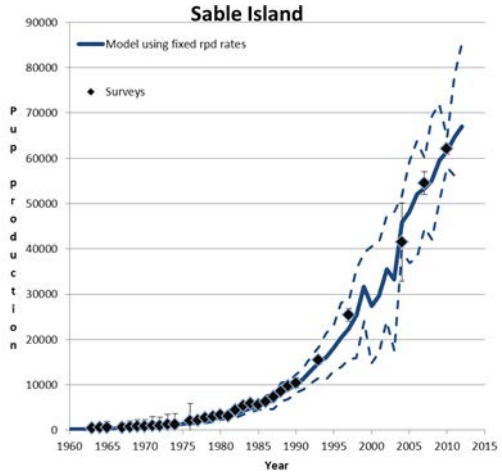
Coastal Nova Scotia herds. Therefore, for this assessment, the reproductive rates observed up to 2008 were extended to 2012 for the Sable Island and Coastal Nova Scotia herds.

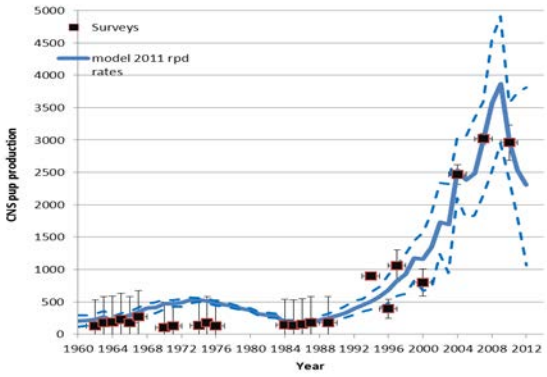
On Sable Island, pup production and total population size estimated from the model continue to increase, although more slowly in recent years (Fig. 3). The 2012 pup production estimate was estimated to be 67,000 (95% CI=56,000 to 85,000), and the associated total population estimate is 262,000 (95% CI 219,000 -332,000). Adult mortality (Ma) rate was estimated to be 0.05, while juvenile mortality was estimated to be 0.64. The environmental carrying capacity (K) was estimated to be 332,000. Fitting the model to the Coastal Nova Scotia estimates of pup production results in a 2012 pup production estimate of 2,300 (95% CI =1,100-3,800), and a total population of 20,000 (95% CI=17,000-23,000), with Ma=0.04 (SE=.002) and K=29,000 (SE=2,500)(Fig. 3). Fitting the data to the Gulf pup estimates and taking into account ice conditions resulted in a 2012 pup production estimate of 7,000 (95% CI=2,900-15,200), a total population of 49,000 (95% CI=27,000-102,000), Ma=0.06 (SE=0.008), and K=45,000 (SE=5,000) (Fig. 3).

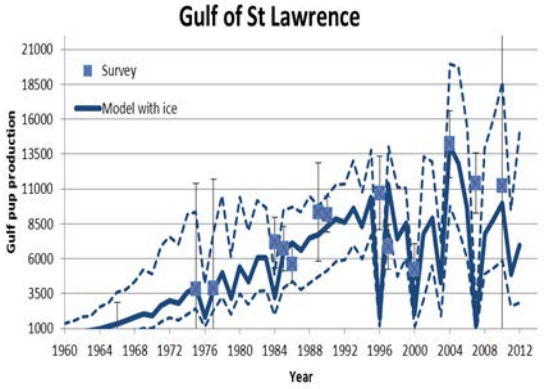
Combining all three herds, total grey seal 2012 pup production in Atlantic Canada is estimated to be 76,200 (95% CI=60,000-105,000) animals, with a total population of 331,000 (95% CI=263,000-458,000)(Fig. 3).

The estimate of the Canadian grey seal population, based on the new model (331,000; 95% CI=263,000-458,000), is less than what was estimated for the population in 2010 (348,900; 95% CI 291,300-414,900). The differences between the two estimates reflect differences in modeling approaches alone, and do not reflect any underlying change in the status of the population. Projecting ahead to 2012 suggests that there has been limited growth (approximately 2% per year) in the population since 2010, owing to a decline in the rate of increase in the Sable Island herd.

