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DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration

RIN 0648-XF507

Takes of Marine Mammals Incidental to Specified Activities; Taking Marine Mammals Incidental to Boost-Back and Landing of Falcon 9 Rockets

AGENCY: National Marine Fisheries Service (NMFS), National Oceanic and Atmospheric Administration (NOAA), Commerce.

ACTION: Notice; issuance of an incidental harassment authorization.

SUMMARY: In accordance with the regulations implementing the Marine Mammal Protection Act (MMPA) as amended, notification is hereby given that NMFS has issued an incidental harassment authorization (IHA) to Space Exploration Technology Corporation (SpaceX) to incidentally harass, by Level B harassment only, marine mammals during boost-back and landing of Falcon 9 rockets at Vandenberg Air Force Base in California, and at contingency landing locations in the Pacific Ocean.

DATES: This Authorization is valid from December 1, 2017, through November 30, 2018.

FOR FURTHER INFORMATION CONTACT: Jordan Carduner, Office of Protected Resources, NMFS, (301) 427-8401. Electronic copies of the application and supporting documents, as well as a list of the references cited in this document, may be obtained online at: *www.nmfs.noaa.gov/pr/permits/incidental/research.htm*. In case of problems accessing these documents, please call the contact listed above.

SUPPLEMENTARY INFORMATION:

Background

Sections 101(a)(5)(A) and (D) of the MMPA (16 U.S.C. 1361 *et seq*.) direct the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if certain findings are made and either regulations are issued or, if the taking is limited to harassment, a notice of a proposed authorization is provided to the public for review.

An authorization for incidental takings shall be granted if NMFS finds that the taking will have a negligible impact on the species or stock(s), will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses (where relevant), and if the permissible methods of taking and requirements pertaining to the mitigation, monitoring and reporting of such takings are set forth.

NMFS has defined "negligible impact" in 50 CFR 216.103 as an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival.

The MMPA states that the term "take" means to harass, hunt, capture, kill or attempt to harass, hunt, capture, or kill any marine mammal.

Except with respect to certain activities not pertinent here, the MMPA defines "harassment" as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (ii) 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 (Level B harassment).

Summary of Request

NMFS received a request from SpaceX for an IHA to take marine mammals incidental to Falcon 9 First Stage recovery activities, including in-air boost-back maneuvers and landings of the First Stage of the Falcon 9 rocket at Vandenberg Air Force Base (VAFB) in California, and at contingency landing locations offshore. SpaceX's request was for harassment only and NMFS concurs that mortality is not expected to result from this activity. Therefore, an IHA is appropriate.

SpaceX's application for incidental take authorization was received on July 11, 2017. SpaceX submitted a revised version of the request on October 13, 2017. This revised version of the application was deemed adequate and complete. The planned activity may exceed one year, hence subsequent MMPA incidental harassment authorizations may be requested for this particular activity.

The planned activities include in-air boost-back maneuvers and landings of the First Stage of the Falcon 9 rocket. The action may occur as many as 12 times and may occur at any time of year. Species that are expected to be taken by the planned activity include harbor seal, California sea lion, Steller sea lion, northern elephant seal, northern fur seal, and Guadalupe fur seal. SpaceX's activities are expected to produce noise, in the form of sonic booms, that are expected to result in harassment of marine mammals that are hauled out of the water. Take by Level B harassment only is expected; no injury or mortality of marine mammals is expected to result from the activities.

This is the second IHA issued by NMFS for this activity. SpaceX applied for, and was granted, an IHA in 2016 that was valid from June 30, 2016 through June 29, 2017 (81 FR 34984; June 30, 2016). SpaceX complied with all the requirements (*e.g.*, mitigation, monitoring, and reporting) of the previous IHA.

Description of Activity

The Falcon 9 is a two-stage rocket designed and manufactured by SpaceX for transport of satellites and SpaceX's Dragon spacecraft into orbit. SpaceX currently operates the Falcon Launch Vehicle Program at Space Launch Complex 4E (SLC-4E) at VAFB. SpaceX plans to conduct recovery of the Falcon 9 First Stage by returning the First Stage to SLC-4 West (SLC-4W) at VAFB for potential reuse, up to twelve times per year. This includes performing in-air boost-back maneuvers and landings of the Falcon 9 First Stage on the pad at SLC-4W. The reuse of the Falcon 9 First Stage enables SpaceX to efficiently conduct lower cost launch missions from VAFB in support of commercial and government clients.

Although SLC-4W is the preferred landing location, SpaceX has identified the need for contingency landing locations should it not be feasible to land the First Stage at SLC-4W. The first contingency landing option is on a barge located at least 27 nautical miles (nm) (50 kilometers (km)) offshore of VAFB. The second contingency landing option is on a barge within the Iridium Landing Area, an area approximately 33,153 square kilometers (km^2) area that is located approximately 122 nm (225 km) southwest of San Nicolas Island and 133 nm (245 km) southwest of San Clemente Island (see Figure 1-3 in the IHA application).

During descent, a sonic boom (overpressure of high-energy impulsive sound) would be generated when the First Stage reaches a rate of travel that exceeds the speed of sound. Sonic booms would occur in proximity to the landing areas and may be heard during or briefly after the boost-back and landing, depending on the location of the observer. Sound from the sonic boom has the potential to result in harassment of marine mammals, either on the mainland at or near VAFB, or at the Northern Channel Islands (NCI). Based on model results, a boost-back and landing of the Falcon 9 First Stage at SLC-4W would produce sonic booms with overpressures

that would potentially be as high as 8.5 pounds per square foot (psf) at VAFB and potentially as high as 3.1 psf at the NCI. Sonic boom modeling indicates that landings that occur at either of the proposed contingency landing locations offshore would result in sonic booms below 1.0 psf. Take of marine mammals that are hauled out of the water are expected to occur only when those hauled out marine mammals experience sonic booms greater than 1.0 psf (this is discussed in greater detail below in the section on Estimated Take). Therefore, take of marine mammals may occur as a result of landings that occur at VAFB; however, take of marine mammals is not expected to occur as a result of landings that occur at either of the proposed contingency landing locations offshore. Sounds resulting from SpaceX's activities other than sonic booms, as well as other aspects of SpaceX's activities such as unsuccessful landings, are not expected to result in take of marine mammals and are not discussed further in this document.

The activities authorized in this IHA are limited to Falcon 9 First Stage boost-back maneuvers and landings. Incidental take of marine mammals resulting from Falcon 9 rocket launches from VAFB is already authorized via regulations (79 FR 10016; February 24, 2014) and a Letter of Authorization (LOA) (79 FR 18528; April 2, 2014). As such, NMFS does not authorize take of marine mammals incidental to launches of the Falcon 9 rocket in this IHA; incidental take resulting from Falcon 9 rocket launches is therefore not analyzed further in this document.

A detailed description of the planned activities is provided in the *Federal Register* notice of the proposed IHA (82 FR 49332; October 25, 2017). Since that time, no changes have been made to the planned activities. Therefore, a more detailed description is not provided here. Please refer to that *Federal Register* notice for a more detailed description of the specific

activities. Mitigation, monitoring, and reporting measures are described in detail later in this document (please see "Mitigation" and "Monitoring and Reporting").

Comments and Responses

NMFS published a notice of proposed IHA in the *Federal Register* on October 25, 2017 (82 FR 49332). During the 30-day public comment period, NMFS received a comment letter from the Marine Mammal Commission (Commission). NMFS has posted the comments online at: *http://www.nmfs.noaa.gov/pr/permits/incidental*. The following is a summary of the public comments received and NMFS's responses.

Comment 1: The Commission recommended that NMFS include Falcon 9 recovery activities as a proposed amendment to the United States Air Force's (USAF) final rule (79 FR 10016; February 24, 2014) rather than authorizing those activities in separate IHAs until the rule expires in 2019, and that NMFS ultimately include Falcon 9 recovery activities in the future proposed rule that will cover all other rocket activities conducted by USAF at VAFB beginning in 2019. The Commission also recommended that NMFS issue the IHA, subject to inclusion of the proposed mitigation, monitoring, and reporting measures, which are included as proposed in the final IHA.

Response: NMFS agrees that streamlining in the MMPA incidental take authorization process is desirable when possible and we will work with the USAF to determine whether it is practicable to incorporate Falcon 9 recovery activities in any future regulations governing the take of marine mammals incidental to rocket launch activities that occur at VAFB.

Description of Marine Mammals in the Area of Specified Activities

Section 4 of the IHA application summarizes available information regarding status and trends, distribution and habitat preferences, and behavior and life history of the potentially

affected species. We have reviewed SpaceX's species descriptions, including life history information, distribution, regional distribution, and acoustics and hearing, for accuracy and completeness, and we refer the reader to Section 4 of the IHA application, rather than reprinting the information here. A detailed description of the species likely to be affected by the specified activities, including brief introductions to the species and relevant stocks as well as available information regarding population trends and threats, and information regarding local occurrence, were provided in the *Federal Register* notice of the proposed IHA (82 FR 49332; October 25, 2017). Since that time, we are not aware of any changes in the status of these species and stocks; therefore, detailed descriptions are not provided here. Please refer to that *Federal Register* notice for these descriptions. Please also refer to NMFS' website (*www.nmfs.noaa.gov/pr/species/mammals/*) for generalized species accounts.

