BEFORE THE SECRETARY OF COMMERCE

PETITION TO LIST THE RIBBON SEAL (*HISTRIOPHOCA FASCIATA*) AS A THREATENED OR ENDANGERED SPECIES UNDER THE ENDANGERED SPECIES ACT

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CENTER FOR BIOLOGICAL DIVERSITY

DECEMBER 20, 2007

Notice of Petition

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Pursuant to Section 4(b) of the Endangered Species Act ("ESA"), 16 U.S.C. §1533(b), Section 553(3) of the Administrative Procedures Act, 5 U.S.C. § 553(e), and 50 C.F.R. §424.14(a), the Center for Biological Diversity ("Petitioner") hereby petitions the Secretary of Commerce, through the National Marine Fisheries Service ("NMFS"), to list the ribbon seal (*Histriophoca fasciata*) as a threatened or endangered species and to designate critical habitat to ensure its survival and recovery.

The Center for Biological Diversity ("Center") is a non-profit, public interest environmental organization dedicated to the protection of native species and their habitats through science, policy, and environmental law. The Center has over 40,000 members in Alaska and throughout the United States. The Center and its members are concerned with the conservation of endangered species, including the ribbon seal, and the effective implementation of the ESA.

NMFS has jurisdiction over this petition. This petition sets in motion a specific process, placing definite response requirements on NMFS. Specifically, NMFS must issue an initial finding as to whether the petition "presents substantial scientific or commercial information indicating that the petitioned action may be warranted." 16 U.S.C. §1533(b)(3)(A). NMFS must make this initial finding "[t]o the maximum extent practicable, within 90 days after receiving the petition." *Id.* Petitioner needs not demonstrate that the petitioned action *is* warranted, rather, Petitioner must only present information demonstrating that such action *may* be warranted. While Petitioner believes that the best available science demonstrates that listing the ribbon seal as endangered *is* in fact warranted, there can be no reasonable dispute that the available information indicates that listing the species as either threatened or endangered *may* be warranted. As such, NMFS must promptly make a positive initial finding on the petition and commence a status review as required by 16 U.S.C. § 1533(b)(3)(B).

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Introduction

The ribbon seal (*Histriophoca fasciata*) is one of nine ice-associated pinnipeds of the Arctic shelf region that is completely dependent on sea ice for its survival. It is readily distinguished by the distinctive banding pattern of its fur, on which four white bands encircle the head, the base of the trunk, and the two fore-flippers against a dark base coat. During late winter through early summer (March-June), the ribbon seal relies on the loose pack ice of the sea-ice front of the Bering and Okhotsk Seas for reproduction, molting, and as a platform for foraging. During summer and fall, the ribbon seal is entirely pelagic, foraging on fish, squid, and crustaceans in the Bering and Chukchi Seas. The current population status of ribbon seal populations is unknown because recent censuses have not been conduced. In its most recent 2007 draft stock assessment, NMFS reported a global population size of 240,000 individuals, with an estimate of 90,000-100,000 ribbon seals in the Bering Sea.

The ribbon seal faces likely global extinction in the wild by the end of this century due to global warming which is resulting in the rapid melt of this species' sea-ice habitat. Sea ice represents the only substrate where ribbon seals rest, give birth, nurse their pups, and molt and where weaned pups rest as they learn aquatic proficiency and foraging skills. In addition to providing habitat for critical life cycle activities (reproduction, molting, resting), sea ice provides numerous other important functions for the ribbon seal, including isolation from polar bears and terrestrial predators, greater proximity to food resources, and passive transport to new feeding areas.

The ribbon seal's sea-ice habitat is threatened by rapid Arctic climate change that is occurring at a pace that is exceeding the predictions of the most advanced climate models. Arctic surface temperatures increased twice as much as the global average during the 20th century. Sea-ice extent in the Bering and Okhotsk Seas has experienced significant declines during the March-June (Meier et al. 2007) ribbon seal reproductive and molting periods in recent decades, sea ice is breaking up progressively earlier in the spring, and sea-ice thickness is declining. Arctic-wide winter sea-ice extent in 2006 and 2007 declined to record minima which most climate models forecast would not be reached until 2070 or beyond (Stroeve et al. 2007), and Arctic-wide summer sea-ice extent in 2007 plummeted to a record minimum (NSIDC 2007b) which most climate models forecast would not be reached until 2050 or later (Stroeve et al. 2007). The unprecedented declines in Arctic summer sea ice are leading to increased ocean warming which results in further reductions in the winter-spring sea ice critical to ribbon seals.

Of foremost concern for the ribbon seal, global warming will accelerate in this century. Arctic air temperatures are projected to increase by an average of 8°C during winter by the end of the century (Christensen et al. 2007), and Arctic summer sea ice may disappear entirely before mid-century under a mid-level emissions scenario (Holland et al. 2006). The ribbon seal's winter sea-ice habitat in the Bering and Okhotsk Seas is predicted to decline by 40% by mid-century under a mid-level emissions scenario (Overland and Wang 2007) which the world is currently on the path to exceeding (Canadell et al. 2007, Raupach et al. 2007). Any remaining sea-ice habitat will likely be of low quality because the sea ice will be thinner and the ice will melt sooner, leading to break-up of the sea ice front during the reproductive and molting periods.

The growing loss of sea ice due to global warming will impact ribbon seals directly by degrading and eliminating critical habitat and indirectly by changing prey availability, altering interactions with predators and disease, and increasing human disturbance throughout the range. Specifically, the impacts of global warming on the ribbon seal include the following:

1) The loss and early break-up of seasonal sea ice in the Bering and Okhotsk Seas could lead to complete breeding failure of the ribbon seal within this century. The ice floes of the sea-ice front must remain stable throughout the period of pup-rearing and pup independence that lasts from late March through mid-June. If females are forced to abandon their pups early, pup mortality would be very high because pups would not have gained a sufficient blubber layer and adequate body condition to survive pre-mature weaning. Additionally, ribbon seals show a strong preference for thick pack ice for pup-rearing and are rarely found on thin ice. Females that are unable to find sea ice of sufficient quality for pupping could abandon their reproductive effort for the year by aborting their pups.

2) Pup mortality after weaning will increase with the early melting and break-up of seasonal sea ice. Ribbon seal pups depend on sea ice as a resting platform from May-June during the post-weaning period when they are learning aquatic proficiency, diving, and foraging skills. Pups that are forced to abandon the sea ice during this energetically stressful period would suffer from decreased fitness and survival.

3) Ribbon seals will be impaired in molting due to early sea-ice melt and break-up which will lower fitness and survival. Ribbon seals depend on the sea ice during April through July to molt. New hair can only grow when ribbon seals are out of the water where the skin can reach higher temperatures. Furthermore, ribbon seal feeding is suppressed during molt and their activity decreases, making sea ice an essential platform for resting during this energetically stressful period. With shrinking sea ice, ribbon seals may suffer physiological stress and associated mortality from being forced into the water before molt completion or onto small, low-quality ice remnants with high concentrations of other animals during the molt period. If ribbon seals were forced to haul out on land to complete molt, depredation from terrestrial predators could be devastating.

4) Ribbon seals are likely to experience more physiological stress due to loss of haul-out sites on the sea ice, which they rely on for resting from winter through summer. Females may be particularly reliant on sea-ice haul-out sites after the demanding pup-rearing period.

5) The sea-ice distribution will shift further northward which is likely to increase the ribbon seal's contact with predators, particularly polar bears which use the pack ice of the Chukchi, Beaufort and Bering Seas. Ribbon seals do not exhibit anti-predator behaviors when they are hauled out on the sea ice. Ribbon seal pups, which are exposed, defenseless, and non-aquatic, would undoubtedly suffer high depredation rate, and molting adults would be particularly vulnerable to predation during this period of inactivity. If ribbon seals were forced to haul out on land to rear their young or complete their molt, they would risk exposure to terrestrial predators including grizzly bears, wolves, and Arctic foxes.

6) The disappearance of seasonal and perennial sea ice in the Arctic will encourage increased shipping activity and oil and gas exploration and development in the ribbon seal range. Commercial fisheries are also likely to expand, which impact ribbon seal directly through bycatch mortality and indirectly through competition for prey resources.

The ribbon seal also faces the threats of renewed overexploitation due to the high harvest levels allowed by the Russian Federation, current oil and gas development throughout its range, rising contaminant levels in the Arctic, and bycatch mortality and competition for prey resources from commercial fisheries. Existing regulatory mechanisms have been ineffective in mitigating the principal threats to the ribbon seal, the most important of which is global warming. The primary international regulatory mechanisms addressing greenhouse gas emissions--the United Nations Framework Convention on Climate Change and the Kyoto Protocol—do not adequately address the impacts of global warming that threaten the ribbon seal with extinction, and there are currently no legal mechanisms regulating greenhouse gases on a national level in the United States. The immediate reduction of greenhouse gas pollution is essential to slow global warming and ultimately stabilize the climate system while there is still suitable ribbon seal sea-ice habitat remaining. Unless greenhouse gas emissions are cut dramatically in the immediate future, the disappearance of sea ice and extinction of the ribbon seal are essentially assured.

This Petition summarizes the natural history of the ribbon seal, its population status, and the threats to the species and its habitat. The Petition then clearly demonstrates that, in the context of the ESA's five statutory listing factors, the National Marine Fisheries Service should promptly list the ribbon seal as endangered.

Natural History and Biology of the Ribbon Seal

I. Species Description

The ribbon seal (*Histriophoca fasciata*) is one of nine ice-associated pinnipeds of the Arctic shelf region (Kelly 2001). Its common name refers to the distinctive banding pattern of its fur which is characterized by four white or yellow bands varying in width against a darker background (Lowry 1984). One band surrounds the neck and covers the base of the head, another encircles the back part of the trunk, and two oval bands encircle each of the two fore flippers from the lower neck to the middle section of the trunk (Burns 1981). The base color of the fur varies from reddish brown to black in males and from tan to gray in females (Allen 1974, Heptner et al. 1976). The banding pattern is most noticeable in adult males because of the darker coloration of their base fur and is less conspicuous or absent in females and juveniles (Allen 1974, Heptner et al. 1976, Burns 1981). The coloration of ribbon seals does not appear to vary seasonally (Heptner et al. 1976). Newborn seals have a long, woolly, white coat that is molted at weaning, replaced by pelage that is silvery grey on the sides and the belly and blue-black on the back (Lowry 1984).

Another distinctive characteristic of the ribbon seal is the shape and appearance of its head (Lowry 1984). Ribbon seals have a broad, short-nosed head with small, widely spaced teeth (Kelly 1988). Their long, flexible neck and a rather slender body give them a particularly long, stream-lined appearance (Lowry 1984). Average body length of mature ribbon seals ranges from

150-175 cm, with maximum length of 198 cm (Heptner et al. 1976, Kelly 1988). The average weight is 55 kg and maximum weight is 150 kg, with males generally being larger than females (Heptner et al. 1976). Newborns ribbon seals range between 73-98 cm in length and between 6-10 kg in weight (Heptner et al. 1976, Burns 1981, Popov 1982). Ribbon seals move over the ice differently than other phocid seals as well. Instead of wriggling forward, ribbon seals slide across the ice with their head and neck held low, pulling their body forward by alternate extensions of the powerful fore flippers and moving the pelvis from side to side (Burns 1981).

Among the seals, ribbon seals possess a unique respiratory anatomy and physiology. Unlike most pinnipeds, they do not have lobes in their lungs (Berta et al. 2006). Additionally, the posterior end of the trachea is connected to an air sac that extends over the ribs on the right side of the body (Kelly 1988, Fedoseev 2002). Adult males possess a well-developed, thin-walled air sac while females have smaller air sacs and those of juveniles are undeveloped (Fedoseev 2002). It is thought that the air sac functions as a buoyancy device, for air storage during diving, or for sound production (Kelly 1988). Ribbon seals are also physiologically and anatomically well adapted to a pelagic lifestyle that involves deep diving and fast swimming. As part of these adaptations they have well-developed internal organs that have higher proportional weights in relation to total body mass than in other seals (Fedoseev 2002). Ribbon seals also have distinctive blood characteristics that give them high oxygen storage capacity, including the highest number (3.9-4.7 million) and volume (52-72%) of erythrocytes and the highest blood hemoglobin contents (18-26 g %) among all seals (Burns 1981, Fedoseev 2002).

II. Taxonomy

The ribbon seal belongs to the order Carnivora, suborder Pinnipedia, family Phocidae, subfamily Phocinae, tribe Phocini, genus *Histriophoca*, and species *H. fasciata* Zimmermann 1783 (Rice 1998). The family Phocidae comprises the true seals with 18 extant species, as distinguished from the Otariidae (eared seals) and Odobenidae (walruses). Within tribe Phocini, the five genera *Phoca, Pusa, Halichoerus, Pagophilus,* and *Histriophoca*, are distinguished from other phocid seals by their unique karyotype and white natal pelage called lanugo (Rice 1998). Within these genera, *Phoca* has two species, harbor seal (*P. vitulina*) and spotted seal (*P. largha*); *Pusa* has three species, ringed seal (*P. hispida*), Caspian seal (*P. caspica*) and Baikal seal (*P. sibirica*); *Halichoerus* has one species, grey seal (*H. grypus*); *Pagophilus* has one species, harp seal (*P. groenlandica*); and *Histriophoca* Gill 1873 has one species, ribbon seal (*H. fasciata*) (Burns 1981).

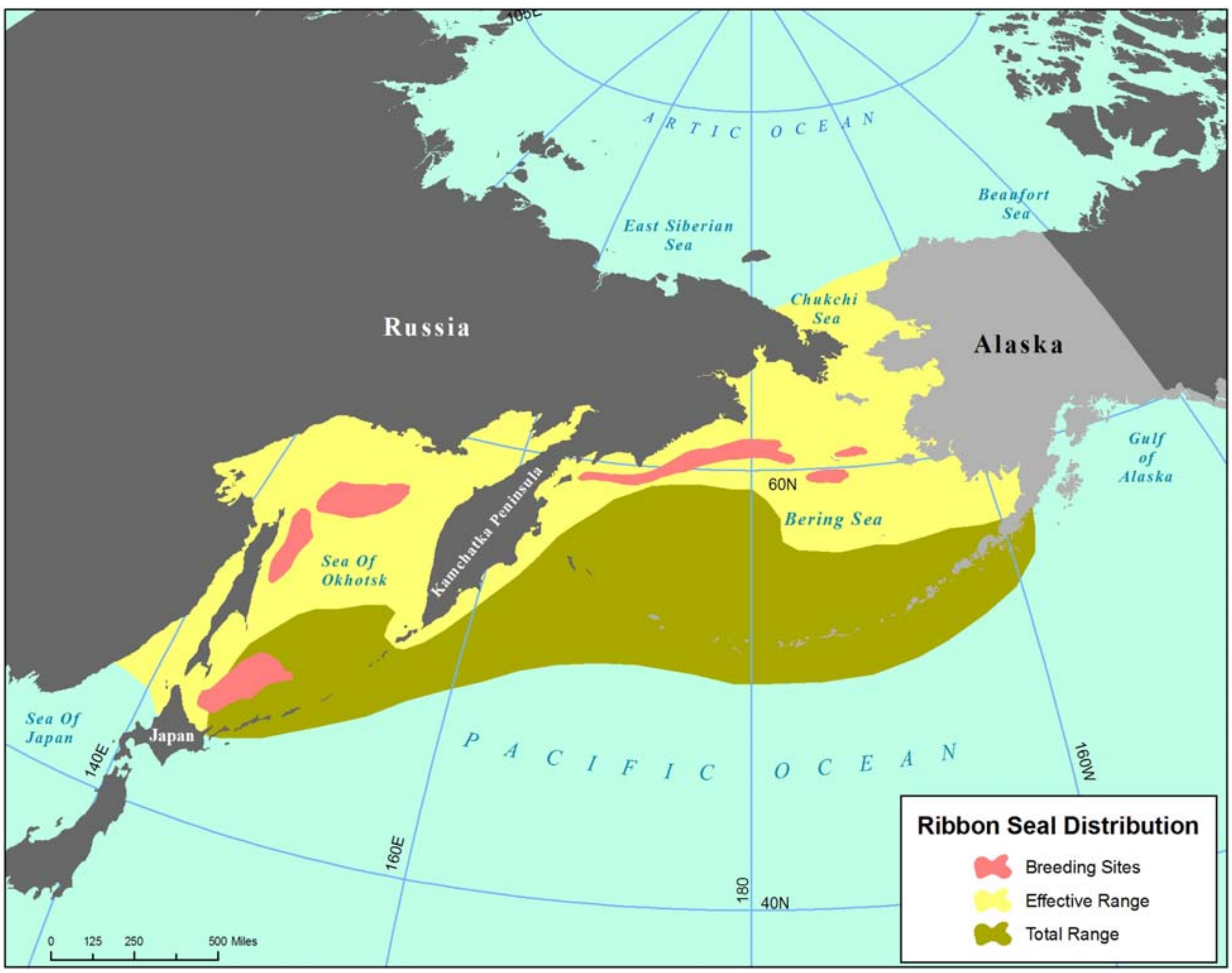
The ribbon seal was first called the “rubbon seal” in 1781 by Pennant (Kelly 1988). In 1783 Zimmermann assigned it the genus and species name *Phoca fasciata*. Subsequently, other authors proposed *Phoca equestris* Pallas (1831), *Phoca foetida* Gray (1866), and *Pagophilus equestris* Gray (1871) to refer to the ribbon seal (Kelly 1988). In 1873 Gill placed the ribbon seal in the genus *Histriophoca* based on its distinctive coloration and teeth (Gill 1873). Allen (1880) reviewed phocid taxonomy and classified the ribbon seal as *Histriophoca fasciata* (Zimmermann) Gill, which was widely accepted (Kelly 1988). However, Burns and Fay (1970) compared cranial morphology of the Phocidae and determined that *Histriophoca* should be combined with *Phoca*. Further cladistic analyses based on morphology and mtDNA found that

Histriophoca should be considered its own genus, which is the current accepted taxonomy (Rice 1998).

III. Distribution

The ribbon seal is endemic to the western and central North Pacific Ocean. Its total distributional range includes the Sea of Okhotsk, northern Sea of Japan, Bering Sea, eastern Chukchi Sea, and western Beaufort Sea (Figure 1) (Kelly 1988). Within in its entire range, ribbon seals appear to be most abundant in the seasonally ice-covered Bering and Okhotsk Seas (Kelly 1988). Burns (1981) distinguished between the 'total range' of the ribbon seal, which includes less commonly used habitat, and the 'effective range' where the ribbon seal is commonly found (Figure 1). Burns (1981) defined the effective range of the ribbon seal as the seasonally ice-covered regions of the Okhotsk, Bering, and Chukchi Seas and the bays and straits contiguous with them. In Alaskan waters, Burns (1981) denoted the effective range as spanning the vicinity of Point Barrow to Unalaska in the Aleutian Islands.

Figure 1. Distribution of the ribbon seal.
Source: Based on Burns (1981) and Fedoseev (2000).



Ribbon seals are widely distributed within the Sea of Okhotsk (Heptner et al. 1976). Their southern distributional limit in the Okhotsk Sea runs along the northern Tartar Strait into the waters off northeastern Hoikkado Island and eastward north of the Kurile Islands (Heptner et al. 1976). The ribbon seal has also been documented in the northern part of the Sea of Japan but mainly during times of high ice extent (Jefferson et al. 1993, Fedoseev 2002). In the Bering Sea, the ribbon seal is distributed from Bristol Bay westward to Karaginsky and Olyutorsky Bays and northward to the Bering Strait (Heptner et al. 1976, Kelly 1988). It also occurs in the southern Chukchi Sea westward along the Chukchi peninsula and in the western Beaufort Sea near Cape Barrow (Heptner et al. 1976, Burns 1981, Popov 1982, Kelly 1988).

The distribution of the ribbon seal is apparently continuous from the Okhotsk Sea to the Bering Sea (Burns and Fay 1970, Fedoseev 2002). Although Heptner et al. (1976) suggested that the ribbon seals of the Bering and Okhotsk Seas represent two different populations due to the partial barrier posed by the Kamchatka peninsula and Kurile Islands, the suitable habitat in between these seas makes population interchange very likely (Lowry 1984). In support, the morphology, anatomy, and craniometrics between ribbon seals in the Sea of Okhotsk and Bering Sea show no significant difference between these two groups (Lowry 1984).
Fedoseev (2002) proposed additionally that ribbon seals in the Okhotsk Sea may consist of two independent populations located in the northwestern and southern part of the Okhotsk Sea, respectively. However, there is no genetic evidence available to split these groups (Kelly 1988). Further research on ribbon seal stock structure is needed.

A. Seasonal Breeding and Foraging Range

The ribbon seal's range is best-known during winter through early summer (November-June) when ribbon seals haul out on the seasonal sea ice of the Bering and Okhotsk Seas for resting, rearing young, and molting (Burns 1981). During the mid-to-late summer and fall (July-October) when sea ice is absent, the ribbon seal is entirely pelagic and its distribution is not well-known (Burns 1981, Popov 1982).

In the Bering Sea, ribbon seals inhabit the sea-ice front during the breeding season from March though May. They are most abundant in the central and western Bering Sea, concentrated in the loose pack of the ice edge zone for 50-70 km inward (Kelly 1988, Fedoseev 2000). Ribbon seals appear to be particularly numerous in breeding areas near the Pribilof and St. Matthew Islands (Lowry 1984). Fedoseev (2000) also notes breeding aggregations in Olyutorsky Bay, Bristol Bay, and between St. Matthew and St. Lawrence Islands. As the sea ice diminishes in May and June, ribbon seals appear to move northward with the melting sea ice and become concentrated on ice remnants where pups learn independence and adults complete their molt (Lowry 1984). Late spring-early summer ice remnants where ribbon seals congregate typically occur in the eastern Gulf of Anadyr, Karaginsky Bay, south and west of St. Lawrence Island, south of Bering Strait near King Island, and the Bering Strait (Lowry 1984, Fedoseev 2000).

When the seasonal sea ice completely disappears from July through October, ribbon seals in the Bering Sea appear to become pelagic (Heptner et al. 1976, Burns 1981). During the ice-free period, ribbon seals rarely occur in coastal waters, nor do they appear to follow the receding summer margin of the sea ice northward in large numbers like ringed and bearded seals (Burns

1981, Lowry 1984). Kelly (1988) reported that ribbon seals may migrate northward into the Chukchi Sea for the summer in larger numbers than is commonly assumed. However, most ribbon seals are thought to remain south of Bering Strait, foraging on the Bering Sea shelf and slope and the deeper waters of the basin (Burns 1981, Lowry 1984). Recent tracking data from ribbon seals tagged in the Bering Sea corroborate that some ribbon seals remain in Bering Sea while others move north through the Bering Strait during the summer months (Bengtson et al. 2006, Boveng et al. 2007). Most seals tagged in 2005 along the central coast of the eastern Kamchatka peninsula in the western Bering Sea dispersed southeast into ice free areas during summer, including several seals that traveled into the North Pacific and foraged south of the western and central Aleutians (Bengtson et al. 2006). Preliminary tracking data from ribbon seals that were tagged in May 2007 on the sea-ice front in the eastern Bering Sea indicated that they either moved north into the Anadyr Gulf or through the Bering Strait into the Chukchi Sea during early summer (Boveng et al. 2007).

In the Sea of Okhotsk, ribbon seal breeding areas occur in three disjunct, isolated regions over the continental slope and deeper basin adjacent to the Terpeniya Gulf (Fedoseev 2000). The densest breeding aggregations for ribbon seals occur northeast of Sakhalin Island and northwest of the Babushkin Gulf (Popov 1982, Fedoseev 2000). Mizuno et al. (2002) also report an important breeding area in the southern Sea of Okhotsk between the Shiretoko Peninsula off Hokkaido and Kunashiri Islands. As sea ice disappears in late spring and early summer, ribbon seals in the Sea of Okhotsk become concentrated along the western ice edge (Fedoseev 2000). Ribbon seals of the Okhotsk Sea appear to become completely pelagic during the summer and fall and to reappear when sea ice re-forms in winter, similar to the Bering Sea population (Burns 1981).

B. Migration

There is very little information on the migratory patterns of the ribbon seal (Heptner et al. 1976). As noted above, ribbon seals from the Bering Sea may migrate to the Chukchi Sea during the summer or may remain in the Bering Sea (Kelly 1988, Fedoseev 2002). Ribbon seals from the Sea of Okhotsk may summer in the Bering Sea (Kelly 1998).

IV. Habitat Requirements: Importance of Sea Ice to Ribbon Seals

During the late winter, spring, and early summer, the subsistence of the ribbon seal is completely dependent on the presence of sea ice (Burns 1981, Jefferson et al. 1993, Fedoseev 2002). Sea ice represents the only substrate where ribbon seals rest, give birth, nurse their pups, and molt and where weaned pups achieve independence (Heptner et al. 1976, Burns 1981, Fedoseev 2000, Mizuno et al. 2002, Fedoseev 2002). Ribbon seals never haul out on land unless extremely distressed (Lowry 1984).

In addition to providing the substrate for critical life-cycle activities (reproduction, molting, resting), sea ice provides numerous other important functions for ice-dependent seals: (1) isolation from terrestrial predators and disturbance; (2) greater space to distribute themselves for feeding, resting, and rearing young; (3) greater proximity to food resources; (4) passive transport to new feeding areas; (5) sanitation provided by increased space, reduced competition for haul-out sites, and the addition of new ice; and (6) shelter from the wind provided by the ridges and cavities of accumulated snow and by the dampening of wave action (Burns et al. 1981).

In the seasonally ice-covered Bering and Okhotsk Seas inhabited by the ribbon seal, the sea ice passes through four stages of an annual ice cycle: ice-free conditions and warmer water (July to October); ice sheet formation beginning along northerly coasts and expanding southward due to forcing from northerly winds, at rates of up to 100 km per day, with increasing areas with cold surface water temperatures (November to January); steady-state seasonal maximum ice cover and cold water (February/March to mid-April); and a transitional decay and northward retreat of ice with rising temperatures (mid-to-late April to June) (Burns et al. 1981, Ray and McCormick-Ray 2004). By February, sea ice typically differentiates into fast ice, pack ice, front, and fringe, which provide different habitat types (Burns et al. 1981). The pack ice is highly dynamic, in constant motion, and is transported southward from November/December to mid-to-late April by the net southerly winds (Burns et al. 1981). The southern edge of the pack ice is subject to continuous melting and periodic disintegration because of its exposure warmer sea surface temperatures and wave action. The ice front is the broad transition zone of loose ice, up to 133 km in width, between rapidly the disintegrating fringe (the southern margin of the pack ice) and the heavier, southward-drifting pack ice (Burns et al. 1981). In the Bering Sea, the floes of front tend to be about 20 m in diameter except in Bristol Bay where floes of 100 m diameter are common (Burns et al. 1981).

Ribbon seals haul out on loose pack ice in the Bering and Okhotsk Seas. Specifically, in the Bering Sea, ribbon seals occur almost exclusively on the front of the pack ice along the breadth of the Bering Sea, and are most numerous on the ice front in the central and western Bering Sea (Burns et al. 1981). Ribbon seals prefer the inner ice front, which can extend inward 50-70 km from the ice edge zone, where ice floes are thicker, larger, more deformed, and more snow-covered than the fringe ice (Burns 2002). In concordance, NMFS surveys of ice seals in the eastern Bering Sea from April-June 2007 found that ribbon seals were most abundant at the southern edge of the sea ice, in close proximity to the shelf break and deep water (Cameron and Boveng 2007).

The location of the sea-ice front in the Bering Sea varies from year to year. Typically, sea ice covers 25-60% of surface of the Bering Sea and averages 35% cover (Fedoseev 2002). This is because sea ice forms over the shallow Bering Sea shelf but does not extend over the deeper waters of the Bering Sea basin (Ray and McCormick-Ray 2004). The maximum sea-ice extent and associated front usually occur about 1,000 km south of Bering Strait at the shelf break near the 200 m isobath, but varies in location from year-to-year. In heavy ice years, the ice edge reaches St. Paul Island (57.3°N, 170.3°W) or beyond. A light ice year might have a maximum extent only to St. Matthew Island (60.7°N, 172.7°W) or Nunivak Island (60.4°N, 166.5°W) (Clement et al. 2004).

