COSEWIC
Assessment and Status Report

on the

Northern Fur Seal
Callorhinus ursinus

in Canada

THREATENED
2010

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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COSEWIC
Assessment Summary

Assessment Summary – November 2010

Common name
Northern Fur Seal

Scientific name
Callorhinus ursinus

Status
Threatened

Reason for designation
Most of the animals that winter in Canadian waters breed at four islands, of which three are in Alaska (two in the Pribilof Islands – St. Paul, St. George – plus Bogoslof) and one in California (San Miguel). Pup production is used as an index of population size. Pup production at the two largest breeding colonies, both in the Pribilof Islands, which presently account for 90% of all fur seals in the eastern Pacific, has been declining for the last 45 years and pup numbers at these colonies have declined by 38% over the last 30 years (3 generations). Numbers of pups have been increasing in the much smaller colony at Bogoslof Island. Taken together, these trends in pup production mean it is likely that numbers of mature individuals will continue to decline. In 2008 there were approximately 650,000 fur seals in the eastern Pacific compared with more than 2 million in the 1950s. There is potential for rescue from Asian colonies in the western Pacific, although little is known about dispersal in mature females. The causes of the declines are unknown, but continuing and potential threats include entanglement, prey limitation, oil spills and the effects of contaminants.

Occurrence
British Columbia, Pacific Ocean

Status history
Designated Not at Risk in April 1996. Status re-examined and designated Threatened in April 2006. Status re-examined and confirmed in November 2010.

COSEWIC
Executive Summary

Northern Fur Seal
Callorhinus ursinus

Wildlife species description and significance

The Northern Fur Seal (*Callorhinus ursinus*, Linnaeus 1758) is a sexually dimorphic species. Mature males are 3.4-5.4 times larger than females and are black to reddish brown. Females are grey-brown along their dorsal surface, and lighter along their ventral surface.

Distribution

Northern Fur Seals range throughout the North Pacific Ocean and Bering Sea. They breed at three sites in Russia (Robben Island, the Kuril Islands and the Commander Islands) and three in the United States (Pribilof Islands, Bogoslof Island, and San Miguel Island). Approximately half of the world population breeds on the Pribilof Islands. Fur seals tend to migrate along the coast of either North America or eastern Asia, depending upon where they breed. Most of the fur seals that winter in Canadian waters breed in the eastern Bering Sea (Pribilof Islands and Bogoslof Island) although tagging data indicate that some of the animals that winter off the west coast of North America (including Canadian waters) originate from breeding sites in Russia.

Habitat

Northern Fur Seals are predominantly pelagic, feeding along the continental slope and shelf break from the Bering Sea to California. Waters off British Columbia are important habitat for migrating and overwintering Northern Fur Seals that breed on islands in the eastern North Pacific. Based on harvest and sampling records the area of LaPerouse Bank off SW Vancouver Island appears to be particularly important for migrating and wintering animals, although juveniles appear also to use nearshore areas. Breeding individuals, of both sexes, exhibit strong fidelity to traditional breeding sites on islands in the North Pacific, and often return to breed at the same specific location in a rookery year after year.

Biology

The Northern Fur Seal is polygynous, with bulls establishing and maintaining territories on land and mating with several females, in a ratio of about nine females to one male. Adult males arrive at the rookery in mid-May. Both sexes reach sexual maturity at 3-7 years of age and have a generation time of about 10 years. Females give birth to a single pup shortly after arriving on shore in June and July. Females typically make 3-10 day foraging trips after giving birth, and return to suckle their pups for 1-2 days. Pups are weaned in late October or early November when they are about 40% of their mother's mass. This rate of growth requires that breeding sites be near feeding grounds that provide an abundance of forage fish such as juvenile Walleye Pollock, Pacific Herring, Northern Anchovy, Capelin, Pacific Hake, Eulachon, Rockfish, myctophids, and salmonids and/or squid. Female and immature fur seals from the Pribilof Islands embark on a southward migration that extends to California, while mature males tend to stay in more northern waters. Mortality to age two is high, but decreases as the animals approach sexual maturity. Northern Fur Seals forage at relatively shallow depths. About seventy different species of prey have been identified in stomachs and scats. In Canadian waters, Pacific Herring is the predominant prey in inshore waters from February through June, whereas in oceanic waters the seals prey almost exclusively on onychoteuthid squids and salmonids. The diet of Northern Fur Seals may have varied over time in response to changes in prey abundance.

Population sizes and trends

The global population of Northern Fur Seals in 2004-2005 was calculated to be ~1.1 million animals, with estimates suggesting that global abundance has declined by about 27% in the last 30 years or three generations. Decline rates have varied between breeding sites. Most Northern Fur Seals that overwinter in or migrate through Canadian waters breed at the Pribilof and Bogoslof Islands in Alaska. Pup abundance at Alaskan breeding sites declined by ~38% from 1978 to 2008, and fitted trends indicate that the total abundance of fur seals at these breeding sites has declined by 36% over 30 years, and has declined by up to 60% since the 1950s.

Since the late 1700s there have been three major declines in the worldwide population of Northern Fur Seals. These global declines have been driven by trends in abundance at the largest breeding sites on the Pribilof Islands. The initial Pribilof Island rookery of 2-3 million was reduced by Russian over-hunting but recovered when killing was limited to immature males. This limitation was disregarded by the U.S. when it purchased Alaska in 1867 and fur seal abundance had declined to ~300,000 animals by the early 1900s. Reinstating the male-only harvest and international protection from at-sea hunting allowed fur seals at the Pribilof Islands to increase to ~2.1 million individuals in the 1950s. However, a harvest program designed to increase the productivity of the population by killing mature females caused a renewed decline through the late 1950s and 1960s. A short-lived recovery occurred in the early 1970s when females were again protected. An unexplained decline of about 6.1% per year occurred between 1975 and 1981. Abundance stabilized at about 900,000 for most of the next two decades, but began to decline steeply again in 1998. This decline was continuing at the time of the most recent surveys in 2008. A large male-only harvest, which ended in 1973 on St. George Island and 1984 on St. Paul Island, likely affected the sex and age structure of fur seals breeding on the Pribilof Islands, and complicates interpretation of trends in abundance. Northern Fur Seals are now taken on the Pribilof Islands only for subsistence use.

A small colony (see later definitions) that became established in 1980 on Bogoslof Island in the southeastern Bering Sea has grown rapidly. Its growth, due partly to immigration from other breeding sites (notably the Pribilofs), likely ensures the continued presence of the species in Canadian waters even if declines on the Pribilof Islands continue. A small colony also became established on San Miguel Island off the coast of California in the early 1960s, after an absence of ~1,000 yrs. The founders of this colony were principally from the Pribilof Islands although a few came from colonies in the western Pacific.

Threats and limiting factors

The ultimate cause of the current decline of fur seals on the Pribilof Islands is not known; the proximate cause appears to be low survival of young seals. Entanglement in marine debris, discarded fishing gear, interactions with commercial fisheries, changes in prey abundance and climate change are thought to be contributing factors in the decline. Oil spills and contaminants pose additional threats. Killer whale predation may have contributed to the decline and could be a limiting factor in the recovery of fur seals in some areas. The relative importance of these threats and limiting factors may have changed over time. Little is known about threats off the coast of British Columbia and in other regions outside the Bering Sea where fur seals migrate and overwinter.

Protection, status, and ranks

In Canadian waters, Northern Fur Seals are protected under the *Marine Mammal Regulations* of the *Fisheries Act* of Canada, which generally forbid hunting or disturbing pinnipeds except for subsistence use. The species was classified by COSEWIC in 1996 as ‘not at risk’. It was reassessed in 2006 and COSEWIC recommended a ‘threatened’ status due to declines in pup production on the Pribilof Islands. This recommendation was referred back to COSEWIC by the Governor in Council for reconsideration. In the United States, Northern Fur Seals are protected by the *Marine Mammal Protection Act*, under which the eastern North Pacific population, specified as consisting of seals from the Pribilof Islands and Bogoslof Island colonies, is designated as ‘depleted’.

Globally the Northern Fur Seal is red-listed by IUCN as ‘Vulnerable’ because the eastern stock contains one half of the world-wide population and it “has experienced a significant, steep decline in recent years and has failed to recover despite the cessation of commercial harvesting. Although the global population is still over a million animals, the current downward trend in abundance remains a mystery”. The Northern Fur Seal is not listed in any of the CITES Appendices.

TECHNICAL SUMMARY

Callorhinus ursinus
Northern Fur Seal — Otarie à fourrure du Nord
Range of occurrence in Canada: Pacific Ocean (Coastal and offshore waters of British Columbia)

Demographic Information

Generation time (York 1983)	10 yrs
Is there a continuing decline in number of mature individuals? (inferred from decline in pups)	Yes
Estimated percent of continuing decline in total number of mature individuals within 5 years or 2 generations	Not calculated
Observed, estimated, inferred, or suspected percent reduction or increase in total number of mature individuals over the last 10 years, or 3 generations * – 36% decline in *total fur seal abundance* (all animals) on rookeries in Alaska (known to overwinter in or migrate through Canadian waters) from 1978-2008 (derived from an exponential decay fitted to pup counts – this document). ** – 38% decline in pup production at Alaskan breeding sites, used as an index of abundance.	-36%* -38%**
Projected or suspected percent reduction or increase in total number of mature individuals over the next 10 years, or 3 generations.	Unknown
Observed, estimated, inferred, or suspected percent reduction or increase in total number of mature individuals over any 10 years, or 3 generations period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased?	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (see text)	>20,000 km^2
Index of area of occupancy (IAO) (see text) * coastal and offshore waters of British Columbia ** area of breeding rookeries at Pribilof and Bogoslof Islands	>2,000 km^2 (BC*) <50 km^2 (breeding**)
Is the total population severely fragmented?	No
Number of locations	N/A
Is there a continuing decline in extent of occurrence?	No
Is there a continuing decline in index of area of occupancy?	Unknown
Is there a continuing decline in number of populations?	No
Is there a continuing decline in number of locations?	No
Is there a continuing decline in habitat?	Unknown
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Pribilof and Bogoslof Islands (44%* of 627,000)	275,880
San Miguel Island (44% of 9,424)	4,150
Total	280,030
* Olesiuk (2007) – for an unexploited population	

Quantitative Analysis

Probability of extinction in the wild is at least:	No

Threats (actual or imminent, to populations or habitats)

Entanglement in debris and abandoned fishing gear and interaction with fisheries Prey availability Climate change Oil spills and contaminants Predation by killer whales (limiting)

Rescue Effect (immigration from outside Canada)

Status of outside population(s) Russia (2006): Commander Islands: 268,000 animals X 44%* = 117,920 mature Robben Island: 128,000 animals X 50% = 56,320 mature Kuril Islands: 126,000 animals X 50% = 55,440 mature * Olesiuk (2007) – for an unexploited population	
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Probably
Is rescue from outside populations likely?	Yes

Current Status

COSEWIC: Threatened (November 2010)

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** A2b
Reasons for designation: Most of the animals that winter in Canadian waters breed at four islands, of which three are in Alaska (two in the Pribilof Islands – St. Paul, St. George – plus Bogoslof) and one in California (San Miguel). Pup production is used as an index of population size. Pup production at the two largest breeding colonies, both in the Pribilof Islands, which presently account for 90% of all fur seals in the eastern Pacific, has been declining for the last 45 years and pup numbers at these colonies have declined by 38% over the last 30 years (3 generations). Numbers of pups have been increasing in the much smaller colony at Bogoslof Island. Taken together, these trends in pup production mean it is likely that numbers of mature individuals will continue to decline. In 2008 there were approximately 650,000 fur seals in the eastern Pacific compared with more than 2 million in the 1950s. There is potential for rescue from Asian colonies in the western Pacific, although little is known about dispersal in mature females. The causes of the declines are unknown, but continuing and potential threats include entanglement, prey limitation, oil spills and the effects of contaminants.	