Table 1 lists all marine mammal species with expected occurrence in the project area (including at VAFB, on the NCI, and in the waters surrounding VAFB, the NCI and the contingency landing location) that are expected to be affected by the specified activities, and summarizes information related to the populations, including regulatory status under the MMPA and Endangered Species Act (ESA). There are an additional 28 species of marine mammals (all cetaceans) with expected or possible occurrence in the project area. However, we have determined that sonic booms are the only potential stressor associated with the activity that could result in take of marine mammals, and that sonic booms only have the potential to result in harassment of marine mammals that are hauled out of the water. Therefore, we have concluded that the likelihood of the planned activities resulting in the harassment of any cetacean to be so low as to be discountable. As we have concluded that the likelihood of any cetacean being taken incidentally as a result of SpaceX's activities to be so low as to be discountable, cetaceans are

not considered further in this document and no take of cetaceans is authorized in the IHA. Please see Table 3-1 in SpaceX's IHA application for a complete list of species with expected or potential occurrence in the project area.

All values presented in Table 1 are the most recent available at the time of publication and are available in NMFS's stock assessment reports (SAR) (*e.g.*, Carretta *et al*., 2017; Muto *et al*., 2017). Please see the SARs, available at *www.nmfs.noaa.gov/pr/sars*, for more detailed accounts of these stocks' status and abundance. Abundance estimates presented in Table 1 represent the total number of individuals that make up a given stock or the total number estimated within a particular study area. NMFS's stock abundance estimates for most species represent the total estimate of individuals within the geographic area, if known, that comprises that stock. For some species, this geographic area may extend beyond U.S. waters. PBR, defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population, is considered in concert with known sources of ongoing anthropogenic mortality to assess the population-level effects of the anticipated mortality from a specific project (as described in NMFS's SARs). While no mortality is anticipated or authorized in this IHA, PBR and annual serious injury and mortality are included here as gross indicators of the status of the species and other threats. For taxonomy, we follow Committee on Taxonomy (2017). For status of species, we provide information regarding U.S. regulatory status under the MMPA and ESA.

Table 1. Marine Mammal Species Potentially Present in the Project Area.

Species	Stock	ESA/MMPA status; Strategic (Y/N)[1]	Stock abundance (CV, N_{min}, most recent abundance survey)[2]	PBR[3]	Annual M/SI[4]	Relative occurrence in project area; season of

						occurrence
Order Carnivora – Superfamily Pinnipedia						
Family Otariidae (eared seals and sea lions)						
California sea lion (*Zalophus californianus*)	U.S.	-; N	296,750 (n/a; 153,337; 2011)	9,200	389	Abundant; year-round
Northern fur seal (*Callorhinus ursinus*)	California	-; N	14,050 (n/a; 7,524; 2013)	451	1.8	Abundant; year-round; peak occurrence during summer
Guadalupe fur seal (*Arctocephalus philippii townsendi*)	n/a	T / D; Y	20,000 (n/a; 15,830; 2010)	542	3.2	Rare; slightly more common in summer
Steller sea lion (*Eumetopias jubatus*)	Eastern U.S.	-; N	71,562 (n/a; 41,638; 2015)	2,498	108	Rare; year-round
Family Phocidae (earless seals)						
Harbor seal (*Phoca vitulina richardii*)	California	-; N	30,968 (n/a; 27,348; 2012)	1,641	43	Abundant; year-round
Northern elephant seal (*Mirounga angustirostris*)	California breeding	-; N	179,000 (n/a; 81,368; 2010)	4,882	8.8	Abundant; year-round; peak occurrence during winter

[1]ESA status: Endangered (E), Threatened (T)/MMPA status: Depleted (D). A dash (-) indicates that the species is not listed under the ESA or designated as depleted under the MMPA. Under the MMPA, a strategic stock is one for which the level of direct human-caused mortality exceeds PBR or which is determined to be declining and likely to be listed under the ESA within the foreseeable future. Any species or stock listed under the ESA is automatically designated under the MMPA as depleted and as a strategic stock.

[2]NMFS marine mammal stock assessment reports online at: *www.nmfs.noaa.gov/pr/sars/*. CV is coefficient of variation; N_{min} is the minimum estimate of stock abundance. In some cases, CV is not applicable.

[3]Potential biological removal, defined by the MMPA as the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population size (OSP).

[4]These values, found in NMFS's SARs, represent annual levels of human-caused mortality plus serious injury from all sources combined (*e.g.*, commercial fisheries, ship strike). Annual mortality/serious injury (M/SI) often cannot be determined precisely and is in some cases presented as a minimum value or range. A CV associated with estimated mortality due to commercial fisheries is presented in some cases.

Marine Mammal Hearing – Hearing is the most important sensory modality for marine mammals underwater, and exposure to anthropogenic sound can have deleterious effects. To appropriately assess the potential effects of exposure to sound, it is necessary to understand the frequency ranges marine mammals are able to hear. Current data indicate that not all marine mammal species have equal hearing capabilities (*e.g.*, Richardson *et al*., 1995; Wartzok and Ketten, 1999; Au and Hastings, 2008). To reflect this, Southall *et al*. (2007) recommended that marine mammals be divided into functional hearing groups based on directly measured or

estimated hearing ranges on the basis of available behavioral response data, audiograms derived using auditory evoked potential techniques, anatomical modeling, and other data. Subsequently, NMFS (2016) described generalized hearing ranges for these marine mammal hearing groups. Generalized hearing ranges were chosen based on the approximately 65 decibels (dB) threshold from the normalized composite audiograms. The relevant functional groups and the associated frequencies are indicated below (note that these frequency ranges correspond to the range for the composite group, with the entire range not necessarily reflecting the capabilities of every species within that group):

- Pinnipeds in water; Phocidae (true seals): generalized hearing is estimated to occur between approximately 50 hertz (Hz) to 86 kilohertz (kHz), with best hearing between 1-50 kHz;
- Pinnipeds in water; Otariidae (eared seals): generalized hearing is estimated to occur between 60 Hz and 39 kHz, with best hearing between 2-48 kHz.

The pinniped functional hearing group was modified from Southall *et al*. (2007) on the basis of data indicating that phocid species have consistently demonstrated an extended frequency range of hearing compared to otariids, especially in the higher frequency range (Hemilä *et al*., 2006; Kastelein *et al*., 2009; Reichmuth and Holt, 2013).

Table 2. Relevant marine mammal functional hearing groups and their generalized hearing ranges.

Hearing Group	Generalized Hearing Range*
Phocid pinnipeds (PW) (underwater) (true seals)	50 Hz to 86 kHz
Otariid pinnipeds (OW) (underwater) (sea lions and fur seals)	60 Hz to 39 kHz

* Represents the generalized hearing range for the entire group as a composite (*i.e.*, all species within the group), where individual species' hearing ranges are typically not as broad. Generalized hearing range chosen based on ~65 dB threshold from normalized composite audiogram, with the exception for PW pinniped (approximation).

For more detail concerning these groups and associated frequency ranges, please see NMFS (2016) for a review of available information. Of the six marine mammal species that may be affected by the planned activities, four are classified as otariids and two are classified as phocids.

Potential Effects of Specified Activities on Marine Mammals and their Habitat

The effects of noise from SpaceX's activities have the potential to result in behavioral harassment of marine mammals in the vicinity of the action area. The *Federal Register* notice of proposed IHA (82 FR 49332; October 25, 2017) included a discussion of the effects of anthropogenic noise on marine mammals and their habitat, therefore that information is not repeated here; please refer to that *Federal Register* notice for that information. No instances of injury, serious injury or mortality are expected as a result of SpaceX's activities.

Estimated Take by Incidental Harassment

This section provides an estimate of the number of incidental takes authorized through this IHA, which will inform both NMFS' consideration of whether the number of takes is "small" and the negligible impact determination.

Harassment is the only type of take expected to result from these activities. Except with respect to certain activities not pertinent here, section 3(18) of the MMPA defines "harassment" as: any act of pursuit, torment, or annoyance which (i) has the potential to injure a marine mammal or marine mammal stock in the wild (Level A harassment); or (ii) 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 (Level B harassment).

All authorized takes are by Level B harassment only, in the form of disruption of behavioral patterns for individual marine mammals resulting from exposure to sounds associated with the planned activities. Based on the nature of the activity, Level A harassment, serious injury, and mortality are neither anticipated nor authorized in this IHA.