In the Sea of Okhotsk, sea ice typically covers 50-97% of the surface and averages 80% cover (Fedoseev 2002). Ribbon seals haul out in areas with stable white ice broken into large chunks where cracks and leads are available, and avoid areas of solid ice floes since they cannot break through ice thicker than 10-15 cm (Fedoseev 2002). The main reproductive rookeries are located far from the coast on drifting ice floes usually overlying depths not exceeding 200m (Heptner et al. 1976). In the southern Sea of Okhotsk, they can also be found where ice is more spaced out due to water turnover over the deep sea bed (Fedoseev 2002). Fedoseev (2000) noted that breeding and molting ribbon seals are typically located in the zone of "broken ice massifs" located at a distance of 30-50 km from the sea-ice edge.

Both the presence and quality of ice affect the abundance of the ribbon seal. Ribbon seals haul out primarily on moderately thick, firm "clean" ice in both the Okhotsk and Bering Seas (Heptner et al. 1976, Burns 1981, Kelly 1988). They are rarely observed on dirty "thin" ice, mostly at the end of the icy season (Heptner et al. 1976).

A. Importance of Sea Ice to Reproduction

Ribbon seals give birth and nurse their pups exclusively on the sea ice in the Bering Sea and Sea of Okhotsk (Figure 2). The sea ice provides several advantages that influence reproductive success and pup survival (Lowry 1984). First, the sea ice allows ribbon seals to avoid excessive predation on their dependent, non-aquatic young (Burns 2002). Since the sea-ice front occurs south of consolidated pack ice, polar bears typically cannot reach ribbon seal birthing areas (Burns et al. 1981). Second, the sea ice provides a dry platform necessary for pup survival during the lactation period and a necessary resting platform as pups learn aquatic proficiency after weaning (Burns 1981). Third, sea ice provides pupping locations close to food resources since females may need to feed actively during lactation and pups must learn to forage on their own after weaning (Lowry 1984).

Of critical importance to ribbon seal reproductive success, the ice floes used for pupping must remain stable throughout the period of pup-rearing and pup independence that typically lasts from late March through mid-June. In the Bering and Okhotsk Seas, ribbon seals give birth from mid-to-late March through late April (Burns et al. 1981, Fedoseev 2000). Ribbon seal pups are born exposed on the ice floes and depend on the dry platform provided by the sea ice during the nursing period, using irregularities of the ice surface for protection from winds (Burns et al. 1991). Pups can only survive periods of submersion in the icy waters after they have formed their subcutaneous blubber layer that provides protective thermoinsulation (Fedeseev 2000).

Ribbon seal pups are also highly dependent on the sea ice for the 2-3 week transition period after weaning (Burns 1981). At three to four weeks old, pups are weaned abruptly and left to achieve independence on their own (Burns et al. 1981). Weaned pups have poor swimming and diving skills because their hefty blubber stores make them buoyant. They spend substantial time on the sea ice while they slowly learn diving and foraging skills and eventually achieve aquatic proficiency in mid-June by the time the ice starts to disappear (Burns 1981). This is an energetically stressful transition period for pups during which time they lose a significant amount of weight, which drops from 27-30 kg when weaned to 22 kg during early June (Burns 1981). Therefore, the persistence of sea ice during this period undoubtedly influences pup fitness.

Lowry (1984) observed that pup survival and subsequent vigor may depend in part in the stability and persistence of ice selected by its mother. Fedoseev (2000) noted that the process of spring ice break-up has crucial influence on the timing of pupping, duration of lactation, rates of development, and growth of pups.

Figure 2. Ribbon seal pup resting on sea ice.
Source: © G. Carleton Ray.

B. Importance of Sea Ice to Molting

Ribbon seals require the sea-ice platform for the annual molt of their fur since they do not haul out on land (Lowry 1984). In seals, growth of new hair depends on high skin temperatures and these temperatures are only reached when the seals are out of the water (Feltz and Fay 1966). Furthermore, during molt feeding reflexes are inhibited and overall activity decreases, meaning that ribbon seals need to spend most of their time sleeping on ice during this physiologically demanding period (Fedoseev 2000).

The molting period lasts approximately three months spanning April to July (Heptner et al. 1976, Kelly 1988). Individuals initiate molt at different times depending on their reproductive condition (Burns 1981, Fedoseev 2000). Adult molt occurs from late April to June after the completion of pupping and mating while immature molt starts earlier and is completed earlier, typically finishing in early-to-mid May (Burns 1981, Fedoseev 2000). Therefore, persistence of the sea ice through July is critical to allowing ribbon seals adequate time to complete their molt.

C. Importance of Sea Ice to Resting

Ribbon seals use the sea ice for resting throughout the period of seasonal sea-ice cover from late winter to early summer (Burns 1981). Breeding and molting activities are physiologically demanding and the sea ice provides an important resting platform which may also serve in thermoregulation. During sunny weather, ribbon seals spend most of their day on the ice and then gather in the water only in the evening and night (Heptner et al 1976). During cloudy weather, seals have been observed resting on ice sheets in the morning and evening but they move in the water around noon (Heptner et al 1976). In contrast, on rainy days, most seals prefer to be in the water and they only occasionally venture onto the ice (Heptner et al 1976). Resting periods on sea ice may be particularly critical for adult female seals. Carlens et al. (2006) found that ringed seal adult females haul-out for the longest periods (up to 141 hours of continuous haul-out), likley due to an increased need for rest after a demanding nursing period.

D. Importance of Sea Ice for Transportation

In the Bering Sea, the seasonal sea ice advance and retreat is more extensive than in any other Arctic region (Ray and McCormick-Ray 2004). The ice edge moves freely in response to dynamic and thermodynamic forces, resulting in high variability in sea-ice cover (Francis et al. 2005). By associating with the loose pack of the sea-ice front, ribbon seals can be transported substantial distances as the sea ice moves across the Bering Sea shelf. An advantage of transportation by sea ice is that new feeding areas (leads) are continually being opened up as sea ice moves (Ray and McCormick-Ray 2004).

V. Reproduction and Reproductive Behavior

The mating system of the ribbon seal is thought to be polygamous (Burns 1981). Mating occurs shortly after pup weaning (Burns 1981). Males are in breeding condition from March to mid-June (Burns 1981). Females that had successful pregnancies mate during late April and early May, while females which did not breed or had unsuccessful pregnancies may mate outside of this period (Burns 1981, Kelly 1988). After reaching sexual maturity, most females (95%) conceive in successive years (Burns 1981).

Implantation of the blastocyst occurs approximately two and a half months after fertilization and gestation takes approximately 9 months (Popov 1982). Hence, parturition occurs eleven months after mating. The proportion of gestating females in a year varies from 30 to 60% (Shustov 1965 cited in Heptner et al. 1976). Females give birth on the ice to a single pup generally over a period of almost five weeks (Burns 1981) beginning in mid-March in the southern Okhotsk Sea and during April in the northern Okhotsk and Bering Seas (Fedoseev 2002). The sex ratio is close to 1:1 at birth as well as in maturity (Burns 1981).

At birth, newborn ribbon seal pups weigh approximately 10.5 kg, measure an average of 86 cm long, and are covered in a dense coat of white lanugo (Burns 1981). Females nurse their pups for three to four weeks following birth (Burns 1981). Throughout the nursing period, pups are often left unattended on the ice for long periods of time (Burns 1981). Pups develop a thick blubber labor, more than double their weight, and molt for the first time into a silver-grey coat that covers the lower flanks and belly with blue-black coloration on the upper flanks and back (Burns 1981). Weaning occurs abruptly when females abandon their pups on the ice floes (Burns 1981). At four weeks of age, the average weight of pups is 28.3 kg and average length is 112 cm (Heptner et al. 1976).

VI. Diet and Foraging Behavior

The diet of the ribbon seal is primarily known from the spring ice season when ribbon seals are more easily captured while they are hauled out on the sea ice. Diet studies indicate that the ribbon seal diet shifts with age, that diet varies regionally, and that ribbon seals tend to forage pelagically. During the first year of life, ribbon seals appear to feed mostly on pelagic invertebrates (euphausiids, amphipods, mysids, and isopods), as immatures (1-2 years old) they feed mostly on shrimp and other crustaceans (Heptner et al 1976, Fedoseev 2002), while as adults they consume mainly cephalopods and fish (Lowry 1984, Fedoseev 2002). A study of ribbon seal diet from the Sea of Okhotsk indicated that young ribbon seals consumed more squid and smaller walleye pollock than did adults, and divergence in diet between age groups was attributed to differences in foraging techniques and diving abilities (Deguchi et al. 2004). The observed switch in diet from lower trophic level prey as immatures to higher trophic level prey as adults was supported by stable isotope analyses of ribbon seal diet from molting animals in the Bering Sea (Dehn et al. 2007). The $\delta^{15}N$, which is a proxy of trophic level, was positively correlated with age meaning that ribbon seals switched from lower to higher trophic level prey as they got older.

Regional diet studies indicate that demersal and pelagic fishes, cephalopods, and crustaceans are important in the diet of ribbon seals in the Bering and Okhotsk Seas, and that ribbon seal diet varies geographically (Heptner et al. 1976, Lowry and Frost 1981). Shustov ((1965) cited in Burns 1981) examined the stomach contents of 1207 ribbon seals in the Bering Sea (of which only 32 had food) collected primarily during May and June and found that crustaceans (crabs, shrimp, and mysids) were most frequently encountered, followed by fish and cephalopods. A study of fish in the diet of 28 ribbon seals collected from March to June in the Bering Sea found Alaska pollock and eelpout to be dominant prey species in the south central and central Bering Sea and arctic cod to be the major prey north and east of St Lawrence Island (Lowry and Frost 1981). In the Sea of Okhotsk, Alaska pollock and cephalopods are important prey species (Heptner et al. 1976). Deguchi et al. (2004) conducted a three-year (1996-1998) survey during February-April of the stomach contents of ribbon seals in the southern the Sea of Okhotsk. Of nine fish and five squid species found in 64 seal stomachs, walleye pollock and magister armhook squid were the two predominant species in the diet. This study also detected age-related prey preferences but found no association between prey composition and body size of male and female ribbon seals (Deguchi et al. 2004).

Stable isotope analysis of ribbon seal diet and telemetry studies in the Bering Sea during molting suggest that ribbon seals are primarily pelagic foragers. Using stable isotope analysis of ribbon seal tissue collected in the Bering Sea during the summer, Dehn et al. (2007) found that the level of $\delta^{13}C$ in ribbon seals was similar to that of pelagic-feeding ringed and spotted seals and lower than that of benthically-feeding bearded seals (Dehn et al. 2007). Dive data from 20 ribbon seals tagged the coast of eastern Kamchatka, Russia, in June 2005 indicated that most ribbon seals made dives of less than 150 m when over the continental shelf, perhaps to the sea floor, but made deeper dives as they moved into offshore waters (Bengtson et al. 2006).

Overall, diet studies indicate that at least 35 species comprise the diet of the ribbon seal (Table 1), but this information is likely incomplete. As noted above, most of the information regarding the diet of the ribbon seal has been collected almost exclusively during the period of their residence on ice sheets, most during late spring (Heptner et al. 1976). No data has been collected from early winter and only two samples are available from mid-winter (Burns 1981). Furthermore, in most censuses, the stomachs of the ribbon seals have been found to be empty (Heptner et al. 1976).

Table 1. Prey species in the ribbon seal diet.

Species	**Common name**	**Source**
Crustaceans		
Amphipodae	Amphipods	Jefferson et al. 1993
Crangon communis	Twospines crangon	Dehn et al. 2007
Crangon dalli	Ridged crangon	Shustov 1965
Eualus gaimardii	Circumpolar eualid	Shustov 1965, Popov 1982
Lebbeus sp.	Shrimp	Shustov 1965
Pandalus sp.	Shrimp	Burns 1981
Pandalus borealis	Alaskand pink shrimp	Shustov 1965, Popov 1982
Pandalus gonionus	Shrimp	Shustov 1965, Popov 1982
Pandalus tridens	Yellowleg pandalid	Dehn et al. 2007
Pandalopsis sp.	Shrimp	Shustov 1965, Popov 1982
Sclerocrangon sp.	Shrimp	Burns 1981
Spirontocaris murdochi	Murdoch blade shrimp	Shustov 1965
Stilomysis grandis		Shustov 1965
Themisto sp.	Shrimp	Shustov 1965, Popov 1982
Fish		
Ammodytes hexapterus	Pacific sand lance	Shustov 1965
Aptocyclus ventricosus	Smooth lumpsucker	Shustov 1965
Boreogadus saida	Arctic cod	Burns 1981, Dehn et al. 2007
Clupea harengus	Atlantic herring	Shustov 1965
Eleginus gracilis	Saffron cod	Shustov 1965, Deguchi et al. 2004
Eleginus navaga	Atlantic navaga	Popov FAO 1982
Gadus m. macrocephalus	Pacific cod	Shustov 1965, Popov 1982
Lampanyctus regalis	Pinpoint lampfish	
Lumpenus medius		Shustov 1965, Popov 1982
Mallotus villosus	Capelin	Shustov 1965, Popov 1982
Pholis sp.	Rock blennies	Burns 1981
Theragra chalcogramma	Alaska pollock	Shustov 1965, Burns 1981, Popov1982
Osmerus epelanus	Smelt	Shustov 1965
Cephalopods		
Berryteuthis magister	Magister armhook squid	Deguchi et al. 2004

VII. Sources of Natural Mortality

A. Predation

Potential predators of ribbon seals include polar bears (*Ursus maritimus*), walruses (*Odobenus rosmarus*), killer whales (*Orcinus orca*), sharks (Pleurotremata), eagles (*Halieaetus* species), and gulls (*Larus hyperboreus* and *L. argentatus*) (Kelly 1988). Polar bears, walruses and killer whales prey upon other seal species in the ribbon seal range and are presumed to occasionally take ribbon seals as well (Kelly 1988). Kelly (1988) reports evidence of ribbon seal wounds from polar bear and shark attacks. Heptner et al. (1976) reported that ribbon seals are occasionally depredated by killer whales, polar bears, and the Greenland shark. Overall, the ribbon seal is thought to have few predators during the sea-ice season (Heptner et al. 1976) because it uses the sea-ice front which is largely inaccessible to polar bears and terrestrial predators, and because it does not haul out on land. Predation by marine predators is more difficult to quantify.

B. Disease

Diseases suffered by ribbon seals have not been well-studied, although individuals with skin diseases are regularly encountered (Heptner et al. 1976). Animals with skin diseases are partly or even wholly devoid of hair coat, their epidermis is peeled, bleeding cracks occur in affected sections of skin, and their mobility is greatly reduced (Heptner et al. 1976). Kelly (1988) noted that molting seals may be especially vulnerable to microbial skin infections. Ribbon seals appear to harbor low numbers of ectoparasites but are affected by numerous species of endoparasites, primarily helminthes (Kelly 1988). Helminthes can damage the intestines, stomach, lungs, and potentially the liver of the ribbon seal but their contribution to ribbon seal mortality is unknown (Kelly 1988). Heptner et al. (1976) reported that parasites can cause death in ribbon seals, although to a small extent.

VIII. Demographic Rates

Demographically, ribbon seals exhibit delayed maturity, low reproductive rates, high adult survival, and high longevity which are associated with a ‘slow’ life history strategy (Saether and Bakke 2000). Accordingly, their population growth rates are sensitive to changes in adult survival (Saether and Bakke 2000) and they are slow to recover from population declines.

A. Age of first breeding

Female ribbon seals reach sexual maturity at a slightly younger age (4-5 years) than males (5-6 years) (Heptner et al. 1976, Popov 1982). During the period of ribbon seal overexploitation from hunting in the 1960s, the age of first breeding of ribbon seals decreased. Burns (1981) reported the age of sexual maturity as 2-4 years for females and 3-5 years for males during this period.

B. Fecundity

Information on fecundity of ribbon seals comes from studies in the Okhotsk and Bering Seas in the mid-1980s during the period of population increase after harvest levels were reduced (Fedoseev 2000). The proportion of female ribbon seals reproducing each year was 54.2% in the Okhotsk Sea and 62.2% in the Bering Sea (Fedoseev 2000). The average number of offspring produced by a ribbon seal during her lifetime (net reproductive rate R_0) was 1.36 in the Okhotsk Sea and 1.14 in the Bering Sea (Fedoseev 2000).

C. Survival

Ribbon seal survival is lowest during the first year of life, with mortality rates estimated at 44% (Fedoseev 2000) and 40% (Shustov 1969). Survival increases with age. Fedoseev (2000) estimated the annual mortality rate of adults at 8-10%, while Shustov (1969) estimated mortality at 16.5% for ages 3-10 and 14.9% for ages 11-20.

D. Lifespan

The maximum lifespan of ribbon seals may approach 30 years, but average life span is likely 20 years (Burns 1981). In a sample of 2500 individuals for which age was determined, less than 1.2% of seals were older than 20 years (Burns 1981).

Abundance and Population Trends of the Ribbon Seal

The population size of ribbon seals is difficult to estimate since they inhabit a remote and harsh environment and spend much time underwater (Kelly 1988). In the mid-20th century, the ribbon seal population experienced a significant decline due to commercial hunting in the Bering and Okhotsk Seas, but populations are thought to have increased again beginning in the 1970s when harvest levels were reduced. Historically, ribbon seals were harvested only by local hunters in limited numbers, which is thought to have had little impact on ribbon seal populations (Heptner et al. 1976, Fedoseev 2000). In the 1930s, hunting with ships became organized in the Sea of Okhotsk and harvest levels increased during the next two decades, although harvest was still considered “comparatively low” (Heptner et al. 1976). However, commercial hunting in the Sea of Okhotsk increased dramatically in the early 1950s with the expansion of the sealing fleet, and an estimated 13,000 to 20,000 ribbon seals were killed annually through 1969 (Heptner et al. 1976, Fedoseev 2000). Commercial hunting in the Bering Sea began in 1961 and an estimated ~10,000 ribbon seals were killed annually until 1969 (Fedoseev 2000). Population estimates during the 1960s reflect a decline in ribbon seal numbers due to overexploitation.

In response to declining seal numbers, regulation of seal hunting began in 1969. In the 1970s and 1980s, the ribbon seal population size is thought to have increased due to the reduction of the annual harvest to 5,000-6,000 individuals in the Sea of Okhotsk and 3,000-4,000 individuals in the Bering Sea (Popov 1982). However, commercial harvest in the Sea of Okhotsk increased substantially by 1990, if not before, and averaged 13,520 ribbon seals killed each year during 1990-1993 (Grachev 2006), which may have led to renewed population declines. Vessel-based sealing reportedly declined markedly after 1995 as a result of the economic transition following the collapse of the USSR (Grachev 2006). In the 2000s, the Russian Federation has set high total allowable harvest levels for ribbon seals in the Okhotsk and Bering Seas, ranging from

16,700-21,000 individuals during 2002-2005 (MMC 2007). These high harvest quotas would permit hunting levels nearing those in the 1950s and 1960s when ribbon seal populations were heavily over-exploited and therefore allow the potential for large-scale population reductions.

The current status of ribbon seal populations is unknown because recent censuses have not been conduced. As a result, population estimates for the ribbon seal vary between sources. In its most recent 2007 draft stock assessment, NMFS reports a global population size of 240,000 individuals, with an estimate of 90,000-100,000 individuals in the Bering Sea, based on the Burns (1981) estimate from the mid-1970s. Other sources also place the global population at ~200,000 individuals. Shustov (1972) estimated the world population at 200,000. Popov (1982) estimated 60,000 in the Bering Sea and 133,000 in the Sea of Okhotsk in 1969.

Fedoseev (2002) has reported a higher global population size of ribbon seals, estimated at ~500,000 individuals, based on population censuses from the 1980s (Table 2).

Table 2. Estimated population size of the ribbon seal in the Bering and Okhotsk Sea based on aerial surveys.

Population	Year	Population Size	Source
Bering Sea	1961	115,000 – 120,000	Shustov 1975 (cited in Fedoseev 2000)
	1964	80,000 – 90,000	Shustov 1969 (cited in Heptner et al. 1976)
	1969	60,000 – 70,000	Popov 1982, Fedoseev 2002
	1974	95,000	Fedoseev 2000
	1975	90,000 – 100,000	Burns 1981
	1976	84,000	Fedoseev 2000
	1979	134,000	Fedoseev 2000
	1987	120,000 – 140,000	Fedoseev 2002
Okhotsk Sea	1968	116,000	Fedoseev 2000
	1969	208,000	Fedoseev 2000
	1974	173,000	Fedoseev 2000
	1976	201,000	Fedoseev 2000
	1979	449,000	Fedoseev 2000
	1981	410,000	Fedoseev 2000
	1986	508,000	Fedoseev 2000
	1988	630,000	Fedoseev 2000
	1989	445,000	Fedoseev 2000
	1990	562,000	Fedoseev 2000

The most recent population census in the Bering Sea in 1987 estimated a total population of 120,000-140,000 ribbon seals (Fedoseev 2000, 2002). In the Sea of Okhotsk, the long-term average (1969-1990) was 370,000 ribbon seals, with the central northwestern population at 320,000 individuals and the southern population at 50,000 individuals (Fedoseev 2002). These estimates are based primarily on aerial surveys conducted in the spring when the seals haul out on the ice and include several sources of uncertainty. First, the variation in the proportion of the population visible on the ice during surveys is unknown (Kelly 1988). Furthermore, total population size must be estimated by extrapolating the sample densities to the total area of similar habitat, which adds uncertainty because of incomplete knowledge of habitat requirements (Kelly 1988). Undoubtedly, modern censuses of population size with updated methodologies are critically needed for assessing the population status of this species. Current estimates of population size and trends are essential for understanding the effects of global warming and other threats on ribbon seal populations.

The Ribbon Seal Warrants Listing Under the ESA

I. Criteria for Listing Species as Endangered or Threatened

Under the ESA, 16 U.S.C. § 1533(a)(1), NMFS is required to list a species for protection if it is in danger of extinction or threatened by possible extinction in all or a significant portion of its range. In making such a determination, NMFS must analyze the species' status in light of five statutory listing factors:

> (A) the present or threatened destruction, modification, or curtailment of its habitat or range;
> (B) overutilization for commercial, recreational, scientific, or educational purposes;
> (C) disease or predation;
> (D) the inadequacy of existing regulatory mechanisms;
> (E) other natural or manmade factors affecting its continued existence.

16 U.S.C. § 1533(a)(1)(A)-(E); 50 C.F.R. § 424.11(c)(1) - (5).

A species is "endangered" if it is "in danger of extinction throughout all or a significant portion of its range" due to one or more of the five listing factors. 16 U.S.C. § 1531(6). A species is "threatened" if it is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." 16 U.S.C. § 1531(20). While the ESA does not define the "foreseeable future," NMFS must use a definition that is reasonable, that ensures protection of the petitioned species, and that gives the benefit of the doubt regarding any scientific uncertainty to the species.

Because global warming is one of the foremost threats to the ribbon seal, NMFS should consider the timeframes used in climate modeling. The minimum time period that meets these criteria is 100 years. Predictions of impacts in the next 100 years or more are routine in the climate literature, demonstrating that impacts within this timeframe are inherently "foreseeable." The IUCN threatened species classification system, described below, also uses a timeframe of 100 years. Moreover, in planning for species recovery, NMFS and the US Fish and Wildlife Service (USFWS) routinely considers a 75-200 year foreseeable future threshold (Suckling 2006). For example, the Alaska Region of the USFWS stated in the Steller's Eider Recovery Plan:

> The Alaska-breeding population will be considered for delisting from threatened status when: The Alaska-breeding populations has <1% probability of extinction in the next 100 years; AND Subpopulations in each of the northern and western subpopulations have <10% probability of extinction in 100 years and are stable or increasing. The Alaska-breeding population will be considered for reclassification from Threatened to Endangered when: The populations has > 20% probability of extinction in the next 100 years for 3 consecutive years; OR The population has > 20% probability of extinction in the next 100 years and is decreasing in abundance (USFWS 2002 (emphasis added)).

With regard to the Mount Graham red squirrel, the USFWS stated "At least 10 years will be needed to stabilize the Mt. Graham red squirrel population and at least 100 to 300 years will be needed to restore Mt. Graham red squirrel habitat" (Suckling 2006 (emphasis added)). With regard to the Utah prairie dog, the Service defined the delisting criteria as "[t]o establish and maintain the species as a self-sustaining, viable unit with retention of 90 percent of its genetic diversity for 200 years" (Sucking 2006 (emphasis added)). NMFS stated of the Northern right whale: "[g]iven the small size of the North Atlantic population, downlisting to threatened may take 150 years even in good conditions" (Suckling 2006 (emphasis added)).

Perhaps most importantly, the time period that NMFS uses in its listing decision must be long enough so that actions can be taken to ameliorate the threats to the petitioned species and prevent extinction. Slowing and reversing impacts from anthropogenic greenhouse gas emissions, a primary threat to the ribbon seal, will be a long-term process for a number of reasons, including the long lived nature of carbon dioxide and other greenhouse gases and the lag time between emissions and climate changes. For all these reasons, Petitioner suggests a minimum of 100 years as the "foreseeable future" for analyzing the threats to the continued survival of the ribbon seal. The use of less than 100 years as the "foreseeable future" in this rulemaking would be clearly be unreasonable, frustrate the intent of Congress to have imperiled species protected promptly and proactively, and fail to give the benefit of the doubt to the species as required by law. NMFS must include these considerations in its listing decision.

II. The Ribbon Seal Qualifies for Listing Under the Endangered Species Act

Petitioner believes that all five listing factors threaten the future existence of the ribbon seal. Global warming poses the most immediate and grave threat to the ribbon seal since this species is likely to become extinct with the rapid degradation and loss of its sea-ice habitat in this century. Growing threats resulting from climate change include depletion of prey resources due to ocean acidification, more frequent contact with polar bear predators as sea ice retreats northward, and increasing shipping activity and oil and gas development (and associated oil and noise pollution) in the ribbon seal range as sea-ice loss increases the accessibility of previously ice-covered regions. The ribbon seal also faces the threat of renewed overexploitation due to the high harvest levels allowed by the Russian Federation, current oil and gas development throughout its range, rising contaminant levels in the Arctic, and bycatch mortality and competition for prey resources from commercial fisheries. Existing regulatory mechanisms have proven ineffective in mitigating these threats to the ribbon seal. Clearly, the ribbon seal is in dire need of the additional protections that only listing under the ESA can provide.

A. The Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

1. Global Climate Change

Global warming represents the gravest threat to the long-term survival of the ribbon seal. The ribbon seal depends on sea ice for birthing, rearing its pups, molting, and resting, and the disappearance and degradation of the ribbon seal's sea-ice habitat due to global warming is the primary threat to its continued existence. The ribbon seal's Arctic habitat has already warmed more than twice as fast as the global average, and a number of climate feedbacks will continue to accelerate future levels of warming in the Arctic. Even slight increases in average Arctic temperature will likely cause dramatic changes in the sea ice. Observed changes to date in sea ice include significant declines in winter and spring sea-ice cover in the Bering and Okhotsk Seas which the ribbon seal depends on for reproduction and molting, progressively earlier break-up dates of sea ice, and decreasing sea-ice thickness. Unprecedented declines in summer sea ice are enhancing the ice-albedo feedback, leading to further reductions in the winter-spring sea ice critical to ribbon seals.

Global warming will continue to accelerate in this century, with the best available science indicating the near complete disappearance of summer sea ice by mid-century or before. Of importance for the ribbon seal, winter sea ice in the Bering and Okhotsk Seas could decline by 40% by <u>mid-century</u>. Without sea ice, the ribbon seal is very likely to become extinct, and without question would qualify as an endangered species. Unless greenhouse gas emissions are cut dramatically in the immediate future, the disappearance of sea ice is essentially assured. As discussed under "The Inadequacy of Existing Regulatory Mechanisms," below, such emission cuts are not likely to happen absent significant changes in domestic and global energy policies.

This section reviews the best available scientific information regarding (a) the greenhouse effect and current levels of greenhouse gases; (b) climate feedbacks that result in accelerated global warming in the Arctic; (c) environmental changes due to global warming observed to date in the Arctic and specifically in the seasonally ice-covered seas inhabited by the ribbon seal; (d) impacts to ice-dependent Arctic seals from global warming observed to date; (e) projected climate change in the Arctic and specifically in the range of the ribbon seal; and (f) future impact to ribbons seals from global warming.

a. The Climate System, Greenhouse Gas Concentrations, the Greenhouse Effect, and Global Warming

That global warming as a result of anthropogenic greenhouse gas emissions is occurring, and will continue to occur, is no longer subject to credible scientific dispute. In its most recent 2007 report, the Intergovernmental Panel on Climate Change (IPCC) expressed in the strongest language possible its finding that global warming is occurring: "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level" (IPCC 2007: 5). The international scientific consensus of the IPCC is that most of the recent warming observed has been caused by human activities and that it is "very likely" due to increased concentrations in anthropogenic greenhouse gases (IPCC 2007). One of the most troubling recent findings is that the concentration of atmospheric carbon dioxide, the biggest contributor to global warming, has been rapidly increasing throughout the 2000s and is generating stronger-than-expected and sooner-than-predicted climate forcing (Canadell et al. 2007, Raupach et al. 2007). Studies that have used climate projections to examine the ecological consequences of global warming have forecast catastrophic species extinctions. Using a mid-range climate scenario, Thomas et al. (2004) predicted that 15-37% of species are committed to extinction by 2050. Malcolm et al. (2006) estimated that 11-43% of endemic species in biodiversity hotspots will go extinct by the end of the century under a scenario of doubled carbon dioxide concentrations, which includes an average of 56,000 endemic plants and 3,700 endemic vertebrate species.