Applicability of Criteria

Criterion A: Meets Threatened under A2b because there has been a decline of 38% over the last 3 generations based on the pup counts as an index of abundance.
Criterion B: Not applicable
Criterion C: Not applicable as number of mature individuals exceeds the thresholds.
Criterion D: Not applicable
Criterion E: None conducted

PREFACE

The Northern Fur Seal was assessed by COSEWIC as Threatened in 2006, but was referred back to COSEWIC in 2009 on the advice of the Minister of Fisheries and Oceans for consideration of new available information. COSEWIC's status designation was based upon an inferred decline in the abundance of mature animals in the Northern Fur Seal populations which breed on U.S. islands in Alaska. Abundance estimates for Northern Fur Seals are derived from pup counts conducted at breeding sites throughout the range of the species. Although Northern Fur Seals do not breed in Canada, female and immature seals migrate through and overwinter in Canadian coastal and offshore waters. It is this portion of the global Northern Fur Seal population that is considered to use Canadian waters and is thus eligible for assessment by COSEWIC. Most (about 95%) of the Northern Fur Seals overwintering or migrating through Canadian waters are thought to come from Alaskan breeding sites on the Pribilof Islands and Bogoslof Island; the remaining 5% come from Asian breeding locations. Thus, it is the status of the Northern Fur Seal at the Alaskan breeding sites that is considered in this report. About 85% of the fur seals in the Northeast Pacific (and 50% of the world's population) breed on the Pribilof Islands, where pup production has been declining significantly for the last 45 years.

When the Governor in Council (GIC) referred the Northern Fur Seal back to COSEWIC it identified several concerns regarding the assessment. These concerns were based upon a Recovery Potential Assessment conducted by the Department of Fisheries and Oceans (Olesiuk 2007). The first concerns were that new genetic data indicated a lack of genetic structure in the Northern Fur Seal throughout the North Pacific, and that satellite tagging data suggested significant movement of fur seals between breeding grounds and/or across the Pacific basin. This led the GIC to suggest that COSEWIC should assess the global population as being the total population in Canada and not just the animals known to winter in or migrate through Canadian waters. The second concern was that, due to changes in the population structure of fur seals, the pup count data used by COSEWIC to infer declines in fur seal abundance may exaggerate the magnitude of the overall decline. In this status report the new genetic and tagging data are included and the decline in fur seal abundance at Alaskan breeding sites, based upon pup counts, is recalculated to reflect the effects of ending fur seal harvests at the Pribilof Islands.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2010)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada / Environnement Canada
Canadian Wildlife Service / Service canadien de la faune

Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and classification

The Northern Fur Seal (*Callorhinus ursinus*, Linnaeus 1758) is an eared seal in the family Otariidae and is the only extant species of the genus *Callorhinus*. Names in other languages include *Otarie des Pribilofs* (French), *Lobo fino del norte* (Spanish), and *Nördliche Pelzrobbe* (German). Indigenous names for the species include *Hlaaqudax* (western dialect Unangan/Aleut), *Laaqudax* (eastern dialect Unangan/Aleut), and *Algax* (Commander Island dialect Unangan/Aleut)

Morphological description

Northern Fur Seals (Figure 1) are a sexually dimorphic species, with males up to 3.4 times larger than females before mating and 5.4 times heavier during breeding season (Scheffer and Wilke 1953; Trites and Bigg 1996). Adult males have a body mass of 100-200 kg and reach 1.5-2.0 m in length whereas females are 35-45 kg and reach an average length of 1.3 m (Jefferson *et al.* 1993; Trites and Bigg 1996; Gentry 1998). Pup mass is between 4.5 and 5.4 kg at birth, with males about 0.6 kg heavier than females (Trites 1991; Reeves *et al.* 1992). The guard hairs on adult males are black to reddish brown whereas females are grey-brown along the dorsal surface and lighter on the belly. Males have a mane over the shoulders. The under fur is brown on both sexes. Pups are born with black fur and a lighter belly which darkens after the first moult (Scheffer 1962). *Callorhinus* has a short rostrum and does not show the dog-like profile of the other fur seal genus, *Arctocephalus* (Gentry and Kooyman 1986).

Figure 1. The Northern Fur Seal (*Callorhinus ursinus*). Photo by A.W. Trites.

Population spatial structure and variability

Callorhinus is the oldest extant genus of the Otariidae. Results from genetic analyses are consistent with the fossil record and suggest that the Northern Fur Seal diverged from the line leading to the remaining fur seals and sea lions 3-6 million years ago (Kim *et al.* 1975; Repenning *et al.* 1979; Wynen *et al.* 2001).

Mature male and female fur seals show a high degree of philopatry to breeding islands, returning to natal sites to breed (Gentry 1998, Baker *et al.* 1995). In general, reproductive isolation leads to genetic structure in species displaying such levels of philopatry (e.g., Hoffman *et al.* 2006). However, despite this philopatry, recent analyses of both nuclear microsatellites and the mitochondrial (mtDNA) control region of samples collected from Northern Fur Seals at the six existing breeding sites indicate a lack of genetic structure (Ream 2002; Dickerson *et al.* 2010). Using seven microsatellite loci, no significant differentiation was detected across all populations (F_{ST}= 0.004; P = 0.273). Likewise F_{ST} estimates at each locus were not significantly different across all populations ($F_{ST} \leq 0.0026$: $P \geq 0.11$; Ream 2002). MtDNA analyses did not indicate genetic differentiation between breeding islands (AMOVA P = 0.87) or between the eastern and western breeding areas (AMOVA P = 0.80). Including the recently occupied and reoccupied breeding sites, there was slight, but not significant, differentiation between the eastern breeding sites and the Russian breeding sites, suggesting 'some' level of population structure between the western and eastern North Pacific (Dickerson *et al.* 2010). Recent analysis of ancient MtDNA (aMtDNA) from middens along the west coast of North America suggests that population structure was not greater in the past and that dispersal, which facilitates the formation of new breeding sites, along with high abundance prevented the loss of genetic diversity despite a large range contraction 200-800 years ago (Pinsky *et al.* 2010).

The results of these studies, taken together, suggest that despite strong philopatry there is only very weak genetic structure in the Northern Fur Seal population (Ream 2002; Dickerson *et al.* 2010). Dickerson *et al.* (2010) propose that this lack of genetic structure may reflect (a) the (relatively) recent rapid population expansion (post-glacial and post-intense harvest) and (b) some contemporary migration occurring between breeding sites. Those authors did not, however, rule out the possibility of genetic structure in Northern Fur Seals, pointing out that analyses of additional microsatellite loci could reveal structure, as has occurred for other pinniped species (e.g., Trujillo *et al.* 2004). According to Ream (2002), experimental design that involves pooling samples from numerous breeding areas on each island may have obscured genetic structure that exists among breeding areas on the same island.

Breeding dispersal to nonnatal breeding sites is well documented (NMFS 2007). About 1% of the males harvested on the Pribilof Islands had been born at other islands (Lander and Kjimura 1982), whereas from 1958 to 1963 an estimated 12-21% of the tagged juvenile males taken on the Commander Islands came from the Pribilof Islands and less than 1% of the tags came from the closer but smaller colony at Robben Island (NMFS 2007). However, estimates of dispersal using these tagging data may be confounded by differences in tagging effort and harvest rates (Olesiuk 2007).

When fur seals colonized San Miguel Island off California, in the early 1960s, the population increased 45% yr^{-1} from 1969 to 1978, largely due to immigrants from the Pribilofs, Commanders and Robben Island (Antonelis and Delong 1985). Pups were first seen on Bogoslof in 1980; pup production increased 58% yr^{-1} from 1988 to 1997, a rate attributed to female immigration from the Pribilof Islands (Ream *et al.* 1999). Despite these observations, there is no estimate of how often females emigrate, but the rate is thought to be low (Gentry 1998). Females often use other islands to rest during the breeding season, which may have confounded estimates of immigration and emigration rates (NMFS 2007).

Designatable units

In the early 1900s it was thought that Northern Fur Seals breeding at different North Pacific sites represented three distinct species or subspecies (Gentry 1998; Rice 1998). However, later research indicated that these populations were morphologically indistinguishable and *C. ursinus* is currently recognized as a single species (Rice 1998) with no subspecies. The Canadian population of Northern Fur Seals consists primarily of individuals (mostly females and juveniles) from several Alaskan breeding sites that visit Canadian waters during migration or to spend the winter months. It is this portion of the global Northern Fur Seal population that is considered for assessment by COSEWIC. There is no basis for subdividing the population into more than a single designatable unit.

Special significance

The Northern Fur Seal is the only species of fur seal in Canada, and one of only two species of fur seal in the northern hemisphere (the more southern Guadalupe Fur Seal *Arctocephalos townsendii* being the other). In Canada, Northern Fur Seals were hunted by Europeans and Russians off the west coast of Vancouver Island and around Haida Gwaii, perhaps as early as 1866 (Scheffer *et al.* 1984). The commercial hunt was for their pelts, which, when the guard hairs have been removed, produces a luxurious fur. Aboriginal peoples throughout the Aleutian Islands, coastal Alaska, British Columbia, Washington and Oregon have also hunted Northern Fur Seals for several millennia (Gustafson 1968; Huelsbeck 1983; Savinetsky *et al.* 2004; Newsome *et al.* 2007).

Fur seals are killed by Aleuts on the Pribilof Islands in a subsistence harvest, the meat is eaten, and the pelts are used for traditional handicrafts (Corbett and Swibold 2000).

DISTRIBUTION

Global range

The Northern Fur Seal is restricted to the North Pacific Ocean, ranging from central Japan (36ºN) and the Aleutian Islands to the Gulf of Alaska, British Columbia and the U.S.-Mexican border (32ºN) (Figure 2; Gentry 1998). Fossils found in California, Oregon, and Alaska suggest that the species probably evolved within at least part of its present range (Lyman 1988; Gentry 1998; Pyle *et al.* 2001); in fact Northern Fur Seals pre-date some of the islands on which they now breed.

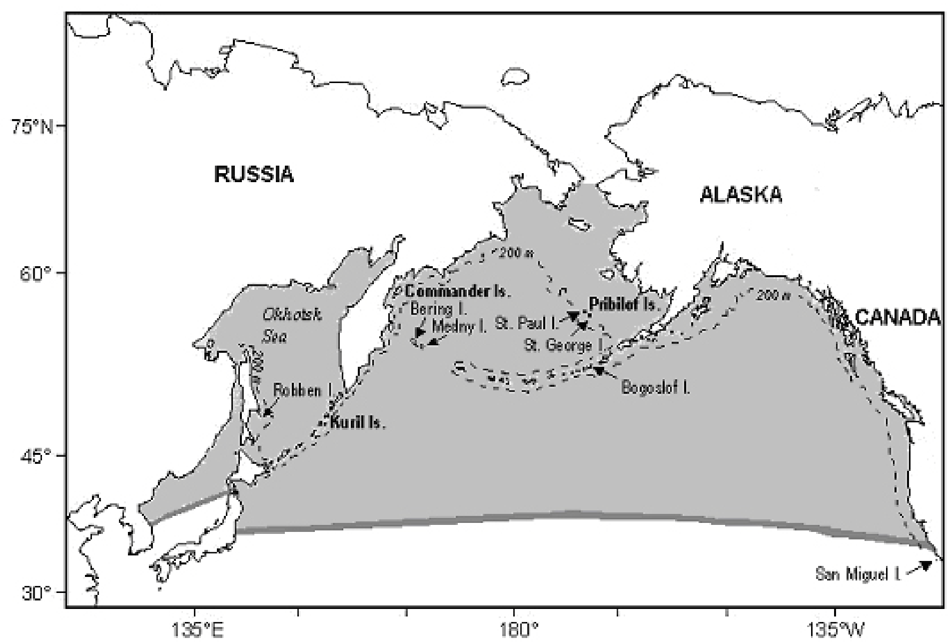

Figure 2. Worldwide range of the Northern Fur Seal and the locations of its breeding islands. The dashed line approximates the 200m isobath; the darker shading represents the southern limit of the pelagic distribution. Modified from Gentry (1998).

Fur-seal bones occur in archaeological sites from California to the Aleutian Islands. All age classes are represented in many of these midden sites, with the presence of unweaned pups confirming that breeding colonies occurred at temperate latitudes in Canada and the U.S. Isotope analyses of teeth and bones indicate that many of these fur seals were resident, and not migrants from northern waters (Burton *et al.* 2001; Gentry 2002; Newsome *et al.* 2007). Why these temperate-latitude breeding populations disappeared is not known.

