BEFORE THE SECRETARY OF COMMERCE

PETITION TO LIST ILIAMNA LAKE SEAL, A DISTINCT POPULATION SEGMENT OF PACIFIC HARBOR SEAL (*PHOCA VITULINA RICHARDSI*) UNDER THE ENDANGERED SPECIES ACT

CENTER FOR BIOLOGICAL DIVERSITY

NOVEMBER 19, 2012

Notice of Petition

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Pursuant to Section 4(b) of the Endangered Species Act ("ESA"), 16 § 1533(b), Section 553(3) of the Administrative Procedures Act, 5 U.S.C. § 533(e), and 50 C.F.R. § 424.14(a), the Center for Biological Diversity ("Petitioner") hereby petitions the Secretary of Commerce and the National Oceanographic and Atmospheric Administration ("NOAA"), through the National Marine Fisheries Service ("NMFS" or "NOAA Fisheries"), to list the Iliamna Lake seal 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 approximately 40,000 members, and over 474,000 members and online activists throughout the United States and internationally. The Center and its members are concerned with the conservation of endangered species, including seal species, and the effective implementation of the ESA.

NMFS has jurisdiction over this petition. This petitions 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 Iliamna Lake seal as threatened or endangered is in fact warranted, there can be no reasonable dispute that the available information indicates that listing this 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).

The term "species is broadly defined under the ESA to include "any subspecies of fish or wildlife or plants and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." 16 U.S.C. §1532 (16). A Distinct Population Segment (DPS) of a vertebrate species can be protected as a "species" under the ESA even though it has not formally been described as a separate "species" or "subspecies" in scientific literature. A species may be composed of several DPSs, some or all of which warrant listing under the ESA. Petitioners ask that the Secretary of Commerce list the Iliamna Lake seal as a threatened or endangered species because the continued existence of this species is threatened by one or more of the five listing factors. As described in this petition, the Iliamna Lake seal population qualifies as a species under the ESA as a DPS of Pacific harbor seal (*Phoca vitulina richardsi*).

EXECUTIVE SUMMARY

The Iliamna Lake seal is a rare and unique freshwater seal found exclusively in Iliamna Lake, the largest and deepest body of freshwater in Alaska. Iliamna Lake seals are generally considered to be a population of the Pacific harbor seal (*Phoca vitulina richardsi*). Seals in the lake are isolated from other seal populations through a combination of ecological, behavioral and geographical factors, and constitute a distinct population segment (DPS) of Pacific harbor seal eligible for listing under the Endangered Species Act (ESA).

The Iliamna Lake seal is only known to occur in the northeastern half of Lake Iliamna. Approximately 200 km of lake and river separates Iliamna Lake seal habitat from the nearest population of saltwater seals in Bristol Bay. While there are no apparent geographical or physical barriers such as waterfalls or other obstacles that would absolutely preclude migration in or out of Lake Iliamna, distance alone is an impediment to such movement and connectivity. The distance between the area occupied by the Iliamna Lake seal and the nearest saltwater seals is significantly greater than the distance known to be traveled by other harbor seals in Alaska, and is significantly greater than the average home range of a related freshwater harbor seal subspecies, Canada's Lac de Loups seal. Additionally, there is no biological reason for the seals to make the long, energetically expensive trek across the lake and down the Kvichak River in the winter. There are ample fish in the lake to sustain a year-round population of seals, including abundant salmon runs in late summer and early fall, and there is suitable wintering habitat.

Although population estimates are uncertain, Iliamna Lake seals probably number from 250 to 350 adults. Over the last 28 years of aerial surveys, seal observations have ranged from zero to over 340 seals, with the highest counts recorded during the August molt period when hauled out seals are easily visible for aerial counts. In 2009, seals were first documented at Iliamna Lake in the winter, and 2010 was the first time pups were observed. Prior to scientific observation, local traditional knowledge (LTK) reported pupping and winter use by seals in the lake. LTK also indicates that the number of seals in the lake has remained steady over the years, and that seals do not leave the lake in the winter. Population trends over the years are difficult to assess due to inconsistent surveys and a lack of demographic data.

Iliamna Lake seals have unique reproductive timing, pupping about one month later than the closest population of harbor seals in Bristol Bay. The seals are also described as morphologically distinct from saltwater harbor seals, with a darker pelt, specific fur pattern, and larger head and body size. Behaviorally, the seals also differ from saltwater seals, as winter use of the lakes requires different hunting and hauling out strategies.

Iliamna Lake seals primarily use islands in the eastern part of the lake for hauling out during ice-free months, and likely use cracks in the ice (polynyas), ice caves, or underground caves for hauling out during the winter. Salmon comprise the primary prey consumed by Iliamna Lake seals during the summer and fall spawning season. Freshwater fish including grayling, stickleback, whitefish, pike and sculpin provide a year-round food source. Unlike species of saltwater seals, Iliamna Lake seals are heavily reliant on salmon, which comprise 90 percent of their prey during the summer and fall. Decomposing salmon are also an important source of nutrients in the Iliamna Lake system and provide the basis for thriving freshwater fish populations.

The loss of Iliamna Lake seals would create a significant gap in the range of the taxon as it would eliminate the only population of resident freshwater seals in the U.S. known to live exclusively in an inland lake environment.

Existing regulatory mechanisms are ineffective in mitigating the principal threats to the Iliamna Lake seal, the most important of which are climate change and ocean acidification resulting from greenhouse gas emissions and the Pebble Project development. Immediate reduction of greenhouse gas pollution is essential to slow global warming and ultimately stabilize the climate system and also prevent rapid ocean acidification and other major disruptions to the Bristol Bay and larger North Pacific/Bering Sea ecosystem. Unless greenhouse gas emissions are cut dramatically in the immediate future, wide-scale ecological changes including declines of Bristol Bay salmon are essentially assured and threaten the Iliamna Lake seal with extinction.

The Pebble Project is a massive open pit mining operation that, if built, would be among the largest open pit mining operations in the world, with a 4.1 billion metric ton open pit and a 3.4 billion metric ton subservice mine. A proposed 225-km access road and transport corridor would run from the mine site to Cook Inlet and parallel the north shore of Iliamna Lake for 80 to 96 km, where Iliamna Lake seals are known to haul out and hunt for salmon and other fish. The Pebble Project would pose a catastrophic threat to Iliamna Lake seal, as well as other wildlife and the people that depend on the fragile Bristol Bay ecosystem for their livelihoods. The largest sockeye salmon run in the world occurs in the Kvichak River watershed. These salmon are a key prey species for the Iliamna Lake seal and are an integral component of the lake ecosystem. Virtually all of the largest copper-sulfide mines in the world have had serious accidents or failures, degrading or destroying the water quality and ecosystems around them. The Pebble Project would likely result in loss or severe decline of salmon runs, decreased water quality, increased human noise and activity, and degradation of both aquatic and terrestrial habitat. Any of these impacts would pose a serious threat to the continued existence of Iliamna Lake seals. Absent ESA listing, there are no regulatory mechanisms in place that would specifically protect the Iliamna Lake seal from the likely devastating impacts of Pebble Project development.

The Iliamna Lake seal is in danger of extinction, or likely to become so within the foreseeable future, due to its inherent vulnerability from being a small, isolated population, and ongoing, high-magnitude threats posed by climate change, ocean acidification, the Pebble Project development and operations. The Center for Biological Diversity (Center) requests that the National Oceanic and Atmospheric Association (NOAA) list the Iliamna Lake seal under the U.S. Endangered Species Act to provide it with essential and much-needed protections, with concurrent designation of critical habitat.

PART I. SPECIES ACCOUNT

1. INTRODUCTION AND SPECIES DESCRIPTION

Iliamna Lake seals are unique freshwater seals that are year-round residents of Lake Iliamna, Alaska (Smith et al. 2006, Burns et al. 2010, Withrow and Yano 2011). Iliamna Lake seals are similar in outward appearance and many aspects of ecology and behavior to Alaskan populations of saltwater harbor seals (*Phoca vitulina richardsi*), but have unique reproductive timing, food preferences, morphological characteristics, habitat use, ecology, and behavior. While their taxonomy remains uncertain, based on the current best available science, throughout this petition, the seals will be treated as a distinct population segment (DPS) of the Pacific harbor seal and referred to as "Iliamna Lake seals."

In terms of appearance, Iliamna Lake seals are described as having a larger body size, larger head, and darker fur coloration and distinct fur patterns than saltwater harbor seals (Burns et al. 2010). Indigenous subsistence hunters have harvested Iliamna Lake seals for many generations, and describe the animals as having a "different color" than saltwater seals, and also as "bigger than the saltwater seals" and "really fat," with thicker and softer fur than saltwater seals, resulting in pelts that are softer and "harder to process because of increased oil" (Withrow and Yano 2011, Burns et al. 2012b).

Winter habitat use and hauling out behavior are little known but likely unique features of lake seal ecology (Van Lanen et al. 2012a). Iliamna Lake seals also have separate reproductive timing, pupping about one month later than the closest population of saltwater seals in Bristol Bay (Withrow and Yano 2011, Van Lanen et al. 2012a).

A. Taxonomy

Iliamna Lake seals almost certainly belong to the genus *Phoca*, with the best available science indicating they are an isolated population of the Pacific harbor seal (*Phoca vitulina richardsi*) (Burns 2002, Burns et al. 2012b, Van Lanen et al. 2012a). The harbor seal belongs to the order Carnivora, suborder Pinnipedia, family Phocidae, subfamily Phocinae, tribe Phocini, and genus *Phoca* (Rice 1998). The five different subspecies of harbor seal were originally recognized on the basis of geographical separation and skeletal morphology alone, and recent genetic analysis of harbor seals in Alaska supports these taxonomic separations (Burns 2002, Allen and Angliss 2012).

The taxonomy of the Iliamna Lake seal to the species level remains uncertain, with speculation that they may be spotted seals (*Phoca largha*), harbor seals, originating as a hybrid of the two species, or their own unique taxon (Burns et al. 2011). However, Iliamna Lake seals have generally been considered most likely to be harbor seals, based on general outward appearance and geographical location, and the best available science at present support this treatment (Kiinkhart et al. 2008, Hauser et al. 2008, Holen 2009, Withrow and Yano 2011, Allen and &

Angliss, 2012; D. D. W. Hauser, Allen, Rich, & Quinn, 2008; Holen, 2009; Kiinkhart, Pitcher, & Blundell, 2008; Withrow & Yano, 2011).

Scientists have recently increased research efforts on Iliamna Lake seals, prompted in part by the extensive baseline research required for permitting efforts for the proposed Pebble Project, and by subsistence hunters' concern about the Iliamna Lake seals if the Pebble Project were to proceed. Researchers' efforts include year-round aerial surveys, LTK questionnaires, and physiological and morphological measurements of harvested lake seals, along with tissue sampling for DNA analysis (Burns et al., 2011). As of this writing, Iliamna Lake seal taxonomic identification to the species level has yet to be confirmed by DNA sampling or by behavioral, morphological or physiological metrics.

B. Genetics and Population Isolation

As of spring 2012, the single mtDNA analysis of a tissue sample from an Iliamna Lake seal indicated that the animal was genetically a Pacific harbor seal (Van Lanen 2012). However, this sample size of one is too small to draw definitive conclusions on the genetics of the lake seals (Haig 1998, O'Corry-Crowe et al. 2003, Fallon 2007), and additional tissue sampling and/or DNA analysis must be conducted to conclusively determine the species or subspecies of the lake seals (Burns et al. 2011, Van Lanen 2012). Moreover, analysis of mtDNA data is confounded by inadequate sample size in many areas of Alaska, making analysis and comparison to other known mtDNA-analyzed populations of seals difficult. This is especially true for Iliamna Lake seals as there are few samples collected from harvested seals available at any time, meaning it will be always be difficult to find genetic differences due to small sample size (O'Corry-Crowe et al. 2003).

Alaska harbor seal stocks are derived from a historically large population, which means that geographic differentiation between populations may take many generations to develop within mtDNA, further compounding difficulties in distinguishing between populations based on genetics alone. Recent analysis of mtDNA variation in Alaska harbor seals revealed that genetic differences were mainly due to geographic distances (Westlake and O'Corry-Crowe 2002). Alaskan harbor seals are subdivided into a series of partially isolated sub-populations, with substantial levels of genetic differentiation over relatively small spatial scales (O'Corry-Crowe et al. 2003). This indicates that dispersal distances are small compared to range, and that when Alaska harbor seals do disperse, it is primarily to neighboring areas. Female dispersal occurs at the demographically low rate of less than 4.25 females per year at distances of just 150 km to 540 km (O'Corry-Crowe et al. 2003).

For the Iliamna Lake seal, assessments of demographic history and past changes in genetic diversity are hampered by a lack of information on population origins, initial diversity, and isolation time (Valtonen et al. 2012). Iliamna Lake seals have been documented as resident to the lake since at least the early 19th century. Native Alaskans on Iliamna Lake including Yup'ik, Alutiiq, and Athabascan people have been hunting Iliamna Lake seals for many generations. The earliest known written account of seal hunting on Iliamna Lake is an 1819 journal entry by Russian explorer Petr Korsavkiy. How long the species has remained genetically isolated remains uncertain, but LTK and written records indicate that genetic isolation of the population has been occurring for at least 200 years and probably much longer.

In terms of ecological separation, harbor seals generally utilize coastal habitat and ice-free areas, although they do make use of icebergs in glacial fjords in Alaska. Harbor seal populations are found in Bristol Bay, which is at the outlet of the Kvichak River. While long-distance movements of harbor seals are not unheard of, permanent or annual migrations are not common for this species, with most populations showing high site-fidelity, and long-distance movements recorded for just a few individuals (Baird 2001). Telemetry studies on seal habitat use from the other North American population of freshwater harbor seals, Lac de Loups seals on the Ungava Peninsula in Canada, found that lake seals' ranges varied from 83 square km to 891 square km (longest straight line distance of 30 km), with core areas from 7 square km to 126 square km (longest straight line distance of 11 km). If Iliamna Lake seals have similar range sizes, travel down the Kvichak River and across the lake would be unlikely to occur, because the some 200 km of travel required to make the journey would be significantly longer than the longest straight line travel observed for Lac de Loups seals of just 30 km.

Harbor seals have been observed in the beginning reaches of the Kvichak River near Bristol Bay (Burns et al. 2011), but have not been observed near the outlet to the Kvichak River in Iliamna Lake. Aerial surveys have also never observed seals in the western half of the lake. LTK indicates that harbor seals do not migrate in or out of the Kvichak river and across Iliamna Lake, and there have been no substantiated reports of seals traveling the length of the river, nor photographs or aerial survey reports of seals in any part of the lake but the eastern half. This is despite at least two aerial surveys covering the entire lakeshore and length of the Kvichak River looking for seals during the time of year following molt when seals would be traveling the river if they did indeed migrate in and out (Burns et al. 2011, Withrow and Yano 2011, Van Lanen 2012).

All of the above strongly indicates that the Iliamna Lake seals do not migrate in or out of the lake and are genetically isolated. How long they have been isolated, and the degree of genetic separation from saltwater seals, have yet to be determined.

C. Physiology, Morphology and Behavior

Unfortunately, there are little scientific data available on morphological characteristics of Iliamna Lake seals. According to information collected to date, it may be difficult to differentiate Pacific harbor seals and the seals in the lake based on appearance alone. That said, there appear to be certain morphological differences between Iliamna lake seals and saltwater harbor seals, which, as described by local hunters in the area, include a unique fur pattern, darker fur color, larger head and larger body size (Fall et al. 2006).

Because Iliamna Lake seals are described as larger than saltwater seals, they likely fall at the higher end of the ranges for body weight and length known for harbor seals in Alaska. The average length and weight of a harbor seal varies among populations, with both the smallest and largest seals occurring in the North Pacific. In Alaska, adult male harbor seals range from 160 cm to 186 cm and 87 kg to 170 kg, while adult females range from 148 cm to 169 cm and 65 kg to 142 kg (Burns 2002).

Fur colors (pelage) and coat patterns vary among populations of harbor seals. Harbor seals generally exhibit both a light and dark phase of its base coat (Quakenbush 1988, Rice 1998). The Iliamna Lake seal's fur pattern is described by hunters as unique and thus more valuable, and the color is described as darker than saltwater harbor seals.

Cranial measurements may also provide useful metrics for distinguishing between Iliamna Lake seals and Pacific harbor seals as such techniques have been used to distinguish harbor seals from spotted seals (Burns 1981).

Blubber fatty acid composition has been used to distinguish between populations of freshwater and marine ringed and harbor seals, and may be a useful parameter for further research on Iliamna Lake seals (Smith et al. 1996, Strandberg et al. 2011). Blubber thickness may be an especially useful measurement, as this metric was used, in part, to identify Lac de Loups seals as a subspecies of harbor seals (Smith et al. 1996).

A North Pacific Research Board (NPRB) study is currently gathering data from subsistence harvested seals, aerial surveys, and LTK in order to determine what genetic, behavioral, or morphological differences exist between Iliamna Lake seals and Pacific harbor seals. However, the small available sample size of harvested animals (roughly eight lake seals are harvested annually), and difficulty in obtaining viable samples from subsistence hunters, may limit the usefulness of these preliminary measurements until a number of years' data have been collected (Fallon 2007). Ultimately, however, these data should provide clarification on the taxonomic identity and evolutionary history of the Iliamna Lake seal.

D. Similarities to Other Populations of Freshwater Seals

Year-round residency of a seal population in a freshwater lake is highly unusual. In addition to Lake Iliamna, four other lakes in the northern hemisphere host populations of freshwater seals: Lake Baikal (~85,000 seals) and Lake Lagoda (~ 3,000 seals) in Russia, Lake Saimaa (~270 seals) in Finland, and Lac de Loups (160-600 seals) on the Ungava Peninsula, Quebec, Canada (Rice 1998, Smith et al. 2006, Burns et al. 2011, 2012a). Seals are also present in the brackish Caspian Sea. Saltwater seals occasionally visit freshwater lakes, and short-term utilization of inland waters is common among harbor seal populations. Physiologically, the transition from saltwater to freshwater does not appear to be a problem. Harbor seals are often seen traveling many miles upstream in rivers of the Pacific Northwest, and occasionally utilize freshwater areas in parts of Alaska, Canada and the Northeast U.S. (Peterson et al. 2012).

Canada's population of Lac de Loups harbor seals, *Phoca vitulina mellonae*, is a subspecies endemic to the lakes of northern Quebec on the Ungava Peninsula. Lac de Loups seals were designated as Endangered in 2007 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) and are in the process of being upgraded from Schedule 3 (Special Concern) to Schedule 1 (Endangered) under Canada's Species at Risk Act (SARA). This freshwater seals species is considered endangered because of a lack of information on the seals, a very limited range, low populations numbers, and potential threats from proposed development in the region (Burns 2002, Canadian Science Advisory Secretariat 2008). This subspecies bears many similarities to the Iliamna Lake seal including reproductive isolation, unique reproductive timing, distinctive morphology, limited range, and small population size.

2. DISTRIBUTION: GEOGRAPHIC AND BIOLOGICAL SETTING

Iliamna Lake is located in southwest Alaska, some 200 miles southwest across Cook Inlet from Anchorage, and is nestled between Lake Clark National Park and Preserve to the north, and Katmai National Park and Preserve to the south. Bristol Bay is to the Southwest, and Cook Inlet (Gulf of Alaska) lies to the east of Iliamna Lake. According to the U.S. Geological Survey, the lake was named for “a mythical great blackfish supposed to inhabit this lake, which bites holes in the bidarkas of bad natives” (Withrow and Yano 2011). Other sources assert that the name Iliamna is derived from the Inland Dena’ina Athabascan name “Nila Vena” which means “island’s lake.”

This large glacial lake is often described as an “inland sea” and covers a total of 1,600 sq. mi (2,590 sq. km). At 77 mi (124 km) long, up to 22 mi (35 km) wide, and 984 ft (300 m) deep, Iliamna Lake is the largest lake in Alaska and the eighth largest freshwater lake in the U.S. Many islands, including Seal, Porcupine, Flat and Triangle, dot the lake’s surface. Numerous rivers and streams run into Iliamna Lake, including the Newhalen River, which starts at Fall Lake and runs 40 miles south to empty into Iliamna Lake. The 70-mile-long (113 km) Kvichak River drains the lake southwest into Bristol Bay and is the only outlet to the sea (see Figure 1).

