Amstrup Evaluation of the DEIS describing proposed development of the Arctic Refuge Coastal Plain

Summary:

The Drafters of the DEIS repeatedly describe how oil and gas exploration and development activities on the Arctic Refuge Coastal Plain will have detrimental effects on polar bears. They point out anticipated impacts from polar bear/human conflict situations will increase in accordance with the most recent literature on this topic (Atwood et al. 2017). They acknowledge that interference with polar bear maternal denning is virtually assured. And, they recognize that these impacts will be magnified by sea ice loss and other ongoing symptoms of global warming. Yet in each case, after explaining why negative effects are virtually certain, the Drafters walk back their assertions by concluding those impacts will be negligible. The Drafters attempt to make a case that existing incidental take regulations combined with new operational restrictions intended to avoid some areas preferred by polar bears (including selected fractions of maternal denning habitat and efforts to detect dens in advance of on-the-ground disturbances) will prevent population-level negative impacts from exploration and development. The Southern Beaufort Sea polar bear population, however, already is in decline due largely to poor survival of cubs (Bromaghin et al 2016) and polar bears

have been granted protection as a threatened species under the U.S. Endangered Species Act. The negative impacts acknowledged in the DEIS are not consistent with conservation in light of the polar bear's threatened status in that the impacts are virtually certain to accelerate the existing population decline. For that reason, they cannot be considered "negligible."

In addition to unconvincing and contradictory arguments about the risks to polar bears from oil and gas development activities, the Drafters largely ignore the potential impact on polar bear maternal dens of exploratory seismic testing that would occur in advance of on-the-ground developments. The Drafters of the DEIS acknowledge that climate change has already reduced this population by approximately half, and a major symptom contributing to that decline is reduced cub survival (Bromaghin et al. 2016). They further admit that 22% of Southern Beaufort Sea polar bears may den annually on the Arctic Refuge Coastal Plain. Yet, the DEIS claims the impacts on denning mother bears and their cubs will be negligible. But what is negligible for a population already in steep decline? As proposed, the 3 dimensional (3D) seismic testing would disturb 88% of maternal denning habitat. If the survey is actually conducted in the fashion of other recent seismic surveys, including multiple paths along grid lines, it would impact 92% or more of identified maternal denning habitats. Such a survey could disturb up to 14 denning mother bears, and it would on average run directly over 2.2 occupied dens with likely fatal consequences for mother bears and cubs. Even assuming the lowest possible estimate of 10 undetected maternal dens, there is a 79% chance one or more dens will be run over, and, on average 1.4 dens would be crushed. Therefore, even with

the lowest probable number of dens occurring on the Arctic Refuge Coastal Plain, the risk of fatal encounters with seismic vehicles is too high to be considered negligible.

The Arctic Refuge Coastal Plain includes the highest density of denning habitat in Alaska. The U.S. Fish and Wildlife Service Conservation Management Plan (U. S. Fish and Wildlife 2016), which was prepared in response to the polar bear's threatened status, concludes that protecting denning habitats is a critical measure for maintaining the maximum possible numbers of polar bears until humans halt greenhouse gas rise and stabilize the sea ice that polar bears require. Because the Arctic Refuge Coastal Plain provides terrestrial denning habitats vital to the survival of the species, it has been designated critical habitat for polar bears of the Southern Beaufort Sea. The importance of polar bear denning habitats on the Arctic Refuge Coastal Plain and the dramatically declining status of this population mean the impacts of exploration and development of oil and gas reserves are not likely to be negligible or in any way compatible with the U.S. Fish and Wildlife Service goal of assuring that polar bear populations are maintained to the maximum extent possible until greenhouse gas rise is halted. Rather, the combined impacts of activities and developments proposed in the DEIS are virtually certain to accelerate the current declining trend of the Southern Beaufort Sea polar bear population.

Major Flaws/Omissions in the DEIS:

Failure to discuss seismic testing—Without giving any detail, the DEIS states "Processed area-wide three-dimensional (3D) seismic data would be available for licensing to all potential bidders at the time of the first lease sale. (Volume 2 B-8)." Such

testing would be used to precisely define drilling sites, other pad locations, and spatial footprints of roads and pipelines. Because no such seismic data currently exist, and would need to be newly acquired, the fact that pre-development seismic exploration is not analyzed in the polar bear section of the DEIS is an egregious omission. Other than stating 3D data would be given to bidders, the DEIS essentially hides the plan for this testing and the impact that testing could have on polar bears. Instead of including it in the DEIS, proposals for the 3D seismic testing on the Coastal Plain need to be acquired from the BLM website as documents separate from the DEIS. The website (https://eplanning.blm.gov/epl-front-office/eplanning/projectSummary.do?methodName=renderDefaultProjectSummary&projectId=111085) provides two proposals from SAExploration. Here I evaluate the most recent and most detailed of those proposals[1]. While news articles indicate that the exploration proposal may have shifted, these documents remain the most recent public information. If and when new information is released, our comments may be updated. The most recent and most detailed of the two documents (released August 6, 2018) (Marsh Creek Plan of Operations) specifies that the seismic testing will include a 200-meter by 200-meter grid system (specified as ~660 ft), with receiver lines running perpendicular to the source lines. Estimates of the impacts of such an intensive survey follow.

Knowledge of polar bear responses to disturbances near dens—The proposed high-density seismic grid system poses severe risk of disturbance to mother

[1] A seismic proposal with a lower density grid was analyzed previously. Comments here reflect a more precise analysis of the probability that maternal dens will be directly under and/or within 65-meters of heavy equipment pathways.

polar bears and the cubs occupying maternal dens. Published accounts (Amstrup 1993) and other observations affirm that many maternal polar bears will remain in dens despite high levels of activity nearby. Reluctance to abandon a den can be viewed as "tolerance" of disturbances near dens, and bears may hold tight while industrial activities occur nearby. But when the potential disturbance is both intensive and expansive, like 3D seismic testing, that apparent tolerance could have negative consequences. Heavy vehicle traffic and associated activities can cause bears denning within 65-meters of seismic lines to emerge from their dens (Amstrup 1993). On the other hand, tolerance of disturbances near dens is highly variable (Amstrup 1993), and some documented records of close encounters with occupied dens suggest many maternal polar bears are reluctant to leave their dens—despite major disturbances right at den sites.

Three examples of this tolerance illustrate how reluctant some bears can be to abandon dens. 1) In 1984, B.P. Kelly observed a female bear and single cub depart a den after close approach by a large helicopter on 8 March. Kelly entered the den and made some measurements. On 11 March he returned to the den to make more measurements but upon entering the den realized the bears were back. Even after this close encounter these bears remained in the den at least until 13 March (Amstrup 1993), suggesting a great degree of tolerance for disturbance, and attachment to the den. 2) While probing the snow and digging test holes, on April 6, 2001, to locate and measure a previously observed den, S. C. Amstrup suddenly fell through the den roof and realized the den was still occupied. It was not until the roof of the den collapsed and a researcher fell into the den that this mother bear emerged. 3) B. J. Kirschhoffer and R.