The IPCC's[1] *Fourth Assessment Report – Climate Change 2007* and the Arctic Climate Impact Assessment's[2] ("ACIA's") *Impacts of a Warming Arctic* (ACIA 2005) have synthesized the best available science on global warming, including a detailed analysis of observed climate trends and future climate projections for the Arctic in the range of the ribbon seal. An ever-growing body of newer climate studies provides continuous updates to the IPCC findings. Based on these synthesis reports and the latest research, this section briefly reviews global warming, the greenhouse effect, and the contributions of greenhouse gases to global warming.

The basic physics underlying global warming are as well established as any phenomena in the planetary sciences. The earth absorbs heat in the form of radiation from the sun, which is then redistributed by atmospheric and oceanic circulations and also radiated back to space (Le Treut et al. 2007). The earth's climate is the result of a state in which the amount of incoming and outgoing radiation is approximately in balance (Le Treut et al. 2007). Changes in the earth's climate can be caused by any factor that alters the amount of radiation that reaches the earth or the amount that is lost back into space, or that alters the redistribution of energy within the atmosphere and between the atmosphere, land, and ocean (Le Treut et al. 2007). A change in the

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[1] The IPCC was established by the World Meteorological Organization and the United Nations Environment Programme in 1988 (IPCC 2001a). The IPCC's mission is to assess available scientific and socio-economic information on climate change and its impacts and the options for mitigating climate change and to provide, on request, scientific and technical advice to the Conference of the Parties to the United Nations Framework Convention on Climate Change (IPCC 2001b). Since 1990, the IPCC has produced a series of reports, papers, methodologies, and other products that have become the standard works of reference on climate change (IPCC 2001). The 2007 *Fourth Assessment Report* is the most current comprehensive IPCC reference and has built and expanded upon the IPCC's past products.

[2] The Arctic Council is a high-level intergovernmental forum that addresses the common concerns and challenges faced by the Arctic people and governments of the eight Arctic nations – Canada, Denmark/Greenland/Faroe Islands, Finland, Iceland, Norway, Russia, Sweden, and the United States, as well as six Indigenous Peoples organizations – Aleut International Association, Arctic Athabaskan Council, Gwich'in Council International, Inuit Circumpolar Conference, Russian Association of Indigenous Peoples of the North, and Saami Council, as well as official observers (ACIA 2005). The Arctic Council commissioned the ACIA project and charged its working groups – Arctic Monitoring and Assessment Programme ("AMAP"), Conservation of Arctic Flora and Fauna ("CAFF"), and the International Arctic Science Committee ("IASC") - with its implementation. The efforts of hundreds of scientists over four years, as well as the special knowledge of indigenous peoples, contributed to the ACIA report. In sum, the ACIA (2004) is a comprehensively researched, fully referenced, and independently reviewed evaluation of Arctic climate change and its impacts (ACIA 2005).

net radiative energy available to the global earth-atmosphere system is called "radiative forcing" (Le Treut et al. 2007). Positive radiative forcings tend to warm the earth's surface while negative radiative forcings tend to cool it (Albritton et al. 2001).

Radiative forcings are caused by both natural and anthropogenic factors (Albritton et al. 2001, ACIA 2005, Le Treut et al. 2007). The level of scientific understanding of these different forcings varies, and the forcings themselves and interactions between them are complex (Le Treut et al. 2007). The primary cause of global warming, however, is society's production of massive amounts of "greenhouse gases" such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and halocarbons that cause positive radiative forcings (Forster et al. 2007, Le Treut et al. 2007).

The Enhanced Greenhouse Effect is caused by increasing concentrations of these greenhouse gases in the earth's atmosphere. As greenhouse gas concentrations increase, more heat reflected from the earth's surface is absorbed by these greenhouse gases and radiated back into the atmosphere and to the earth's surface. Increases in the concentrations of greenhouse gases slow the rate of heat loss back into space and warm the climate, much like the effect of a common garden greenhouse (Forster et al. 2007, Le Treut et al. 2007). The higher the level of greenhouse gas concentrations, the larger the degree of warming experienced. While much smaller amounts of other greenhouse gases are emitted, these other gases still make an important contribution to climate change because they have global warming potentials many times that of carbon dioxide (Forster et al. 2007).

By the time of the Fourth Assessment Report of the IPCC in 2007, the atmospheric concentration of carbon dioxide had increased by 36% since 1750 to a level that has not been exceeded during the past 650,000 years and likely not during the past 20 million years (Denman et al. 2007). About three fourths of anthropogenic carbon dioxide emissions come from fossil fuel burning, and most of the remaining emissions are due to land-use changes, primarily deforestation (Denman et al. 2007). Carbon dioxide is considered the most important greenhouse gas overall because the volume emitted is greater that of all the other greenhouse gases combined.

Of great concern, the rate of increase of total atmospheric carbon dioxide concentrations is accelerating, with especially rapid increases observed in the 2000s (Canadell et al. 2007). Carbon dioxide emissions increased from 3.2 ± 0.1 GtC yr^{-1} during the 1990s to 4.1 ± 0.1 GtC yr^{-1} during 2000-2005 (Denman et al. 2007). These increased emissions have been attributed to rises in fossil fuel burning and cement production (average proportional growth increased from 1.3% yr^{-1} to 3.3% yr^{-1}) rather than emissions from land-use change which remained approximately constant (Canadell et al. 2007). During the past 50 years, carbon dioxide sinks on land and oceans have become less efficient in absorbing atmospheric carbon dioxide, which is also contributing to the observed rapid rise (Canadell et al. 2007). As of March, 2006, the atmospheric carbon dioxide concentration was 381 ppm, and rising at over 2 ppm per year (Shukman 2006).

The atmospheric concentration of methane, another important greenhouse gas, has increased by about 150% since 1750, continues to increase, and has not been exceeded during the past 650,000 years (Forster et al. 2007). About 60% of current methane emissions come from human activities, and there is also evidence that current carbon monoxide (CO) emissions are a cause of increasing methane concentrations (Denman et al. 2007). Over a 100-year period, methane will trap about 23 times more heat than an equal amount of carbon dioxide (Albritton et al. 2001).

The atmospheric concentration of nitrous oxide (N_2O) has increased by about 18% since 1750, continues to increase, and has not been exceeded during at least the last 2000 years (Forster et al. 2007). About half of the nitrous oxide emissions to the atmosphere come from human activities (Denman et al. 2007). Over a 100-year period, nitrous oxide will trap about 296 times more heat than an equal amount of carbon dioxide (Albritton et al. 2001).

Halocarbons are carbon compounds that contain fluorine, chlorine, bromine, or iodine (Forster et al. 2007). Most types of halocarbons are produced exclusively by human activities (Forster et al. 2007). Halocarbons that contain chlorine, like chlorofluorocarbons, ("CFCs") also cause depletion of the stratospheric ozone layer and are regulated under the Montreal Protocol (Forster et al. 2007). The combined tropospheric abundance of ozone-depleting gases peaked in 1994 and is now declining slowly (Forster et al. 2007). However, some compounds which have been promoted as substitutes for now-regulated CFCs are themselves greenhouse gases, and concentrations of these gases, such as hydrochloroflurocarbons ("HCFCs") and hydroflurocarbons ("HFCs") are now increasing (Forster et al. 2007). There are many different types of halocarbons, which have global warming potentials that vary between 12 and 12,000 times that of carbon dioxide (Forster et al. 2007).

Ozone is another important greenhouse gas found in both the troposphere, the portion of the atmosphere that begins at the earth's surface and extends from 8 to 14.5 kilometers (5 to 9 miles) high, and the stratosphere, the portion of the atmosphere that starts just above the troposphere and extends to 50 kilometers (31 miles) high (Albritton et al. 2001). Ozone is not directly emitted, but rather is formed from photochemical processes involving both natural gases and manmade emissions (Albritton et al. 2001). Because ozone persists in the atmosphere for only a short period of time varying from weeks to months, its role in radiative forcing is more complex and less certain than for more persistent greenhouse gases (Albritton et al. 2001).

On one hand, the loss of ozone from the stratosphere (a phenomenon popularly termed a "hole in the ozone layer") has resulted in negative radiative forcing that has offset some portion of the warming caused by other greenhouse gases (Albritton et al. 2001). However, the ozone layer is expected to rebound as a result of the Montreal Protocol, and the negative forcing caused by the current depressed levels of ozone in the stratosphere is expected to reverse (Albritton et al. 2001). The most recent findings of the Fourth Assessment Report indicate that global stratospheric ozone decreased between the late 1970s to early 1990s but has increased slightly since the early 1990s (Forster et al. 2007).

On the other hand, increases of ozone in the troposphere cause positive radiative forcing (Albritton et al. 2001). Ozone in the troposphere is in fact the third most important greenhouse gas after carbon dioxide and methane (Albritton et al. 2001). Tropospheric ozone is estimated to have increased by approximately 35% since the Industrial Revolution, though increases have varied by region (Albritton et al. 2001). Ozone concentrations respond relatively quickly to changes in the emissions of ozone precursors such as NO and NO_2 (the sum of which is denoted NO_x) and volatile organic compounds ("VOCs") (Albritton et al. 2001).

Black carbon, or soot, consists of particles or aerosols released through the inefficient burning of fossil fuels, biofuels, and biomass (Quinn et al. 2007). Black carbon warms the atmosphere as a solid, not a gas. Unlike greenhouse gases, which warm the atmosphere by absorbing longwave infrared radiation, soot has a warming impact because it absorbs shortwave radiation, or visible light (Chameides and Bergin 2002). Black carbon is an extremely powerful greenhouse pollutant. Scientists have described the average global warming potential of black carbon as about 500 times that of carbon dioxide over a 100 year period (Hansen et al. 2007, *see also* Reddy and Boucher 2007). This powerful warming impact is remarkable given that black carbon remains in the atmosphere for only a few days to a few weeks, with a mean residence time of 5.3 days (Reddy and Boucher 2007).

Black carbon contributes to Arctic warming through the formation of "Arctic haze" and through deposition on snow and ice which increases heat absorption (Quinn et al. 2007, Reddy and Boucher 2007). Arctic haze results from a number of aerosols in addition to black carbon, including sulfate and nitrate (Quinn et al. 2007). The effects of Arctic haze may be to either increase or decrease warming, but when the haze contains high amounts of soot, it absorbs incoming solar radiation and leads to heating (Quinn et al. 2007). Soot also contributes to heating when it is deposited on snow because it reduces reflectivity of the white snow and instead tends to absorb radiation. A recent study indicates that the direct warming effect of black carbon on snow can be three times as strong as that due to carbon dioxide during springtime in the Arctic (Flanner et al. 2007). Black carbon emissions that occur in or near the Arctic contribute the most to the melting of the far north (Quinn et al. 2007, Reddy and Boucher 2007).

Other gases, such as NO_x, volatile organic compounds, and carbon monoxide are called indirect greenhouse gases because of their impact on the abundance of tropospheric ozone and other greenhouse gases such as methane (Forster et al. 2007). These compounds interact and contribute to global warming in complex ways. For example, increases in NO_x concentrations decrease methane concentrations but increase tropospheric ozone (Forster et al. 2007). Moreover, deposition of the reaction products of NO_x fertilizes the earth, thereby decreasing atmospheric carbon dioxide (Albritton et al. 2001).

Many other natural and human caused factors contribute to positive or negative radiative forcing, including aerosol emissions, land-use changes, and changes in solar and volcanic activity, water vapor, and cloud cover (Le Treut et al. 2007). Nevertheless, scientists now know that greenhouse gases are the most important force driving global warming, and that carbon dioxide is in turn the most important of the greenhouse gases (Forster et al. 2007, Solomon et al. 2007). Carbon dioxide emissions from fossil fuel burning are virtually certain to remain the dominant control over trends in atmospheric carbon dioxide concentrations during this century (Forster et al. 2007).

b. The Arctic is Warming Much Faster than Other Regions

Due to its unique characteristics, the Arctic[3] has warmed and is projected to warm more rapidly than any other region on earth (ACIA 2005, Anisimov et al. 2007). 'Arctic amplification' is the phenomenon of greater and more rapid warming over the Arctic compared with other regions as a result of several interactions and feedbacks. The following section reviews the most important feedbacks that contribute to rapid Arctic warming.

The first major feedback relating to Arctic climate change involves surface reflectivity, referred to as the ice-albedo feedback (ACIA 2005). As the Arctic warms, rising temperatures melt snow and ice, which begin to form later in the autumn and melt earlier in the spring (ACIA 2005). Less snow and ice cover results in lower reflectivity of solar radiation (i.e. lower "albedo") because the land and water surfaces beneath the snow and ice are much darker and absorb more of the sun's energy than the snow or ice (ACIA 2005). While sea ice reflects 85-90% of solar radiation, ocean water reflects only 10% (ACIA 2005). Greater heat absorption leads to more warming. This increased warming creates a self-reinforcing cycle by which global warming is amplified and the warming trend is accelerated (ACIA 2005). The ice-albedo feedback process is already underway in the Arctic (ACIA 2005).

An important aspect of the ice-albedo feedback that influences the melting of sea ice is that the extra heat absorbed by the ocean in the summer is carried through winter to the following year (Serreze and Francis 2006). As described above, as more sea ice melts during the summer due to rising temperatures, the ocean absorbs more heat. The growth of the autumn and winter sea ice is delayed and the resulting ice is thinner. Due to this decrease in thickness, the autumn-to-spring sea ice, which is typically 1 to 4 meters thick, is not as effective in insulating the Arctic ocean from the colder autumn-to-spring air temperatures, and more of the heat absorbed by the ocean in the summer escapes to the atmosphere, explaining why surface temperatures are expected to rise most in autumn and winter over the ocean. However, some of the extra ocean heat will be retained through the ice season and will promote the earlier melting of sea ice in spring, exposing more of ocean surface which will absorb more solar energy. As a result of this positive feedback loop, the heat content of the ocean continues to rise, and the cycle continues until none of the sea ice survives the melt season, resulting in an ice-free Arctic summer (Serreze and Francis 2006).

The ice-albedo positive feedback loop is enhanced by three physical processes. First, as sea ice melts, meltwater pools forming on the surface of the sea ice have lower reflectivity and thus lead to increased melting of the surface (Serreze and Francis 2006). Secondly, as more gaps (i.e. leads and polynyas) open in the sea ice, more radiation is absorbed by the exposed ocean surface which triggers further melting of the edges and undersides of the ice floes (Serreze and Francis 2006). Finally, as snow melts, the snow grains increase in size which reduces the reflectivity and increases the melt rate (Serreze and Francis 2006).

Another factor that enhances the ice-albedo feedback is the deposition of black carbon in the Arctic. Black carbon, or soot, consists of particles or aerosols released from the burning of fossil fuels, in particular from fossil fuels and biomass, which are carried by winds and deposited in the Arctic (ACIA 2005). The soot deposition slightly darkens the surface of the otherwise

[3] IPCC and ACIA publications' general definition of the "Arctic" is the area within (i.e., north of) the Arctic Circle which corresponds to 60°N to 90°N.

white snow and ice, further reducing surface reflectivity, increasing heat absorption, and therefore increasing warming (ACIA 2005). Arctic warming will also be further accelerated by reflectivity changes that occur as boreal forests expand further northward and replace existing tundra (ACIA 2005). Forests are taller, darker, and more textured than the relatively smooth tundra, and therefore absorb more radiation (ACIA 2005). While the greater carbon intake of forests versus tundra may moderate this impact, scientists believe that the impacts from decreases in surface reflectivity are likely to outweigh the impacts from greater carbon uptake (ACIA 2005).

The second positive feedback that enhances Arctic warming is the interaction between rising temperatures and release of greenhouse gases from permafrost (ACIA 2005). Large amounts of carbon are currently trapped as organic matter in the permafrost that underlies much of the Arctic (ACIA 2005). During the summer when the surface layer of permafrost thaws, organic matter in this layer decomposes, releasing carbon dioxide and methane into the atmosphere (ACIA 2005). Global warming accelerates the decomposition rate of organic matter in the permafrost, increasing the release of greenhouse gases and further increasing their atmospheric concentrations (ACIA 2005). A positive feedback loop is created which amplifies the rate of warming (ACIA 2005). A long-term concern is the release from the permafrost of large amounts of methane, a potent greenhouse gas that traps about 23 times more than the same amount of carbon dioxide over a 100-year period. Large amounts of methane are currently stored in permafrost and at shallow depths in cold ocean sediments (ACIA 2005). Even a relatively small rise in temperature of the permafrost or water at the seabed could initiate the release of this methane and greatly increase global warming.

c. Climate and Environmental Changes Observed to Date

Climate change in the Arctic is occurring at a rapid pace that is exceeding the predictions of the most advanced climate models. The mean model forecast from the IPCC's Fourth Assessment Report significantly under-estimates the declining trend in both summer and winter Arctic sea-ice extent (Stroeve et al. 2007). Winter sea-ice extent in 2006 and 2007 declined to a minimum which most climate models forecast would not be reached until 2070 or beyond (Stroeve et al. 2007), and summer sea-ice extent in 2007 plummeted to a record minimum (NSIDC 2007b) which most climate models forecast would not be reached until 2050 or later (Stroeve et al. 2007). 2007 shattered records for Arctic climate change in other ways. Greenland ice sheet melt has been accelerating, and in 2007, an unprecedented 552 billion tons of ice melted from the ice sheet, which is ~12% more than in the previous worst year of 2005 (Borenstein 2007). The Bering Strait and Chukchi Sea inhabited by the ribbon seal experienced sea surface temperatures that were 3.5°C warmer than historical averages and 1.5°C warmer than the historical maximum (Hines 2007). Climate scientists are warning that the Arctic may have already passed a tipping point beyond which an ice-free Arctic summer is inevitable. Clearly, rapid degradation of the ribbon seal's habitat throughout its range poses a grave threat to the persistence of this species.

This section reviews the best available science on observed changes in Arctic climate conditions that are most relevant to the ribbon seal. The most recent scientific information on

Arctic-wide climate change is presented, followed by information on regional climate change in the range of the ribbon seal.

Increases in surface temperature

Arctic surface temperatures increased twice as much as the global average during the 20th century (Trenberth et al. 2007), and warming trends have accelerated in recent decades. The Arctic Climate Impact Assessment (ACIA) evaluated the spatial and temporal variations in temperature over all land areas in the Arctic for the 20th century (1900-2003) using the Climatic Research Unit and GHCN databases (ACIA 2005). Temperature trends in the Arctic were similar to the global trends: the Arctic was cooler than average from 1890-1920, warmer from 1920s-1940s, cooler from the 1940s to the mid-1960s, and warmer from the mid-1960s onward, with warming especially strong from 1990 to present (ACIA 2005). One of the most important findings was that the rate of temperature increase in the Arctic was much larger than the global average increase during the 20th century and has been particularly rapid since the mid-1960s. The average rate of temperature increase during 1966-2003 over the Arctic was 0.4 ºC/decade, approximately four times greater than the average for 20th century (ACIA 2005). The land-surface annual air temperature trends in northwestern Alaska and northeastern Russia in coastal areas surrounding the Bering, Chukchi, and Okhotsk Seas inhabited by the ribbon seal have increased by 1 to 2ºC per decade during 1966-2003 (ACIA 2005: Figure 2.7(d)). In some areas of western Alaska and eastern Russia, winter and spring (December-May) temperatures over land have increased by as much as 4-8°C over the last 40 years (1966-2003) (ACIA 2005: Figure 2.8(d)).

Satellite-derived temperature data for <u>both</u> land and sea surfaces, providing full coverage of the Arctic for the past 25 years, verify that warming trends are accelerating. From 1981-2005, the Arctic region has been warming at a rate of 0.72 ± 0.10 °C per decade (Comiso 2006b). Regionally, the trends are 0.54 ± 0.11 °C per decade over sea-ice, 1.19 ± 0.20 °C per decade over Greenland, 0.84 ± 0.18 °C per decade over North America and 0.13 ± 0.16 °C per decade over Northern Eurasia (Comiso 2006b). Notably, high temperature anomalies were much more prevalent in the 2000s compared to the 1980s (Comiso 2006b).

In the ribbon seal range, regional analyses of surface air and ocean temperatures indicate that temperatures are rising across the Bering Sea. Temperature data from 1950-2002 at St. Paul Island on the southeastern Bering Sea shelf show a transition from cold to warm anomalies in 1976, consistently earlier springs beginning in 1996, and longer warm periods extending from February through November beginning in 2000 (Overland and Stabeno 2004). At St. Lawrence Island in the northern Bering Sea, air temperatures have increased from 1997-2004 (Grebmeier et al. 2006). Depth-averaged summer ocean temperatures measured at a mooring at 70 m depth on the southeastern Bering Sea shelf were 2°C warmer in 2001-2003 compared to the mid-1990s (Overland and Stabeno 2004). In the Northern Bering Sea, bottom water temperatures have been increasing from 1988-2005 (Grebmeier et al. 2006).

In a recent study of ocean temperature change, Arctic Ocean surface warming trends were analyzed over the past 100 years (Steele et al. 2007) and showed pronounced warming in the ribbon seal range. Temperature increases were particularly large after 1995, especially since

2000 (Hines 2007). The region just north of the Chukchi Sea experienced sea surface temperatures 5°C above average in 2007, a record high never before observed (Hines 2007). Of concern for the ribbon seal, the Bering Strait and Chukchi Sea experienced the greatest summer warming. Recent sea surface temperatures for this region were generally 3.5°C warmer than historical averages and 1.5°C warmer than the historical maximum (Hines 2007).

Changes in precipitation

Precipitation has increased in the Arctic (Anisimov et al. 2007) perhaps by as much as 8% in the past 100 years (ACIA 2005). Rain on snow events have also increased significantly across much of the Arctic, with increases of 50% recorded over the past 50 years in western Russia (ACIA 2005). At the same time, snow cover has decreased by about 10% over the Northern Hemisphere as a whole since 1972 (ACIA 2005). On a regional basis, snow cover in North America has decreased in spring extent since the 1950s (ACIA 2005). There is also evidence of a general decrease in snow depth in Canada since 1946, especially in the spring, and of decreases in winter snow depths over European Russia since the beginning of the last century (Serreze et al. 2000). Overall, decreasing snow cover over land and sea ice will lower its surface albedo and accelerate ice melt.

Changes in permafrost

Changes in the temperature and extent of permafrost in the Arctic have been recorded as temperatures warm, providing another indicator of global warming (Lemke et al. 2007). Permafrost warming is occurring in the North American and Russian Arctic. Permafrost temperature has increased by up to 2-3°C in northern Alaska since the 1980s, by 0.3-0.8°C in the Canadian High Arctic since the 1990s, and by 0.3-0.7°C in the 1980s in western Siberia in parallel with increasing air temperature and decreasing insulating snow cover (Lemke et al. 2007). Permafrost degradation, where the thickness and areal cover of permafrost are reduced by thawing, is especially severe along Arctic coasts with ice-bearing permafrost. Over the Alaskan Beaufort Sea coast, mean annual erosion rates range from 0.7 to 3.2 m/year with maximum observed rates of 16.7 m/year (Lemke et al. 2007). Along the Russian Arctic coast, erosion rates range from 2.5-3.0 m/year for ice-rich coasts to 1.0 m/year for ice-poor permafrost coasts (Lemke et al. 2007). Overall, warming permafrost is releasing greenhouse gases that will further increase warming.

Changes in the Greenland ice sheet

Melting of the Greenland ice sheet has accelerated far beyond what scientists predicted even just a few years ago. Using satellite observations, Rignot and Kangaratnam (2006) found that mass loss from the Greenland ice sheet more than doubled between 1996 and 2005, increasing from 91 to 224 km^3 per year, due to the acceleration of ice discharge in western and eastern Greenland. Using a longer study period, Steffen et al. (2007) reported a 30% increase in the ice sheet melt area in western Greenland between 1979 and 2006, with record melt years in 1987, 1991, 1998, 2002, 2005, and the most extreme melt year in 2007. In 2007, 552 billion tons of ice melted from the Greenland ice sheet, which is ~12% more than the previous worst year of

2005 (Borenstein 2007). These losses have been linked to extended, warm air temperatures over the Greenland ice sheet, which have increased by 4°C since 1991 (Steffen et al. 2007).

The rate of ice loss from the Greenland ice sheet has been consistently under-estimated by climate models because they do not include important physical processes that influence the magnitude of glacier response to changes in air and ocean temperature (Rignot and Kangaratnam 2006). Such physical processes include reduced surface albedo, loss of buttressing ice shelves, lowered ice surface altitude, and the formation of rivers of melt water, called "moulins," that flow down several miles to the base of the ice sheet, where they lubricate the area between the ice sheet and the rock, speeding the movement of the ice towards the ocean (Hansen et al. 2006, Rignot and Kangaratnam 2006). The accelerating melt of the Greenland ice sheet is relevant to ribbon seal population persistence because it further reduces surface albedo in the Arctic, thus enhancing warming, and provides another warning that Arctic ice is melting much faster than climate models predict.

Decreases in sea ice

A key climate indicator of critical importance to the ribbon seal is sea-ice extent, thickness, and timing of formation and break-up. During the winter, spring, and early summer, the ribbon seal is dependent on sea ice for resting, birthing, rearing its pups, molting, and as a resting platform for pups while they are learning aquatic proficiency. Early melting of sea ice and reductions in sea-ice extent will increase stress and mortality of ribbon seals by disrupting these essential life history behaviors. Of primary concern for the future survival of the ribbon seal is the accelerating loss of winter and spring sea ice in the seasonally ice-covered Bering and Okhotsk Seas inhabited by the ribbon seal for reproduction and molting. Unprecedented losses of summer sea ice have also occurred throughout the 2000s, including significant, large-scale declines in the Chukchi and Beaufort Seas in the northern ribbon seal range, which culminated with the dramatic, unpredicted summer sea-ice decline of 2007. Many climate scientists have warned that the Arctic may have already passed a tipping point beyond which an ice-free Arctic summer is inevitable. The loss of summer sea ice will increase ocean surface warming, increasing the ice-albedo feedback and accelerating the melt of winter and spring sea ice that the ribbon seal depends on.

Sea-ice extent

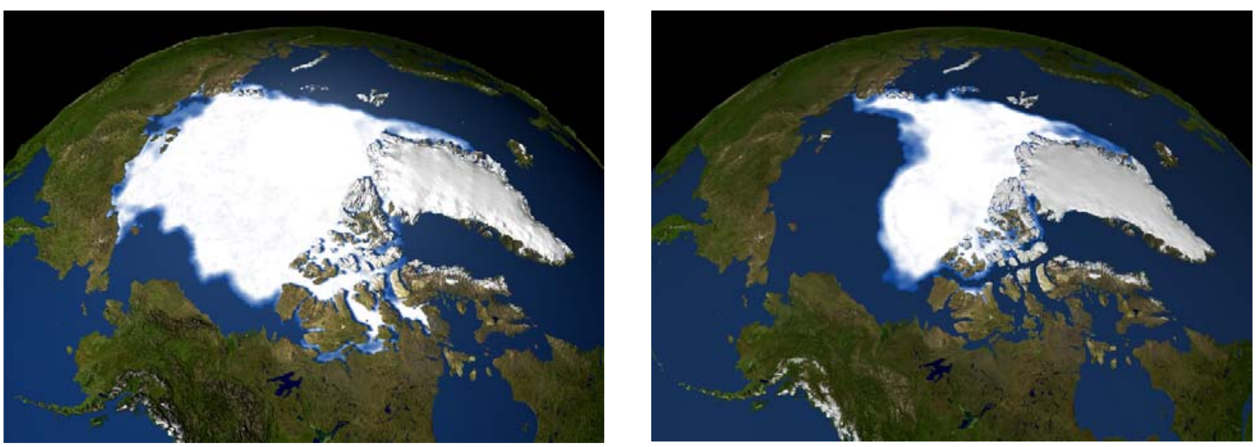
The extent of sea ice is a key indicator of climate change (ACIA 2005). It significantly influences climate by affecting surface reflectivity, cloudiness, humidity, exchanges of heat and moisture at the ocean surface, and ocean currents, and thus likely exerts a substantial influence on climate change related to global warming (ACIA 2005). Within each year, the Arctic sea-ice cover reaches its maximum extent in March and its minimum extent in September at the end of the melt season (ACIA 2005). The perennial ice is the sea ice that survives the summer melt season which consists mainly of the thick multi-year ice floes that are the mainstay of the Arctic sea-ice cover (Comiso 2005).