There is potential for confusion in the terminology used to describe Northern Fur Seal population structure. A ‘rookery’ is a distinct area on an island in which breeding seals congregate; a ‘breeding island’ is an island on which a ‘colony’ of seals breeds; and a population or stock comprises the seals from a group of breeding islands that are thought largely to share a migratory pattern and wintering grounds.

Five management stocks are recognized, based on breeding islands: Robben (Tyulenyi) Island (Russia); the Kuril Islands (Russia); the Commander (Komandorsky) Islands (Russia); the Pribilof Islands and Bogoslof Island (U.S.); and San Miguel Island (U.S.) (Figure 2, NMFS 1993). Breeding on San Miguel Island dates from 1965 (Peterson *et al.* 1968) and on Bogoslof Island from ~1980 (Lloyd *et al.* 1981); some islands in the Kuril chain have also been recolonized (Lloyd *et al.* 1981).

Fur seals tend to migrate off the coast of either North America or Asia (Bigg 1990), so breeding stocks have been grouped as eastern and western ‘populations’ based on the breeding islands and their restricted migratory routes (Figure 2, Gentry 1998). Tags collected from seals caught in the pelagic fur seal harvest indicate that most of the animals wintering in Canadian waters bred on Alaskan islands (Bigg 1990; Loughlin *et al.* 1999). The U.S. National Marine Fisheries Service regards the San Miguel stock as distinct from the ‘eastern North Pacific’ (Alaska-breeding) stock and assesses it separately. The significance of this stock to fur seal abundance in Canadian waters in winter is probably low because of the small number of animals (~10,000) that breed there (NMFS 2007; Olesiuk 2007).

Canadian range

Northern Fur Seals occur off the west coast of Canada, where females and sub-adult males are typically found off the continental shelf during winter and spring (Bigg 1990; Trites and Bigg 1996). In waters off British Columbia, the largest numbers of fur seals occur from January through June about 20-150 km offshore (Baird and Hanson 1997; Heise *et al.* 2003). Some Northern Fur Seals have been observed ashore at sea-lion haulouts and rookeries in Canada and in southeast Alaska (Fiscus 1983; Baird and Hanson 1997; Trites pers. comm. 2010). Fur seals are not known to breed in Canada but certainly did in the past (Newsome *et al.* 2007). Fur seals, including unweaned pups, dominate mammalian assemblages at almost all of the excavated archaeological sites along western Vancouver Island (Moss *et al.* 2006) and have been found in middens along the central coast of British Columbia (Newsome *et al.* 2007) and on Haida Gwaii (Szpak *et al.* 2009). Fur seals were identified as an important resource by the Haida, Heiltsuk and Namgis (Brown and Brown 2009).

The extent of occurrence in Canada, including all offshore territorial and coastal waters is > 20,000 $km^{2.}$ The index of area of occupancy is difficult to assess with precision but is estimated to be > 2,000 km^2. The index of area of occupancy based on the breeding sites for Northern Fur Seals overwintering in Canadian waters is < 50 km^2 and includes the beaches of the Pribilof Islands, Bogoslof Island in Alaska and the breeding beaches of San Miguel Island off the coast of California.

Search effort

Northern Fur Seals use a few traditional sites to give birth, and do not generally haul out at other times of year (Baker *et al.* 1995; Gentry 1998). Surveys of pinniped breeding sites (Harbour Seals, *Phoca vitulina,* and Steller Sea Lions, *Eumetopias jubatus*) are conducted regularly throughout coastal British Columbia, but concentrations of hauled-out fur seals have not been reported (Olesiuk 2007).

The at-sea distribution of fur seals in Canada is known from ship-board studies conducted from 1958 to 1974 (Lander 1980a), However, during these research harvest trips, fur seals were collected from sites along the continental shelf where they were known to be most abundant and there was no effort to find other areas in the North Pacific where fur seals might also occur in large numbers. There have been no recent attempts to locate fur seals on their annual migration through Canadian waters, although they have been observed during cetacean surveys of offshore waters conducted by DFO (J. Ford pers. comm. 2010).

HABITAT

Habitat requirements

Northern Fur Seals are one of the most pelagic pinnipeds, spending up to 330 days at sea foraging on small fish and squid over deep water and along the continental shelf break from the Bering Sea to California (Antonelis and Perez 1984; Bigg 1990; Loughlin *et al.* 1993; Gentry 1998). The highest concentrations of Northern Fur Seals, in the open ocean, are associated with oceanographic frontal features such as canyons and sea mounts along the continental shelf (Lander and Kajimura 1982; Kajimura 1984; Ream *et al.* 2005; Sterling 2009).

Habitat requirements vary between and within the sexes. Adult females use continental shelf and slope waters off British Columbia, Washington, Oregon and California in winter months (Bigg 1990), whereas adult males from Alaskan populations appear to remain mainly in Alaskan waters year-round (Loughlin *et al.* 1999). Sub-adults of both sexes use coastal waters off British Columbia and Washington as well as offshore areas of the North Pacific (Kajimura 1984; Bigg 1990; Trites and Bigg 1996; Olesiuk 2007; Sterling 2009).

During the summer breeding season, adult females and subadult males forage mainly in waters over the continental slope in the eastern Bering Sea (Loughlin *et al.* 1987; Goebel *et al.* 1991; Robson 2001; Sterling and Ream 2004). Nursing females from St. Paul Island in the Pribilofs feed in different areas from those used by females from St. George Island, and even on the same island, females from different groups of rookeries tend to feed in different areas (Robson *et al.* 2004; Zeppelin and Ream 2006; Call *et al.* 2008). Territorial males do not forage during this period, but remain on the breeding beaches to defend their territories (Peterson 1968).

Within Canada, the offshore waters of British Columbia represent important habitat for migrating and wintering Northern Fur Seals (Bigg 1990; Trites and Bigg 1996; Heise *et al.* 2003). Between 300,000 and 500,000 animals are thought to pass through Canadian waters on migration (Antonelis and Perez 1984). Data collected by the North Pacific Fur Seal Commission suggest that as many as 123,000 fur seals (34% of those off the west coast of North America) occurred off the west coast of Vancouver Island during May, the period of peak abundance (Olesiuk 2007).

Historically, the highest concentration of fur seals, during this period of peak abundance, occurred at LaPerouse Bank off the southwest coast of Vancouver Island. Using data collected by the North Pacific Fur Seal Commission research program and harvest records, Olesiuk (2007) calculated that in Canada, 81% of the fur seals sampled between 1958 and 1974 and 52% of the seals harvested from 1891 to 1911 came from this region. Fur seals also occurred, albeit at lower densities, off northwest Vancouver Island, in Hecate Strait, and up inlets, the latter being largely juveniles and yearlings (Bigg 1990). Little is known about the current distribution of fur seals in Canadian waters.

Overwintering grounds and migration routes in Canada may be particularly important in providing abundant and suitable prey species, particularly to pregnant females who increase their mass in the latter part of their northward migration (Trites and Bigg 1996).

Habitat trends

Colonization of new and historic breeding sites over the past 30 years has resulted in an increase of the amount of habitat used for breeding. However, compared with some other fur seal species, Northern Fur Seals are conservative and slow to colonize new breeding sites (Gentry 1998, Gentry 2002). Two new breeding colonies have formed since 1786, on San Miguel Island, California in 1965 (Peterson *et al.* 1968), and on Bogoslof Island, Alaska in 1980 (Lloyd *et al.* 1981; Loughlin and Miller 1989). Historic breeding sites on Lovushek and Srednev Islands in the Kuril Islands have been re-colonized by fur seals (Lloyd *et al.* 1981) and Northern Fur Seals tagged on San Miguel Island were first observed on the Farallon Islands, California between 1991 and 1996 (Pyle *et al.* 2001). At least 24 pups were born there in 2005 (NMFS 2007).

BIOLOGY

Much of what is known about at-sea fur seal diet, migration and distribution comes from harvests made during the pelagic fur seal research program (Lander 1980a) and from data collected from harvests and counts conducted at breeding sites in Alaska (Lander 1980b).

Life cycle and reproduction

The Northern Fur Seal is a polygynous species with a breeding ratio of about 9:1 females to males (Gentry 1998). Males establish territories of approximately 110 m^2, which are defended with vocal and postural threats; fighting is rare (Bartholomew and Hoel 1953; Peterson 1968). Territorial males do not feed during the breeding season but stay on shore to defend their territories and mate with females (Gentry 1998).

Fur seals generally show strong site fidelity (Baker *et al.* 1995; Gentry 1998). This is particulalry true of females who often give birth within 8-10 m of where they delivered the previous year (Kenyon and Wilke 1953; Kenyon 1960), and within 8.3 m of their own place of birth (Gentry 1998). Similarly, a male defends only one territory throughout his reproductive lifetime (Gentry 1998). As a result, breeding aggregations are extremely predictable, with little change in size or shape between years (Gentry 1998).

The breeding season lasts from June to October (Bartholomew and Hoel 1953; Peterson 1968). Its onset and duration do not appear to vary with weather or climate (Trites 1992a; Trites and Antonelis 1994). Territorial males arrive at the rookery in mid-May whereas mature females arrive from mid-June through August, peaking in early July (Trites 1992a). Mating occurs 3-8 days after parturition, with the average being 5.3 days (Bartholomew and Hoel 1953; Gentry 1998). Males abandon their territories and return to sea in late July or early August (Peterson 1968). About 8-10 days after parturition, females begin to leave the rookery for 3-10 day periods to forage, returning for 1-2 days at a time to nurse their pups (Costa and Gentry 1986; Gentry and Holt 1986). Such prolonged feeding trips require that breeding areas are near good feeding grounds and food resources may limit the occupancy or productivity of breeding sites. For example, the San Miguel colony declined during two separate El Niño events when upwelling failed and low productivity levels reduced prey abundance (Gerber and Hilborn 2001; Carretta *et al.* 2004).

Pups are nursed for 4 months and wean in late October or early November at ~40% of adult female mass (Gentry 1998). This brief nursing period, relative to other otariids, may be an adaptation to short summers because nitrogen isotope ratios from midden bones suggest that populations of fur seals that bred at temperate latitudes nursed for longer (Newsome *et al.* 2007). Once weaned, pups leave the rookery and embark on the southward migration with the rest of the population (Ragen *et al.* 1995).

Both sexes reach sexual maturity at 3-7 years of age (mean = 5), and have a generation time of 10 years (York 1983). Males are not usually large enough to hold a territory until they are 8-9 years old (Gentry 1998). Most males have a short reproductive span, averaging 1.5 seasons (Peterson 1968), although one male held the same territory for 10 years (Gentry 1998). Female Northern Fur Seals mate soon after they reach sexual maturity, continue to reproduce into their 20s (Lander 1981), and may produce up to 20 offspring in their lifetime. The pregnancy rate is about 60% for females aged 3 or more, 68% for those aged 4 or more, and nearly 90% for females aged 8-13 years, after which pregnancy rates decline (Lander 1981; York 1987). There is some evidence that both pregnancy rates and age at first birth declined in Northern Fur Seals from 1958 to 1972 (Trites and York 1993), and that these rates may fluctuate over time (Olesiuk 2007). The sex ratio at birth is 1:1 (Trites 1991). After the birth of the single pup and subsequent mating, the implantation of the blastocyst and the start of active pregnancy are delayed for 4 months until the newborn pup is weaned (Daniel Jr. 1981; Trites 1991; York and Scheffer 1997).

Estimates suggest that 60-80% of pups do not survive to age two (Lander 1975; Trites 1989), the age at which they first return to land (Fiscus 1978). Most of this mortality is thought to occur in the first winter (Lander 1979). Approximately 10% of pups die before weaning (Trites 1989) from starvation, trauma, parasites, and various diseases (Bigg and Lyons 1981; Calambokidis and Gentry 1985; Spraker and Lander 2010). More than 80% of females that reach maturity survive until age 15, after which survival decreases to about 30% by age 19 (Smith and Polacheck 1981). Mortality in adult males is higher, especially after age 7-10 years when they start to compete for, and hold, territories on breeding beaches (Johnson 1968; Lander 1981).