Robinson attempted to measure a den they thought had been abandoned, on 29 March 2009, only to find it still occupied. After identifying the location of the den by probing with metal rods, they began digging an access hole. When they penetrated the lair, they realized it was still occupied. They also realized they had parked their snow-mobiles right on top of the den. Despite probing with a metal rod and despite considerable walking around and digging, and despite coming face to face with an intruding researcher, the family remained in the den after the researchers left the area. So, whereas some female bears may emerge from dens as a result of disturbances or activities nearby, others clearly will stay in their dens even through significant disruptions. It is important to emphasize that it is unknown whether or not those bears that stayed in their dens after being exposed disturbances ultimately left their dens sooner than they otherwise would have in the absence of any disturbance.

Both ends of the polar bear's behavior spectrum, with regard to potential disturbances around dens, can result in negative impacts from activities such as 3D seismic testing. Whether from an innate feeling of security in a den or habituation to noises and vibrations of vehicles moving around them; the "comfort level" many polar bears show with activities outside their dens could result in waiting too long to leave a den when the disturbance is truly dangerous for them. The above observations make it clear that some bears will not leave before their den is actually run over and crushed. Even if a mother bear is able to exit her den ahead of oncoming seismic vehicles—in a circumstance where a den is in the direct path of seismic vehicles, her departure threshold might have been exceeded so suddenly as to prompt hurried evacuation

resulting in cubs being left behind and either crushed or abandoned. Other females may be prompted to emerge and even leave dens if an unnatural stimulus is only nearby.

We know that very small cubs cannot survive outside the den (Amstrup and Gardner 1994), and we know early den departure is accompanied by reduced cub survival (Amstrup and Gardner 1994, Rode et al. 2018). Polar bear cubs grow rapidly because they receive extremely rich milk from their mothers (Ramsay and Dunbrack 1986). During years of research in Alaska I noted several very small cubs that survived only short periods after den emergence. These cubs whose mothers emerged from dens very thin and probably not producing adequate milk had more difficulty keeping up with their mother as she moved on the ice to hunt and were clearly more vulnerable than larger cubs. Every additional day in the protection of a den, therefore, can benefit cub survival potential, and a too-early emergence even if cubs appear able to move away with their mother, can reduce post-emergence survival (Amstrup and Gardner 1994, Rode et al. 2018).

How many dens occur on the Coastal Plain each year?

Data source for estimating current and future den numbers—Calculating the expected number of polar bear maternal dens that might occur on the Arctic Refuge Coastal Plain in any one winter depends on estimating the number of female bears in the population, estimating the number of females that may be breeding and entering dens, estimating the number that may be denning on land; and finally estimating the number of land dens that might occur on the Arctic Refuge coastal plain.

The proportion of Southern Beaufort Sea polar bears seeking to den on land has changed as the quantity and quality of sea ice has declined (Amstrup and Gardner

1994, Fischbach et al. 2007, Olsen et al. 2016). Population welfare also has declined with recent reductions in sea ice availability (Amstrup et al. 1986, Regehr et al, 2006, Regehr et al. 2009, Rode et al. 2010, Bromaghin et al. 2016). Therefore, I focus on the locations of dens known by radio-telemetry from spring 2000 to 2010 (Durner et al. 2010). This period coincides with the most recent documentation of the status of the population (Bromaghin et al. 2016), and with nearly 100 females followed by radio-telemetry to maternal dens during this period, the Durner et al. (2010) data set provides sufficient observations to meaningfully reflect recent patterns in den distribution.

Estimating the number of denning bears—The number of female polar bears seeking dens each autumn can be estimated by the number of adult females in the population and their litter production or breeding rate. In the 1980s, as many as 142 polar bears may have been denning in Alaska or offshore of Alaska each winter (Amstrup et al. 1986, see below). Although the Southern Beaufort Sea polar bear population is now only about half the size it was in the 1980s (Bromaghin et al. 2016), the influence of cub mortality on the multi-year breeding cycle of polar bears means that we cannot simply conclude that half as many females would now be entering dens each year. Polar bears breed at the start of the spring foraging season, and cubs are born in a very undeveloped state the following winter (Amstrup 2003). It is only after birth and initiation of lactation that mother bears invest significant energy in their cubs (Ramsay and Dunbrack 1986), and it is during lactation that the weight gain mother bears were able to achieve the previous summer becomes critical. Nearly all females available to breed (that is all adult females not encumbered with offspring) in spring will do so (Derocher et al. 1992). In years when summer foraging is good, pregnant females enter

dens with enough fat reserves to provide abundant milk to their cubs after birth. In years, when mother bears may not have been very successful hunting and are unable to produce enough milk, their cubs may perish. Having lost her cubs, a mother bear protects her own reserves—assuring she can survive and try breeding again in another and hopefully better year. Hence, the strategy of low pre-birth maternal investment allows female polar bears to defer reproduction in poor foraging years without impacting their own survival. Deteriorating sea ice means that the frequency of “bad” years is higher now than it used to be, and more females are entering dens with insufficient weight gain to nourish cubs after birth. More females losing their cubs means more are available to breed and den again in the same year they emerged from their last den.

Over most of their range polar bears that are successful in raising cubs normally wean them at 2.3 years of age, meaning they can complete a reproductive effort no more frequently than every 3 years. Due to early weaning (always rare in the Beaufort Sea) or early cub mortality (which is now common), the breeding interval can be shorter than 3 years. Due to loss of older cubs, mother bears needing a break from reproduction in order to rebuild body stores, or other unknown factors, the breeding interval also can be longer. The estimated number of females denning each year in the 1980s was based on an observed average breeding interval of 3.6 years. At that time, more females than now were well nourished and able to complete their reproductive cycle, but there were some apparent interruptions preventing the perfect 3-year breeding interval. Dividing the 3.6-year breeding interval into a population size estimated at that time to be 511 adult females, yielded the estimate that approximately

142 were annually entering dens in the Southern Beaufort Sea region during the 1980s (Amstrup et al. 1986).

Currently, the Southern Beaufort Sea population is only about half of what it was in the 1980s with an estimated 236 adult females (Bromaghin et al. 2016, supplemental online material). But, the proportion of cubs and yearlings in the population also is less than half of what it was in the 1980s, suggesting the present survival rate of cubs is only about half of what it used to be (Amstrup 1995). With more females losing cubs shortly after den emergence, we would expect a higher proportion of females that had lost their cubs in spring, to be entering dens each year. In essence, the breeding interval has increasingly become severed from the true reproductive interval. In other words, although females are breeding and producing cubs, poor survival means those cubs are not being recruited into the population. Because the breeding interval is approximately the reciprocal of the breeding rate (Ramsay and Stirling 1988), a 1.8-year cycle would mean a breeding rate or probability of ~0.55[2]. With a population of ~236 females, and a breeding interval of 1.8 years we could expect ~131 bears to be denning each winter[3].

Estimating the distribution of denning bears—In the 1980s, when as many as 142 polar bears may have been denning in Alaska or offshore of Alaska each winter (Amstrup et al. 1986), only 46% or 65 dens may have been on land each winter (Amstrup and Gardner 1994). Due to declining availability of sea ice habitat suitable for denning, members of the Southern Beaufort Sea polar bear population increasingly

[2] Because the breeding interval does not account for litter size, and because proportions of cubs in the population represent some litters of multiple (usually 2) cubs. The actual breeding probability is most probably higher than 0.55. So this estimate must be considered conservative.

