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Canadian Science Advisory Secretariat
Quebec and Maritimes Regions | Science Advisory Report 2014/010

# STOCK ASSESSMENT OF CANADIAN GREY SEALS *(HALICHOERUS GRYPUS)*

*Photograph by W. D. Bowen*

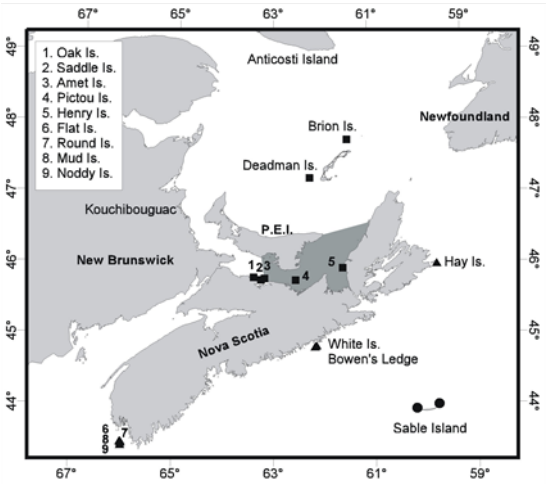


*Figure 1. Southern gulf of St Lawrence and Scotian Shelf showing location of Sable Island (●), coast of Nova Scotia (▲), Gulf (■) grey seal colonies and general location of ice-breeding animals (dark grey area).*

## 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 has been to maintain an 80% probability that the population will remain above 70% (N70) of the largest estimated population size (Nmax). N30, corresponding to 30% of Nmax, is the level below which the population is considered to suffer serious harm.*

*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, have shown little to no sign of recovery. Predation by grey seals is considered to be one of the factors involved in this lack of recovery for some stocks, particularly the southern Gulf of St. Lawrence cod stock (NAFO fishing zone 4T).*

*Given interest in commercial hunting and the potential for population management of grey seals, advice is required on trends in population size and the impact of harvest age composition and level on future population trends of grey seals. Science was requested to provide advice for the following scenarios for a new five-year management plan (2014-2018). The management objective is to maintain an 80% probability that the population would remain in the healthy zone. Consequently, what is the risk that the Grey seal population will drop below 50% and 70% of Nmax at a TAC of 50,000, 60,000, 70,000 and 90,000, 100,000 with a composition of 30% adults / 70% beaters; 10% adults / 90% beaters; 5% adults / 95% beaters.*

*Advice has also been requested on the 'triggers' that might be used to indicate a need to reassess the population and TAC within the multi-year management plan.*

## SUMMARY


- Canadian 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 (Sable), while 15% are born in the Gulf of St Lawrence (Gulf) and 4% are born along the coast of Nova Scotia (CNS). These proportions have 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 2012 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 2014 grey seal pup production in Atlantic Canada of 93,000 (95% CI=48,000-137,000) animals, with an associated total population of 505,000 (95% CI=329,000-682,000). The model predicts that population size in all three management areas continues to grow.
- The current estimate of population size is higher than what was presented in the last assessment. The higher estimate of population size results from differences in the reproductive rates applied between the two assessments, as well as relaxing the limits on environmental carrying capacity in the current assessment which allowed the modelled population to increase more rapidly. Although, there is evidence of a reduction in juvenile survival on Sable Island, there is not sufficient information in the time series of pup production to estimate the carrying capacity. This is reflected in higher estimates of total population.
- Removals from the population during the last five years include animals taken in the commercial harvest, for scientific collections and as nuisance seals (seals removed for damaging gear and catches). Estimates of the number of seals killed as nuisance seals are poorly known. There are 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. To maintain an 80% probability of staying above N70 and assuming that young of the year (YOY) comprise 95% of the catch, then harvests of 39,200 animals (Sable:33,000; CNS:1,200; Gulf:5,000) could be taken. If YOY comprise 90% of the catch then the maximum total harvest would be 36,600 (Sable=31,000; CNS: 1,100; Gulf: 4,500). If YOY comprise 70% of the catch, then the total harvest would be 28,200 (Sable: 24,000; CNS: 700; Gulf: 3,500). Higher harvest levels would result in lower probabilities of remaining above N70.
- If the management objective is to maintain an 80% probability of staying above N50 and assuming that YOY comprise 95% of the catch, then harvests of 43,400 animals (Sable:36,000; CNS:1,400; Gulf:6,000) could be taken. If YOY comprise 90% of the catches then the maximum total harvest would be 40,700 (Sable=34,000; CNS: 1,200; Gulf: 5,500). If YOY comprise 70% of the catch, then the maximum total harvest would be 30,900 (Sable: 26,000; CNS: 900; Gulf: 4,000).
- Advice was request to evaluate the risk of falling below N70 and N50 for harvests of 50,000, 60,000, 70,000 and 90,000, 100,000 seals per year, assuming age compositions of 95%, 90% and 70% young of the year. Assuming that harvests are proportional to pup production in each herd (0.04 CNS, 0.19 Gulf, 0.77 Sable), the risk of falling below N70 and N50 for a total harvest of 50,000 with 95% YOY, are 0.76 and 0.73 for CNS, 0.56 and 0.52 for the Gulf, and 0.25 and 0.22 for Sable. For a total harvest of 50,000 with 70% YOY, the probabilities of falling below N70 and N50 are 0.86 and 0.86 for CNS, 0.73 and