Described in the most basic way, we estimate take by considering: 1) acoustic thresholds above which NMFS believes the best available science indicates marine mammals will be behaviorally harassed; 2) the area that will be ensonified above these levels in a day; 3) the density or occurrence of marine mammals within these ensonified areas; and 4) and number of days of activities. Below, we describe these components in more detail and present the take estimate.

Acoustic Thresholds

Using the best available science, NMFS has developed acoustic thresholds that identify the received level of sound above which exposed marine mammals would be reasonably expected to be behaviorally harassed (equated to Level B harassment) or to incur PTS of some degree (equated to Level A harassment). As described above, Level A harassment is not expected to occur as a result of the planned activities and we do not authorize take by Level A harassment, thus criteria and thresholds for Level A harassment are not discussed further. Thresholds have been developed identifying the received level of in-air sound above which exposed pinnipeds would likely be behaviorally harassed. In this case, we are concerned only with in-air sound as the planned activities are not expected to result in harassment of marine mammals that are underwater. Thus, only in-air thresholds are discussed further.

Level B Harassment for non-explosive sources

Though significantly driven by received level, the onset of behavioral disturbance from anthropogenic noise exposure is also informed to varying degrees by other factors related to the source (*e.g.*, frequency, predictability, duty cycle), the environment, and the receiving animals (hearing, motivation, experience, demography, behavioral context) and can be difficult to predict (Southall *et al.*, 2007, Ellison *et al.*, 2011). Based on what the available science indicates and the practical need to use a threshold based on a factor that is both predictable and measurable for most activities, NMFS typically uses a generalized acoustic threshold based on received level to estimate the onset of behavioral harassment. For in-air sounds, NMFS expects that harbor seals exposed to sound above received levels of 90 dB re 20 micro Pascals (μPa) (root mean squared (rms)) will be behaviorally harassed, and all other species of pinnipeds exposed to sound above received levels of 100 dB re 20 μPa (rms) will be behaviorally harassed (Table 3).

Table 3. Recommended criteria for pinniped harassment from exposure to airborne sound.

Species	Level B harassment threshold
Harbor seals	90 dB re 20 μPa
All other pinniped species	100 dB re 20 μPa

Typically, NMFS relies on the acoustic criteria shown in Table 3 to estimate take as a result of exposure to airborne sound from a given activity. However, in this case we have the benefit of more than 20 years of observational data on pinniped responses to the stimuli associated with the planned activity that we expect to result in harassment (sonic booms) in the particular geographic area of the planned activity (VAFB and the NCI). Therefore, we consider these data to be the best available information in regard to estimating take based on modeled

exposures among pinnipeds to sounds associated with the planned activities. These data suggest that pinniped reactions to sonic booms are dependent on the species and the intensity of the sonic boom (Table 4).

The USAF has monitored pinniped responses to rocket launches from VAFB for over 20 years. Though rocket launches are not part of the planned activities (as described above), the acoustic stimuli associated with launches (*e.g.,* sonic booms) is expected to be substantially similar to those expected to occur with Falcon 9 boost-backs and landings; therefore, we rely on observational data on responses of pinnipeds to sonic booms associated with rocket launches from VAFB in making assumptions about expected pinniped responses to sonic booms associated with Falcon 9 boost-backs and landings.

Observed reactions of pinnipeds at the NCI and at VAFB to sonic booms have ranged from no response to heads-up alerts, from startle responses to some movements on land, and from some movements into the water to occasional stampedes (especially involving California sea lions on the NCI). We therefore assume sonic booms generated during the return flight of the Falcon 9 First Stage may elicit an alerting or other short-term behavioral reaction, including flushing into the water if hauled out.

Data from launch monitoring by the USAF has shown that pinniped reactions to sonic booms are correlated with the level of the sonic boom. Low energy sonic booms (< 1.0 psf have resulted in little to no behavioral responses, including head raising and briefly alerting but returning to normal behavior shortly after the stimulus (Table 4). More powerful sonic booms have resulted in pinnipeds flushing from haulouts. No pinniped mortalities have been associated with sonic booms. No sustained decreases in numbers of animals observed at haulouts have been observed after the stimulus. Table 4 presents a summary of monitoring efforts at the NCI from

1999 to 2014. These data show that reactions to sonic booms tend to be insignificant below 1.0 psf and that, even above 1.0 psf, only a portion of the animals present have reacted to the sonic boom. Time-lapse video photography during four launch events revealed that harbor seals that reacted to the rocket launch noise but did not leave the haul-out were all adults.

Data from previous monitoring also suggests that for those pinnipeds that flush from haulouts in response to sonic booms, the amount of time it takes for those animals to begin returning to the haulout site, and for numbers of animals to return to pre-launch levels, is correlated with sonic boom sound levels. Pinnipeds may begin to return to the haulout site within 2-55 minutes of the launch disturbance, and the haulout site usually returned to pre-launch levels within 45-120 minutes.

Monitoring data has consistently shown that reactions among pinnipeds vary between species, with harbor seals and California sea lions tending to be more sensitive to disturbance than northern elephant seals and northern fur seals (Table 4). Because Steller sea lions and Guadalupe fur seals occur in the project area relatively infrequently, no data has been recorded on their reactions to sonic booms. At VAFB, harbor seals generally alert to nearby launch noises, with some or all of the animals going into the water. Usually the animals haul out again from within minutes to two hours or so of the launch, provided rising tides or breakers have not submerged the haul-out sites. Post-launch surveys often indicate as many or more animals hauled out than were present at the time of the launch, unless rising tides, breakers or other disturbances are involved (SAIC 2012). When launches occurred during high tides at VAFB, no impacts have been recorded because virtually all haulout sites were submerged.

At the Channel Islands, California sea lions have been observed to react strongly to sonic booms relative to other species present. California sea lion pups have sometimes reacted more

than adults, either because they are more easily frightened or because their hearing is more acute. Harbor seals also generally appear to be more sensitive to sonic booms than most other pinnipeds, often startling and fleeing into the water. Northern fur seals generally show little or no reaction. Northern elephant seals generally exhibit no reaction at all, except perhaps a heads-up response or some stirring, especially if sea lions in the same area or mingled with the elephant seals react strongly to the boom. Post-launch monitoring generally reveals a return to normal patterns within minutes up to an hour or two of each launch, regardless of species (SAIC 2012).

Table 4 summarizes monitoring efforts at San Miguel Island during which acoustic measurements were successfully recorded and during which pinnipeds were observed. During more recent launches, night vision equipment was used. The table shows only monitoring data for launches during which sonic booms were heard and recorded. The table shows that little or no reaction from the four species usually occurs when overpressures are below 1.0 psf. In general, as described above, elephant seals do not react unless other animals around them react strongly or if the sonic boom is extremely loud, and northern fur seals seem to react similarly. Not enough data exist to draw conclusions about harbor seals at the NCI, but considering their reactions to launch noise at VAFB, it is likely that they are also sensitive to sonic booms (SAIC 2012).

Table 4. Observed pinniped responses to sonic booms at San Miguel Island.

Launch Event	Sonic Boom Level (psf)	Monitoring Location	Species and Associated Reactions
Athena II (April 27, 1999)	1.0	Adams Cove	California sea lion – 866 alerted; 232 (27%) flushed into water Northern elephant seal – alerted but did not flush Northern fur seal – alerted but did not flush
Athena II (September 24, 1999)	0.95	Point Bennett	California sea lion –12 of 600 (2%) flushed into water Northern elephant seal – alerted but did not flush Northern fur seal – alerted but did not flush
Delta II 20 (November 20, 2000)	0.4	Point Bennett	California sea lion – 60 pups flushed into water; no reaction from focal group Northern elephant seal – no reaction
Atlas II (September 8,	0.75	Cardwell	California sea lion (Group 1) – no reaction (1,200 animals)

2001)		Point	California sea lion (Group 2) – no reaction (247 animals) Northern elephant seal – no reaction Harbor seal – 2 of 4 flushed into water
Delta II (February 11, 2002)	0.64	Point Bennett	California sea lion and northern fur seal – no reaction among 485 animals in 3 groups Northern elephant seal – no reaction among 424 animals in 2 groups
Atlas II (December 2, 2003)	0.88	Point Bennett	California sea lion – approximately 40% alerted; several flushed to water (number unknown – night launch) Northern elephant seal – no reaction
Delta II (July 15, 2004)	1.34	Adams Cove	California sea lion – 10% alerted (number unknown – night launch)
Atlas V (March 13, 2008)	1.24	Cardwell Point	Northern elephant seal – no reaction (109 pups)
Delta II (May 5, 2009)	0.76	West of Judith Rock	California sea lion – no reaction (784 animals)
Atlas V (April 14, 2011)	1.01	Cuyler Harbor	Northern elephant seal – no reaction (445 animals)
Atlas V (September 13, 2012)	2.10	Cardwell Point	California sea lion – no reaction (460 animals) Northern elephant seal – no reaction (68 animals) Harbor seal – 20 of 36 (56%) flushed into water
Atlas V (April 3, 2014)	0.74	Cardwell Point	Harbor seal – 1 of ~25 flushed into water; no reaction from others
Atlas V (December 12, 2014)	1.16	Point Bennett	Calif. sea lion – 5 of ~225 alerted; none flushed

