APPENDIX H

BIOLOGICAL ASSESSMENT

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National Aeronautics and
Space Administration

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, VA 23337

Reply to Attn of: 250.W

July 24, 2012

Mr. Brad Smith
Protected Resources Division
NOAA Fisheries Service
222 West 7th Avenue, #43
Anchorage, Alaska 99513-7577

Dear Mr. Smith:

In accordance with Section 7 of the Endangered Species Act of 1973 (ESA), as amended, and its implementing regulations, this letter serves as the National Aeronautics and Space Administration's (NASA) request for conference and concurrence with its determinations of effect on listed and proposed species.

The action that is the subject of this conference is NASA's continued launch of sounding rockets from the University of Alaska Fairbanks-owned Poker Flat Research Range (PFRR). In consideration of the scope of the proposed action and the extent of species and habitat within the action area, NASA has concluded that it is "not likely to jeopardize the continued existence of" Ringed seal *(Phoca hispida)*. Other listed and proposed species identified by NOAA Fisheries as potentially occurring within the action area have been assessed and given a "no effect" determination. Please find enclosed a Biological Assessment (BA) that provides analysis and justification for NASA's determinations of effect.

As the Federal agency funding the launch of sounding rockets from PFRR, NASA is serving as the lead agency for ESA compliance. The U.S. Department of the Interior's Bureau of Land Management and U.S. Fish and Wildlife Service would undertake actions connected to NASA's and are participating in NASA's ESA process. The effects of their actions are also considered in the enclosed BA. As such, please include all three action agencies in future correspondence regarding this conference.

If you have any questions, please contact me at (757) 824-2319 or Joshua.A.Bundick@nasa.gov.

Sincerely,

Joshua A. Bundick
Lead, Environmental Planning

Enclosure

cc:
BLM/Ms. L. Heppler
USFWS Arctic NWR/Mr. R. Voss
USFWS Yukon Flats NWR/Mr. M. Bertram

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National Aeronautics and
Space Administration

Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, VA 23337

Reply to Attn of: 250.W

July 24, 2012

Mr. Ted Swem
Ecological Services Office
U.S. Fish and Wildlife Service
101 12th Avenue, Room 110
Fairbanks, Alaska 99701

Dear Mr. Swem:

In accordance with Section 7 of the Endangered Species Act of 1973 (ESA), as amended, and its implementing regulations, this letter serves as the National Aeronautics and Space Administration's (NASA) request for U.S. Fish and Wildlife Service (USFWS) concurrence with its determinations of effect on listed species and designated critical habitat.

The action that is the subject of this consultation is NASA's continued launch of sounding rockets from the University of Alaska Fairbanks-owned Poker Flat Research Range (PFRR). In consideration of the scope of the proposed action and the extent of species and habitat within the action area, NASA has concluded that it "may affect, not likely to adversely affect," Polar bear *(Ursus maritimus)* and its designated critical habitat. Other listed and candidate species identified by USFWS as potentially occurring within the action area are assessed and have been given a "no effect" determination. Please find enclosed a Biological Assessment (BA) that provides analysis and justification for NASA's determinations of effect.

As the Federal agency funding the launch of sounding rockets from PFRR, NASA is serving as the lead agency for ESA compliance. The U.S. Department of the Interior's Bureau of Land Management and USFWS would undertake actions connected to NASA's and are participating in NASA's ESA consultation. The effects of their actions are also considered in the enclosed BA. As such, please include all three action agencies in future correspondence regarding this consultation.

If you have any questions, please contact me at (757) 824-2319 or Joshua.A.Bundick@nasa.gov.

Sincerely,

Joshua A. Bundick
Lead, Environmental Planning

Enclosure

cc:
BLM/Ms. L. Heppler
USFWS Arctic NWR/Mr. R. Voss
USFWS Yukon Flats NWR/Mr. M. Bertram

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Biological Assessment

NASA Sounding Rockets Program at Poker Flat Research Range

National Aeronautics and Space Administration
Goddard Space Flight Center
Wallops Flight Facility
Wallops Island, VA 23337

July 2012

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1. **Introduction**

1.1. Purpose of this Document

Section 7(c) of the Endangered Species Act (ESA) of 1973 requires that a Biological Assessment (BA) be prepared for all Federal actions that may affect Federally-listed threatened or endangered species or critical habitat. The National Aeronautics and Space Administration (NASA) has prepared this BA to consider the potential impacts of its Sounding Rockets Program (SRP) at the University of Alaska Fairbanks (UAF) – owned Poker Flat Research Range (PFRR), Alaska (AK). This BA considers the potential effects of the SRP on listed, proposed, and candidate species, as well as designated critical habitat under the jurisdiction of both the NOAA Fisheries Service (NOAA Fisheries) and U.S. Fish and Wildlife Service (USFWS) (collectively, "the Services").

Also considered in this BA are connected Federal actions undertaken by two independent agencies of the Department of the Interior - the Bureau of Land Management (BLM) and the USFWS. Each agency manages lands within the eastern Interior of Alaska and issue authorizations to UAF (on NASA's behalf) for sounding rocket launches; specifically BLM manages the Steese National Conservation Area and White Mountains National Recreation Area under the Federal Land Policy and Management Act of 1976, as amended; USFWS manages Arctic and Yukon Flats National Wildlife Refuges in accordance with its responsibilities under the National Wildlife Refuge System Administration Act of 1966, as amended.

This BA has been prepared to assist NASA and its cooperating agencies in determining whether the proposed action is "likely to adversely affect" listed species or critical habitat, thereby warranting formal consultation pursuant to the ESA. In the case of proposed species, a determination of "likely to jeopardize the continued existence of" would trigger the need to undertake formal conference. If, based upon the findings within this BA, NASA determines that the proposed action would have "no effect" or is "not likely to adversely affect" listed species or critical habitat, or "not likely to jeopardize the continued existence of" proposed species, NASA would request written concurrence from the Services with its determinations. In the case of a "likely to adversely affect" or "likely to jeopardize the continued existence of" determination, formal consultation (or conference in the case of proposed species) with the Services would then ensue.

Although including candidate species in this BA is not required by law, it is USFWS policy to consider candidate species during its decision-making process. Therefore, NASA has included an assessment of potential effects on candidate species in this BA.

1.2. Previous ESA Communications

<u>NOAA Fisheries</u>

On September 6, 2011 NASA sent a letter requesting information from NOAA Fisheries regarding listed species within the PFRR flight corridor. NOAA Fisheries responded in a September 6, 2011 email, providing the requested information.

On February 3, 2012, NASA and UAF met with NOAA Fisheries at its office in Anchorage, AK to continue project-related ESA discussions.

On March 21, 2012, NASA requested confirmation that the project's species list was still valid; NOAA Fisheries provided confirmation.

USFWS

On April 14, 2011, NASA sent a letter to USFWS requesting information regarding ESA listed species within the PFRR flight corridor. On May 23, 2011, USFWS provided the requested species list.

Subsequent to the written correspondence, NASA and its environmental contractor held a teleconference with USFWS on September 30, 2011 to discuss the proposed action and the ESA consultation. On February 2, 2012, NASA met with USFWS at its office in Fairbanks, AK to continue such discussions.

On March 21, 2012, NASA requested confirmation that the project's species list was still valid; USFWS provided confirmation.

2. Description of the Action

NASA has prepared a Draft Environmental Impact Statement (EIS) that addresses both its launch and recovery operations at PFRR; the Draft EIS considers four action alternatives as well as a no action alternative. Although NASA has not yet identified a preferred alternative in the EIS (upon which an ESA consultation would typically be based), the key difference among all alternatives is the level of recovery or avoidance of interior lands, none of which would have a potential effect on areas known to harbor ESA listed, proposed, or candidate species.

The component common to all alternatives that would have the potential to affect areas ESA species or habitat is the flight and subsequent re-entry of sounding rocket motors and payloads within the Beaufort Sea/Arctic Ocean. Accordingly, this section of the BA provides only a description of the launch, flight, and re-entry of NASA sounding rockets with no further reference to recovery operations. Furthermore, only those sounding rocket configurations (and typically associated payloads) that have the potential to overfly or land within ESA species habitat are presented in detail.

For a full description of the NASA SRP and its operations at PFRR, the reader is directed to the *Sounding Rockets Program Final Supplemental EIS* **(NASA 2000)** and the *Sounding Rockets Program at Poker Flat Research Range EIS* **(NASA 2012).**

2.1. Poker Flat Research Range

PFRR is located in the center of Alaska near Fairbanks, approximately 1.5 degrees below the Arctic Circle at 65°2' N latitude and 147°5' W longitude. The facility consists of approximately 2,100 hectares (5,200 acres) on Steese Highway (Alaska Route 6) in the village of Chatanika, approximately 48 kilometers (30 miles) northeast of Fairbanks. Directly north of PFRR are its downrange flight zones, over which rockets are launched and within which spent stages and payloads impact the ground.

Since the late 1960s, NASA and other government agencies have launched suborbital rockets from PFRR **(Davis 2006)**. While PFRR is owned and managed by the Geophysical Institute of UAF, since the 1980s, the NASA SRP has provided sole funding support to PFRR.

2.2. *NASA Sounding Rockets*

Each NASA sounding rocket consists of one to four ground-launched; solid-propellant rocket motors staged in series, the purpose of which is to propel a scientific payload to the upper atmosphere. These rocket motors are configured to meet scientific requirements driven by payload size, flight time, and target altitude desired by the researchers. As NASA sounding rockets are suborbital, their upper stages or payloads do not enter an Earth orbit, rather they return to Earth along parabolic trajectories **(Figure 1)**.