A)



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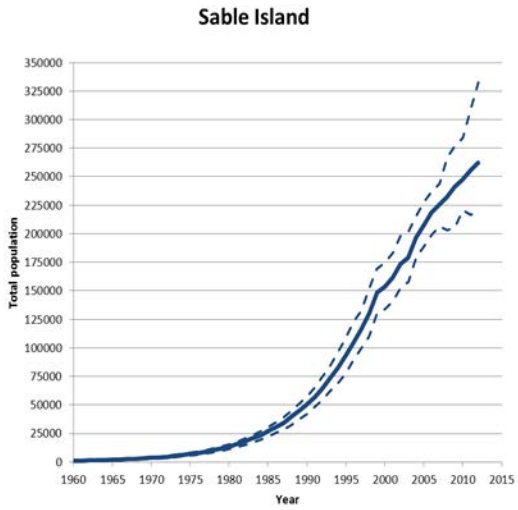
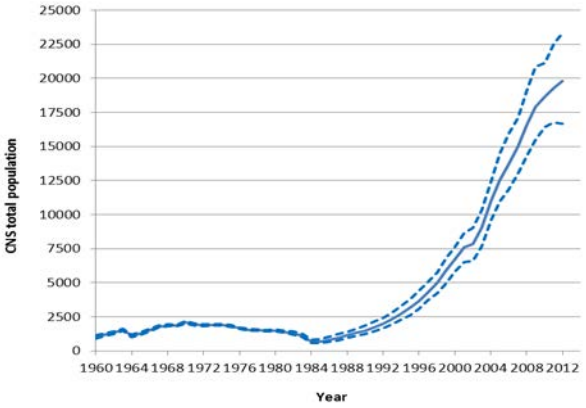
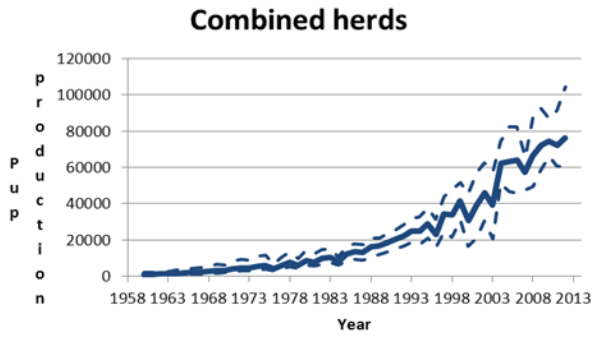



C)



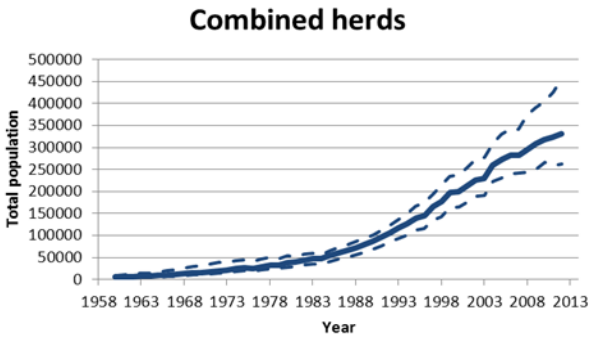




*Figure 3. Estimated trajectories (mean ±95% CI) of pup production (A), the total population for each herd (B) and the entire Canadian Atlantic population (C).*