0.71 for the Gulf, and 0.36 and 0.34 for Sable. The risk of falling below N70 and N50 increases with increased harvest levels.

- A new pup production estimate is needed to reduce uncertainty in the estimate of grey seal population size.
- Several factors should be monitored to determine if a multiyear TAC should be re-evaluated. In general, significant changes in any of the major assumptions used in the projections should trigger a new analysis; the most important being annual reproductive rates. Significant changes in the age structure of the harvest or mortality should also result in a re-analysis.

# BACKGROUND

The current status of the Canadian Atlantic grey seal population (*Halichoerus grypus*) was re-assessed. The dynamics of the population was described using an age-structured model that incorporates data on reproductive rates updated to 2012, removals and estimates of ice-related mortality updated to 2013. 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. A new five-year management plan is to be developed beginning with the 2014 harvest season.

## 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 230 cm and weigh as much as 350 kg. Females are smaller, reaching 200 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 colonies. Grey seals are a coastal and continental shelf species feeding on a wide variety of forage fish and groundfish species.

## Human Induced Mortality

There is a small commercial harvest for grey seals (Table 1). Harvests occur in the Gulf of St. Lawrence and along Coastal Nova Scotia. Animals are also taken under scientific permit, under a nuisance seal permit provision of the Marine Mammal Regulations, and as incidental catches in commercial fisheries. There is no information on the magnitude of this latter mortality although numbers are thought to be small. 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.*

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|
| **Commercial harvest 1+** | 1,471 | 263 | 58 | 215 | 218 | 106 |
| **Science collections** | 0 | 0 | 0 | 320 | 90 | 0 |
| **Nuisance seals[1]** | 3,018 | 5,218 | 1,853 | 1,722 | 5,428 | 3,525 |

## ASSESSMENT

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 combines estimates of pup production with data on reproductive rates (age-specific pregnancy rates) and mortality from removals, including seals that are struck and lost.

Reproductive rates have been high among Gulf of St. Lawrence grey seals throughout most of the time-series (Fig. 2). Since 2009, there has been an apparent decline in reproductive rates across age classes 4-7 years old, but sample sizes are small and therefore this conclusion is uncertain. There is no evidence of a similar decline for animals age 8 years and older, which produce 75% or more of the pups (Fig. 2).