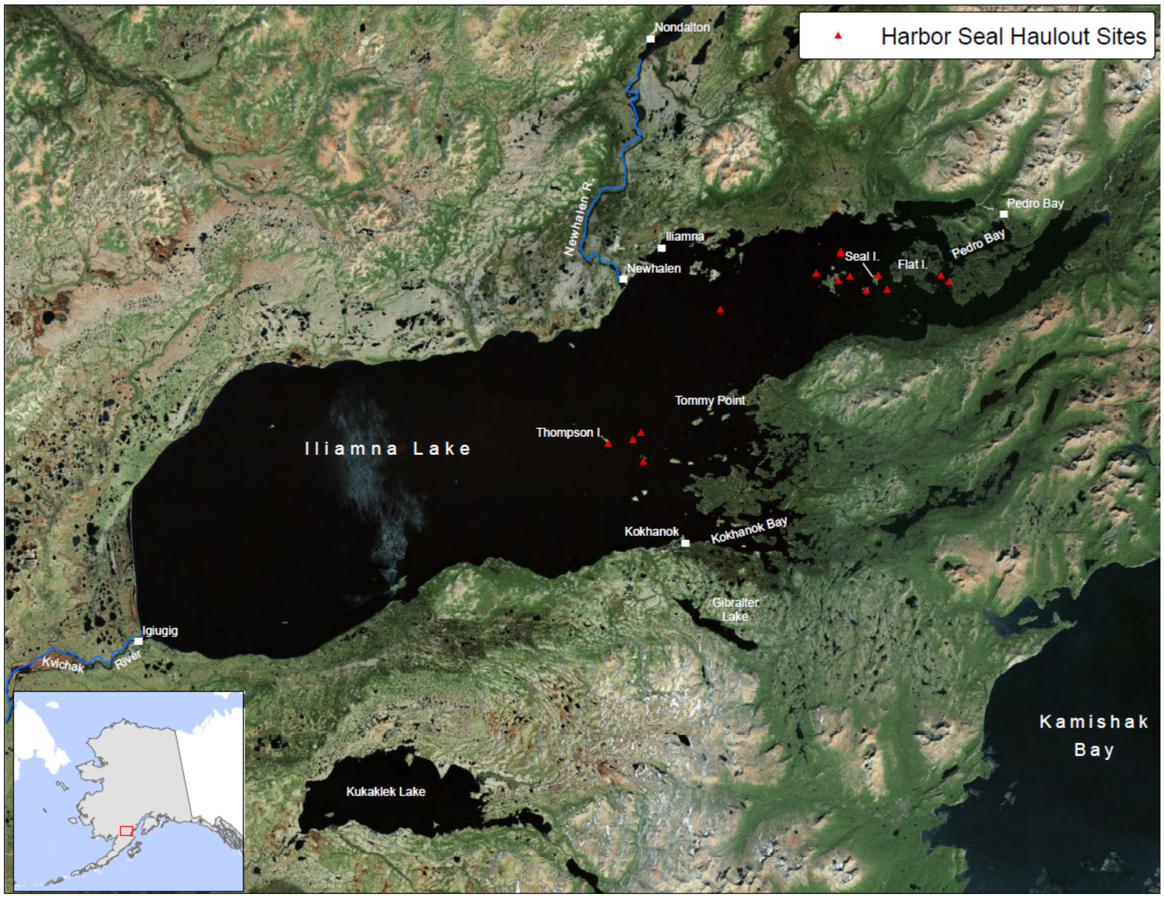

Figure 1: Location of Lake Iliamna. Red circles illustrate known seal haul out sites. Figure developed based on Withrow and Yano 2011.

Iliamna Lake and the Kvichak river system support the world's largest sockeye (red) salmon run, along with healthy runs of silver, king, chum and pink salmon and rainbow trout. Resident freshwater fish in the lake include whitefish, Arctic grayling, and northern pike. Spawning salmon are fed upon by a large population of brown bears. Other terrestrial mammals common to the lake area include grey wolves, wolverines, red foxes, moose and caribou. Ravens, bald eagles, gulls and jays frequent the lake year round. The lake and river provide renowned sport fishing opportunities, and also support local subsistence fishing, while salmon that spawn in the Iliamna Lake and Kvichak River system are taken by large commercial fisheries operating in Bristol Bay (Duffield 2009).

The shores of Iliamna Lake are largely unpopulated, and the lake is accessible primarily by air travel, with limited barge service also available, leaving the vast majority of the Iliamna Lake area free of human influence. Lakeshore communities include Iliamna, Newhalen, Kekhanok, Pedro Bay, Pope-Vannoy Landing, and Iguigig, with the largest village, Kekhanok, counting only 200 permanent residents (Bille 2004). Year-round residents are primarily Yupik Eskimos, Aleuts and Athabascans, with residents highly dependent on subsistence fishing and hunting, especially red and silver salmon (Igiugig Tribal Village Council 2012). Fishing and hunting lodges on the lakeshore and along the Kvichak River draw sportsmen to the lake area during the summer.

3. ABUNDANCE AND POPULATION TRENDS

A. Difficulties in Determining Year-round Population Numbers of Iliamna Lake Seal

Several factors make it difficult to accurately assess Iliamna Lake seals' abundance and trends. The remoteness of their lake habitat, the amount of time seals spend below the surface or in areas not visible through aerial surveys, extreme weather in the area, difficulty in covering all haul-out sites, and the dynamic nature of ice cover makes surveying Iliamna Lake seals expensive and logistically challenging. The variability of the number of seals hauling out at any given time is also influenced by both environmental factors and behavioral or physiological factors of the seals. These include weather, wind, ice cover, time of day, and food availability, along with disturbance levels, body condition, age, and reproductive status (Simpkins et al. 2003, Huber et al. 2006).

Ideally, aerial survey methods for seals should reduce these variables by repeating survey counts at the same time of day, during specific weather conditions, and at specific stages in the life cycle. Otherwise, it is difficult to determine what kind of natural variability may be influencing survey numbers, particularly when comparing summer counts to winter counts. Even a difference of just three weeks in survey timing can cause as much as an 85 percent reduction in the estimated number of harbor seals (Mathews and Kelly 1996). Thus comparing counts in April to counts in July is unlikely to provide a reliable estimate of the total number of seals in the lake for that year. The timing of annual snow and ice melts also varies widely year to year, so comparison between years are problematic. Also, surveys for Iliamna Lake seals by various research entities are not identical in methodology, such as height of flight or areas covered, further complicating comparison between or even within years. When natural environmental variability is controlled for, aerial surveys between years that were flown under similar temporal, environmental, and life-cycle conditions can be compared to determine population trends (Simpkins et al. 2003). Unfortunately, environmental variability has not been adequately controlled during Iliamna Lake seal surveys, making population estimates difficult.

One method to reduce the influence of environmental and physiological variability is to use modeling to calculate a corrective factor that can be used to estimate total population counts. However, there is insufficient information regarding Iliamna Lake seals at this time to create a model of Iliamna Lake seal haul out patterns under various conditions that could provide corrective factors that could be used to estimate population size. Existing models based on saltwater seals must be adjusted for the lake environment, as diel patterns and other preferences and characteristics are unique to this freshwater population.

Reliability of aerial surveys for Iliamna Lake seals are further complicated by the remoteness and extreme weather conditions often present in the seal's habitat. Iliamna Lake is a very large and remote area, and subject to severe weather and often limited visibility. This makes surveying logistically difficult and increases the expense and risk of winter surveys.

Surveys are also limited in total area, meaning that seals hauling out in unusual or unknown (to science) areas may be overlooked. The vast majority of aerial surveys flown to date focused on known haul-out sites, as shown in Figure 2. There are few, if any, year-round surveys of the entire lakeshore, including the islands (Pebble Partnership 2008, Burns et al. 2010, Withrow and Yano 2011). It is unlikely that all the major haul-out sites for Iliamna Lake seals are currently known, especially those reserved for winter use. Thus, a significant number of seals may be routinely missed during aerial counts.

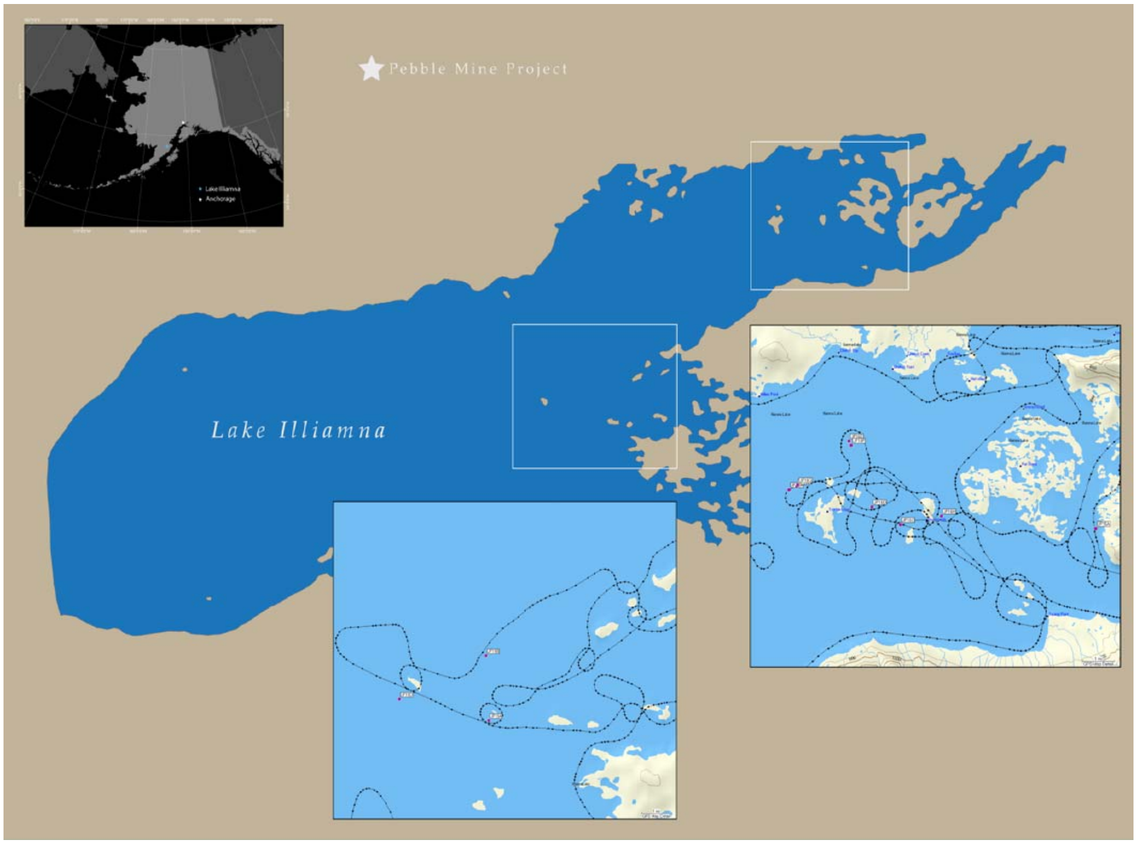

Figure 2: Aerial survey routes flown by NMML consortium researchers in 2010. Note the focus of the surveys on the two major known haul out sites in the lake, which leaves much of the lake un-surveyed, especially near the outlet to the Kvichak River.

Due to the above factors, single counts, or counts from one year only, are unlikely to provide an accurate population estimate or be conclusive in determining population trends within or between years. With these limitations in mind, the best scientific and commercial data on population abundance and trends are summarized below.

B. Population Size

The Alaska Department of Fish and Game (ADF&G) and later the National Marine Fisheries Service (NMFS) conducted periodic aerial surveys of Iliamna Lake seals from 1984 to 2008. Over the last 28 years of aerial surveys, seal counts have ranged from zero to over 300 seals, with highest counts recorded during the August molt period. Funding through the National Pacific Research Board (NPRB) has provided for more consistent, year-round aerial seal surveys by ADF&G biologists, in consortium with NMFS's National Marine Mammal Laboratory (NMML), the University of Alaska Anchorage (UAA) and Bristol Bay Native Corporation starting in 2008 and ending in 2012 (see Figure 2 for survey locations). In 2009 seals were first documented in the winter, and 2010 was the first time pups were observed during aerial surveys, with long-term pup presence in the lake also supported by LTK. The vast majority of aerial surveys for Iliamna Lake seals were conducted during the summer molt period of July to August, when the highest number of marine harbor seals haul out (Simpkins et al. 2003).

In addition to state and federal agency surveys, Alaska Biological Research (ABR) under contract for the Pebble Partnership, conducted aerial surveys of known haul-outs and also searched for additional haul-out sites between 2005 and 2008. Twenty aerial surveys were flown between March and December 2005; nine surveys were flown between May and October 2007; and seven surveys were flown in August 2008 (Pebble Partnership 2011).

The majority of ABR's surveys were conducted from noon to 2:00 p.m. or 3:00 p.m., with two flown in the evening at 7:00 p.m. and 7:30 p.m., and 11 flown from 9:30 am to noon. In Alaska, the majority of saltwater seals are known to haul out in mid-afternoon from around 2:00 p.m. to 3:00 p.m., but recent observations have reported that the majority of Iliamna Lake seals haul out in the evening well after 5 p.m. (Withrow and Yano 2011). Thus, the ABR surveys may have underestimated the number of seals in the lake, especially in the winter when limited daylight, poor visibility, uncertain haul-out locations, and weather make for more difficult survey conditions. ABR results from 2005 and 2007 are summarized in Table 1 below.

Date	**# Seals Observed**	**Time**
March 30, 2005	0	1200
April 25, 2005	1	1200
May 4, 2005	101	1500
May 10, 2005	5	1400
May 11, 2005	1	1300
May 25, 2005	0	1900
May 26, 2005	0	1300
May 31, 2005	0	1030
June 28, 2005	105	1600
June 29, 2005	98	0930
July 21, 2005	30	1200
July 22, 2005	107	1200
July 26, 2005	125	1600
August 11, 2005	194	1600
August 17, 2005	276	1000
August 29, 2005	199	1300
September 8, 2005	64	1500
October 10, 2005	2	1400
December 13, 2005	0	1200
May 21, 2007	0	1600
June 20, 2007	51	1130
July 16, 2007	238	1500
July 27, 2007	40	1030
August 14, 2007	311	1300

August 15, 2007	313	1430
August 29, 2007	86	1300
September 12, 2007	79	1030
October 11, 2007	0	1100

Table 1: Surveys of Iliamna Lake seals counted by ABR under contract for Pebble Partnership in 2005 and 2007. (Pebble Partnership 2010).

Beginning in 2009, NPRB-funded surveys were conducted in June, July, and August, with one additional survey conducted in April and again in November in 2010 and 2011. The last publicly accessible progress report on the NPRB-funded research indicates that year-round surveys were planned from mid-summer 2011 into fall 2012, although, as of this writing, results are not yet publicly available for the 2012 surveys. Figure 3 summarizes the maximum number of seals observed in the lake during each year surveyed from 1998 to 2011.

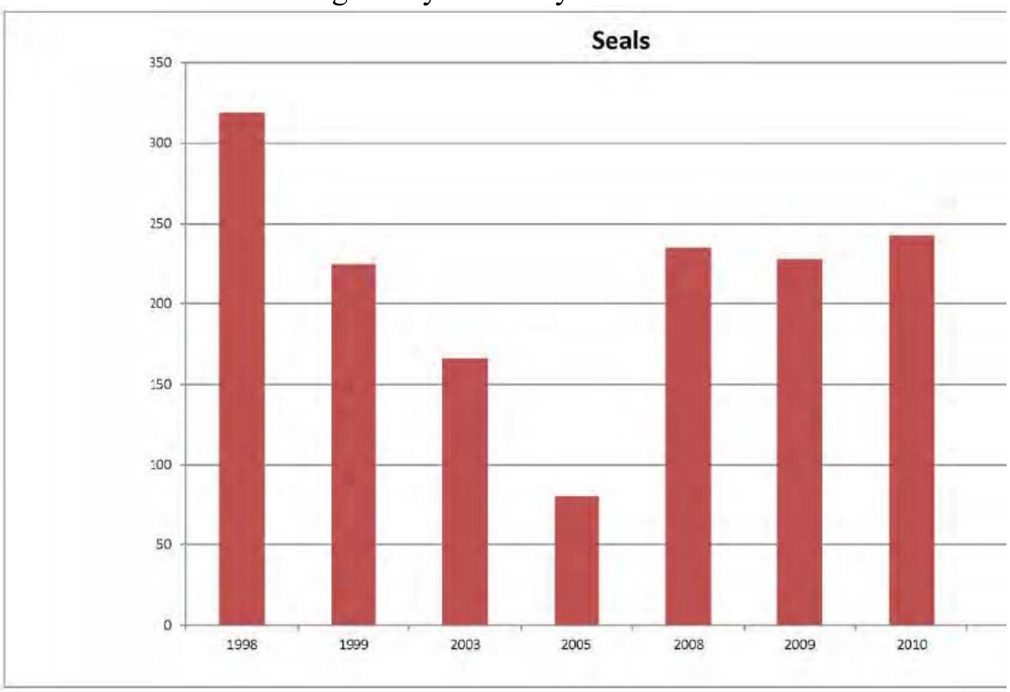

Figure 3. Unadjusted (raw) maximum counts by year (Withrow 2011)

Results from the 2009 to 2011 surveys are summarized in Table 2. The large difference in number of pups observed in July 2010 (63 pups) compared to July of 2011 (4 pups) emphasizes the high variability in aerial count surveys, and the necessity for consistent, annual surveys. Without such consistency, it is difficult to reach meaningful conclusions about the dynamics of year-long use of the lake, annual population numbers and population trends, reproductive timing, and pupping.

Date	Adult	Pups
June 14, 2009	27	0
August 15, 2009	131	0
August 20, 2009	180	0
August 22, 2009	228	0

April 1, 2010	11	0
May 28, 2010	35	0
July 9, 2010	142	63
August 3, 2010	188	55
August 24, 2010	179	0
November 3, 2010	8	0
April 14, 2011	73	0
June 17, 2011	75	4
August 13, 2011	180	16
August 15, 2011	136	22
November 7, 2011	0	0

Table 2: Adult and pup counts during NPRB surveys June 2009 to November 2011.

Annual pup production figures have been used to estimate population size, but this method is best used for seals that are known to stay out of the water during the lactation period such as the spotted seal. If Iliamna Lake seal pups are similar to harbor seal pups, and do enter the water shortly after birth, using pup production as an estimate of population size is problematic as harbor seal mark-recapture counts and telemetry have demonstrated that the number of seal pups produced each year is considerably larger than the maximum number observed at haul-outs (Thompson and Harwood 1990).

Winter Use

Winter counts of seals are especially scarce, with only four surveys, two in November and two in April, completed as of the 2011 NPRB report. One November survey reported eight seals, the next zero seals, with April surveys recording 11 and 73 seals. These numbers leave almost 280 seals thus far unaccounted for in winter, based on summer aerial surveys of seals at haul-outs.

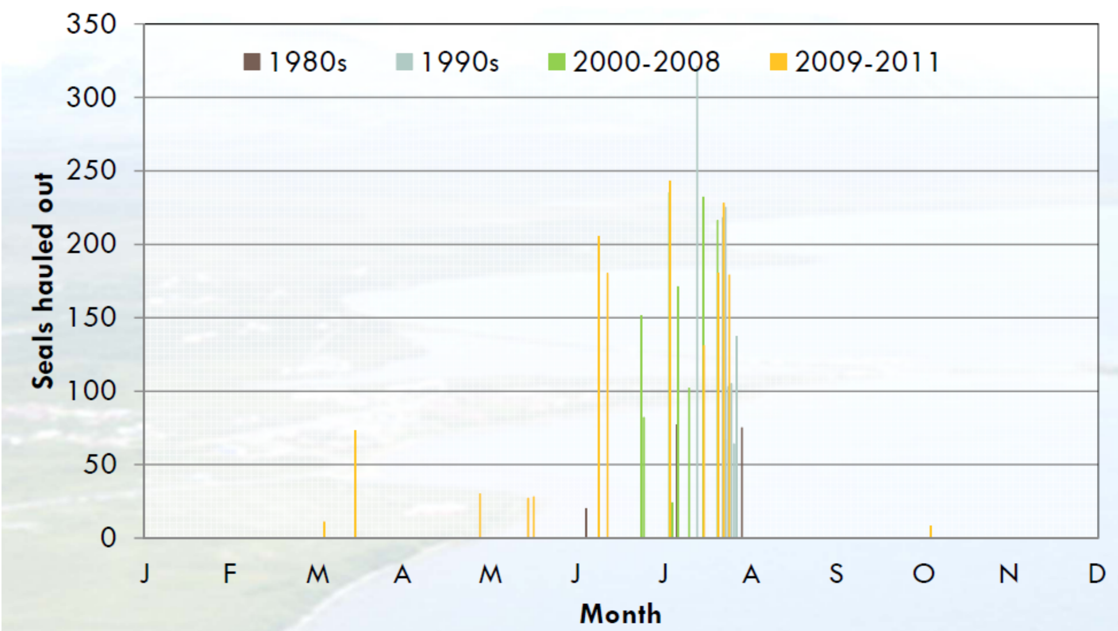

Figure 4: Number of seals hauled out by month during all aerial surveys conducted to date excluding those by ABR for Pebble Partnership. (Burns et al. 2012a).

While these results have been used to support the conjecture that seals must leave the lake to overwinter in Bristol Bay, there is no evidence of migration, and the high variability in survey counts, along with the lack of winter surveys limit making any such conclusions. Researchers have observed seals in the lake during winter, hauled out near cracks in the ice and open water (see Figure 5), but haven't located a major winter haul-out site. The use of haul outs under the lake ice that would be readily available when the lake's surface level drops during the winter months, and would not be visible during aerial surveys, would be a reasonable explanation for low seal counts during aerial surveys. Local residents who have harvested small numbers of lake seals for generations report that there are more seals in the lake than most people assume, with an especially large number of seals on an island near Newhalen (Fall et al. 2006).