[3] Modeling the polar bear's life cycle against demographic data collected from 2001-2005, Regehr et al. (2009) estimated an almost identical breeding probability of 0.541.

have chosen to den on land. Fischbach et al. (2007) determined 63% of radio collared bears entered dens on land, and between spring 2000 and spring 2010, 76 of 99 dens (77%) located by radio-telemetry were on land (Durner et al. 2010)[4]. Of these recent dens 15 (15%) were on the Arctic Refuge Coastal Plain, suggesting we could expect 20 dens (15% of 131 dens) each year on the Arctic Refuge Coastal Plain. Drafters of the DEIS concluded 22% of known maternal dens between 2000 and 2010 were on the Arctic Refuge Coastal Plain (Vol. 1, 3-128). Multiplying 0.22 by the estimated 131 females likely denning each year suggests up to 29 maternal dens may be found annually within the bounds of the Arctic Refuge Coastal Plain.

Considering varying assumptions and current and future conditions, the best estimate for future annual denning on the Arctic Refuge is on the upper end of the estimated range (20-29) of dens occurring each year on the Arctic Refuge Coastal Plain. For starters, proportions of cubs in the population represent some litters of multiple (usually 2) cubs and estimating the breeding probability as the reciprocal of the breeding interval does not account for variation in litter size. Therefore, the actual current breeding probability is likely higher than 0.55. Add to this, the fact that cub mortality is only likely to increase as sea ice quality and availability continues to negatively impact foraging abilities. This means that whatever breeding probability is now, it is likely to be higher in the future as more and more females confront increasingly frequent poor foraging conditions, and reproductive success becomes lower. Also, the proportion of female polar bears choosing to den on land has continued to increase, from 46% in the 1980s to 77% between 2000 and 2010. Finally, summer-

[4] As in past studies, bears denning on land-fast ice adjacent to shore are included with dens on land.

time land use has increased three-fold (Atwood et al. 2016) in recent years, and numbers of bears on land in summer is expected to continue to increase. Because there are few nutritious foods available on land, a majority of the Southern Beaufort Sea polar bears that spend all or part of summer on land take advantage of supplemental food in the form of whale remains at the "bone pile" near the village of Kaktovik (Atwood et al. 2016)[5]. Higher numbers of bears supplementing their pre-denning foraging near Kaktovik is likely to translate into higher numbers of bears denning on the adjacent Arctic Refuge Coastal Plain close to this large food source. Therefore, for purposes of estimating the number of dens that may be impacted by oil and gas development of the Arctic Refuge Coastal Plain, it seems likely that 29 or more maternal bears will den there each year as we go into the future.

How many maternal denning bears will be impacted?

Drafters of the DEIS suggest dens will be detected and avoided by use of forward looking infrared (FLIR) surveys conducted in advance of on-the-ground activities (see below, discussion of advance detection of dens). The track record of such surveys in active oil field areas west of the Arctic Refuge reveals significant limitations, however. Between 2004 and 2016, FLIR surveys conducted in advance of various oil field operations along Alaska's North Slope correctly identified 12 maternal dens but missed 11 dens (essentially a 50% detection rate) that were within the survey areas. The denning habitat on the Arctic Refuge Coastal Plain is more expansive and far more complex than other areas of Alaska's north slope where oil and gas activity has

[5] The "bone pile" is where remains (not consumed by people) of bowhead whales (*Balaena mysticetus*) harvested by residents of the Kaktovik community are deposited.

occurred—and where FLIR has been used to find dens. Therefore, it seems unlikely detection rates on the Arctic Refuge Coastal Plain will be any higher than the ~50% historic record. With between 20 and 29 pregnant females denning on the much more expansive and complicated Arctic Refuge Coastal Plain each year, and with a ~50% detection rate for FLIR, half or between 10 and 15 of the dens annually expected to occur on the Coastal Plain are likely to be undetected before seismic testing begins in winter.

Assuming there are 10-15 undetected maternal dens on the Arctic Refuge Coastal plain, we can estimate how many dens will be disturbed by the proposed 3D seismic testing[6]. With seismic vehicles leaving a footprint approximately 3m wide, ~3% of the Arctic Refuge Coastal Plain, and the denning habitat, would be run over by tracks of these vehicles. Additionally, past observations suggest that seismic vehicle traffic and associated activities can cause den emergence for females within ~65-meters of the seismic survey lines (Amstrup 1993). Observations suggest great individual variability in sensitivity to disturbances outside the den (Amstrup 1993). Some bears are much more tolerant and likely not to exit their den without far greater stimulus and others seem more sensitive. But, within 65 meters of seismic traffic, past observations suggest many bears are likely to exit their dens, and those that don't may remain inside even as vehicles drive over them. Each 200 x 200-meter seismic grid cell would include a "doughnut hole" of 70 X 70 meters that is not within 65 meters of a survey line. Applying the 65-meter buffer to each side of survey lines would mean 87.75% of each grid cell

[6] Again, because BLM has failed to provide the public with further information about pending Coastal Plain seismic survey proposals, this analysis considers the most recent proposal from SAExploration that BLM did make public.

would be exposed to disturbance at distances known to cause den emergence. That same buffer intersects 87.70% of the mapped denning habitat on the Arctic Refuge Coastal Plain, verifying the conclusion of Durner et al. (2006) that the distribution of maternal denning habitat on the Arctic Refuge Coastal Plain is essentially uniform. Only 12.30% of all denning habitat on the Arctic Refuge Coastal Plain therefore falls inside the gaps or "doughnut holes" that are not within 65 meters of a survey line. Figure 1 illustrates how completely the Arctic Refuge Coastal Plain would be covered by the proposed seismic survey grid.

The previous paragraph illustrates how much denning habitat will be impacted by the 3D seismic survey proposed by BLM and SAExploration. Estimated numbers of dens that will be impacted by the proposed seismic survey are shown in Table 1. If there are 15 undetected dens on the Refuge, a seismic survey of the proposed intensity and areal extent would have a 36% chance of actually running over the top of and crushing one or more occupied dens, with fatal consequences for the mother bear and or her cubs. If such a survey were conducted multiple times, the average number of dens crushed would be 0.45, and on average 13 dens would be exposed to potential disturbance. Similarly, if 10 undetected dens are present there would be a 26% chance that vehicles would run directly over one or more. And, if there are as few as 4 dens present, it is virtually certain that that at least one occupied den would be exposed within the 65-meter buffer surrounding each side of proposed grid lines. Whereas all bears denning within 65 meters of a survey path may not exit their dens, records show that some will. Even if the immediate effect of such a disturbance is not fatal, early departure from maternal dens leads to poorer cub survival (Amstrup and Gardner 1994,

Rode et al. 2018), and there could be latent lethal consequences. Given the declining status of the Southern Beaufort Sea population is driven largely by poor survival of young, such disturbances, added to immediate mortalities, can only exacerbate ongoing declines.