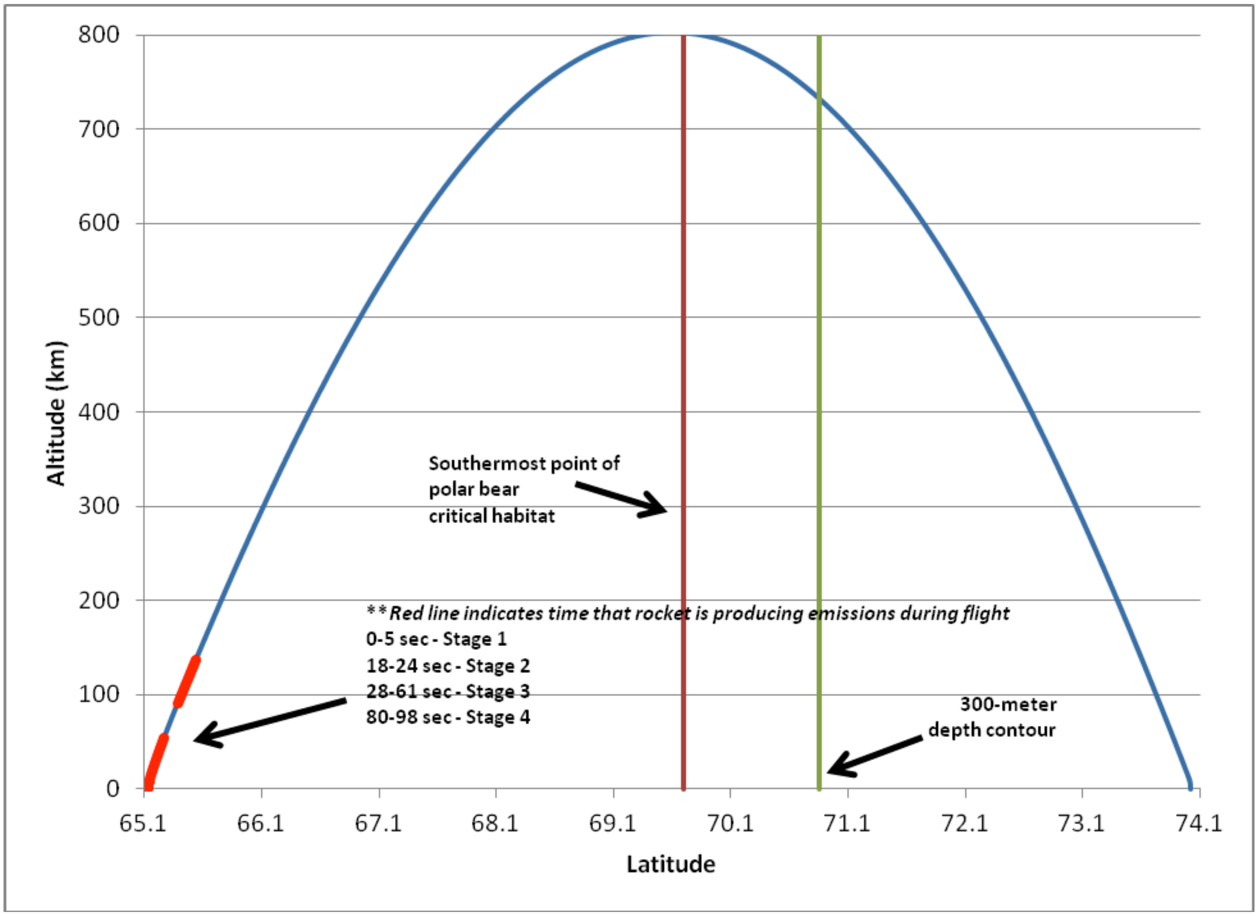

Figure 1. Example Sounding Rocket Trajectory (only 4th stage and payload depicted for clarity)

The rockets having the potential to either overfly or land within the Beaufort Sea/Arctic Ocean are the Black Brant-class vehicles which employ either three or four rocket motors. Although only the Black Brant XII is shown below in **Figure 2,** other similar vehicles, including the Black Brant X, could be flown, however they would not materially differ from the Black Brant XII in terms of potential effects on listed species or habitat. In fact, the Black Brants X and XII share the same final stage (the Nihka rocket motor), which is discussed in more detail below.

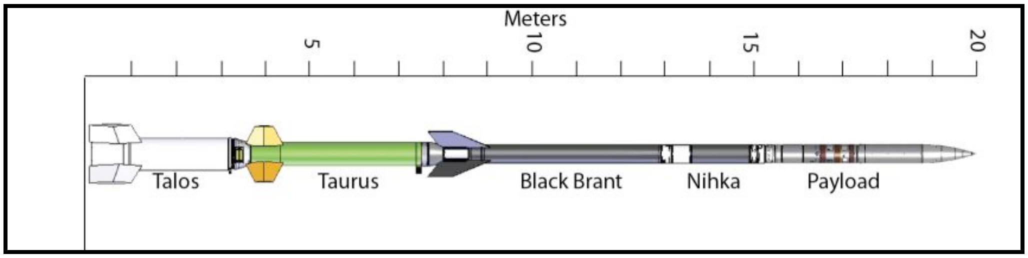

Figure 2. Black Brant XII Sounding Rocket

Rocket Motors

All rocket motors launched by NASA at PFRR are spin stabilized, unguided, and solid fueled. Propellants typically include ammonium perchlorate and aluminum or nitrocellulose and nitroglycerine. Section 2.2 of the *SRP SEIS* **(NASA 2000)** defines these propellants and their exhaust products in full detail. Individual motors range in size from 36 to 78.7 centimeters (14 to 31 inches) in diameter and are 1.9 to 5.7 meters (76 to 223 inches) long. In **Figure 2**, the Black Brant XII's motors are identified as the Talos, Taurus, Black Brant, and Nihka. Of those motors, only the fourth stage Nihha would overfly or land within the Beaufort Sea/Arctic Ocean.

The diameter of the Nihka is about 44 centimeters (17 inches) and its length is about 1.90 meters (76 inches). The loaded motor weight is 408 kilograms (900 pounds), which includes 320 kilograms (700 pounds) of propellant of the ammonium perchlorate/aluminum/plastic binder type, with carbon black, iron, sulfur, and ferric oxide additives. The rocket exhaust emissions are mainly aluminum oxide, hydrogen chloride, carbon monoxide, water, and nitrogen. They occur during the 18-second burning time over a typical altitude range from 96 to 150 kilometers (60 to 96 miles), with a spent rocket weight at final impact of 93 kilograms (200 pounds). Due to the nature of solid rocket motors, all propellant is burned once ignited; therefore, only trace residual amounts remain on each stage after flight.

The rocket motors used by NASA consist of steel cases and steel, aluminum, or similar metallic alloy fins and attachment hardware. The Nihka is finless due to its exo-atmospheric flight. Future rocket motor cases may be made of composite materials such as fiberglass, Kevlar, or similar materials. However, the dimensions and overall appearance would remain consistent with current inventory for the foreseeable future.

Payloads

There are a variety of payloads and experiments that are flown on SRP missions at PFRR. These payloads/experiments range in size from 0.76 to 5.3 meters (30 to 210 inches) long, are of similar diameter to the rocket motor on which they are flown, and weigh from less than 45 kilograms (100 pounds) to over 140 kilograms (300 pounds). They all utilize mechanical structures made of a variety of materials, including aluminum, steel, magnesium, other lightweight metals, or occasionally composites such as fiberglass, graphite/epoxy, etc. Internal components consist mainly of electronic subsystems, batteries, pressure systems (pressure vessels, tubing, regulators, valves, etc.), and a variety of sensors and instruments such as magnetometers, optical devices, and antennas of varying shapes and sizes. A drawing of a typical payload after deployment is shown below in **Figure 3**.

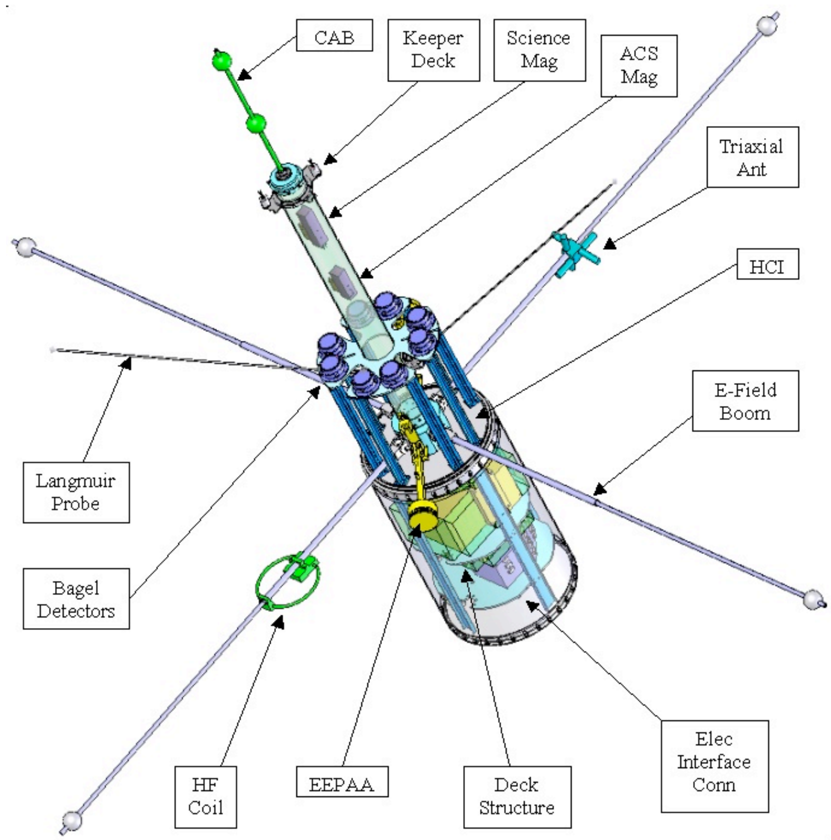

Figure 3. Typical PFRR Sounding Rocket Payload

The payloads often contain deployable devices, such as a nose cone used to cover sensitive electronic instruments during ascent, releasable doors, antennas, de-spin weights, cables, and other similar components. In many cases, a payload flown on a single rocket will be separated in flight into multiple pieces, each designed to carry out a specific scientific objective.