Predation

The major predators of Northern Fur Seals are large sharks and Killer Whales (*Orcinus orca*) (Gentry 2002; NMFS 2004a; Scheffer *et al.* 1984; see **THREATS AND LIMITING FACTORS**, below). Pups may also be preyed upon by Steller Sea Lions and Foxes (*Vulpes vulpes*) (Gentry and Johnson 1981; Reeves *et al.* 1992; Baird and Hanson 1997). Predation rates are not known.

Diet

Northern Fur Seals are opportunistic foragers preying on fish, cephalopods, and crustaceans. Over seventy different prey species have been identified in Northern Fur Seal scats and stomachs. Principal prey species include juvenile Walleye Pollock (*Theragra chalcogramma*), Pacific Herring (*Clupea harengus pallasi*), Northern Anchovy (*Engraulis mordax*), Capelin (*Mallotus villosus*), Pacific Hake (*Merluccius productus*), Eulachon (*Thaleichthys pacificus*), Rockfish (*Sebastes* spp.), myctophids, salmonids and numerous species of squid (Kajimura *et al.* 1980; Kajimura 1984; Perez and Bigg 1986; Sinclair *et al.* 1994; Sinclair *et al.* 1996; Antonelis *et al.* 1997; Mori *et al.* 2001; Robson 2001; Robson *et al.* 2004).

In Canadian waters, Pacific Herring is the predominant prey in inshore waters from February through June. In oceanic waters they eat almost exclusively Onychoteuthid Squid and salmon (Kajimura 1984; Perez and Bigg 1986). Gentry (1998) suggested that female diet is affected by environment with breeding females eating fish where the continental shelf is wide, squid where it is narrow and a mix of fish and squid where the shelf is intermediate in size. Other prey documented in British Columbia from 1958 to 1968 included Eulachon, Sablefish (*Anolopoma fimbria*), Pacific Cod (*Gadus macrocephalus*), and Pacific Saury (*Cololabias saira*) (Perez and Bigg 1986).

Over the entire winter range (western Alaska to California) overwintering and migrating female fur seals (December to August) feed primarily on small schooling fishes including Northern Anchovy (*Engraulax mordax* – 20%), Pacific Herring (*Clupea harengus* – 19%), Capelin (*Mallotus villosus* – 8%) and Pacific Sandlance (*Ammodytes hexapterus* – 8%). During the breeding range, in the Bering Sea (June-October) females prey on juvenile Walleye Pollock (*Theragra chalogramma*), Capelin, Pacific Herring, and squid (*Berryteuthis magister*) and (*Gonatopsis borealis*) (Perez and Bigg 1986).

The diet of Northern Fur Seals may have varied over time with changes in the availability of fish stocks (Perez and Bigg 1986; Bigg 1990; Sterling 2009). Changes in fish abundance, thought to be caused by shifts in oceanographic conditions, have been suggested as a potential cause for the decline of Steller Sea Lions (Trites *et al.* 2007). Changes to the diet of fur seals in eastern Bering Sea have been reported, with some species declining (Capelin) and others increasing (Walleye Pollock) (Sinclair *et al*. 1994; Sinclair *et al.* 1996; Antonelis *et al.* 1997). The diet of Northern Fur Seals in Canadian waters has not been examined since the work of Perez and Bigg (1986).

Physiology and adaptability

Northern Fur Seals keep warm by heating air trapped in their dense, water-repellent underfur. The insulating properties of the fur are compromised by oil, which makes fur seals particularly at risk from oil spills (Reed *et al.* 1989; St. Aubin 1990). On land, fur seals avoid overheating by keeping their hind flippers damp, fanning them, or panting (Bartholomew and Wilke 1956; Irving *et al.* 1962).

The theoretical aerobic dive limit for a 45-kg adult female, is ~ 4 minutes, and requires a 20-minute recovery period at the surface (Gentry 2002). The larger size of males may allow them to dive longer and deeper reaching prey that females cannot. This may partially explain why males do not migrate at the end of the breeding season like females and juveniles (Gentry 1998).

Growth depends on season, with the greatest increase in biomass occurring in May-July as they migrate through the coastal waters of northern British Columbia and Alaska on their way to the Pribilof Islands (Trites and Bigg 1996). For females, the energy reserves they put on in this period may be important during pregnancy and lactation, making the abundance of prey in wintering areas and on migration routes potentially as important in maintaining fur seal populations as it is around breeding areas (Trites and Bigg 1996)

Northern Fur Seals use a few traditional sites to give birth and mate, and undertake age-structured annual migrations with precise predictable timings that cover a broad area of the North Pacific (Bigg 1990; Baker *et al.* 1995; Trites and Bigg 1996). Their highly structured life cycle and the limited number of breeding sites suggest that they are not particularly adaptable to environmental changes. However, Gentry (1998) proposes that, despite this philopatry, Northern Fur Seals may be flexible enough to move between breeding sites and occasionally to new locations during periods of environmental change.

Dispersal and migration

Northern Fur Seal migration begins in November, when females and juveniles of both sexes leave the breeding islands and disperse through the North Pacific (Bigg 1990) (Figure 3). From November through March fur seals concentrate offshore along continental margins, generally remaining north of about 35ºN. In contrast, adult males remain in the northern waters around the breeding areas before eventually moving into the Gulf of Alaska and eastern Pacific Ocean or west to the Kuril Islands (Loughlin *et al.* 1993; Gentry 1998; Burton and Koch 1999; Loughlin *et al.* 1999). Adult females tend to migrate to the mid-Pacific into the transition zone, whereas juveniles may be found all over the North Pacific. The migratory routes of pups are not well known, but it appears that their migration is widely dispersed, and may be affected by the weather (Ragen *et al.* 1995; Baker 2007; Lea *et al.* 2009). In November, pups migrate south through the Aleutian passes and into the North Pacific Ocean, and are seen along the coasts of British Columbia, Washington, and Japan by the following January (Scheffer 1950; Lea *et al.* 2009). They may remain at sea for up to 22 months before returning to their natal rookery (Trites 1989; Bigg 1990; Gentry 1998).

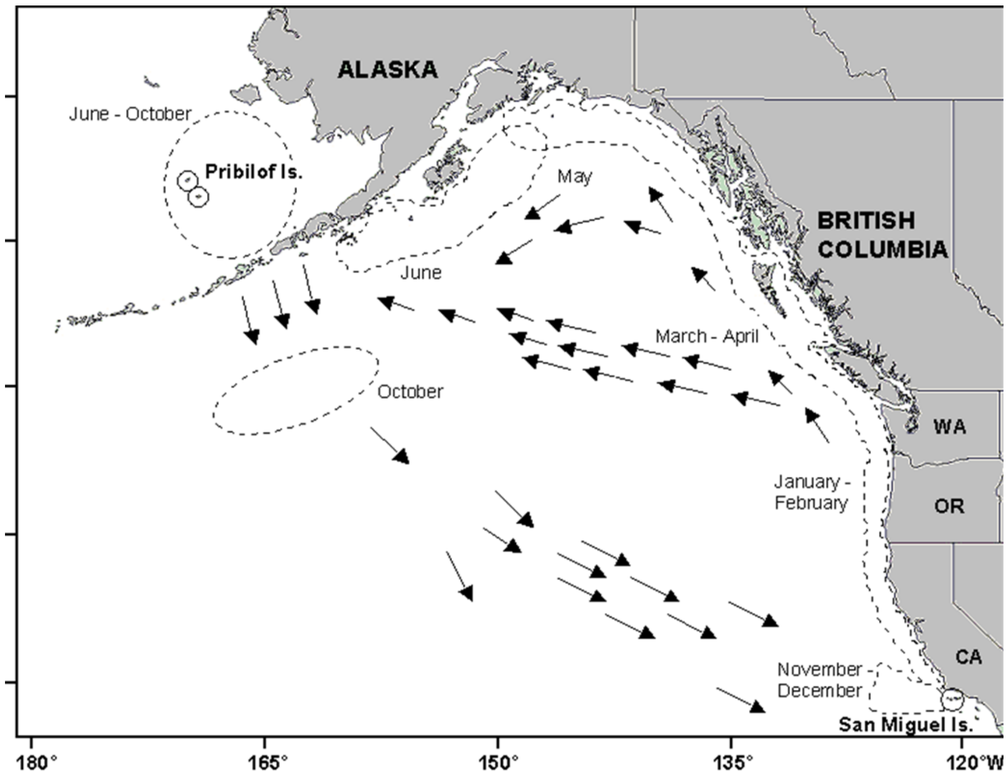

Figure 3. Approximate migratory pattern of Northern Fur Seals from the eastern Pacific populations. Modified from Gentry (1998). Dashed lines indicate the at-sea distribution of most of the seals in this population, by month.

In the spring, females move to areas along the continental shelf break and begin migrating northward to breeding islands in the Bering Sea (Bigg 1990; Trites and Bigg 1996; Gentry 1998). Adult males arrive at the breeding areas in mid-May and pregnant females in June (Trites 1992a; Trites and Bigg 1996). Juveniles and some non-breeding females may spend the early summer in the Pacific (French *et al.* 1989; Bigg 1990), feeding in the transition zone between the Oyashio and Kuroshio currents (Gentry 1998), and not returning north until early August (Trites and Bigg 1996).

Although Northern Fur Seals generally display a high degree of site fidelity (see section on **Population spatial structure and variability**) often returning to the same location on a rookery to breed (Baker *et al.* 1995; Gentry 1998) there is exchange of males and females between rookeries; but the rate of this is not known. Females are more likely to be philopatric than males (Gentry 1998).

During their pelagic migration, fur seals disperse widely through the north Pacific. Females from rookeries at Bogoslof and the Pribilof Islands are most likely to winter along the west coast of North America whereas females from Asian breeding grounds are most likely to winter in the western Pacific. Taylor *et al.* (1955) suggested about 5% of females breeding on the Pribilofs wintered off Asia, and tags recovered from harvested animals suggested 6% of the seals off Japan were from the Pribilofs (NPFSC

1975 – cited in Olesiuk 2007). In all of the tagged animals harvested off the west coast of North America, 96% were tagged on the Pribilofs, 4% in the Kuril Islands and 1% at Robben Island (Lander and Kajimura 1982, Delong 1982 – cited in Olesiuk 2007). A total of 225 tagged seals were harvested off Washington and B.C. and of these 97% were from the Pribilof Islands and the remainder were from the Commander Islands (Perez 1997). However, tag recoveries may not accurately reflect dispersal rates because tagging efforts were not even across all breeding sites, with more seals being tagged in the Pribilofs than elsewhere (Olesiuk 2007).

Telemetry studies support the view that fur seals disperse about the north Pacific during the winter. Baba *et al.* (2000) followed three female fur seals tagged at the Commander Islands. Two of these seals wintered in Asian waters whereas the third travelled to the eastern Aleutian Islands where fur seals from the Pribilof Islands also overwinter. Loughlin *et al.* (1999) attached satellite transmitters to eight adult male fur seals and tracked them from when they departed the Pribilof Islands until February. Four of these seals moved into the Gulf of Alaska, three moved towards the Kuril Islands and one remained in the Bering Sea. Ream *et al.* (2005) tracked 13 adult female fur seals as they left the Pribilof Islands and moved across the open ocean to their overwintering areas. Four overwintered in the transition zone of the central North Pacific, seven overwintered in coastal regions of the eastern North Pacific and tags on the two remaining seals stopped transmitting while south bound.

Interspecific interactions

Northern Fur Seals are occasionally observed at California (*Zalophus californianus*) and Steller Sea Lion haulouts (Kuzin *et al.* 1977; Fiscus 1983; Baird and Hanson 1997; Trites pers. comm. 2010). However, sea lions sharing haulouts with Northern Fur Seals in the Kuril Islands seem to use lower and more topographically even sites (Kuzin *et al.* 1977).

Sea lions and other high-trophic-level marine mammals may compete with fur seals for prey. Although the diets of both California and Steller sea lions overlap considerably with that of Northern Fur Seals, there are important differences. Fur seals prey more on forage fish and the juvenile stages of larger fish species, whereas sea lions tend to prey on larger species and older life stages. Additionally, sea lions forage in nearshore areas whereas most fur seals forage on the outer continental shelf and the shelf break (Gentry 1998). Despite these spatial differences, fur seals and sea lions feed on many of the same migratory prey species in different portions of their ranges (e.g., Pacific Herring and Salmon – Olesiuk 2007). Likewise Harbour Seals prey on many of these same migratory fish species as the fish return to coastal areas to spawn (Olesiuk 2007). Despite this potential for competition little is known about how this overlap in diet affects pinniped populations.