The calculations in Table 1 are based on the proposed 3D seismic survey being constructed of a 200 x 200-meter grid of survey lines, where the lines are actually paths ~3m wide and a zone of influence extends ~65m either side of the line. In actual practice, however, on-the-ground footprints of seismic surveys conducted as recently as last year have far wider footprints and influenced far more habitat. Aerial photos of the tracks made by seismic testing vehicles working west of the Arctic Refuge during the winter of 2017-2018 reveal that grid lines were actually composed of 2 or more passes by seismic vehicles (Walker et al. 2019). These multiple passes, evident because they were made by vehicles heavy enough they compressed the vegetation and altered snow collection and melt patterns, showed that strips of disturbed habitat were approximately 15 meters in width (http://fairbanksfodar.com/science-in-the-1002-area) rather than the 3 meters assumed for calculations in Table 1. In addition to survey lines impacting a much wider path than proposed, there is photographic evidence of numerous “off transect” vehicle paths that crossed the survey grid at numerous angles and with varying concentration. The purpose of multiple tracks is not known, but their presence indicates we cannot assume that seismic testing grids are composed of perfect lines only as wide as one vehicle. If implementation of the seismic plan for the Arctic Refuge includes multiple passes and other off-transect traffic, the zone of influence and the number of dens potentially disturbed would be far greater than shown

in Table 1. With a 15-meter wide footprint, over 14% of the Arctic Refuge Coastal Plain denning habitat would be “run over” by seismic vehicles and 92% of the habitat would be within the 65-meter-wide zone known to disturb some mother bears in their dens (Table 2). If the true path falling under seismic vehicles is 15 meters wide rather than 3 meters wide and if there are 15 undetected dens on the Refuge, each such survey would have a 90% probability of running over one or more occupied maternal dens, and on average (if the survey were repeated multiple times) vehicles would run over 2 maternal dens. If there were 10 undetected dens, there would be a 79% probability that one or more den will be run over, and on average 1.4 dens would be crushed. And, we must remember these outcomes do not include the additional (and *a priori* inestimable) risk from the miscellaneous cross-grid tracks that apparently accompany seismic surveys as they are actually conducted.

Therefore, whether as few as 20 females enter maternal dens on the Arctic Refuge Coastal plain, or as many as 29, the risk of fatal encounters with seismic vehicles is very real and its impacts cannot be described as negligible.

Figure 1. Map of the Arctic Refuge Coastal Plain (1002 area) showing denning habitat (narrow red polygons, Durner et al. 2006), and proposed 200 x 200-meter seismic survey grid (pale orange lines). The grid is so closely spaced it appears merely as shading at the scale of the entire Coastal Plain. The left inset illustrates the seismic grid spacing (orange lines) and a small area of denning habitat (red polygons) at much larger scale. The right inset shows the same larger scale view of the seismic grid plus a 65-meter zone of disturbance (grey-green shading) either side of the survey line. Blue-green squares in the right-hand inset are "doughnut holes" not within the 65-meter zone of influence. Red bands in these doughnut holes reveal how little denning habitat could escape potential disturbance[7]. The dark grey polygon illustrates the Kaktovik Inupiat Corporation lands, which are not included in this analysis because they were not part of the seismic survey application proposed to BLM.

[7] Denning females >65 meters from transect also may be disturbed. Dens within the doughnut holes, therefore, are not protected from disturbance, but may experience a reduced likelihood of disturbance.

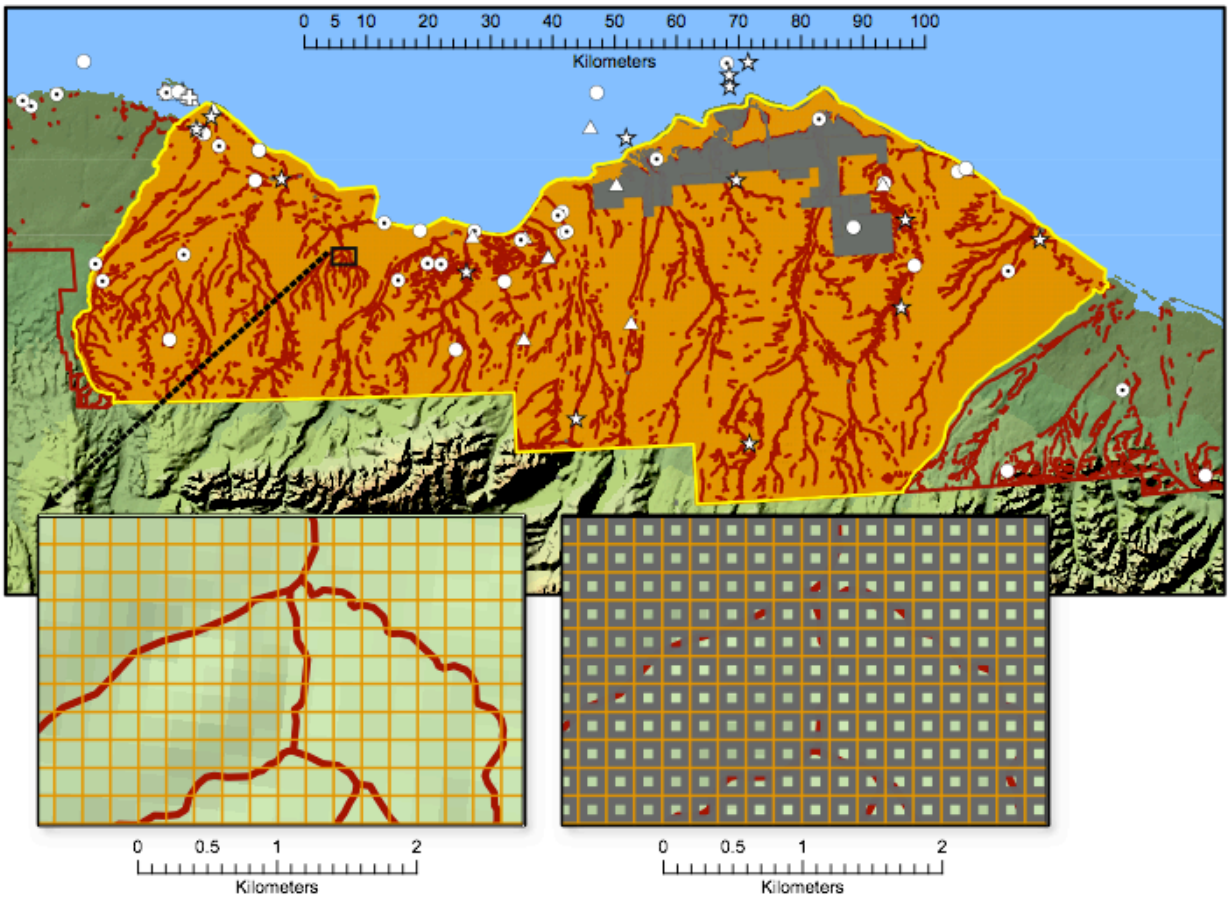

Table 1. Probabilities of disturbance and/or mortality of polar bears resulting from the 3D seismic survey proposed by BLM for the Arctic Refuge Coastal Plain. Probabilities of encounter appear in columns while average (e.g. if multiple such surveys were conducted) number of dens impacted is expressed in the last row. The proportion of available denning habitat covered by the 3-meter wide vehicle path, which corresponds with probability ($\hat{\mathbf{p}}$) of fatal impact, is 0.03, or 3%. If there was one undetected den on the Refuge the probability of not running over it would be $1-\hat{\mathbf{p}}$ or 0.97. The probability of impacting at least one den increases with the decline in the n^{th} power of $1-\hat{\mathbf{p}}$ where n is the number of dens present. For example, if there are 2 undetected dens randomly located on the refuge the probability of not running over either would be $(1-0.03)^2$ or 0.94, and the probability of crushing at least one would be $1-(1-0.03)^2$ or 0.06. With 15 undetected maternal dens on the refuge, there is a 36% chance seismic vehicles would drive over at least one of them. Similarly, if there are 4 or more undetected dens on the Refuge, the chance that one or more will fall within the 65-meter disturbance buffer approaches 100% (in other words, the probability that none of the four will be within the 65-meter disturbance buffer becomes infinitesimally small). Whereas all bears denning

within 65-meters of a survey path may not exit their dens, records show that some will. Even if the immediate effect of such a disturbance is not fatal, early departure from maternal dens leads to poorer cub survival (Amstrup and Gardner 1994, Rode et al. 2018), suggesting there could be latent and undetected lethal consequences.