Re-Entry

All metallic and other solid heavier-than-air objects that are propelled into the atmosphere by sounding rockets land back on Earth in more or less ballistic trajectories. The objects include spent rocket stages, payloads; nose cone doors (released in flight for instruments to "see" their targets); and spin weights, which were released to change rotation of a rocket stage of a launch.

Recent data on average sea ice thickness in the Beaufort Sea **(Kwok and Rothrock 2009)** was used as a gauge to determine whether the re-entering objects would fully penetrate the ice. Assuming an average sea ice thickness of 1 meter (3.3 feet), it is highly unlikely that re-entry would result in a penetration depth that would exceed the average ice thickness. Payloads and spent motors would likely impact the ice and undergo elastic and plastic deformation while creating an impact crater but would not pierce the ice and immediately sink into the water **(Wilcox 2012)**.

Upon impacting the sea ice, it is expected that the enclosed sections of the payload (telemetry sections, attitude control systems, etc.) would experience damage but would be largely intact as a result of impact. On the other hand, exposed experiment sections (such as the booms and probes shown in **Figure 3**) would be broken up as a result of the impact; a resulting debris field would include structural elements as well as experiment components of various material make-up.

It is expected that extreme re-entry dynamics would result in deployed booms and detectors being separated from their primary structures. However, the primary structures without aluminum skin sections would survive until impact. It is likely that these structures would undergo sufficient deformation such that they, along with any components housed in these locations, would be dispersed around the impact point. It is possible that batteries could be located in these exposed assemblies but this is not the typical case. Electronic boards, wiring, connectors and other small components are likely to be numerous in the debris field.

Spent motors and enclosed portions of payloads would experience plastic deformation and significant damage but are not likely to break apart to the extent that internal elements would be significantly exposed (e.g. residual propellant, telemetry components such as batteries, etc.).

A description of materials and equipment that would be relevant in assessing potential effects on listed species or habitat is presented below.

<u>Materials of Interest</u>

Pyrotechnics - In addition to the rocket propellant, each rocket motor contains a series of small explosive charges. To provide perspective regarding size, the largest charge currently employed is just less than 0.3 grams (0.01 ounce). These charges serve two primary functions: rocket motor ignition and separation of the stage after it has finished burning.

Payloads also contain a number of the above-described pyrotechnic charges for purposes such as removing doors and nosecones to expose the scientific experiment. The size and number of these charges would be mission-specific and would vary; however even in the case that all charges were of the largest variety, the total charge mass would be less than 28 grams (g) (1ounce [oz]). Once activated, under normal flight conditions, these pyrotechnic systems would pose no hazard to wildlife on the ground.

Batteries **–** Small electrical systems are required on each rocket motor such that the ignition and separation functions described above may occur. As only the first stage can be ignited from a ground-based circuit, rechargeable batteries are employed **(Figure 4)**. On the forward end of each motor, approximately 1.8 kg (4 lbs) of nickel-cadmium cells are housed within rigid plastic containers bolted to the head cap of the motor. To assist in providing perspective, this quantity of batteries is comparable to approximately 48 "AA" cells typically used in consumer electronic devices. Of the total battery mass, approximately 15 percent is the cadmium metal, totaling approximately 270 g (0.6 lb) per stage. In addition to the nickel-cadmium cells, small quantities of silver oxide cells are used in the motor ignition systems. Weighing less than a gram each, this equates to an approximate mass of 50 grams (0.1 lb) onboard each motor. These types of batteries are most commonly used in small personal electronic devices, including wristwatches.

Figure 4. Typical Rocket Motor Ignition Battery Pack

In addition to the batteries onboard the rocket motor, the payload would contain batteries for the attitude control system, telemetry, and scientific experiments **(Figure 5)**. The total mass of batteries onboard would vary based upon mission requirements; however, a typical mission would be expected to employ approximately 9 kg (20 lb) of nickel-cadmium batteries. This would equate to approximately three packs of 24 "C" cells and single packs of 24 and 16 "A" cells. Assuming that the payload's batteries contain 15 percent cadmium by mass, the total cadmium returning to Earth would be approximately 1.4 kg (3 lb) per flight.

Figure 5. Typical Payload Battery Configuration

In addition to the cadmium found in the batteries themselves, very small quantities of lead containing solder are used on sounding rocket electrical systems. Although the majority of electrical systems are connected with crimps, some soldered connections are still employed, including those in the battery packs. It is estimated that approximately 100 g (3.5 oz) of solder would be used on a rocket's entire electrical system, with 40 percent (40 g [1.4 oz]) of this solder consisting of lead. To assist in providing perspective, this quantity of lead is slightly more than what is contained within a single 12-gauge shotgun shell used for small-game hunting.

Balance Weights – To ensure that the spinning rocket components do not "wobble," between 2.3 and 4.5 kg (5-10 lb) of lead balance weights are employed on most sounding rocket payloads. These weights would typically be in the form of 0.6 or 1.3 cm (0.25 or 0.5 in) thick curved plates that are bolted to the inside of the payload skin sections. It would be highly unlikely that these weights would be dislodged such that they would separate from the payload upon impact.

Pressure Systems – Onboard the payload section of the rocket are small cylinders of high pressure (generally 5,000 psi) compressed gas, typically argon or nitrogen **(Figure 6)**. These gases are vented during normal flight to align the payload in optimum position for taking its respective measurement. The typical quantity onboard a sounding rocket is small, estimated to be approximately 0.009 m^3 (0.05 ft^3). Although both gases are non-hazardous, damage to the cylinder could cause the cylinder to rupture or act as a projectile. However, the likelihood of such an incident occurring would be very low as this system is designed to vent its contents during reentry.

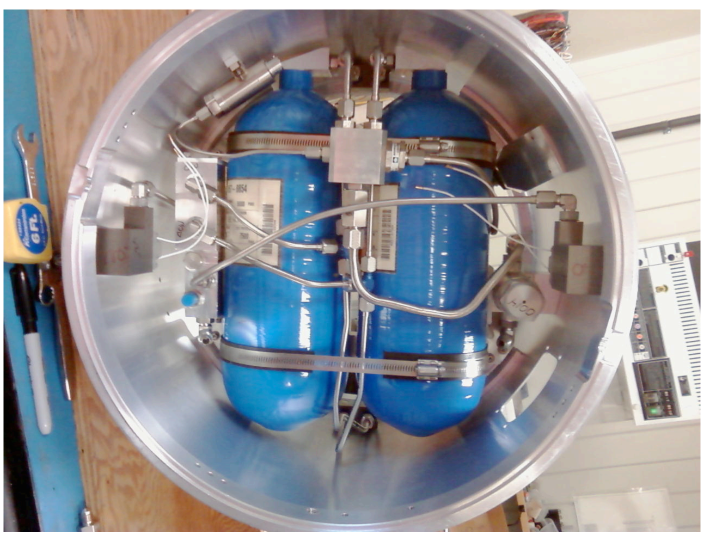

Figure 6. Typical 43 cm (17 inch) diameter Payload High Pressure Tank Configuration

Chemical Tracers – Payloads launched from PFRR sometimes carry small quantities of metal vapors (including barium, lithium sodium, strontium, and samarium) or trimethyl aluminum (TMA) that are intentionally dispersed at high altitude to study high-altitude phenomena. Sodium and lithium releases are produced by burning a mixture of thermite (titanium diboride, the reaction product of boron and titanium) and the metal to produce a vapor. TMA, on the other hand, is a pyrophoric liquid that reacts on contact with oxygen to produce chemiluminescence.

To provide the reader perspective, compounds containing several of these elements are commonly used in non-science-related applications requiring luminescence. In particular, barium creates the green color in fireworks whereas strontium produces the red color.

To provide perspective regarding size, for some TMA payloads (the most commonly employed tracer), modules are released during flight with each containing approximately 380 ml (12.9 oz) of the liquid; slightly more than the contents of a typical soda can. Larger canisters are most commonly used as they release the material along a longer duration of the trajectory and typically hold approximately 6 liters (1.6 gallons). In general, the primary on-the-ground hazard associated with these materials is the potential for fire or burns. During normal flight, these materials are released high in the atmosphere, with only trace amounts (estimated to be less than 100 g [3.5 oz]) present in hardware that returns to earth. The small soda can sized modules would not contain any residual as they rupture during flight; the most likely location of the trace quantities would be within the piping of the canister-type systems.

Dispersion in Impact Locations

A key concept to understand when discussing sounding rockets is the effect that dispersion can have on the ultimate landing location of spent stages, payloads, and other miscellaneous flight hardware. The term "dispersion" in this BA means the statistical deviation of the actual impact location of a spent rocket stage from the predicted value. All sounding rocket launch vehicles lack onboard guidance systems, which are typically employed on larger rocket systems such that the vehicle will fly along a pre-programmed route, correcting its flight path along the way.