Figure 5: Iliamna Lake seals hauled out near an opening in the lake ice (Withrow and Yano 2011).

It is unknown if aerial surveys have adequately estimated the number of seals in the lake at different times of year, or if local residents may be aware of seal habitat areas unknown to western science. Figure 6 illustrates the number of seals observed during joint-NPRB aerial surveys, from 1998 to 2010, specifying when the lake if frozen and when pupping and molting occur. This graphic illustrates how few surveys are conducted during the winter months, and how the majority of surveys occurred during the molt period.

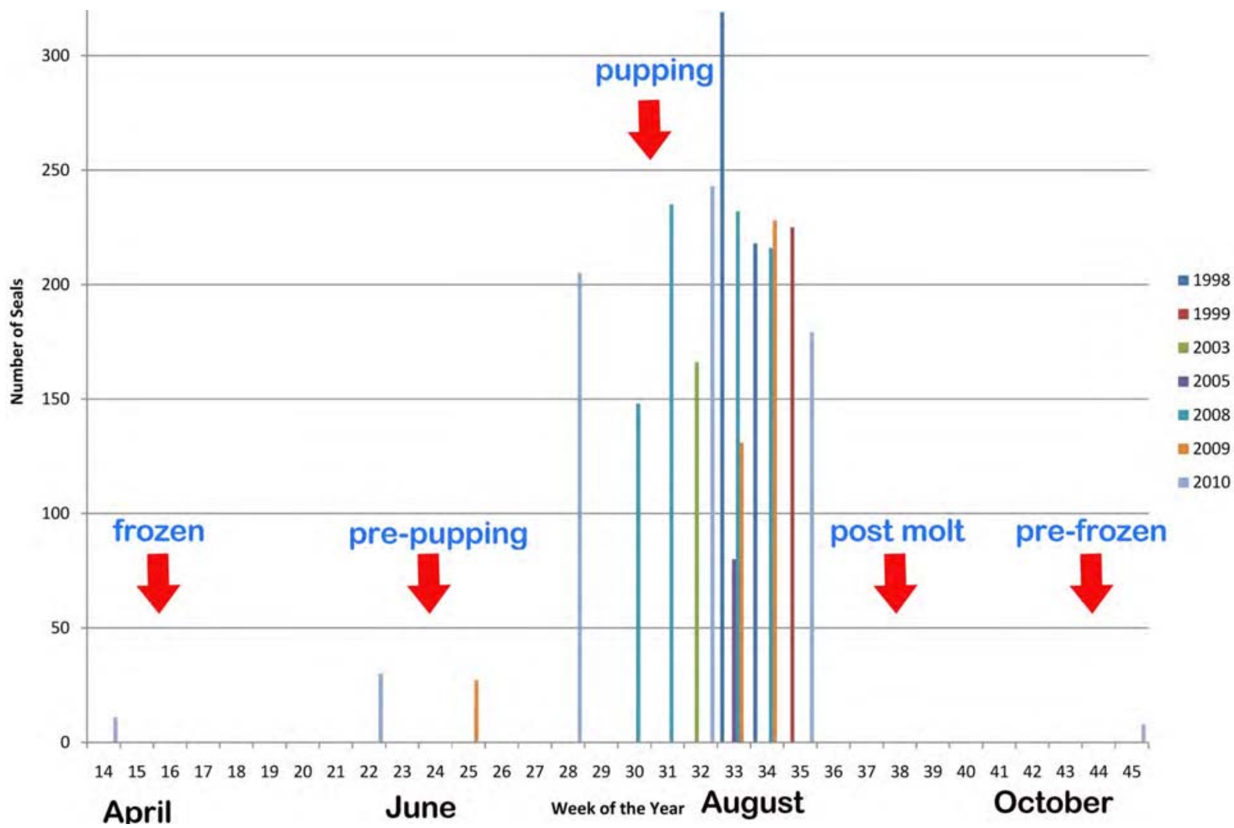

Figure 6: Number of seals and pups observed over year-round surveys 2009 to 2010 Compiled from NPRB 2012, Burns 2011.

C. Population Trends

Currently, harbor seal populations in Bristol Bay are declining slightly, but the 2011 stock assessment included no information on the Iliamna Lake seal (O'Corry-Crowe et al. 2003, Allen and Angliss 2012). Since there are no historic aerial survey data available for most of the year, and none before 1984, it is not possible to reevaluate the more recent count data based on historic scientific research. Population trends for better known pinnipeds are notoriously difficult to quantify, especially for seals that haul out on ice, as the Iliamna Lake seals do during the spring and winter months (Taylor et al. 2007). Thus, population trends for the Iliamna Lake seal remain uncertain, due to survey inconsistencies, difficulty in comparing survey results, and lack of long-term study.

Low population counts for Iliamna Lake seal over the winter may be due to the seals moving into unsurveyed areas of the lake, into habitat not visible by aerial survey (ice/underground caves), or because animals are spending significantly more time in the water. LTK asserts that the winter seal population is much larger than that observed thus far during aerial surveys (Van Lanen 2012), and that the seal population has been steady over the years (Fall et al. 2006). One subsistence respondent reported that one island near the village of Newhalen has an exceptionally large population of seals, and it is unknown if this is reflected in aerial surveys (Fall et al. 2006). Subsistence harvest is poorly understood, and collected data has not demonstrated any significant declines in seal abundance, but with the number of seals harvested at less then 10 per year, a decline would likely not be reflected in harvest data (Small et al. 2008).

4. HABITAT USE

A. Habitat

In the ice-free season, seals prefer to haul out on islands located in the northeastern end of the Iliamna Lake (see Figure 7). The highest level of use occurs at haul-outs on the Flat and Seal Island group, located southwest of Pedro Bay, and on the Thompson Island group located north of Kokhanok (Fall et al. 2006, Pebble Partnership 2008, Burns et al. 2011, Withrow et al. 2011). Salmon also spawn in the northeastern end of the Lake in clear, shallow waters near islands and at the mouths of the Newhalen River, the river than drains into the west side of Pedro Bay, and the river that drains Gilbralter Lake. These areas include Seal Island and surrounding shoals and bars, shoals and shoreline off Tommy Point and in Pedro and Kokhanok Bay, and rocks near the villages.

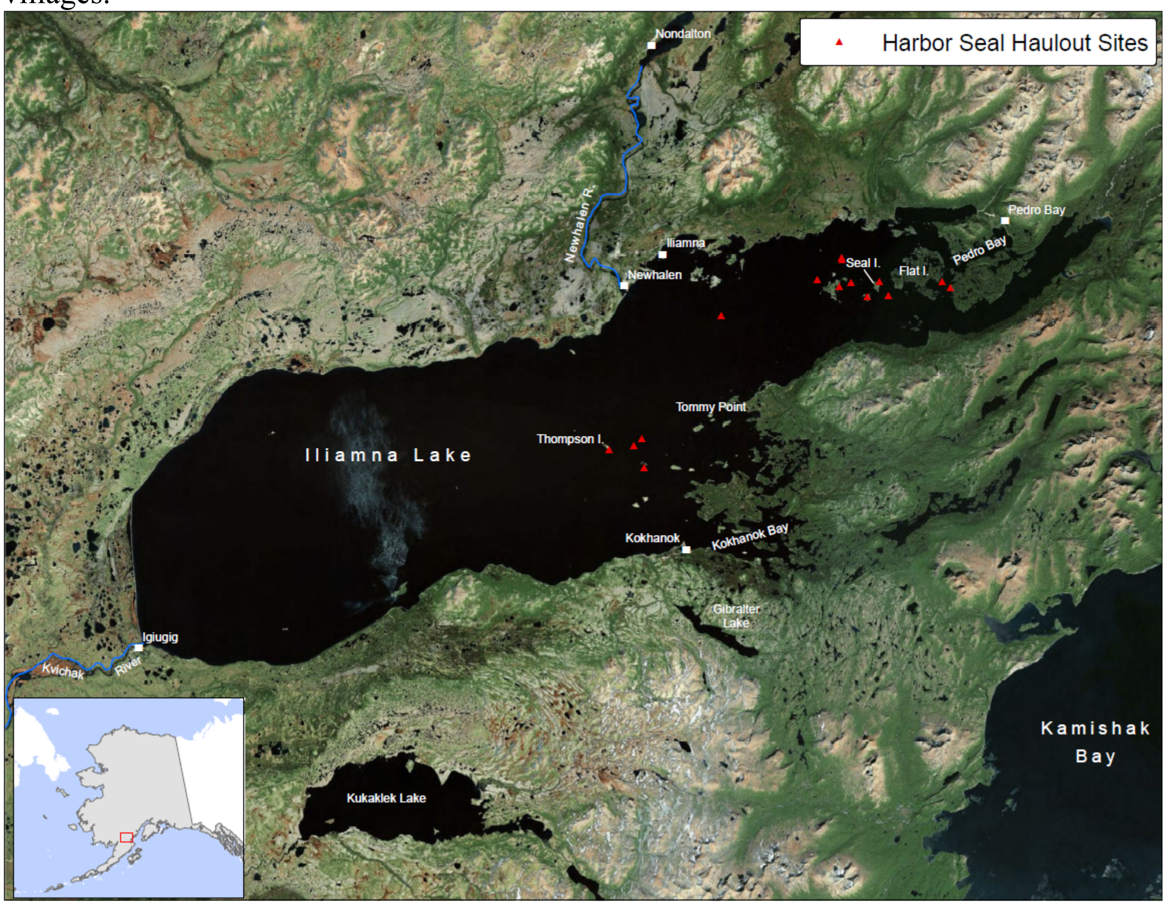

Figure 7: Haulout sites for the Iliamna Lake seal, and other important geographic markers such as the Newhalen River, Pedro Bay, Kokhanok, and Tommy Point.

Iliamna Lake is a large, isolated, little-studied body of water, with few intrusions by humans. Lake seal behavior, especially in winter, has never been studied by western scientists, and winter habitat use by seals remains relatively unknown. Local hunters assert that overwintering for Iliamna Lake seals occurs in the northeastern area of the lake, which is corroborated by subsistence hunting reports and aerial surveys. Most freshwater seal hunts take place in mid- to late March, with hunters following pressure cracks in the ice in order to find breathing holes (Fall et al. 2010). According to the locals, in the past hunters used to venture onto the thin ice in December or January to spear the seals at their breathing holes, which the seals needed to keep open until the lake dropped enough to create air spaces between the water and ice (Dickerson 2008). As the level of water in the lake steadily drops from September until breakup in May, it leaves air spaces and caverns in the ice and around the islands and rocky reefs (USGS 2012). This would provide the Iliamna Lake seals a protected area to haul out, access open water, and come up for air. The use of the "ice caverns" by seals in the winter is further supported by LTK reports of a hidden rookery in the form of a cave, which would provide shelter and access to unfrozen waters (Van Lanen 2012). On-ground surveys and/or radio telemetry would be a simple method scientists could use to determine winter use by the seals. All evidence to date shows that seals have no reason to leave the lake during the winter because they have access to open water, an abundant food source and safe and sheltered areas to haul out, and are not subject to high levels of predation or hunting that would drive them across the lake and down the Kvichak River. Iliamna Lake seals likely spend the majority of the winter in the water under the ice, coming up to breath at cracks in the ice, and hauling out in ice or underground caves in unknown locations that are not visible by air. This is similar to habitat use by other lake seal species in the winter (Sipila 2003, Canadian Science Advisory Secretariat 2008).

The habitat preferences of seals may also be influenced by predators. Predation has been found to influence the behavior of seals, where Arctic pinnipeds, subject to predation by land predators (polar bears and arctic foxes) tend to take refuge in water, while Antarctic seals, subject to predation by aquatic predators (leopard seal and killer whales) take refuge on ice. Stirling (1977) compared the behavior of Arctic ringed seals to Antarctic Weddell seals and found significant differences in distribution patterns, morphology, choice of pupping sites, means of underwater communication, and various other behaviors (Stirling 1977).

It is possible that large terrestrial predators that are active during the winter, including gray wolves and wolverines, may prey upon seals, especially because the frozen lake would provide easy access to islands where seals are known to haul out (Harkonen et al. 2008, Leahy 2010, EPA 2012). This may influence the seals' behavior, prompting them to seek refuge in areas inaccessible to terrestrial predators, and thus not visible from the air, or to spend the majority of their time in open-water habitat, coming up only to breathe.

B. Environmental and Ecological Variables Associated With Haul-Out Preferences of Iliamna Lake Seal

Iliamna Lake seals prefer to haul-out at night, with the highest number of seals observed at this time (see Figures 8 and 9). The timing of peak haul-out was a surprise to ADF&G biologists (Withrow and Yano 2011) because the highest counts of saltwater harbor seals generally peak near midday (solar noon) and are lowest at night (Watts 1996, Jemison et al. 2001). For saltwater seals, some studies attribute this pattern of low nighttime or late evening counts to nocturnal foraging bouts (Watts 1996).

Figure 8. Seals hauled out at Iliamna Lake at 5:00 p.m. Just over two dozen seals are hauled out at this time. (Withrow and Yano 2011)

Figure 9: Aerial photos of seals hauled out at the same location at 11 p.m. Counts of seals are more than triple those observed at 5:00 pm (Withrow and Yano 2011).

It is possible that Iliamna Lake seals do not need to forage at night due to an abundance of readily available, high-nutrient fish, and few natural predators. If this pattern of late evening haul-out preference continues into the winter months, it may help explain the significantly lower counts of Iliamna Lake seals during winter aerial surveys. Due to a lack of daylight during the winter at high latitudes, aerial surveys that rely on photography cannot take place in the evening, as there is insufficient light.

Iliamna Lake seal counts at haul-outs also vary with water levels. With high water from snow melt or river runoff, fewer seals were observed during aerial surveys (Withrow and Yano 2011). As an inland lake, there are no tides in Lake Iliamna, but lower seal counts with high or rising water corresponds to saltwater harbor seals' preference to haul out at low tide (Jemison et al. 2001).

Air temperature, wind speed, wave action, time of year, precipitation, physical disturbance and even moonlight have all been correlated with the number of seals hauled out at marine locations (Watts 1996). Haul-out use by seals in Iliamna Lake is known to be influenced by substrate conditions, seasonal variations in water level of the lake, and by annual variation in the extent and duration of winter ice cover. The timing and location of salmon spawning activities in summer and early fall may also influence haul-out use by seals. Biological and ecological factors such as molting, lactation, predation pressure and nutritional status further complicate haul-out patterns (Thompson et al. 1989). Numerous studies have observed increased numbers of seals hauling out during the molt period, which may correspond to decreased metabolism and reduced food requirements (Watts 1996). Several studies have indicated that harbor seals haul out less frequently and for shorter durations after molting (Johnson and Johnson 1979, Sullivan 1980, Thompson and Harwood 1990).

Spring-harvested Iliamna Lake seals are described as “fatter,” “bigger” and “more oily” than saltwater seals, indicating that there are ample fish available to the seals year round. Thus Iliamna Lake seals are not likely to be constrained by food availability So haul-out timing is likely influenced by other factors.

C. Movements

In all studies to date, researchers have found that adult harbor seals worldwide typically limit their seasonal movements and activity to less than 50 km (31 miles) from their primary original capture area, and harbor seals are considered a non-migratory species (O’Corry-Crowe et al. 2003, Peterson et al. 2012). Adult harbor seals monitored in Prince William Sound, Alaska, had a mean year-round distance between haul-outs of less than 10 km (6 miles). Juvenile seals had a slightly larger mean distance at 20 km (12 miles). Juveniles generally moved more than adults with larger home ranges. Three juvenile seals traveled 300 km to 500 km before returning to Prince William Sound, but population-level migration was not observed.

There are no confirmed reports of movements of Iliamna Lake seals up or down the length of Kvichak River in the spring and fall. Thus, despite low counts in aerial surveys, migration is unlikely, and the entire population of Iliamna Lake seals probably remains in the lake year-round and uses open areas of water near islands or polynyas for feeding and movement during the winter.

5. REPRODUCTIVE BEHAVIOR

Unfortunately, very little is known about reproductive parameters for Iliamna Lake seals. If this population is similar to its marine counterparts, then the average age at first reproduction would be about three to four years for females and four to five years for males. At sexual maturity, about 85 percent of females would breed each year, which comprises the majority of the adult population (Burns 2002). First year survival rates for marine harbor seal pups range from 60 to 90 percent (Harding et al. 2005). Adult survival is consistently higher, with a maximum survival rate of about 90 percent achieved as the animal reaches sexual maturity (Burns 2002). Reproductive rates for freshwater seals may be lower than those for saltwater seals. For example, Saimaa lake ringed seals in Finland (*Phoca hispida saimenses*) are less productive than marine ringed seals, with pregnancy rates of just 70 percent (Sipila 2003).

Aerial surveys in 2010 provided the first documented evidence that Iliamna Lake seals pup in the lake. Pups were observed in July and August where Iliamna Lake seals haul out in herds of mostly mothers and pups (Withrow and Yano 2011). More recent surveys were conducted as part of NPRB-funded Project 1116 (see Figure 10 and Table 2), which confirmed that pupping occurs in mid-July (Van Lanen et al. 2012a).

Figure 10: Example of pup counts for Iliamna Lake seals in July, 2011 (Withrow and Yano 2011).

The breeding behavior observed for Iliamna Lake seals is similar to that of Pacific harbor seals, but unique to the seals in the lake in terms of timing of reproduction. LTK notes that “everything happens in the lake about a month later than everywhere else” (Withrow and Yano 2011). Indeed, aerial surveys have pinpointed peak pupping for Iliamna Lake seals as mid-July (see Figure 11), which is approximately two weeks to one month later than pupping of harbor seal populations in Bristol Bay, which runs from June 8 to July 10 (Jemison and Kelly 2001, Withrow and Yano 2011). Iliamna Lake seals’ earlier reproductive timing would help to promote genetic isolation from nearby populations of harbor seals in Bristol Bay.

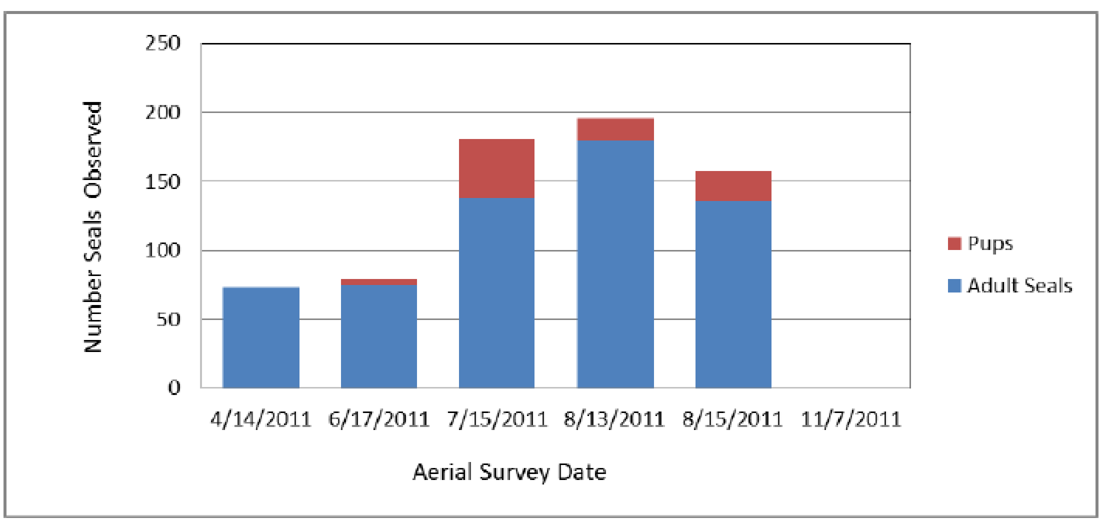

Figure 11: Aerial survey counts of Iliamna Lake seal pups and adults during 2011 (Van Lanen et al. 2012b)

There have been no studies on social organization or behavior of Iliamna Lake seals, but they appear to be similar to harbor seals. During the breeding season, saltwater harbor seals form herds with no apparent social organization (Burns 2002). Similarly, Iliamna Lake seals in aerial surveys appear to haul in small herds during the breeding season.

Aerial surveys in 2010 indicate that Iliamna Lake seals utilize exposed rocky sandbars when pupping (Withrow and Yano 2011). This is similar to saltwater harbor seals, which utilize coastal breeding habitat, giving birth at onshore rookeries, including beaches, sandbars and rocky reefs, and occasionally on iceberg fragments calved from tidewater glaciers in protected fjords (Bishop 2011).

Appearance and precocity of newborn Iliamna Lake seal pups appear to be similar to that of Pacific harbor seals. The pelage (fur) of newborn Pacific harbor seals is similar to that of adults because the lanugo is shed before birth, and pups generally swim within an hour of birth. From aerial surveys to date, Iliamna Lake seal pups do not appear to retain the wooly lanugo, and pups appear to be precocial and swim quickly after birth, indicating similarity to the Pacific harbor seal.