# DENS PRESENT	DEN RUN OVER $\hat{P}$	DEN NOT RUN OVER 1- $\hat{P}$	DEN DISTURBED $\hat{P}$	DEN LESS DISTURBED[8] 1- $\hat{P}$
1	0.03[9]	0.97	0.88	0.12
2	0.06	0.94	0.94	0.06
3	0.09	0.91	0.99	0.01
4	0.11	0.89	1.00	0.00
5	0.14	0.86	1.00	0.00
6	0.17	0.83	1.00	0.00
7	0.19	0.81	1.00	0.00
8	0.21	0.79	1.00	0.00
9	0.24	0.76	1.00	0.00
10	0.26	0.74	1.00	0.00
11	0.28	0.72	1.00	0.00
12	0.30	0.70	1.00	0.00
13	0.32	0.68	1.00	0.00
14	0.35	0.65	1.00	0.00
15	0.36	0.64	1.00	0.00
MEAN[10]	0.45		13.16	
VARIANCE	0.44		1.61	

[8] Denning females >65m from transect also may be disturbed. Dens within the doughnut holes, therefore, are not protected from disturbance, but may experience a reduced likelihood of disturbance.

[9] Table entries rounded to 2 decimal places.

[10] The mean of the binomial distribution is $n^*\hat{p}$ *(n times* $\hat{p}$*) and t*he variance is $n^*\hat{p}(1-\hat{p})$. If there are 15 undetected dens on the refuge therefore, each survey like that proposed by BLM would disturb ~13 dens, and seismic vehicle tracks would directly run over ~0.4 of a den. Lethal disturbances are virtually assured when a heavy vehicle actually runs over an occupied den.

Table 2. Probabilities of disturbance and/or mortality of polar bears caused by seismic testing. As in Table 1 except assuming multiple seismic vehicle paths and 15-meter impact zone. With a 15-meter impact zone along grid lines, there is a 90% probability that at least one den would be run over. And the average for a survey like this would be to run over 2+ dens.

# DENS PRESENT	DEN RUN OVER $\hat{P}$	DEN NOT RUN OVER $1-\hat{P}$	DEN DISTURBED $\hat{P}$	DEN LESS DISTURBED $1-\hat{P}$
1	0.14	0.86	0.92	0.08
2	0.27	0.73	0.99	0.01
3	0.37	0.63	1.00	0.00
4	0.46	0.54	1.00	0.00
5	0.54	0.46	1.00	0.00
6	0.61	0.39	1.00	0.00
7	0.66	0.34	1.00	0.00
8	0.71	0.29	1.00	0.00
9	0.75	0.25	1.00	0.00
10	0.79	0.21	1.00	0.00
11	0.82	0.18	1.00	0.00
12	0.85	0.15	1.00	0.00
13	0.87	0.13	1.00	0.00
14	0.89	0.11	1.00	0.00
15	0.90	0.10	1.00	0.00
MEAN	2.17		13.87	
VARIANCE	1.85		1.05	

Failure to acknowledge the inability to detect dens in advance—Much of the justification for concluding that impacts on polar bears from activities described in the DEIS might be negligible stems from claims that "denning surveys" conducted in advance of on-the-ground activities would mean only a "small number" of maternal denning bears would be impacted (DEIS at 3-146). On page 3-141, the DEIS asserts that denning surveys would "minimize" potential risks; on page 3-138, the DEIS concludes that "Behavioral disturbance on the productivity of polar bears in the program area is likely to be low" based on the assumptions that "all mitigative measures are implemented… and that preconstruction den surveys detect **most** maternal dens in the affected areas."; on page 3-137, the DEIS relies on use of surveys to assert that ITRs will ensure that impacts on occupied dens are "negligible"; on page 3-134 the DEIS says that use of FLIR and dogs has proven to be effective.

Available evidence, however, confirms these claims for reliability of denning detection surveys are unfounded. Dens are invisible to the eye throughout winter and attempts to discover them have relied on forward looking infrared (FLIR) surveys designed to detect the heat emitted by denning mother bears and their cubs. Research published 14 years ago and refined 4 years ago (Amstrup et al. 2004, York et al. 2004, Robinson 2014) emphasized shortcomings in such surveys. Some of the shortcomings can be overcome by multiple surveys and by limiting surveys to weather conditions ideal for FLIR operation. In practice, however, the den detection rate of FLIR, as it has been applied in oil-field areas west of the Arctic Refuge, has been unacceptably low. Between 2004 and 2016, FLIR surveys conducted in advance of various oil field operations along Alaska's North Slope correctly identified 12 maternal dens but missed 11 dens that were

within the survey areas (Smith et al. In Prep). These surveys also identified 22 “hotspots” that were presumed to be maternal dens but turned out not to be dens. So, not only did these surveys miss almost as many dens as they detected (11 versus 12, an approximately 50% detection rate), they also led to much wasted time and effort—as staff attempted to monitor and avoid sites that were not dens at all.

A survey conducted in February of 2018 suggests FLIR surveys might be even less effective in the more complicated terrain of the Arctic Refuge Coastal Plain. At that time, the U.S. Fish and Wildlife Service contracted a 10-day intensive FLIR survey over portions of the Arctic Refuge Coastal Plain and adjacent habitat that is known to be used frequently by denning females. Ten hotspots were recorded (Owyhee Air Research, Inc. 2018), but only 2 actually turned out to be dens. There were no known (by radio telemetry) dens in the area searched, so we cannot know how many dens this FLIR survey aircraft actually flew over and failed to detect. However, based on recent patterns of observed denning, nearly 30 denning bears could have been on and immediately adjacent to the Refuge last winter. Many of these dens could have been in the area within which this February 2018 FLIR survey was conducted, and several dens may have been missed. The higher density and greater complexity of denning habitat on the Coastal Plain, and thicker snow collecting over the tops of dens in the more-deeply incised gullies on the Arctic Refuge, increase likelihood that more dens will be missed compared to flatter and more well-defined habitats farther west. All of these factors make it likely that FLIR den detection methods, which have been only about 50% successful in the existing oil field areas, are likely to be even less successful on the Arctic Refuge Coastal Plain.

The DEIS suggests that ground-truthing with search dogs can enhance detections. Carefully trained dogs can find denned bears. However, dogs that have been used in Alaska mark the locations of dens by digging into them, and therefore must be retrieved by their handlers before they compromise the den. Dogs attempting to dig into dens simulates the activity of wolves and other bears, the only predators that can be a threat to polar bears (Richardson and Andreashek 2006, Amstrup et al. 2006). At the very least, using such dogs to find dens is an added source of stress that may cause den abandonment/relocation during a time in the denning cycle that could impact young cubs. More importantly, dogs have historically been used only in small areas with relatively high historic denning frequency, or to verify whether a FLIR hotspot was a den. Dog surveys in mid-winter require travel by Tucker or other enclosed vehicles to protect dogs from the harsh weather, and dogs are often outside searching for only relatively brief periods. Dogs have never been used to search expansive areas of habitat. Suggesting they can efficiently, effectively, and without probable disturbance of denning bears, search the 3000 km of denning habitat on the Arctic Refuge Coastal Plain seems dubious at best.