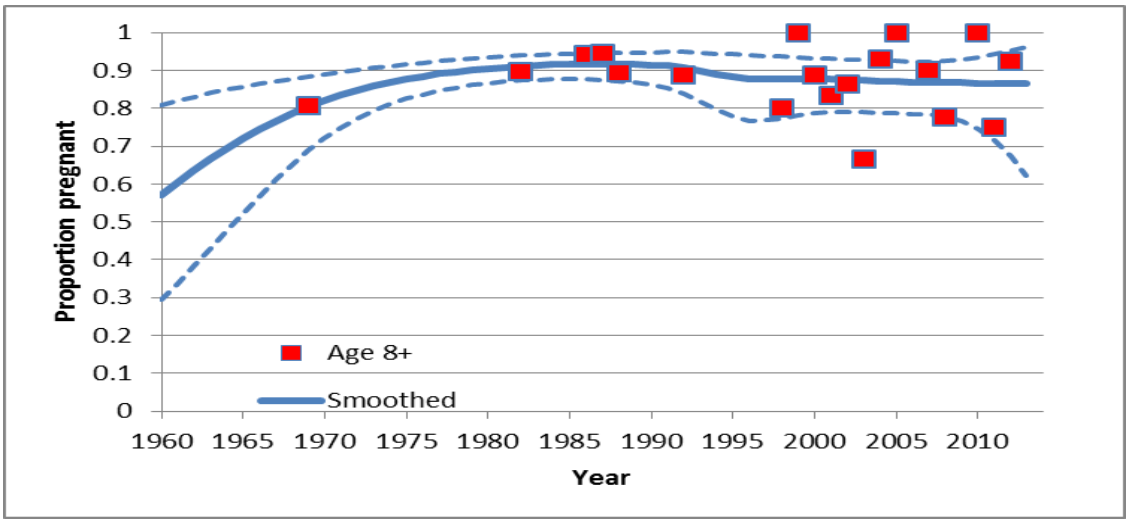


*Figure 2. Reproductive rates and non-parametric smoothed rates for animals aged 8 and older for the period 1960 to 2012. Dotted lines represent 95% CI. Animals aged 8+ years account for approximately 75% of the pup production.*

An analysis of sightings of individually branded females on the Sable Island breeding colony during two time periods, 1987-1999 and 1998-2002, was used to estimate juvenile survival (weaning to age 4), adult survival, age at first birth, and sighting probabilities (ages 4 to 14), which can be used as a proxy for average birth rate (den Heyer et al. 2013). Estimated apparent survival rates of adult females averaged 0.95 between 1987 and 1999, and 0.97 between 1998 and 2002. Estimated average age of first birth (over ages 4 to 14 yr) for cohorts brandied in mid-80s and those branded between 1998 and 2002, increased from 5.6 to 6.5. However, the change in apparent juvenile survival was most notable with a decrease from 0.78 for the 1980s

cohorts to 0.33 for the recently branded cohorts. As non-breeding female grey seals are not sighted, the capture probability in this mark-recapture analysis is the product of probability of breeding and the probability of being sighted in a given year, and thus provides a lower bound for average birth rates at 53 to 78 %, which is broadly consistent with the reproductive rates estimated from the Gulf of St. Lawrence samples (Fig. 2).

## Pup Production

Females in the eastern Canadian grey seal population give 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 eastern Canadian grey seals in 2010 (the most recent survey) was estimated to be 76,300 (SE=6,500). This consists of 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%) were born on Sable Island, 15% were born in the Gulf and 4% were born along Coastal Nova Scotia. This geographic distribution has changed over time, with a decline in the fraction of pups born on the ice compared to on small islands, and an increase in the proportion of animals born along Coastal Nova Scotia, compared to the Gulf.

## Population Model

An age-structured model that incorporates information on age-specific reproductive rates and removals was fitted to the time series of estimated pup productions by adjusting the model estimates of initial population size, adult mortality rate, and environmental carrying capacity. The model is fitted to each grey seal herd separately and it is assumed that the movement of breeding animals between herds does not occur. It is also assumed that reproductive rates are similar in all three herds and that these rates can be described using age-specific reproductive rates from the Gulf of St. Lawrence.

The model was fitted to the pup production estimates from all three herds using the reproductive data up to 2012. It predicts that the population is continuing to grow. Overall, the population increased at an annual rate of 5.2 % between the survey completed in 2007 and that completed in 2010. Since then, the model predicts that the population has continued to grow at a slightly slower rate of 4.5% per year.