POPULATION SIZES AND TRENDS

Sampling effort and methods

Northern Fur Seal populations are assessed at breeding colonies, with the number of Northern Fur Seals wintering in Canadian waters being inferred from breeding-colony monitoring (Olesiuk 2007). Although the fur seals in Canadian waters come predominantly from Alaskan breeding islands (Bigg 1990), the proportion that pass through Canadian waters is unknown.

Pup counts are routinely used as population indices for pinnipeds (Berkson and DeMaster 1985), and represent a minimum estimate of the number of breeding females in polygynous species. The total abundance of Northern Fur Seals (of all ages) is calculated by estimating the number of pups at rookeries and multiplying that number by expansion factors determined from life table analyses (Lander 1980b; Lander 1981). The U.S. National Marine Fisheries Service uses biennial pup counts on St. Paul and St. George Islands (Pribilofs) to track overall abundance trends for fur seals breeding at Alaskan islands (Angliss and Outlaw 2005). Pup numbers are estimated using mark-resight methods. Marks are created by shaving the heads of pups to expose the lighter underfur (Towell *et al.* 2006). Monitoring on breeding islands also includes counting harem-holding and 'idle' males (peripheral males without female company – Lander 1980b). Not all rookeries are counted every year, so minimum estimates are generated, based on the expansion factor multiplied by the aggregate of the most recent pup counts. A coefficient of variation (CV) that incorporates the variance due to the expansion factor is not available for Bogoslof or the Pribilof Islands (NMFS 2007), so a default CV of 0.2 (CV (N)) is used to calculate a minimum population estimate by using an equation (equation 1) from the Potential Biological Removal (PBR) guidelines produced in 1997 by Wade and Angliss (see Allen and Angliss 2009 for an explanation).

Abundance

The global population of Northern Fur Seals in 2004-2005 was calculated to be ~1.1 million animals (NMFS 2007). About 44% of these animals are mature, although in this highly polygynous species not all males reproduce (Table 2). The total population is divided among the six breeding sites (Figure 2). In Russia, fur seals breeding at Robben Island and the Kuril Islands each account for about ~10% of the global population whereas fur seals at the Commander Islands acount for ~ 22% of the total. The two breeding areas in Alaska at the Pribilof Islands and Bogoslof Island account for 52% and 5% of the total population respectively, and fur seals breeding at San Miguel Island account for less than 1% of the total population (Olesiuk 2007). The stock status at each of the areas varies, but most are stable or growing, with the exception of the Pribilof Islands which is declining (NMFS 2007).

For management purposes fur seals are generally divided into western and eastern Pacific 'populations' (San Miguel is usually considered separately). Those breeding in Russia are thought to principally migrate and overwinter along the Asian coast, the Aleutians and into the central Pacific, whereas fur seals breeding in Alaska and California are thought to principally migrate into the central Pacific, along the Aleutians and along the coasts of British Columbia, Washington, Oregon and California (Bigg 1990, Gentry 1998). It is generally believed that fur seals from all rookeries intermix in the central north Pacific and Bering Sea (NMFS 2007).

Fur seal abundance at the Pribilof Islands has declined significantly over the last 45 years. Between 1940 and 1959 there were over 2 million Northern Fur Seals at the Pribilof Islands (Briggs and Fowler 1984). By 2000 the minimum abundance estimate for the total number (all ages) of Northern Fur Seals in the north eastern Pacific was 941,756 animals (Angliss and Lodge 2002). By 2002 this had declined to 888,120 animals (Angliss and Lodge 2003), with the decline continuing into 2005 (709,881 fur seals – Angliss and Outlaw 2007) and 2006 (654,437 fur seals – Angliss and Outlaw 2007). The 2007 assessment, which was based on pup counts made in 2002 on Sea Lion Rock, in 2006 on St. Paul and St. George and in 2007 on Bogoslof Island, was 676,416 (Allen and Angliss 2009). Although this represents a slight increase in abundance, it was not considered sufficient to determine that the overall decline had ceased – because fur seal pups on the declining Pribilof colonies (assessed biennally) were not counted in that year (Allen and Angliss 2009). The 2008 assessment of ~ 653,000 animals was derived from the sum of pups counted on the Pribilof Islands and Sea Lion Rock in 2008 (Towell and Ream 2008) and from 2007 on Bogoslof Island (Allen and Angliss 2009).

Fluctuations and trends

There have been three major declines in eastern Pacific Northern Fur Seals since the stocks were first known to Europeans. There were likely 2-3 million fur seals when the Pribilofs were discovered in 1742 (Lander and Kajimura 1982; Roppel 1984). The first decline occurred under Russian management. Aleuts, brought to the Pribilof Islands in 1786, harvested an average of 100,000 fur seals (mostly pups) annually for the next 40 years (Roppel 1984). This harvest continued until 1822, when harvest limits were imposed, and the policy of harvesting immature males only was initiated. When the United States purchased Alaska from Russia in 1867 the population was likely at historic levels with 30,000-35,000 immature male fur seals being killed annually (Scheffer *et al.* 1984).

The second decline occurred after the U.S. took ownership of Alaska in 1867 and harvesting proceeded without regulation; ~240,000 fur seals were killed in 1868 alone. Northern Fur Seals were also harvested at sea, where at least 800,000 seals, mostly adult females, were killed from 1868 to 1911. Many of these were harvested off the coast of B.C. (Scheffer *et al.* 1984). By the early 1900s, fewer than 300,000 seals were breeding on the Pribilof Islands and the colony was in danger of extinction (Kenyon *et al.* 1954; Lander and Kajimura 1982). A moratorium on all fur seal hunting was introduced from 1911 to 1917. This was later restricted to harvesting immature males on land (Roppel 1984).

The moratorium and harvest restrictions allowed the abundance of Pribilof Island fur seals to increase to 2.2 million animals by the 1950s (Lander 1980b; Briggs and Fowler 1984). But when fur seal abundance on the Pribilof Islands stopped increasing a 'herd' reduction program, based on theoretical ideas of density-dependent growth, was initiated in 1957. Calculations suggested a smaller 'herd' would have higher pregnancy and survival rates (Lander 1981). Thus began the third decline. From 1956 to 1968, over 300,000 female fur seals were killed on the Pribilof Islands (Lander 1980b; Roppel 1984). An additional 16,000 animals were killed at sea between 1958 and 1974 (York and Hartley 1981). The experimental female harvest failed to increase population productivity and the male-only harvest policy was reinstated in 1969 (Figure 4, Roppel 1984; Trites and Larkin 1989). Commercial harvests of immature males ceased in 1973 on St. George Island and in 1984 on St. Paul Island (Trites and Larkin 1989).

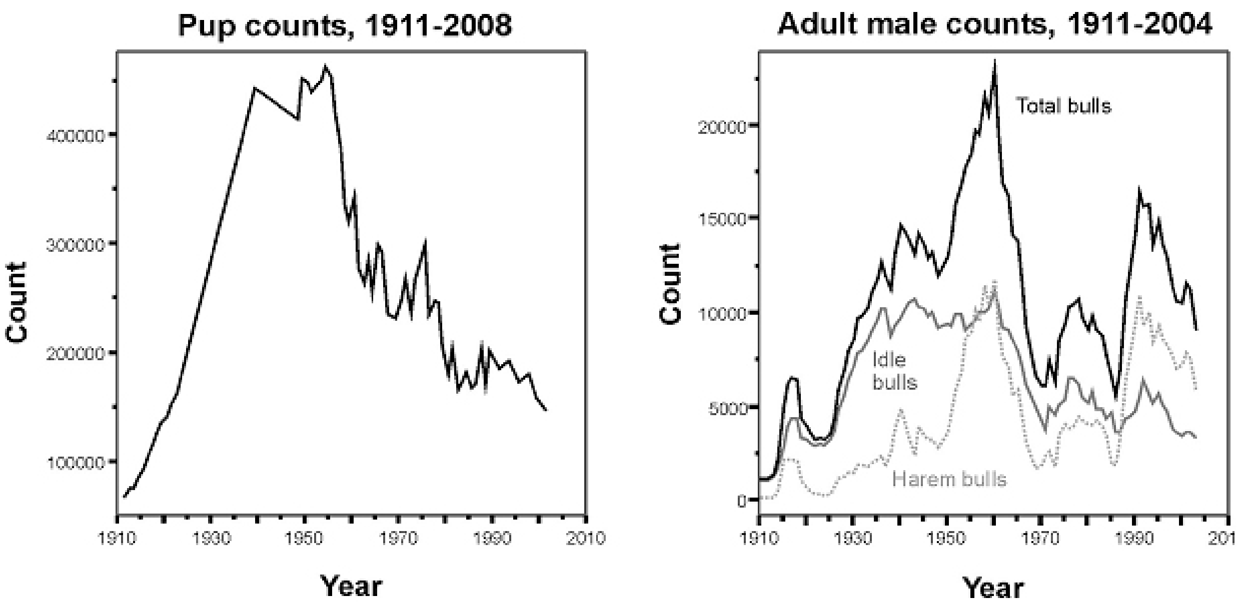

Figure 4. Pup (1911-2008) and adult male counts (1911-2004) on St. Paul Island. (modified from U.S. National Marine Fisheries Service). Declines in pup production started following an experimental harvest of females in the 1950s. Although there have been brief periods of recovery and stability since the 1950s the population began declining steeply again in 1998.

The population on the Pribilof Islands was estimated to be just under one million animals by 1992 (Loughlin 1992; Baird and Hanson 1997) and it remained relatively stable through the mid-1990s, with about 973,000 animals in 1998 (Robson 2000). But between 1998 and 2002, pup production declined by 5.1% yr^{-1}on St. Paul Island, by 5.4% yr^{-1} on St. George, and by 5.2% yr^{-1} for the Pribilofs as a whole (NMML 2002). By 2002, the pup count was the lowest in over a decade, at less than 200,000 animals (Angliss and Lodge 2003).

The 2004 estimate of pups born on St. Paul Island was 122,825 (SE 1,290), 15.7% less than in 2002, and 22.6% less than in 2000 (Angliss and Outlaw 2005); the 2004 estimate for St. George was 16,876 (SE=415), 4.1% less than in 2002, and 16.4% less than in 2000. The number of pups born on St. Paul and St. George Islands (using a 4.5 multiplier) led to a 2004 population estimate of ~625,000 animals of all ages. Estimated pup numbers on the two islands declined at 6.0% yr^{-1} from 1998 to 2004 (Figure 4; NMFS 2004b).

Subsequent counts indicated a continued downward trend. The 2006 pup count on St. Paul and St. George islands was 127,007, i.e., about 9% down from 2004, and in 2008 nearly 5% down again at 121,000 (Table 1). Pup counts on Sea Lion Rocks in the Pribilofs declined by 3.3% yr^{-1} from 1994 to 2008 (Towell and Ream 2008).

Table 1. Recent pup counts at Alaskan breeding islands, eastern North Pacific stock of the Northern Fur Seal *Callorhinus ursinus* (Angliss and Allen 2007; Towell and Ream 2008).

	St. Paul I.	Sea Lion Rock	St. George I.	Bogoslof I.	Sum of most recent counts
1992	182,437	10,217	25,160	898	218,712
1994	192,104	12,891	22,244	1,472	228,711
1996	170,125		27,385	1,272	211,673
1998	179,149		22,090	5,096	219,226
2000	158,736		20,176		196,899
2002	145,716	8,262	17,593		176,667
2004	122 825		16,876		153,059
2005				12,631	160,594
2006	109,937		17,070		147,890
2007				17,574	152,867
2008	102,674	6,741	18,160		145,149

Between 2002 and 2003, the number of adult males on St. George Island decreased by 13.4% and on St. Paul by 2.8% (Table 2, NMML 2003). The total number of adult males on the Pribilof Islands was 9,978 in 2004, a decrease of 23.8% in one year (Table 2, NMML 2004). This was the lowest count of adult males since 1930 when there had been a harvest of more than 20,000 juvenile males per year only 3-5 years earlier. Trites and Larkin (1989) suggested that the overall decline in pup counts on the Pribilof Islands was largely due to low survival of young seals. Likewise, Olesiuk (2007) found that low rates of pup survival could explain the decline in pup production at the Pribilof Islands, although he proposed that other very modest changes in vital rates could also explain the decline. Counts of males from 2004 to 2008 have been stable (Table 2) and unusually large numbers of juvenile and sub-adult males were seen at haulouts on the north side of St. George Island in 2007 (Towell and Ream 2008).