Pacific harbor seals nurse pups for about four weeks to six weeks, after which the pups are rather abruptly weaned, and subsequently left to fend for themselves. Pups may possibly be given a few lessons in fishing and obtaining food. Harbor seal pups are already catching their own food in the late stages of the nursing period. Pup behavior is unknown for Iliamna Lake seals, save an LTK report of freeing a seal pup from a fishing net while the mother waited nearby. Based on this, it is assumed that Iliamna Lake seal pups are quite successful in fishing for themselves once weaned.

6. DIET AND FEEDING ECOLOGY

The resident Iliamna Lake seal population is supported by massive annual salmonid runs, and by abundant lake fish species including grayling, stickleback, whitefish, pike and sculpin (Hauser et al. 2008, Withrow and Yano 2011, Van Lanen 2012). Iliamna Lake contains a variety of freshwater fish, anadromous salmonid species, and various invertebrates.

Adult sockeye salmon start entering Iliamna Lake at the end of June and run through the end of August, and are followed by spawning silver, chum, and pink salmon. Beginning in August and running through October, rainbow trout return to the Kvichak and Iliamna Lake system. Abundant salmon in mid- to late summer provide a source of high-fat nutrition for seals in preparation for the winter months. In the only published study to date examining the diet of Iliamna Lake seals, fecal samples indicated that Iliamna Lake seals predominately fed on adult salmonids during the summer period of high sockeye abundance in the lake (Hauser et al. 2008). The Iliamna Lake seal population is unique in that its diet composition was dominated by salmonids, whereas less than 10 percent of saltwater seals' diets typically consist of salmonids (Hauser et al. 2008). Other species consumed by Iliamna Lake seals included resident lake trout (*S. namacush*) and Arctic char (*S. alpinus*), as well as species that often migrate from the rivers to the lake, such as rainbow trout (*O. mykiss*) and Dolly Varden (*S. malma*) (Hauser et al. 2008).

Iliamna Lake seals also ate juvenile salmonids, as well as lamprey and smelt, and the occasional whitefish, sculpin and stickleback. These resident lake species, and juvenile salmon, likely comprise the majority of the Iliamna Lake seal's diet when adult salmonids are absent (Figure 12).

Figure 12: Iliamna Lake seal eating salmon (Burns et al. 2011)

Iliamna Lake seals gorge on salmon, often consuming the fatty bodies of the fish but leaving the heads (Hauser et al. 2008, Duffield 2009, Fall et al. 2009). Gillnets for salmon set by subsistence fishers near the outlet of the Newhalen River are reportedly often raided by seals, with one family estimating that two groups of seals took between 30 and 40 fish from their nets in summer 2007 (Fall et al. 2009). Juvenile seals may accompany their mothers into the water during fish hunts, as one hunter reported freeing a young seal from his net in the summer of 2007 (Fall et al. 2009).

Ecosystem dynamics differ between the open ocean and aquatic communities in freshwater lakes, where fish and seals are confined to a more limited space. This dynamic was found for the other North American population of lake seals. Lac de Loups harbor seals (*P. v. mellonae*) in freshwater landlocked lakes in northern Quebec were found to strongly influence the lake's fish communities (Power and Gregoire 1978). Predation by seals on fish in Lower Seal Lake resulted in significantly fewer and smaller lake trout than in similar lakes without seals. The lake trout (*Salvelinus namaycush*) subjected to harbor seal predation not only had a high mortality rate but grew more quickly with younger age of maturity and higher reproductive rates than trout in lakes without seals. Brook trout (*S. fontinalis*) seemed to be more common in lakes with seals, whereas lake trout were the most abundant species in lakes without seals. Similar changes in freshwater or anadromous fish dynamics have not been observed in Iliamna Lake, but predation by seals on salmon is very minor compared to take by commercial or subsistence fisheries, and Iliamna Lake comprises a very large ecosystem, so that predation by seals in the eastern part of the lake likely plays a relatively minor role in determining fish community profiles, especially when contrasted with commercial harvests of Kvichak River sockeye salmon in Bristol Bay.

7. CAUSES OF MORTALITY

A. Pollution and Contaminants

The Iliamna Lake ecosystem is currently relatively pristine. Salmon traveling upstream from the ocean are likely the greatest source of contaminants, particularly of the heavy metal mercury. This may impact the Iliamna Lake seals' immune responses and reproductive success, but the occurrence or level of such impacts is unknown.

B. Natural Causes, Disease, Predation, and Accidents

i. Natural Causes

Harbor seal pups may die of exposure and starvation (Steiger et al. 1989, Allen and Angliss 2011). As there are few disturbance events that would force a mother to abandon her pup, nor known rates of high mortality from predation that would kill a nursing mother, these are likely relatively rare causes of mortality for Iliamna Lake seal pups. Natural adult mortality for Iliamna Lake seals due to starvation is likely to be low as food availability and habitat restrictions are not known to be limiting factors.

ii. Disease

The occurrence of and mortality caused by disease outbreaks has been neither quantified nor observed for Iliamna Lake seals.

iii. Predation

In Iliamna Lake, terrestrial carnivores that have the capacity to prey on seals, particularly the vulnerable pups, are common year-round, but there is no documentation of predation on Iliamna Lake seals. Lack of documented predation may be due to the complete lack of behavioral studies on Iliamna Lake seals. There are also very few observations of the seals when salmon are not running, and during the winter, when both terrestrial and aquatic predators are more likely to seek alternative prey (see Figure 4 and Figure 6 above). Thus, a lack of documented predation does not mean that seals are not preyed upon.

Other inland seal populations are impacted by terrestrial and avian predators, with predation by eagles and wolves reported to be a major cause of mortality of Caspian seals (*Phoca caspica*) (Harkonen et al. 2008). Aquatic predators also can be major sources of mortality in saltwater seals, with a population of harbor seals in British Columbia estimated to have a 50 percent to 80 percent chance of being eaten by killer whales before adulthood (Watts 1996).

Predators of saltwater harbor seals include eagles, ravens (*Corvus* spp.) and gulls as well as shore-based predators including brown bears (*Ursus arctos*), wolves (*Canis lupus*), wolverines (*Gulo gulo*) and red foxes (*Vulpes vulpes*) (Burns 2002). Some of these species may also prey on Iliamna Lake seals.

a. Terrestrial Predators

Lake Iliamna and the Kvichak River system support the largest sockeye salmon run in the world, which is fed upon by one of the largest brown bear populations in North America. Thus, it is possible that bears may be a significant predator of Iliamna Lake seals, especially when salmon are not present. Smaller animals including red foxes, wolverines, wolves, eagles, ravens and gulls also are likely to prey on seal pups or occasionally adults.

b. Aquatic Predators

There are no documented aquatic predators in Iliamna Lake that are large enough to take a seal. The Iliamna Lake "monsters" are generally agreed to be either cryptic (mythical) animals or white sturgeons (Withrow and Yano 2011, Radford 2012).
In summer 2012, the capture of a 12-foot-long, 1,100-lb white sturgeon in the Fraser River, British Columbia, (see Figure 13) confirms that large sturgeon continue to be found in northern waters (Strege 2012). Sturgeons are not known to prey on aquatic mammals, and are generally bottom feeders, eating fish, invertebrates, and decaying matter. If large sturgeons do inhabit Iliamna Lake, they would not pose a predation risk for Iliamna Lake seals. Rather, smaller sturgeon may be eaten by seals (Hauser et al. 2008).


Figure 13: 1,100 lb sturgeon caught in Canada in 2012. (Strege 2012)

An additional postulated, but unconfirmed potential predator for the Iliamna Lake seal is the sleeper shark (*Somniosus microcephalus*) (Wright 2012). While primarily a saltwater species, these animals have been documented in brackish waters, and Wright (2012) speculated that a population of these predators could have colonized the lake. Although there is no substantiated evidence for a sleeper shark population in Iliamna Lake, the possibility of such a population and the implications for Iliamna Lake seal haul-out behavior and ecology are intriguing.

C. Subsistence Harvest

Subsistence hunting of Iliamna Lake seals has occurred for many generations, and residents of the lake report that seals have been hunted for as long as anyone can remember (Van Lanen 2012), and continue today (see Figure 15). The earliest written account of Iliamna Lake seal hunts is from a 1819 journal entry by a Russian explorer (Fall et al. 2006, Van Lanen 2012). Hunting usually takes place in February to mid-March, when the ice is still thick, but seals also may be harvested in summer, and more rarely in winter (Fall et al. 2006, Burns et al. 2011). Villagers report that the time of year for harvest does not matter because seals are always “fat and healthy looking” (Fall et al. 2006). Hunters state that people do not take large numbers of seals or travel great distances to hunt them (Fall et al. 2006). Total take of Iliamna Lake seals varies year to year, with 13 reported harvested by the villages of Newhalen and Kohkanok in 2009, and only three seals reported harvested in 2010 (Burns et al. 2011). Records and interviews find that subsistence hunters generally take three to five seals per year, but the number of seals harvested remains poorly documented (Fall et al. 2006, Burns et al. 2011, Van Lanen et al. 2012a). Seals provide supplemental meat and highly valued seal oil, which is used as a condiment for dipping salmon strips and other dried meat (Fall et al. 2006, Van Lanen 2012).

Figure 14: Hunter with Iliamna Lake seal. Source: Anchorage Daily News

Hunters target areas of known Iliamna Lake seal abundance, including Seal Island and the surrounding bars and shoals, areas off Tommy Point and inside Kokhanok and Pedro Bay, including Porcupine and Fast Islands, and rocks near the villages (Fall et al. 2006, Burns et al. 2011). During the spring, hunters search for areas of open water or polynyas in the ice along which seals are known to haul out. Seals are approached first by snowmobiles and then on foot and are dispatched with a shot to the head. The meat and oil from harvested seals are usually shared among villagers (Burns et al. 2011, Van Lanen 2012).

D. Fisheries Bycatch

Fishing activities are widespread on Lake Iliamna. Gillnets for salmon set by subsistence fishers near the outlet of the Newhalen River are reportedly often raided by seals, and seals may become entangled in the nets. One hunter reported freeing a young seal from his net in the summer of 2007 (Fall et al. 2009). It is likely that Iliamna Lake seals do drown in fishing nets or other fishing gear, but there is no documentation of this occurring, and subsistence hunters try to avoid operating in areas subject to excessive seal “picking,” as seals destroy the net and remove salmon

(Fall et al. 2009). Drowning in fishing nets is a major cause of mortality in other freshwater seal populations such as Lake Saimaa in Finland, but is not known to occur at anywhere near these rates for Iliamna Lake seals (Sipila 2003, Canadian Science Advisory Secretariat 2008).

8. CONSERVATION STATUS

Seals are protected under the Marine Mammal Protection Act (MMPA), but the Iliamna Lake seal has not yet been described as a separate stock in NMFS's Stock Assessment Reports (SARs). Similarly, Alaska Fish and Game has included Iliamna Lake in aerial surveys for the Bristol Bay harbor seal stock. Counts of these seals were reported, but the Iliamna Lake seal was not given separate consideration in terms of management status. As the Iliamna Lake seal population remains lumped together with the Bristol Bay harbor seal stock in both State and Federal assessments, there are no specific legal or management protections for this distinct population segment of seals.

PART II. THE ILIAMNA LAKE SEAL IS A LISTABLE ENTITY UNDER THE ESA

The term "species" is defined broadly under the ESA to include "any subspecies of fish or wildlife or plants and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature." 16 U.S.C. § 1532 (16). A distinct population segment (DPS) of a vertebrate species can be protected as a "species" under the ESA even though it has not been formally described as a separate "species" or "subspecies" in the scientific literature. A DPS is a "vertebrate population or group of populations that is discrete from other populations of the species and significant in relation to the entire species" (NOAA 2005, Rosen 2007). A species may be composed of several DPSs, some or all of which may warrant listing under the ESA (Haig et al. 2006).

NMFS considers a group of organisms to be a DPS when it is "both discrete from other populations and significant to the taxon to which is belongs" (61 FR 4722). The lack of detailed information based on genetic, morphological or behavioral studies, and the minimal number aerial surveys, does not preclude listing of the Iliamna Lake seal as a "species" under the ESA (Fallon 2007). Based on the best available science, the Iliamna Lake seal is a DPS of Pacific harbor seal and qualifies for designation as a DPS by the criteria required under the 1996 joint Fish and Wildlife Service (FWS)-NMFS policy (61 FR 4722).

A. Discreteness

Under the joint FWS-NMFS policy, a population segment of a vertebrate species is considered discrete if it is "markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, or behavioral factors (USFWS and NOAA 1996:4725).

Quantitative measurements of genetic or morphological discontinuity may provide evidence of this separation" (61 FR 4725). The Iliamna Lake seal satisfies this criterion.

i. Iliamna Lake seal is a discrete population and is markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological or behavioral factors.

Iliamna Lake seals are markedly separated from saltwater harbor seals found in Alaska based on physical, morphological, ecological, and behavioral factors as discussed in the following section.

a. Physical factors

Iliamna Lake seals live in a unique physical and ecological setting. Their range in Iliamna Lake is spatially separate from other saltwater seals, including their closest neighbor, Pacific harbor seals in Bristol Bay (Withrow and Yano 2011, Van Lanen et al. 2012a). While there are no geographical or physical impediments, such as waterfalls or obstacles that would require difficult bouts of extended overland travel by the seals, distance alone is an impediment. To get to Bristol Bay from their known habitat in the eastern part of the lake, Iliamna Lake seals would have to swim some 97 km across Iliamna Lake and another 113 km down the Kvichak River, for a total journey of around 200 km. The length of this journey would be significantly greater than the distance traveled by most populations of harbor seals in Alaska, and is greater than the distance between the lakes occupied by Canada's Lac de Loups seal and Hudson Bay, which is just 160 km (O'Corry-Crowe et al. 2003). Additionally, there are ample fish in the lake to sustain a year-round population of seals, and no reason for the seals to leave in the winter to search for food (Fall et al. 2004, Rich et al. 2009).

b. Genetic factors

Although there is very limited genetic data on Iliamna Lake seals (one genetic sample tested as of spring 2012), the best available science indicates that Iliamna Lake seals are reproductively isolated due to behavioral and geographical separation factors, and therefore likely to be genetically distinct (Burns et al. 2011, Withrow and Yano 2011, Van Lanen 2012). This is because there is no evidence that Iliamna Lake seals travel in or out of the lake (Pebble Partnership 2008, Burns et al. 2011, Withrow and Yano 2011, Van Lanen 2012, Van Lanen et al. 2012a). Therefore, Iliamna Lake seals have a high degree of reproductive isolation from other North Pacific harbor seal populations with no interbreeding among the populations.

c. Morphological factors

As of this writing, there have been no skull or morphological measurements at a scientifically rigorous level that could be used to distinguish Iliamna Lake seals from harbor seals (Burns et al. 2011). However, LTK reports are that the Iliamna Lake seals are bigger, darker in color, have a unique fur pattern, and have a more oily pelt than saltwater seals (Burns et al. 2011; Fall et al.

2006). Similar descriptions of outward appearance were used to differentiate Lac de Loups seals (*Phoca vitulina mellonae*) as a subspecies of harbor seal. The freshwater population of Lac de Loups harbor seal is distinct from saltwater populations based on both morphological and behavioral characteristics, including "an enlarged coronoid process on the mandible" and an "unusually dark pelage"(Smith et al. 1994). Although the initial determination of subspecies status of this Canadian freshwater seal population was based on anecdotal observations of morphological differences, more recent movement tracking indicate that subspecies status is correct, and the species is considered endangered by the Committee on the Status of Endangered Wildlife in Canada (Smith et al. 2006). Similarly, observations of unique morphological characteristics support DPS status for the Iliamna Lake seal.

d. Ecological Factors

Iliamna Lake seals not only inhabit a unique ecological setting in a freshwater lake, but are also distinct in their feeding ecology. Adult salmon dominate the diets of Iliamna Lake seals during the summer months, while salmonids typically comprise less than 10 percent of a seal's diet in marine environments (Hauser et al. 2008). Saltwater seals may be intermittently present in freshwater systems, often following runs of anadromous fish, especially salmon, but Iliamna Lake seals are unique in that the entire population utilizes only the lake area year-round and depends solely on prey present in freshwater for feeding (Middlemas et al. 2006). Iliamna Lake is also singular in that is has ample fish available year-round, is exceptionally large and deep, and is very little known, with uncertainties persisting about dynamics of fish populations and other creatures that may live in the lake (Van Lanen 2012).

e. Behavioral Factors

Iliamna Lake seals are behaviorally unique. During LTK surveys, subsistence hunters told Withrow (2011) that everything happens one month later in the lake. Indeed, this has been corroborated by aerial surveys that indicate that Iliamna Lake seals reproduce (pup) about one month later than the closest population of saltwater seals in Bristol Bay (Burns 2002, Withrow and Yano 2011).

Winter use habitat may also be unique to this lake seal population. While aerial surveys fail to observe nearly as many seals in Iliamna Lake in the winter as in the summer, researchers believe this could be due the seal's use of protected haul-out sites or common-use ice caverns unknown to science (Van Lanen 2012). LTK reports support this hypothesis. If so, use of this important winter habitat may be a learned behavior, unique to Iliamna Lake seals, that is critical to the seals' survival.

B. Significance

According to the 1996 DPS policy, once a population is established as discrete, its biological and ecological significance should then be considered (61 FR 4722). This consideration may include, but is not limited to, the following:

> (1) Persistence of the discrete population segment in an ecological setting unusual or unique to this taxon.
>
> (2) Evidence that loss of the discrete population would result in a significant gap in the range of a taxon.
>
> (3) Evidence that the discrete population segment represents the only surviving natural occurrence of a taxon that may be more abundant elsewhere as an introduced population outside its historical range.
>
> (4) Evidence that the discrete population segment differs markedly from other populations of the species in its genetic characteristics. ((61 FR 4725).

The Iliamna Lake seal meets at least two of the "significance" criteria, as well as other criteria that highlight the significance of this population, as detailed below.

i. The Iliamna Lake seal occupies a unique ecological setting

As noted above, the Iliamna Lake seal is a discrete population. It also occupies a unique ecological setting as one of only two populations of resident lake seals in North America, is the only freshwater population of the Pacific harbor seal, and the only population of freshwater seals in the United States (Smith et al. 2006).

The seals also occupy a unique ecosystem that supports the most prolific salmon runs in the world, meaning that, compared to saltwater seals, the seals have an ample food supply that is easily accessible and readily available year-round. Compared to saltwater seals of Bristol Bay, Iliamna Lake seals have a diet exceptionally high in salmon for about three months of the year, while juvenile salmon and other freshwater fish are consumed when salmon are not actively spawning (Hauser et al. 2008, Burns et al. 2011). Iliamna Lake seals are specially adapted to this ecological setting, which may also allow them to genetically maintain a larger size, due to high availability of food resources.

ii. The loss of the Iliamna Lake seal would result in a gap in the species' range

A loss of Iliamna Lake seals would create a significant gap in the range of the taxon as it would eliminate the only population of harbor seals in the U.S. known to live exclusively in an inland lake environment (Burns et al. 2011, Van Lanen 2012). Iliamna Lake seals are also an important subsistence resource to villagers (Burns et al. 2012a). If the Iliamna Lake seal were to go extinct, the loss of the seals would create a distinct gap in the range of the taxon (Pacific harbor seal). There is no evidence showing that migration from other saltwater harbor seal populations into Iliamna Lake would be successful. Even if such migration were possible, because of the differences in reproductive timing, and because locations for successful winter use areas may be a learned behavior, it is likely that migratory saltwater seals' attempts to occupy this habitat would fail (Withrow and Yano 2011, Van Lanen 2012).

iii. Iliamna Lake seals differ markedly from saltwater seal populations

As noted above, the Iliamna Lake seals are markedly different from saltwater seals in behavior, morphology, ecology and range. Behavioral and morphological evidence suggests that Iliamna Lake seals and saltwater populations of harbor seals do not interbreed and that interactions with saltwater populations are rare if they occur at all (Burns et al. 2011, Withrow and Yano 2011, Van Lanen et al. 2012a). Iliamna Lake seals also are described as having unique morphology, including large body size, distinct coat patterns, and darker coloration (Withrow and Yano 2011). This implies that there is genetic differentiation between Iliamna Lake seals and saltwater harbor seal populations, despite the lack of reliable genetic data that could be used to provide DNA evidence (Smith et al. 1994, Burns et al. 2011, Van Lanen et al. 2012a). In addition to reproductive separation, Iliamna Lake seals have unique ecology, behavior and range, as detailed above.

Genetic differentiation should not be considered independent of ecological, geographical and other life history differences (Haig 1998), and some traits reflected in behavioral and morphological differences may be detected or evolve prior to genetic variation (Fallon 2007). Therefore, genetic and/or blubber fatty acid profile analyses are not necessary for determining that this DPS of harbor seals is significant (Fallon 2007). For an ESA listing decision, other types of data including geographic, ecological and morphological data must be considered.