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 2014 pup production estimate was 71,000 (95% CI=39,000 - 123,000), and the associated total population estimate is 394,000 (95% CI 238,000 - 546,000). Adult mortality (M) rate was estimated to be 0.07 (SE=0.01). The environmental carrying capacity (K) was estimated to be 815,000 (SE=260,000). Fitting the model to the Coastal Nova Scotia estimates of pup production results in a 2014 pup production estimate of 3,500 (95% CI =2,000 - 6,000), and a total population of 13,800 (95% CI=9,300-27,300), with M=0.037 (SE=0.01) and K=16,700 (SE=9,000) (Fig. 3). Fitting the model to the Gulf pup surveys and taking into account ice conditions resulted in a 2014 pup production estimate of 18,000 (95% CI=8,000-35,000), a total population of 98,000 (95% CI=54,000 - 179,000), M=0.07 (SE=0.01), and K=545,000 (SE=326,000) (Fig. 3).

Combining all three herds, grey seal pup production in 2014 is estimated to be 93,000 (95% CI=48,000 -137,000) animals, with a total population of 505,000 (95% CI=329,000 - 682,000) (Fig.3).

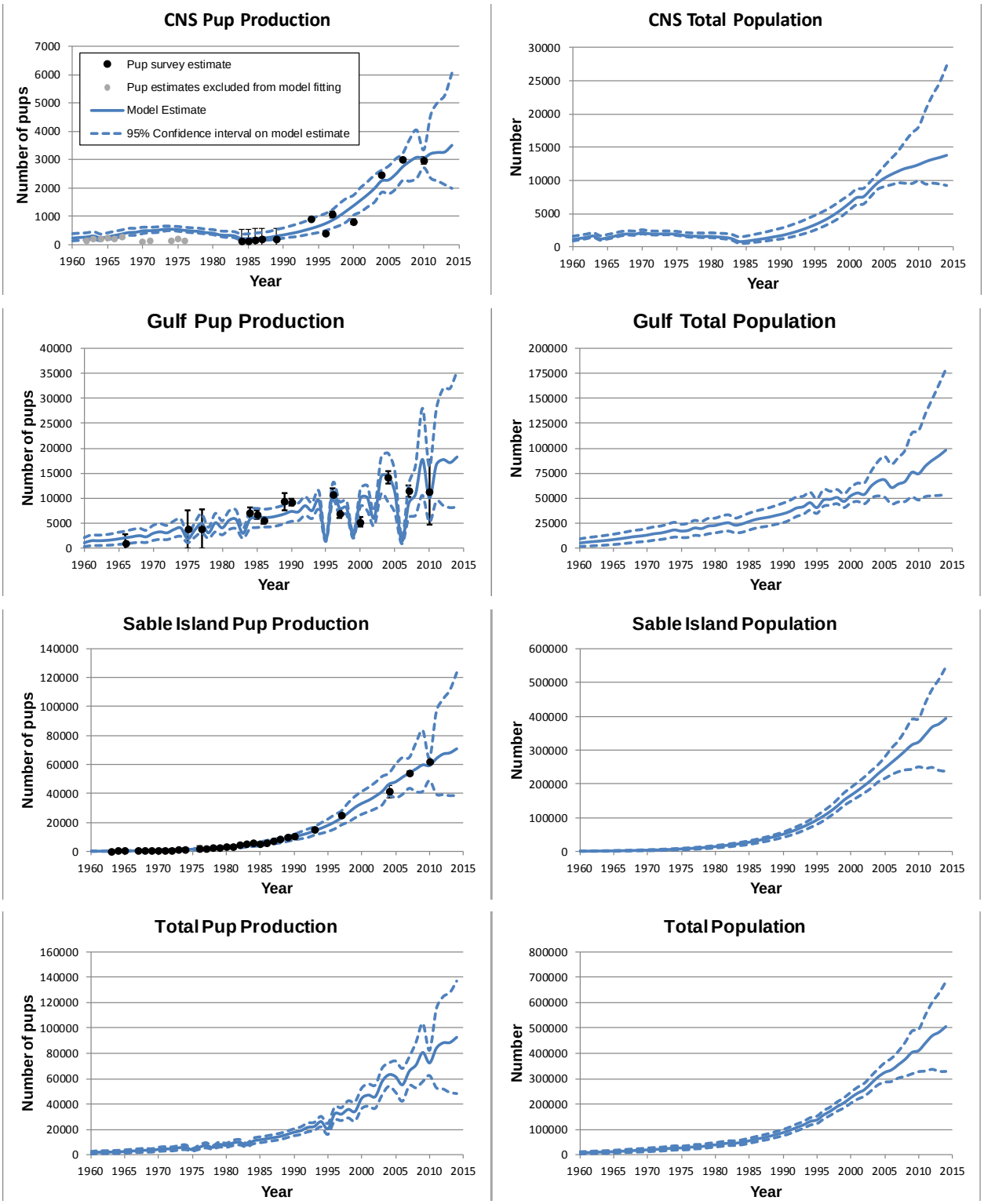


*Figure 3. Estimated trajectories (mean ±95% CI) of pup production (left), the total population for each herd (right) and the entire Canadian Atlantic population (bottom row).*

The estimate of the total Canadian grey seal population in 2012 from this assessment model (469,000, 95% CI=337,000 to 602,000) is greater than the estimate for 2012 of 331,000 (95% CI=263,000 to 458,000) presented at the last assessment (DFO 2013). Differences from the previous assessment result from using updated reproductive rates and changes in some model assumptions. Marine mammal populations are expected to level off as they approach environmental carrying capacity (K). This is expected to result from a decline in juvenile survival, followed by a decline in age-specific reproductive rates, and finally a reduction in adult survival. These population responses are referred to as density-dependent changes in the population. Grey seals were severely depleted by the mid-1800s, and have been recovering from this depletion since the 1960s. The environmental carrying capacity for this population is not known, nor is there sufficient information available concerning the form of the density–dependent relationship which describes the reduction in population growth rate as the population approaches the carrying capacity. Recent