Due to slight differences in the physical properties of each rocket (e.g., fin misalignment, weight variation) and the variability of atmospheric conditions, actual trajectories deviate from the predicted ones. The dispersion has downrange (short or long) and cross-range (left or right) components and is used to calculate the probability of impacting within a given distance of the nominal impact point. This distance is referenced to a standard deviation, or "sigma" value, from the mean point of impact **(Figure 7)**. In the case of sounding rockets, a circular dispersion is employed; such that for each launch the probability of a stage landing within 1-sigma of its predicted impact point is approximately 40 percent; within 2-sigma, 87 percent; and within 3-sigma, 99 percent.

In general, dispersion is dependent on apogee, e.g., dispersion is higher for a light payload with higher apogee than for a heavy payload with lower apogee (for a given launch vehicle), and dispersion is somewhat higher as the number of rocket stages in a launch vehicle increases. Although dispersion values will be mission-specific, a "typical" 1-sigma dispersion for the fourth stage or payload of a Black Brant XII would be between 125 and 150 km (78 and 93 mi), with the downrange component being the longer of the two.

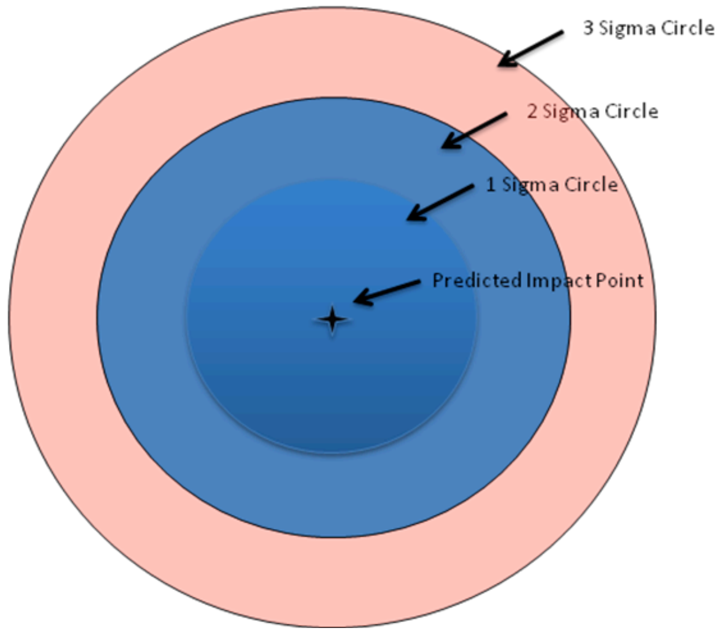

Figure 7. Illustration of a Sounding Rocket Dispersion

2.3. *Launch Frequency*

Future NASA SRP missions at PFRR could average from two to four launches every year. It is expected that no more than eight multi-stage suborbital rockets would be launched in any one year from PFRR under any action alternative. The eight launches could be spread across 8 separate days or concentrated into only 2 or 3 separate days with multiple launches.

This launch frequency estimate is based upon the past ten years of PFRR activity; this timeframe was selected to be representative of recent launch activity at PFRR and to demonstrate the anticipated future level of activity and resultant impact associated with SRP at PFRR. Sounding rocket launches at PFRR prior to this time were typically of shorter range and are therefore not representative of recent SRP activities at PFRR.

2.4. *Launch Season*

Future launches are expected to occur within the winter months, consistent with PFRR launch activity over the past ten years. However, the potential for a researcher to propose an experiment during the non-winter months cannot be discounted. Furthermore, the potential environmental effects from a non-winter launch would be highly mission-specific. In the event that a future non-winter launch were to be proposed, supplemental analysis would be required to determine potential effects on ESA species or habitat, potentially requiring further consultation with the Services.

2.5. Cooperating Agency Actions

BLM and USFWS would continue to review UAF-submitted permit applications and decide whether the proposed activities could be authorized, which would allow NASA to continue to land rocket motors and payloads on Federal properties. BLM-managed properties to which this action would apply are the White Mountains National Recreation Area and Steese National Conservation Area; USFWS-managed properties are the Arctic and Yukon Flats National Wildlife Refuges. Authorizations by BLM and USFWS, if granted, would be issued to the UAF on NASA's behalf.

3. Action Area

The action area is defined in 50 CFR 402.02 as "All areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." **Figure 8** depicts the action area for the SRP at PFRR. The action area for this BA includes the following:

- The land, water, and airspace within PFRR Flight Zones 1, 2, 3 , 4, 4 extended, 4 arctic extension, and 5; and
- The land, water, and airspace within a 400 km (248 mi) circle centered approximately 1,000 km (620 mi) north of the PFRR launch site.

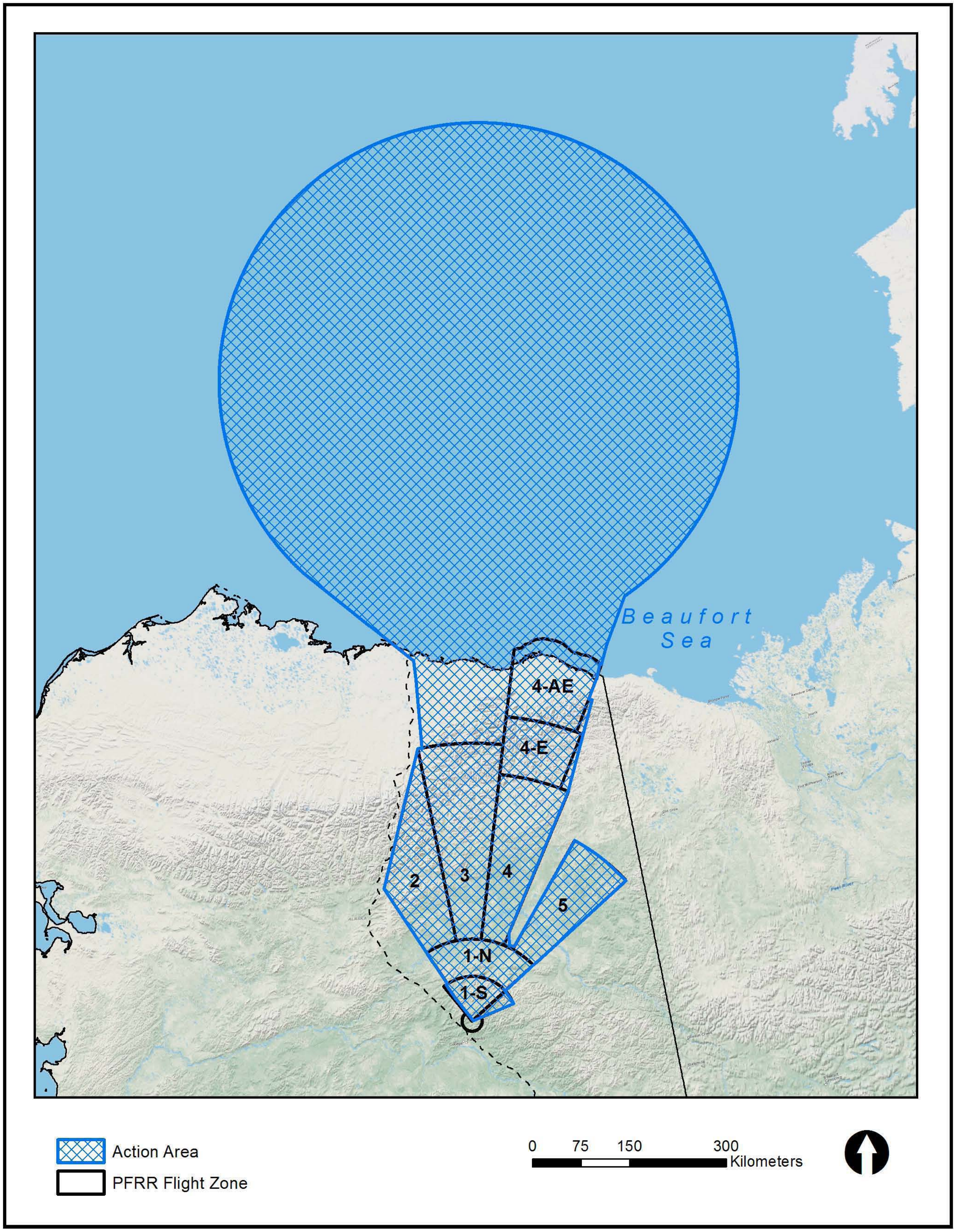

Figure 8. SRP at PFRR Action Area

4. Species Potentially within the Action Area

4.1. Species under NOAA Fisheries' Jurisdiction

4.1.1. Bowhead Whale

The western Arctic stock of bowhead whales *(Balaena mysticetus)* was listed as endangered on June 2, 1970, and has been on the endangered species list since then. Because of the ESA listing, the stock is classified as a depleted and a strategic stock under MMPA **(Angliss and Allen 2009)**. However, the western Arctic bowhead whale population appears to be healthy and growing under a managed hunt and has recovered to historic abundance levels. NMFS will use criteria developed for the recovery of large whales in general **(Angliss *et al.* 2002)** and bowhead whales in particular in the next 5-year ESA status review to determine if a change in listing status is needed **(Shelden *et al.* 2001)**.

The bowhead whale spends its entire life in the Arctic. There are four stocks recognized, of which the Bering-Chukchi-Beaufort stock occurs within the PFRR launch corridor. Based on a bowhead whale census in 2001, the population growth rate was estimated to be about 3.4 percent and the estimated population size, 10,470 **(George *et al.* 2004)**, revised to 10,545 by **Zeh and Punt (2005)**. Most of the western Arctic bowhead whales migrate annually from wintering areas in the northern Bering Sea, through the Chukchi Sea in the spring, and into the Beaufort Sea, where they spend the summer. In autumn, they migrate through nearshore and offshore waters of the Beaufort Sea to return to their wintering grounds in the Bering Sea. Alaskan coastal villages along this migratory route, mainly Kaktovik, participate in traditional subsistence hunts of these whales **(Angliss and Allen 2009)** along the coast of the Beaufort Sea and within the PFRR launch corridor. Bowheads appear to migrate farther offshore during heavy-ice years and nearer shore during years of light sea ice **(Treacy *et al.* 2006)**.