The DEIS acknowledges that den detection surveys are “not perfect” (3-134) but gives no hint that they actually have been effective only about half the time—a much lower detection rate than most reasonable people would call just “not perfect.” At present, there is no reliable way to assure that dens will not be affected by exploratory surveys or subsequent development activities.

The DEIS acknowledges that the Southern Beaufort Sea polar bear population is in decline and that its status can only become more precarious as we move into the future. The DEIS also acknowledges that activities related to oil and gas development, if allowed in the Arctic National Wildlife Refuge, will further compromise the status of the polar bear population. Seismic testing and other on-the-ground activities, regardless of the presumed safeguards described in the DEIS, are highly likely to cause direct mortalities of polar bear mothers and/or their cubs. They are certain to increase stresses in denning and non-denning animals, and they are virtually certain to accelerate the decline in abundance of this population. Given that the Southern Beaufort Sea polar bear population declined from around 1800 in the 1980s to approximately 900 animals in 2010 (Bromaghin et al. 2016), the added disruptions described in the DEIS are inconsistent with population conservation and established management and conservation plans.

Selective protection of denning habitat—The DEIS argues that special protections afforded to parts of the Arctic Refuge Coastal Plain also can serve to minimize impacts to maternal denning bears. Alternative D for example, suggests placing a one-mile wide buffer on each side of several streams and running inland from the coast for 5 miles. The purported justification for these restrictions is that 37% of dens observed in the past were on or near these stream segments (3-147). These restrictions to protect areas frequently used in the past are, of course, better than "no restrictions." However, offering special protections for a small amount (8.8%) of identified denning habitat prompts serious questions. Most important among those questions is that they ignore areas composing 92% of denning habitat. Even if 37% of

pregnant females choose future dens in these protected areas, what about the habitat elsewhere on the Arctic Refuge where the majority (63%) of bears have denned in the past? Given that the Southern Beaufort Sea polar bear population is declining due largely to poor survival of cubs, the BLM should be working to maximize protection for all of the denning mother bears and not implementing management actions that it admits will compromise those protections.

Although we have no evidence of individual bears returning to the same den location in multiple years, we know they do tend to return to the same general location (Amstrup and Gardner 1994). Some pieces of den habitat have seemed more "preferred" than others, but these "preferences" are not always hard and fast. For example, an abandoned staging pad on the coast near Prudhoe Bay was used repeatedly for many years but has apparently not been used recently. We know that the Arctic Refuge Coastal Plain habitats have been consistently preferred since the earliest data on denning have been collected. We don't know why some areas within the Refuge may previously have been preferred over others that have similar habitat and snow depth features. But we do know that as human-caused climate change continues, the distribution of snow will be changing, and coastal erosion will alter some currently desirable locations. Sections of suitable den habitat that have been preferred for maternal denning in the past may become less preferred and other less used areas of suitable habitat may become more preferred. We also know that the Southern Beaufort Sea polar bear population is experiencing serious decline due in large part to poor survival of cubs (Bromaghin 2016). Therefore, BLM should protect all identified habitat to assure polar bears face the fewest restrictions possible in giving birth to their cubs.

As discussed in the section on seismic testing, because of poor cub survival, the numbers of bears constructing dens on the Arctic Refuge Coastal Plain may not have greatly declined, despite significant population declines. And, there are reasons to expect maternal denning on the Arctic Refuge Coastal Plain may increase in the future. Up to 20% of the Southern Beaufort Sea population is currently spending all or part of summer on land (Atwood et al. 2016). This is in contrast the 1980s when polar bears did not spend summer on land. Also, a majority of bears now stuck on land in summer spend at least some time at the Kaktovik bone pile[11], which is the only consistent source of high energy food on land in northern Alaska. Higher numbers of bears that supplement their pre-denning foraging in Kaktovik is likely to translate into higher numbers of bears denning on the adjacent Arctic Refuge Coastal Plain to be closer to this food source. All indications are that numbers of polar bears denning on the Arctic Refuge Coastal Plain will continue to be high in the absence of the proposed oil and gas program. The distribution of den sites may or may not differ from that in the past, but the long history of polar bear preference for maternal denning on the Arctic Refuge Coastal Plain emphasizes the importance of protecting all, rather than only a portion, of the available denning is paramount.

After proposing that spatial restrictions on activities in certain drainages will mitigate impacts, the DEIS goes on to conclude (3-148): “Nevertheless, expansion of oil and gas development along the arctic coast on both land and sea may reach a level at which such effects become problematic for polar bears in the future”. Avoiding such

[11] The “bone pile” is where remains (not consumed by people) of bowhead whales (*Balaena mysticetus*) harvested by residents of the Kaktovik community are deposited.

"problematic" consequences for the species is precisely why keeping the Arctic Refuge Coastal Plain undeveloped is important.

The DEIS recommends special protections for some denning female bears (e.g. ROP 10 (2-20). Such provisions, however, are only of value if locations of dens are known. In the past, only about half of the dens in areas surveyed with forward looking infrared (FLIR) have been detected. This means that half of the dens on the Coastal Plain area in any given year will be undetected and vulnerable to possible disruption. Also, this operating procedure states that "alternate protective measures (for detected dens) may be approved by BLM Authorized Officers." But it does not explain what kinds of protective measures might be invoked or how BLM would evaluate and approve them. Given that this proposed activity is on a National Wildlife Refuge, in an area of critical habitat, and mandated for protection in order to aid polar bear reproduction; details of what kinds of protections might be invoked, and how den detection rates will be improved, are necessary. Similar language occurs elsewhere in the DEIS. For example, at 3-102 the DEIS states "Exceptions to stipulations of no surface occupancy would be made for roads, pipelines, barge landings, and docks." There is, however, no explanation of what conditions and at whose discretion these protections would be waived. This kind of language could be used to void even the minimal protections for polar bears described in the DEIS and is totally unacceptable. Given the likelihood that protections proposed in the DEIS are unlikely to provide polar bears the protections they need, it is especially alarming that even those protections might be waived without explicit descriptions of why.

Improper reliance on the "success" of past mitigation—The DEIS suggests repeatedly that past mitigation efforts have been successful in preventing non-negligible impacts on polar bears, claiming for example (3-137) that the "types of activities typical of oil and gas exploration, development, and production projects in northern Alaska were not likely to have population-level effects on polar bear populations…." The DEIS describes incidental take regulations (ITRs) as the principal mechanism for regulating human activities in regard to polar bears (3-140). The current regulations allow industry operators non-fatal takes of small numbers of polar bears provided that such takes result in negligible impacts on the species. It is critical to note, however, that the protections adopted in ITRs can be applied only once a bear or den is detected. The principal challenge for protecting bears in maternal dens, the most important threat to polar bears from activities proposed in the DEIS, is detecting them (see section on seismic survey). Whereas industry has been pretty good at implementing avoidance procedures when dens or bears are detected, we know that detection rates have been too low to be considered adequate protection for denning bears. There is no documentation of how many undetected dens may have been disturbed over the years of oil and gas activities in Alaska. Importantly, we also do not know the fate of bears (disturbed before being detected), after they left the denning area from which they were disturbed. We usually do not know whether cubs survived to weaning age after they traveled out of sight onto the ice or whether they perished shortly thereafter. What we do know is that post-birth cub loss of recent years is more than double that of the past, and we know that mother bears that stay in dens longer are more successful in rearing their cubs (Amstrup and Gardner 1994, Rode et al. 2018). We also know that the habitat

complexity and density of maternal dens on the Arctic Refuge Coastal Plain are far greater than other parts of Arctic Alaska where oil and gas exploration and development have occurred. Because previously implemented “safeguards” have been at most marginally effective elsewhere, we can be confident they will be less effective on the more complicated habitat of the Arctic Refuge Coastal Plain, and that the numerous impacts described in the DEIS can only further compromise this already compromised population.