information on juvenile survival indicates that density-dependent factors are affecting the Sable Island herd, but such data are not available for the other herds. Neither reproductive rates nor the time series of pup production estimates show significant slowing in population growth that would be indicative of a population approaching carrying capacity. Unfortunately, without a strong signal from the reproductive rates or pup surveys, the population model is unable to estimate the environmental carrying capacity with much confidence. Consequently, we allowed the model to explore a wider range of carrying capacity limits. This, along with the updated reproductive rates reduced the strength of density dependence operating on juvenile survival resulting in larger estimates of population size.

## 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 (Table 2). Overall, harvests of 39,200, 36,600 and 28,200 animals, respectively, comprised of 95%, 90% and 70% YOY would have an 80% probability of remaining above N70 during the management plan. Harvest of 43,400, 40,700 and 30,900 animals, respectively, comprised of 95%, 90% and 70% YOY would have an 80% probability of remaining above N50.

*Table 2. Harvest levels that have 80% or greater probability of respecting N70 and N50 and 95% or greater probability of respecting N30. Probabilities were calculated for harvest levels incremented by 100 animals for CNS, 500 for the Gulf and 1000 for Sable Island herds.*

| Harvest Strategy | Herd | Reference Level | | |
|---|---|---|---|---|
| | | **N70** | **N50** | **N30** |
| ***A - Harvest 95% YOY*** | CNS | 1,200 | 1,400 | 1,300 |
| | Gulf | 5,000 | 6,000 | 5,000 |
| | Sable | 33,000 | 36,000 | 29,000 |
| | **Total** | 39,200 | 43,400 | 35,300 |
| ***B - Harvest 90% YOY*** | CNS | 1,100 | 1,200 | 1,200 |
| | Gulf | 4,500 | 5,500 | 4,500 |
| | Sable | 31,000 | 34,000 | 2,6000 |
| | **Total** | 36,600 | 40,700 | 3,1700 |
| ***C - Harvest 70% YOY*** | CNS | 700 | 900 | 900 |
| | Gulf | 3,500 | 4,000 | 3,500 |
| | Sable | 24,000 | 26,000 | 21,000 |
| | **Total** | 28,200 | 30,900 | 25,400 |

For the Sable Island herd, harvests of 33,000, 31,000 and 24,000 animals would respect N70, assuming a composition of the catch of 95%, 90% and 70% YOY, respectively. Harvests of 36,000, 34,000 and 26,000 would respect N50, assuming an age composition of the catch of 95%, 90% and 70% YOY, respectively.