4.1.2. Ringed Seal

Ringed seals *(Phoca hispida)* have a circumpolar distribution and are year-round residents of the Beaufort Sea, where they are the most commonly encountered seal species in the area. No reliable population size estimate of the Alaska ringed seal stock is currently available **(Angliss and Allen 2009)**. Ringed seal population estimates in the Bering-Chukchi-Beaufort area ranged from 1–1.5 million **(Frost 1985)** to 3.3–3.6 million **(Frost *et al.* 1988)**. **Frost and Lowry (1981)** estimated the population in the Alaskan Beaufort Sea to be 80,000 during the summer and 40,000 during the winter. More recent estimates based on extrapolation from aerial surveys and on predation estimates for polar bears **(Amstrup 1995)** suggest an Alaskan Beaufort Sea population of approximately 326,500 animals. NMFS is considering listing the Alaska stock of ringed seals species under the ESA due to the potential loss of seal habitats resulting from current warming trends. On December 10, 2010, NMFS published a proposed rule to list three subspecies of the ringed seal as threatened under the ESA **(75 FR 77496)**. This proposed listing includes the Arctic subspecies *(Phoca hispida hispida)*, the distribution of which includes the Beaufort Sea. Ringed seal densities depend on food availability, water depth, ice stability, and distance from human disturbance. Seal densities reflect changes in the ecosystem's overall productivity in different areas **(Stirling and Oritsland 1995)**. When sexually mature, they establish territories during the fall and maintain them during the pupping season (time of year seals give birth to seal pups). Pups are born in late March and April in lairs that seals excavate in snowdrifts and pressure ridges. During the breeding and pupping season, adults on shorefast ice (floating ice attached to land) usually move less than individuals in other habitats. In this habitat, they depend on a relatively small number of holes and cracks in the ice for breathing and foraging. During nursing (4 to 6 weeks), pups usually stay in the birth lair. This species is a major resource harvested by Alaskan subsistence hunters. Ringed seal is also the chief prey species for polar bears.

4.1.3. Bearded Seal

Bearded seals *(Erignathus barbatus)* are the largest of Alaska's seals, weighing up to 340 kilograms (750 pounds). Bearded seals are found throughout the Arctic Ocean and usually prefer areas of less stable or broken sea ice, a zone where breakup occurs early **(Cleator and Stirling 1990)**. Most of the 300,000 to 450,000 bearded seals estimated to occur in the Alaskan outer continental shelf area are found in the Bering and Chukchi Seas **(USDOI 1996)**. Reliable estimates of the abundance of bearded seals in Alaska Beaufort Sea waters currently are unavailable, although bearded seals are reported annually during aerial surveys for other marine mammals. Seasonal movements of bearded seals are directly related to water depth and the advance and retreat of sea ice **(Boveng *et al.* 2009)**. During winter, most bearded seals in Alaskan waters are found in the Bering Sea. Favorable conditions are more limited in the Chukchi and Beaufort Seas, and consequently, bearded seals are not abundant there during winter. Pupping takes place on the ice from late March through May, mainly in the Bering and Chukchi Seas, although some pupping might take place in the Beaufort Sea. Bearded seals do not form herds, but sometimes form loose groups. Bearded seals are a main subsistence resource and a highly valued food of subsistence hunters. The form of bearded seal that occurs in the Beaufort Sea under the PFRR launch corridor is part of the Beringia Distinct Population Segment of *Erignathus barbatus barbatus*, which was proposed for listing as endangered on December 10, 2010 **(75 FR 77496)**.

4.2. Species under USFWS Jurisdiction

4.2.1. Polar Bear

Polar bears *(Ursus maritimus)* and are the top predator in the Arctic ecosystem and the largest land carnivore in the world. Occurring in 19 relatively discrete subpopulations, polar bears have a circumpolar Arctic distribution. The total number of polar bears worldwide is estimated to be between 20,000 and 25,000 **(Schliebe *et al.* 2008)**. The subpopulation ranges overlapping the action area are the Southern Beaufort Sea (SBS), Northern Beaufort Sea (NBS), and Arctic Basin (AB). The most recent population estimate for the SBS subpopulation is approximately 1,526 **(Regehr *et al.* 2006)**; 980 for the NBS subpopulation **(Stirling *et al.* 2011)**; and unknown for the AB.

Polar bears are classified as marine mammals because of their dependence on sea ice; as such, they are protected under MMPA as well as the ESA. On May 15, 2008, USFWS listed the polar bear as threatened throughout its range under the ESA **(73 FR 28212)**. The listing is in part a response to increased concerns about the effect of climate change on sea ice. Sea ice provides a hunting platform for polar bears and has been in decline in recent years. A polar bear's diet is made up almost exclusively of marine mammals, mainly ice seals that also depend on sea ice habitat. Additionally, sea ice provides a portion of winter denning habitat for pregnant female polar bears. On November 24, 2010, USFWS announced the designation of 484,000 square kilometers (187,000 square miles) of polar bear critical habitat containing sea ice, terrestrial denning habitat, and barrier islands. The designated critical habitat occurs under the northern portion of the PFRR launch corridor **(Figure 10)**. The critical habitat includes the Beaufort Sea and land within 32 kilometers (20 miles) inland from the Beaufort Sea coast within the PFRR launch corridor. For purposes of this BA, NASA assumes polar bears may occur up to 40 kilometers (25 miles) inland from the Beaufort Sea coast **(USFWS 2011c)**.

Polar bear movements are influenced by sea ice conditions and follow a predictable seasonal pattern. In July and August, polar bears move offshore as the pack ice recedes. In the case of the SBS and CBS populations, polar bears may move hundreds of miles to stay with the ice during summer. From August through October, polar bears hunt ringed seals (their most important prey species) near shore in areas of unstable ice and leads between ice floes. From November to June, male polar bears remain on offshore ice. Years with less sea ice seem to result in bears being on land for longer periods of time. Their preferred habitat is the annual ice over the relatively shallower waters of the continental shelf and inter-island channels, where biological productivity is higher and seals are more abundant than in the deep polar basin **(Stirling and Øritsland 1995)**.

Mating occurs from March to May **(Ramsay and Stirling 1986)**. Approximately 50 percent of females den on drifting pack ice from November until April, although evidence suggests that this number is decreasing with recent changes in sea ice extent and distribution **(Fischbach *et al.* 2007)**. The remaining females that are in reproductive condition den on land from November through April then move offshore.

November through April is the most sensitive period of the year for polar bears. Dens are dug in snow drifts in areas of shallow relief along sea ice pressure ridges, creek and stream banks, river bluffs, and shorelines. Cubs are born in December and continue to develop in the den until April. Dens have been located up to 40 kilometers (25 miles) inland in landscape features that trap drifting snow in sufficient depth to allow a female polar bear to dig a den **(Durner *et al.* 2006)**. The highest density of land dens in Alaska occurs along the coastal barrier islands of the eastern Beaufort Sea and within Arctic NWR **(Angliss and Allen 2009)**.

Current regulations prohibit work activities within a 1.6-kilometer (1-mile) radius of a known den location. Denning females are sensitive to disturbance and may abandon cubs if disturbed. Cubs are very vulnerable at this stage, so protection of the maternal den habitat is vital to polar bear conservation **(Angliss and Allen 2009)**. The results of surveys for polar bears confirm that large numbers of polar bears aggregate around Barter Island (on which Kaktovik is located) and Cross Island (west of the ROI between Prudhoe Bay and Point Barrow), probably due to the presence of hunter-harvested bowhead whale remains, which provide an alternate food source for polar bears.

4.2.2. Spectacled Eider

Spectacled eiders *(Somateria fischeri)* are large sea ducks and rare breeder and uncommon visitor along Alaska's north coast. They spend most of the year in marine waters feeding on bottom-dwelling mollusks and crustaceans. Nesting and breeding typically occur in wet coastal tundra to the west of the PFRR launch corridor, although the historical range extended along the Arctic coastal plain, including the coastal portion of the PFRR launch corridor, nearly as far east as the Canadian border **(USFWS 2011a)**. Critical habitat designated for this species is far outside the boundaries of the PFRR launch corridor. Primary molting areas are generally west and south of Point Lay, well outside of the action area. Spectacled eiders winter primarily in the Bering Sea, moving far offshore, following areas of open water **(USFWS 2011a)**.

4.2.3. Steller's Eider

Although formerly considered locally common at a few sites on both the Yukon-Kuskokwim Delta in western Alaska and the Arctic coastal plain of northern Alaska, Steller's eiders *(Polysticta stelleri)* have nearly disappeared from most nesting areas in Alaska **(USFWS 2011b)**, and the Alaska population is listed as threatened. Of the world breeding population of Steller's eiders, most nest in Russia. The nearest known nesting area is located to the west of the action area at Prudhoe Bay. Molting and wintering is in the southern Alaska from the eastern Aleutians to the lower Cook Inlet, well outside of the action area.