The extent of September sea ice declined at a rate of 7.8% per decade from 1953–2006 (Stroeve et al. 2007) and the rate of loss appears to be accelerating. In the more recent period from 1979–2006, September sea ice declined by 9.1% per decade, equaling a loss of more than 100,000 km^2 of sea ice per year (Stroeve et al. 2007). Comiso (2006b) reported that the average area of the perennial ice cover from 2002-2005 was 4.95 x 10^6 km^2 while the corresponding value from 1979-1982 was 6.33 x 10^6 km^2. This equates to an overall loss of 1.38 x 10^6 km^2 of sea ice over this period and a decline of 9.9% per decade (Comiso 2006b). Alarmingly, these estimates of sea-ice decline do not incorporate the unprecedented loss of summer sea ice in 2007, which would drive the rate of decline even higher.

Arctic summer sea ice is melting more rapidly than recent climate models predict. Stroeve et al. (2007) evaluated how well the IPCC Fourth Assessment Report multi-model ensemble simulated observed Arctic sea-ice loss over the 1953-2006 study period, and found that the mean model forecast significantly underestimated the declining trend in September sea-ice extent. The most striking finding was that recent summer sea-ice minima are approximately 30 years ahead of the IPCC ensemble mean model predictions (Stroeve et al. 2007).

In 2007, the year after Stroeve et al. (2007)'s study period ended, summer sea-ice extent reached an utterly stunning new record minimum (NSIDC 2007b). At 4.28 million km^2 (1.65 million square miles), the minimum sea-ice extent on September 14, 2007 was about one million square miles[4] below the average minimum sea-ice extent between 1979 and 2000 (NSIDC 2007b) (Figure 3). At the lowest extent on record, 2007 summer sea-ice extent was nearly 25% less than the previous low in 2005 (NSIDC 2007b). The 2007 minimum was lower than the sea-ice extent most climate models predict would not be reached until 2050 or later (Figure 4).

Figure 3. Sea-ice extent on September 21, 1979 and September 14, 2007.
Source: Images courtesy NASA/Goddard Space Flight Center Scientific Visualization Studio.



Sea-Ice Extent in September, 1979

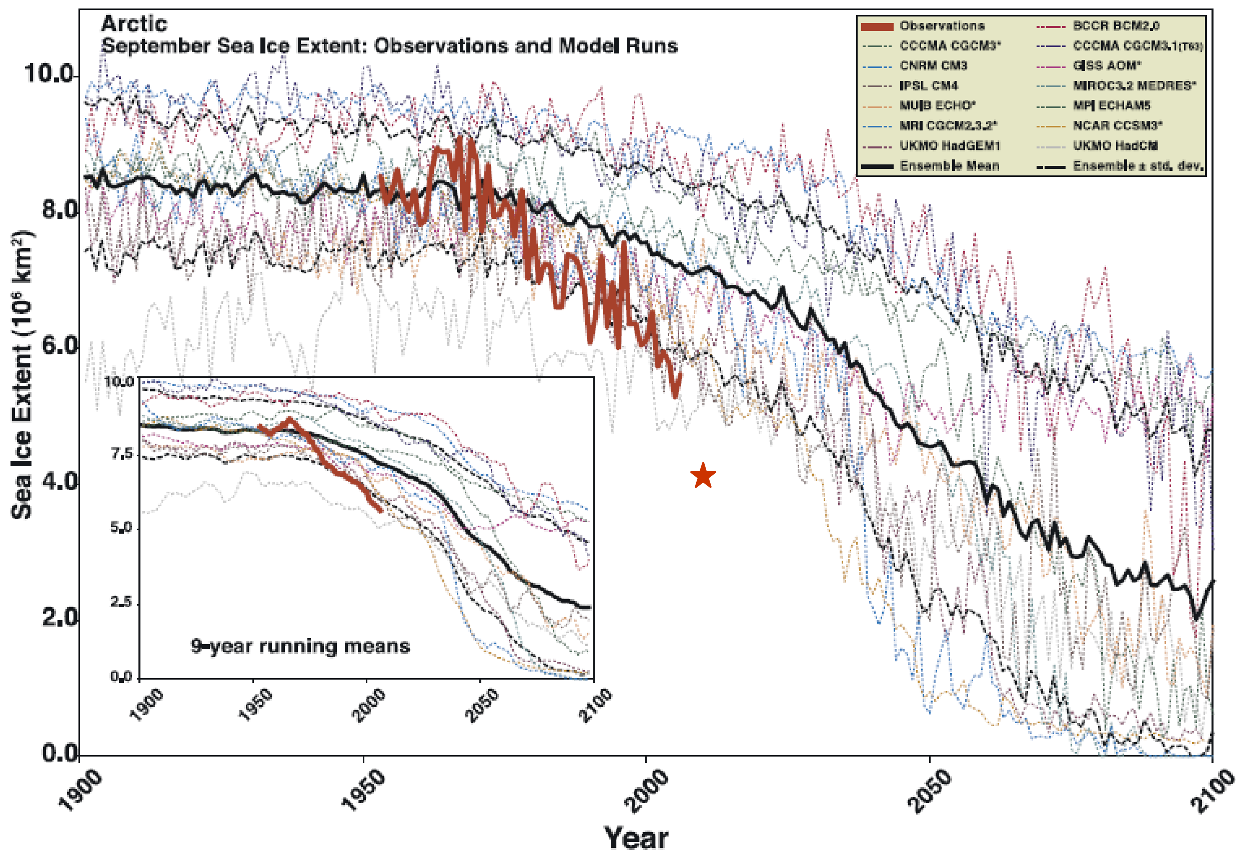
Sea-Ice Extent in September, 2007

In response to this unprecedented loss of summer sea ice, NSIDC senior scientist Mark Serreze warmed that the positive feedback loop of arctic amplification may have reached a tipping point:

[4] One million square miles is equal to about the area of Alaska and Texas combined.

The sea-ice cover is in a downward spiral and may have passed the point of no return. As the years go by, we are losing more and more ice in summer, and growing back less and less ice in winter. We may well see an ice-free Arctic Ocean in summer within our lifetimes....The implications for global climate, as well as Arctic animals and people, are disturbing (NSIDC 2007b).

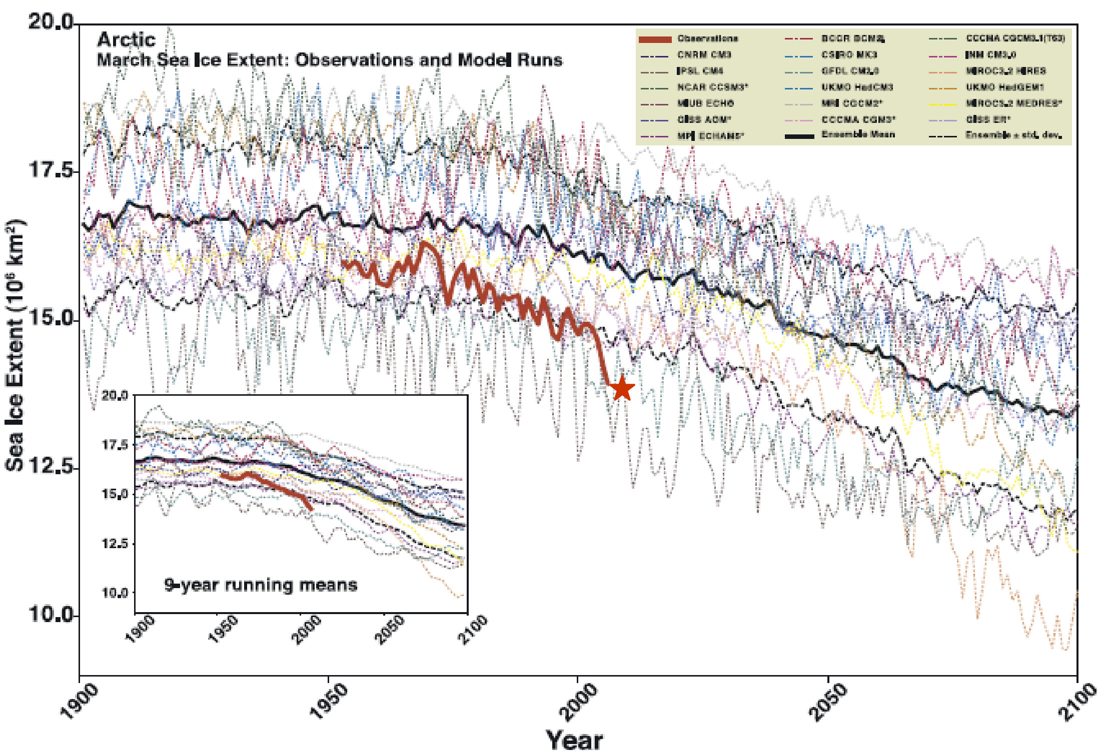
Figure 4. Arctic September sea-ice extent (x 10^6 km^2) from observations (thick red line) and 13 IPCC AR4 climate models, shown with the multi-model ensemble mean (solid black line) and standard deviation (dotted black line). Inset shows 9-year running means. Red asterisk shows 2007 observed sea-ice extent (added by Petitioner).
Source: Based on Stroeve et al. 2007: Figure 1.



Another worrisome trend is the recent accelerated loss of winter sea-ice extent that the ribbon seal depends on for critical life history behaviors. Through the early 2000s, the decline in sea-ice extent was much greater in the summer than in the winter (Meier et al. 2007). Despite decreasing summer sea-ice extent, winter sea ice was largely able to rebound during the winter time. Downward trends in March sea-ice extent, which represents the climatological sea-ice maximum, were -1.8% per decade from 1953-2006 and higher over recent decades: -2.9% per decade from 1979-2006 (Stroeve et al. 2007). However, researchers have detected anomalously low winter sea-ice extent in the most recent years of 2004-2006. Meier et al. (2005) found that sea-ice extent was anomalously low during the winter and spring (December-May) of 2004 and 2005, when every month except May 2005 had a record-low sea-ice extent. Declines in winter sea-ice extent occurred in all regions of the Arctic, including the north Atlantic and north Pacific, indicating that the onset of freeze-up is being delayed throughout the Arctic. In a second study, Comiso (2006a) found that winter sea-ice cover in 2005 was the lowest during the satellite era and was followed by even lower winter sea-ice cover in 2006, corresponding to values ~6% lower than average in each year. Winter sea-ice declines were correlated with rising surface temperatures and occurred in the marginal Arctic seas, including the Sea of Okhotsk in 2005 and 2006 and the Bering Sea in 2006 (Comiso 2006a: Figure 3) and in the eastern part of the Arctic basin where declining perennial ice cover is becoming increasingly vulnerable. Comiso (2006a) warned that greenhouse gas warming in the Arctic is becoming evident even in the dark winter months and that winter ice cover is likely to continue to retreat in the near future.

Consistent with these studies, Stroeve et al. (2007) found that winter sea ice is also melting more rapidly than the IPCC Fourth Assessment Report multi-model ensemble predicts (Figure 5). March sea-ice extent in 2006 fell to a record-low minimum (NSIDC 2007a) which most climate models forecast would not be reached until 2070 or beyond (Stroeve et al. 2007). March sea-ice extent in 2007 was the second-lowest in the satellite record (14.7 km^2), narrowly missing the 2006 low (14.5 km^2) (NSIDC 2007a).

Figure 5. Arctic March sea-ice extent (x 10^6 km^2) from observations (thick red line) and 18 IPCC AR4 climate models, shown with the multi-model ensemble mean (solid black line) and standard deviation (dotted black line). Inset shows 9-year running means. Red asterisk shows 2007 observed sea-ice extent (added by Petitioner).
Source: Based on Stroeve et al. 2007: Figure 2.



Regional losses in sea ice in the ribbon seal range

The regions inhabited by the ribbon seal are experiencing some of the most pronounced losses in summer and winter sea-ice cover. The Beaufort and Chukchi Seas have lost significant perennial sea-ice cover where areas of melted sea ice reached a record high in 1998 and have since remained higher than average (Comiso 2006b). Abnormally large open water areas in late summer in the Beaufort, Chukchi, and Siberian Seas occurred in 2002, 2003, 2004, 2005 (Comiso 2005) and most recently in 2007. The loss of summer sea-ice cover has resulted in large decreases in the albedo of the Beaufort and Chukchi Seas in recent decades which will lead to further warming (Comiso 2006b).

Of particular importance to the ribbon seal, the seasonally ice-covered Okhotsk and Bering Seas are experiencing significant losses in winter and spring sea ice during March-June (Meier et al. 2007) which are the months critical for ribbon seal breeding and molting. A study of regional trends in sea-ice extent from 1979-2006 using pan-Arctic satellite data indicates that sea ice has been declining significantly in the Sea of Okhotsk and Bering Sea during these critical months (Table 3) (Meier et al. 2007). Sea ice losses have been particularly severe in the Sea of Okhotsk, where significant declines have occurred throughout the fall, winter, spring, and early summer months (October-June) (Table 3) (Meier et al. 2007).

Table 3. Regional trends in sea ice extent in the Arctic seas given as % per decade for each month for 1979-2006. Standard deviation values are provided in parentheses for the annual trends. Trends in bold are statistically significant at the 99% level and in italics at the 95% level. Blank fields indicate months where little or no ice is found in the region. A trend of zero generally reflects 100% ice cover in a region throughout the time series.
Source: Based on Meier et al. (2007: Table 2).

Month	**Okhotsk**	**Bering**	**Chukchi**	**Beaufort**
Jan	**-11.8**	5.4	0.0	0.0
Feb	**-7.9**	2.0	0.0	0.0
Mar	**-7.8**	*-4.8*	0.0	0.0
Apr	**-14.3**	-1.8	0.0	0.0
May	**-20.6**	-10.9	-0.19	0.0
Jun	-11.4	-7.8	**-4.3**	-1.5
Jul		-39.4	**-6.7**	-0.8
Aug			**-15.4**	-2.6
Sep			**-26.3**	**-9.6**
Oct	**-22.0**	**-42.9**	**-18.6**	-2.3
Nov	**-20.3**	*-20.3*	**-8.0**	0.0
Dec	-4.6	3.0	0.0	0.0
Annual	**-9.3 (4.6)**	-1.9 (3.5)	**-4.9 (1.1)**	*-1.2 (0.9)*

A second series of regional studies using satellite, field, and Yupik traditional ecological observations also indicate that seasonal sea-ice concentrations are declining throughout the Bering Sea (Grebmeier et al. 2006). In the southeastern Bering Sea, sea ice monitored in a 1° rectangle of latitude (57-58°N) has exhibited two downward shifts. First, sea ice decreased in the mean number of days for which there was more than 5% ice cover after January 1, declining from 130 days during 1971-1976 to 67 days during 1977-1989 (Overland and Stabeno 2004). Beginning in 2000, there has been an almost complete absence of sea ice in this region (Overland and Stabeno 2004). In the northern Bering Sea, sea-ice concentrations in April, averaged for 2000-2004 from satellite measurements, were below 70% in the region between the Alaska coastline and St. Lawrence Island (Grebemeier et al. 2006).

Declining length of the ice season

The length of the sea-ice season, including the timing of sea ice freeze-up and break-up, is another critical variable of immediate concern for the ribbon seal which depends on the presence of the sea ice through spring and early summer. Numerous studies have found that the length of the ice season is shrinking. A recent analysis by Stroeve et al. (2006) using satellite passive microwave data from 1979 to 2005 over Arctic sea ice detected a trend to an earlier onset of spring melt and a longer melt season, particularly north of Alaska and Siberia, corresponding to large retreats of sea ice observed in these regions. Stroeve et al. (2006) also found that the Arctic is experiencing an overall lengthening of the melt season by 2 weeks/decade. All regions in the Arctic (except for the central Arctic) showed statistically significant (at the 99% level or higher) lengthening of the melt seasons by more than 1 week/decade, and the central Arctic showed a statistically significant increase of 5.4 days/decade (Stroeve et al. 2006).

Similarly, Comiso (2006b) reported a shift to a delayed onset of the Arctic ice growth period between 1979 and 2005, which is resulting in shorter ice season and longer melt season. Using pan-Artic satellite data, Comiso (2006b) found that the length of the melt season has increased by 15.2 days/decade over sea ice, 1.5 days/decade over the Greenland ice sheet, 2.0 days/ decade over northern Eurasia, and 5.5 days/decade over northern North America. Of importance for the ribbon seal, the duration of the melt season over sea-ice has increased by more than 5 weeks between 1979 and 2005. This equates to a shorter ice season and thinner sea ice in the seasonally ice-covered Bering and Okhotsk Seas.

Declining sea-ice thickness

The thickness of sea ice has decreased by 15-20% overall in recent decades, with some areas showing reductions of up to 40% between the late 1960s and late 1990s (ACIA 2005), though there is variability throughout the Arctic (Anisimov et al. 2007). Rothrock et al. (1999) detected a mean decrease in sea-ice thickness of 1.3 m in most of the deep water portion of the Arctic Ocean, from 3.1 m in 1958-1976 to 1.8 m in the 1990s. The greatest decrease occurred in the central and eastern Arctic in a band from the Chukchi Sea to the Fram Strait (Rothrock et al. 1999, ACIA 2005). The Polar Science Center at the University of Washington's Applied Physics Laboratory has found that the region of thick ice (greater than 3 meters) has diminished in recent decades from a large swath covering much of the central Arctic Basin to a narrow band along the northern Greenland and Canadian coasts (National Snow and Ice Data Center, http://nsidc.org/news/press/2007_seaiceminimum/20070810_index.html).

Attribution of sea-ice loss to global warming and natural variability

The observed losses of Arctic sea ice have been attributed to rising temperatures from global warming and to natural climate variability favoring sea-ice loss. The most recent scientific consensus is that global warming has contributed and continues to contribute significantly to sea-ice loss; that rising temperatures from global warming have acted synergistically with natural climate variability to accelerate sea-ice loss in recent decades; and that the influence of greenhouse gas warming on sea-ice loss is strengthening while the influence of natural variability is weakening. Below studies examining attribution of sea-ice loss to global warming versus natural climate variability are briefly reviewed.

The loss of sea ice is influenced by the natural variability in large-scale atmospheric circulation patterns--the Arctic Oscillation (AO) and North Atlantic Oscillation (NAO)--which are important in driving atmospheric variability and sea-ice circulation in the northern hemisphere. The closely related AO and NAO refer to cyclical shifts in sea level pressure between the high latitudes and mid latitudes (ACIA 2005, Serezze et al. 2007). The AO enters a positive mode when sea level pressure over the Arctic is low and sea level pressure over mid-latitudes is high. Similarly, the NAO enters a positive mode when sea level pressure of the Icelandic Low pressure system is low and pressure of the mid-latitude Azores High is high. When the AO-NAO is in a positive phase, surface winds produce a counterclockwise motion of sea ice and a greater net transport of sea ice away from the Siberian and Alaskan coasts. Sea ice is transported from Siberia, across the pole, and through the Fram Straight into the North Atlantic (i.e. an enhanced Transpolar Drift Stream). In short, a positive AO-NAO mode results in thinning of ice along the coast and the enhanced movement of ice out of the Arctic basin.

The AO-NAO was in a positive mode from 1970 to the mid-1990s and was particularly strong during 1989-1995 (Stroeve 2007). The positive AO-NAO mode is thought to have acted synergistically with rising temperatures from global warming to accelerate declines sea-ice thickness and volume from the late 1980s to mid-1990s (Lindsay and Zhang 2005, Rothrock and Zhang 2005). Lindsay and Zhang (2005) propose a three-part mechanism by which this occurred: (1) air temperatures (fall, winter, spring) over the Arctic Ocean increased due to global warming, resulting in the thinning of the first-year ice at the start of summer (pre-conditioning); (2) a positive AO-NAO mode triggered the accelerated decline of sea ice by flushing some ice out of the Arctic basin, thereby reducing sea-ice thickness and increasing summer open water, (3) and subsequent increasing temperatures combined with the ice-albedo feedback prevented sea-ice recovery (i.e. increased absorption of solar radiation further melts ice and warms water, creating thinner first year ice; thinner ice provides less insulation and more heat loss to the atmosphere, leading to higher spring temperatures and earlier melt season). The most important aspects of this cycle are that increased warming pre-conditioned the sea ice for declines and that warmer temperatures contributed to the ice-albedo feedback after the AO-NAO cycle returned to more favorable conditions for ice growth.

Although natural variability contributed to the loss of sea ice during the 1980s to mid-1990s, the scientific consensus is that sea-ice extent would have declined due to global warming even without the influence of the AO-NAO (Francis et al. 2005, Lindsay and Zhang 2005, Rothrock and Zhang 2005). Three main lines of evidence support this consensus. First, Rothrock and Zhang (2005) simulated sea-ice thickness and volume changes during 1948-1999 and found a steadily downward trend in sea ice (-4% per decade) that occurred during both negative and positive phases of the AO-NAO cycle and which was best explained by rising Arctic surface temperatures. Similarly, Meier et al. (2007) examined Arctic sea-ice extent during 1979-2005 and detected a strong relationship between sea-ice extent and air temperatures (correlation of -0.74) throughout this period, while the AO did not seem to have a prevailing effect, especially after the late 1990s. Most notably, the rate of decline of summer sea ice accelerated in the 2000s despite the reversion of the AO-NAO to a neutral phase in the mid-1990s that would not promote sea-ice loss (Meier et al. 2007, Serreze et al. 2007).

Secondly, Stroeve et al. (2007) partitioned out the variance in the observed sea-ice loss in summer and winter from greenhouse gas forcing and natural variability and found that greenhouse gas forcing contributed significantly to sea-ice declines. Stroeve et al. (2007) estimated that 33–38% of the observed September trend from 1953–2006 was forced by greenhouse gas warming, which grew to 47–57% from 1979–2006 despite the strong influence of the AO-NAO during that period. The trend in winter (March) sea-ice decline also showed a large and rising contribution from greenhouse gas forcing: 34-39% from 1953-2006 and 45-52% from 1979–2006. In a second study, Francis et al. (2005) found that greenhouse gas forcing explained most of the variability in the northern ice edge position in six marginal Arctic seas (East Siberian, Chukchi, Beaufort, Barents, Kara, and Laptev)–approximately 40%--and more than other thermal or dynamic explanatory factors.

Third, the observed declines in sea-ice extent are simulated by climate models only when greenhouse gas forcing is incorporated into the models. Specifically, Zhang and Walsh (2006) found that the models used in the IPCC Fourth Assessment Report, which incorporate a range of greenhouse gas emissions levels, produced a multi-model mean annual trend in sea-ice extent within 20% of the observed climatology from 1979–1999, with a good simulation of the seasonal cycle of more sea-ice loss in the summer than in the winter (Zhang and Walsh 2006).

A final important finding of these attribution studies is that the influence of greenhouse gas warming on sea-ice loss is strengthening while the influence of natural climate variability is weakening. As discussed above, Meier et al. (2007) found that the rate of summer sea decline accelerated in the 2000s despite the reversion of the AO-NAO to a neutral state that would not promote sea-ice loss, pointing to a weakening influence of the AO-NAO on sea-ice loss (Meier et al. 2007, Serreze et al. 2007). Secondly, Stroeve et al. (2007) extended the above-cited analysis of Zhang and Walsh (2006) to a longer time period (1953-2006 versus 1979-1999) to evaluate how well the IPCC Fourth Assessment Report multi-model ensemble simulated observed sea-ice loss. Stroeve et al. (2007) found that the mean model forecast significantly underestimated the declining trend in September Arctic sea-ice extent. The most striking finding was that recent summer sea-ice minima are approximately 30 years ahead of the IPCC ensemble mean model predictions. Stroeve et al. (2007) hypothesized that the models used in this analysis appeared to under-represent the greenhouse gas response most likely due to short-comings of the models in representing important feedback processes in the Arctic. In support, the two models that best matched observations over the satellite record incorporated more sophisticated sea-ice models. Stroeve et al. (2007) concluded that "it appears that impacts of GHG loading on Arctic sea ice in September are strong, and growing, and have also impacted March ice extent."

A final aspect of understanding sea-ice loss in the range of the ribbon seal is untangling the effects of rising temperatures from global warming and natural climate variability in the Bering Sea, which is influenced by a third atmospheric oscillation pattern, the Pacific Decadal Oscillation (PDO). The PDO influences climate in the North Pacific, including the Bering Sea, and is thought to affect sea-ice melt in this region. While the AO and NAO affect the sea ice of nearly the entire basin, the PDO exerts a more localized influence on the Siberian sector of the basin and specifically on the sea ice of the marginal, seasonally ice-covered seas used by the ribbon seal. The PDO refers to the dominant mode of sea surface temperature in the North Pacific Ocean and oscillates between a warm, positive mode and a cool, negative mode during 20–30 year periods. During the positive phase, sea level pressure of the Aleutian low pressure system is lower than average and stronger easterly winds prevail in the Bering Sea. These easterly winds influence the edge of the winter sea ice (Francis and Hunter 2007).

The PDO entered a positive phase in 1976/77, and the Bering Sea shifted from a predominantly cold, Arctic climate to a warmer, subarctic maritime climate. The increase in easterly winds with the shift in the PDO has been linked to decreases in the winter sea-ice edge in the Bering Sea between 1979-1994 (Francis and Hunter 2007). However, the PDO entered a more neutral state after 1995, which is reflected in the weaker correlations between easterly wind anomalies and the ice-edge location during 1995-2005 (Francis and Hunter 2007). From 1995 onward the winter sea-ice edge has continued to retreat, largely independent of the PDO (Francis and Hunter 2007). Studies of the influence of the PDO on the Bering Sea oceanography have reached similar conclusions to those of the AO-NAO: (1) conditions during the positive phase of the PDO may have acted synergistically with rising temperatures due to global warming to influence the retreat of sea ice in the Bering Sea; (2) the PDO entered a neutral phase in 1995, but warming and the retreat of the sea-ice edge have continued; and (3) the Bering Sea may have shifted to a new phase on a warming trajectory where it is less sensitive to the intrinsic climate variability of the North Pacific (Francis and Hunter 2007). Francis and Hunter (2007) warned that continuing warming will produce large disruptions in the Bering Sea ecosystem that ribbon seals depend on:

> The winter ice in the Barents and Bering seas is thinner and more mobile than perennial or land-fast ice, resulting in an enhanced sensitivity to regional atmospheric and oceanic circulation features. As the oceans continue to warm and storminess increases in response to increasing concentrations of greenhouse gases, as predicted by state-of-the-art global climate models [Chapman and Walsh, 2007], winter ice extent will likely also continue to retreat northward, although the drivers will vary in different locations. Losses of perennial sea ice may be accelerated by the consequent reduction in ice volume at the beginning of the melt season, and normal life cycles of marine organisms will be profoundly disrupted (Francis and Hunter 2007: 5)

A recent analysis by the North Pacific Marine Science Organization (PICES) on the implications of climate regime shifts for North Pacific fisheries reached a similar conclusion that the Bering Sea will likely continue on a warming trajectory and experience a weakening influence of the PDO:

> We hypothesize that the overall climate change occurring in the Arctic, as indicated by warmer atmospheric and oceanic temperatures and loss of 15% of sea ice and tundra area over the previous two decades, is making the Bering Sea less sensitive to the intrinsic climate variability of the North Pacific. Indeed, when the waters off the west coast of the continental United States shifted to cooler conditions after 1998, the subarctic did not change (Victoria pattern), in contrast to three earlier PDO shifts in the twentieth century. Thus we project that the Bering Sea will more likely continue on its current warm trajectory, with biomes transitioning northward, allowing pollock a larger domain at the expense of cold and ice-adapted species, rather than transitioning back to a cold regime (PICES 2005: 124).

Tipping Point in Arctic Sea Ice

Numerous researchers have warned that the global warming may have already pushed the Arctic past a 'tipping point' beyond which continued declines in Arctic sea ice are unavoidable and which will not abate until greenhouse gas emissions are drastically reduced. Lindsay and Zhang (2005) identified 1989 as a potential tipping point for the Arctic ice–ocean system in which triggering events were able to initiate a process of continual rapid change:

> It is quite possible that the large changes initiated by the gradual winter warming and the atmospheric circulation anomalies of the early 1990s have forced the system into a new state in which very large extents of summer open water and winter first-year ice are the norm. The old regime may not be regained until there is either a prolonged cooling period or a prolonged period of very negative AO index and positive PDO index that can once again build the reservoir of thick ridged ice through strengthening the circulation of the Beaufort gyre. The gradually increasing winter air temperatures may reflect a global warming signal that will preclude a return to the old regime (Lindsay and Zhang 2005: 4893).