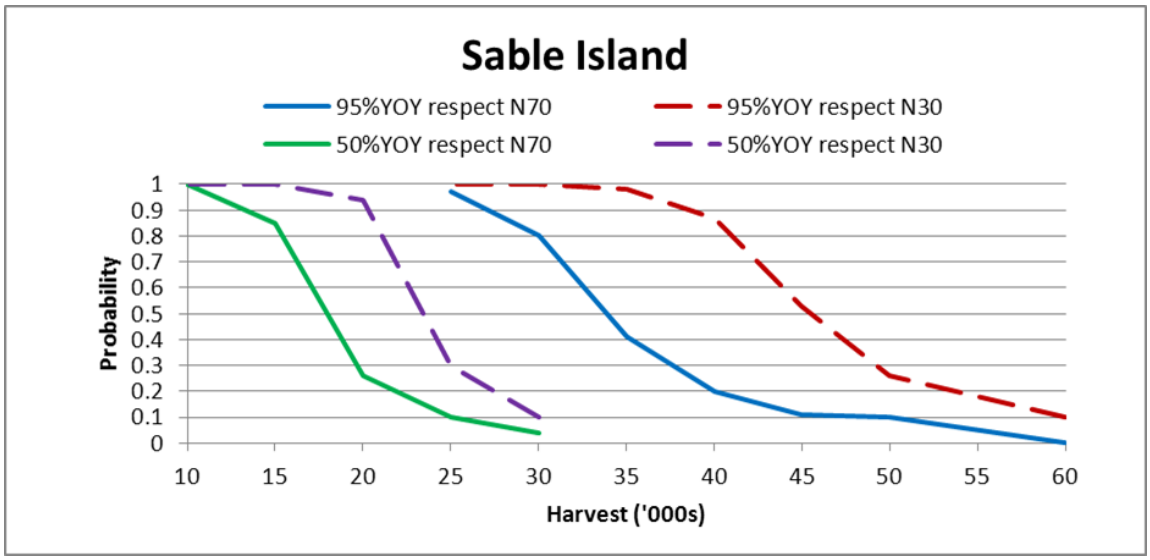
## Assessment of Population Consequences of Harvest Strategies

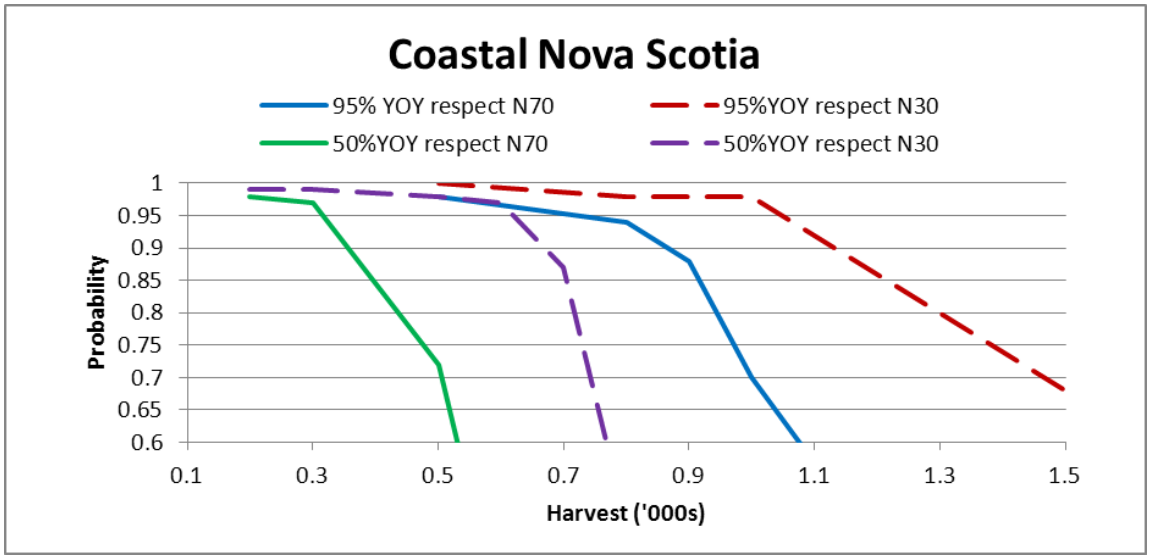
The population dynamics model was used to investigate the consequences of a range of harvest strategies on the future population trends. Harvest advice was provided for each herd separately. For the Sable Island herd, different harvest levels and the probability that they would respect N70 or N30 are shown in Fig 4. Probabilities of remaining above N70 or falling below

N30 for each harvest composition can be read from Fig. 4. Assuming that future reproductive rates are constant, a two year TAC, with an annual harvest of up to 30,000 animals assuming Young of the Year (YOY) comprise 97% of the catch, would respect the management objective of remaining above N70, while a harvest of 37,000 would have a 95% probability of remaining above N30. If YOY only comprised 50% of the catch, then a harvest of 15,000 would continue to respect the management objective of N70, while a harvest of 20,000 would have a 95% probability of remaining above N30 (Fig. 4).