As described above, data from launch monitoring by the USAF on the NCI and at VAFB have shown that pinniped reactions to sonic booms are correlated to the level of the sonic boom. Low energy sonic booms (< 1.0 psf) have typically resulted in little to no behavioral responses, including head raising and briefly alerting but returning to normal behavior shortly after the stimulus. More powerful sonic booms have flushed animals from haulouts (but not resulted in any mortality or sustained decreased in numbers after the stimulus). Monitoring data from the NCI and VAFB from 1999 to 2014 show that reactions to sonic booms tend to be insignificant below 1.0 psf and that, even above 1.0 psf, only a portion of the animals present react to the sonic boom (Table 4). Therefore, for the purposes of estimating the extent of take that is likely to occur as a result of the planned activities, we assume that Level B harassment occurs when a pinniped (on land) is exposed to a sonic boom at or above 1.0 psf. Therefore, the number of expected takes by Level B harassment is based on estimates of the numbers of animals that would be within the areas exposed to sonic booms at levels at or above 1.0 psf.

Ensonified Area

As described above, modeling was performed to estimate overpressure levels that would be created during sonic booms that occur during the return flight of the Falcon 9 First Stage. The predicted acoustic footprint of the sonic boom was computed using the computer program PCBoom (Plotkin and Grandi 2002; Page *et al.* 2010). As described above, the highest sound generated by a sonic boom would generally be focused on the area where the Falcon 9 ultimately lands. Based on model results, a boost-back and landing of the Falcon 9 First Stage at SLC-4W would produce a sonic boom with overpressures as high as 8.5 psf at SLC-4W, which would attenuate to levels below 1.0 psf at approximately 15.90 mi. (25.59 km) from the landing area (Figure 2-2 in the IHA application). This estimate is based, in part, on actual observations from Falcon 9 boost-back and landing activities at Cape Canaveral, Florida. A boost-back and landing of the Falcon 9 First Stage at SLC-4W would produce a sonic boom with overpressures up to 3.1 psf on the NCI, based on model results.

During a contingency barge landing event, sonic boom overpressure would be directed at the ocean surface while the first-stage booster is supersonic. Model results indicate that sonic booms would not exceed 1.0 psf on any part of the NCI during a boost-back and landing of the Falcon 9 First Stage at the contingency landing location at least 27 nm (50 km) offshore (Figure 2-6 and Figure 2-7 in the IHA application). Additionally, First Stage boost-backs and landings within the Iridium Landing Area would not likely produce measurable overpressures at any land surface (Figure 2-8 and Figure 2-9 in the IHA application). Therefore, take of marine mammals is not expected to occur as a result of boost-back and landing activities at the contingency landing location at least 27 nm (50 km) offshore, nor within the Iridium Landing Area. Estimated

takes are therefore based on the possibility of boost-back and landing activities occurring at SLC-4W.

Marine Mammal Occurrence

In this section we provide the information about the presence, density, or group dynamics of marine mammals that will inform the take calculations. Data collected from marine mammal surveys, including monthly marine mammal surveys conducted by the USAF at VAFB as well as data collected by NMFS, represent the best available information on the occurrence of the six pinniped species expected to occur in the project area. The quality and amount of information available on pinnipeds in the project area varies depending on species; some species are surveyed regularly at VAFB and the NCI (*e.g.*, California sea lion), while other species are surveyed less frequently (*e.g.*, northern fur seals and Guadalupe fur seals). However, the best available data was used to estimate take numbers. Take estimates for all species are shown in Table 6.

Harbor Seal – Pacific harbor seals are the most common marine mammal inhabiting VAFB, congregating on several rocky haulout sites along the VAFB coastline. They also haul out, breed, and pup in isolated beaches and coves throughout the coasts of the NCI. Harbor seals may be exposed to sonic booms above 1.0 psf on the mainland and the NCI. Take of harbor seals at VAFB was estimated based on the maximum count totals from monthly surveys of VAFB haulout sites from 2013-2016 (ManTech SRS Technologies, Inc., 2014, 2015, 2016; VAFB, unpubl. data). Take of harbor seals at the NCI and at Point Conception was estimated based on the maximum count totals from aerial survey data collected from 2002 to 2012 by the NMFS Southwest Fisheries Science Center (SWFSC) (Lowry *et al*., 2017).

California sea lion – California sea lions are common offshore of VAFB and haul out on rocks and beaches along the coastline of VAFB, though pupping rarely occurs on the VAFB

coastline. They haul out in large numbers on the NCI and rookeries exist on San Miguel and Santa Cruz islands. California sea lions may be exposed to sonic booms above 1.0 psf on the mainland and the NCI. Take of California sea lions at VAFB was estimated based on the maximum count totals from monthly surveys of VAFB haulout sites from 2013-2016 (ManTech SRS Technologies, Inc., 2014, 2015, 2016; VAFB, unpubl. data). Take of California sea lions at the NCI was estimated based on the maximum count totals from aerial survey data collected from 2002 to 2012 by the SWFSC (Lowry *et al*., 2017). We note that in the *Federal Register* notice of the proposed IHA (82 FR 49332; October 25, 2017) we estimated takes of California sea lions on Santa Cruz Island (811 takes of California sea lions were estimated per boost-back and landing activity). However, since the notice of the proposed IHA was published, we have reviewed the sonic boom models presented in the IHA application and determined that a sonic boom of 1.0 psf or above is not expected to impact Santa Cruz Island, and, therefore, no takes of marine mammals on Santa Cruz Island are expected to occur as a result of the specified activities. Therefore we do not authorize any takes of California sea lions on Santa Cruz Island in this IHA.

Steller Sea Lion – Steller sea lions occur in small numbers at VAFB and on San Miguel Island. They have not been observed on the Channel Islands other than at San Miguel Island and they do not currently have rookeries at VAFB or the NCI. Steller sea lions may be exposed to sonic booms above 1.0 psf on the mainland and the NCI. Take of Steller sea lions at VAFB was estimated based on the largest count totals from monthly surveys of VAFB haulout sites from 2013-2016 (ManTech SRS Technologies, Inc., 2014, 2015, 2016; VAFB, unpubl. data). Steller sea lions haul out in very small numbers on the NCI, and comprehensive survey data for Steller sea lions in the NCI is not available. Take of Steller sea lions at the NCI was estimated based on

subject matter expert input suggesting that as many as four Steller sea lions have been observed on San Miguel Island at a time (pers. comm., S. Melin, NMFS Marine Mammal Laboratory (MML), to J. Carduner, NMFS, Feb 11, 2016).

Northern elephant seal – Northern elephant seals haul out sporadically on rocks and beaches along the coastline of VAFB and at Point Conception and have rookeries on San Miguel Island and Santa Rosa Island and at one location at VAFB. Northern elephant seals may be exposed to sonic booms above 1.0 psf on the mainland and the NCI. Take of northern elephant seals at VAFB was estimated based on the largest count totals from monthly surveys of VAFB haulout sites from 2013-2016 (ManTech SRS Technologies, Inc., 2014, 2015, 2016; VAFB, unpubl. data). Take of northern elephant seals at the NCI and at Point Conception was estimated based on the maximum count totals from aerial survey data collected from 2002 to 2012 by the NMFS SWFSC (Lowry *et al*., 2017).

Northern fur seal – Northern fur seals have rookeries on San Miguel Island, the only island in the NCI on which they have been observed. No haulouts or rookeries exist for northern fur seals on the mainland coast, including VAFB, thus they may be exposed to sonic booms above 1.0 psf at the NCI but not on the mainland. Comprehensive survey data for northern fur seals in the project area is not available. Estimated take of northern fur seals was based on subject matter expert input which suggested a maximum of approximately 6,000–8,000 northern fur seals may be present on San Miguel Island at the height of breeding/pupping season (early July). After the height of the breeding/pupping season, numbers fluctuate but decrease as females go on foraging trips and males begin to migrate in late July/August. Numbers continue to decrease until November when most of the population is absent from the island until the following breeding/pupping period (starting the following June) (pers. comm., T. Orr, NMFS

NMML, to J. Carduner, NMFS OPR, February 27, 2016). It was therefore conservatively estimated that numbers peak at 8,000 animals hauled out at any given time in July and decrease to a minimum of 2,000 animals hauled out at any given time in the winter, then increase again until the following July. This results in an average estimate of 5,000 northern fur seals hauled out at San Miguel Island at any given time over the course of the entire year.