Although they offer little protection for denning bears, the DEIS argues ITRs have potential value for prevention of conflicts between free-ranging polar bears and humans. Bear/human interactions in the existing oilfields have been increasing in recent years as more bears are spending more time on land. The DEIS makes the case that, despite numerous encounters, lethal takes associated with oil and gas activities have been rare (3-140). The DEIS reports only three polar bears killed at oil and gas industrial sites in Alaska since the late 1960s. Four additional bears were killed as a result of human interactions and died away from oil field facilities. One of these was a defense kill at a military radar station. The other three were polar bears that ingested toxins from unknown sources.

Two personal examples illustrate the kinds of interactions that could become common if oil field activities expand into the Arctic National Wildlife Refuge as polar bear welfare is declining due to sea ice loss. In September 2002, I had to kill a severely emaciated bear that was posing a safety threat to workers traveling to and from the Endicott Island production facility. This bear had become so aggressive it was attacking vehicles passing by. Attempts to deter the actions and drive the bear away were

unsuccessful. This situation posed imminent threats to workers in the area, and after consultation with the U. S. Fish and Wildlife Service, I went out and killed the bear before a worker could be injured or killed. During the same autumn season, I had to help kill a bear that had taken up residence under a house in the village of Utqiagvik (previously known as Barrow). This was a very large male in prime condition. Part of its prime condition may have been attributed to the fact that its recent activity had been limited to sleeping under a local resident's house by day and feeding on the food caches of local people by night. The attraction of this "artificial" food overcame any of the bear's natural fears of being around people. Whereas the owner of the house under which the bear was sleeping might have been concerned, the village had a bigger concern. This house was right next to the path along which dozens of primary school children walked to and from school each day. After attempts to haze the bear away failed, it was decided human safety concerns prevailed and the bear had to be killed. The bear killed in the oilfield probably would have died regardless of my intervention. The point raised by that bear, however, is that more and more desperately hungry bears, like that one, are assured to be on shore as sea ice continues to decline. Most will be attracted to the Kaktovik bone pile, and if the developments described in the DEIS take place, their opportunity to present life-threatening conflict situations will increase. The Utqiagvik bear shows that problem bears don't necessarily have to be starving. The mere presence of large numbers of bears in close proximity to people, and seeking supplemental food while they wait for the sea ice to freeze or for enough snow to enter maternal dens, increases the likelihood that bears will be killed to defend human safety. Considering the numbers of bear/human interactions that have

previously occurred in Alaska's oil fields, the number of fatal incidents does seem low. When the population was growing and robust, this small number of fatal interactions may have been inconsequential. But in a population already declining, and facing continuing loss of foraging habitats, even small numbers of human-caused deaths, may hasten the ongoing decline. The examples above verify that in the future, we can anticipate numbers of serious incidents are unlikely to remain small, but rather can be expected to increase.

Are past impacts of oil field activities understood and applicable?—The DEIS states repeatedly that exploration and development of the Arctic Refuge Coastal Plain region will result in added impacts on the population. Although the DEIS also repeatedly asserts that all impacts from developments will be magnified by ongoing global warming and its associated sea ice decline, it doesn't adequately address the impact of sea ice decline, or other symptoms of global warming, on likely future human/bear conflicts. In 15 years, the numbers of bears spending summer on land has tripled (Atwood et al. 2016) and increasing numbers of bears are loitering around the village of Kaktovik—the only place on Alaska's northern coast where highly nutritious food is predictably available. Numbers of maternal dens and numbers of free-ranging polar bears historically have been higher in the Arctic Refuge area than other parts of Alaska's Arctic where oil and gas activities have occurred. Polar bear/human interactions, Arctic wide, have been increasing as sea ice has declined (Towns et al. 2009, Atwood et al. 2017), and further increases are virtually assured. The "success" of Incidental Take regulations is cited as assurance that industry operations in the Arctic

Refuge will have only “negligible” impact on polar bears. The lessons of the past, even if learned perfectly, simply may not apply in the current situation.

The Southern Beaufort Sea polar bear population is experiencing catastrophic decline even without any new perturbations. Therefore, there is no such thing as a “sustainable” additional yield, the concept of a maximum potential biological removal (PBR)[12] does not apply, and no additional impacts could be considered negligible. Persistence of the population depends on a halt to the rise of atmospheric greenhouse gas concentrations. The USFWS Conservation Management Plan (2016) has declared the Arctic Refuge Coastal Plain as habitat critical to preserving as many polar bears as possible until greenhouse gas rise is halted. BLM should be working to meet the objectives of the Conservation Management Plan for polar bears (USFWS 2016) and to eliminate negative impacts rather proposing significant new ones.

The DEIS acknowledges that as a result of global warming induced sea-ice declines, polar bears have had to make longer and more laborious movements from the sea ice to denning areas (3-125). Hence, requiring additional movements to avoid new structures and activities in coastal regions of the Arctic Refuge will compound ongoing negative impacts by requiring more energy drain to accomplish even greater movements. Because polar bears can only become progressively less well-nourished as sea ice continues to decline, added movements during the critical pre-denning time of year are sure to result in increasingly negative impacts. The more energy a female must expend to access, establish, and maintain her maternal den, the less energy she

[12] The **potential biological removal (PBR) level** is defined by the Federal Marine Mammal Protection Act 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.

has to give to her cubs. Similarly, forcing the increased number of bears that are spending more time on land and therefore are hungrier, to move around new activities and infrastructure, is almost sure to lead to even greater increases in bear/human conflict situations. The DEIS correctly points out that consequences of these more frequent interactions can be severe, but it offers no suggestions for eliminating those consequences.

Cumulative Oil Field Impacts and Worsening Climate Change

Can timing of human activities reduce impacts?— Female polar bears have made little maternal investment at the time they are establishing their dens in the autumn (see section on seismic impacts). Some observations suggest they are more willing to relocate if disturbed from a denning location at that time of year (Belikov 1976). Years ago, I proposed this could mean that if activities which could be disruptive to denning activity are begun in autumn, they might cause mother bears to move away from denning sites they would have chosen but where there will be winter-time disturbances (Amstrup 1993, DEIS: 3-136). In moving, these bears would relocate to a site where winter industrial activities might not occur or would be less intense. In contrast to the seemingly logical hypothesis, the reality is quite different. In practice, many oil and gas activities require solidly frozen ground and hence cannot start early enough in winter to precede the time when bears are establishing dens. Also, oil field activities often do not occur at uniform intensity throughout winter, rather they often "ramp up" in intensity after ground is solidly frozen and snow covered. So even though autumn activities might be at a level tolerated by a pregnant bear, the intensity of activities may escalate to non-tolerable levels later in the winter. More important is that

even if development activity levels did remain constant through winter and if initiating activities in autumn resulted in a “gentle push” to assure bears didn’t den too nearby, ongoing impacts of climate change mean the situation is different. When I suggested that strategy, we had a flourishing population with high reproductive and survival rates.