For the Coastal Nova Scotia herd, an annual harvest of up to 1,200, 1,100 and 700 animals would respect N70 assuming an age composition of the catch of 95%, 90% and 70% YOY, respectively. Harvests of 1,400, 1,200 and 900 would respect N50, assuming an age composition of the catch of 95%, 90% and 70% YOY, respectively.

For the Gulf herd, an annual harvest of up to 5,000, 4,500 and 3,500 animals would respect N70 assuming an age composition of the catch of 95%, 90% and 70% YOY, respectively. Harvests of 6,000, 5,500 and 4,000 would respect N50, assuming an age composition of the catch of 95%, 90% and 70% YOY, respectively.

Fisheries management requested Science to evaluate the risk of falling below N70 and N50 for harvests of 50,000, 60,000, 70,000 and 90,000, 100,000 seals per year, assuming age compositions of 95%, 90% and 70% young of the year. Although Canadian grey seals form a single population, the dynamics of the three herds differ. Consequently, each herd is assessed separately and it was assumed that all animals were in their resident areas. To evaluate the risk of an overall harvest of 50,000 to 100,000 animals causing the population to decline below N70 and N50, harvest effort was allocated to each herd assuming that they are proportional to pup production in each herd (0.04 CNS, 0.19 Gulf, 0.77 Sable) (Table 3).

*Table 3. Decision table reporting the probability of falling below N70 and N50 based on regional allocations for different harvest levels, assuming that harvests are proportional to pup production (0.04 CNS, 0.19 Gulf, 0.77 Sable), under 3 harvest strategies (95, 90 and 70% YOY).*

| **Total TAC** | **CNS** | | | **Gulf** | | | **Sable** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **TAC** | **N70** | **N50** | **TAC** | **N70** | **N50** | **TAC** | **N70** | **N50** |
| ***A - Harvest 95% YOY*** | | | | | | | | | |
| **50,000** | 2,000 | 0.76 | 0.73 | 9,500 | 0.56 | 0.52 | 38,500 | 0.25 | 0.22 |
| **60,000** | 2,400 | 0.83 | 0.81 | 11,400 | 0.64 | 0.62 | 46,200 | 0.31 | 0.3 |
| **70,000** | 2,800 | 0.85 | 0.85 | 13,300 | 0.69 | 0.67 | 53,900 | 0.41 | 0.39 |
| **90,000** | 3,600 | 0.89 | 0.88 | 17,100 | 0.78 | 0.76 | 69,300 | 0.69 | 0.66 |
| **100,000** | 4,000 | 0.92 | 0.91 | 19,000 | 0.83 | 0.8 | 77,000 | 0.83 | 0.81 |
| ***B - Harvest 90% YOY*** | | | | | | | | | |
| **50,000** | 2,000 | 0.8 | 0.79 | 9,500 | 0.6 | 0.57 | 38,500 | 0.27 | 0.26 |
| **60,000** | 2,400 | 0.85 | 0.84 | 11,400 | 0.69 | 0.67 | 46,200 | 0.34 | 0.33 |
| **70,000** | 2,800 | 0.87 | 0.86 | 13,300 | 0.73 | 0.71 | 53,900 | 0.46 | 0.44 |
| **90,000** | 3,600 | 0.92 | 0.91 | 17,100 | 0.81 | 0.8 | 69,300 | 0.78 | 0.76 |
| **100,000** | 4,000 | 0.94 | 0.94 | 19,000 | 0.87 | 0.86 | 77,000 | 0.9 | 0.89 |
| ***C - Harvest 70% YOY*** | | | | | | | | | |
| **50,000** | 2,000 | 0.86 | 0.86 | 9,500 | 0.73 | 0.71 | 38,500 | 0.36 | 0.34 |
| **60,000** | 2,400 | 0.88 | 0.88 | 11,400 | 0.79 | 0.78 | 46,200 | 0.5 | 0.48 |
| **70,000** | 2,800 | 0.92 | 0.92 | 13,300 | 0.84 | 0.83 | 53,900 | 0.71 | 0.69 |
| **90,000** | 3,600 | 0.98 | 0.97 | 17,100 | 0.9 | 0.9 | 69,300 | 0.97 | 0.96 |
| **100,000** | 4,000 | 0.99 | 0.99 | 19,000 | 0.93 | 0.92 | 77,000 | 0.99 | 0.99 |