Guadalupe fur seal – There are estimated to be approximately 20-25 individual Guadalupe fur seals that have fidelity to San Miguel Island (pers. comm. S. Mellin, NMFS NMML, to J. Carduner, NMFS OPR, February 11, 2016). No haulouts or rookeries exist for Guadalupe fur seals on the mainland coast, including VAFB, thus they may be exposed to sonic booms above 1.0 psf at the NCI but not on the mainland. Comprehensive survey data on Guadalupe fur seals in the project area is not readily available. Estimated take of Guadalupe fur seals was based on the maximum number of Guadalupe fur seals observed at any one time on San Miguel Island (13) (pers. comm., J. LaBonte, ManTech SRS Technologies Inc., to J. Carduner, NMFS, Feb. 29, 2016); it was therefore conservatively assumed that 13 Guadalupe fur seals may be hauled out at San Miguel Island at any given time.

Take Calculation and Estimation

Here we describe how the information provided above is brought together to produce a quantitative take estimate.

NMFS currently uses a three-tiered scale to determine whether the response of a pinniped on land to acoustic or visual stimuli is considered an alert, a movement, or a flush. NMFS considers the behaviors that meet the definitions of both movements and flushes to qualify as behavioral harassment. Thus a pinniped on land is considered by NMFS to have been behaviorally harassed if it moves greater than two times its body length, or if the animal is

already moving and changes direction and/or speed, or if the animal flushes from land into the water. Animals that become alert without such movements are not considered harassed. See Table 5 for a summary of the pinniped disturbance scale.

Table 5. Levels of pinniped behavioral disturbance on land.

Level	Type of response	Definition	Classified as behavioral harassment by NMFS
1	Alert	Head orientation or brief movement in response to disturbance, which may include turning head towards the disturbance, craning head and neck while holding the body rigid in a u-shaped position, changing from a lying to a sitting position, or brief movement of less than twice the animal's body length.	No
2	Movement	Movements in response to the source of disturbance, ranging from short withdrawals at least twice the animal's body length to longer retreats over the beach, or if already moving a change of direction of greater than 90 degrees.	Yes
3	Flush	All retreats (flushes) to the water.	Yes

As described above, the likelihood of pinnipeds exhibiting responses to sonic booms that would be considered behavioral harassment (based on the levels of pinniped disturbance as shown in Table 5) is dependent on both the species and on the intensity of the sonic boom. Data from rocket launch monitoring by the USAF at VAFB and the NCI show that pinniped reactions to sonic booms are correlated to the level of the sonic boom, with low energy sonic booms (< 1.0 psf) typically resulting in little to no behavioral responses, and higher energy sonic booms resulting in responses ranging from no response to heads-up alerts, startle responses, some movements on land, and some movements into the water (flushing). Based on model results, a boost-back and landing of the Falcon 9 First Stage at SLC-4W would produce a sonic boom with greater intensity at VAFB (overpressures potentially as high as 8.5 psf) than at the NCI (overpressures potentially as high as 3.1 psf). Responses of pinnipeds to sonic booms are also highly dependent on species, with harbor seals, California sea lions and Steller sea lions

generally displaying greater sensitivity to sonic booms than northern elephant seals and northern fur seals (Table 4). We are not aware of any data on Guadalupe fur seal responses to sonic booms, but we assume responses by Guadalupe fur seal responses to be similar to those observed in northern fur seals as the two species are physiologically and behaviorally very similar.

Take estimates were calculated by overlaying the modeled acoustic footprints of sonic booms from boost-back and landing events at SLC-4W with known pinniped haulouts on the mainland (including those at VAFB) and the NCI to determine the pinniped haulouts that would potentially be affected by sonic booms with overpressures of 1.0 psf and above. Only haulouts along northeastern San Miguel Island and northern and northwestern Santa Rosa Island would be expected to experience overpressures greater than 1.0 psf during a boost-back and landing at SLC-4W (Figures 2-3, 2-4, 2-5 and 2-6 in the IHA application). Take estimates also account for the likely intensity of the sonic boom as well as the relative sensitivity of the marine mammal species present, based on monitoring data as described above.

A boost-back and landing of the Falcon 9 First Stage at SLC-4W that results in a sonic boom of 1.0 psf and above at VAFB was conservatively estimated to result in behavioral harassment of 100 percent of all species hauled out at or near VAFB and Point Conception (Table 6). A boost-back and landing of the Falcon 9 First Stage at SLC-4W that results in a sonic boom of 1.0 psf and above at the NCI was estimated to result in the behavioral harassment of 100 percent of California sea lions, harbor seals, and Steller sea lions that are hauled out at the NCI and of five percent of northern elephant seals, northern fur seals, and Guadalupe fur seals that are hauled out at the NCI. The five percent adjustment in the take estimates for these species at the NCI is also considered conservative, as launch monitoring data shows that elephant seals and fur seals sometimes alert to sonic booms but have never been observed flushing to the water

or responding in a manner that would be classified as behavioral harassment even when sonic booms were measured at > 1.0 psf (see Table 4 for a summary of launch monitoring data).

The take calculations presented in Table 6 are based on the best available information on marine mammal populations in the project location and responses among marine mammals to the stimuli associated with the planned activities.

Table 6. Estimated numbers of marine mammals, and percentage of marine mammal populations, potentially taken as a result of the planned activities.

Species	Geographic Location	Estimated Number of Level B Harassment Exposures Per Event, By Location	Estimated Combined Number of Level B Harassment Exposures Per Event	Total Number of Takes by Level B Harassment Authorized[1]	Takes by Level B Harassment Authorized as a Percentage of Population
Pacific Harbor Seal [2]	VAFB	366	1,384	16,608	4.4
	Pt. Conception	516			
	San Miguel Island	310			
	Santa Rosa Island	192			
	Santa Cruz Island	0			
California Sea Lion	VAFB	416	3,750	45,000	15.2
	Pt. Conception	N/A			
	San Miguel Island	2,134			
	Santa Rosa Island	1,200			
	Santa Cruz Island	0			
Northern Elephant Seal	VAFB	190	227	2,724	1.5
	Pt. Conception	11			
	San Miguel Island [3]	18			
	Santa Rosa Island [3]	8			
	Santa Cruz Island	0			
Steller Sea Lion	VAFB	16	20	240	0.3
	Pt. Conception	N/A			
	San Miguel Island	4			
	Santa Rosa Island	N/A			
	Santa Cruz Island	N/A			
Northern Fur Seal	VAFB	N/A	250	3,000	21.4
	Pt. Conception	N/A			
	San Miguel Island [3]	250			
	Santa Rosa Island	N/A			
	Santa Cruz Island	N/A			
Guadalupe Fur Seal	VAFB	N/A	1	12	0.1
	Pt. Conception	N/A			
	San Miguel Island [3]	1			
	Santa Rosa Island	N/A			
	Santa Cruz Island	N/A			

Species	Geographic Location	Estimated Number of Level B Harassment Exposures Per Event, By Location	Estimated Combined Number of Level B Harassment Exposures Per Event	Total Number of Takes by Level B Harassment Authorized[1]	Takes by Level B Harassment Authorized as a Percentage of Population

[1] Based on twelve boost-back and landing events. Total number of takes authorized represents incidences of harassment and not necessarily individuals.
[2] As the same individual harbor seals are likely to be taken repeatedly over the course of the specified activities, we use the estimate of 1,384 individual animals taken per Falcon 9 First Stage recovery activity for the purposes of estimating the percentage of stock abundance likely to be taken over the course of the entire activity.
[3] Number shown reflects five percent of total number of predicted potential exposures, *i.e.* five percent of animals exposed to sonic booms above 1.0 psf at these locations are assumed to experience Level B harassment.

Take estimates are believed to be conservative based on the assumption that all twelve Falcon 9 First Stage recovery activities would result in landings at SLC-4W, with no landings occurring at contingency landing locations. However, some or all actual landing events may ultimately occur at the contingency landing locations; as described above, landings at the contingency landing locations would be expected to result in no takes of marine mammals. However, the number of landings at each location is not known in advance, therefore, we assume all landings would occur at SLC-4W. In addition, as described above, it is conservatively assumed that 100 percent of any species of pinniped hauled out on the mainland (VAFB and Point Conception), and 100 percent of harbor seals, California sea lions and Steller sea lions hauled out at the NCI, would be harassed (Level B harassment only) by a Falcon 9 boost-back and landing event at SLC-4W that results in a sonic boom of >1.0 psf. However, it is possible that less than this percentage of hauled out pinnipeds will be behaviorally harassed by a Falcon 9 boost-back and landing at SLC-4W. While there may be some limited behavioral harassment of pinnipeds that occurs at psf levels <1.0, we account for that in the overall conservativeness of the total take number, as described above.