4.2.4. Yellow-Billed Loon

The yellow-billed loon *(Gavia adamsii)* is listed as a candidate species. Feeding mostly on small fish and invertebrates, it breeds in low densities in coastal and inland low-lying tundra within the arctic coastal plain of Alaska. The greatest breeding concentrations in Alaska are found on the North Slope, with highest densities between the Meade and Ikpikpuk rivers, on the Colville River Delta, and in areas west, southwest and east of Teshekpuk Lake **(USFWS 2006)**. These areas are west of the action area. It is possible that individuals may migrate through coastal plain portion of the action area during either spring or fall migration. The wintering range includes coastal waters of southern Alaska from the Aleutian Islands to Puget Sound, well outside of the action area.

5. Effects of the Action

This section addresses potential impacts on listed, proposed, and candidate endangered or threatened species that NOAA Fisheries and USFWS have identified as having the potential to occur within the action area. There are no listed, proposed, or candidate species known to live in the vicinity of the PFRR launch site or under the launch corridor until it approaches the coast of the Beaufort Sea. Of the species discussed in Section 4 of this BA, only the ringed seal (proposed threatened) and the polar bear (threatened) have the potential to occur year-round within the action area and could be affected by descending payloads or spent stages.

The bowhead whale (endangered), bearded seal (proposed endangered), and yellow-billed loon (candidate) are summer residents and would be absent during the winter season when launches would occur. Spectacled and Steller's eiders (threatened) are accidental in occurrence and uncommon within the action area. They would also most likely be present during the summer months, if they were present at all. Therefore, given these species' seasonal absence from the action area, they will not be discussed further.

5.1. Species under NOAA Fisheries' Jurisdiction

5.1.1. Ringed Seal

Potential impacts on ringed seals from launch operations would be associated with re-entering payloads and/or stages landing within seal habitat, and more specifically, seal concentration areas. During the months when the sea ice extends to the coast (October to June), ringed seals tend to concentrate on shorefast ice adjacent to the coastal areas of Alaska **(Marz 2004)**. From July to September, when the sea ice retreats northward and large stretches of open water appear along the coast, the seals tend to expand their range both northward and westward, diminishing their overall density in the project area.

Probability of Impact

To evaluate the probability of a direct impact adversely affecting a ringed seal, a typical 3-sigma impact ellipse was created for a spent stage or payload predicted to land in the Beaufort Sea (1,000 kilometers [621 miles] from PFRR). The large size of this ellipse (over 500,000 square kilometers [190,000 square miles]) is due to the various factors (such as winds) that affect the flight and descent of the unguided rocket. The impact point location is typical of launches from PFRR into the Beaufort Sea. Of the 24,000-square-kilometer (9,400-square-mile) winter habitat concentrated along the coast, only 45 square kilometers (17 square miles) were intersected by the ellipse (see **Figure 4**). This equates to a probability of approximately 2.0×10^{-5} (one chance in 50,000 per launch) that a spent stage or payload would land within the winter concentration area of the ringed seals (see **Table 1**).

It is possible that ringed seals could exist throughout the entire Beaufort Sea on sea ice during the winter. Expected density values for ringed seal in areas of concentrated occurrence in the Beaufort Sea are 0.35 individuals per square kilometer (average density) and 1.42 individual per square kilometer (maximum density) for nearshore areas, where the seals are most concentrated, and 0.25 individuals per square kilometer (average density) and 1.00 individual per square kilometer (maximum density) for ice margins **(Shell Exploration and Production, Inc. and LGL Alaska Research Associates, Inc. 2010, referencing Moulton and Lawson [2002] and Kingsley [1986])**. Assuming a conservative density of 1 individual per square kilometer throughout the Beaufort Sea and Arctic Ocean and allowing for a 10-meter (33-foot) radius buffer zone around each seal, the per-launch chance of an impact near a ringed seal is very low, approximately 3.1×10^{-4}, or 1 chance in 3,200 (see **Table 1**).

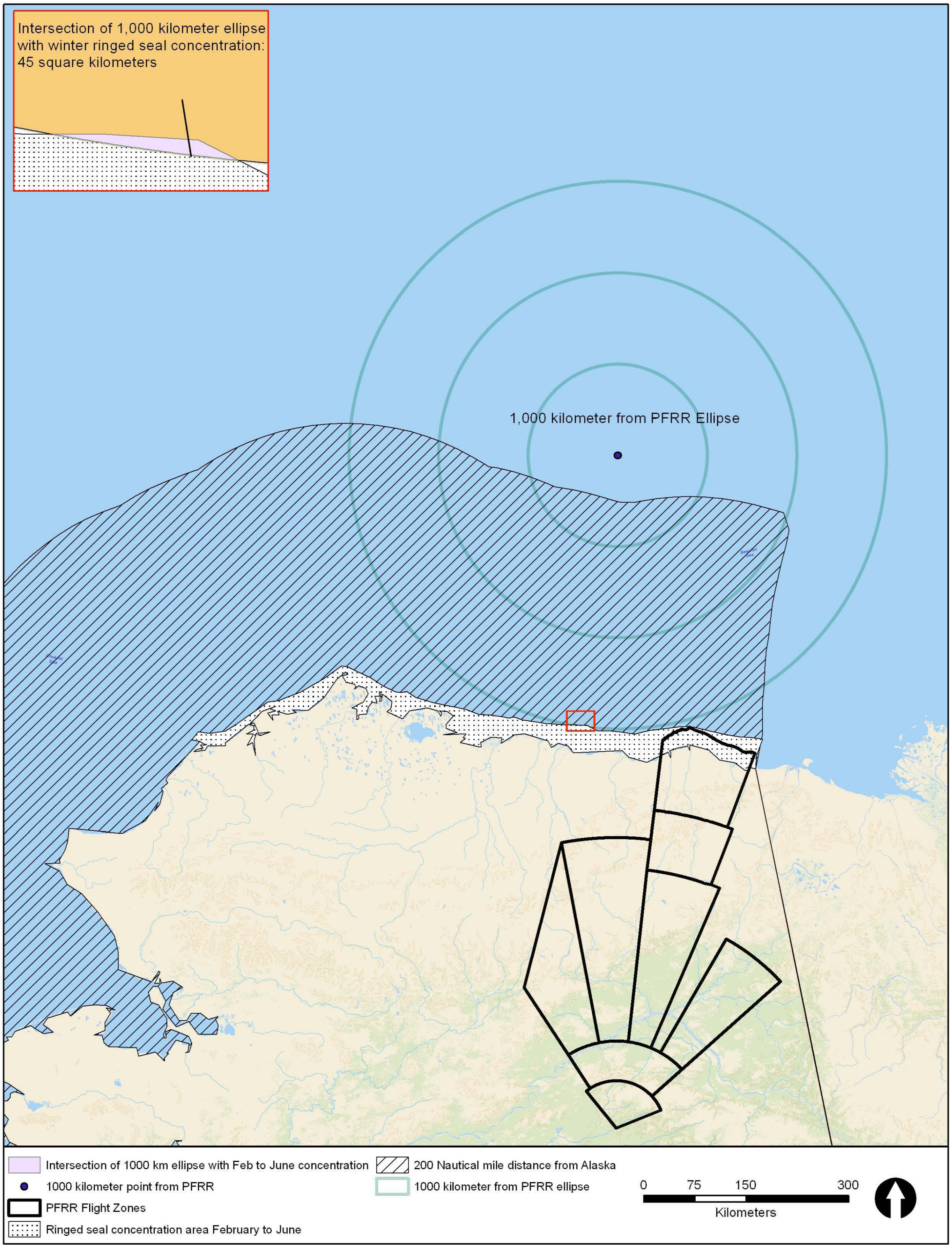

Figure 9. Typical Offshore Impact Location with Respect to Highest Winter Ringed Seal Concentration (adapted from Smith 2010)

Table 1. Probability of Impact on Ringed Seals in the Beaufort Sea

Ringed Seal Resource	Potential Impact Ellipse (square kilometers)	Ringed Seal Resource Area (square kilometers)	Probability of Spent Stage or Payload Impacting Ringed Seal Resource
Nearshore ice [a]	503,375	45	2.0×10^{-5}
Individual within 3-Sigma Dispersion [b]	503,375	159	3.1×10^{-4}

a. Assumed to be concentrated on the nearshore ice during the winter months. Wintering concentration areas for the ringed seal *(Pusa hispida)* were interpreted and mapped from **Smith *et al.* 2010**, Figure 37.

b. Based on information collected over the years, a population density of 1 ringed seal per square kilometer was assumed across the entire Beaufort Sea **(Shell Exploration and Production, Inc. and LGL Alaska Research Associates, Inc. 2010)** within the typical 3-sigma dispersion. Assuming a safety zone within a 10-meter (33-foot) radius of seal, the potential area of disturbance around a ringed seal that could result in either injury or death is estimated to be approximately 315 square meters (380 square yards) per seal, or 159 square kilometers (61 square miles) for the approximately 503,375 ringed seals that could be within the impact ellipse.

Note: To convert kilometers to miles, multiply by 0.62137; square kilometers to square miles, by 0.38610.

Sounding Rocket-Generated Sound

Sounding rockets reach supersonic speeds very quickly (i.e., after several seconds); however they generally would not generate a sonic boom noticeable on the ground due to their high angle of ascent **(Downing 2011)**. As long as the rockets motors are burning, noise would be generated, especially at the lower altitudes when the air density is appreciable. Above a 10-kilometer (6-mile) altitude, where vacuum conditions are approached, no sound would be propagated. A typical Black Brant XII would be expected to reach this altitude at just over 25 seconds of flight time, well south of the action area **(Figure 1)**. When the rockets motors are no longer burning, only aerodynamic noise will prevail.