The evaluation of the risk of different TAC levels on the population differ substantially from the advice provided in 2012, but is similar to some scenarios presented in the 2011 advice. The higher harvest levels in this advice, compared to 2012, result from differences in the reproductive rates applied between the two assessments, as well as relaxing the limits on environmental carrying capacity in the current assessment, which allowed the population to increase more rapidly.

The 2011 advice indicated that the population could sustain higher harvest levels than what is recommended in the current advice. This difference results from a change in our to evaluating harvest impacts on the population. In the 2011 advice, the impacts of certain harvest scenarios were examined over a short time frame of 3-5 years, which allowed for higher relative harvest levels compared to our understanding of the population at that time However, when harvests target young of the year, as is common for seals, the full impact of the harvest will not be expressed in the population until the young are fully recruited into the breeding population. Therefore, the assessment of the impact of proposed harvests should be extended to cover the lifespan of the species, to determine the consequences of removals on the full age structure. The TAC levels provided here were assessed over 30 years, and are similar to TAC levels from scenarios examined in 2011 when harvest impacts were examined over a similar period.

## Triggers for re-assessment

Several factors should be monitored to determine if a multiyear TAC should be re-evaluated. In general, significant changes in any of the major assumptions used in the projections should trigger a new analysis. The most important of these assumptions is associated with annual monitoring of reproductive rates; changes in reproductive rates either leading to an increase or to a decrease in productivity, will have an important impact on the trajectory of the population. A significant decline in average reproductive rates, or multiple years with rates below the average rates used in these projections should trigger a re-assessment to ensure that the TACs will not adversely harm the population. Significant changes in the magnitude and age structure of the harvest or a major unusual mortality event would also result in a need to re-evaluate the TAC.

## Sources of Uncertainty

There are four principal sources of uncertainty which have a significant impact on our understanding of the dynamics of grey seal population in Atlantic Canada. These are (1) current levels of pup production, (2) reproductive rates, (3) carrying capacity and the nature of density-dependent relationships, and (4) the sex ratio of seals age 1 year and older in the population. Other sources of uncertainty include reproductive rates in the population projections, the movement of animals between regions, uncertainty in ice-related mortality in the Gulf herd, and to a lesser extent levels of removals.

There are relatively few survey points in the time series to fit population models and to explore population trends over time. DFO has conducted pup production surveys for grey seals every 3-5 years, and sometimes at longer intervals. Relatively infrequent pup production surveys means the impacts of harvests and changes in vital rates or management decisions will only be known 10-15 years later. This is because pups do not begin to recruit to the breeding population until 5-7 years of age Owing to the uncertainties identified above; it is likely that the true risks to the population are underestimated. In many jurisdictions (e.g. USA), the probability that the population suffers serious harm is set at 5% or less. Simulations indicate that this is best achieved, if impacts of harvest scenarios use an 80% or higher probability of remaining above N70 over periods of 15 years or more. The probability of a population suffering serious harm will

likely be greater than 5% if lower thresholds such as N50 are used (Hammill and Stenson 2009).

Important inputs to the population model are estimates of age-specific reproductive rates. Recent samples are quite small, complicating efforts to determine if rates are changing. Although we have data since the late 1960s, in many years and younger age classes, there are few samples. Even among animals aged 8+ years, which account for approximately 75% of the pup production, sample sizes are limited. These data have been smoothed to compensate for any inter-annual changes that are likely due to small samples, as well as interpolating for years where data are missing, but this approach may also dampen any major signals in the reproductive data. As these reproductive data are collected during summer or early fall, they may overestimate birth rates, since late term abortions will not be detected. Although abortions do occur in grey seals, the rate of abortions is not known.