As described above, in the *Federal Register* notice of the proposed IHA (82 FR 49332; October 25, 2017) we estimated 811 takes of California sea lions would occur at Santa Cruz

Island per boost-back and landing activity; however, since the notice of the proposed IHA was published, we have reviewed the sonic boom models presented in the IHA application and determined that a sonic boom of 1.0 psf or above is not expected to impact Santa Cruz Island, and therefore no takes of marine mammals on Santa Cruz Island are expected to occur as a result of the specified activities. Therefore, we do not authorize any takes of California sea lions on Santa Cruz Island in this IHA. We authorize a total of 45,000 takes of California sea lions in this IHA (a total of 54,732 takes of California sea lions was proposed in the proposed IHA). We also note that in the *Federal Register* notice of the proposed IHA (82 FR 49332; October 25, 2017) we proposed to authorize a total of 1,384 takes of harbor seals. This was an error, as the number 1,384 represents the estimated number of takes of harbor seals per boost-back and landing activity. We intended to propose to authorize a total of 16,608 takes of harbor seals, which represents the number of estimated takes per boost-back and landing activity (1,384) times the number of activities (12). We therefore authorize a total of 16,608 takes of harbor seals in this IHA. These revisions in the take estimates have not changed any of our determinations.

Given the many uncertainties in predicting the quantity and types of impacts of sound on marine mammals, it is common practice to estimate how many animals are likely to be present within a particular distance of a given activity, or exposed to a particular level of sound. In practice, depending on the amount of information available to characterize daily and seasonal movement and distribution of affected marine mammals, it can be difficult to distinguish between the number of individuals harassed and the instances of harassment and, when duration of the activity is considered, it can result in a take estimate that overestimates the number of individuals harassed. For instance, an individual animal may accrue a number of incidences of harassment over the duration of a project, as opposed to each incident of harassment accruing to

a new individual. This is especially likely if individual animals display some degree of residency or site fidelity and the impetus to use the site is stronger than the deterrence presented by the harassing activity.

Take estimates shown in Table 6 are considered reasonable estimates of the number of instances of marine mammal exposures to sound resulting in Level B harassment that are likely to occur as a result of the planned activities, and not necessarily the number of individual animals exposed.

Mitigation

In order to issue an IHA under Section 101(a)(5)(D) of the MMPA, NMFS must set forth the permissible methods of taking pursuant to such activity, and other means of effecting the least practicable impact on such species or stock and its habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for taking for certain subsistence uses (latter not applicable for this action). NMFS regulations require applicants for incidental take authorizations to include information about the availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks and their habitat (50 CFR 216.104(a)(11)).

In evaluating how mitigation may or may not be appropriate to ensure the least practicable impact on species or stocks and their habitat, as well as subsistence uses where applicable, we carefully balance two primary factors: 1) the manner in which, and the degree to which, the successful implementation of the measure(s) is expected to reduce impacts to marine mammals, marine mammal species or stocks, and their habitat – which considers the nature of the potential adverse impact being mitigated (likelihood, scope, range), as well as the likelihood

that the measure will be effective if implemented; and the likelihood of effective implementation, and; 2) the practicability of the measures for applicant implementation, which may consider such things as cost, impact on operations, and, in the case of a military readiness activity, personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity.

Any mitigation measure(s) prescribed by NMFS should be able to accomplish, have a reasonable likelihood of accomplishing (based on current science), or contribute to the accomplishment of one or more of the general goals listed below.

1. Avoidance or minimization of injury or death of marine mammals wherever possible (goals 2, 3, and 4 may contribute to this goal).

2. A reduction in the numbers of marine mammals (total number or number at biologically important time or location) exposed to activities expected to result in the take of marine mammals (this goal may contribute to 1, above, or to reducing harassment takes only).

3. A reduction in the number of times (total number or number at biologically important time or location) individuals would be exposed to activities expected to result in the take of marine mammals (this goal may contribute to 1, above, or to reducing harassment takes only).

4. A reduction in the intensity of exposures (either total number or number at biologically important time or location) to activities expected to result in the take of marine mammals (this goal may contribute to 1, above, or to reducing the severity of harassment takes only).

5. Avoidance or minimization of adverse effects to marine mammal habitat, paying special attention to the food base, activities that block or limit passage to or from biologically important areas, permanent destruction of habitat, or temporary destruction/disturbance of habitat during a biologically important time.

6. For monitoring directly related to mitigation – an increase in the probability of detecting marine mammals, thus allowing for more effective implementation of the mitigation.

Mitigation for Marine Mammals and their Habitat

SpaceX's IHA application contains descriptions of the mitigation measures proposed to be implemented during the specified activities in order to effect the least practicable adverse impact on the affected marine mammal species and stocks and their habitats.

It should be noted that it would not be feasible to stop or divert an inbound Falcon 9 First Stage booster. Once the boost-back and landing sequence is underway, there would be no way for SpaceX to change the trajectory of the Falcon 9 First Stage to avoid potential impacts to marine mammals. The proposed mitigation measures include the following:

- Unless constrained by other factors including human safety or national security concerns, launches would be scheduled to avoid boost-backs and landings during the harbor seal pupping season of March through June, when practicable.

Based on our evaluation of SpaceX's proposed mitigation measures, NMFS has determined that the mitigation measures provide the means effecting the least practicable impact on the affected species or stocks and their habitat, paying particular attention to rookeries, mating grounds, and areas of similar significance.

Monitoring and Reporting

In order to issue an IHA for an activity, Section 101(a)(5)(D) of the MMPA states that NMFS must set forth, requirements pertaining to the monitoring and reporting of such taking. The MMPA implementing regulations at 50 CFR 216.104 (a)(13) indicate that requests for authorizations must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and of the level of taking or

impacts on populations of marine mammals that are expected to be present in the action area. Effective reporting is critical both to compliance as well as ensuring that the most value is obtained from the required monitoring.

Monitoring and reporting requirements prescribed by NMFS should contribute to improved understanding of one or more of the following:

- Occurrence of marine mammal species or stocks in the area in which take is anticipated (*e.g.*, presence, abundance, distribution, density);
- Nature, scope, or context of likely marine mammal exposure to potential stressors/impacts (individual or cumulative, acute or chronic), through better understanding of: (1) action or environment (*e.g.*, source characterization, propagation, ambient noise); (2) affected species (*e.g.*, life history, dive patterns); (3) co-occurrence of marine mammal species with the action; or (4) biological or behavioral context of exposure (*e.g.*, age, calving or feeding areas);
- Individual marine mammal responses (behavioral or physiological) to acoustic stressors (acute, chronic, or cumulative), other stressors, or cumulative impacts from multiple stressors;
- How anticipated responses to stressors impact either: (1) long-term fitness and survival of individual marine mammals; or (2) populations, species, or stocks;
- Effects on marine mammal habitat (*e.g.*, marine mammal prey species, acoustic habitat, or other important physical components of marine mammal habitat); and
- Mitigation and monitoring effectiveness.

Monitoring

SpaceX submitted a monitoring plan as part of their IHA application. SpaceX's proposed marine mammal monitoring plan was created with input from NMFS and was based on similar plans that have been successfully implemented by other action proponents under previous authorizations for similar projects, specifically the USAF's monitoring of rocket launches from VAFB.

Marine Mammal Monitoring

SpaceX will determine a monitoring location for each boost-back and landing activity, taking into consideration predictions of the areas likely to receive the greatest sonic boom intensity as well as current haulout locations and the distribution of pinniped species and their behavior. The selection of the monitoring location will also be based on what species (if any) have pups at haulouts and which of those species would be expected to be the most reactive to sonic booms. SpaceX prioritizes the selection of rookery locations if they are expected to be impacted by a sonic boom and prioritizes the most reactive species if there are multiple species that are expected to be hauled out in the modeled sonic boom impact area. For instance, if harbor seals were pupping, SpaceX will prioritize selection of a harbor seal rookery for monitoring because they tend to be the most reactive species to sonic booms. There is also thought given to the geography and wind exposure of the specific beaches that are predicted to be impacted, to avoid inadvertently selecting a portion of a beach that tends to be abandoned by pinnipeds every afternoon as a result high winds. As VAFB is an active military base, the selection of appropriate monitoring locations must also take into account security restrictions and human safety as unexploded ordnance is present in some areas

Marine mammal monitoring protocols will vary based on modeled sonic boom intensity, the location and the season. As described above, sonic boom modeling will be performed prior to

all boost-back and landing activities. Although the same rockets will be used, other parameters specific to each launch will be incorporated into each model. These include direction and trajectory, weight, length, engine thrust, engine plume drag, position versus time from initiating boost-back to additional engine burns, among other aspects. Various weather scenarios will be analyzed from NOAA weather records for the region, then run through the model. Among other factors, these will include the presence or absence of the jet stream, and if present, its direction, altitude and velocity. The type, altitude, and density of clouds will also be considered. From these data, the models will predict peak amplitudes and impact locations.