Meier et al. (2007) also point out that the sea ice may have passed a tipping point beyond which an ice-free Arctic summer is certain:

> The AO 'triggered' the accelerated decline of the sea ice by reducing the average thickness of the ice cover, and subsequent increasing temperatures have not allowed the ice to recover. This may have caused the sea ice to pass a tipping point, where further decline to the ice-free Arctic summer state is inevitable (Meier et al. 2007: 428).

Serreze and Francis (2006) concluded:

> [o]ur guarded interpretation of the available evidence is that the Arctic is in a state of 'preconditioning', setting the stage for larger changes in coming decades. This preconditioning is characterised by general warming in all seasons, a longer melt season, and retreat and thinning of sea-ice, upon which the effects of natural variability are superimposed. Before the projected widespread increase in surface temperatures over the Arctic Ocean can clearly emerge, more sea-ice must be removed. Extreme sea-ice losses in recent years seem to be sending a message: the ice-albedo feedback is starting. With greenhouse gas concentrations on the rise, there may be no counteracting mechanism in the climate system powerful enough to stop it (Serezze and Francis 2006: 68-69).

d. Observed Impacts to Ice-dependent Seals from Global Warming

Researchers and native peoples have long noted the importance of sea-ice cover and climate conditions to the distribution and abundance of the ice-dependent Arctic seals (Vibe 1967, ACIA 2005). Studies of the ways that changing climate conditions are affecting ribbon seals have not yet been completed. However, studies of how sea-ice cover affects other ice-dependent seal species permit insights into the ways that melting sea ice may be impacting the ribbon seal.

Like ribbon seals, harp seals (*Pagophilus groenlandicus*) and hooded seals (*Cystophora cristata*) depend on pack ice in spring for giving birth, nursing, and weaning their pups. In years of low sea-ice cover, pup mortality of these species is high, leading to low reproductive success and a lack of recruitment of younger age classes into the population. For example, harp seals pup mortality in the Gulf of St. Lawrence, Canada, was estimated at 75% during the poor ice year of 2002 (Simmonds and Isaac 2007). During the summer of 2007, harp seals may have experienced complete reproductive failure due to low, poor quality sea-ice conditions. Friedlaender et al. (2007) reviewed sea-ice conditions in harp and hooded seal habitat in the Gulf of St. Lawrence and the east coast of Newfoundland and Labrador during 1969-2006, and found that sea-ice cover was below average in 9 of 11 of the most recent years (1996-2006). They warned that the trend of diminishing sea ice threatened seal reproductive success by increasing abortion rates when female seals did not find ice on which to birth and increasing pup mortality when sea ice broke up or melted before the nursing period ended (Friedlaender et al. 2007). In addition, they noted that sea-ice loss could alter timing of reproduction, prey availability, and seal predator distributions, with concomitant effects on seal condition, growth, reproductive success, and survival (Friedlaender et al. 2007).

Low spring sea-ice conditions have also been found to negatively affect reproductive success of the ringed seal (*Pusa hispida*), another ice-dependent Arctic seal. Reproduction and body condition of ringed seals was monitored in the Canadian Arctic in the 1970s and 1990s, and both unusually heavy and unusually light sea-ice conditions resulted in poor overall reproductive success of ringed seals. The unusually heavy sea-ice conditions in 1974 resulted in reduced food availability for seals and lead to low rates of ovulation, presumably from poor body condition (Kelly 2001). The light ice conditions of 1998, when sea ice broke up 43 days earlier than the preceding 8-year average, were associated with more abundant prey and high ovulation rates of seals (Kelly 2001). However, pup survival was low due to the premature weaning of pups caused by the early break-up of the sea ice on which ringed seals nurse their pups (Kelly 2001). Overall, although early sea-ice break-up may have enhanced food availability, it had an overall negative impact on the ringed seal population by interrupting nursing and increasing pup mortality.

Decreasing snow cover and earlier snow melt are also resulting in low pup survival of ringed seals, which build sub-nivian dens on the sea ice for pup-rearing. In ringed seal populations monitored in the Beaufort Sea off northern Alaska, pups are being exposed at earlier ages to predators and to freeze-thaw cycles that make them vulnerable to hypothermia due to decreasing snow depths and earlier melt that expose their sub-nivian dens (Kelly 2001). When ringed seals are forced to birth in the open due to lack of snow cover, nearly 100% of pups succumb to predation (Kelly 2001). In years of early sea-ice break-up, 1996 and 1997, more ringed seal pups were stranded on beaches (Pungowiyi 2000). These studies demonstrate the devastating population impacts that low sea-ice cover and early sea-ice melt exert on the ice-dependent Arctic seals.

e. Projected Climate and Environmental Changes

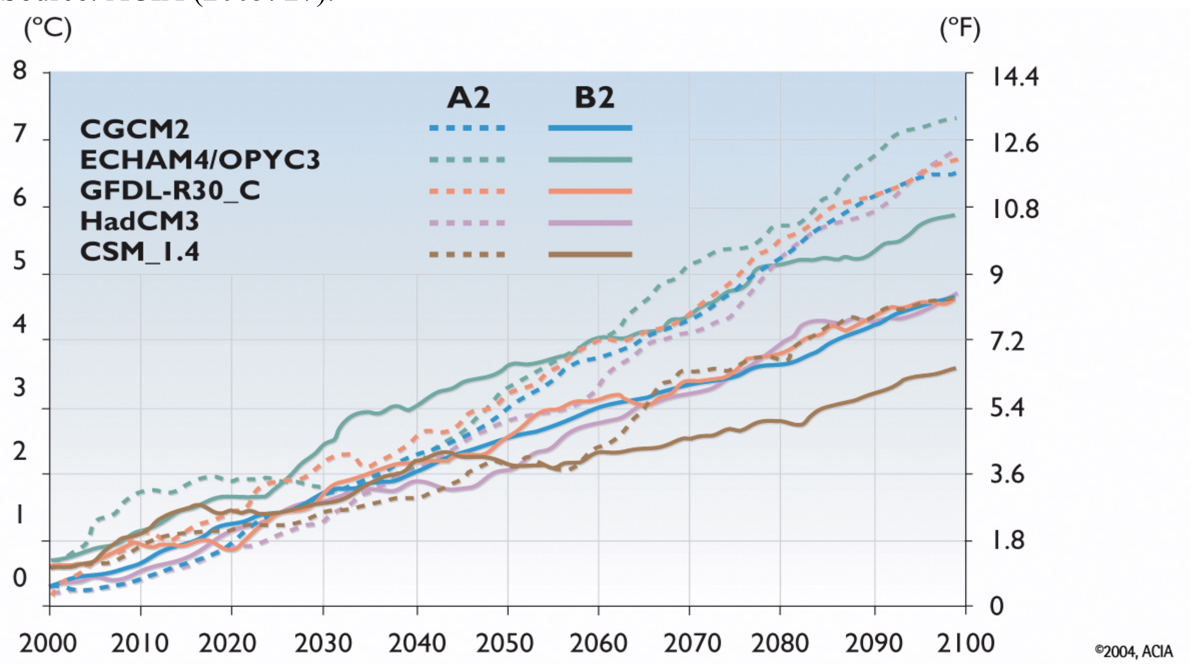
There is no credible scientific dispute that global warming will continue and may accelerate if greenhouse gas emissions are not reduced. All climate models in the IPCC and ACIA assessments predict significant warming in this century, with variation only as to the rate and magnitude of the projected warming (ACIA 2005). For its Fourth Assessment Report ("AR4"), the IPCC performed an unprecedented internationally coordinated climate change experiment using 23 models by 14 modeling groups from 10 countries to project future climate conditions. This large number of models that range from simple to complex, running the same experiments, provides more accurate quantification of future climate conditions, the importance of different model parameters, and the uncertainty in the results. For projecting future climate change, the model experiments used an array of different emission scenarios. These include three of the six Special Report on Emissions Scenarios ("SRES'), B1, A1B, and A2 that represent low, medium and high greenhouse gas growth scenarios during this century, respectively. In addition, experiments included scenarios with CO_2 doubling and quadrupling and scenarios with different levels of greenhouse gas mitigation, including (1) constant composition commitment scenarios in which greenhouse gas concentrations are fixed at year 2000 levels, (2) zero emission commitment scenarios in which emissions are set to zero in the year 2100 and (3) overshoot scenarios in which greenhouse gas concentrations are reduced after year 2150 (Meehl et al. 2007). The ACIA utilized the climate models used in the IPCC's Third Assessment Report and is a comprehensively researched, fully referenced, and independently reviewed evaluation of arctic climate change and its impacts for the region and for the world. It involved an international effort by hundreds of scientists over four years, and also included the special knowledge of indigenous people (ACIA 2005). This section reviews changes in climate condition in the Arctic and specifically in the range of the ribbon seal that are projected by the IPCC and ACIA multi-model ensembles.

Surface air temperature, precipitation, and permafrost melt

Climate models projections are unanimous that temperatures will continue to rise throughout the 21st century and that warming will be the largest in the high northern latitudes of the Arctic (Serreze and Francis 2006, Christensen et al. 2007). According to the IPCC Fourth Assessment Report (IPCC-AR4), annual mean warming in the Arctic in this century will be more than twice the level of global annual mean warming, while Arctic winter warming will be four times the level of global mean warming (Christensen et al. 2007). By the end of the 21st century, annual Arctic temperatures are projected to rise by an average of 4.9°C under the A1B mid-level emissions scenario, based on the average from 21 models (range: 2.8-7.8°C) (Christensen et al. 2007: Table 11.1). Mean warming will be larger under the A2 higher-emissions scenario (5.9°C) and smaller under the B1 lower-emissions scenario (3.4°C). Notably, winter temperatures will rise more significantly (4.3-11.4°C) than in summer (1.2-5.3°C) (A1B scenario) (Christensen et al. 2007). In the marine realm, temperatures will rise by 5-7°C over the central Arctic Ocean, and warming in winter and autumn will be especially extreme due to reduced sea-ice cover (Christensen et al. 2007).

The ACIA (2005) projected that annual average temperatures will increase across the entire Arctic, with increases of approximately 3-5° C over the land areas and up to 7° C over the oceans within this century under the B2 emissions scenario (Figure 6). Consistent with IPCC projections, winter temperatures will rise even more significantly, with increases of approximately 4-7° C over land areas and approximately 7-10° C over oceans (ACIA 2005). Patterns of temperature change predicted by regional climate models (RCMs) are quite similar to those simulated by the ACIA general circulation models. However, regional climate models project more warming along the sea-ice margins possibly because they better capture mesoscale weather systems and air-sea fluxes associated with the ice edge (ACIA 2005).

Figure 6. ACIA projected Arctic surface air temperature during 2000-2100 from 60°-90°N under the B2 and A2 emissions scenarios, expressed as the change from the 1981-2000 average.
Source: ACIA (2005: 27).



Recently, New (2005) projected that the average global temperature will have risen 2° C above pre-industrial levels sometime between 2026 and 2060, a result that is consistent with the results of the ACIA (2005) discussed above. A 2°C rise in average global temperature will translate into an average Arctic temperature increase of 3.2-6.6°C by mid-century, which will be greater in winter (4-10°C) and lower in summer (1.5-3.5°C) (New 2005).

Despite some variation among climate models and some remaining uncertainty regarding climate sensitivity, the salient point is that <u>all</u> models predict a warming climate in the relatively near future. The differences in the models are primarily only in the rate of change and occasionally geographic variation in the strength and timing of effects (ACIA 2005). Even using the lowest emissions scenario and the model that generates the least warming in response to atmospheric composition leads to a projection of warming in this century more than double that experienced in the last (ACIA 2005). All models project that the world will warm significantly as a result of human activities and that the Arctic is likely to experience this warming particularly early and intensely (ACIA 2005, Christensen et al. 2007).

Precipitation is projected to increase by ~18% (range 10-28%) over the Arctic by the year 2100 under the A1B scenario, with most of the increase falling as rain (Christensen et al. 2007). Projected precipitation increases are larger (22%) under the A2 scenario and smaller (13%) under the B1 scenario, but overall precipitation increases are robust among models (Christensen et al. 2007). The increase is projected to be largest in the winter and smallest in the summer, consistent with higher projected warming in the winter (Christensen et al. 2007). Regionally, precipitation is expected to increase over all land areas except southern Greenland (ACIA 2005). During the summer, precipitation will increase over northern North America and Chukotka, Russia (ACIA 2005).

Arctic snow cover will undergo widespread reductions during the 21st century under the IPCC model simulations, due to the strong association between higher air temperature and reduced snow cover (Meehl et al. 2007). Under the B2 lower emissions scenario, mean Arctic snow cover over land will decrease by 9-18% by the end of this century, in addition to the approximately 10% decline already observed over the past three decades (ACIA 2005). The decreases are projected to be greatest in spring and late autumn/early winter, suggesting a further shortening of the snow cover season (ACIA 2005, Meehl et al. 2007). Snow cover will decrease since the beginning of the snow accumulation season will start later and the beginning of the snow melt season will be earlier (ACIA 2005, Meehl et al. 2007). Snow quality is also expected to change, including an increase in thawing and freezing in winter that leads to ice layer formation (ACIA 2005). Overall, projected decrease in snow cover over land and sea ice will continue to lower its surface albedo and accelerate ice melt (ACIA 2005).

Declining sea-ice extent

Climate models are in near universal agreement that Arctic sea-ice extent will decline through the 21st century in response to atmospheric greenhouse gas forcing (Stroeve et al. 2007). The largest declines will occur during the summer with the loss of the perennial sea-ice cover. The most recent studies using the IPCC-AR4 models (Zhang and Walsh 2006, Arzel et al. 2006) predict losses of 50-80% of the summer Arctic-wide sea-ice extent within this century depending on the emissions scenario used. Some model projections indicate that summer Arctic sea ice could be gone by mid-century or before (Arzel et al. 2006, Holland et al. 2006). Of foremost concern for the ribbon seal, accelerating declines in winter sea ice (March-April) may lead to the loss of 40% of the winter sea ice by 2050 in the Bering and Okhotsk Seas (Overland and Wang 2007).

Sea-ice loss across the Arctic

Using the IPCC-AR4 multi-model ensemble, <u>mean</u> summer (September) Arctic sea-ice area is projected to decrease by 65.0% under the A2 scenario, 59.7% under the A1B scenario, and 45.8% under the B1 scenario by the end of this century (Zhang and Walsh 2006). In a similar assessment of the IPCC-AR4 model ensemble, Arzel et al. (2006) found that September Arctic sea-ice extent will decrease by an <u>average</u> of 62% between 1981-2000 and 2081-2100, with a smaller 15% decrease in winter (March) sea ice under the A1B scenario. Strikingly, half of the models exhibited an ice-free summer Arctic by 2100 (Arzel et al. 2006). One of the important implications of retreating perennial (i.e. summer) sea ice is that the average thickness of the ice cover becomes thinner and more vulnerable to future summer melt as the fraction of multi-year ice floes decreases and the fraction of seasonal ice floes increases (Comiso 2005).

Another important finding of IPCC-AR4 modeling efforts is that sea-ice extent is unlikely to decline linearly but may instead experience periods of abrupt and rapid declines. Holland et al. (2006) examined the potential for future abrupt transitions in Arctic summer sea-ice extent using a subset of models employed in the IPCC-AR4 analysis (seven ensemble members from Community Climate System Model, version 3) under a middle-of-the-road A1B scenario. Abrupt transitions, defined as periods of rapid sea-ice loss, commonly occurred in all of these 21st century model simulations, as early as 2015 (Holland et al. 2006). Abrupt reductions in sea ice were associated with thinning of the spring sea ice which increased the formation of open water and accelerated summer ice loss due to an enhanced ice-albedo feedback. An important result of this work was that lower greenhouse gas emissions decreased the severity and likelihood of abrupt transition events. Under the lower emission B1 scenario, 3 of 15 models show abrupt transitions lasting 3-5 years, whereas 7 of 11 models using a higher emissions A2 scenario showed abrupt transition lasting 3-10 years with larger rates of change (Holland et al. 2006).

Another study has projected the average Arctic perennial ice cover based on 25 years of continuous, spatially detailed satellite data (Comiso 2005) and the projection that a 2° C global warming will occur between the years 2026 to 2060 (New 2005). The results show "ever increasing open ocean areas in the Beaufort, Siberian, Laptev and Kara Seas. The impact of such a largely increasing open water area could be profound. It could mean changes in the ocean circulation, marine productivity, ecology, ocean circulation and the climate of the region" (Comiso 2005:53). This study also revealed that for each 1° C increase in surface temperature (global average), the area of the average perennial ice cover decreased by about 1.48 million km^2, an area over three times the size of the state of California (Comiso 2005).

Sea-ice loss in the ribbon seal range

Regional projections of changes in sea-ice extent in the ribbon seal range were recently forecast by Overland and Wang (2007), who used the IPCC AR4 models to better understand how declining sea-ice extent will affect Arctic ecosystems on a regional scale. Overland and Wang (2007) used a robust subset of IPCC AR4 models that best simulated observed sea-ice concentrations from 1979-1999 to predict sea-ice extent in the Arctic basin during summer (August–September) and in the more southerly seasonal ice zones during winter (March–April) by 2050 under the mid-level A1B emissions scenario. The models projected a consistent loss of summer sea-ice area greater than 40% by mid-century for the entire Arctic basin, including the marginal seas used by the ribbon seal—Chukchi and Beaufort—that are typically covered by sea ice in the summer months (Overland and Wang 2007). More importantly, the Bering and Okhotsk Seas were projected to lose 40% loss of their March-April sea-ice area by 2050 (Overland and Wang 2007). Thus, by mid-century, ribbon seals may lose 40% of the spring sea-ice habitat that they depend on for breeding and molting across their entire breeding range. In addition, the remaining sea-ice habitat in 2050 will be of lower quality and will likely not persist during the period needed for pupping and molting because the winter sea ice will be thinner and the period of sea-ice melt will be longer (later fall sea-ice formation and earlier spring melt),

Feedbacks of sea-ice loss on the Arctic and global environment

The loss of sea ice will have important consequences for the Arctic and global climate. First, rising greenhouse gas concentrations may favor the positive mode of AO-NAO that promotes sea-ice loss (Serreze et al. 2007). If this occurs, the ice-albedo feedback would favor continued Arctic sea-ice loss until greenhouse gas concentrations in the atmosphere are reduced. Additionally, delayed autumn and winter sea-ice growth will promote large increases in surface air temperature over the Arctic by allowing a non-insulated ocean (low sea-ice cover) to lose heat to the atmosphere (Serreze and Francis 2006). Finally, sea-ice loss will affect regions outside the Arctic by influencing mid-atmospheric patterns of atmospheric circulation and precipitation (Sewall and Sloan 2004).

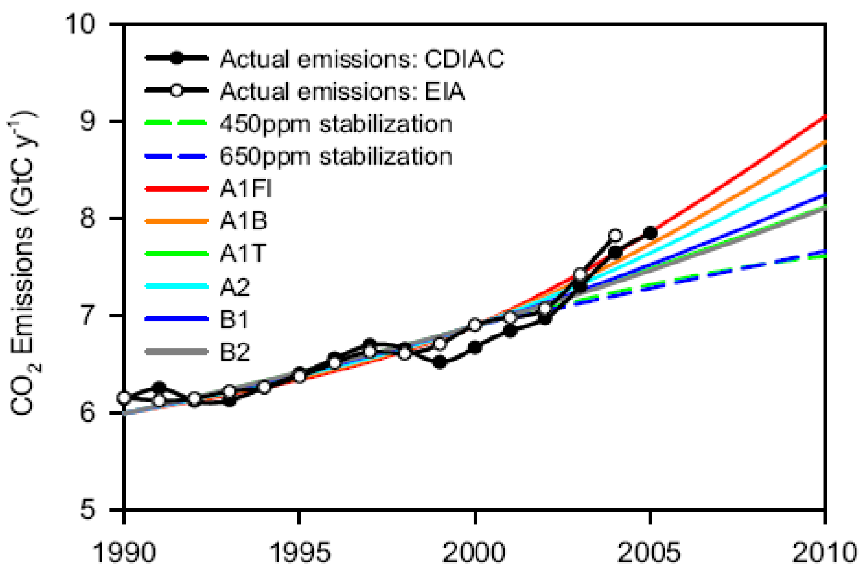
Dangerous Anthropogenic Climate Change and the Climate Commitment

Climate scientists are warning that we are rapidly approaching an emissions threshold beyond which “dangerous climate change” will be unavoidable. Warming of more than 1° C (1.8° F) above year 2000 levels has been defined as “dangerous climate change,” with particular reference to species extinction and sea level rise (Hansen et al. 2006, Hansen et al. 2007). Beyond this point, climate feedbacks will greatly amplify the warming from anthropogenic emissions, leading to rapid additional temperature increases and catastrophic climate impacts. The atmospheric greenhouse gas level “ceiling” that must not be exceeded in order to prevent additional warming of more than 1° C (1.8° F) above year 2000 levels is 450-475 ppm of carbon dioxide (Hansen et al. 2006). With atmospheric carbon dioxide levels already over 380 ppm and increasing at over 2 ppm per year, and worldwide emissions continuing to increase each year, rapid and substantial reductions are needed to stay below this ceiling.

One path to achieving these substantial emissions reductions is known as the “alternative,” as opposed to the “business as usual,” greenhouse gas emissions scenario (Hansen 2006, Hansen et al. 2006, Hansen et al. 2007). In the business as usual scenario, carbon dioxide emissions continue to grow at about 2% per year, and other greenhouse gases such as methane and nitrous oxide also continue to increase. In the alternative scenario, by contrast, carbon dioxide emissions decline moderately between now and 2050, and much more steeply after 2050, so that atmospheric carbon dioxide never exceeds 475 parts per million. The alternative scenario would limit global warming to less than an additional 1°C in this century (Hansen et al. 2006, Hansen et al. 2007).[5]

Since the year 2000, however, society has not followed the alternative scenario. Instead, the emissions growth rate has accelerated since 2000, rising from 1.1% per year from 1990-1999 to ~3.25 % per year from 2000-2004 (Raupach et al. 2007). The emissions growth rate since 2000 has even exceeded that of the most-fossil fuel intensive IPCC SRES emissions scenario, A1F1 (Figure 7) (Raupach et al. 2007). As a result, emissions since 2000 were also far above the mean stabilization trajectories needed in order to reach the 450 ppm stabilization target of the alternative scenario, and even well above a 650 ppm stabilization target (Raupach et al. 2007). If this growth continues for just ten more years, the 49% increase in CO_2 emissions between 2000 and 2015 will make it impractical if not impossible to achieve the alternative scenario (Hansen et al. 2006, Hansen et al. 2007). For this reason, it is essential that strong greenhouse gas limitations be enacted immediately.

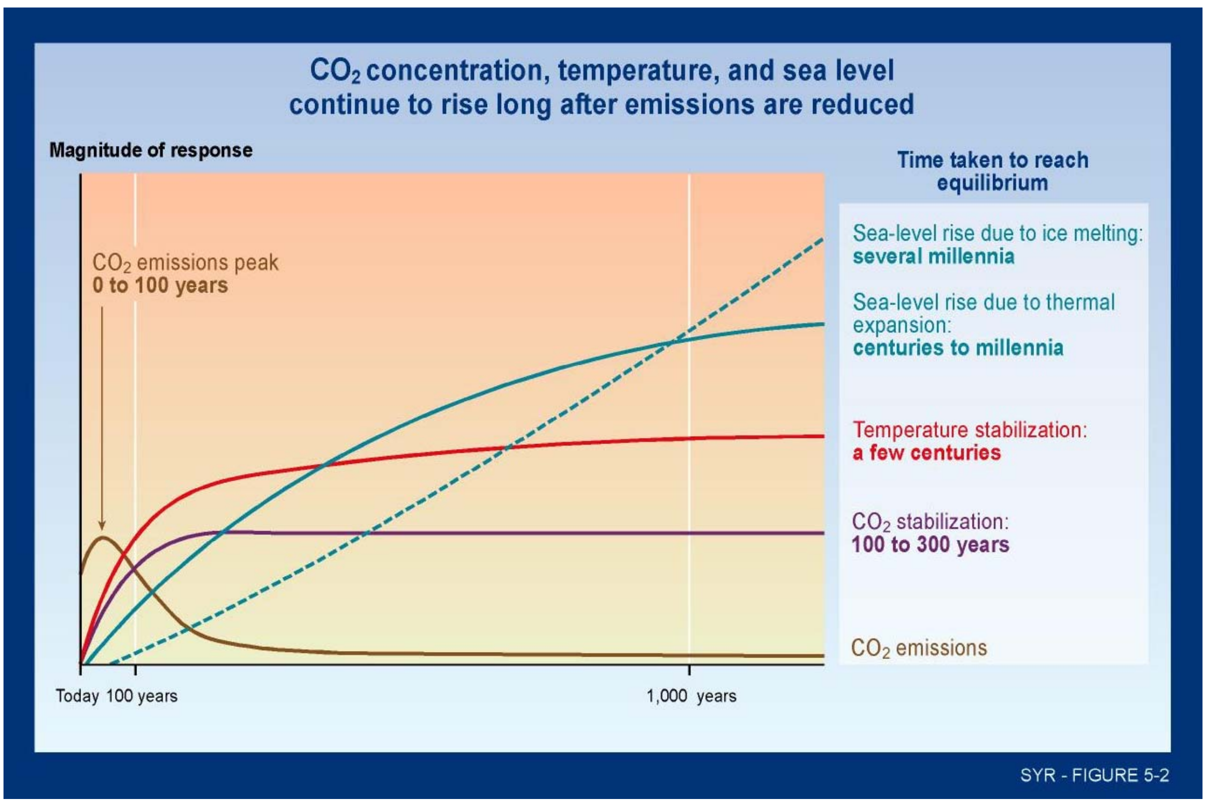
Figure 7. Observed CO_2 emissions from U.S. Department of Energy Energy Information Administration (EIA) data (1980-2004) and U.S. Department of Energy Carbon Dioxide Information and Analysis (CDIAC) data (1751-2005), compared with six IPCC emissions scenarios and with stabilization trajectories describing emissions pathways for stabilization of atmospheric CO_2 at 450 and 650 ppm.
Source: Raupach 2007: Figure 1.



[5] The "tripwire" between keeping global warming to less than 1°C, as opposed to having a warming that approaches the range of 2-3° C, may depend upon a relatively small difference in anthropogenic greenhouse gas emissions (Hansen et al. 2006, Hansen et al. 2007). This is because warming of greater than 1 °C would likely induce positive climate feedbacks, such as the release of large amounts of methane from thawing arctic permafrost, that will further amplify the warming (Hansen et al. 2006, Hansen et al. 2007).

Another difficulty in avoiding dangerous climate change is that the world is already committed to some level of continued warming and climate change for centuries to come even if greenhouse gas emissions were stabilized immediately (Figure 8). The interactions between variables including greenhouse gas emissions, total greenhouse gas levels in the atmosphere, temperature change, and melting of ice sheets create time lags in the climate system (IPCC 2001a). Slow transport of heat into the oceans and slow response of ice sheets are largely responsible for the long time periods needed to reach a new climate system equilibrium (IPCC 2001a). Even absent additional greenhouse gas emissions, this warming commitment equates to additional temperature rise of 0.6° C (1° F) that is already "in the pipeline" (Hansen et al. 2005). The IPCC multi-model climate change commitment experiments indicate that if greenhouse gases were stabilized for 100 years at year 2000, a further warming of 0.5°C (0.9°F) would occur in the 21st century (Meehl et al. 2007).

Figure 8. Relationships between carbon dioxide concentrations, temperature, and sea level rise. After CO_2 emissions are reduced and atmospheric concentrations stabilize, surface air temperature continues to rise slowly for a century or more.
Source: IPCC (2001(a): Figure SPM-5).