For the Coastal Nova Scotia herd, assuming that future reproductive rates remain constant, a two year TAC, with an annual harvest of up to 3,200 animals assuming YOY comprise 95% of the catch, would respect the management objective of remaining above N70. A harvest of 4,000 would have a 95% probability of remaining above N30. If YOY only comprised 50% of the catch, then a harvest of 1,900 would continue to respect the management objective of N70, while a harvest of 2,100 would have a 95% probability of remaining above N30 (Fig 4).

For the Gulf herd, assuming that future reproductive rates are constant, a two year TAC, with an annual harvest of up to 3,500 animals (assuming YOY comprise 97% of the catch) would respect the management objective of remaining above N70. A harvest of 5,500 would have a 95% probability of remaining above N30. If YOY only comprised 50% of the catch, then a harvest of 2,000 would continue to respect the management objective of N70, while a harvest of 3,000 would have a 95% probability of remaining above N30. Assuming that future reproductive rates changed in a density-dependent manner related to population size resulted in annual harvests that respected the plan declining to 2,500 if the harvest was 97% YOY and 2,100 if the harvest was comprised of 50%YOY (Fig. 4).



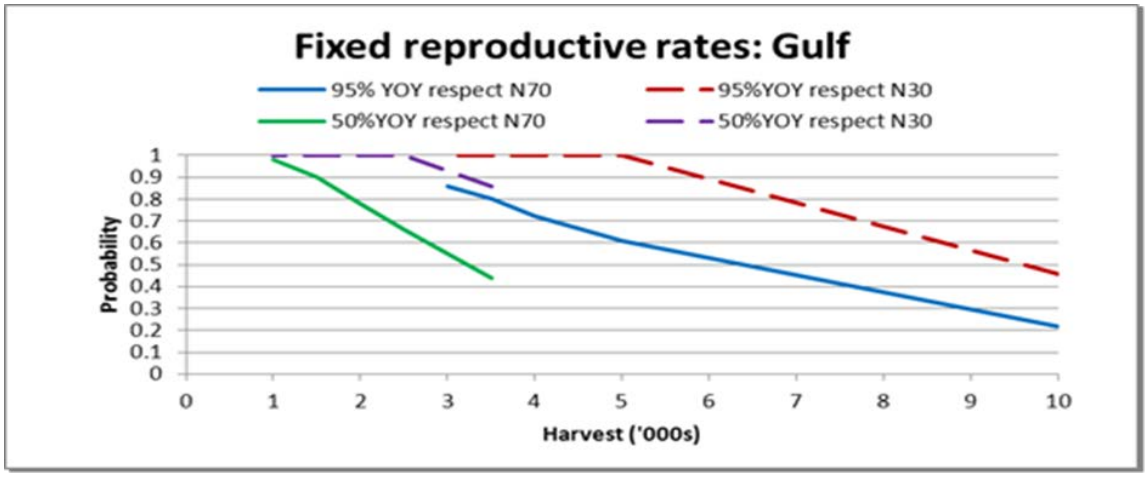




*Figure 4. Different harvests and the probability of respecting N30 and N70 for each herd.*

## Sources of Uncertainty

The main source of uncertainty in this advice is related to the reproductive rate data. In the past, samples obtained in the Gulf of St Lawrence were used to model the dynamics of all three herds. The decline in reproductive rates and modelled decline in pup production in all areas during 2010-2012 is not supported by observations in each area. This is particularly true, where sighting probabilities from the mark-recapture model for Sable Island, can be used as a minimum measure of average birth rates. This index does not show a decline during 2010-2012. During 2010-2012, there was a change in how the reproductive rate material was collected and this may have had an effect on the data. This needs to be examined.