Fatty acid compositional analysis of Iliamna Lake seal blubber could further corroborate Iliamna Lake seals as a DPS of harbor seals (Smith et al. 1996). LTK descriptions of Iliamna Lake seals as “fatter” than saltwater seals may be due, in part, to compositional differences in the blubber layers. Blubber depth and composition is determined, at least in part, by diet composition, and has been used to differentiate marine and freshwater populations of seals (Smith et al. 1996, Strandberg et al. 2011). Iliamna Lake seals may also be better fed, with more easily caught, energy rich, and abundant prey than populations of saltwater seals (Hauser et al. 2008). Iliamna Lake seals maintain superb body condition year-round by gorging on the millions of salmon that enter the lake to spawn during the energetically costly summer months, and into the fall, and because there is a high availability of other species, among them young and adult salmonids (char, trout, salmon), whitefish, and stickleback (Hauser et al. 2008, Howard 2009). Therefore, this observation of outward appearance may reflect further physiological differences of this unique population of freshwater seals.

PART III. THE ILIAMNA LAKE SEAL QUALIFIES AS THREATENED OR ENDANGERED UNDER THE ESA

The persistence of the Iliamna Lake seal is tightly linked to the abundant summer and fall salmon runs and presence of juvenile salmon in the lake year round. The salmon face severe threats from climate change and ocean acidification and from Pebble Project development. The seals are also directly threatened by disturbance from increased human activity, including plane, boat and motor vehicle traffic that would result from the Pebble Project. The Pebble Project would also degrade both terrestrial and aquatic habitat used by the seals. Changes in ice extent, water level, and precipitation patterns from climate change may also alter winter-use habitat for the seals.

1. THE PRESENT OR THREATENED DESTRUCTION, MODIFICATION, OR CURTAILMENT OF THEIR HABITAT OR RANGE

A. The Pebble Project

The Pebble Project is a massive open pit mining operation proposed by developers collectively known as the Pebble Limited Partnership (PLP). The Pebble Project would extract deposits of gold, copper, and molybdenum from a wild area north of Iliamna Lake (see Figure 16), and would straddle the headwaters of the Kvichak and Nushagak Rivers. If built, the Pebble Project would be among the largest open pit mining operations in the world, with a 4.1 billion metric ton open pit and a 3.4 billion metric ton subservice mine (Northern Dynasty Minerals Ltd 2011). A proposed 225-km access road and transport corridor would run from the mine site to a port at Cook Inlet. The road would parallel the north shore of Iliamna Lake for 80 to 96 km until reaching steeper hillsides near the village of Pedro Bay. The access road then would cross the Chignit Mountains of the Aleutian Range to a port site on Cook Inlet (Northern Dynasty Minerals Ltd 2011). The road corridor would also contain the ore slurry pipeline, a pipeline to return recycled water to the mine site, and an electric power transmission line. The lifespan of the Pebble Project is proposed at 40 to 50 years, but even post operations, the mine would leave permanent landscape features affecting some thirty square miles. These include two tailings ponds that would house billions of tons of toxic mine tailings. The entire Bristol Bay ecosystem, and especially the Kvichak River watershed, would be adversely affected by construction and operation of the Pebble Project mine and infrastructure (EPA 2012).

Figure 15: Location of proposed Pebble mine and transportation corridors with proposed port site 1. Known seal haul outs are located on islands and sandbars near Pedro Bay, Newhalen, and Iliamna. (Northern Dynasty Minerals Ltd 2011).

The location of the proposed Pebble Mine area is about 40 km (17 miles) northwest from major Iliamna Lake seal haul outs on the Seal/Flat Island group southwest of Pedro Bay and Thompson Island group north of Kokhanok. Many important salmon streams flow into Iliamna Lake from the Pebble Mine area and the mine would impact major spawning sites used by the salmon on which Iliamna Lake seals feed, along with direct degradation of water quality and habitat (Pebble Partnership 2011, EPA 2012). If the proposed Pebble Project goes forward, construction and operations of the mine site and transportation infrastructure for the mine would have major and population-level impacts on Iliamna Lake seal. These impacts include (1) major adverse impacts to quality and quantity of anadromous and freshwater fish in the lake; (2) severe and long-term impacts on habitat quality especially water quality; (3) toxic effects resulting in direct mortality and decreased survival and reproductive rates from mine contaminants; (4) increased pressure and competition for fish and wildlife resources because of increased human access to the area; and (5) increased stress levels and disturbance from higher human activity and industrial activity levels in the area, especially low-flying aircraft. These impacts would substantially increase in level and duration by accidents or failures of the Pebble Project. There are multiple sites in the Nushagak and Kvichak River watershed being considered for long-term mining development. Risks of mining development on salmon and other fish populations would increase as a result of cumulative impacts of multiple mines (EPA 2012). Failures or accidents have never been avoided at any other open pit mines of similar size throughout the world and are thus almost guaranteed to occur at Pebble Project (Hauser 2007, EPA 2012).

i. The Pebble Project would have major adverse impacts on freshwater and anadromous fish in the Bristol Bay watershed and on Iliamna Lake seals.

The EPA's evaluation of potential impacts of the Pebble Project on natural and anthropogenic resources in the Bristol Bay watershed concluded that, at a minimum, an open pit mine and the 139-km transportation corridor would cause the loss of spawning and rearing habitat for multiple species of anadromous and resident fish in the Nushagak River and Kvichak River watershed (EPA 2012). Iliamna Lake is a key component of the impacted watershed area, and many of the affected waterways flow into Iliamna Lake on their way to the Kvichak River.

According to the EPA, a mine footprint would result in direct loss of 87.5 km to 141.5 km of streams and 10.2 to 1.3 square km of wetlands (EPA 2012). Water withdrawals for mine operations would significantly diminish habitat quality in an additional 2 to10 km of streams (EPA 2012). Siltation caused by road-building activities would smother organisms eaten by fish, and also smother incubating eggs and fish hatchlings (EPA 2012). The access road would affect an estimated 32 square meters, crossing at least 100 streams and waterways including the Newhalen River, a critical route for spawning salmon. Culverts are known to become barriers to adult or juvenile fish, and would also be a barrier to Iliamna Lake seals travelling up streams or up the Newhalen River to hunt for fish (Hauser 2007).

Iliamna Lake seals, as well as brown bears, wolves and bald eagles, depend on salmon for a large fraction of their summer diets (Hauser 2007, EPA 2012). Anadromous salmon are considered a keystone species because the entire freshwater ecosystem depends on the marine-derived nutrients that are released from carcasses of spawned-out salmon (Hauser 2007). The decomposing carcasses of salmon raise the productivity of the entire freshwater ecosystem, providing essential nutrients (Hauser 2007, EPA 2012). Non-anadromous, freshwater species of fish also depend on this increase in primary productivity from salmon-derived nutrients, and are a key prey item for Iliamna Lake seal year round, and are important to the winter feeding ecology of the Iliamna Lake seals (Hauser et al. 2008). Decreases or losses in quality or quantity of salmonids and freshwater fish in the lake would lead to reduced body condition and possibly precipitous population declines of Iliamna Lake seal. A loss of productive salmon runs would also impact ecosystem dynamics of the wildlife in the area, increasing predation risk for the lake seals by both brown bears and eagles, species that are otherwise highly dependent on salmon runs. Increased mortality would be an especially serious concern because the Iliamna Lake seal is a species already at risk of extinction from climate change, ocean acidification and from stochastic influences, due to low population size (Canadian Science Advisory Secretariat 2008, Hutchings et al. 2012).

ii. The Pebble Mine would have severe and long-term impacts on habitat quality

Multiple unavoidable and/or highly likely impacts from the Pebble Project threaten the habitat and consequent viability of the Iliamna Lake seal. Sedimentation, changes in water levels in the lake, toxic effluents and mine failure or accidents would cause severe degradation of habitat quality for Iliamna Lake seals and salmon (EPA 2012). Siltation of the lake from construction and use of the road is inevitable, and road traffic, erosion, and dust production will degrade water quality and reduce primary production of organisms consumed by fish and survival of fish eggs (EPA 2012). Erosion and siltation would be greatest during road construction. This would result in lower reproductive rates for salmon, reductions in numbers of freshwater fish in the lake, and reduced water quality, impacts that would travel up the food chain to Iliamna Lake seal (Fall et al. 2006, Hauser 2007).

Degradation of water quality, including increased turbidity, would limit salmonid use of clear-water spawning habitat near islands in the eastern part of the lake and near stream outlets. This would in turn limit the availability of fishing habitat for Iliamna Lake seals (Hauser et al. 2008). The seals' haul-out sites year round could also be limited, especially if road construction, changes in drainage and landscape-level impacts result in alteration of preferred winter habitat or haul-out sites. The ice caves that may be utilized by Iliamna Lake seals for shelter and resting during the winter months would be especially vulnerable to alterations from Pebble Project especially if the timing of water level drops shift, so that drops in water level over the winter do not occur, or solid ice formation fails to take place, or there is a variation in timing of ice formation. Loss of this critical winter haul-out habitat would likely threaten the continued viability of the Iliamna Lake seal population.

iii. Toxic effects

Seals are sensitive to environmental toxins which cause increased mortality, immunotoxicity, and decreased reproductive success (Harding 2000, Baird 2001). Toxic chemicals leached from the Pebble Project could directly impact the seals' survival through poisoning, and would also adversely impact salmon and fish populations in the lake, which would impact nutritional status and survival rates of the seals (EPA 2012). In subsistence surveys, the possibility of Pebble Project development has led residents to bring up concerns about contamination of the Kvichak River system fish species, and contamination of the Iliamna Lake seal population (Fall et al. 2006).

Leakage of copper is inevitable at a porphyry copper mine like Pebble (Saunders and Sprague 1967, EPA 2012). Because copper does not biomagnify, copper-contaminated fish are not considered a significant risk to wildlife consuming them. However, copper pollution could have major impacts on the ability of salmon to successfully spawn by affecting the salmon's sense of smell and navigation (Hansen et al. 1999, Baldwin et al. 2003, EPA 2012). Salmon that are unable to smell would be vulnerable to predation and also would not be able to find their way back to their natal stream for spawning (Hansen et al. 1999). Additionally, even trace amounts of copper in a creek could cause salmon with intact senses of smell to refuse to travel up river to spawn even if the salmon can find their natal stream (Saunders and Sprague 1967, Hansen et al. 1999). This would reduce spawning salmon numbers in the Iliamna Lake system and could ultimately result in the loss of entire salmon runs.

iv. Impacts of accidents and failures of the Pebble Project

Metallic sulfide mines have a poor environmental record especially where the ore body is at groundwater, as the Pebble deposit. Maest et al's (2006) study of recently permitted mines in the U.S. found that sulfide mines are very likely to develop pollution problems. Mines involving metallic sulfides have such a high risk that water quality exceedences are almost certain to occur for acid drainage and contaminant leaching. This analysis found that 85% of sulfide based mines polluted surface water, and 93% of sulfide mines polluted ground water. Significantly, the environmental documents for 89% of the sulfide mines that developed acid mine drainage did not predict that this would occur (Maest et al. 2006).

Any accidents or failures of Pebble Mine operations would greatly increase impacts on the salmon ecosystem and hence on Iliamna Lake seals. The EPA (2012) reports that, "accidents, process failures, and infrastructure failures could increase the spatial scale and severity of mining impacts on fish populations," (EPA 2012). Accidents include (1) the release of acid, metal, or other contaminants from the mine site, waste rock piles, and tailing storage facilities; (2) the failure of roads, culverts, and pipelines in the transportation corridor, including spills of copper concentrate; and (3) the catastrophic failure of the tailings dam. Evidence from other long-term mines of similar design and scope suggest that one of more of these accidents or failures are likely to occur, and would result in immediate, severe, and long-term impacts on salmon and salmon habitat and production (EPA 2012).

A tailings dam failure would result in billions of tons of mining waste, including potentially toxic materials, washing downstream. Water quality would be destroyed and fish populations in the Kvichak and Nushagak Rivers would suffer massive casualties, resulting in tainting of all or much of Bristol Bay salmon production (Hauser 2007). This would have major impacts on Iliamna Lake seals, resulting in high levels of direct mortality through toxic effects, decreased reproductive success, and suppression of the immune system resulting in increased disease risk.

Tainted salmon would also suffer high mortality rates, which would influence the amount of prey available to Iliamna Lake seals.

According to the EPA, accidents and failures of some kind at some point in the Pebble Mine operations, or post operations, are almost guaranteed. Location in an active seismic zone further increases this risk. Because they are highly dependent on habitat that would be directly impacted by any accident or failure, the population viability of Iliamna Lake seals would be at risk in the event of a major accident or failure. This is because (1) they are highly dependent on fish species that would be directly impacted by this event, (2) they are limited in population size and in ability to adapt or survive any major mortality events or changes to the ecosystem.

v. The Pebble Project would result in disturbance responses and increased stress for seals due to increased human use of the area

a. Types of disturbance associated with the Pebble Project

Activities associated with the Pebble Project would be concentrated primarily in the eastern half of Lake Iliamna, near the landing strip between Iliamna and Newhalen, and on the proposed transportation route that passes next to the eastern half of the lake (Figure 17; Northern Dynasty Minerals Ltd 2011). This area is the preferred hauling out, feeding, and winter use habitat of the Iliamna Lake seal (Small 1999, Pebble Project, Northern Dynasty Mines 2007, Pebble Partnership 2008).

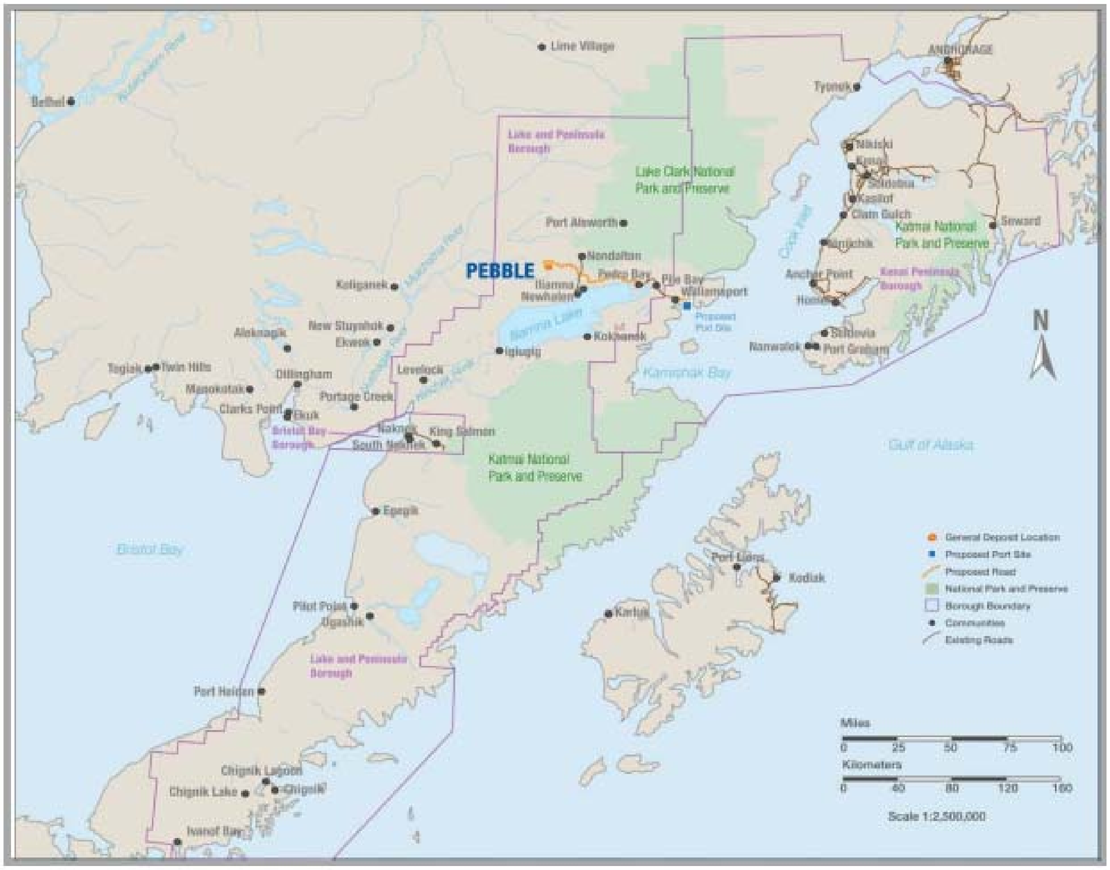

Figure 16: Pebble Project Location with proposed road and Iliamna lakeshore villages of Pedro Bay, Iliamna, Newhalen, Kokhanok, and Igiugig. (Northern Dynasty Minerals Ltd 2011).

During Pebble Project construction, the population of just 1,500 people in the Lake and Peninsula Borough would more than double. Northern Dynasty Minerals (2011) states that construction of the Pebble mine would take 4 years, with a peak labor force of 2,080 (Northern Dynasty Minerals Ltd 2011). Total workforce for mine operations is projected at 1,120 over the initial 25-year life of the mine. This influx of workers will result in direct disturbance of the seals through human presence and also through the construction, transportation, and other activities associated with the Pebble Project.

Impacts to the Iliamna Lake seal may already be occurring. The route that contractors and employees follow to access the Pebble Project site, via airplane and then helicopter (Northern Dynasty Minerals Ltd 2011), passes directly over known haul-out locations for Iliamna Lake seals in the eastern part of the lake. As planes start a descent for landing in the village of Iliamna, the path of flight passes directly over the two most heavily used haul-out sites for seals and also passes over known foraging grounds for seals at the outlets for the Newhalen River and other streams used by spawning salmon (Hauser et al. 2008). Helicopters travelling the 17 miles (27 km) from Iliamna to the Pebble Project mine site would also potentially pass over or near seals hauled out or foraging near the village of Iliamna.

Barge services are available via the Kvichak River (Alaska Community Database 2012), and may be utilized by workers for the Pebble Project, increasing disturbances and stress from boating activities on Iliamna Lake seals..

There are no reports that Pebble Partnership aerial surveys for Iliamna Lake seals disturbed the animals, but stress behaviors would be difficult to observe in the absence of behavioral or physiological studies. Surveys are also greatly limited by occurring at a height from which behavioral observations are difficult, if not impossible. Aerial surveys conducted by ABR for Pebble Partnership were flown at 245 to 305 m (weather permitting), and circled back to recount or photograph the seals, increasing the disturbance pressure on the animals. While PLP baseline studies report the flight path as being high enough not to disturb seals (Pebble Project, Northern Dynasty Mines 2007) significant impacts are still possible. Aircraft flying at less than 1,000 m have the potential to disturb hauled-out seals, with even more impacts expected if aircraft fly at less than 500 m (Tyack 2008). Aircraft disturbance is especially stressful during the molt or pupping season, which is when the majority of ABR surveys for the Pebble Project baseline studies were conducted. As noted by the Marine Mammal Commission (MMC) in 2009 comments on a research permit, the number of overflights for such research could lead to "excessive disturbance" (Adams 2009). Of course, any disturbance to the seals from research would be dwarfed by that accompanying development of the Pebble Project itself.

If the Pebble Project moves forward and an access road is constructed, the road would greatly increase land-based disturbances for hauled-out seals. Impacts include anthropogenic noise disturbance of traffic and construction, especially from the large haul vehicles that would regularly travel the access road. There would also be increases in direct disturbance from humans accessing the lakeshore, increased boating activity by industrial and recreational users, increased air traffic into the village of Iliamna, and higher levels of light disturbance especially during the normally dark winters. The access road may also result in increased residential human population in the area. This may lead to increased hunting or poaching of seals, and to increased competition for seals with human fishermen for salmon. Additionally, off-road and all terrain vehicle use in the area near the road would expand. ATVs and other loud motor vehicles travelling at fast rates of speed may be especially disturbing to seals.

b. Impacts of Pebble Project disturbance on Iliamna Lake seals

Activities associated with even short-term industrial activities and human disturbance may have dramatic population-level impacts on harbor seals, even when they may occur over 1 km away from seal haul-out or use areas (Seuront and Prinzivalli 2005). Human disturbances have resulted in population-level impacts for harbor seal populations in Alaska and other areas. In Prince William Sound and the Gulf of Alaska, harbor seals have declined by as much as 80 percent over recent decades, a decline partly attributed to human activities and disturbance (*Exxon Valdez* Oil Spill Trustee Council 2001; National Marine Fisheries Service and Alaska Department of Fish and Game 2000; Alaska Department of Fish and Game 2000a). Compared to other seal species, Iliamna Lake seals may be especially vulnerable to disturbance because of their relatively small size, restricted range and site fidelity. Iliamna Lake seals are also accustomed to very little human interference or anthropogenic noise, and may not easily habituate to human activity.