Overall, the sooner greenhouse gas emissions are stabilized, and the lower the level at which they are stabilized, the smaller the overall temperature increase will be (IPCC 2001a). An important point is that stabilization of carbon dioxide emissions at current or near-current levels will not lead to stabilization of carbon dioxide atmospheric concentrations (IPCC 2001a). Stabilization of carbon dioxide concentrations requires reduction of global carbon dioxide net emissions to a small fraction of the current emission level (IPCC 2001a). As discussed in depth in the section on the "Inadequacy of Existing Regulatory Mechanisms," it is essential that strong greenhouse gas limitations be enacted immediately in order to give the ribbon seal a chance for survival.

f. Future Threats to the Ribbon Seal from Global Warming

The ribbon seal is completely dependent on Arctic sea-ice habitat for survival, and without sea ice, the ribbon seal is very likely to become extinct. Ribbon seals need Arctic sea ice for essential parts of its life cycle--pupping, molting, resting, and as a platform for pups to learn aquatic proficiency. However, the ribbon seal's winter sea-ice habitat in the Bering and Okhotsk Seas is rapidly melting and could decline by 40% by 2050. Arctic air temperatures will increase by an average of 8°C during winter in this century under a mid-level emissions scenario. This warming will accelerate the ice-albedo feedback, leading to massive degradation of the ribbon seal's habitat by shrinking the length of the sea-ice season and through a relentless thinning of the remaining sea ice.

Researchers have consistently warned that the loss of the seasonal sea ice will prove devastating to ice-dependent Arctic seals (Tynan and DeMaster 1997, Kelly 2001, ACIA 2005, Learmonth et al. 2006, Simmonds and Isaac 2007). According to the ACIA, "the reduction in sea ice is very likely to have devastating consequences for polar bears, ice-dependent seals, and local people for whom these animals are a primary food source" (ACIA highlights:1). The ACIA (2005) warned that changes in the timing of formation and disappearance of seasonal sea ice, in the quality of the sea ice, and in the extent of total coverage of both seasonal and multiyear ice will likely impact ice-dependent species. Based on its projections of sea-ice loss, the ACIA (2005) predicted that "negative consequences are very likely within the next few decades for arctic animals that depend on sea ice for breeding or foraging" (ACIA 2005: 509). Moreover, "the worst-case scenarios in terms of reduced sea-ice extent, duration, thickness, and concentration by 2080 are very likely to threaten the existence of whole populations and, depending on their ability to adapt to change, are very likely to result in the extinction of some species" (ACIA 2005: 509). Ribbon seals are among five Arctic ice-dependent seal species that the ACIA has determined with high confidence will suffer declining population trends due to climate warming (ACIA 2005: Table 9.10). In a recent news article, the director of the National Marine Mammal Laboratory, John Bengtson, warned that "we could be looking at the extinction of ribbon seals within this century" (Doughton 2006).

The following section details the ways by changing climate conditions in this century will impact the ribbon seal. Global warming will impact ribbon seals directly by degrading and eliminating critical sea-ice habitat and indirectly by changing prey availability, altering interactions with predators and disease, and increasing human disturbance throughout the range.

Habitat loss

Sea-ice extent in the Bering and Okhotsk Seas has already experienced large declines throughout the March-June ribbon seal reproductive and molting periods in recent decades. For example, during 1979-2006, sea ice in May declined by 20.6% per decade in the Sea of Okhotsk and by 10.9% per decade in the Bering Sea (Meier et al. 2007). By 2050, the Bering Sea and Sea of Okhotsk are projected to lose 40% of their winter sea ice under a "business-as-usual" A1B emissions scenario (Overland and Wang 2007). In addition, because winter sea ice will be thinner and the period of sea-ice melt will be longer (later fall sea-ice formation and earlier spring melt), the remaining sea-ice habitat will likely be lower quality and will likely not persist during the period needed for pupping and molting. Habitat loss of this magnitude will undoubtedly commit ribbon seal populations to an increased risk of extinction. This section discusses four ways by which continuing sea-ice loss will impact the ribbon seal:

- The loss and early break-up of seasonal sea ice in the Bering and Okhotsk Seas could lead to complete breeding failure of the ribbon seal within this century. The ice floes of the sea-ice front must remain stable throughout the period of pup-rearing and pup independence that lasts from late March through mid-June. Females must have a stable ice platform for birthing and nursing their pups from late March-May. If females are forced to abandon their pups early, pup mortality would be very high because pups would not have gained a sufficient blubber layer and adequate body condition to survive premature weaning. Additionally, ribbon seals show a strong preference for thick pack ice for pup-rearing and are rarely found on thin ice. Females that are unable to find sea ice of sufficient quality for pupping could abandon their reproductive effort for the year by aborting their pups.

- Pup mortality after weaning will increase with the early melting and break-up of seasonal sea ice. Ribbon seal pups depend on sea ice as a resting platform from May-June during the post-weaning period when they are learning aquatic proficiency, diving, and foraging skills. Loss of sea ice during this period, which is an energetically stressful time during which pups rapidly deplete their energy stores, would undoubtedly decrease pup fitness and survival.

- Ribbon seal will be impaired in molting due to early sea-ice melt and break-up, which would lower immature and adult survival. Ribbon seals depend on the sea ice during April through July to molt. New hair can only grow when ribbon seals are out of the water where the skin can reach higher temperatures. Furthermore, ribbon seal feeding is suppressed during molt and their activity decreases, making sea ice an essential platform for resting during this energetically stressful period (Fedoseev 2000). With shrinking sea ice, ribbon seals may suffer physiological stress and associated mortality from being forced into the water before molt completion or onto small, low-quality ice remnants with high concentrations of other animals during the molt period. If ribbon seals were forced to haul out on land to complete molt, depredation from terrestrial predators could be devastating.

- Ribbon seals are likely to experience more physiological stress due to loss of haul-out sites on the sea ice, which they rely on for resting from winter through summer. Females may be particularly reliant on sea-ice haul-out sites after the demanding pup-rearing period (Carlens et al. 2006).

Changing prey availability

Changing climatic conditions in Arctic and sub-Arctic oceans are driving changes in the biodiversity, distribution and productivity of marine biota, most obviously through the reduction of sea ice (Anisimov et al. 2007). As detailed below, the loss of sea ice in the Bering Sea may alter the abundance and distribution of prey species of the ribbon seal.

A current and ongoing consequence of global warming is that the northern Bering Sea ecosystem is experiencing a shift from arctic to sub-Arctic conditions in response to rising temperatures and associated sea-ice loss (Grebmeier et al. 2006) that is altering the prey community for ribbon seals from Arctic to sub-Arctic species. The Bering Sea is a transition region between the Arctic ecosystem of the northern Bering Sea, which is influenced by winter sea-ice cover, and the sub-Arctic southern Bering Sea ecosystem, which is an open-water region devoid of seasonal sea ice (Overland and Stabeno 2004). The presence or absence of sea-ice cover influences the timing of primary production which in turn plays a primary role in shaping ecosystem structure. The seasonally ice-covered Bering Sea currently experiences two blooms of primary production: an early "ice edge bloom" followed by a later "open-water bloom" after the ice has melted. The intense, spring ice-edge bloom follows the melting sea-ice edge, as the melting ice releases nutrients and fresh water that promote phytoplankton growth. Due to cold spring water temperatures, spring zooplankton populations are low and do not consume much of the organic matter before it settles the benthos, and the heavy rain of organic matter from the ice edge bloom supports a rich benthic community (Grebmeier et al. 2006). Benthic-feeding seabirds and marine mammals are the primary consumers in the northern Bering Sea (Grebmeier et al. 2006). In addition, crustaceans (copepods and amphipods), adapted for life at the sea-ice edge, and fish such as polar cod that feed on the ice-associated crustaceans are important components of the Arctic Bering Sea ecosystem. In contrast, the southern, sub-Arctic Bering Sea experiences only one bloom—the later summer "open-water bloom." Zooplankton and microbes, which are more abundant due to warmer summer ocean temperatures, graze most of the organic matter before it settles to the benthos. Upper-trophic-level fish and epifaunal invertebrates are the primary consumers in this pelagic-dominated ecosystem (Grebmeier et al. 2006).

Coincident with rising temperatures and associated sea-ice loss, the Arctic Bering Sea region is undergoing a shift from a benthic to more pelagic-dominated marine ecosystem (Grebmeier et al. 2006), which will alter prey availability for ribbon seals if the loss of sea ice continues. This shift may increase, at least initially, the abundance of some prey taken by ribbon seal, such as walleye pollock, and will decrease the abundance of other prey species, including arctic cod, crab, and shrimp (Overland and Stabeno 2004). Most certainly, as the sea-ice edge moves northward, crustaceans adapted for life at the sea-ice edge and fish such as polar cod which forage on them will decline in abundance (Anisimov et al. 2007). Arctic cod, a forage species for the ribbon seal, is a pivotal species in Arctic food web due to its high abundance in marginal ice zones and high energetic value compared to other arctic prey (Tynan and DeMaster 1997).

An additional concern regarding sea-ice loss is its effects on levels of primary productivity, which could have cascading ecosystem impacts on the ribbon seal. Two lines of evidence suggest that there could be negative effects on production from the increase in ice-free open water. As sea-ice cover is reduced, growing regions will lose the spring ice edge bloom and the productivity associated with it. Clement et al. (2004) found initial evidence that the ice edge bloom might not be replaced by an open water bloom in spring. Clement et al. (2004) examined water column production during spring in the northern Bering Sea during a heavy-ice year (1999) and a light-ice year (2001) characterized by thinner, lower ice cover. They found that the open water areas in the light ice year did not experience a spring bloom because seasonal winds produced too much vertical mixing. They concluded that "higher or temporally accelerated seasonal biological production may not be a consequence of expected global change in the northern Bering Sea that would reduce ice cover" (Clement et al. 2004: 13).

Secondly, as the summer open-water bloom becomes the dominant mode of primary production, the strength of this bloom will have a large effect on overall ecosystem productivity. A primary factor influencing the strength of the summer open-water bloom is wind mixing in summer and fall (May-September) which is necessary to bring nutrients to surface waters (Hunt et al. 2002). However, since 1980, summer wind speeds in the Bering Sea have been below average, reflecting the slackening of summer storms. The rising temperature of the upper ocean layer due to global warming combined with a continuing trend of calmer summers would result in reduced production during the summer (Hunt et al. 2002). This could affect the availability of food needed to support late-season growth of copepods and larval fish, which would compromise their over-winter survival (Hunt et al. 2002). In this scenario, the abundance of crustaceans and fish that the ribbon seal depends on could decline.

Changing interactions with predators, competitors, and disease

Changing climate conditions due to global warming are likely to affect the ribbon seal's interactions with its predators and increase ribbon seal mortality. Of foremost concern, the loss and early melt of seasonal sea ice will continue to shift the ribbon seal's distribution further northward, which is likely to increase their contact with predators, particularly polar bears which use the pack ice of the Chukchi, Beaufort and Bering Seas (Simmonds and Isaac 2007). Ribbon seals do not exhibit anti-predator behaviors when they are hauled out on the sea ice, presumably because they utilize the sea-ice front which is largely inaccessible to polar bears and terrestrial predators. Therefore, increasing their contact with these predators during the vulnerable pupping and molting periods could prove devastating for adult and pup survival. Ribbon seal pups, which are exposed, defenseless, and non-aquatic, would undoubtedly suffer high depredation rate, and molting adults would prove particularly vulnerable to predation during this period of inactivity. If ribbon seals were forced to haul out on land to rear their young or complete their molt, they would risk exposure to terrestrial predators including grizzly bears, wolves, and Arctic foxes. Furthermore, as sea ice declines, ribbon seals will be concentrated in increasingly smaller ice areas shared with other ice-dependent marine mammals which could lead to higher predation by walruses, which are known to depredate seal adults and pups especially when other food resources are less available (Lowry and Fay 1984). The break-up of the sea ice may also permit more interactions with killer whales that would be able to further penetrate the ice (Lowry 2000).

Ribbon seals may also face ever-increasing competition for food from temperate species whose ranges are expected to expand northward as temperatures continue to rise (ACIA 2005, Simmonds and Isaac 2007). Climate change also poses a risk to ribbon seals by improving conditions for disease spread (Harvell et al. 1999, ACIA 2005). Many wildlife pathogens are sensitive to temperature, rainfall, and humidity (Harvell et al. 2002). As the climate has warmed, these pathogens, in many cases, have expanded their ranges northward because warmer temperatures (1) have allowed their survival and development in areas that were previously below their temperature threshold, (2) increased their rates of development, (3) increased rates of reproduction and biting of their vectors, and (4) lowered the resistance of their hosts (Harvell et al. 2002, Parmesan 2006). Of concern for ribbon seals, warming temperatures may increase the prevalence of diseases and disease vectors, exposing ribbon seals to new diseases or increasing the transmission of existing diseases.

Increased human disturbance in the ribbon seal range

The disappearance of seasonal and perennial sea ice in the Arctic will encourage increased development and human traffic in previously inaccessible, ice-covered areas, which will increase impacts to Arctic marine mammals including the ribbon seal (ACIA 2005). Shipping activity and oil and gas exploration are expected to increase with declines in sea ice, and tourism and commercial fisheries are also likely to expand (AMAP 2003).

Increased shipping activity in ribbon seal habitat is almost certain to occur with the opening of two international shipping routes—the Northwest Passage and the trans-polar route—and the expansion of the Northern Sea Route, all of which pass directly through ribbon seal habitat in the Bering and Chukchi Seas. The Northwest Passage is a potential shipping route that has been historically blocked by perennial sea ice and which connects the Pacific and Atlantic Oceans through the Arctic Ocean along the northern coast of North America. The Northern Sea Route refers to the seasonally ice-covered marine shipping routes from Novaya Zemlya in the west, along the coast of northern Eurasia, to the Bering Sea in the east (ACIA 2005). The Northern Sea Route is administered by the Russian Ministry of Transport and has been open to marine traffic of all nations since 1991, although sea ice poses major challenges and requires specially reinforced ships as well as ice-breakers (ACIA 2005). A trans-polar route across the Arctic Ocean would connect the Atlantic and Pacific Oceans.

The navigation season for the Northern Sea Route is expected to increase from the current 20-30 days per year to 90-100 days per year by 2080, and the Northwest Passage was predicted to open sometime in the 21st century (ACIA 2005). However, expanding access to Arctic shipping routes is occurring much faster than predicted. In September 2007, the European Space Agency reported that the most direct route of the Northwest Passage was fully navigable due to the extreme loss of perennial sea ice, while the Northern Sea Route remained only partially blocked (ESA 2007).

Marine shipping vessels are already a significant source of oil pollution and greenhouse gas emissions, including carbon dioxide, nitrous oxides, and black soot (Earthjustice 2007). Increased shipping will heighten the risk of oil spills, increases emissions of greenhouse gases that with further accelerate Arctic warming, and increases emissions of black carbon that increase local melting of Arctic sea ice by reducing the ice albedo. Russian scientists also cite increasing use of a Northern Sea Route for transit and regional development as a major source of disturbance in the Russian Arctic (Belikov and Boltunov 1998). Ships involved in the expanded use of the Northern Sea Route would likely use leads and polynyas to avoid breaking ice and reduce transit time, and this loose ice with openings is preferred habitat for ribbon seals and other ice-dependent seals. Overall, heavy shipping traffic on the Northern Sea Route, Northwest Passage, and trans-polar route is likely to disturb ribbon seal reproductive and foraging activities, increase the risk of oil spills in critical ribbon seal habitat, and further accelerate global warming.

Oil and gas exploration and commercial fisheries are also expected to expand into Arctic waters as the sea ice diminishes (AMAP 2003). The threats posed to ribbon seals by oil and gas exploration and commercial fisheries are discussed beginning on pages 63 and 71, respectively.

B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Ribbon seals were overexploited by commercial hunting in the 20th century which resulted in significant decreases in population size and changes in population structure. Currently, high allowable harvest levels set by the Russian Federation in the 2000s create the potential for renewed overexploitation of ribbon seals.

Historically, ribbon seals were harvested only by local hunters in limited numbers along the Alaskan and Siberian coasts (Burns 1981, Fedoseev 2000). In the Sea of Okhotsk, historic native hunting of the ribbon seal was apparently negligible as the seals occurred far from shore (Fedoseev 2000). However, intensive commercial hunting of ribbon seals was initiated in the early 1950s in the Sea of Okhotsk and in 1961 in the Bering Sea by the large-scale sealing fleet of the USSR (Heptner et al. 1976, Burns 1981, Fedoseev 2000). Ribbon seals were killed in particularly high numbers between 1961-1968 before sealing was regulated. During this period, the average annual harvest numbered 13,000 to 20,000 individuals per year in the Sea of Okhotsk and 9,971 individuals per year in the Bering Sea, and ribbon seals quickly became overexploited (Heptner et al. 1976, Kelly 1988, Fedoseev 2000). Indicators of overexploitation included: (1) a steady increase in catch effort and a steady decline in catch per unit effort; for example, in 1963, catch per sealing boat had fallen to 44% of 1961 levels; (2) a decrease in the average age of killed seals, which fell from 9.8 in 1961 to 6.9 in 1962 to 4.9 in 1963; and (3) a decline in reproductive rate due to the lower number of adults of breeding age in the population (Fedoseev 2000).

Dramatic declines in ribbon seal populations lead to reductions in hunting levels by the USSR in 1969. In 1969, the annual harvest was reduced to 5,000-6,000 individuals per year in the Sea of Okhotsk and 3,000-4,000 individuals per year in the Bering Sea. Commercial harvest levels were further reduced to 3,500 in the Sea of Okhotsk and 3,000 in the Bering Sea by the early 1980s (Popov 1982). Kelly (1988) reported that the average annual Soviet ribbon seal harvest was 2,933 seals (range: 2,433-3,871, sd=312) from 1969-1982. However, commercial harvest in the Sea of Okhotsk had increased substantially by 1990, if not before, and averaged 13,520 ribbon seals killed each year during 1990-1993 (Table 4) (Grachev 2006). After the collapse of the USSR in 1991, sealing gradually became less economically viable during the *Perestroika* transition, and after 1995, vessel-based sealing reportedly largely disappeared (Grachev 2006).

Table 4. Commercial harvest of ribbon seals in the Sea of Okhotsk by sealing vessels during 1990-1994.
Source: Based on Grachev 2006: Table 1.

Year	Number of vessels	Number of seals killed
1990	4	14,625
1991	4	14,626
1992	3	11,381
1993	3	13,447
1994	1	3,519

In the 2000s, the Russian Federation has been setting high total allowable harvest levels for ribbon seals in the Okhotsk and Bering Seas, ranging from 16,700-21,000 individuals during 2002-2005 (Table 5) (MMC 2007). Currently, the actual harvest of ribbon seals appears to be a fraction of the allowed quota (Grachev 2006). However, if the allowed harvest were realized, this take of ribbon seals would approach harvest levels during the 1960s when ribbon seal populations were heavily over-exploited. Of particular concern, Grachev (2006) reported that the government of the Magadan region of the Okhotsk Sea invested in the resumption and stimulation of coastal sealing in 2005. Grachev (2006) further reported a growing interest in Russia in resuming the commercial harvest of ribbon and other seals due to the profitability of extracting the internal organs, which are rich in biologically active compounds, for use in the pharmaceutical industry. Grachev (2006) extrapolated that three sealing vessels would be able to harvest 15,000 ribbon seals annually. Overall, the high allowable harvest levels and growing interest in resuming commercial sealing in Russia provide an opportunity for future overexploitation of the ribbon seal.

Table 5. Total allowed harvest of ribbon seals in Russian Federation in territorial waters, on the continental shelf, and in the exclusive economic zone during 2002-2005.
Source: Marine Mammal Council, Government of the Russian Federation Decree #1482-r, #1644-r, #1603-r, #1551-p; accessed at http://2mn.org/engl/directory_en.htm.

Region	2002	2003	2004	2005
Western Bering Sea	5,800	5,800	5,800	5,600
Eastern Kamchatka	200	100	100	100
Sea of Okhotsk	15,000	11,000	11,000	11,000
Total	**21,000**	**16,900**	**16,900**	**16,700**

In the United States, commercial hunting is prohibited by the Marine Mammal Protection Act (16 U.S.C. § 1361 *et seq.*), and levels of subsistence hunting in the US are quite low. In

Alaskan waters, ribbon seals are harvested exclusively by Alaska native subsistence hunters (Kelly 1988). From 1968 to 1980, the annual subsistence harvest was estimated to take less than 100 ribbon seals (Burns 1981). The Division of Subsistence of the Alaska Department of Fish and Game estimated that 193 ribbon seals were harvested for subsistence from 1990 to 1998 (NMFS 2007a). Currently, there are no efforts to quantify the harvest level of ribbon seals by all Alaskan communities (NMFS 2007a). A recent approximation is available from the US Fish and Wildlife Service's Walrus Harvest Monitoring Program which reported that 13 ribbon seals were harvested annually between 1999-2003 by 5 of over 100 villages that participate in seal harvest (NMFS 2007a). Because of the small sampling of villages, the total number of ribbon seals harvested by subsistence hunting is likely larger. Subsistence hunting by native Alaskans is not subject to regulation under the ESA (16 U.S.C § 1539e) and appears to be sustainable and well-managed.

C. Disease or Predation

Global warming is likely to increase depredation and disease occurrence in ribbon seal populations. Of foremost concern, the loss and early melt of seasonal sea ice will continue to shift the ribbon seal's distribution further northward during the spring and early summer, which is likely to increase their contact with predators, particularly polar bears which use the pack ice of the Chukchi, Beaufort and Bering Seas (Simmonds and Isaac 2007). Ribbon seals do not exhibit anti-predator behaviors when they are hauled out on the sea ice, presumably because they utilize the sea-ice front which is largely inaccessible to polar bears and terrestrial predators. Therefore, increasing their contact with these predators during the vulnerable pupping and molting periods could prove devastating for adult and pup survival. Ribbon seal pups, which are exposed, defenseless, and non-aquatic, would undoubtedly suffer high depredation rate, and molting adults would be particularly vulnerable to predation during this period of inactivity. If ribbon seals were forced to haul out on land to rear their young or complete their molt, they would risk exposure to terrestrial predators including grizzly bears, wolves, and Arctic foxes. Furthermore, as sea ice declines, ribbon seals will be concentrated in increasingly smaller ice areas shared with other ice-dependent marine mammals which could lead to higher predation by walruses, which are known to depredate seal adults and pups especially when other food resources are less available (Lowry and Fay 1984). The break-up of the sea ice may also permit more interactions with killer whales that would be able to further penetrate the ice (Lowry 2000).

Climate change also poses a risk to ribbon seals by improving conditions for disease spread (Harvell et al. 1999, ACIA 2005). Many wildlife pathogens are sensitive to temperature, rainfall, and humidity (Harvell et al. 2002). As the climate has warmed, these pathogens, in many cases, have expanded their ranges northward because warmer temperatures (1) have allowed their survival and development in areas that were previously below their temperature threshold, (2) increased their rates of development, (3) increased rates of reproduction and biting of their vectors, and (4) lowered the resistance of their hosts (Harvell et al. 2002, Parmesan 2006). Of concern for ribbon seals, warming temperatures may increase the prevalence of diseases and disease vectors, exposing ribbon seals to new diseases or increasing the transmission of existing diseases.

D. Inadequacy of Existing Regulatory Mechanisms

1. Regulatory Mechanisms Addressing Greenhouse Gas Pollution and Global Warming Are Inadequate

Greenhouse gas emissions and global warming are the greatest threats to the ribbon seal and yet also the least well regulated. The primary international regulatory mechanisms addressing greenhouse gas emissions global warming are the United Nations Framework Convention on Climate Change and the Kyoto Protocol. While the entering into force of the Kyoto Protocol on February 16, 2005 marks a significant partial step towards the regulation of greenhouse gases, it does not and cannot alone adequately address the impacts of global warming that threaten the ribbon seal with extinction. There are currently no legal mechanisms regulating greenhouse gases on a national level in the United States. As detailed below, all existing regulatory mechanisms are clearly inadequate to ensure this ribbon seal's survival in the wild. The immediate reduction of greenhouse gas pollution is essential to slow global warming and ultimately stabilize the climate system while there is still suitable ribbon seal sea-ice habitat remaining.

a. The United Nations Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change ("UNFCCC") was adopted in May 1992 at the first Earth Summit held in Rio de Janeiro, Brazil, and entered into force in March 1994 (EIA 2004). The stated objective of the UNFCCC is the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system (EIA 2004). Due to the complexity of climate issues and the widely divergent political positions of the world's nation states, the UNFCCC itself was unable to set emissions targets or limitations, but instead created a framework that set the stage for a range of subsequent actions (UNFCCC 2004). The UNFCCC covers greenhouse gases not otherwise controlled by the Montreal Protocol on ozone-depleting substances (UNFCCC 2004).

The UNFCCC assigns differing responsibilities to its 189 parties, based on their differing levels of economic development (UNFCCC 2004). Annex I parties include 41 mostly developed countries. Annex I countries set a goal (but not a requirement) of returning their emissions by 2000 to 1990 levels (UNFCCC 2004). They are required to make regular reports on implementation, including reporting on levels of greenhouse gas emissions and policies and measures to reduce them (UNFCCC 2004). Annex II is a subset of Annex I countries which includes the 23 highly developed countries which are required to financially and otherwise support the efforts of the developing countries (UNFCCC 2004). Countries with economies in transition ("EITs") include 14 countries in Eastern and Central Europe and the former Soviet Union which are listed in Annex I but do not have the additional responsibilities of the other Annex I countries. Non-Annex I parties include all parties not included in one of the former categories and are mostly developing countries (UNFCCC 2004). Non-Annex I parties have general commitments to respond to climate change but have fewer obligations and are expected to rely upon external support.

The UNFCCC has not yet effectively controlled greenhouse gas emissions. The year 2000 has come and gone without the UNFCCC's goal of reducing greenhouse gas emissions from Annex I countries to 1990 levels being met. More than thirteen years after the UNFCCC came into force, "dangerous anthropogenic interference with the climate system" remains undefined (International Climate Change Taskforce 2005). There is a growing body of evidence, however, that anthropogenic greenhouse gas emissions have already caused "dangerous" climate change.

b. The Kyoto Protocol

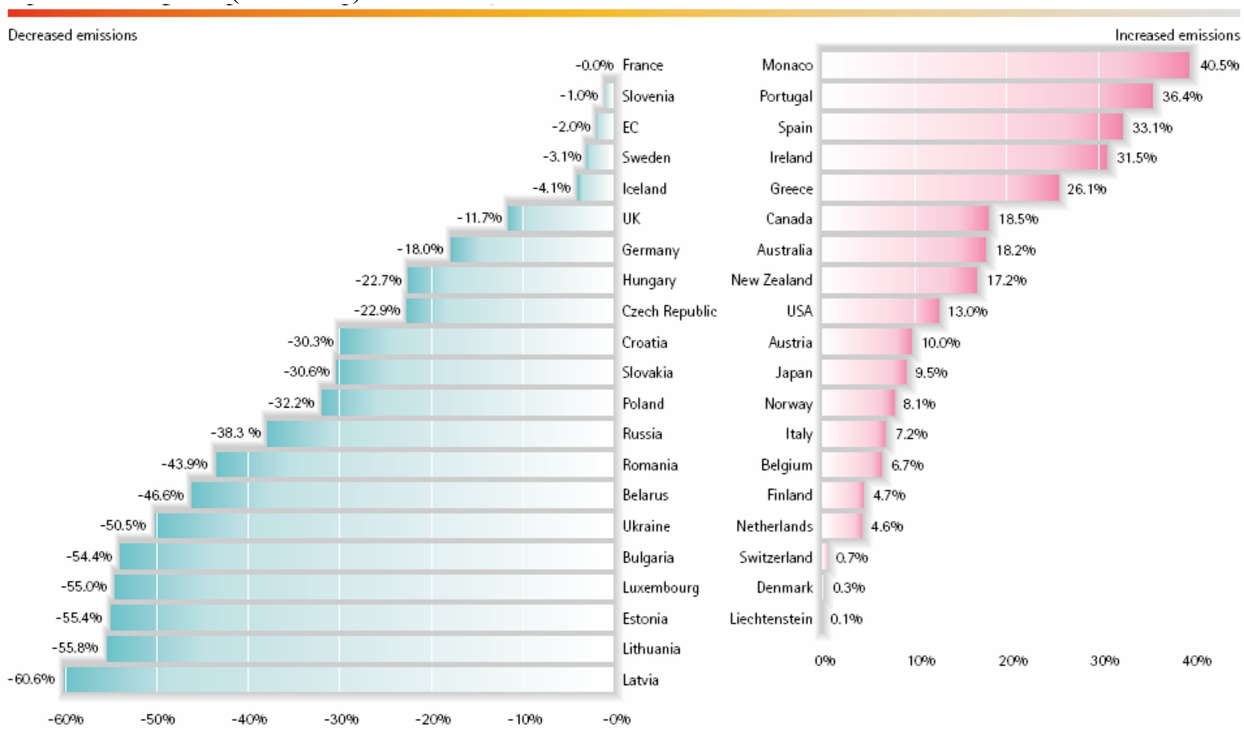
In 1997 the Kyoto Protocol became the first additional agreement added to the UNFCCC to set emissions targets. The Kyoto Protocol set goals for developed countries only to reduce their emissions to at least 5% below their 1990 levels between 2008-2012, the "first commitment period" (UNFCCC 2004). The Kyoto Protocol required ratification by a minimum of 55 countries, encompassing at least 55% of the carbon dioxide emissions of Annex I countries before it would enter into force. Over seven years passed before this occurred. The Kyoto Protocol entered into force on February 16, 2005, 90 days after it was ratified by Russia (UNFCCC 2005).