Table 2. Counts of 'harem' and 'idle' males on St. Paul and St. George islands, 1997-2008 (Fritz *et al.* 2008; Towell and Ream 2008).

	'Harem'	'Idle'
1997	5,974	10,034
1998	5,878	9,480
1999	4,819	8,505
2000	4,517	8,298
2001	4,231	8,770
2002	4,568	9,142
2003	4,368	8,730
2004	4,046	5,932
2005	4,420	6,445
2006	4,389	6,933
2007	4,312	5,829
2008	4,924	5,688

The systematic harvesting of juvenile males on the Pribilof Islands probably reduced the number of males in the eastern North Pacific population. Ending the juvenile-male harvest increased the life expectancy of males in the youngest age classes and the proportion of older males in the population would have changed, increasing the ratio of total numbers to pup counts (Olesiuk 2007). Thus, the multipliers for calculating the total number of seals and the number of adult seals of both sexes, from the number of pups born would have increased (the multiplier for adult females would not change much). Consequently, the pup multipliers now in use are calculated for populations with no juvenile harvest (Lander 1981; Loughlin *et al.* 1994).

Furthermore, if adult males and females compete for food (the extent of which is not known), and if food resources limited female survival or productivity (which is likely), removing large numbers of young males could have resulted in a larger female population than if the male harvest had not occurred. In this manner pup production under the juvenile-male harvest regime could have been maintained at unnaturally high levels. Under these circumstances, ending juvenile-male harvests in the early 1980s would have allowed 1) the age distribution of males to shift to a greater mean age and mass, 2) the numerical proportion of males in the stock to increase, and 3) the proportional mass of males to increase (geometrically). The resulting increased pressure on prey resources (assuming competition between the sexes) would have reduced first time pregnancy rates and pup survival. Eventually, the number of adult females and pup production would have declined even if pregnancy rates recovered (see Olesiuk 2007 for further discussion).

Ending the male hunt may have affected the population in one of two ways. Halting juvenile male harvests requires that the multipliers for calculating population numbers from pup counts are increased (because males become more abundant), regardless of whether or not males and females compete for prey (and pregnancy rates drop). However, if there is competition between the sexes for prey, ending the male hunt might have reduced pregnancy rates (as females became prey-limited) and affected pup production even if the food supply was constant.

Changes in population structure, caused by competition between males and females, might have contributed to declines in pup counts on the Pribilof Islands in the 1980s and 1990s. However, from 1980 to 2000 pup production remained relatively stable and changes in pup production associated with ending the young-male hunt should have concluded by the late 1990s. Thus, the effect of halting the male harvest might explain 12-13 years of overall decline, but pup production continued to decline from 1992 to 2008 (Table 1). Furthermore, if competition affected pregnancy rates the decline would have been small compared to the 4- to 5-fold decline in pup production seen at the Pribilof Islands from the late 1950s onwards.

In 2005 the pup count at Bogoslof Island was nearly 2.5 times the 1998 value, equivalent to an increase of ~14% yr^{-1}. Likewise the increase in pup production in 2007 was 1.4 times the 2005 value, an increase of ~17% yr^{-1} (Table 1). These values exceed the 8.6% yr^{-1}maximum rate at which the species is thought to naturally increase, indicating growth of the fur seal colony at Bogoslof Island is partly due to immigration (Lloyd *et al.* 1981; Loughlin and Miller 1989; Ream *et al.* 1999). Moreover, despite its rapid growth since being founded, the fur seals breeding on Bogoslof now occupy most of the available space on this tiny volcanic island (A. Trites pers. comm. 2010) and still produce few pups compared with the hundreds of thousands that were once born on the Pribilof Islands.

An overall population trend for recent changes in the number of Northern Fur Seals from the Alaskan breeding sites was calculated (Appendix 1) by fitting separate exponential trend curves to pup counts from 1998 to 2008 for St. Paul (average change – 5.7% yr^{-1}), St. George (– 2.2% yr^{-1}), Sea Lion Rock (– 3.3% yr^{-1}) and Bogoslof I. (+ 13.7% yr^{-1}), summing the fitted values and re-fitting an exponential trend to the sum. The resulting rate of change was – 4.1% yr^{-1}, and the decrease over 10 years (1998–2008) was – 34.1%. This compounded trend cannot be extrapolated, as its components are going in different directions at different speeds; it was calculated to give a summary of recent change.

In analyzing the trend over 30 years (3 generations), the potential effects of ending the juvenile-male harvests were taken into account. The multiplier for total numbers from pup counts, for an assumed stable population under harvest, was taken as 3.8 (Lander 1981), and was changed linearly with time to 4.5, the multiplier value for an unharvested population (Loughlin *et al.* 1994), over the 15 years after harvesting was ended. Multipliers were applied separately to pup counts on St. Paul and St. George Islands and an exponential trend fitted to the sum of their total numbers. The result was a decrease of 36.2% in total numbers (all age classes) over 30 years (1978–2008). This agrees with decline estimated by a similar analysis for 10 years (1998–2008), because the exponential model fits poorly to the 30 years' data, appearing to underestimate the decrease over the longer period (Appendix 1). The past and continued decline in pup production makes it likely that the number of fur seals breeding at Alaskan breeding sties will continue to decline.

Thus, some of the 30-year decrease in fur seal abundance might be attributed to ending the juvenile-male harvests, through its possible effect on the sex and mass structure of the population (Olesiuk 2007). However, the greatest declines in total numbers on the Pribilof Islands were not closely associated with the end of the largest male harvests, but occurred before or long after. Within the 30-year period, the Pribilof Island pup counts decreased by 37% between 1978 and 1983 and by 40% between 1998 and 2008 (Figure 5). Between 1984 and 1998, the 14 years after harvests stopped on St. Paul, pup counts were generally stable, and the calculated total numbers, with trend in the multipliers included, increased slightly (Appendix 1).

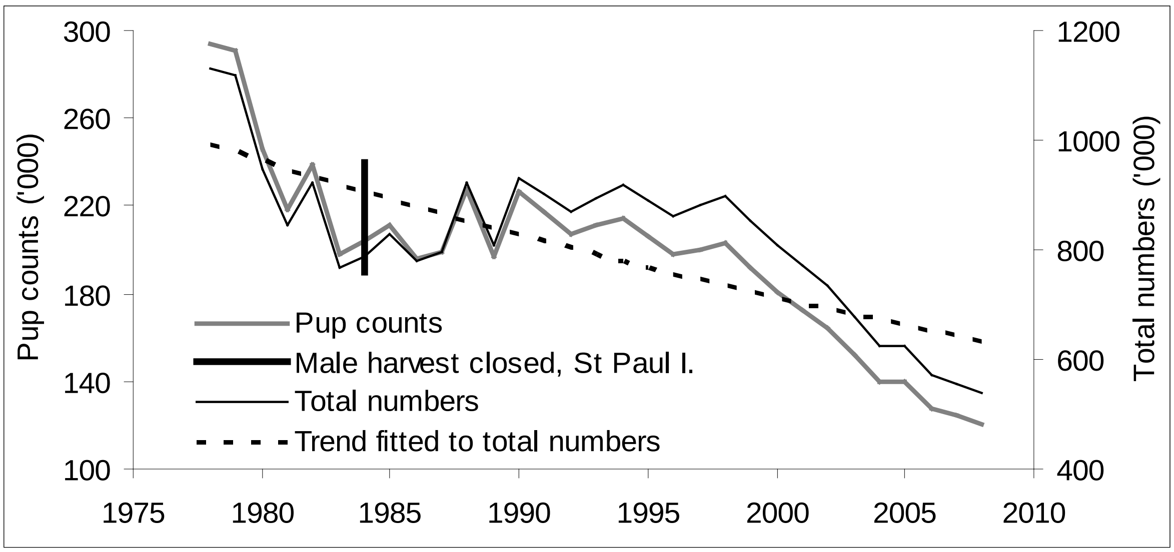

Figure 5. Pup counts and estimated total numbers of Northern Fur Seals, St. Paul and St. George islands, 1978-2008. The amount by which the decrease in pup counts 'exaggerates the decline in total numbers' is evident from the difference in the two traces.

Olesiuk (2007) suggested that because of mixing and dispersal the assessment of the Canadian population of Northern Fur Seals should integrate the status of seals at all of the breeding colonies, not just those in the eastern Pacific and Bering Sea. Consequently, he examined the rate of decline in the global population of the Northern Fur Seal by applying the appropriate (harvested versus unharvested) population multipliers (see Olesiuk 2007) to pup counts from each of the northern breeding sites. He estimated that the global abundance of fur seals had declined by 27% over the last 30 years (3 generations), from 1.7 million in 1972-1976 to 1.2 million in 2002-2006. This contrasts with the 38% decline in pup production observed in the eastern Pacific over that same time period. The difference may be because the composition of the largest colonies shifted towards older animals after commercial harvesting ended (Olesiuk 2007). Furthermore, Olesiuk calculated that if only mature individuals (females aged 4+ and males aged 6+) were used as an index of population size, the global population of Northern Fur Seals would have declined by 23% over the last 30 years (Olesiuk 2007). Olesiuk (2007) did not calculate a decline rate for the abundance of mature Northern

Fur Seals breeding at Alaskan sites but noted that the decline in pup production observed at the Pribilofs in the 1960s and 1970s cannot be explained by emigration. Although these calculations allow for an estimate of the number of mature fur seals in the global population, in a highly polygynous species with a skewed breeding sex ratio like fur seals, not all mature males will breed, and a lower estimate of mature animals to account for this is required (COSEWIC 2010).

Using the method outlined in Appendix 1 the total decline of Northern Fur Seals (all age classes) from all U.S. rookeries (including San Miguel) is – 28% from 1978 to 2008 (P. Olesiuk pers. comm. 2010).

Rescue effect

The overall abundance of fur seals makes it unlikely that fur seals will become extirpated from Canadian waters in the foreseeable future. Providing the populations at Bogoslof and San Miguel Islands remain stable, the seals from those colonies, as well as individuals from the stable or growing breeding colonies in the western Pacific, ensure the presence of fur seals in Canadian waters, even if the decline in numbers at the Pribilof Islands continues.

Although Northern Fur Seals exhibit extreme site fidelity (Gentry 1998), in the past 50 years new colonies were established at Bogoslof and San Miguel Islands and colonies in the Kuril Islands were re-established (Peterson *et al.* 1968; Loughlin and Miller 1989). Recent genetic analysis of subfossil fur seal bones collected from midden sites along the west coast of North America suggests that despite being extirpated from much of their Northeastern Pacific range 200-800 years ago, fur seals were able to form new breeding colonies and maintain their genetic diversity (Pinsky *et al.* 2010). These studies along with telemetry studies (e.g., Baba *et al.* 2000) and flipper tag recoveries from the commercial fur seal hunt (see Olesiuk 2007 for a review) further suggest that emigration of fur seals from the stable or growing breeding sites in Asia represents potential for a rescue effect, although globally, fur seals are assessed as vulnerable by the IUCN (see section on **Legal protection and status**)

THREATS AND LIMITING FACTORS

The cause or causes of the recent population declines of Northern Fur Seals in the Pribilof Islands are not known although several factors have probably contributed to the decline and may have acted synergistically (Trites 1992b).. Furthermore, the relative importance of threats and limiting factors may have changed over time. The primary threats thought to be involved in the decline include entanglement in debris and discarded fishing gear and interactions with fisheries, prey limitation and climate change. Additional threats and limiting factors include contaminants, oil spills and possibly predation by killer whales.