Exposure to Pebble Project activities may also have sublethal impacts or impacts that would be harder to quantify. As a result of exposure to disturbance, the seals may shift habitat use, increase energy expenditure due to the stress associated with alert and flight behaviors, and abandon ideal haul-out and hunting spots (Suryan and Harvey 1999, Seuront and Prinzivalli 2005, Becker et al. 2009, Hoover-Miller et al. 2011, London et al. 2012, Andersen et al. 2012, Valtonen et al. 2012). Increased mortality and reduced reproductive success are possible, although this is difficult to quantify.

Studies have found that seals are sensitive to disturbance by boats, aircraft, motor vehicles, or human presence. The degree of habituation or sensitization to disturbance varies based on population, ecology, and resource availability at a site. Some seals abandon a disturbed haul-out site completely, others reduce overall use of a site, or switch to nocturnal use of a site subject to high level of diurnal disturbances (Grigg et al. 2012). Seals forced to rely on areas subject to high level of human disturbances may suffer physiological costs, including higher stress levels resulting in poor body condition, although these are difficult to quantify based on behavioral observations alone (Becker et al. 2009). Harbor seals rarely haul-out in areas with constant disturbance, and may abandon areas subject to disturbance (Newby 1973, Henry and Hammill 2001). Harbor seals appear to respond most strongly to noisy disturbances, fast-moving and directly approaching disturbances, and those that approach via their water escape routes (Harvell 1999, Andersen et al. 2012). Proximity of the disturbance is also important, and human activities closer than 100 m almost always cause seals to abandon haul-out sites, while those at a distance greater than 800 m may have no or little impact on seals (Andersen et al. 2012).

Mother-pup pairs are most vulnerable to disturbance, especially if a disturbance results in reduced nursing time or abandonment of the pup (Moss 1992). During the birth and suckling periods, females with pups are nervous and constantly on the alert. At a sign of danger, the mother, usually followed by her pup, will abandon a haul out site and flee into the water. Disturbances can also lead to panic-driven rushes to the water by all mothers and pups at a haul-out site. During this stressful event, mothers and pups may become separated, and a permanently separated pup will starve (Osinga et al. 2012). Reduced nursing time due to disturbance could reduce pup survival rates. This means that recurring disturbances during the breeding season may result in an increased negative energy burden on the seals, and hence have a considerable negative impact on breeding success (Henry and Hammill 2001, Andersen et al. 2012).

Barge traffic associated with mine development and operation could affect seals hauled out on Iliamna Lake. During the pupping season, and when there are small pups in the lake, local residents have historically avoided areas where seals are feeding, such as the mouth of the Iliamna and Newhalen River (Fall et al. 2006). This is because residents believe that barge or boat traffic near hauled out seals affects pupping success through disturbing the seals and decreasing survival of the young (Fall et al. 2006). Any increase in boat traffic near sites used by seals could adversely affect the Iliamna Lake seals, especially during salmon runs and the pupping season.

Iliamna Lake seals might respond with flight and/or alert behaviors to aircraft flying at or below approximately 1,000 m altitude, especially helicopters. In studies, aircraft appear to disturb seals more by the sound they produce than by the visual (Pitcher and Calkins 1976, Osinga et al. 2012). Born et al. (1999) found that fixed-wing aircraft are less disturbing to hauled out ringed seals than helicopters, and that disturbance could be reduced if helicopters approached no closer than 1,500 m and small fixed wing planes no closer than 500 m (Born et al. 1999). Iliamna Lake seals at foraging sites near the village of Iliamna where helicopters take off and land may be especially impacted (Northern Dynasty Minerals Ltd 2011). Helicopters likely pass directly over or very close to important foraging sites enroute to the Pebble Project area. Frost et al. (1993) found that spotted seals responded to an approaching aircraft at a distance of over 1 km, even when the plane's flying altitude was 760 m (Frost et al. 1993). Thus, increased air traffic of any kind, especially larger jets used for transporting personnel associated with Pebble Project to and from the proposed larger airstrip that would be constructed near the village of Iliamna would likely significantly disturb the seals.

As detailed, the many types of both long and short-term anthropogenic and industrial disturbances from Pebble Mine could have population-level impacts on the Iliamna Lake seals (Powles et al. 2000). Disturbance of Iliamna Lake seal would especially impact vulnerable age categories, including unweaned pups and juveniles during their first year of life. Disturbance could also result in changes in habitat use, with seals abandoning or decreasing use of the most productive foraging sites at the eastern end of the lake and near the outlet to the Newhalen River because they occur in areas that will be heavily impacted by human activity.

c. Anthropogenic noise disturbance

Construction and operation of the Pebble Mine would result a significant increase in anthropogenic noise in and around Iliamna Lake (Michael Minor & Associates 2008). Anthropogenic sounds would include (1) aircraft, both helicopter and fixed-wing, (2) motor vehicles including haul trucks and boat traffic (2) construction related activities, especially those from road construction which would occur near Iliamna Lake seal haul out and foraging sites in the eastern part of the lake, (3) human vocalizations from people on the road and visitors to the lakeshore from the road, and (4) low frequency sounds from mining activities. According to the Pebble Project documents, noise levels for the area of Williamsport, Iliamna and Iniskin bays are predicted to range from 30 dBA to over 60 dBA (Michael Minor & Associates 2008). The report states that the haul vehicles would be a major noise source in the area during summer, with a typical noise level range from 86 to 90 dBA at 50 ft from the source of the noise (Michael Minor & Associates 2008).

Studies on marine mammals show that anthropogenic noise can cause a variety of impacts. These include (1) change in behavior, such as cessation of feeding or mating, increased vigilance, escape or avoidance behavior (Myrberg 1990); (2) changes in movement patterns where animals temporarily or permanently leave an area as found in studies on harbor seals (Henry and Hammill 2001); (3) masking of important sounds, affecting navigation and predator-prey interactions (Petel et al. 2006); (4) temporary or permanent hearing loss; and/or (5) physical injury or death (Tyack 2008).

Increased levels of anthropogenic noise from Pebble Project development could result in negative population-level effects due to any of the above-detailed impacts. Impacts would be greatest in areas where human use and preferred seal habitat overlap such as at salmon spawning areas at the outlets of the Iliamna and Newhalen Rivers, or at haul-outs near the villages of Iliamna and Newhalen. As with disturbance, noise associated with Pebble Project development could also limit, reduce, or extinguish the seal's use of certain habitats.

vi. Other habitat changes

The Iliamna Lake area currently has very little human influence, but this is likely to change if Pebble Project opens up access routes to the area. If the Pebble Project proceeds, the addition of a road route from a port on the shores of Cook Inlet to the Pebble Mine site could significantly increase the amount of human influence in the area, along with increased land development and human activities. This may degrade habitat currently used by seals, due to either disturbance or landscape impacts, such as increased boat traffic on the lake and turbidity in preferred forage sites (Henry and Hammill 2001). The introduction of domestic dogs, or increase in scavenger species like coyotes and even black and brown bears that are associated with human populations, could also impact seals at haul-out sites. These impacts could drive the seals to a different, less productive part of the lake and/or decrease survival and reproduction rates.

vii. Conclusion

While its small and isolated population render the Iliamna Lake seal inherently vulnerable and hence of great conservation concern, the numerous and severe impact to the seal, its habitat and its food source from the construction and operations of the Pebble Project are of sufficient magnitude to threaten the continued existence of the this unique animal. Consequently, even absent the significant impacts of climate change and ocean acidification described below, the Lake Iliamna seal qualifies for listing under the ESA.

B. Climate Change

Anthropogenic climate change poses a long-term threat to the Iliamna Lake seal through impacts to the ecologically important salmon that comprise the seals' primary food source and by degrading the seal's foraging and resting habitat including essential haul-out areas.

A loss or major reduction in salmon runs will be one of the most significant impacts of climate change to Iliamna Lake seals and to the entire Bristol Bay ecosystem. Climate change is likely to cause significant changes in the fish population of Iliamna Lake, especially anadromous salmonids (Rich et al. 2009, Aicher 2012) and studies have found that population fluctuations of Pacific salmon are highly correlated with changes in climate regimes (Rich et al. 2009). Salmonids are a key prey source for Iliamna Lake seal and, through an input of marine-derived nutrients, determine the productivity of the entire lake area (Cederholm et al. 1991). A loss of this critical resource and depletion and a resulting loss of lower trophic levels, would in turn impact both freshwater and anadromous fish in Iliamna Lake through decreased availability of primary nutrients. This would have major population-level impacts on the Iliamna Lake seals.

The sections below summarize the best-available science on anthropogenic greenhouse gas emissions including (i) the international scientific consensus on climate change, (ii) current and future impacts of rising greenhouse gas emissions, (iii) faster warming in Alaska compared to the global average, (iv) impacts of climate change on the Iliamna Lake region, (v) impacts of climate change on Iliamna Lake salmon, (vi) impacts of ocean acidification on Iliamna Lake salmon, and (vii) impacts of greenhouse gas emissions on the Iliamna Lake seal. As described in Part III, section A of this petition, existing regulatory mechanisms are inadequate to address threats from anthropogenic greenhouse gas emissions.

i. The international scientific consensus on climate change

There is a strong, international scientific consensus that climate change is occurring, is primarily human-induced, and threatens human society and natural systems. The Intergovernmental Panel on Climate Change (IPCC) in its 2007 Fourth Assessment Report 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 2011) The IPCC concluded that most of the recent warming observed has been caused by human activities (IPCC 2007). In the United States, the U.S. Global Change Research Program in its 2009 report *Climate Change Impacts in the United States* stated that "global warming is unequivocal and primarily human-induced" and "widespread climate-related impacts are occurring now and are expected to increase," and the U.S. National Research Council concluded that "[c]limate change is occurring, is caused largely by human activities, and poses significant risks for—and in many cases is already affecting—a broad range of human and natural systems"(NRC 2010). Based on observed and expected harms from climate change, in 2009 the U.S. Environmental Protection Agency concluded that greenhouse gas pollution endangers the health and welfare of current and future generations (Federal Register 74: 66496-66546).

ii. Greenhouse gas emissions are resulting in severe climate change impacts which will worsen as emissions rise

Current atmospheric concentrations of greenhouse gases are already resulting in severe and significant climate change impacts that are projected to worsen as emissions rise (USGCRP 2009a). Key changes include warming temperatures, the increasing frequency of extreme weather events, rapidly melting glaciers, ice sheets, and sea ice, rising sea levels, and a thirty percent increase in surface ocean acidity (USGCRP 2009a). Many climate change risks are substantially greater than assessed by the IPCC in 2007 (Smith et al. 2009, Fussel 2009), and the rates of many negative changes are tracking the worst case scenarios projected by the IPCC.(Rogers and Laffoley 2011) As summarized by Fussel (2009), "many risks are now assessed as stronger than in the AR4 [IPCC Fourth Assessment Report], including the risk of large sea-level rise already in the current century, the amplification of global warming due to biological and geological carbon-cycle feedbacks, a large magnitude of 'committed warming' currently concealed by a strong aerosol mask, substantial increases in climate variability and extreme weather events, and the risks to marine ecosystems from climate change and ocean acidification" (Fussel 2009).

The average global temperature has warmed by more than 0.8 degrees Celsius (1.4 degrees Fahrenheit) since the industrial revolution, most of which has occurred in the past three decades (IPCC 2007). In the United States, temperatures have warmed by more than 1.1°C (2ºF) over the past 50 years, with the greatest warming in Alaska (USGCRP 2009a). Globally, the decade from 2000 to 2010 was the warmest on record (NASA 2012), and 2005 and 2010 tied for the hottest years on record (NOAA 2012a). By the end of this century, the average temperature in the United States is expected to increase by 2.2 to 3.6°C (4 to 6.5°F) under a lower emissions scenario and by 3.9 to 6.1°C (7 to 11°F) under a higher emissions scenario (USGCRP 2009a).

Extreme weather events are striking with increasing frequency, most notably heat waves and rainfall extremes such as droughts and floods (USGCRP 2009a, IPCC 2012, Coumou and Rahmstorf 2012), with deadly consequences for people and wildlife. In the United States in 2011 alone, a record 14 weather and climate disasters occurred, including droughts, heat waves, and floods, that cost at least $U.S. 1 billion each in damages and loss of human lives (NOAA 2012b, WMO 2012). Summertime heat extremes[1] which covered much less than 1% of Earth's surface during 1951-1980 now cover about 10% of the Earth's land area, and extreme heat anomalies such as the record heat waves that hit Texas and Oklahoma in 2011 can be attributed with a high degree of confidence to global warming (Hansen et al. 2012). Several studies predict that climate change will increase the frequency of high-severity hurricanes in the Atlantic (Elsner et al. 2008, Bender et al. 2010, Kishtawal et al. 2012), which would increase the economic damages by $25 billion by 2100 in the United States alone (Mendelsohn et al. 2012).

The Arctic has experienced some of the most severe and rapid warming associated with climate change, warming at twice the rate of the rest of the globe on average (Trenberth et al. 2007). Arctic summer sea ice extent and thickness have decreased to about half of what they were several decades ago (Stroeve et al. 2008, Kwok and Rothrock 2009), with an accompanying drastic reduction in volume (Schweiger et al. 2012), which is severely jeopardizing ice-dependent animals (Center for Biological Diversity 2012). In September 2012, Arctic summer sea ice extent reached a stunning new record low, falling to half the average size of summer sea ice between 1979 and 2000 (NSIDC 2012). Arctic warming and the loss of sea ice have been linked to the increased frequency of extreme weather events, including droughts, floods, heat waves, and cold spells, in the United States and other mid-latitude regions of the Northern Hemisphere due to disruption of the jet stream (Francis and Vavrus 2012). Glaciers and ice sheets are rapidly melting, threatening water supplies in many regions and raising sea levels (IPCC 2007).

Global average sea level rose by roughly eight inches (20 centimeters) over the past century, and sea level rise is accelerating in pace (USGCRP 2009a). Although the IPCC Fourth Assessment Report projected a global mean sea-level rise in the 21st century of 18 to 59 centimeters (7 to 23 inches), the IPCC acknowledged that this estimate did not represent a "best estimate" or "upper bound" for sea-level rise because it assumed a negligible contribution from the melting of the Greenland and west Antarctic ice sheets (IPCC 2007). Recent studies documenting the accelerating ice discharge from these ice sheets indicate that the IPCC projections are a substantial underestimate (Hansen et al. 2008, Pritchard et al. 2009, Rignot et al. 2011). Studies

[1] Summertime heat extremes are defined as more than three standard deviations (3σ) warmer than the climatology of the 1951–1980 base period.

that have improved upon the IPCC estimates have found that a mean global sea-level rise of at least 1 to 2 meters is highly likely within this century (Rahmstorf et al. 2007, Pfeffer et al. 2008, Vermeer and Rahmstorf 2009, Grinsted et al. 2009, Jevrejeva et al. 2010), and larger rates of 2.4 to 4 meters per century are possible (Milne et al. 2009). Storms and storm surge also will increase in intensity under warming climate conditions (Meehl et al. 2007) and will exacerbate the effects of sea level rise.

iii. Alaska is warming much faster than other regions

Climate change is significantly impacting Alaska. Evidence includes warming sea and land temperatures, changing precipitation patterns, altered stream flows, and a loss of sea ice and coastal erosion (Meehl et al. 2007). Average annual temperatures in Alaska have increased by 1.9 degrees C over the past 50 years, which is almost three times the global average over the same time period (USGCRP 2009b). In winter, the temperatures have increased by 3.5ºC over the same time period (USGCRP 2009b). By the end of this century, the Arctic is expected to warm by an additional 3 to 5ºC over land and up to 7ºC over the oceans under a mid-level (AIB) emissions scenario (Meehl et al. 2007).

iv. Climate change impacts on Iliamna Lake ecosystem

Spring temperatures in the Iliamna Lake region have warmed by about 3.3ºC since 1962, causing a significantly earlier date of ice breakup and warmer spring water temperatures at the lake's outlet (Rich et al. 2009). Warmer temperatures can reduce the duration of ice cover and lengthen the growing season, which has a variety of inter-related effects especially on timing and amount of primary productivity in the lake. Schindler et al. (2005) found that in nearby Lake Aleknagik, Alaska, spring ice breakup occurred 7 days earlier over the years from 1962 – 2002 (Schindler et al. 2005, Rich et al. 2009).

In the Bristol Bay watershed, climate change will continue to increase freshwater and sea surface temperatures and cause earlier spring ice breakup and changes in lake ice extent, increased evaporation, changes in precipitation type and amount, changes in ocean currents, increased glacial retreat and freshwater run-off, and changes in magnitude and timing of water flow (Battin et al. 2007, Rich et al. 2009, Aicher 2012). Climate models predict an average 4.5ºC increase in temperature by the end of the century in the Kvichak watershed (Aicher 2012). Bristol Bay is expected to warm by 4.3ºC by the end of this century, with winter temperatures increasing the most, warming by 6ºC by 2100 (Aicher 2012). Mean precipitation in the Bristol Bay watershed is also project to increase overall, by approximately 240 mm by the end of the century (Aicher 2012). Figure 18 below illustrates the projected seasonal differences in temperatures in the Bristol Bay watershed.

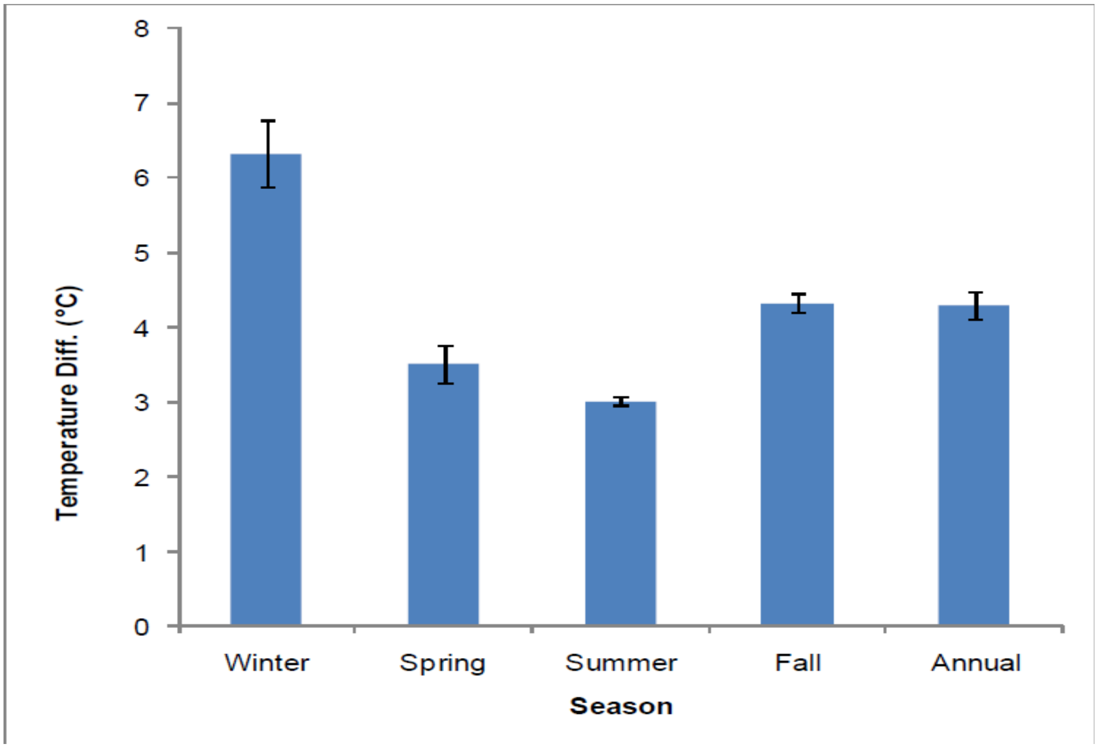

Figure 17: Seasonal and annual temperature differences in Bristol Bay watershed by 2100 (Aicher 2012).

Regional analyses in the Bering Sea have similarly found that surface air and ocean temperatures are rising. 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 increasingly longer warm periods extending from February through November (add citation). In the Bering Sea, average surface air temperatures are predicted to increase by approximately 1ºC to 1.5ºC in the next 10 years to 20 years and by 3ºC to 5ºC by the end of the century (IPCC 2007).

v. Climate change impacts on Iliamna Lake salmon

Climate change resulting from greenhouse gas emissions poses a serious threat to salmon utilizing the Kvichak River watershed and Iliamna Lake, and thus to Iliamna Lake seal that depends on salmon and the productivity they foster in the Iliamna Lake ecosystem. Rapid changes in the production levels of major Alaskan salmon stocks have been connected to climate variability in the North Pacific (Mantua et al. 1997), and climate change could spur rapid and unpredictable declines in Iliamna Lake salmon populations.

Climate change will limit the thermally suitable areas for coldwater-dependent salmon. Thermal habitat in the North Pacific that is suitable for sockeye salmon is predicted to shrink with warming oceans, along with a reduction in prey (Hirons et al. 2001). Higher water temperatures in lake and marine environments are predicted to be harmful to salmon during the spawning, incubation, and rearing stages of their life cycle (Schindler et al. 2005). Warmer temperatures also lead to earlier snowmelt, with a lower percentage of precipitation falling as snow. This could result in elevated peak winter flows, which scour the streambed and destroy salmon eggs. Less snowpack, in turn, results in lower flows in the summer and fall, which reduces the available spawning habitat and further increases water temperatures. Climate change may also alter rainfall patterns, with similar impacts (Battin et al. 2007), as well as changing productivity, predator-prey dynamics, and other processes important for salmon.