Despite its long-awaited ratification, the Kyoto Protocol is inadequate to prevent significant climate change, and consequently the decline to extinction of the ribbon seal. First, the Protocol's overall emissions reduction targets for the first commitment period are highly unlikely to be met, due in large part to the continuing refusal of the United States to ratify the agreement. Second, even if the Kyoto targets were met, they are far too modest to impact greenhouse gas concentrations and global warming sufficiently to ensure the survival of the ribbon seal. Third, negotiations for emissions reductions beyond 2012 are just beginning after being blocked for years by the US. Each of these issues is addressed in turn below.

The refusal of the United States to ratify the Kyoto Protocol, announced by the Bush Administration in 2001, is a major reason why Kyoto targets are unlikely to be met. Because the United States is responsible for over 20% of worldwide carbon dioxide emissions (EIA 2004), it is highly unlikely that overall targets can be met without US participation. The Kyoto target for the US was a 7% reduction in greenhouse gas emissions levels from 1990 levels by 2012 (EIA 2004). Between 1990 and 2001, United States emissions have in fact increased by 13%. Total United States emissions are projected to grow a staggering additional 43.5% through the period 2025 (GAO 2003a).

In addition to the outright intransigence of the United States, the overall and many country-specific Kyoto targets are unlikely to be met based on current progress and data. While some Annex I countries have achieved their Kyoto targets or at least some reductions, many other Annex I countries have seen their emissions increase substantially (Figure 9). Emissions also increased in many of the developing nations between 1990 and 2000 (UNFCCC 2004). In addition, although emissions of the EIT countries decreased significantly from 1990-2000 as a result of economic contraction in these countries, they increased from 2000 to 2001 and are projected to continue to do so (EIA 2004). Overall, the EIA estimates that worldwide carbon emissions in 2025 will exceed 1990 levels by 72% (EIA 2004).[6]

Figure 9. Changes in greenhouse gas emissions by Annex I Countries, 1990-2001.
Source: UNFCC (2004: 25).



There are other problems with implementation of the Kyoto Protocol as well. For example, accurate, consistent, and internationally comparable information that is essential for sound policymaking is still lacking in many areas (UNFCCC 2004). Many countries have yet to build a sound institutional framework and a number have yet to even report on their institutional arrangements or have pointed out that their systems are weak (UNFCCC 2004). The Protocol will only succeed at meeting its modest goals if the parties fulfill their commitments, yet mechanisms for enforcement have not yet been tested and are likely ineffective. There are no financial penalties or automatic consequences for failing to meet Kyoto targets (UNFCCC 2004).

Even in the unlikely event that overall Kyoto targets were fully met by the year 2012, the reductions are far too small to substantially reduce global warming and improve the plight of the ribbon seal. Implementation of the Kyoto Protocol would only slightly reduce the rate of growth of emissions – it would not stabilize or reduce atmospheric greenhouse gas concentrations (Williams 2002). Carbon dioxide levels currently stand at over 380 ppm, from pre-industrial levels of 280 ppm, and are increasing at more than 2 ppm per year (International Climate Change Taskforce 2005). Stabilizing carbon dioxide concentrations at 440 ppm (23% above current

[6] EIA (2004) projections do not reflect the potential impacts of the Kyoto treaty, because it had not yet come into force when the projections were prepared (EIA 2004). Compliance with Kyoto or other measures to reduce greenhouse gases could cause actual emissions to differ from the projections (EIA 2004), however, as discussed above, compliance with overall Kyoto targets is unlikely.

levels, and a level likely to lead to a greater than 2° C average global temperature rise) would require global emissions to drop below 1990 levels within a few decades, with emissions eventually declining to a very small fraction of current levels, despite growing populations and an expanding world economy. These cuts will not be achieved simply by compliance with Kyoto (Williams 2002). The IPCC SRES scenarios predict carbon dioxide concentrations of between 490 and 1260 ppm by 2100 (Albritton et 2001), and these scenarios all assume significant reductions in the rate of greenhouse gas emissions (Nakićenović et al. 2000).

Additionally, Kyoto only sets targets for action through 2012. There is no current regulatory mechanism governing greenhouse gas emissions in the years beyond 2012. Discussions for targets for the second compliance period from 2012-2016 began at the Bali, Indonesia, UNFCCC conference in 2007. While the European Union delegation attempted to begin discussions at the Conference of the Parties in Milan, Italy in 2003, in Buenos Aires in 2004, in Montreal in 2005, in Nairobi in 2006, not until Bali 2007 did the US agree to a framework for the regulation of post-2012 emissions reductions. No binding or even voluntary agreement yet exists to deal with the cuts needed beyond the Kyoto Protocol.

c. United States Climate Initiatives are Ineffective

Because the United States is responsible for over 20% of global greenhouse gas emissions, regulation of United States emissions is essential to saving the ribbon seal from extinction. Unfortunately, despite the nature and magnitude of the risks, and a variety of actions by Congress and the Executive Branch, there is still no regulation of greenhouse gas emissions on the national level in the United States.

Beginning in 1978, Congress established a "national climate program" to improve understanding of global climate change through research, data collection, assessments, information dissemination, and international cooperation. National Climate Program Act of 1978, 15 U.S.C. §§ 2901 *et seq.* Two years later, in the Energy Security Act, Congress directed the Office of Science and Technology Policy to engage the National Academy of Sciences in a study of the "projected impact, on the level of carbon dioxide in the atmosphere, of fossil fuel combustion, coal-conversion and related synthetic fuels activities" authorized by the Energy Security Act. Pub. L. No. 96-294, tit. VII, § 711, 94 Stat. 611, 774-75 (1980). In 1990, Congress enacted the Global Change Research Act, 15 U.S.C. §§ 2931-2938, which established a 10-year research program for global climate issues, directed the President to establish a research program to improve understanding of global change, and provided for scientific assessments every four years that analyze current trends in global change. *Id.* at §§ 2932, 2933, 2936(3). Congress also established a program to research agricultural issues related to global climate change. Pub. L. No. 101-24, tit. XXIV, § 2402, 104 Stat. 4058, 4058-59 (1990). Finally, two years later, in the Energy Policy Act of 1992, Congress directed the Secretary of Energy to conduct several assessments related to greenhouse gases and report to Congress. Pub. L. No. 102-486, § 1604, 106 Stat. 2776, 3002.

The Global Climate Protection Act of 1987 directed the Secretary of State to coordinate US negotiations concerning global climate change. 15 U.S.C. § 2901 note; § 2952(a). Following those negotiations, President George H.W. Bush signed, and the Senate approved, the UNFCCC, which, as discussed above, has yet to effectively control greenhouse gas emissions.

Greenhouse gas emissions have also not yet been effectively regulated under the United States Clean Air Act ("CAA"). Section 103(g) directs the Environmental Protection Agency ("EPA") to establish a "basic engineering research and technology program to develop, evaluate, and demonstrate nonregulatory strategies and technologies for air pollution prevention" that would address substances including carbon dioxide. 42 U.S.C. § 7403(g). The CAA also states that nothing in Section 103(g) "shall be construed to authorize the imposition on any person of air pollution control requirements." *Id.*

In 2003, the EPA rejected a petition urging it to regulate greenhouse gas emissions from automobiles under CAA Section 202, stating as follows:

> After careful consideration of petitioners' arguments and the public comments, EPA concludes that it cannot and should not regulate [greenhouse gas] emissions from U.S. motor vehicles under the CAA. Based on a thorough review of the CAA, its legislative history, other congressional action and Supreme Court precedent, EPA believes that the CAA does not authorize regulation to address global climate change. Moreover, even if [carbon dioxide] were an air pollutant generally subject to regulation under the CAA, Congress has not authorized the Agency to regulate [carbon dioxide] emissions from motor vehicles to the extent such standards would effectively regulate car and light truck fuel economy, which is governed by a comprehensive statute administered by DOT.
>
> In any event, EPA believes that setting [greenhouse gas] emission standards for motor vehicles is not appropriate at this time. President Bush has established a comprehensive global climate change policy designed to (1) answer questions about the causes, extent, timing and effects of global climate change that are critical to the formulation of an effective, efficient long-term policy, (2) encourage the development of advanced technologies that will enable dramatic reductions in [greenhouse gas] emissions, if needed, in the future, and (3) take sensible steps in the interim to reduce the risk of global climate change. The international nature of global climate change also has implications for foreign policy, which the President directs. In view of EPA's lack of CAA regulatory authority to address global climate change, DOT's authority to regulate fuel economy, the President's policy, and the potential foreign policy implications, EPA declines the petitioners' request to regulate [greenhouse gas] emissions from motor vehicles. 68 Fed. Reg. 52922, 52925 (footnote omitted).

In 2007, the Supreme Court overturned the EPA's refusal to regulate these emissions, and remanded the matter to the agency for further consideration. *Massachusetts v. U.S. EPA*, 127 S. Ct. 1438 (2007). The EPA has yet to act following the remand. Moreover, the EPA has yet to act upon California's request for a waiver to implement its Clean Vehicle Law, passed in 2002 (AB 1493, Pavley) which requires greenhouse gas reductions from automobiles sold in California, and is thus actively preventing this law from going into effect.

The George W. Bush Administration's climate initiative, referenced by the EPA as a primary reason for declining to regulate greenhouse gas emissions from motor vehicles and revealed after the Administration renounced the Kyoto Protocol, plainly fails to effectively address global warming. This initiative is based entirely on voluntary measures which are incapable of effectively controlling greenhouse gas emissions. This climate plan, termed the Global Climate Change Initiative, also focuses only on reducing the amount of greenhouse gas emissions per unit of energy produced ("emissions intensity"), not the overall level of emissions (GAO 2003a). In the absence of new climate initiatives, United States emissions intensity is expected to decrease by 14% by 2012, while total emissions continue to increase (GAO 2003a). The Bush plan, if fully implemented and successful, would decrease emissions intensity by a mere additional 4%, for an overall reduction of 18%, but total emissions would still continue to increase. Even according to the Bush Administration's own arithmetic, full implementation and success of the plan will result in US greenhouse gas emissions in 2012 that are 30% higher than 1990 emissions, as opposed to the 7% reduction called for by the Kyoto Protocol (Holdren 2003). Cumulative emissions between 2002-2012 will continue to grow and would be only 2% less with the plan than without it (GAO 2003a).

Moreover, the US Government Accounting Office ("GAO") found that the Bush plan does not explain how even the modest 4% claimed reduction in energy intensity will be met. The Bush plan fails to provide any emissions savings estimates at all for 19 of the 30 plan elements (GAO 2003b). Of those 19, at least two seem unlikely to yield any emissions savings at all by 2012 (GAO 2003b). Of 11 initiatives for which savings estimates were provided, at least eight were not clearly attributable to the Bush plan, and there were problems with others as well (GAO 2003b). Overall, the GAO could confirm that emissions savings would be realized from only three of the Bush plan elements (GAO 2003b), an extremely inauspicious finding for the ultimate success of the already modest proposal.

In the absence of federal leadership, state and local governments have taken the lead in measures to reduce greenhouse gas emissions. While certainly a step in the right direction, unfortunately, these measures on their own are insufficient to prevent the extinction of the ribbon seal. For example, the strongest law enacted to date is the California Global Warming Solutions Act of 2006. Signed into law in September, 2006, it is the nation's first mandatory cap on a state's overall greenhouse gas emissions. The California Legislature declared:

> Global warming poses a serious threat to the economic well-being, public health, natural resources, and the environment of California. The potential adverse impacts of global warming include the exacerbation of air quality problems, a reduction in the quality and supply of water to the state from the Sierra snowpack, a rise in sea levels resulting in the displacement of thousands of coastal businesses and residences, damage to marine ecosystems and the natural environment, and an increase in the incidences of infectious diseases, asthma, and other human health-related problems. (Cal. Health and Safety Code § 38501(a))

The Global Warming Solutions Act requires the reduction of greenhouse gas emissions to 1990 levels by the year 2020. *Id.* at § 38550. The law will be implemented through a series of California Air Resources Board (CARB) rulemakings including establishing emission source monitoring and reporting requirements, discrete early action emission reduction measures, and finally greenhouse gas emission limits and measures to achieve the maximum feasible and cost-effective reductions in furtherance of the greenhouse gas emission cap. *Id.* at § 38550. While the California Global Warming Solutions Act is a promising first step, like the Kyoto Protocol, it is insufficient on its own to slow global warming sufficiently to ensure the survival of the Ribbon seal.

For all the reasons discussed above, existing regulatory mechanisms relating to global warming are inadequate to ensure the continued survival of the ribbon seal. Ensuring the ribbon seal's survival requires immediate and dramatic action, particularly in the United States, to reduce greenhouse gas emissions. Protecting the ribbon seal under the Endangered Species Act will bring attention to its plight and encourage both voluntary and regulatory action.

2. Regulatory Mechanisms Addressing Other Threats to the Ribbon Seal Are Inadequate

Oil and Gas Development

The impacts of ongoing and proposed oil and gas development on the ribbon seal are described starting on page 63. Existing regulatory mechanisms are inadequate to address these impacts. With the lease sales in the Beaufort, Chukchi, and Bering Seas that occurred under the 2002-2007 U.S. Oil and Gas Leasing Program and those scheduled under the 2007-2012 U.S. Oil and Gas Leasing Program (MMS 2007), a substantial proportion of the ribbon seal's habitat subject to U.S. jurisdiction is now open for oil and gas leasing and development. The Minerals Management Service analyzes the impacts of lease sales for oil and gas development on the ribbon seal and other species and NMFS authorizes "take" of the species from such operations pursuant to the Marine Mammal Protection Act ("MMPA"). Unfortunately, neither agency is adequately considering the impacts of these activities on the ribbon seal. For example, most egregiously, in NMFS's proposed authorizations of incidental take of small numbers of marine mammals from seismic surveys in the Beaufort and Chukchi Seas off Alaska by Shell Offshore, Inc. and WesternGeco, Inc. (72 Fed. Reg. 31553, June 7, 2007), none of the relevant documents even mentioned the presence of the ribbon seal in areas subject to the seismic surveys even though the species' presence in the region is unequivocally established. On August 20, 2007 NMFS issued an incidental harassment authorization for these surveys without considering the ribbon seal. Unpermitted and unlawful take of the ribbon seal undoubtedly occurred from these activities with no environmental review of its impacts on the ribbon seal, much less imposition of any species-specific mitigation measures. Similar deficiencies are found in most MMS environmental analyses regarding oil leasing and development in ribbon seal habitat. As described in the oil section below, environmental protections for the ribbon seal are largely absent from oil and gas projects in the Russian portion of the species' range.

Given the rapidly changing conditions in the Arctic, the precarious status of multiple ice-dependent organisms, and the numerous adverse impacts of oil and gas industry activities on these species, there should be a moratorium on new oil and gas leasing and development in the Arctic. Such a moratorium should be implemented immediately and remain in effect until and unless such activity can be demonstrated to not have adverse impacts on the ribbon seal and other ice-dependant species, and any greenhouse emissions directly or indirectly associated with such activities are shown to be consistent with a comprehensive national plan to reduce CO_2 and non-CO_2 pollutants to levels determined necessary to avoid the continued loss of sea ice. However, to date the US has not undertaken any of these actions and the impacts of oil and gas development on the ribbon seal and its sea-ice habitat continue to accrue.

Shipping

Existing shipping regulations both domestically and internationally are inadequate to protect ribbon seals and their habitat from harm. First, the US Environmental Protection Agency ("EPA") does not regulate greenhouse gas and black carbon emissions from ships although the Clean Air Act gives it this authority (Earthjustice 2007). The EPA has the authority to regulate emissions from marine shipping vessels, because, consistent with the threshold determinations required under section 213(a)(4) of the Clean Air Act, greenhouse gas and black carbon emissions from marine engines and vessels significantly contribute to global climate change, which may be reasonably anticipated to endanger public health or welfare. 42 U.S.C. § 7547(a)(4). The Clean Air Act also establishes a system for the regulation of fuels based on whether any emission product of a fuel causes or contributes to air pollution which may reasonably be anticipated to endanger the public health or welfare. 42 U.S.C. § 7545(c)(1). Upon making the finding, the EPA has the authority to control or eliminate the manufacture or sale of the offending fuel. *Id.* Accordingly, the EPA should promulgate regulations (1) requiring marine shipping vessels to meet emissions standards by operating in a fuel-efficient manner, using cleaner fuels, and/or employing technical controls, so as to reduce emissions of carbon dioxide, nitrous oxide, and black carbon, and (2) controlling the manufacture and sale of fuels used in marine shipping vessels by imposing fuel standards to reduce emission products that contribute to global warming.

In addition, the current and projected impacts of shipping on the Arctic are almost wholly unregulated. The U.S. should work in appropriate international forums such as the International Maritime Organization ("IMO") and the Arctic Council to prevent the establishment of new shipping routes in the Arctic. Simultaneously, the U.S. should require that any vessel transiting Arctic waters subject to U.S. jurisdiction apply for and operate consistent with take authorizations under the MMPA and ESA so as to minimize direct impacts to the ribbon seal and their prey. However, to date the U.S. has not undertaken any of these actions nor have the IMO or any other relevant international body taken action to protect Arctic resources from shipping.

Ocean acidification

As discussed below, ocean acidification represents a significant threat to the ribbon seal and its prey base. Because ocean acidification is driven by anthropogenic carbon dioxide emissions, and, as described above, no adequate mechanisms are in place domestically or internationally to reduce such emissions, regulatory mechanisms to address ocean acidification must also be deemed inadequate.

E. Other Natural and Anthropogenic Factors

1. Ocean Acidification

Ocean acidification poses an ever-increasing risk to the ribbon seal because of its deleterious effects on the crustaceans, fish, and squid species that the ribbon seal depends on for food. The world's oceans have been absorbing large volumes of carbon dioxide from the atmosphere and cycling it through various chemical, biological, and hydrological processes. The oceans have thus far absorbed approximately 30% of the excess carbon dioxide emitted since the beginning of the industrial revolution (Feely et al. 2004, WBGU 2006). The world's oceans, in fact, store about 50 times more carbon dioxide than the atmosphere (WBGU 2006), and most carbon dioxide released into the atmosphere from the use of fossil fuels will eventually be absorbed by the ocean (Caldeira and Wickett 2003). As the ocean absorbs carbon dioxide from the atmosphere it changes the chemistry of the sea water by lowering its pH. The oceans' uptake of these excess anthropogenic carbon dioxide emissions, therefore, is causing ocean acidification (WBGU 2006).

Surface ocean pH has already dropped by about 0.1 units on the pH scale, from 8.16 in 1800 to 8.05 today -- a rise in acidity of about thirty percent (Orr et al. 2005). The pH of the ocean is currently changing rapidly at a rate 100 times anything seen in hundreds of millennia, and may drop by another 0.3 or 0.4 (100 – 150% increase in the concentration of H+ ions) by the end of this century (Orr et al. 2005, Meehl et al. 2007). If carbon dioxide emissions continue unabated, resulting changes in ocean acidity could exceed anything experienced in the past 300 million years (Caldeira and Wickett 2003). Even if carbon dioxide emissions stopped immediately, the ocean would continue to absorb the excess carbon dioxide in the atmosphere, resulting in further acidification until the planet's carbon budget returned to equilibrium.

Ocean acidification from unabated anthropogenic carbon dioxide emissions poses a profound threat to marine ecosystems because it affects the physiology of numerous marine organisms, causing detrimental impacts that may ripple up the food chain. Changes that have been observed in laboratory experiments include impacts to the productivity of algae, photosynthesis of phytoplankton, metabolic rates of zooplankton and fish, oxygen supply of squid, reproduction of clams, nitrification by microorganisms, and the uptake of metals (WBGU 2006). King crab and silver seabream larvae exhibit very high mortality rates in CO_2-enriched waters (Ishimatsu et al. 2004, Persselin 2007). Exposure of fish to lower pH levels can cause decreased respiration rates, changes in blood chemistry, and changes in enzymatic activity. Sea urchins raised in lower-pH waters show evidence of inhibited growth due to their inability to maintain internal acid-base balance (Kurihara and Shirayama 2004). Squid which are a key prey species for the ribbon seal and other deep-diving mammals are especially vulnerable to ocean acidification because their high energy swimming method and high metabolism require a good supply of oxygen. Increasing ocean CO_2 concentrations lower blood pH and its capacity to carry oxygen (Learmonth et al. 2006, Simmonds and Isaac 2007).

Perhaps most importantly, increasing ocean acidity reduces the availability of carbonate ions that marine algae and free-floating plants and animals rely on to build their shells and skeletons (Feely et al. 2004, Orr et al. 2005). Marine organisms including phytoplankton (coccolithophores and foraminifera), coralline algae, corals, echinoderms (sea urchins and starfish), and mollusks (snails, clams, oysters, and squid) are impaired in producing their shells with increasing ocean acidity (Kleypas et al. 2006). Normally, ocean waters are saturated with carbonate ions that marine organisms use to build skeletons (WBGU 2006). However, the acidification of the oceans shifts the water chemistry to favor bicarbonate, thus reducing the availability of carbonate to marine organisms (WBGU 2006). Acidic waters also dissolve existing protective carbonate skeletons and shells (Orr et al. 2005). Of importance for the ribbon seal, the North Pacific has conditions less favorable for calcification due to the increased solubility of calcium carbonate at lower temperatures and the inflow of CO_2-rich waters from deep ocean basins (Persselin 2007). Because calcifying organisms are at the base of the food web, negative impacts on these organisms will have a cascading effect on other species that rely on these organisms. Therefore, the deleterious effects of ocean acidification may already be affecting populations of the ribbon seal's crustacean, fish, and cephalopod prey.

Ocean acidification and its impacts on marine biota will worsen in this century due to the continuing rise in atmospheric carbon dioxide concentrations. In the range of the ribbon seal, a large region of the sub-Arctic Pacific bordering the southern edge of the Aleutian Islands is predicted to experience aragonite undersaturation in surface waters within this century under the IPCC IS92a emissions scenario of 788 ppm CO_2 by 2100 (Orr et al. 2005). Under this scenario, the aragonite saturation horizon would shoal from depths of 120 m to the surface, and organisms that use aragonite would no longer be able to survive in this region before the end of the century (Orr et. al 2005). Pteropod marine snails which build their shells from aragonite are important food sources for pollock, herring, and cod, all of which are major components of ribbon seal diet. Thus, reductions in pteropods may lead to declines in the fish species that ribbon seals depend upon. Additionally, the ocean surface layer has lost 10% of its carbonate compared to preindustrial levels (WBGU 2006) and continuing carbon dioxide emissions could result in a decrease in calcification rates by up to 60% by the end of this century (Ruttimann 2006). Ribbon seals in immature age classes rely heavily on crustacean prey, and these prey species may suffer declines due to the decreasing ability to build their carbonate shells. Squid and other cephalopods are also vulnerable to ocean acidification which reduces their ability to carry oxygen in their blood and could experience declines as acidity increases (Learmonth et al. 2006, Simmonds and Isaac 2007). By the close of this century, the acidification of the ocean is likely to have significant effects on the principal prey species of the ribbon seal if greenhouse gas emissions are not abated.

2. Oil and Gas Exploration and Development

The ribbon seal faces severe and immediate threats from growing offshore oil and gas developments that have the potential to destroy or modify large portions of its foraging and breeding habitat and exert lethal and sub-lethal impacts on populations from oil and noise pollution. Specifically, the adverse impacts of oil industry activities on the ribbon seal include (1) contact with and ingestion of oil from acute and chronic spills; (2) disturbance from industrial noise from ice-breakers, aircraft, and seismic surveys; and (3) harassment from aircraft, ships, and other vehicles that can disrupt ribbon seal breeding, foraging, resting, and breathing activities (Fair and Becker 2000). Additionally, increased oil and gas production eventually translates into higher greenhouse gas production, which furthers global warming's impact on the ribbon seal and its habitat. This section describes the existing and projected oil and gas exploration and development in the ribbon seal's range and the effects from resulting oil and noise pollution.

a. Existing and projected oil and gas exploration and development

United States (Alaska)

Both onshore and offshore oil and gas exploration and development activities have been extensive in the U.S. Arctic. Current and growing large-scale offshore leasing for oil and gas development in the Beaufort, Chukchi, and Bering Seas poses a significant threat to the ribbon seal. In 2003 the National Research Council noted that "[c]limate warming at predicted rates in the Beaufort Sea region is likely to have serious consequences for ringed seals and polar bears, and those effects will accumulate with the effects of oil and gas activities in the region" (NRC 2003). Since the NRC report, both the impacts of global warming on sea-ice dependent species and the cumulative impacts of oil and gas activities have greatly accelerated.

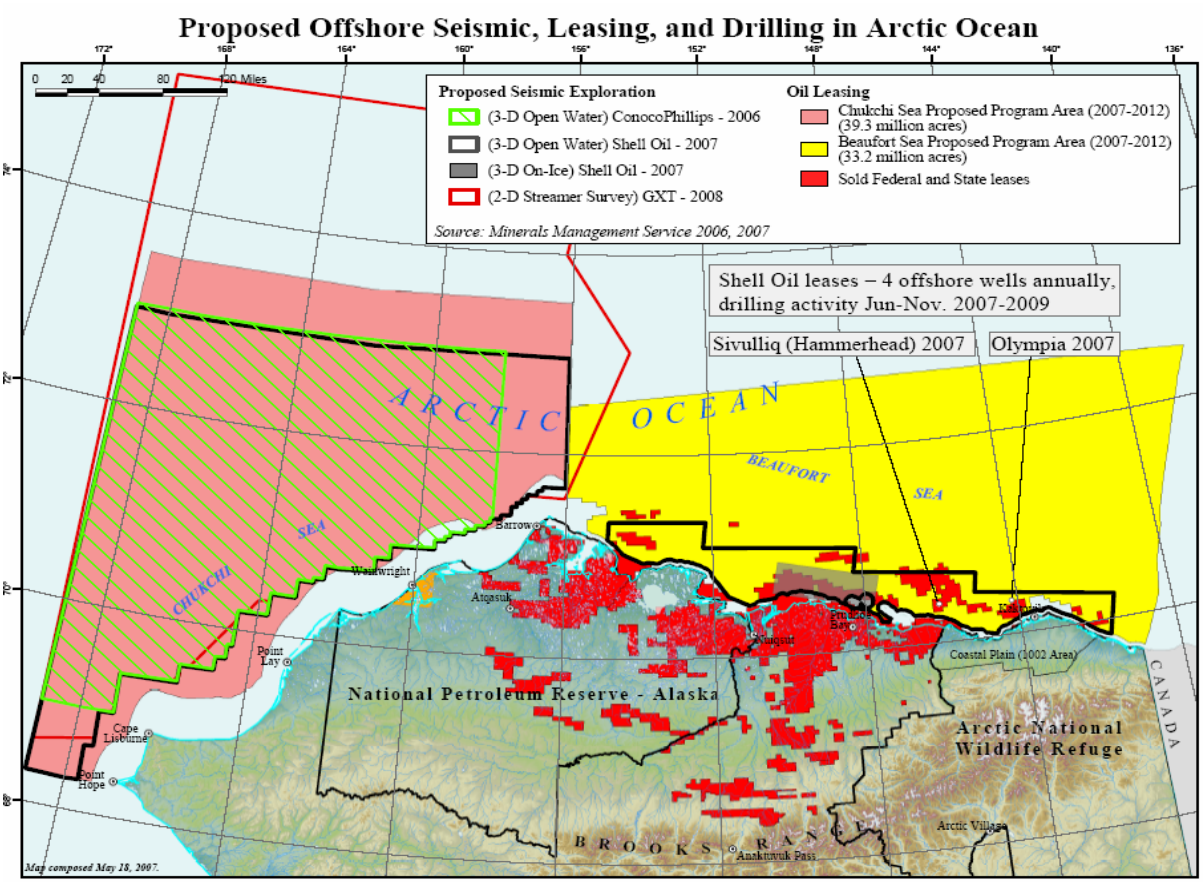
In April 2002, Secretary of Interior Norton issued the Proposed Final 2002-2007 Oil and Gas Leasing Program for the Outer Continental Shelf which resulted in four lease sales in ribbon seal habitat: one in Norton Sound in northern Bering Sea and three on the Beaufort Sea outer continental shelf which leased ~1,280,000 acres overall (Table 6). In June 2007 Secretary of Interior Kempthorne approved the 2007-2012 Offshore Oil and Gas Leasing Program. In this Program, lease sales in ribbon seal foraging habitat are planned in the Chukchi Sea in 2008, 2010, and 2012, in the Beaufort Sea in 2009 and 2011, and in Bristol Bay in the southeastern Bering Sea in 2011 (Table 6, Figure 10) (MMS 2007). Bristol Bay was opened for development in January 2007 when President Bush reversed the presidential withdrawal of this region from oil and gas development that was instituted from 1998-2012 to protect its rich biological diversity. In addition to planned lease sales, activity on existing offshore leases is scheduled or now underway, including exploration drilling by Shell Offshore, Inc. and BP's planned development of the Liberty prospect in the Beaufort Sea. With the lease sales in the Beaufort, Chukchi, and Bering Seas that occurred under the 2002-2007 U.S. Oil and Gas Leasing Program and those scheduled during 2007-2012 (MMS 2007), a substantial proportion of ribbon seal habitat subject to U.S. jurisdiction is now open for oil and gas leasing and development.