Changes in adult female and juvenile survival may underlie the continuing decline in the number of Northern Fur Seals breeding on the Pribilof Islands (York and Hartley 1981; Trites and Larkin 1989; Trites 1992b, Olesiuk 2007). However, the factors affecting the survival of Northern Fur Seals are poorly understood, particularly while the animals are outside the Bering Sea (Calambokidis and Gentry 1985; Trites 1992b; Trites 1992c). By analogy with Steller Sea Lions, the most significant recent (1998-2008) limiting factors are likely to be predation by Killer Whales (Springer *et al.* 2003) and changes in the quality or quantity of prey (DeMaster and Atkinson 2002; NRC 2003; Trites and Donnelly 2003).

Entanglement in debris and fishing gear

Entanglement in debris and discarded fishing gear and direct interactions with commercial fisheries may have contributed to the decline of Northern Fur Seals from the mid-1970s until the early 1990s (Fowler 1982, 1987; Trites and Larkin 1989; Laist 1997); however, the importance of entanglement as a source of mortality appears to have declined over time (Allen and Angliss 2009). An average of 22 Northern Fur Seals per year were incidentally killed in the foreign and joint U.S.-foreign commercial groundfish trawl fisheries in the North Pacific from 1978 to 1988 (Perez and Loughlin 1991). In contrast, the foreign high seas driftnet fisheries incidentally killed large numbers of Northern Fur Seals (likely juveniles), with an estimated 5,200 (95% CI: 4,500-6,000) animals taken during 1991 (Larntz and Garrott 1993). These driftnet fisheries are no longer legal, but may still occur illegally (Angliss and Lodge 2003). Commercial net fisheries in the international waters of the North Pacific have decreased significantly in recent years, and the incidental catch of Northern Fur Seals in them is thought to be insignificant (Allen and Angliss 2009). Although reduced in importance, entanglement is still considered to be an ongoing problem (Gelatt and Lowry 2008).

Entanglement of adult females (e.g., DeLong *et al.* 1988; Robson *et al.* 1996; Kiyota and Baba 2001), adult males (Zavadil *et al.* 2003), and juvenile males (Scordino and Fisher 1983; Scordino 1985; Fowler *et al.* 1992; Stepetin *et al.* 2000) on the Pribilof Islands has been studied. Kiyota and Baba (2001) reported that from 1991 to 1994, 0.013% of female fur seals on St. Paul Island were observed to be entangled and 0.029% of the females displayed scars indicating past entanglement. Trawl nets were the most common source of entanglement (Kiyota and Baba 2001). Fowler *et al.* (1994) examined entanglement in juvenile males on St. Paul Island in 1992 and reported an entanglement rate of 0.29%. They suggested that an entangled animal had half the chance of surviving compared to an unencumbered individual. The incidence of entanglement went from a low of 0.15% in 1967 to a high of 0.72% in 1975 and declined sharply to ~0.30% thereafter (Fowler *et al.* 1994).

Although the exact levels of entanglement at sea are unknown, there are likely large numbers of animals that entangle and die, and it could be a significant source of mortality (Laist 1997). Although fur seals less than 2-3 years old are thought to be more likely to entangle in debris than adults (Fowler 1987), tests of this hypothesis were not significant, suggesting that entanglement alone was not the cause for the decline of fur seals on the Pribilof Islands (Trites 1992b).

Prey limitation

Changes in water temperature and ocean currents, commercial fisheries, and the extreme depletion of baleen whale populations all may have contributed to changes in the prey base or rates of predation in the North Pacific Ocean and Bering Sea ecosystems (Trites *et al.* 1999; Benson and Trites 2002; Hunt Jr. *et al.* 2002; Springer *et al.* 2003; DeMaster *et al.* 2006). Ecosystem studies of the North Pacific and Bering Sea have described long-term fluctuations or oceanographic regime shifts that may have influenced prey availability for Northern Fur Seals, specifically a lack of early-life-stage forage fish (Sinclair *et al.* 1994; Beamish and Bouillon 1995; Sinclair *et al.* 1996; Anderson *et al.* 1997; McFarlane *et al.* 2000; Benson and Trites 2002). Other studies suggest that environmental factors have caused changes at the base of the food web (Burton and Koch 1999; Hirons *et al.* 2001; Trites *et al.* 2007), affecting patterns of fur seal foraging (Sterling 2009). Changes in prey base and thus diet, brought about by shifts in ocean conditions, have been implicated in the decline of Steller Sea Lions (Trites *et al.* 2007); likewise changes in the diet of fur seals have been reported, with some prey species declining (Capelin) and others increasing (Walleye Pollock) (Sinclair *et al.* 1994; Sinclair *et al.* 1996; Antonelis *et al.* 1997).

Commercial fisheries could also affect prey availability for Northern Fur Seals. There is a large commercial fishery for Walleye Pollock in the Bering Sea, a species that is presently an important prey for fur seals (Sinclair *et al.* 1994; Sinclair *et al.* 1996; Antonelis *et al.* 1997) and numerous other mammals, seabirds and fish (Livingston 1993; Merrick and Calkins 1996; Trites *et al.* 1999). However, the extent of overlap between the age class of pollock consumed by Northern Fur Seals and those caught by commercial fisheries is not well known (NMFS 2004a). Recent evidence suggests there are considerable spatial and species overlaps between pinniped feeding areas and fisheries, but the extent of these overlaps in the case of Northern Fur Seals is unknown (Kaschner and Pauly 2004; Olesiuk 2007).

Climate change

The effects of long- and short-term environmental change on Northern Fur Seal reproduction and survival are mostly unknown (NMFS 2004a: NMFS 2007). Climate change or oceanic regime shifts are likely to affect Northern Fur Seals more indirectly than directly (Gentry 1998; Lea *et al.* 2009; Sterling 2009).

For example a 1-2 degree change in water temperature could have serious effects on the spawning and larval survival of Northern Fur Seal prey (Gentry 1998), but would not cause large changes in fur seal metabolic rates (Miller 1978). York (1995) correlated the survival rate of juvenile fur seals with sea surface temperature (SST), and suggested that SST affected the availability of prey both to attendant mothers and recently weaned pups.

Climate events such as severe storms, extremely cold periods or oceanographic shifts can cause episodes of high mortality (Blix *et al.* 1979; Trites 1990; Trites and Antonelis 1994). Lea *et al.* (2009) suggest that climate conditions at weaning, particularly the intensity and frequency of autumn storms, affect when and where pups disperse to, which may affect their survival. At San Miguel Island in California, El Niño Southern Oscillation events (ENSO), which reduce the availability of prey, likely regulate Northern Fur Seal population growth through increased pup mortality and during severe events increased female mortality (Delong and Antonelis 1991; Melin *et al.* 2005). There is no clear relationship between ENSO events and population growth of Northern Fur Seals in the eastern Bering Sea, although there are some indications that long-term cycles in oceanic productivity brought about by the Pacific Decadal Oscillation may affect the foraging patterns of Northern Fur Seals (Newsome *et al.* 2007).

Oil spills and contaminants

Oil affects the insulative properties of Northern Fur Seal fur (see section on **Physiology and adaptability**). Unlike seals and sea lions, Northern Fur Seals do not have a thick layer of blubber for insulation, but rely on their dense under fur to keep warm. Oiled fur is a poor insulator, causing some animals to become hypothermic and die (St. Aubin 1990). Oil irritates mucous membranes, inflames skin, and causes other deleterious effects if ingested or inhaled (St. Aubin 1990).

Oil released at sea off British Columbia would probably cause less harm than oil released near breeding grounds. Nevertheless, oil spilled from tankers carrying crude oil from the Valdez terminal along the B.C. coast or the United States could easily affect overwintering or migrating Northern Fur Seals (NMFS 2004a). The proposed 400,000 barrel/day pipeline to Kitimat, B.C. (Enbridge 2007) and the associated tanker terminal in Kitimat, B.C. would increase oil transportation along the B.C. coast. Ships passing to the west of Vancouver Island generally follow the ‘Great Circle’ route to and from Asia or travel in outer waters past Prince Rupert to Alaska (O’Hara and Morgan 2006). These shipping lanes pass through areas used by overwintering and migrating fur seals (see Olesiuk 2007). Over 15,000 ships passed through Canadian Pacific shipping lanes in 2003 (O’Hara and Morgan 2006).

The release of bunker C oil into the waters surrounding the Pribilof Islands, which occurred in February and March 1996, affected overwintering seabirds (Flint *et al.* 1999) but had no documented effect on fur seals which were at sea. The routine discharge of oil, a chronic problem for seabirds (O’Hara and Morgan 2006), probably also affects Northern Fur Seals but fur seals may occur too far offshore for oiled carcasses to wash ashore. Like pelagic pinnipeds, seabirds are most likely to contact oil while foraging in the vicinity of ocean features that enhance biological productivity (O'Hara and Morgan 2006). The direct effects of hydrocarbon exploration and development on fur seals are unknown.

The weight of evidence from numerous studies indicates that organochlorines have a number of serious health effects on pinnipeds. These effects include immune dysfunction, reproductive failure, birth defects and disruption of endocrine function (see Ross *et al.* 1996 for a review). Studies of PCBs and DDTs as well as mercury concentrations in blubber and tissue samples suggest environmental pollutants affect Northern Fur Seals (e.g., Noda *et al.* 1995; Krahn *et al.* 1997; Beckmen *et al.* 1999; Saeki *et al.* 2001; Beckmen *et al.* 2002; Loughlin *et al.* 2002; Kajiwara *et al.* 2004). In particular, organochlorine concentrations in Northern Fur Seal blubber samples from St. George Island exceeded recommended levels for human consumption (Loughlin *et al.* 2002) and were high enough to impair pup immune systems (Beckmen *et al.* 1999). Mercury concentrations were higher in the fur of Northern Fur Seals from the Pribilof Islands than in the eastern and western stocks of Steller Sea Lions (Beckmen *et al.* 2002) but the direct effects of these ubiquitous contaminants on Northern Fur Seals is not known.

Predation

Mammal-eating Killer Whales are known to prey on fur seals (Jefferson *et al.* 1991; Matkin *et al.* 2007), particularly in the Bering Sea. Killer Whales almost certainly prey on fur seals in the offshore waters of B.C.; a Killer Whale carcass recovered on Price Island on the central coast of B.C. had a large volume of Northern Fur Seal fur in its stomach (G. Ellis pers. comm. 2010). There has been considerable debate over whether declines of pinniped populations in western Alaska are due to Killer Whale predation (e.g., Springer *et al.* 2003). Although it is generally agreed that predation by Killer Whales may keep already reduced prey populations at low levels (Fisheries and Oceans 2007; Guenette *et al.* 2007), the role that Killer Whale predation has played in the decline of fur seals and its role preventing depressed fur seal populations from increasing in the eastern Pacific is uncertain (Matkin *et al.* 2007).

Exploitation

Extreme fidelity to breeding sites makes Northern Fur Seals particularly vulnerable to exploitation (Gentry 1998) and disturbance (Gentry *et al.* 1990). Past management plans have focused on male harvests, depending on the fur seal's highly polygynous mating system to ensure that more males survive to adulthood than is necessary for reproduction. The differential arrival of age and sex classes at the haulout sites allows certain age groups to be exploited selectively. Killing moderate numbers of young males for fur (mostly ages 2-6 y) did not change the adult sex ratio to the point where pregnancy rates were put at risk (Roppel and Davey 1965; Roppel 1984). In the past, periods of low population size (= pup production) coincided with harvesting females (Roppel and Davey 1965; Scheffer *et al.* 1984). However, there has been no commercial harvest in the Pribilof Islands for more than 20 years (Scheffer *et al.* 1984; Gentry 1998), and current levels of subsistence harvests are not thought to be affecting the population (NMFS 2004a). The subsistence harvest is currently limited to a 47-day season targeting subadult males from 23 June to 8 August (NMFS 2004a). The mean annual take from 1997 to 2001 was 1,132 animals (range 750-1 558) (Angliss and Lodge 2003). Fewer than 1,000 juvenile male fur seals have been harvested annually on the Pribilof Island since 2000 (NMFS 2007). Fur seals are not protected while at sea outside the exclusive economic zones of Canada and the United States (Baird and Hanson 1997), because attempts to establish a new fur seal treaty have been unsuccessful (see **Legal protection and status** below).