In the Bristol Bay watershed, climate change will result in (1) shifts in species ranges, (2) changes in prey availability (timing and abundance), (3) changes in the amount and form of precipitation (snow to rain), (4) increased diseases and parasites, (5) increasing lake stratification, and (6) changes in streamflow (amount and intensity) and thus shifts in seasonal water levels in the lake (Rich et al. 2009), all of which will affect salmon.

Impacts from climate change to salmon include (1) increased water temperature and decreased water flows during salmon migration resulting in pre-spawning mortality, (2) increased water temperatures during egg incubation resulting in a too-early emergence of salmon fry, increasing mortality, (3) increased severity and frequency of winter floods resulting in reduced survival rates of eggs, fry and young juveniles, (4) increased stream and water temperatures resulting in unsuitable spawning and survival conditions for salmon, (5) alterations in timing and volume of stream flow discharges resulting in reduced capacity of streams to support juvenile salmon, (6) altered conditions in Iliamna Lake and Kvichak watershed resulting in the lakes and watershed being less suitable nursery habitat, (7) increased water temperatures that will alter aquatic and marine ecological communities, with adverse impacts on salmon populations, and (8) shifts in the timing of spring freshet and snow melt into rivers and streams, increasing mortality of out-migrating salmon (Hirons et al. 2001, Schindler et al. 2005, Battin et al. 2007).

The marine life phase of anadromous salmon that spawn in Iliamna Lake will also be highly impacted by climate change. There is a complex relationship between increases in sea temperature, climate variability, and salmon abundance response. The early marine period for juvenile salmon has an impact on their overall survival and survival is highly dependent on coastal temperatures. Thus, salmon that spawn in the Iliamna Lake watershed may be significantly impacted by changes in the marine environment, especially increased temperatures, changes in dissolved organic carbon, and ocean acidification.

Salmon numbers are already declining in the Iliamna Lake system. The Iliamna Lake drainage system once supported much larger runs of sockeye salmon (*Oncoryhynchus nerka*) with post-fishery escarpments totalling 2 to 10 million adults per year and abundant runs of all five species of Pacific salmon. Recently, estimates of return have been much lower, and the Kvichak River run of sockeye has been identified as a stock of management concern in Alaska. ADF&G has taken extensive management measures to conserve the stock, but the dynamics of this vitally important salmon population remains little understood, and measures to date have produced no appreciable increase in sockeye numbers (Clark et al. 2006, Fall et al. 2010, Alaska Department of Fish and Game 2012, EPA 2012). Management measures will likely become increasingly ineffective, as climate change is known a driving force behind salmon recruitment and abundance and will place increasing stress on salmon populations.

vi. Ocean acidification impacts on Iliamna Lake salmon

Ocean acidification resulting from anthropogenic greenhouse gas emissions poses a severe threat to salmon populations in the North Pacific and Bering Sea through a variety of processes discussed below. As Iliamna Lake seals and the prey they depend on require the annual input of anadromous salmon for survival, a disruption of the salmon resource during the marine part of their lifecycle may drastically change the lake's ecosystem, and result in population declines or extinction of the Iliamna Lake seal.

Ocean acidification occurs when CO_2 reacts with seawater to generate carbonic acid, which releases hydrogen ions to form bicarbonate and carbonate ions (Wolf-Gladrow et al. 1999, Turley et al. 2007). This increases the concentration of hydrogen ions in seawater and lowers the pH, thus giving rise to the term "ocean acidification." While the uptake of CO_2 by the oceans has buffered the effects of climate change on land, it has resulted in rapid changes in seawater chemistry. The ocean's absorption of anthropogenic CO_2 has already resulted in about a 30 percent increase in the acidity of ocean surface waters. The current rate of ocean acidification is faster than any other changes over the past 300 million years. Ocean acidity is projected to increase by 100 percent to 150 percent by the end of the century if CO_2 emissions continue unabated (Orr et al. 2005, Feely et al. 2009, Hönisch et al. 2012). Anadromous salmonid species are very sensitive to changes in the marine environment (Schindler et al. 2005, Middlemas et al. 2006, Hauser et al. 2008).

Ocean acidification will directly affect the calcifying planktonic organisms which form the basis of the marine food chain and are a food source for both salmon and the prey species salmon consume. For salmon species that spawn in the Iliamna Lake ecosystem, calcifying planktonic organisms (pteropods and foraminifera) likely serve as the critical food source (Schindler et al. 2005, Orr et al. 2005, Hofmann et al. 2010). Researchers have found that calcifying plankton have a reduced ability to form protective $CaCO_3$ shells with changes in ocean chemistry associated with anthropogenic greenhouse gas emissions (Gattuso et al. 1998, Langdon et al. 2000, Riebesell et al. 2000, Feely et al. 2004, Orr et al. 2005, Guinotte et al. 2006).

The aragonite shells of pteropods are particularly sensitive to ocean acidification (Comeau et al. 2009) and aragonite undersaturation in the North Pacific is predicted to become widespread in the next few decades, with many areas undersaturated as soon as 2016 (IPCC 2007, Comeau 2011). As this process occurs, pteropods in parts of the North Pacific may be unable to precipitate aragonite and could suffer drastic declines as early as the second half of this century (Young et al. 2012, Orr et al. 2008, Doney et al. 2009, Comeau et al. 2011). Studies of Antarctic species support these predictions. The shells of actively swimming subarctic pteropods started to dissolve within 48 hours when they were exposed to aragonite undersaturation levels projected for the Southern Ocean surface waters by 2100 (Orr et al. 2005, Fabry et al. 2009).

Calcite-forming foraminifera and coccolithophorids may fare better than pteropods in the short-term, but widespread calcite undersaturation at high latitudes is expected to lag behind aragonite by only 50 years (Orr et al. 2005, Fabry et al. 2009, Feely et al. 2009). Experimental evidence found that calcification rates decreased and malformation increased for coccilophores in waters with dissolved CO_2 levels at or below present concentrations occurring in northern latitude waters (Langer et al. 2006). In laboratory experiments with foraminifera, shell mass decreased as ocean acidification increased, declining by four percent to 18 percent compared to pre-industrial seawater values (Spero et al. 1997, Bijma et al. 1999). Shell weights of Southern Ocean foraminifera are already 30-35% lighter than those from the sediments, which is believed to be induced by acidification (Moy et al. 2009).

As ocean acidification and $CaCO_3$ undersaturation continue to progress in northern latitudes, pteropods will likely be the first calcifying planktonic species to experience widespread mortality, followed by foraminifera and coccolithophorids (Holligan and Roberson 1996, Moy et al. 2009, Comeau et al. 2010). It is unlikely that these critically important species at the base of the marine food web will continue to reach current population levels under conditions that will occur over much of the high-latitude surface ocean during the twenty-first century.

The availability of planktonic species for consumption by salmonid species and their prey as nutrition is critical to the trophic functioning of the Iliamna Lake ecosystem and to the Iliamna Lake seal. Changes in availability of salmonids and freshwater fish due to ocean acidification processes would result in direct mortality and decreased reproductive rates for the seals. A loss or decline in this critical nutritional source may also exacerbate the direct negative effects of climate change and ocean acidification on Iliamna Lake seals.

vii. Impacts on the Iliamna Lake Seal from anthropogenic greenhouse gas emissions

Climate change and ocean acidification resulting from greenhouse gas emissions threaten the Iliamna Lake seal through impacts on salmon and other fish that comprise the seal's primary food and by degrading the seal's foraging and resting habitat.

Iliamna Lake seals time energetically expensive activities including pupping, molting and mating to occur synchronously with periods of high prey availability. This synchronous timing allows for seals to feed on ample, nutritionally dense salmon during these energetically costly periods of their life cycle. In order to accommodate the amount of time it takes for salmon to travel into the lake from Bristol Bay, Iliamna Lake seals pup one month later than saltwater seals (Withrow et al. 2011). The timing of salmon runs may be shifted by climate-change-caused changes in ice break-up, changes in precipitation patterns and other variables (Hodgson et al. 2006). This may lead to lack of synchronicity between prey availability and the seals' pupping, molt, and other energetically costly essential activities. As a result, Iliamna Lake seal's reproductive success would be limited, and overall mortality rates would increase.

As fewer salmon return to the Kvichak River system to spawn, Iliamna Lake seals will suffer bottom-up impacts from a precipitous decline in productivity at lower trophic levels as well, due to a lack of marine-derived nutrients from decomposing salmon. Additionally, year-round populations of freshwater species of lake fish may be reduced, as there will be less primary productivity to provide food for the fish. There will also be fewer juvenile salmon which function both as prey for other fish and prey for Iliamna Lake seals. A side effect of a loss of salmon and other fish in the lake ecosystem could be increased predation on the Iliamna Lake seals by predators including brown bear, eagles, and wolverines. Increased depredation of the lake seal, along with lack of a major food source and overall decline in habitat quality could cumulatively result in the extinction of the seals.

Iliamna Lake seals are also likely to suffer habitat loss and declines due directly to habitat changes wrought by anthropogenic greenhouse gas emissions. Changes in ice cover in the lake could mean that the sheltered ice caves that seals presumably use for haul-out sites in the winter may not form or could collapse on seals. Warmer water temperatures and increased freshwater flows into the lake due to ice and glacial melt could result in widespread areas of overflow and flooding of ice caves. Higher summer temperatures and high run-off rates in summer could flood preferred haul-out sites on islands and exposed rocks, forcing seals to use areas that may be more vulnerable to predators or are not in ideal locations to access salmon or other prey. As habitat quality declines, seals are likely to suffer higher mortality and lower reproductive success.

viii. Conclusion

Anthropogenic greenhouse gas emissions threaten Iliamna Lake seals and the salmonid and freshwater fish species they feed upon throughout the year (Middlemas et al. 2006). If the number of salmon returning to the lake to spawn were significantly decreased or ceased to occur, Iliamna Lake seal would likely suffer nutritional deficiencies, along with other ecosystem-wide changes such as increased predation and decreased primary production. Climate change will also severely degrade habitat quality for Iliamna Lake seals through changes in ice extent and cover, which may impact winter-use areas.

2. DISEASE OR PREDATION

A. Disease

Iliamna Lake seals are vulnerable to mortality from a variety of diseases introduced by wild or domestic canids in the Iliamna Lake area (Barrett et al. 2003, Himworth et al. 2010). Disease impacts on the population of lake seals may be significant because in small, isolated populations of seals, disease can be a major cause of mortality (Harding 2000, Barrett et al. 2003). High mortality levels from disease may cause a genetic ‘bottleneck’ which results in low genetic diversity. This directly results in a higher incidence of morbidity and mortality due to low genetic diversity and higher incidence of genetic disease (Pastor et al. 2004). It also makes the population of animals less resilient to disease in future (Broquet et al. 2010).

Disease is a significant and emerging cause of mortality in saltwater seal populations in Alaska and throughout the world. Over the last 15 years, the genus *Morbillivirus* has caused significant disease outbreaks in seals (Barrett et al. 2003), with populations of freshwater seals suffering high mortality due to disease. A canine distemper virus (CDV) outbreak killed thousands of freshwater seals (*Phoca sibirica*) in Lake Baikal in 1988, caused a mass die off of Caspian Seals (*P. caspica*) in 1997, and led to another mass casualty in 2000 of over 10,000 inland Caspian seals (Barrett et al. 2003, Quakenbush et al. 2009). These outbreaks were likely caused by seals having contact with terrestrial carnivores that carried the disease (Barrett et al. 2003, Quakenbush et al. 2009). Phocine distemper virus (PDV) is similar to the CDV and causes high mortality rates in harbor seals and has been detected in 1% of harbor seals in the Gulf of Alaska.

Antibodies to PDV were detected in 40% of sea otters in the eastern Aleutian Islands, Alaska Peninsula, and Kodiak Archipelago in 2009 (Goldstein et al. 2009). Phocine herpesvirus (PhHV-1 and 2) has been detected in stranded harbor seals and causes fever, vomiting and diarrhea (Quakenbush et al. 2009). Brucella levels are generally low in Arctic and sub-Arctic species, but may increase with climate change (Quakenbush et al. 2009).

A disease outbreak in 2009-2011 is continuing to cause unexplained deaths in Arctic seals, walruses and polar bear, with ringed, bearded and spotted seal populations suffering the highest mortality rates (NMFS 2012a). This ‘unusual mortality event’ is being investigated by both the National Atmospheric Administration (NOAA) and Canadian scientists. Affected animals suffer from hair loss and skin lesions with preliminary research finding that most seals died from bacterial infection. Lung and heart abnormalities and diseased liver tissue are also reported (NMFS 2012a). To date, scientists have yet to identify the vector causing the disease, with a spring 2012 report by NOAA stating that bacterial and fungal testing are still in progress. This unknown disease may be fungal in origin, which is one of the more deadly and difficult to eradicate vectors of diseases in wildlife. The fungal disease ‘white nose syndrome’ continues to kill tens of thousands of bats in the Eastern US and is spreading west, while the chyrtid fungus is killing off frog species worldwide. If this unknown disease affecting marine mammals in Alaska and Canada is indeed fungal in origin, Iliamna Lake seals and many other marine mammals in the Arctic and Alaska may be at risk from high rates of mortality with little hope for complete eradication of the disease from the population.

If, as hypothesized by some researchers and asserted by LTK, Iliamna Lake seals do congregate in an under-ice “cave” or other communal spot in the winter (Van Lanen 2012), the entire population could essentially act as a giant Petri dish for any viral, bacterial, or fungal disease to which even just one individual was exposed (NMFS 2012a). Additionally, the populations’ small size of only 250 to 350 known individuals means that a deadly disease could wipe out a large percentage of the population. This would leave the remaining seals vulnerable to extirpation via another disease outbreak and more prone to genetic abnormalities due to small population size (Barrett et al. 2003).

B. Natural Predation

Currently, brown bear or other terrestrial or avian predators are not known to be a significant contributor to Iliamna Lake seal mortality, but they likely do take a number of pups and adults each year. Smaller animals including red foxes, wolverines, wolves, eagles, ravens and gulls also are likely to prey on Iliamna Lake seal pups or occasionally adults. In the event salmonid runs were to fail, hungry brown bears, eagles, and other predators would likely search for alternative prey, and would be more likely to hunt seals, especially the more vulnerable young of the year or mothers and pups. Other inland seal populations are impacted by terrestrial and avian predators, with predation by eagles and wolves reported to be a major cause of mortality of Caspian seals (*Phoca caspica*) (Harkonen et al. 2008).

See Part I, Section 7-B-iii for more details on predation risks for Iliamna Lake seals.

3. OTHER NATURAL AND ANTHROPOGENIC FACTORS

A. Risks of Rarity

Although there are no accurate population estimates for the Iliamna Lake seal (*Phoca* sp.) it is clear that they are quite rare and likely number less than 350 individual adults. This low population size makes Iliamna Lake seal particularly susceptible to stochastic perturbations. There are four types of stochastic perturbations to which small populations of a species may be subject: demographic stochasticity, environmental stochasticity, genetic stochasticity, and natural catastrophes.

Demographic stochasticity refers to accidental variations in birth rate, death rate, and the ratio of the sexes (Canadian Science Advisory Secretariat 2008). Environmental stochasticity refers to fluctuations in weather, in food supply, and in the population levels of predators, competitors, parasites, and disease organisms that may affect a species. Genetic stochasticity refers to the loss of specific alleles through the processes of genetic drift, and the increased expression of the genetic load of the population. All of these stochastic effects lower survival rates for populations (Pastor et al. 2004). Indeed, these stochastic factors, combined with the effects of natural catastrophes, can interact in a feedback cycle by which a small population spirals to extinction (Pastor et al. 2004).

Iliamna Lake seals have a number of ecological and life history characteristics that make this population especially vulnerable to demographic and environmental stochasticity (Box et al. 1996, Harding 2000, Hutchings et al. 2012), including low reproductive capacity, late maturation, specific habitat requirements, dependence on a few prey species, and a narrow distribution. The seals are also dependent on a habitat susceptible to degradation by climate change and by human activities if the Pebble Project or other commercial or residential development occurs in the Iliamna Lake area (Powles et al. 2000).

In terms of genetic stochasticity, when the effective population of a species falls below 500 individuals, the population faces an overall net-loss of genetic variability through the loss of rare alleles, known as genetic drift. In populations below this size, the gains of genetic diversity brought on through mutation are outpaced by the loss brought on by genetic drift (Broquet et al. 2010). As the population continues to decline, the rate of loss tends to increase, because smaller populations have lower rates of mutation. Overall, this effect leads to loss of long-term genetic adaptability or resistance to disease by a population.

Further genetic risks occur when a population declines to 50 individuals (Box et al. 1996). At this point, the population becomes susceptible to inbreeding depression, with increased expression of deleterious alleles. A population with historically large numbers, or that derived from a population with historically large numbers, could harbor a larger genetic load--or a greater burden of potentially harmful alleles--and will be extremely vulnerable to inbreeding depression (Franklin 1980). This is because the large genetic load may be expressed in a proportionately higher number of the individuals within the population. For populations with a large genetic load, inbreeding can be especially devastating.

A small population of just 250 to 350 resident Iliamna Lake seals would likely to subject to stochastic impacts which would be compounded by threats from the Pebble Project, climate change, and ocean acidification. If the Iliamna Lake seal population derived from a small number (10 to 50 breeding adults) of seals that were isolated in the lake and reproduced with extensive inbreeding, the risks from genetic stochasticity and the expression of deleterious alleles would also increase. Cumulatively, or singularly, stochastic perturbations could result in loss of genetic diversity and lead to severe population declines for the Iliamna Lake seal.

B. Entanglement in Fishing Gear and Illegal hunting

Local residents report that Iliamna Lake seals have been shot and left to die, either by locals or by visitors. In fall 2005, one subsistence survey respondent reported that there were three seals on the beach that had been shot, although he did not know who shot the seals. Pedro Bay residents reported that they have seen "boatloads of armed tourists" travelling on the lake and shooting at anything that moves, including beaver and birds, and that they may be disturbing or shooting seals as well (Fall et al. 2006). Survey respondents also indicated that people who are not local residents are killing seals for their skins, which are said to have a distinct pattern from saltwater harbor seals. They state that this unique pattern makes the skin more valuable, and worth the risk of getting caught for an illegal hunt (Fall et al. 2006).

Fishing activities are widespread on Lake Iliamna. Gillnets for salmon set by subsistence fishers near the outlet of the Newhalen River are reportedly often raided by seals, and seals may become entangled in the nets. One hunter reported freeing a young seal from his net in the summer of 2007 (Fall et al. 2009). Drowning in fishing nets is a major cause of mortality in other freshwater seal populations such as Lake Saimaa in Finland (Sipila 2003, Canadian Science Advisory Secretariat 2008).

While seals, especially pups, may occasionally become entangled in fishing gear, this is not considered a major source of mortality for the Iliamna Lake seal. Human use in the lake area is currently very low, and subsistence hunters generally place nets in areas to avoid interference by seals, as seals are known to pick salmon from nets, destroying the net in the process (Fall et al. 2009).

Subsistence hunting by Alaskan natives of Iliamna Lake seal generally takes less than 10 animals a year, although monitoring is relatively unspecific (Fall et al. 2010). Subsistence hunting is generally not subject to regulation under the ESA (16 U.S.C. § 1539(e)).

C. Oil and Gas Exploration and Development

Impacts to the marine stages of salmon populations that utilize the Kvichak watershed for spawning will impact Iliamna Lake seals, as discussed in detail above. Oil and gas development has been proposed in Bristol Bay in the past, and if it was allowed to go forward could have devastating impacts on salmon in the event of an oil spill or other catastrophic failure (Heintz et al. 2000). Additionally, increased shipping due to decreased sea ice and offshore drilling in the

Beaufort and Chukchi seas is likely to increase shipping in the North Pacific and Bristol Bay, which would result in an increased risk of oil spills from these vessels.

D. Contaminants

Environmental pollutants, especially heavy metals and halogenated compounds, may have contributed to declines of up to 80% in populations of harbor seals throughout southcentral Alaska (Marino et al. 2011). Fish -eating Iliamna Lake seals are long lived, have high fat stores, and occupy an upper trophic level and are thus vulnerable to high levels of lipophilic contaminants (Neale et al. 2005). Organochlorines including polychlorinated biphenyls (PCBs) and DDT are common environmental contaminants associated with various physiological disorders, such as impaired immune function and decreased reproductive success (Neale et al. 2005).

Heavy metals are also a serious threat, with mercury being the most toxic, affecting a wide range of organs in the seals and reducing disease resistance (Addison et al. 2005, Mos et al. 2006). Mass mortality events for seals in Lake Baikal, and other areas have been attributed to loss of immune function due to high contaminant levels (Watanabe et al. 1996). Salmon travelling upriver from marine systems are the most likely carriers of contaminants. Iliamna Lake seals are likely exposed to these contaminants and suffer adverse impacts that may impact survival. As discussed above, construction and operation of the Pebble Project would significantly increase contaminants in the Iliamna Lake system and in the salmon themselves. Organ failure, decreased survival and reproduction, immune repression, and direct mortality in Iliamna Lake seals may result from exposure to these contaminants.