The ballistic re-entry of a representative stage or payload would generate a mild sonic boom (0.2 pounds per square foot) at an altitude between 18,000 m (60,000 ft) and 9,000 m (30,000 ft) AGL. The peak instantaneous sound pressure received on the ice would be approximately 114 dB and be of very low frequency (less than 100 Hz) **(Downing 2011)**. The duration on the low frequency sound would be very brief at approximately 30 milliseconds. In an unrelated study of sonic booms of similar magnitude, observers on the ground who were operating the sonic boom recording equipment within the predicted footprint of the sounding rocket boom "heard the boom but felt that they would not have noticed it had they been engaged in an unrelated activity" **(Plotkin *et al.* 2006)**. By comparison, sonic booms generated by supersonic aircraft typically have overpressures 5 to 10 times as large (5 to 10 kilograms per square meter [1 to 2 pounds per square foot]) and last for 100 to 500 milliseconds.

In addition to the sonic boom, the stage or payload would eventually land on the presumably frozen surface of snow-covered ice, generating a momentary impulse sound estimated to be 131 dB (at 15 m [50 ft] distance from the impact site) in air; 192 dB in the water below the impact site. This conservative estimate is based upon the kinetic energy of the impacting piece of flight hardware.

Applicable Regulatory Criteria

Under the MMPA, NOAA Fisheries has defined levels of harassment for marine mammals. Level A harassment is defined as "…any act of pursuit, torment, or annoyance which has the potential to injure a marine mammal or marine mammal stock in the wild." Level B harassment is defined as "…any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering." NOAA Fisheries has adopted the MMPA take definition for assessing effects on ESA listed marine mammals.

Since 1997, NOAA Fisheries has been using generic sound exposure thresholds to determine when an activity in the ocean produces sound potentially resulting in impacts to a marine mammal and causing take by harassment **(70 FR 1871)**. The current Level A (injury) threshold for underwater impulse noise is 190 dB root mean square (rms) for pinnipeds (e.g., seals). The current Level B (disturbance) threshold for underwater impulse noise is 160 dB rms for cetaceans and pinnipeds.

In addition, NOAA Fisheries is developing new science-based thresholds to improve and replace the current generic exposure level thresholds, but the criteria have not been finalized **(Southall *et al.* 2007)**. Based upon the recommendations of the referenced study, the generic exposure criteria are likely conservative, however they are currently in use by NOAA Fisheries for ESA consultations. Therefore, this BA assesses potential effects within the context of both the generic and the science-based criteria.

Physiological Effects

A primary concern of sound exposure on pinnipeds is whether the source would result in either temporary or permanent hearing loss. Although based upon the conservatively derived source levels from flight hardware impacting the sea ice, it is possible that individuals directly under the area of impact could be exposed to levels above the 190 dB Level A threshold (which in essence would be equivalent to a direct hit), it is highly unlikely that this would occur based upon the probability of impact calculations presented in **Table 1**.

Regarding science-based criteria, **Southall *et al.* (2007)** proposed a 149 dB exposure criterion for assessing the potential injury to pinnipeds in air exposed to a single sound pulse. Likewise, a similar conservative criterion for injury (218 dB) was suggested for pinnpeds in water. Therefore, when considered within the context of these recommended criteria, the expected sonic boom and snow/ice impact of a re-entering sounding rocket payload or stage would cause no temporary or permanent hearing damage to ringed seals.

Behavioral Effects

Similar to the discussion of potential physiological effects from the impact of a flight hardware on the sea ice, it is likely that the sound levels in the immediate vicinity of the landing site would exceed the 160 dB criterion that is used to gauge a behavioral response, however as shown in **Table 1**, the chance of landing near an individual such that it would be exposed to elevated sound levels would be slight.

Regarding science-based criteria, the same study **(Southall *et al.* 2007)** also proposed a 109 dB criterion for single pulse sound behavioral disturbance of pinnipeds in air. The criterion, noted by the authors as likely conservative, was mostly based upon observation of strong responses (e.g., stampeding behavior) of some species, especially harbor seals, to sonic booms from aircraft and missile launches in certain conditions **(Berg *et al.*, 2001, 2002; Holst *et al.*, 2005a, 2005b)**. A 212 dB criterion for pinnipeds in water was proposed based upon the level at which some temporary hearing effects may be observed in some species.

The most notable sound-related behavioral response for out-of-water seals would be the potential for trampling and/or separation of young from females, especially following birth. PFRR launch operations could overlap the general birthing and suckling period (i.e., mid-March to April). During much of this time, female seals and their young remain in snow dens, which have been found to be very effective in muffling sound **(Blix and Lentfer 1992)**. In the referenced article, the authors highlight one particular event during which a helicopter noise level of 115 dB was reduced to 77 dB in an artificial polar bear den covered by less than 1 m (3 ft) of snow just 3 m (10 ft) away. The snow dens were also found to be effective in absorbing vibration. Even with relatively modest attenuation, it may be concluded that in-den received sound levels from an incoming sounding rocket section would be below the criteria proposed by **Southall *et al.* (2007)** and would have negligible adverse effects. Furthermore, as nearly all of the sound energy of the sonic boom is below 75 Hz (the minimum estimated range of hearing as presented in **Southall *et al.* [2007]**), it is doubtful that boom-induced sounds received outside of dens would be detected by seals. Impacts on in-water seals would be negligible as source levels of the impacting flight hardware are estimated to be below the 212 dB recommended criterion.

In summary, the sound resulting from the impact on the snow and ice would not be expected to cause adverse effects on individuals in or out of water. Although this analysis cannot discount the possibility that ringed seals would hear the sounds generated by stage and payload reentry, it is reasonable to conclude that such effects would be temporary and similar to other natural sounds in their marine environment, such as the sounds of ice cracking, popping, and colliding **(Greening and Zakarauskas 1994; Milne 1972; Milne and Ganton 1964; Xie and Farmer 1991)**.

<u>Effects of Remaining Flight Hardware</u>

Although a re-entered sounding rocket payload is unlikely to fully penetrate the sea ice, given the buildup of heat generated by friction with the atmosphere, some items may be expected to sink into the ice where they would eventually be frozen over and covered by drifting or blown snow. Other items would remain on the ice surface until covered by snow and would remain there until the summer thaw. This is the same expected fate of a spent rocket stage, with the exception that it would be less susceptible to breakup.

Based on the melting patterns of sea ice in the Beaufort Sea over the last few years **(NSIDC 2011)**, over 80 percent of the payloads and spent fourth stages are expected to land on sea ice that melts annually, at which time they would sink to the bottom of the ocean. Employing the same analysis, less than 20 percent of the payloads and spent fourth stages are expected to land on "permanent" ice. Assuming an average of four launches per year, the maximum number of items that would enter the Beaufort Sea annually would be four payloads and up to four spent stages (from the final stage).

Payloads and spent stages that enter the marine environment are expected to reach the ocean floor and lodge in oxygen-poor sediments or remain on the ocean floor and corrode or become encrusted by marine organisms. In nearly all cases, these items would ultimately be interred at water depths greater than 300 m (1,000 ft). Under normal conditions, spent stages are essentially inert steel tubes with an electronic system on the forward end, which contains batteries and wiring. Payloads contain small quantities of batteries and other materials that would gradually enter the water column, resulting in limited and localized contamination that would be rapidly dispersed by currents.

Summary

Considering the low per-launch probability of landing near an individual, the limited number of launches per year (an average of four), the relatively small size of spent stages and payloads, and the largely inert or non-reactive nature of the items, negligible adverse impacts on ringed seals and their habitat are anticipated.

5.2. Species under USFWS Jurisdiction

5.2.1. Polar Bear

Potential impacts on polar bears from launch operations would be associated with re-entering payloads and/or stages landing within their habitat. Given their trophic relationship to ringed seals, during the winter months polar bears are also in greatest concentrations along the coast. Defined by the offshore extent of the 300 m (1,000 ft) depth contour **(Regehr *et al.* 2006)**, this area of preferred habitat also corresponds with the boundaries of designated critical feeding habitat. Within the general extent of this preferred area is where the majority (70-80 percent) of individuals would be expected to occur based on past observations **(Durner *et al.* 2009)**.

Probability of Impact

To quantify potential impacts on polar bears, NASA performed a similar probability calculation to that described for ringed seals. **Table 2** shows the probability of a typical spent stage or payload landing within polar bear critical habitat. Typically these items would land far offshore in the Beaufort Sea or Arctic Ocean but there is a small chance that they could land closer to shore in areas that include designated critical feeding and denning habitat. Critical denning habitat would not typically be affected by these launches as it is outside the 3-sigma dispersion. The chance that one of these launches would typically impact designated critical feeding habitat is less than one chance in 150 (6.6×10^{-3}).

The probability of a piece of flight hardware landing on a polar bear den was also estimated using information on known polar bear dens in the area. The chance that one of these launches directly impacting a polar bear den is less than one chance in 21 million (4.6×10^{-8}).

Table 2. Probability of Impact on Polar Bear Critical Habitat and Dens

Distance from the PFRR Launch Site (kilometers)	Polar Bear Critical Habitat	Potential Impact Ellipse (square kilometers)	Amount of Polar Bear Critical Habitat Within Ellipse (square kilometers)	Probability of a Spent Stage or Payload Landing in Polar Bear Critical Habitat
1,000	Feeding habitat	503,375	14,964	6.6×10^{-3}
1,000	Denning habitat	503,375	0	0
1,000	Polar bear dens within potential impact area[a]	503,375	0.022	4.6×10^{-8}

a. An estimated 69 known polar bear dens could be within the area potentially impacted by a typical National Aeronautics and Space Administration launch into the Beaufort Sea (Based on information from **Amstrup and Gardner 1994**) based on information collected over the years by the National Oceanic and Atmospheric Administration. Assuming each den covers an area of approximately 3 square meters (30 square feet) **(Stirling 1988)**; this analysis assumes a safety zone within a 10-meter (33-foot) radius of the den. The potential area of disturbance around a polar bear den that could result in either damage to the den or injury or death to the polar bear is estimated to be approximately 315 square meters (380 square yards) per den, or 0.022 square kilometers (0.0085 square miles) for 69 dens.