PROTECTION, STATUS, AND RANKS

Legal protection and status

The large numbers of Northern Fur Seals taken throughout the 19th century led to the ratification of the *Treaty for the Preservation and Protection of Fur Seals and Sea Otters* by Great Britain (for Canada), Japan, Russia, and the United States in 1911. Pelagic sealing was stopped, and the harvest of fur seals on land was reduced. The treaty was in effect until 1941 when Japan abrogated (Roppel 1984). In 1957 a new treaty, the *Interim Convention on Conservation of North Pacific Fur Seals,* was ratified by Canada, Japan, Russia, and the United States. Under the terms of that agreement, Northern Fur Seals were protected from hunting at sea, but females were still taken by the United States and Canada for research purposes. Additionally, a commercial harvest of fur seals in the Pribilof Islands was still allowed, and Canada received 15% of skins from harvests and was required to initiate research on the species (Baird and Hanson 1997). In 1984 the international convention lapsed when the United States Senate failed to ratify a protocol for extension. Management of Northern Fur Seals in U.S. waters thus became subject to the *Fur Seal Act* of 1966 and the *Marine Mammal Protection Act* of 1972. The commercial harvest on the Pribilof Islands was terminated after the National Marine Fisheries Service (NMFS) determined that it could not occur under domestic laws.

In June 1988 Northern Fur Seals on the Pribilof Islands were designated as depleted under the *Marine Mammal Protection Act* (MMPA) owing to population declines of about 35% since the 1970s (when there had been ~ 1.3 million animals) and as much as 60% since the 1950s (~ 2.2 million animals) (Briggs and Fowler 1984). A conservation plan was prepared in 1993 that included protective measures and research programs (NMFS 1993), and an updated plan was released in 2007 (NMFS 2007). In 1994, amendments to the MMPA made intentional lethal take of any marine mammal illegal except for subsistence hunting by Alaskan natives or when imminently necessary to protect human life (Angliss and Lodge 2002).

The Northern Fur Seal is not listed in any Appendix to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

In Canada the Northern Fur Seal is protected under the 1993 *Marine Mammal Regulations* of the *Fisheries Act* of Canada. These regulations prohibit disturbance, broadly defined as an activity that alters, disrupts or prevents a marine mammal from carrying out its normal life processes (DFO 2002). Hunting of Northern Fur Seals in Canadian waters is not permitted except by First Nations people, who must obtain a licence, issued at the discretion of the Minister of Fisheries and Oceans and valid for one year.

The Northern Fur Seal was designated as ‘Not At Risk’ by COSEWIC in 1996 (Baird and Hanson 1997). In 2006 COSEWIC assessed the species as ‘Threatened’ (COSEWIC 2006). This assessment was based upon the decline in pup counts and the inferred decline in adult fur seals on the Pribilof Islands. However the status of the Northern Fur Seal was referred back to COSEWIC in 2009 on the grounds that 1) there were new data from genetic studies and satellite telemetry to suggest that fur seals from Russian breeding sites should also be included in the assessment , and that 2) the decline in pup counts exaggerates the decline in the total or adult population.

Non-legal status and ranks

The Northern Fur Seal has been assigned a NatureServe global conservation status rank of G3 (Vulnerable), which was last reviewed in 2008. In Canada the species has a national status rank of NNA (the species is not a suitable target for conservation activities) and in the U.S. it is assigned the rank of N3 (Vulnerable). Within Canada the Northern Fur Seal has the subnational rank of S2M (Imperiled Migrant) in British Columbia. Within the United States it has the subnational ranks of S3 (Vulnerable) in Alaska and S1 (Critically Imperiled) in California (NatureServe 2009). The most recent Canada General Status Rank is 1 (At Risk) (CESCC 2006). The Northern Fur Seal has been assessed by the IUCN as Vulnerable (Gelatt and Lowry 2008) and it is on the Province of British Columbia’s red list (BCCDC 2010).

Habitat protection and ownership

All Northern Fur Seal breeding sites located in the United States are on federally owned land and are protected. Of the U.S. sites where the species breeds, only the Pribilof Islands are inhabited by humans. Inhabited lands near the rookeries and haulouts are owned by the local Aleut community, while the U.S. federal government owns all the lands on which fur seal rookeries and haulouts lie (Baird and Hanson 1997; Corbett and Swibold 2000). Wintering habitat in Canadian territorial waters is managed by the Canadian federal government; exclusive economic rights within the 200-mile limit give Canada some control over activities that might harm this species, notably hunting and fishing.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

This report, by Michael Kingsley, is an update of the 2006 Update Status report.

Michael Kingsley is recently retired from the Greenland Institute for Natural Resources and is now a part-time senior professor with the Norwegian Institute of Marine Research. He has twenty years' experience as a biologist and research scientist studying marine mammals, both seals and cetaceans, in Arctic and eastern Canada. He has used this knowledge to advise on the status, management and exploitation and evaluation of environmental impacts on marine mammal populations. His earlier career was as an applied mathematician and wildlife biometrician. He is recognized for his aptitude for quantitative analyses in wildlife statistics, population assessments, and population dynamics.

Appendix 1. Calculation of rates of change of numbers.

There is no quantitative information on numbers of Northern Fur Seals wintering in Canadian waters from which trends or rates of change can be calculated. Most of the fur seals wintering in Canadian waters are thought to breed on the Pribilof Islands (Perez 1997) and more recently Bogoslof Island. Some of the seals that breed on San Miguel Island off California visit Canadian waters in winter, but this colony is small and probably makes only a small contribution to the total wintering numbers. Perez (1997), based on research collections, suggested that at least 4% of the fur seals overwintering in Canadian waters came from breeding sites in Russia.

The quantitative index used to estimate the number of breeding fur seals or mature individuals at the eastern north Pacific breeding sites is the count of pups at the rookeries. Over the 30 years 1978-2008 the pup counts declined dramatically in an irregular fashion. From 1978 to 1983 pup counts declined rapidly, but from 1983 until about 1996-1998 they stabilized. After 1998 pup counts again declined rapidly. Because the rate of decline was irregular it cannot be calculated based on a comparison of the end points; instead the rate of decrease was determined by fitting an exponential decay trend line to the numbers.

A second source of uncertainty relates to how well the decrease in pup counts reflects a decrease in total numbers. Multipliers, based on the estimated age and sex composition of the standing stock, have been calculated so that total numbers can be estimated from pup counts. These multipliers are larger for the unharvested fur-seal stocks than for harvested stocks where the number of adult and older subadult males is much reduced. Thus ending the juvenile-male harvests should result in a decline in pup abundance that would exaggerate any corresponding decrease in total numbers.

Therefore, to estimate a trend in total numbers from the pup counts data, over a time-span covering the closure of the juvenile-male harvests on the Pribilofs, it was necessary to consider the possible change in the multiplier when the population moved from the harvested to unharvested state. This was achieved by applying a harvested-state multiplier up to the closure of the harvest, and then changing to an unharvested-state multiplier linearly over the following 15 years. This was computed separately for St. George and St. Paul, as juvenile-male harvesting ceased 11 years earlier on St. George than on St. Paul.

There were two multiplier estimates available for unharvested stocks of Northern Fur Seals, and three multipliers for harvested stocks. These multipliers were all combined with one another, providing six combinations for calculating a harvest-closure-corrected trend in total numbers.

The data used were pup counts for St. Paul and St. George Islands only, and only for those years when pups had been counted on both islands. Between 1978 and 2008 there were 15 years when this happened.

Depending on the multipliers used to convert pup counts to total numbers before and after the closing of the juvenile male harvest, the average annual decrease in total numbers from a fitted exponential-decay trend line ranged from 1.1%/yr to 1.8%/yr, and the decrease over thirty years ranged from 28% to about 42%.

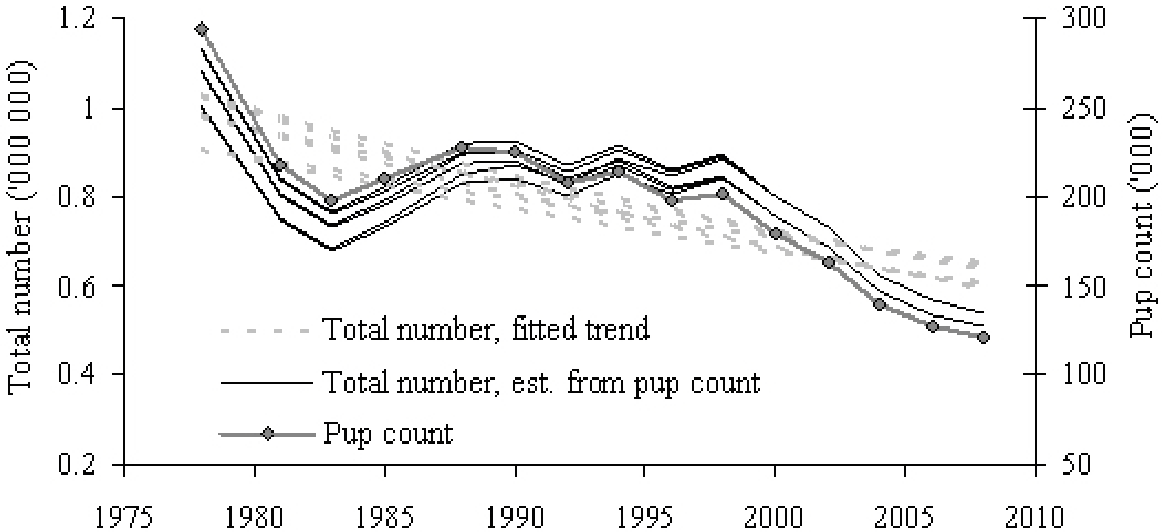

Figure A1. Pup counts, estimated total numbers and fitted trends using multipliers calculated by Kenyon *et al.* 1954, Lander 1980, Loughlin *et al.* 1994, and Olesiuk 2007.

To calculate a ten-year rate of change 1998-2008 in pup counts in the eastern Bering Sea, it was considered necessary to include the smaller islands, Bogoslof Island and Sea Lion Rock. The juvenile-male harvest being well in the past, pup counts were not converted to total numbers but analyzed as recorded. Pups are unfortunately not counted in the same years on all these different islands, so a separate exponential trend line was calculated for each island, and fitted values were calculated for the years for which observations were not available. Then the available values – either observed or fitted – were added and an overall trend line calculated for the 10 years.

Table A1. Observed pup counts (thousands) and *fitted values* on the Pribilof Islands and Bogoslof Island, 1998-2008. San Miguel Island pup counts are also provided.

	St. Paul I.	St. George I.	Sea Lion Rock	Bogoslof I.	Total	Total fitted	San Miguel I
1998	179.15	22.09	*9.46*	5.10	215.80	*210.91*	0.627
1999	*168.74*	*20.26*	*9.15*	*5.79*	203.93	*202.53*	1.083
2000	158.74	20.18	*8.84*	*6.63*	194.39	*194.48*	1.646
2001	*150.27*	*19.40*	*8.55*	*7.60*	185.81	*186.75*	2.035
2002	145.72	17.59	8.26	*8.70*	180.27	*179.33*	1.946
2003	*133.83*	*18.57*	*7.99*	*9.96*	170.35	*172.21*	2.134
2004	122.83	16.88	*7.72*	*11.40*	158.83	*165.37*	2.528
2005	*119.19*	*17.78*	*7.46*	12.63	157.06	*158.80*	2.356
2006	109.96	17.07	*7.21*	*14.95*	149.20	*152.49*	3.549
2007	*106.15*	*17.02*	*6.97*	17.57	147.72	*146.43*	4.204
2008	102.67	18.16	6.74	*19.61*	147.18	*140.61*	4.981
Annual rate of change (%)	-5.63	-2.15	-3.33	14.51	-3.97		18.47

The overall annual rate of change was a decrease of about 4%/yr, providing a 10-year decrease of 34.1%. This trend should not be extrapolated, because its different components go in different directions at different speeds, ranging from 5.5%/yr decrease on St. Paul Island to a 14.5%/yr increase on Bogoslof Island. The overall rate serves to summarize the change in pup numbers