The pace of the industrialization of America's Arctic by oil and gas development shows no signs of slowing and, in fact, is being actively promoted by the U.S. government (NRC 2003). Since oil and gas production began on Alaska's Arctic Slope in the early 1970s, about 14 billion barrels of oil have been extracted from underground deposits (NRC 2003). As much as 20 billion additional barrels of oil may be extracted in the future (NRC 2003). In 2001, President Bush issued Executive Order 13212 which directed U.S. departments and agencies to take appropriate actions to expedite projects that increase the production, transmission, or conservation of energy (MMS 2003, 2004). Of concern for the ribbon seal, offshore oil development in particular is expanding now and will continue to do so in the future. Thus far, offshore oil development has accounted for only a small percentage of oil production on Alaska's Arctic slope – only about 0.429 billion barrels have been produced offshore compared to approximately 13.256 on shore as of December 2001 (NRC 2003). In total, 7 of 31 producing oil fields on Alaska's Arctic Slope were offshore (MMS 2004). However, reasonably foreseeable future development includes 16 discoveries, 9 of which are offshore oil fields that may undergo some development-related activities such as site drilling, permitting, appraisal drilling, or construction, within the next 15-20 years (MMS 2004:Table V1a). Therefore, offshore oil development represents a large proportion of reasonably foreseeable future development in the U.S. Arctic.

Table 6. Lease Sales for Oil and Gas Development in the Ribbon Seal Range completed and proposed by the Minerals Management Service in 2002-2012.
Source: Minerals Management Service

Previous 5-Year Program (2002-2007)	
Sale Location and Number	**Sale Year**
Beaufort Sea Sale 186	2003
Norton Basin Sale 188	2004
Beaufort Sea Sale 195	2005
Beaufort Sea Sale 202	2007
Chukchi Sea Sale 193	Delayed
Current 5-Year Program (2007-2012)	
Sale Location and Number	**Proposed Sale Year**
Chukchi Sea Sale 193	2008
Beaufort Sea Sale 209	2009
Chukchi Sea Sale 212	2010
Beaufort Sea Sale 217	2011
North Aleutian Basin Sale 214	2011
Chukchi Sea Sale 221	2012

Figure 10. Proposed Offshore Seismic, Leasing, and Drilling in the Chukchi and Beaufort Seas during 2006-2012.
Source: Minerals Management Service



Russia

Growing oil and gas development in the Okhotsk, Bering, and Chukchi Seas in Russian Federation waters represent a grave threat to the survival of this ribbon seal. In particular, a large oil spill would have catastrophic impacts on the large breeding population in the Sea of Okhotsk and the productive foraging regions of the Anadyr Bay in the Bering Sea. Oil and gas companies have already begun or are planning ambitious development projects in the Sakhalin, Magadan, and Kamchatka regions of the Sea of Okhotsk and in the Chukotka region of the Bering and Chukchi Seas (Lapko and Radchenko 2000).

In the Sakhalin region, large-scale offshore oil and gas development has already begun off northwest Sakhalin Island which is one of three important breeding areas for ribbon seals in the Okhotsk Sea. Specifically, at least six oil operations (Sakhalin-1,2,3,4,5,6) have already begun to exploit the oil and gas fields on the shelf off the northeastern coast of Sakhalin Island (Figure 11). Sakhalin-1 is estimated to contain 310 mt of oil, 425 billion m^3 of gas and 33 billion m^3 of gas condensate (Lapko and Radchenko 2000. Sakhalin-2 is estimated to contain 140 mt of oil and 408 billion m^3 of gas (Lapko and Radchenko) and will liquefy and export gas to Japan, Korea, and the U.S. (Chernenko 2007). Oil extraction from these projects has already started about 18.5 km from the northeastern coast, with a platform, a terminal for oil shipment and a floating oil tank with a capacity of one million barrels (Lapko and Radchenko 2000). According to the 10th International Conference "Oil and gas of Sakhalin" which was held in Yuzhno-Sakhalinsk on September, 27-28, 2006, it was noted that the projects Sakhalin-3, Sakhalin-4 and Sakhalin-5 have begun to work on Sakhalin Island with participation of the company Rosneft (Chernenko 2007). Seismic prospecting was carried out as part of the project Sakhalin-6 in the summer of 2002 (Chernenko 2007). Illustrating the hazards of this growing oil and gas development, the Sakhalin 1 and Sakhalin 2 projects have already been charged with significant environmental violations, which led to the company Gazprom taking over the Sakhalin-2 project in 2006.

In the Magadan Region in the northern Okhotsk Sea, an investment project called "Prospects, investigation and development of oil and gas fields in offshore sectors of the Sea of Okhotsk - Magadan 1 and Magadan 2" is planned for development through initiation by the Ministry of Natural Resources of the Russian Federation and the Administration of the Magadan Region (Figure 11) (Chernenko 2007). Each sector includes three blocks that are subject to licensing. These sectors will enable the annual extraction of 15-20 million tons of oil and 35-50 billion m^3 of gas (www.magadan.ru). The oil company Rosneft is showing interest in Magadan projects, but it can pursue these projects only after the commencement of operations in offshore zones of Sakhalin and Western Kamchatka (www.magpravda.ru).

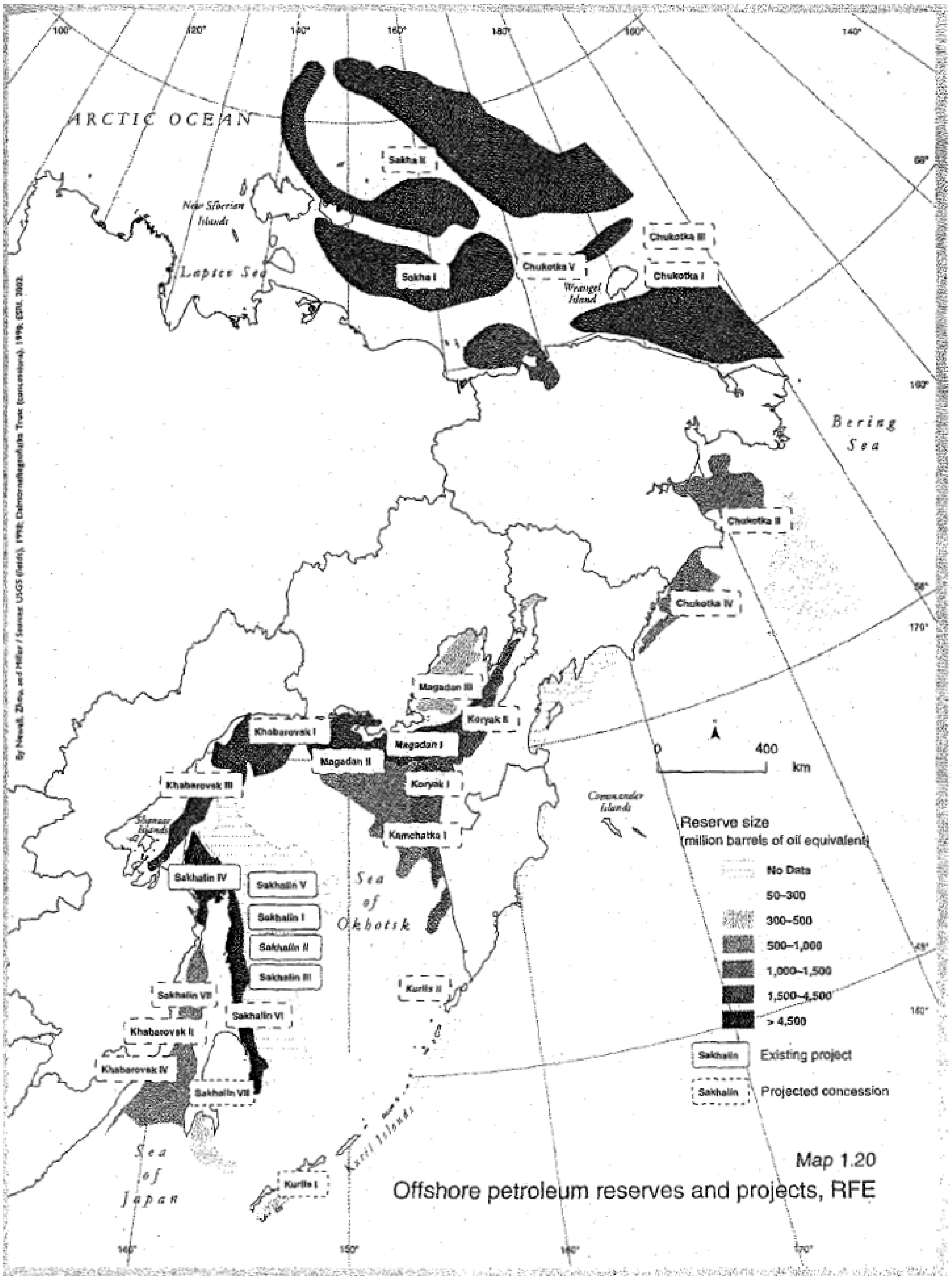
The western side of Kamchatka shelf is also considered as a prospective area for oil development (Figure 11). The program "Development of the oil-and-gas complex in the Kamchatka Region 2005-2010" is exploring the opportunities for developing an oil-and-gas complex in the Kamchatka shelf region (Chernenko 2007). Actual oil and gas extraction is planned to begin by 2015. Licenses were given to the company Rosneft on August, 8, 2003 by the Ministry of Natural Resources valid until August 1, 2008 (Chernenko 2007).

Oil and gas development in the Chukotka region is targeting regions of the Bering and Chukchi Seas, including the Anadyr Gulf, which is an important ribbon seal foraging area (Figure 11). Five prospective petroleum basins in the Chukotka Autonomous District and offshore zones have been identified: Anadirsky, East-Khatirsky, South-Chukotsky, North-Chukotsky and East-Siberian. The total volume of reconnoitered gas stocks equals 11.8 billion m^3. The company Sibneft-Chukotka has been finishing work on drilling and exploratory well in the Anadirsky petroleum basin for the purpose of identifying its oil and gas content (www.chukotka.org). According to the newspaper *Kommersant*, the quaterly report "Gazprom of oil" indicates that Sibneft-Chukotka completed geologic exploration of the Bering and Central blocks on April 1, 2007 (www.kommersant.ru).

Oil and gas development in the Sea of Okhotsk has already resulted in a large oil spill in 1999, and future oil spills are very likely. Lapko and Radchenko (2000) warned against the future impacts from oil spills and dredging on the marine ecosystem:

> Unfortunately, oil exploration and development on the shelf cause dredging, leaking oils and oil pollution. Already by the end of September 1999 an accident

Figure 11. Offshore petroleum reserves and projects in the Sea of Okhotsk and Bering Sea.
Source: Chernenko 2007: Exhibit 1.



> on one production complex resulted in a spill of about 3.5 t of oil. No doubt other cases will occur in the future. This kind of industrial activity, as well as the commercial fisher, can seriously degrade the marine ecosystem (Lapko and Radchenko 2000: 186).

Somov (2006) noted that there is no coordinated government agency action among the Sakhalin, Magadan, Kamchatka, and Khabarovsk sectors of the Sea of Okhotsk that could provide an effective cleanup response in the event of an oil spill:

> There is no single coordinated resource or nature protection policy available, which is hazardous to the unique ecosystem of the Sea of Okhotsk. Some departmental and ill-coordinated activities will prove particularly inefficient in case of accidental oil spills. The sea guard bodies are constantly reformed. The Russian regulatory framework for the production of hydrocarbons on the shelf is imperfect, and the requirements are not as strict as those in the western countries (Somov 2006: 505).

Furthermore, the currents in the Sea of Okhotsk are likely to move spilled oil into important ribbon seal breeding areas (Somov 2006). The counter-clockwise movement of water in the Sea of Okhotsk pushes water northward along the Kamchatka peninsula, past the northern coast, and southward along Sakhalin Island.

Canada

Intense offshore oil and gas exploration occurred in the Canadian Beaufort Sea in the 1970s and 1980s, including 85 offshore exploration programs that resulted in significant oil and gas discoveries (Devon Canada Corporation 2004). After a lull of two decades, activity is once again increasing. The Canadian government has granted the Devon Canada Corporation Exploration License (“EL”) 420 to conduct petroleum exploration in the Southern Beaufort Sea (Devon Canada Corporation 2004). Devon has identified nine offshore drilling targets within the landfast ice zone (Devon Canada Corporation 2004). Under Canadian law, Devon must commence drilling at least one well in each of the four areas by the end of the license period on August 15, 2009, or lose the license in that area, with rights reverting back to the federal government (Devon Canada Corporation 2004). Devon plans to drill the first well during the winter of 2005-2006, and one well per winter season thereafter through 2009 (Devon Canada Corporation 2004). Although the Canadian Beaufort Sea is not in the core of the ribbon seal’s range, ribbon seals do occur in this region, making offshore oil and gas development in the Beaufort Sea a relevant threat.

b. Impacts of oil pollution on ribbon seals

The threat posed to ribbon seals by oil spills is increasing with the rapid growth in offshore oil and gas development and shipping across the range. Of added concern, oil spill clean-up in broken ice and open water conditions that characterize the ribbon seal’s habitat is largely ineffective (Fischer and Larned 2004), making ribbon seals highly susceptible to injury and mortality even if a spill is detected and clean-up is attempted. As detailed below, oil spills can produce population-level impacts on marine mammals such as the ribbon seal by decreasing their survival and reproductive success, inhibiting their normal behaviors, and exerting deleterious effects on their health.

The ribbon seal lives in an environment that is energetically very demanding because of the characteristic low temperatures of the Arctic. Fur is an effective thermal barrier because it traps air and repels water; however, petroleum reduces the insulative value of fur by removing natural oils that waterproof the pelage (St. Aubin 1990). Ribbon seals exposed to oil are more likely to experience severe low temperatures reducing their chances of survival, especially for newborns and juveniles that have not yet developed a thick layer of subcutaneous insulative fat (St. Aubin 1990).

The reproduction of the ribbon seal can be adversely affected by oil exposure in multiple ways. Seals depend on scent to establish a mother-pup bond, and mothers often do not recognize their oil-coated pups (St. Aubin 1990). Oiled pups may be prematurely abandoned, reducing the pup's chances of survival. During the nursing period, ribbon seals and most ice-breeding seal species return to the water several times a day between nursing bouts, increasing the chances of repeated contact with oil (St. Aubin 1990).

Oil spills also impede seals' foraging activities. When oil is present in the sea seals are reluctant to enter into the water (St. Aubin 1990), reducing their chances of getting food. Exposure to oil may also interfere with locomotion, especially in young seals. Davis and Anderson (1976, cited in St. Aubin (1990)) observed two gray seal pups drowning because their flippers were stuck to the sides of their bodies, preventing them from swimming.

Petroleum hydrocarbons are extremely irritating to the mucous membranes that surround the eyes and line the oral cavity, respiratory surfaces, and anal and urogenital orifices of pinnipeds. After a few minutes of experimental exposure to crude oil-covered water, ringed seals began to lacrimate profusely and eventually had difficulty keeping their eyes open (Smith 1975). Within 24 hours they developed severe conjunctivitis, swollen nictitating membranes and corneal abrasions and ulcers (Smith 1975).

Inhalation of hydrocarbon vapors can be toxic for pinnipeds. In particular, free-ranging pinnipeds stressed by parasitism or other metabolic disorders may be susceptible to even brief exposure to relatively low concentrations of hydrocarbon vapors. The exposure may even be fatal if combined with other factors that could elicit a major adrenal response (St. Aubin 1990). Parasitized lungs, a relatively common finding in pinnipeds, can exacerbate the effects of even mild irritation of respiratory tissues (St. Aubin 1990).

Some of the components of petroleum are toxic if ingested (St. Aubin 1990). Ingested hydrocarbons irritate and destroy epithelial cells in the stomach and intestine, affecting motility, digestion and absorption (St. Aubin 1990). Ingestion of petroleum hydrocarbons has been the cause of several deaths of gray and harbor seals along the coast of France (St. Aubin 1990). Apparently all pinnipeds have enzymatic systems that help them convert absorbed hydrocarbons into polar metabolites that can be excreted in urine, and extraordinary concentrations of "detoxifying" enzymes have been found in the liver and kidney of oil-exposed seals (St. Aubin 1990). These enzymatic systems help seals tolerate the toxic effects of oil. However, the activation and production of these enzymes could represent an energetic cost that could reduce seal reproduction or survival (St. Aubin 1990).

3. Contaminants

Many Arctic marine mammal species, as long-lived apex predators with high lipid content, have a high potential for long-term accumulation of contaminants and carry high contaminant loads (Tynan and DeMaster 1997, AMAP 2002). The Arctic contains high loads of many toxic pollutants that are transported by air, water and ice from distant sources (AMAP 2002). Of concern for the ribbon seal, increasing precipitation and ice melt as a result of global warming will increase the potential for large introductions of river-borne pollutants and contaminants trapped in sea ice into arctic marine ecosystems (Tynan and DeMaster 1997, ACIA 2005).

Organochlorine compounds and heavy metals are commonly found in high concentrations in phocid seals, but the presence of these contaminants in the ribbon seal has not been studied (Kelly 1988). Quakenbush et al. (2007) measured the concentrations of polybrominated diphenyl ether compounds (PBDEs) in four seal species in the Alaskan Bering Sea, including the ribbon seal, and found that ribbon seals had the highest mean level of total PBDEs (16.5 ng/g wet wt). PBDEs are chemical compounds widely used as flame retardant additives in carpets and in the production of plastics for electrical appliances, that are released into the air and subsequently incorporated in the food web (Strandberg et al. 2001). Laboratory studies indicate that these compounds have endocrine disruptive properties (in particular with regard to the thyroid function and thyroid hormone) and detrimental effects on neurodevelopment in mammals (Viberg et al. 2004). The levels of PBDEs detected by Quakenbush et al. (2007) are not thought to cause health problems for any of the studied seal species or for the humans and polar bears that eat them (Quakenbush 2007). However, the environmental levels of PBDEs are continually increasing in multiple regions in the Arctic (Ikonomou et al. 2002) and higher concentrations of these compounds may eventually become a threat to the ribbon seal. Specifically, the proper functioning of the endocrine systems is essential to enabling mammals to respond adequately to environmental stress (Jenssen 2006). The thyroid hormone, in particular, plays an important role in the process of molting and in the adaptation of Arctic marine mammals to seasonal stresses, like reductions in food availability (Jenssen 2006). Global warming and the reduction in ice extent in the Arctic represent exceptional stress factors for the ribbon seals in their natural habitat. The increasing environmental concentrations of PBDEs are very likely to exacerbate the detrimental effects that global warming and habitat loss are having on the ribbon seal and other Arctic marine mammals (Jenssen 2006).

4. Commercial fisheries

Commercial fisheries pose a threat to the ribbon seal by causing direct mortality through incidental take in fisheries bycatch and by depleting essential prey resources. As sea-ice extent in the Bering, Okhotsk, and Chukchi Seas decreases, there will be new opportunities for commercial fisheries in previously inaccessible regions (AMAP 2003) which could increase ribbon seal mortality and physiological stress.

In the US, bycatch of ribbon seals in the Alaska-based commercial groundfish fisheries appears to be relatively low. Bycatch levels in the Bering Sea/Aleutian Islands groundfish trawl, longline, and pot fisheries were monitored by NMFS observers during 1990-2004. From 1990-1999, three ribbon seal mortalities were reported in the Bering Sea groundfish trawl fishery, resulting in a mean mortality rate of 0.2 (CV = 1.0) individuals per year (NMFS 2002). Between 2000 and 2004, ribbon seals were caught in the Bering Sea/Aleutian Islands pollock trawl and the Bering Sea/Aleutian pacific cod longlining fisheries (Perez 2006). The annual average bycatch mortality of ribbon seals during this period was less than one individual (0.80) per year (Perez 2006). However, bycatch of pinnipeds is typically highest in gill-net and drift-net fisheries (Read et al. 2006), and no bycatch estimates are available for U.S.-operated set and drift gill-net fisheries targeting salmon operating in the Bristol Bay and Aleutian Islands regions. As documented below, ribbon seals have been caught in Japanese coastal salmon gill-net fisheries, so take of significant numbers of ribbon seals in U.S. gill-net fisheries is possible.

Recent bycatch estimates of ribbon seals in international commercial fisheries, including the intensive fisheries operated by Russia and Japan in the ribbon seal range, are not available. However, data from the 1970s and 1980s indicate that ribbon seals were taken regularly and are especially vulnerable to gill-nets. In a literature review of reported pinniped bycatch by international fisheries prior to the 1990s, Woodley and Lavigne (1991) found numerous reports of ribbon seal mortality which are undoubtedly under-estimates since they are based on voluntary reporting:

- 3 in offshore gill-nets in 1969 in coastal waters of the Japanese Islands
- 2 in salmon set nets in 1970-1971 in coastal waters of the Japanese Islands
- 1 in 1978-81 in the eastern North Pacific Ocean and eastern Bering Sea
- 10 of 384 in salmon trap nets in 1982-1983 off southeastern Hokkaido Island
- 1 of 14 in salmon trap nets in 1984 off Daikoku Island

Marine mammal bycatch in international fisheries was also summarized by the NOAA/NMFS National Marine Mammal Laboratory for 1978-1987. Mortalities of 30, 5, 7 and 6 ribbon seals in 1978, 1982, 1983, and 1984 respectively (live, released, and decomposed animals excluded) were reported (Woodley and Lavigne 1991).

Commercial fisheries may also impact ribbon seals by competing with them for prey resources. Both the Bering and Okhotsk Seas are heavily fished, and many species targeted by commercial fisheries (pollock, Pacific cod, herring, capelin) are important prey species for the ribbon seal. NMFS determined that prey depletion by commercial fisheries in the Bering Sea poses a threat to the western population of Steller's sea lion (NMFS 2007b), and commercial fisheries could similarly impact ribbon seals, especially as they face growing stress from sea-ice loss. In the Okhotsk Sea, over-fishing is thought to have contributed to the long-term decline in walleye pollock, which began in the early 1990s and is ongoing (Lapko and Radchenko 2000, PICES 2005). Recent declines in biomass of all major demersal fish species (cod, flatfishes) are also worrisome (PICES 2005).

Specifically, commercial fisheries may affect ribbon seals through overall ecosystem-wide reductions in prey biomass, local and temporal depletions of prey, and reduced quality (size, age and caloric value) of individual prey by selective removal of larger, older individuals (NMFS 2007b). For example, many US fisheries in the North Pacific are managed using a maximum sustainable yield (MSY) single-species strategy. The MSY strategy will eventually reduce the average spawning stock size to 40% and total biomass to approximately 50% of the theoretical pre-harvest levels. On a finer scale, fisheries can also reduce the local abundances of prey when individual vessels concentrate in discrete areas. The potential for fisheries to reduce local abundances of fish was shown for Pacific cod fishery, where local, short-term harvest rates were much greater than the annual target harvest rates on the stocks as a whole (NMFS 2007b). Additionally, fisheries generally target larger, older individuals. As a result, a fished population will be composed of smaller, younger individuals, and have a smaller average size and age than an unfished population of the same species (NMFS 2007b).

These fishery-related changes may have two consequences for ribbon seals. First, the distribution of fish within the water column and geographically, which often correlates with age (NMFS 2007b), will be altered in a way that potentially affects availability to foraging ribbon seals. Second, a reduction in the average size of individual fish will reduce the per capita energy content and may necessitate increased foraging effort by ribbon seals to obtain the equivalent amount of energy in a larger number of small fish (NMFS 2007b).

Research and Management Recommendations

The researchers studying the ribbon seal have made important recommendations regarding studies for monitoring population size and trends and detecting the impacts of threats to ribbon seals. We include these points here because future monitoring will be essential to protecting the ribbon seal from population declines and eventual extinction. NMFS should consider these points in its recovery plan process and in its research funding decisions.

1. Monitor population size and population parameters. Seasonal and inter-annual fluctuations in population size should be monitored to understand the population dynamics of the ribbon seal and the environmental factors that influence its presence and abundance. The development of census methodologies that generate reliable population estimates is critical to this effort. Data on temporal variation in the proportions of ribbon seals hauled out would be valuable for estimating changes in densities over time as well as from area to area. In addition, efforts to monitor ribbon seal demographic rates and timing of important life history events (pupping, mating, molting) in several locations throughout the range would provide valuable information in understanding how threats affect population viability.

2. Monitor sea-ice distribution, quality, and persistence (and other relevant environmental variables) in conjunction with ribbon seal population parameters. Variations in the extent and quality of pack ice undoubtedly influence the distribution and abundance of the ribbon seal at least during the pupping, nursing and molting periods (Kelly 1988). Understanding the effects of weather and ice conditions on ribbon seal populations will require correlating these environmental variables with population size, demographic rates, and the timing of life history events.

3. Continue to characterize ribbon seal diet and foraging behavior. Studying diet and foraging behavior is important to understanding the ribbon seal's ecological relationships and detecting changes in prey species composition and abundance over time and space that may affect population health. The analysis of diet from samples collected throughout the year would increase the understanding of the seasonal variations in diet composition of the ribbon seal. Furthermore, satellite tracking of ribbon seals, using tags that record depth and water temperature, would provide much-needed information on ribbon seal movement, foraging locations, and habitat associations.

4. Identify populations. Resolving the population structure of the ribbon seal and describing dispersal patterns are important to defining meaningful management units and designing effective management strategies. NMFS currently manages the ribbon seal as a single stock in Alaskan waters based on the apparent continuous distribution of the seals in the Bering, Chukchi and Beaufort Seas. To identify populations and subpopulations, Kelly (1988) recommended the long-term tracking of marked individuals and the examination of morphological, molecular and biochemical evidence of any genetic structure.

Critical Habitat

The ESA mandates that, when NMFS lists a species as endangered or threatened, the agency generally must also concurrently designate critical habitat for that species. Section 4(a)(3)(A)(i) of the ESA states that, "to the maximum extent prudent and determinable," NMFS:

> shall, concurrently with making a determination . . . that a species is an endangered species or threatened species, designate any habitat of such species which is then considered to be critical habitat . . . .

16 U.S.C. § 1533(a)(3)(A)(i); *see also id.* at § 1533(b)(6)(C). The ESA defines the term "critical habitat" to mean:

> i. the specific areas within the geographical area occupied by the species, at the time it is listed . . . , on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and
>
> ii. specific areas outside the geographical area occupied by the species at the time it is listed . . . , upon a determination by the Secretary that such areas are essential for the conservation of the species.

Id. at § 1532(5)(A).

Petitioner expects that NMFS will comply with this unambiguous mandate and designate critical habitat concurrently with the listing of the ribbon seal. We believe that all current and historic areas utilized by the species for reproduction and foraging meet the criteria for designation as critical habitat and must therefore be designated as such.

Conclusion

For all the reasons discussed above, Petitioner Center for Biological Diversity requests that NMFS list the ribbon as an endangered species because it is currently in danger of extinction in all or a significant portion of its range. Delaying protection of this species until populations have declined further will only undermine any future conservation efforts. If, however, federal regulatory forces can be mustered to protect this ice-dependent seal from multiple ongoing threats, then it will have a renewed chance at survival. Listing the ribbon seal now will allow the necessary conservation mechanisms to be implemented to the fullest extent possible.

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[7] All references are provided in pdf format on the accompanying compact disk except for those denoted with an asterisk. We are happy to provide NMFS with copies of any references upon request.

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