As described above, impacts to pinnipeds on the NCI, including pups, have been shown through more than two decades of monitoring reports to be minimal and temporary (MMCG and SAIC 2012). Therefore monitoring requirements at the NCI will be dependent on modeled sonic boom intensity and will be based on the harbor seal pupping season, such that monitoring requirements are greater when pups are expected to be present. When pups are present at haulouts, a lower threshold is reasonable in that a sonic boom could theoretically pose a greater risk of abandonment of pups in the event that mothers flush to the water (we note, however, that pup abandonment has never been documented as a result of sonic booms at the NCI). As pups grow older and are more maneuverable, the risk of pup abandonment diminishes. Thus, at the height of the pupping season (between March 1 and June 30) monitoring is required if sonic boom model results indicate a peak overpressure of 1.0 psf or greater is likely to impact one of the NCI. Between July 1 and September 30 monitoring is required if sonic boom model results indicate a peak overpressure of 1.5 psf or greater is likely to impact one of the NCI. Between October 1 and February 28, monitoring is required if sonic boom model results indicate a peak overpressure of 2.0 psf or greater is likely to impact one of the NCI.

Marine mammal monitoring procedures will consist of the following:

- To conduct monitoring of Falcon 9 First Stage boost-back and landing activities, SpaceX will designate qualified (must be able to identify pinnipeds to species, age class, and sex when possible), on-site observers that will be approved in advance by NMFS;
- If sonic boom model results indicate a peak overpressure of 1.0 psf or greater is likely to impact VAFB, then acoustic and biological monitoring at VAFB will be implemented;
- If sonic boom model results indicate a peak overpressure of 1.0 psf or greater is likely to impact one of the NCI between March 1 and June 30; a peak overpressure of greater than 1.5 psf is likely to impact one of the NCI between July 1 and September 30, or a peak overpressure of greater than 2.0 psf is likely to impact one of the NCI between October 1 and February 28, then monitoring of haulout sites on the NCI will be implemented. Monitoring will be conducted at the haulout site closest to the area predicted to experience the greatest sonic boom intensity, at both VAFB and the NCI. If multiple haulouts are located within the area expected to experience the greatest sonic boom intensity, selection of monitoring locations will be based on species (*i.e.*, species known to be more reactive to sonic booms will be prioritized) and pup presence (*i.e.*, haulouts with pups will be prioritized);
- Monitoring will commence at least 72 hours prior to the boost-back and continue until at least 48 hours after the event;
- Monitors will conduct hourly counts for six hours per day centered around the scheduled launch time to the extent possible. Monitors will be at the monitoring location continuously for six hours per day and will record pinniped counts every hour during this period;

- If the activity occurs during daylight hours then the six hourly counts will be centered around the scheduled launch time (such that there are observations for 2-3 hours before and after the event). If the activity occurs during nighttime then hourly counts will commence at daybreak and proceed until six hours after daybreak (counts taken during nighttime are not accurate). Monitors would observe pinniped reactions with night vision binoculars for nighttime events;
- Monitoring will include multiple surveys each day that record the species; number of animals; general behavior; presence of pups; age class; gender; and reaction to noise associated with Falcon 9 First Stage recovery activities, sonic booms or other natural or human caused disturbances, in addition to recording environmental conditions such as tide, wind speed, air temperature, and swell;
- If the boost-back and landing is scheduled during daylight hours, time lapse photography or video recording will be used to document the behavior of marine mammals during Falcon 9 First Stage recovery activities;
- For Falcon 9 First Stage recovery activities scheduled during harbor seal pupping season (March through June), follow-up surveys will be conducted within two weeks of the boost-back and landing;
- Newly documented northern elephant seal pupping locations at VAFB will be prioritized for monitoring when landings occur at SLC-4W during northern elephant seal pupping season (January through February) when practicable.

Acoustic Monitoring

Acoustic measurements of the sonic boom created during boost-back at the monitoring location will be recorded to determine the overpressure level. Typically this will entail use of a

digital audio tape (DAT) recorder and a high quality microphone to monitor the sound environment and measure the sonic boom. This system will be specially tailored for recording the low frequency sound associated with rocket launches and sonic booms. The DAT system will record the launch noise and sonic boom digitally to tape, which will allow for detailed post-analysis of the frequency content, and the calculation of other acoustic metrics, and will record the ambient noise and sonic boom. The DAT recorder will be placed near the marine mammal monitoring site when practicable.

Reporting

SpaceX will report data collected during marine mammal monitoring and acoustic monitoring as described above. The monitoring report will include a description of project related activities, counts of marine mammals by species, sex and age class, a summary of marine mammal species/count data, and a summary of observed marine mammal responses to project-related activities.

A launch monitoring report will be submitted by SpaceX to the NMFS Office of Protected Resources and the NMFS West Coast Region within 60 days after each Falcon 9 First Stage recovery action. This report will contain information on the date(s) and time(s) of the Falcon 9 First Stage recovery action, the design of the monitoring program; and results of the monitoring program, including, but not necessarily limited to the following:

- Numbers of pinnipeds present on the monitored haulout prior to the Falcon 9 First Stage recovery;
- Numbers of pinnipeds that may have been harassed (based on observations of pinniped responses and the pinniped disturbance scale as shown in Table 4);

- The length of time pinnipeds remained off the haulout or rookery for pinnipeds estimated to have entered the water as a result of Falcon 9 First Stage recovery noise;
- Any other observed behavioral modifications by pinnipeds that were likely the result of Falcon 9 First Stage recovery activities, including sonic boom; and
- Results of acoustic monitoring including comparisons of modeled sonic booms with actual acoustic recordings of sonic booms.

In addition, a final monitoring report will be submitted by SpaceX to the NMFS Office of Protected Resources. A draft of the report will be submitted within 90 days of the expiration of the IHA, or, within 45 days of the requested renewal of the IHA (if applicable). A final version of the report will be submitted within 30 days following resolution of comments on the draft report from NMFS. The report will summarize the information from the 60-day post-activity reports (as described above), including but not necessarily limited to the following:

- Date(s) and time(s) of the Falcon 9 First Stage recovery actions;
- Design of the monitoring program; and
- Results of the monitoring program, including the information components contained in the 60-day launch reports, as well as any documented cumulative impacts on marine mammals as a result of the activities, such as long term reductions in the number of pinnipeds at haulouts as a result of the activities.

In the unanticipated event that the specified activity clearly causes the take of a marine mammal in a manner not authorized by the IHA, such as a Level A harassment, or a take of a marine mammal species other than those authorized, SpaceX would immediately cease the specified activities and immediately report the incident to the NMFS Office of Protected Resources. The report would include the following information:

- Time, date, and location (latitude/longitude) of the incident;
- Description of the incident;
- Status of all Falcon 9 First Stage recovery activities in the 48 hours preceding the incident;
- Description of all marine mammal observations in the 48 hours preceding the incident;
- Species identification or description of the animal(s) involved;
- Fate of the animal(s); and
- Photographs or video footage of the animal(s) (if equipment is available).

Activities would not resume until NMFS is able to review the circumstances of the prohibited take. NMFS would work with SpaceX to determine what is necessary to minimize the likelihood of further prohibited take and ensure MMPA compliance. SpaceX would not be able to resume their activities until notified by NMFS via letter, email, or telephone.

In the event that SpaceX discovers an injured or dead marine mammal, and the lead observer determines the cause of the injury or death is unknown and the death is relatively recent (*i.e.*, in less than a moderate state of decomposition), SpaceX would immediately report the incident tomailto: the NMFS Office of Protected Resources and the NMFS West Coast Region Stranding Coordinator. The report would include the same information identified in the paragraph above. Authorized activities would be able to continue while NMFS reviews the circumstances of the incident. NMFS would work with SpaceX to determine whether modifications in the activities are appropriate.

In the event that SpaceX discovers an injured or dead marine mammal, and the lead MMO determines the injury or death is not associated with or related to the activities authorized in the IHA (*e.g.*, previously wounded animal, carcass with moderate to advanced decomposition,

or scavenger damage), SpaceX would report the incident to the NMFS Office of Protected Resources and NMFS West Coast Region Stranding Coordinator, within 24 hours of the discovery. SpaceX would provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network.

This will be the second IHA issued to SpaceX for the specified activity. SpaceX did not perform any Falcon 9 boost-back and landing activities that resulted in return flights to VAFB nor that generated sonic booms that impacted the NCI during the period of validity for the prior IHA issued for the same activity. SpaceX did perform boost-back and landing activities at a contingency landing location located offshore during the period of validity for the prior IHA, however the contingency landing location was located so far offshore that there were no impacts predicted to marine mammals by sonic boom modeling, thus marine mammal monitoring was not required.