E. Commercial Fisheries

While not currently considered a threat, commercial fisheries in Bristol Bay could potentially deplete essential prey resources for Iliamna Lake seals, especially the sockeye salmon and other anadromous salmonids. Many species of marine mammals in the Bering Sea and Aleutian Islands region have suffered long term declines in population numbers. 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 2008), and commercial fisheries could similarly impact prey availability for Iliamna Lake seals. Specifically, commercial fisheries in Bristol Bay may affect Iliamna Lake seals through overall ecosystem-wide reductions in prey biomass, and decreased marine biomass available for primary production in the Kvichak Lake system from decomposing spawned-out salmon.

Threats will be exacerbated if emissions of anthropogenic greenhouse gases continue at current rates. As ocean acidification and climate change take their toll on salmon populations, the permitted catch of salmon by commercial fisheries in Bristol Bay may become unsustainable, lowering recruitment still further. This cycle could lead to a more rapid decline of salmon than would be caused by commercial fishing or climate change alone.

As a result, Iliamna Lake seal may face severe declines in available prey, and the Iliamna Lake and entire Bristol Bay ecosystem, which is dependent on salmon runs, may suffer a loss of productivity and wide-scale ecological changes. Under these conditions, Iliamna Lake seals are unlikely to survive.

4. INADEQUACY OF EXISTING REGULATORY MECHANISMS

Existing regulatory mechanisms are woefully inadequate to curb the primary threats to the petitioned Iliamna Lake seals posed by greenhouse gas emissions and the Pebble Project, as detailed below.

A. Regulatory Mechanisms Addressing Greenhouse Gas Emissions, Climate Change, and Ocean Acidification are Inadequate

Greenhouse gas emissions pose a major threat to the continued existence of the Iliamna Lake seal through impacts from climate change and ocean acidification, especially regarding sockeye and other salmon species that are critical to the ecosystem of Bristol Bay. However, regulatory mechanisms at the national and international level do not adequately protect the Iliamna Lake seal from these impacts, nor do they require the greenhouse gas emissions reductions necessary to protect the Iliamna Lake seal from extinction.

NMFS has acknowledged that regulatory mechanisms are inadequate to regulate greenhouse gas emissions to levels that do not threaten species. In its 2010 proposed listing rules for the ringed and bearded seal, NMFS stated that "there are currently no effective mechanisms to regulate GHG emissions, which are contributing to global climate change and associated modifications to [ringed and bearded] seal habitat. The risk posed to [ringed and bearded] seals due to the lack of mechanisms to regulate GHG emissions is directly correlated to the risk posed by the effects of these emissions" (75 Fed. Reg. 77508). Similarly, NMFS acknowledged in its 2012 *Management Report for 82 Corals Status Review under the Endangered Species Act* that no countries are reducing emissions enough to keep the increase in global temperature below 2 degrees C; and the top ten emitters including the United States, accounting for over 60% of the global emissions, are performing poorly or very poorly at meeting needed greenhouse gas reductions (NMFS 2012b). As detailed below, the continued failure of the U.S. government and the international community to implement effective and comprehensive greenhouse gas reduction measures places the Iliamna Lake seals at ever-increasing risk of extinction.

i. Global greenhouse gas emissions are tracking the worst IPCC emissions scenario

The atmospheric concentration of CO_2 reached ~392 parts per million (ppm) in 2011[2] compared to the pre-industrial concentration of ~280 ppm. The current CO_2 concentration has not been

[2] *See* National Oceanic and Atmospheric Administration, *Trends in Atmospheric Carbon Dioxide*, www.esrl.noaa.gov/gmd/ccgg/trends/global.html (last visited June 5, 2012).

exceeded during the past 800,000 years and likely not during the past 15 to 20 million years (Denman et al. 2007, Tripati et al. 2009). Atmospheric CO_2 emissions have risen particularly rapidly since the 2000s (Raupach et al. 2007, Friedlingstein et al. 2010). The global fossil fuel CO_2 emissions growth rate was 1.1% per year during 1990-1999 compared with 3.1% during 2000-2010, and since 2000, this growth rate has largely tracked or exceeded the most fossil-fuel intensive emissions scenario projected by the IPCC (A1FI) (Raupach et al. 2007, McMullen and Jabbour 2009, Global Carbon Project 2011). The CO_2 emissions growth rate fell slightly in 2009 due largely to the global financial and economic crisis; however, the decrease was less than half of what was expected and was short-lived (Fiedlingstein et al. 2010). Global CO_2 emissions increased by 5.9% in 2010 resulting in a record 33 billion tons of CO_2 emitted (Olivier et al. 2011), and CO_2 emissions reached another record high in 2011 (*See* International Energy Agency, *Global carbon-dioxide Emissions Increase by 1.0 Gt in 2011 to Record High,* http://www.iea.org/newsroomandevents/news/2012/may (last visited June 5, 2012)).

ii. Greenhouse gas emissions reductions needed to protect the Iliamna Lake seal

Recent international agreements have focused on a goal of limiting global temperature increase to 2°C above pre-industrial levels to "prevent dangerous anthropogenic interference with the climate system" as required by the United Nations Framework Convention on Climate Change (UNFCCC 2012).[3] However, many studies demonstrate that a 2°C temperature increase above pre-industrial levels is well past the point where severe and irreversible impacts will occur (Smith et al. 2009). A 2°C temperature rise is projected to result in significant risks to food and water security in many regions of the world, the disappearance of the Arctic summer sea ice which jeopardizes the Arctic sea-ice ecosystem and native communities, a high probability of triggering the irreversible melting of the Greenland ice sheet, an increased risk of extinction for 20-30% of species on Earth, the dieback of 30% of the Amazon rainforest, and "rapid and terminal" declines of coral reefs worldwide with serious consequences for the half billion people who depend on coral reefs directly for their livelihoods (TEEB 2009, Jones et al. 2009, Veron et al. 2009, Warren et al. 2011, Hare et al. 2011, Frieler et al. 2012). One recent study concluded that limiting global mean temperature rise to 1.2°C is needed to preserve at least 50% of the world's coral reefs from collapse due to ocean warming (Frieler et al. 2012). As summarized by a recent study, the impacts associated with 2°C temperature rise have been "revised upwards, sufficiently so that 2°C now more appropriately represents the threshold between 'dangerous' and 'extremely dangerous' climate change" (Anderson and Bows 2011).

Because a 2°C target would commit the world to serious harm, many climate scientists and governments have urged a target of 1.5°C to avoid dangerous climate change (Hansen et al. 2008, Rockström et al. 2009), which roughly corresponds to reducing the atmospheric CO_2 concentration to 350 ppm (Hare and Schaeffer 2009).[4] Limiting warming to 1.5°C has been

[3] The non-legally binding Cancún Agreement of 2010 and Copenhagen Accord of 2009 recognize the objective of limiting warming to 2°C above pre-industrial levels.
[4] An analysis of low emissions pathways found that only those that approach 350 ppm by 2100 have a reasonable probability (40–60%) of limiting warming to 1.5°C.

called for by the Alliance of Small Island States, the Least Developed Countries, and Executive Secretary of the United Nations Framework Convention on Climate Change Christiana Figueres. As climate scientist Dr. James Hansen and colleagues concluded, "if humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced from its current 385 ppm to at most 350 ppm [equivalent to ~1.5°C], but likely less than that" (Hansen et al. 2008). This 350 ppm target must be achieved within decades to prevent dangerous tipping points and "the possibility of seeding irreversible catastrophic effects" (Hansen et al. 2008).

Reducing the atmospheric CO_2 concentration to at most 350 ppm, and perhaps much lower (300 to 325 ppm CO_2) would help protect the Iliamna Lake seal from synergistic threats from climate change and ocean acidification that threaten the seal's essential habitat and the salmon species on which the seals and the Kvichak River watershed depend.

iii. U.S. measures to reduce greenhouse gas emissions are insufficient

While existing domestic laws including the Clean Air Act, Energy Policy and Conservation Act, Clean Water Act, Endangered Species Act, and others provide authority to executive branch agencies to require greenhouse gas emissions reductions from virtually all major sources in the United States, these agencies are either failing to implement or only partially implementing these laws for greenhouse gases. For example, the EPA has issued a rulemaking regulating greenhouse gas emissions from automobiles that will reduce greenhouse emissions emitted per vehicle mile traveled by passenger vehicles in the future, but because the improvements are modest and more vehicles are projected to be driven more miles in the future, the rule will not reduce emissions from this sector overall but will only slow the rate of increase somewhat compared to what it would be without the rule. EPA, Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule, 75 Fed. Reg. 25,324 (May 7, 2010). Meanwhile even the government concedes that "these reductions in emissions are not sufficient by themselves to reduce total HD vehicle emissions below their 2005 levels by 2020." NHTSA, *Medium- and Heavy-Duty Fuel Efficiency Improvement Program – Final Environmental Impact Statement* (June 2011). This means that the vehicle rule is far from achieving emissions goals agreed to by the US in the Copenhagen Accord, which aim to keep global warming below 2˚C.

The EPA has also to date issued only a single proposed rule under the new source pollution standard program for stationary sources of pollution, for electric generating units (power plants). While there is enormous potential to reduce emissions through this program overall and through the power plants rule in particular, the EPA has instead proposed a weak and flawed rule that it admits will not reduce emissions from these sources between now and 2020 compared to what would be expected without the rule. EPA, Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units, 77 Fed. Reg. 22392, 22430-33 (April 13, 2012). Indeed, in the rulemaking the EPA conceded that new power plant rule on greenhouse gas emissions "will not have direct impact on U.S. emissions of greenhouse gases under expected economic conditions." *Id*. at 22401.

While full implementation of our flagship environmental laws, particularly the Clean Air Act, would provide an effective and comprehensive greenhouse gas reduction strategy, due to their non-implementation, existing domestic regulatory mechanisms must be considered inadequate to protect the Iliamna Lake seal from climate change and ocean acidification.

iv. International measures to reduce greenhouse gas emissions are inadequate

International initiatives are also currently inadequate to effectively address climate change. The United Nations Framework Convention on Climate Change, negotiated in 1992 at Rio de Janeiro, Brazil, provides the forum for the international negotiations. In the Framework Convention, signed and ratified by the United States, the world agreed to take the actions necessary to avoid dangerous climate change. Parties to the Convention also agreed as a matter of fairness that the world's rich, developed countries, having caused the vast majority of emissions responsible for the problem, would take the lead in solving it. It was not until the 1997 meeting in Kyoto, Japan, that the first concrete, legally binding agreement for reducing emissions was signed: the Kyoto Protocol. The Protocol requires the world's richest countries to reduce emissions an average of 5 percent below 1990 levels by 2012, while developing nations also take steps to reduce emissions without being subject to binding emissions targets as they continue to raise their standard of living. The United States has been a major barrier to progress in the international negotiations. After the Clinton administration extracted many concessions from the rest of the world in exchange for the United States signing on in Kyoto, the Senate rejected the equity principles behind the Convention, saying the United States shouldn't agree to reduce its own emissions unless all other countries — regardless of their responsibility or ability — were similarly bound. Citing the same excuses, President George W. Bush repudiated the Kyoto Protocol entirely. Thus the United States is the only industrialized country in the world that has yet to ratify the Kyoto Protocol. The United States negotiating team under both the George W. Bush and the Obama administrations has pursued two primary objectives in the international talks: to refuse any legally binding emissions reduction commitments until all other countries— but particularly China and India — do so, and to push back the date for a new agreement. Not surprisingly, the United States had failed to meet its (never ratified) Kyoto pledge to reduce emissions to 7.2% below 1990 levels by 2012; to the contrary, U.S. emissions have increased by 10.5% since 1990 (EPA 2012).

Moreover, the Kyoto Protocol's first commitment period only sets targets for action through 2012, and there is still no binding international agreement governing greenhouse gas emissions in the years beyond 2012. While the 2009 U.N. Climate Change Conference in Copenhagen called on countries to hold the increase in global temperature below 2°C (an inadequate target for avoiding dangerous climate change), the *non-binding* "Copenhagen Accord" that emerged from the conference, and the subsequent "Cancún Accords" of 2010 and "Durban Platform" of 2011, failed to enact binding regulations that limit emissions to reach this goal.[5] Even if countries were

[5] The non-legally binding Copenhagen Accord of 2009 and Cancún Accords of 2010 recognize the objective of limiting warming to 2°C above pre-industrial temperatures, but do not enact binding regulations to achieve this goal (http://cancun.unfccc.int/cancun-agreements/main-objectives-of-the-agreements/#c33; unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf). According to the Durban Platform, developed and developing

to meet their Copenhagen and Cancún pledges, analyses have found that collective national pledges to cut greenhouse gas emissions are inadequate to achieve the 2°C target, and instead suggest emission scenarios leading to 2.5°C to 5°C warming (Rogelj et al. 2010, UNEP 2010, 2011). As of May 2012, many governments were not implementing the policies needed to meet their inadequate 2020 emission reduction pledges, making it more difficult to keep global temperature rise to 2°C and likely leading to a temperature rise of at least 3.5 °C (Höhne et al. 2012). As noted in the NMFS *Management Report*, the U.S. has yet to issue regulations to limit greenhouse gas emissions in accordance with its pledge under the Copenhagen Accord (NMFS 2012b).

B. Regulatory Mechanisms Addressing Other Threats to the Iliamna Lake Seal are Inadequate

i. Introduction to Regulations Pertaining to Pebble Project

The impacts of the Pebble Project are described in Part III, Section A of this petition. Existing regulatory mechanisms are inadequate to address these impacts. Federal and state permits are required to analyze the impacts of the project on the Iliamna Lake water quality and ecosystem, while NMFS would be responsible for authorizing "take" of the seals from Pebble Project operations pursuant to the MMPA. Neither agency is likely to adequately consider the impacts of Pebble Mine on the Iliamna Lake seal because the seal is not included in NMFS's Alaska Marine Mammal Stock assessments, and only given one brief mention in EPA's draft Watershed Impact Assessment for Pebble Mine. Much of the permitting for the Pebble Project falls under the jurisdiction of the State of Alaska DNR, or other state, local or federal jurisdictions, none of which adequately protect Iliamna Lake seal habitat from the Pebble Project.

ii. The Clean Water Act: Environmental Protection Agency

In 1972, Congress passed the Clean Water Act to protect all "water of the United States." Under the Clean Water Act (CWA), the EPA can restrict the disposal of mine waste in Bristol Bay's watershed if the science shows it will harm the ecosystem. Specifically, Section 404(c) of the Clean Water Act authorizes the Environmental Protection Agency (EPA), after public hearings and a scientific review process, to protect rivers and wetlands that are important fish-spawning and wildlife habitat. EPA can veto before a permit application is submitted, while it is pending, or after it has been issued, if the Agency determines that mine discharge will have "unacceptable adverse impacts on water supplies, shellfish beds and fishery areas, wildlife, or recreational areas" (EPA 2012).

nations agreed to a process to develop a "new protocol, another legal instrument, or agreed outcome with legal force that will be applicable to all Parties to the UN climate convention"; this legal instrument must be developed as of 2015 and will not take effect until 2020 (unfccc.int/resource/docs/2011/cop17/eng/l10.pdf).

Alaska tribes, native corporations and commercial fisherman, among others, petitioned the EPA to use its authority under the Clean Water Act to restrict or prohibit disposal of mine waste in Bristol Bay, in order to protect the salmon of the Nushagak and Kvichak watershed that would be directly impacted by the Pebble Project. In response, on May 18, 2012, the EPA released its draft Watershed Assessment of Bristol Bay. As discussed in greater detail in section A-1 above, the EPA's scientific report concludes that even without an extremely likely accident or failure, the Pebble Project will eliminate or block up to 87 miles of salmon streams and remove or bury up to 4,200 acres of wetland critical to salmon habitat. EPA found that evidence from other large mines suggests that "at least one or more accidents or failures could occur, potentially resulting in immediate, severe impacts on salmon and detrimental, long-term impacts on salmon habitat."

Under the Clean Water Act, the EPA has the authority to preemptively stop the Pebble Mine before the state permitting process begins. Whether or not such action will be taken will be determined by the EPA based on the final version of the EPA's Bristol Bay Watershed Assessment, which is due to be released in late 2012 or early 2013. A scientific review panel analyzing the findings of the EPA is due to release a report on the draft assessment in late 2012, and this report will be incorporated into the final assessment. After the final assessment is released, the EPA will determine whether it will use its authority under the CWA to preemptively veto the Pebble Project.

While an EPA veto that actually stops the Pebble Project would ameliorate this significant threat to the Iliamna Lake seal, EPA's use of such authority is almost unprecedented and certain to be challenged by Alaska and PLP as an exceedance of the agency's authority. Until and unless EPA invokes such authority here, it cannot be deemed an adequate regulatory mechanism obviating the need for ESA listing of the Iliamna Lake seal.

iii. The Clean Water Act: U.S. Army Corps of Engineers

A discharge of dredged or fill material, including mine tailings, into waters or wetlands of the United States is prohibited unless authorized by the Corp of Engineers (COE) under Section 404 of the Clean Water Act. To the degree that Pebble Project activities will have an effect on "waters of the United States," these activities will require a Section 404 Permit. Such activities include road or bridge construction, construction of dams for tailings storage, water storage dams, and stream diversion structures. Unless the EPA steps in prior to the submission of permits by the PLP, permits for the Pebble Mine would first have to be approved by the COE.

PLP is reportedly planning to apply for CWA permits later this year (2012). While the Corp has authority and the obligation to deny any such permit if there are significant adverse effects, as there certainly will be with the Pebble Project, Corp denial of 404 permits is extremely rare. Consequently, until and unless the Corps denies any and all permits necessary for the construction of the Pebble Project, the relevant provisions of the CWA cannot be considered adequate regulatory mechanisms to protect the Iliamna Lake seal.

iv. Marine Mammal Protection Act

While the Marine Mammal Protection Act (MMPA) is a strong statute that could and should be better deployed by NMFS to protect the Iliamna Lake seal, it does not provide sufficient tools to address all threats to the species. First, the MMPA does little to address the risks from climate change and ocean acidification. Moreover, given NMFS currently does not recognize the Iliamna Lake seal as a separate stock, this seal population receives no protection separate from that afforded the larger saltwater harbor seal stock in Bristol Bay. And while harassment and other impacts to Iliamna Lake seals from Pebble Project activities would require authorization under the MMPA, to our knowledge NMFS has never denied take authorization for any seal species from industrial activities in Alaska. As such, there is no evidence that the agency will use the MMPA to protect the Iliamna Lake seal from the Pebble Project. Consequently, the MMPA cannot be considered an adequate regulatory mechanism to protect the Iliamna Lake seal.

v. State of Alaska: Alaska Department of Natural Resources

The state of Alaska has never failed to permit a major mine and is not likely to stop the Pebble Project from going forward. As discussed above, if the Pebble Project goes forward, there will be irreversible impacts on the habitat and prey of the Iliamna Lake seal, as well as direct impacts from human disturbance and noise.

The Large Mine Permitting team (LMPT) is responsible for the permitting activities for large mine projects in the state of Alaska, in accordance with Alaska state law (AS 27.05.010(b)). The Department of Natural Resources (DNR) and Office of Project Management and Permitting (OPMP) coordinate the permitting of large mining projects, like Pebble Mine. If one of the permits required for approval of the mine by the AK DNR is denied, this usually results in changes to the project, not denial of the project.

Based on the history of large mine permitting by AK DNR, a permit for Pebble Mine is very likely to be approved, with few mitigations required which would not stop the project from moving forward. Unfortunately, there are no mitigations for Pebble Mine that would reduce or remove impacts on the Iliamna Lake seal or on the vitally important salmon runs supported by the Kvichak Watershed/Iliamna Lake ecosystem. This is shown in EPA's assessment. Regulatory mechanisms through the state of Alaska are unlikely to protect the seals from disastrous population-level impacts and the increased risk of extinction that would result from a large mining project in the Lake Iliamna watershed area.

Critical Habitat Designation

The ESA mandates that, when NMFS lists a species as endangered or threatened, the agency 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).

The Center for Biological Diversity expects that NMFS will comply with this unambiguous mandate and designate critical habitat concurrently with the listing of the Iliamna Lake seal. Critical habitat must include the islands and shoreline in the northeast half of Iliamna Lake that are known to be used by Iliamna Lake seal for hunting and resting.

Conclusion

As demonstrated in this petition, the Iliamna Lake seal faces high-magnitude and growing threats to its continued existence. NMFS must promptly make a positive 90-day finding on this petition, initiate a status review, and expeditiously proceed toward listing and protecting this species. We look forward to the official response as required by the ESA.

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Copies of many of the references cited are included on a compact disc. Please consider these references along with the Petition, and include them in the administrative record for the 90-Day Finding on the Petition.

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