As outlined above, reproductive rates data collected from Gulf of St Lawrence are used to fit the model for the Sable Island herd. Up to 2008 this appears to be appropriate, but birth rate data for the Sable Island herd are needed. Robust analysis of mark-resighting data should provide this information.

Estimates of pup production in the Gulf have been quite variable. This appears to be due to three factors. Grey seals in the Gulf of St Lawrence have their young on small islands and on the ice. In recent years, new colonies have developed, e.g., Brion Island, Anticosti Island. At these new colonies, single counts are completed, and these counts are not corrected for births after the counts have been completed, although numbers appear to be still low in these areas. Secondly, grey seals use both small islands and the pack-ice as substrates for pupping. Mortality on the ice can be quite variable depending on conditions and this can have an important impact on survey estimates. Finally, the reproductive rate data are an important component in the population model, and recent data suggests that pregnancy rates have declined. However, visual impressions in areas such as Pictou Island, which is now the largest colony in the Gulf do not support the indications that reproductive rates are declining (Hammill personal observation).

There is also uncertainty associated with the dynamics of the Coastal Nova Scotia herd, since reproductive rate data are lacking for this area and overall there are fewer counts. If mild winters continue, then expansion may be expected in areas where there is little human disturbance. The accuracy of the assessment will be affected by the detection of new colonies as they develop.

A large number of nuisance seal licences have been issued in Nova Scotia. However, there is incomplete reporting on removals under the nuisance seal permit program. Also, removals from the Scotia Shelf have been assigned to the Sable Island herd. Animals from other herds are likely taken, but the impact of this is not known.

# 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 are a cosmetic nuisance and increase costs associated with processing of fish. 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

The Grey seal population in Atlantic Canada appears to be levelling off, owing to increased juvenile mortality and declines in births in the Gulf. The Sable herd is still increasing, but this rate of increase is slowing down.

The Coastal Nova Scotia and Gulf of St Lawrence herds do not appear to have shown much change in abundance since the last assessment in 2010. Estimates of the Coastal Nova Scotia herd are driven primarily by pup counts from Hay Island, the largest pupping site in the Coastal Nova Scotia herd.

In the Gulf of St Lawrence, there has been considerable variability in the survey estimates of pup production. Pup mortality is considered to be higher in this area, owing to changes in ice conditions. By incorporating ice-related mortality and density dependent changes in juvenile mortality, the model appeared to provide a better fit to the pup survey data than previous assessments. The model suggests that there has been little change in abundance over the last decade, but this is affected by the uncertainty in survey estimates and the reproductive data.

The Sable Island herd is the largest of the three herds. Reproductive rate information specific to this group are needed to reduce uncertainty associated with model projections.

The harvest levels that continued to respect the management framework were much lower than identified in the previous advice. These results from the apparent decline in reproductive rates indicated by samples collected in the Gulf of St Lawrence. Also, previous harvest advice over time-frames of 3-5 years did not take into account demographic momentum induced by harvesting and therefore likely underestimated the probability of a population decline.

There was a request for advice on harvest levels examined different probabilities that harvests would remain above N70 and N30. There is considerable demographic momentum when a harvest is directed primarily towards young of the year. This is because it will be several years before the effects of these removals will impact the dynamics of the population. Simulation work on harp seals has shown that this demographic momentum continues over a period of 15 years and this is taken into account when evaluating the probability of harvests causing the population to fall below N70. The demographic momentum would be greater, but the longer term effects of harvest advice that considers lower probabilities of respecting N30 have not been examined.

## SOURCES OF INFORMATION

This Science Advisory Report is from the October 29 to November 2, 2012 Annual meeting of the National Marine Mammal Peer Review Committee. Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

den Heyer, C., Bowen, W. D., McMillan, J. I. 2013. Long-term changes in grey seal vital rates at Sable Island estimated from POPAN mark-resighting analysis of branded seals. DFO, Can. Sci. Advis. Sec. Res. Doc. 2013/021. vi + 23 p.

Hammill, M.O., Bowen, W.D. and den Heyer, C. 2013. Northwest Atlantic Grey Seal Population Trends, 1960-2012. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/169. vi + 35 p.

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