Negligible Impact Analysis and Determination

NMFS has defined negligible impact as an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival (50 CFR 216.103). A negligible impact finding is based on the lack of likely adverse effects on annual rates of recruitment or survival (*i.e.*, population-level effects). An estimate of the number of takes alone is not enough information on which to base an impact determination. In addition to considering estimates of the number of marine mammals that might be "taken" through harassment, NMFS considers other factors, such as the likely nature of any responses (*e.g.*, intensity, duration), the context of any responses (*e.g.*, critical reproductive time or location, migration), as well as

effects on habitat, and the likely effectiveness of the mitigation. We also assess the number, intensity, and context of estimated takes by evaluating this information relative to population status. Consistent with the 1989 preamble for NMFS's implementing regulations (54 FR 40338; September 29, 1989), the impacts from other past and ongoing anthropogenic activities are incorporated into this analysis via their impacts on the environmental baseline (*e.g.*, as reflected in the regulatory status of the species, population size and growth rate where known, ongoing sources of human-caused mortality, or ambient noise levels).

To avoid repetition, the discussion of our analyses applies to all the species listed in Table 1, given that the anticipated effects of this activity on these different marine mammal species are expected to be similar. Activities associated with Falcon 9 First Stage recovery, as outlined previously, have the potential to disturb or displace marine mammals. Specifically, the specified activities may result in take, in the form of Level B harassment (behavioral disturbance) only, from airborne sounds of sonic booms. Potential takes could occur if marine mammals are hauled out in areas where a sonic boom above 1.0 psf occurs, which is considered likely given the modeled sonic booms of the planned activities and the occurrence of pinnipeds in the project area. Based on the best available information, including monitoring reports from similar activities that have been authorized by NMFS, behavioral responses will likely be limited to reactions such as alerting to the noise, with some animals possibly moving toward or entering the water, depending on the species and the intensity of the sonic boom. Repeated exposures of individuals to levels of sound that may cause Level B harassment are unlikely to result in hearing impairment or to significantly disrupt foraging behavior. Thus, even repeated Level B harassment of some small subset of an overall stock is unlikely to result in any significant realized decrease in fitness to those individuals, and thus would not result in any adverse impact

to the stock as a whole. Level B harassment would be reduced to the level of least practicable impact through use of mitigation measures described above.

If a marine mammal responds to a stimulus by changing its behavior (*e.g.*, through relatively minor changes in locomotion direction/speed), the response may or may not constitute taking at the individual level, and is unlikely to affect the stock or the species as a whole. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on animals or on the stock or species could potentially be significant (*e.g.*, Lusseau and Bejder, 2007; Weilgart, 2007). Flushing of pinnipeds into the water has the potential to result in mother-pup separation, or could result in a stampede, either of which could potentially result in serious injury or mortality and thereby could potentially impact the stock or species. However, based on the best available information, including reports from over 20 years of launch monitoring at VAFB and the NCI, no serious injury or mortality of marine mammals is anticipated as a result of the planned activities.

Even in the instances of pinnipeds being behaviorally disturbed by sonic booms from rocket launches at VAFB, no evidence has been presented of abnormal behavior, injuries or mortalities, or pup abandonment as a result of sonic booms (SAIC 2013). These findings came as a result of more than two decades of surveys at VAFB and the NCI (MMCG and SAIC, 2012). Post-launch monitoring generally reveals a return to normal behavioral patterns within minutes up to an hour or two of each launch, regardless of species. For instance, a total of eight Delta II and Taurus space vehicle launches occurred from north VAFB, near the Spur Road and Purisima Point haulout sites, from February, 2009 through February, 2014. Of these eight launches, three occurred during the harbor seal pupping season. The continued use by harbor seals of the Spur Road and Purisima Point haulout sites indicates that it is unlikely that these rocket launches (and

associated sonic booms) resulted in long-term disturbances of pinnipeds using the haulout sites. San Miguel Island represents the most important pinniped rookery in the lower 48 states, and as such extensive research has been conducted there for decades. From this research, as well as stock assessment reports, it is clear that VAFB operations (including associated sonic booms) have not had any significant impacts on San Miguel Island rookeries and haulouts (SAIC 2012).

In summary, this negligible impact analysis is founded on the following factors:

- No injury, serious injury, or mortality are anticipated or authorized;
- The anticipated incidences of Level B harassment are expected to consist of, at worst, temporary modifications in behavior (*i.e.*, short distance movements and occasional flushing into the water with return to haulouts within at most two days), which are not expected to adversely affect the fitness of any individuals;
- The activities are expected to result in no long-term changes in the use by pinnipeds of rookeries and haulouts in the project area, based on over 20 years of monitoring data; and
- The presumed efficacy of planned mitigation measures in reducing the effects of the specified activity to the level of least practicable impact.

In combination, we believe that these factors, as well as the available body of evidence from other similar activities, demonstrate that the potential effects of the specified activity will be short-term on individual animals. The specified activity is not expected to impact rates of recruitment or survival and will therefore not result in population-level impacts. Based on the analysis contained herein of the likely effects of the specified activity on marine mammals and their habitat, and taking into consideration the implementation of the monitoring and mitigation measures, NMFS finds that the total marine mammal take from the planned activity will have a negligible impact on the affected marine mammal species or stocks.

Small Numbers

As noted above, only small numbers of incidental take may be authorized under Section 101(a)(5)(D) of the MMPA for specified activities other than military readiness activities. The MMPA does not define small numbers and so, in practice, NMFS compares the number of individuals taken to the most appropriate estimation of abundance of the relevant species or stock in our determination of whether an authorization is limited to small numbers of marine mammals. Additionally, other qualitative factors may be considered in the analysis, such as the temporal or spatial scale of the activities.

The numbers of authorized takes would be considered small relative to the relevant stocks or populations (less than 22 percent for all species and stocks). It is important to note that the number of expected takes does not necessarily represent of the number of individual animals expected to be taken. Our small numbers analysis accounts for this fact. Multiple exposures to Level B harassment can accrue to the same individual animals over the course of an activity that occurs multiple times in the same area (such as SpaceX's planned activity). This is especially likely in the case of species that have limited ranges and that have site fidelity to a location within the project area, as is the case with harbor seals.

As described above, harbor seals are non-migratory, rarely traveling more than 50 km from their haulout sites. Thus, while the estimated abundance of the California stock of Pacific harbor seals is 30,968 (Carretta *et al*., 2017), a substantially smaller number of individual harbor seals is expected to occur within the project area. We expect that, because of harbor seals' documented site fidelity to haulout locations at VAFB and the NCI, and because of their limited ranges, the same individuals are likely to be taken repeatedly over the course of the specified activities (maximum of twelve Falcon 9 First Stage recovery actions). Therefore, the

number of instances of Level B harassment among harbor seals over the course of the authorization (*i.e.*, the total number of takes shown in Table 6) is expected to accrue to a much smaller number of individuals encompassing a small portion of the overall regional stock. The maximum number of individual of harbor seals expected to be taken by Level B harassment, per Falcon 9 First Stage recovery action, is 1,384. As we believe the same individuals are likely to be taken repeatedly over the course of the specified activities, we use the estimate of 1,384 individual animals taken per Falcon 9 First Stage recovery activity for the purposes of estimating the percentage of the stock abundance likely to be taken over the course of the entire activity.

Based on the analysis contained herein of the planned activity (including the mitigation and monitoring measures) and the anticipated take of marine mammals, NMFS finds that small numbers of marine mammals will be taken relative to the population size of the affected species or stocks.

Unmitigable Adverse Impact Analysis and Determination

There are no relevant subsistence uses of the affected marine mammal stocks or species implicated by this action. Therefore, NMFS has determined that the total taking of affected species or stocks would not have an unmitigable adverse impact on the availability of such species or stocks for taking for subsistence purposes.

National Environmental Policy Act

To comply with the National Environmental Policy Act of 1969 (NEPA; 42 U.S.C. §§ 4321 *et seq.*) and NOAA Administrative Order (NAO) 216-6A, NMFS must review our proposed action with respect to potential impacts on the human environment.

This action is consistent with categories of activities identified in CE B4 of the Companion Manual for NAO 216-6A, which do not individually or cumulatively have the potential for significant impacts on the quality of the human environment and for which we have not identified any extraordinary circumstances that would preclude this categorical exclusion. Accordingly, NMFS has determined that the issuance of the IHA qualifies to be categorically excluded from further NEPA review.

Endangered Species Act

There is one marine mammal species (Guadalupe fur seal) listed under the ESA with confirmed occurrence in the area expected to be impacted by the planned activities. The NMFS West Coast Region has determined that NMFS OPR's issuance of the IHA to SpaceX for the take of marine mammals incidental to Falcon 9 First Stage recovery activities is not likely to adversely affect the Guadalupe fur seal. Therefore, formal ESA section 7 consultation on this IHA is not required.

Authorization

NMFS has issued an IHA to SpaceX for the potential harassment of small numbers of six marine mammal species incidental to Falcon 9 First Stage recovery activities in California and at contingency landing locations offshore, provided the previously mentioned mitigation, monitoring and reporting requirements are incorporated.

Dated: December 20, 2017.

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Donna S. Wieting,

Director, Office of Protected Resources,

National Marine Fisheries Service.

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