Currently, the reproductive data come from the Gulf herd and are applied to the rest of the Atlantic Canada population. However, this may not be appropriate since the Gulf component only represents less than 20% of the total grey seal population in Canada. Ecosystem conditions in the Gulf and on the Scotia Shelf differ and this may have an impact on reproductive rates of females giving birth on Sable Island.

The population models for all three herds include a density-dependent relationship of first year mortality in such a way that rates change according to an estimated environmental carrying capacity. Currently we have little information to estimate carrying capacity. At the current frequency of surveys every 3-5 years, it could take another 5-10 years to improve our understanding of grey seal dynamics.

Estimates of pup production in the Gulf have been quite variable. This appears to be due to two 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 that occur after the counts have been completed, although numbers are still low in these areas. Secondly, grey seals use pack-ice as a platform for pupping. Mortality on the ice can be quite variable depending on conditions and this can have an important impact on survey estimates of pup production.

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 estimates of production. It is also likely that this population is influenced by immigration from the adjacent larger herds, making it inappropriate to consider this as a separate herd.

The present population model estimates the number of females in the population. Total population size is then determined by assuming the ratio of females to males in the population. Currently, the assumption is that there are equal numbers of males and females, but this assumption needs to be verified. There are several reasons to expect that there are fewer males in the population than females. To the extent this is true, the current model over-estimates population size and therefore the harvest that can be sustained.

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, all 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 for several decades.

## CONCLUSIONS AND ADVICE

The grey seal population in Atlantic Canada continues to increase, but the rate of increase is quite uncertain. There is some evidence that the growth rate is slowing, but there are not enough surveys during the period of reduced growth to be able to describe the dynamics of the density-dependent effects with confidence. The last pup production survey was completed in 2010.

The harvest levels that continued to respect the management framework were much lower than identified in the advice from earlier advice (DFO 2011). This is a result of the rapidly increasing uncertainty associated with not having a recent estimate of pup production and with extending the projection period over 30 years (to reflect the lifespan of the animal) in an attempt to incorporate the impacts of demographic momentum on the future trajectory of the population. Even in the short term, projections are highly uncertain as the model is fitting to a survey time series that ends in 2010, and there is uncertainty in the estimates of reproductive rates, environmental carrying capacity and the form of the density-dependent relationships.

Marine mammal management frameworks in some jurisdictions (e.g., United States) set the risk of a population suffering serious harm at 5% or less. Even assuming that all model assumptions are met, setting harvest levels based on 50% of Nmax results in a >5% risk that the grey seal population will be exposed to serious harm. If any population model assumptions are not met, then this risk will be even higher.

A new pup survey is needed to increase our understanding of Canadian grey seal population size. Without such an assessment, projecting future trends of this population is highly uncertain. A new survey could result in significant changes to our advice.

Several factors should be monitored to determine if a multiyear TAC should be re-evaluated. In general, significant changes in any of the major assumptions used in the projections should trigger a new analysis; the most important being annual reproductive rates. Significant changes in the age structure of the harvest or mortality should also result in a re-analysis.

## SOURCES OF INFORMATION

This Science Advisory Report is from the October 7-11 2013 Annual Meeting of the National Marine Mammal Peer Review Committee (NMMPRC). Additional publications from this meeting will be posted on the Fisheries and Oceans Canada (DFO) Science Advisory Schedule as they become available.

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DFO. 2011. Stock assessment of Northwest Atlantic grey seals (*Halichoerus grypus*). DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2010/091.

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Hammill, M. O. and Stenson, G. B. 2010. A preliminary evaluation of the performance of the Canadian management approach for harp seals using simulation studies. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/093. iv + 47 p.

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*MPO. 2014. Évaluation du stock canadien de phoques gris (Halichoerus Grypus). Secr. can. de consult. sci. du MPO, Avis sci. 2014/010.*