Note: To convert kilometers to miles, multiply by 0.62137; square kilometers to square miles, by 0.38610.

In addition, **Figure 10** provides a graphic representation of the analysis presented in **Table 2**.

This analysis shows that the potential for direct impact on polar bears or their critical habitat would be very low.

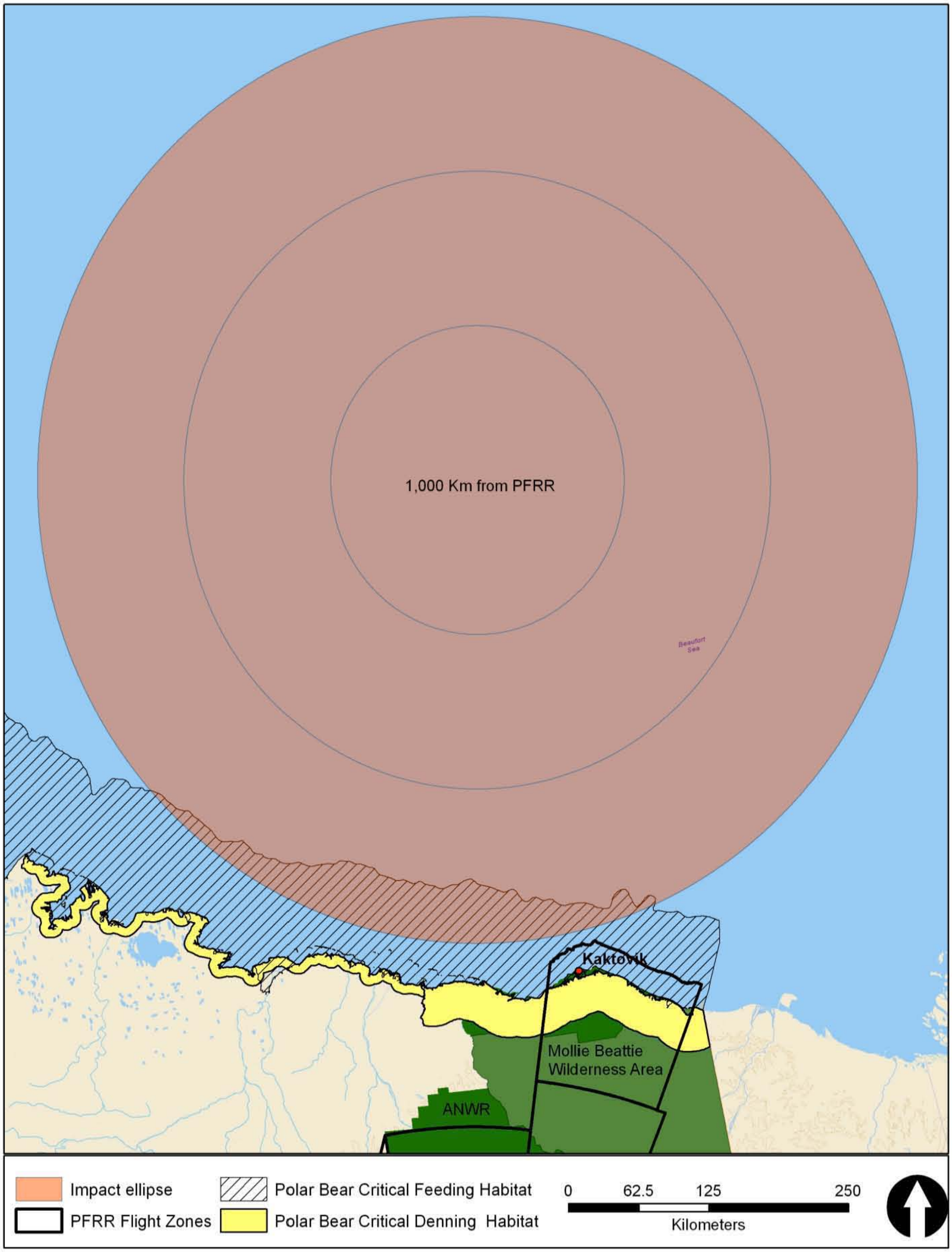

Figure 10. Likelihood of a Spent Stage or Payload Landing within Polar Bear Critical Habitat

Effects of Sound

Sounds associated with an incoming spent stage or payload are discussed in **Section 5.1.1** of this BA under *Sounding Rocket-Generated Sound*.

Polar bears have relatively acute hearing (**Nachtigall *et al.* 2007; Owen and Bowles 2011**). As with ringed seals, the primary noise-induced, disturbance-related concern would be the time following the birth of young, which generally occurs in December or early January **(Ramsay and Dunbrack 1986)**. The cubs remain in dens for several months following birth and therefore are potentially vulnerable to disturbances near dens **(Amstrup 1993)**.

As summarized under the discussion of potential effects on Ringed seals, **Blix and Lentfer (1992)** observed that only seismic testing less than 100 m (330 ft) from a den and a helicopter taking off at a distance of 3 m (10 ft) produced noises inside artificial dens that were notably above background levels. The authors also concluded that a polar bear in its den is unlikely to feel vibrations unless the source is very close. Supporting their findings is **Amstrup (1993)** and **(MacGillivray *et al.* 2003)**, both of which also reported that polar bears residing within dens are well insulated from outside sound and vibration.

Similar to the analysis for ringed seals, this analysis cannot discount the possibility that a polar bear would hear the sounds generated by stage and payload reentry, however it is reasonable to conclude that such effects would be temporary, minor, and similar to other natural sounds in their marine environment, such as the sounds of ice cracking, popping, and colliding **(Greening and Zakarauskas 1994; Milne 1972; Milne and Ganton 1964; Xie and Farmer 1991)**. Therefore, effects of sound would be negligible.

Effects of Remaining Flight Hardware

A potential concern could be flight hardware - related injury as polar bears are curious animals that typically investigate objects or smells that catch their attention **(Stirling 1988)**. Polar bears have been observed to ingest a wide range of indigestible and hazardous materials and to feed at dumps (**Clarkson and Stirling 1994**). Instances of polar bear injury related to human made materials (e.g., pieces of a lead battery, ethylene glycol antifreeze) have been documented (**Amstrup *et al.* 1989**). However, these have been in unnatural settings (including roadsides treated with antifreeze and dye and the Churchill, Manitoba, municipal landfill) that are much different from the habitat within the PFRR flight corridor. The dump example involved individual bears habituated to finding supplemental food in landfills (**Lunn and Stirling 1985**).

Payloads and spent stages that land on sea ice would be unlikely to harm a polar bear in the unlikely event that an individual polar bear were to encounter one. The item is expected to rapidly become covered by ice or drifting snow, essentially isolating it from the environment. As the ice melts the rocket hardware would subsequently enter the marine environment, as discussed above for Ringed seals. Any accumulation of spent stages or payloads that remained would be on the permanent sea ice approximately 400 kilometers (250 miles) from the coast and over 300 kilometers (185 miles) from the nearest designated Critical Habitat (based on information from **NSIDC [2011]**).

Assuming four launches per year, the maximum number of items that would enter the Beaufort Sea annually would be four payloads and up to four spent stages (from the final stage). Typical water depths within these areas would be at least 300 m (1,000 ft). As discussed earlier, payloads and spent stages that enter the marine environment would sink to the bottom and be rapidly colonized by benthic encrusting organisms and become part of the substratum. Unrecovered payloads contain materials (e.g., batteries) that would result in limited and localized contamination as the materials gradually enter the aquatic environment. Considering the limited number of launches per year, the relatively small size and wide spatial dispersion of spent stages and payloads, and the largely inert or non-reactive nature of the items, no impacts on polar bears from these items on the ice or entering the marine environment are anticipated.

Summary

Considering the low per-launch probability of landing near an individual or within designated critical habitat, the limited number of launches per year (an average of four), the relatively small size and wide dispersion of spent stages and payloads, and the largely inert or non-reactive nature of the items, negligible adverse impacts on polar bears and their habitat are anticipated.

Regarding potential indirect effects, the analysis of potential effects on ringed seals (the polar bear's primary food source during the winter months) would also be negligible (see **Section 5.1.1** of this BA), rendering any resultant effects on the polar bear to be nearly non-existent.

5.3. Conclusion and Determinations of Effect

Based upon the analyses contained within this document, NASA expects the effects from its SRP at PFRR on ESA listed, proposed, and candidate species to be negligible. **Table 3** below presents a summary of its determinations:

Table 3. Summary of Endangered Species Act Determinations for Listed, Proposed, and Candidate Species Potentially Occurring within PFRR Flight Corridor

Species	ESA Status	Agency with ESA Jurisdiction	NASA ESA Determination
Bowhead whale	Endangered	NOAA Fisheries	No effect (seasonal absence)
Ringed seal	Proposed Threatened	NOAA Fisheries	Not likely to jeopardize continued existence of
Bearded seal	Proposed Endangered	NOAA Fisheries	No effect (seasonal absence)
Polar bear	Threatened	USFWS	May affect, not likely to adversely affect
Polar bear critical habitat	Designated	USFWS	May affect, not likely to adversely affect
Spectacled eider	Threatened	USFWS	No effect (seasonal absence)
Steller's eider	Threatened	USFWS	No effect (seasonal absence)
Yellow-billed loon	Candidate	USFWS	No effect (seasonal absence)

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