Global warming induced sea ice loss and potentially other factors have negatively affected bears’ nutrition, body weight, and reproductive performance. With more female bears already energetically compromised, stimulating pregnant females to relocate and seek alternative den sites could impose an added and significant energetic cost on the mother bear that could have a latent effect on her survival or the survival of her cubs. Under ideal circumstances, there might be minimal impact on females forced to relocate den sites. However, these are not ideal circumstances. Even if it was true in the past that autumn relocation to an alternate den site merely caused annoyance, it is more likely now that serious harm could result from the increased effort to find an alternative den location. Females are already having increased difficulty providing sufficient provisions for their young, and any unnecessary energy drain can only exacerbate ongoing declines in maternal welfare and cub survival.

Habitat fragmentation—The DEIS records a long list of the negative effects that will result from exploration and development of the Arctic Refuge Coastal Plain. The DEIS also repeatedly states that ongoing climate change and its associated loss of sea ice habitat will compound impacts associated with development. Yet, after describing various impacts, the DEIS does not rationally reconcile the descriptions with its repeated claims that impacts will be negligible. For example, the DEIS claims that “although the potential for injury or mortality could be high when developing new oil and

gas projects in polar bear habitat, the risks are well understood" (3-142) and that mitigation efforts of the past have been effective. Even taken one at a time each of the possible impacts of Arctic Refuge development cannot be considered negligible. The negative impacts on maternal denning alone are virtually certain to exacerbate the ongoing population decline. Taken together and including the fact that the DEIS repeatedly acknowledges the compounding effects of climate change, a finding of negligible impact is illogical at best and irresponsible at worst.

The DEIS describes an extensive industrialization of the Coastal Plain as a Reasonably Foreseeable Development scenario (Appendix B). It assumes there will be barge landings, staging pads, and a seawater treatment plant located along the coastline. It also assumes road/pipeline connections to the seawater plant. (p B-15-16). Although the DEIS claims impacts of new developments are well understood, it only states these developments will occur but doesn't address how that understanding will eliminate negative impacts. For example, nearshore infrastructure and the human activities associated with it are likely to displace bears to more inland denning sites that might be less desirable and in which they might be less successful in their reproductive effort. More than 80% of maternal dens found on land by radio-telemetry in the Alaskan Beaufort Sea were within 10 kilometers of the coast and over 60% were right on the coast or on coastal barrier islands (Amstrup 2003). Although there is abundant satisfactory denning habitat farther inland, in the foothills or mountains, this distribution indicates that bears prefer to den near the sea where minimal effort is required to find and enter a den and where they are close to the sea ice hunting habitat when they emerge in spring. Denning close to the sea also may be a way to minimize predation

risk. Young cubs are at risk from predation by wolves when they are enroute from the den to the sea ice (Richardson and Andreashek 2006). Females emerging from dens near shore minimize the distance they must travel from the den to get onto the sea ice, reducing both the energy expended and exposure to predation risk.

Concerns about potential obstacles bears face while reaching denning habitat are exacerbated directly by warming-induced sea ice decline, but are neglected in the DEIS descriptions. Increasingly, bears coming ashore to den have had to travel greater distances (DEIS 3-125) including prolonged swims (Durner et al. 2011, Pagano et al 2012). Greater movement means bears expend more energy to reach denning areas than they did in the past. Some female bears may move around or through the various kinds of infrastructure encountered as they are coming ashore and move to alternative locations. Others that are initially tolerant may find themselves denning near enough to infrastructure and related disturbances that escalating disturbances in winter or spring cause them to leave the denning area sooner than they would have in the absence of disturbance. Whether a bear moves farther inland in autumn than otherwise would have been the case or is disturbed after den establishment by intensifying winter activities, the extra energy required can only compound the negative energy balance many mother bears in the Southern Beaufort Sea currently experience.

Cumulative effects—Additional pre-denning energy demands, like moving to alternative and potentially deeper inland denning areas, can only be negative. Although the significance of such added energy drain is difficult to estimate, it is one more potential contributor to cumulative effects of Alaska's coastline developments. Currently oil and gas developments extend approximately 185 kilometers from the Colville Delta

to Pt. Thompson. Development of the Arctic Refuge Coastal Plain would extend that development corridor another approximately 90 kilometers to the vicinity of Barter Island. This expansion would mean that essentially half of the Arctic Coast of Alaska is occupied in some form by industrial developments, and the previously pristine coastline pregnant polar bears visit each autumn would be fragmented by human developments, like much of the rest of the Alaska coast. Roads and pipeline corridors running parallel to the coast may influence polar bears to deviate from historically preferred pathways to their denning areas. These impacts would not only compromise bears preferring to den on the Arctic Refuge, but also the habitats between Prudhoe Bay and the Refuge. Some of the most frequently used denning habitat in Alaska is found in the coastal area immediately to the west of the Arctic Refuge boundary. Although cumulative effects of development expansion have not been assessed, additional energetic costs must have occurred as bears negotiate them. Therefore, it is hard to imagine additional habitat fragmentation will not require more energetic costs as polar bears are forced by new developments to alter movements and habitat uses.

There are no studies showing that effects of the existing oil and gas developments in Alaska have been directly detrimental to polar bears at the population level. There are reasons, however, why possible negative effects of past developments should not be overlooked. Consider the trajectory of the Southern Beaufort Sea polar bear population. By the mid-1980s, the polar bear population in the Southern Beaufort Sea was robust and recovering from decades of excessive harvest that began in the 1950s (Amstrup 1995, Amstrup et al. 1986). By the late 1990's, however, the population trend had reversed and since then the population has declined by about half

(Bromaghin et al. 2016). We are confident that the major contributor to the ongoing population decline among Southern Beaufort Sea polar bears is global warming induced loss of the sea ice habitat upon which polar bears depend for catching their seal prey. Despite the fundamental link between declining polar bear welfare and declining availability of sea ice, we cannot overlook the hypothesis that the expanding human footprint in and near polar bear habitat also may have played a role in contributing to the recent declining trend in Southern Beaufort Sea polar bear numbers. Population declines since the late 1990s, have coincided with major expansion of oil exploration and development activities, and the parallels in timing between oil field expansion in Alaska and declining welfare of the polar bear population should at least give pause to the conclusion in the DEIS (3-142) that the risks of development and how to eliminate those risks are "well understood." Even if we did understand past impacts, the Southern Beaufort Sea polar bear population now is severely compromised. And, any additional negative impact needs to be viewed differently than when the population was thriving.

Conclusions:

The Southern Beaufort Sea polar bear population has been on a declining trend since the early 2000s (Bromaghin et al 2015). Despite considerable interannual variation in sea ice conditions, the secular warming trend resulting from increasing greenhouse gas concentrations guarantees that the long-term trend in sea ice and polar bear numbers will continue to be downward. Recognizing this, the Polar Bear Conservation Management Plan (U. S. Fish and Wildlife, 2016) warns that without mitigating greenhouse gas rise, it is unlikely that polar bears will be recovered, and calls for prompt action to reduce greenhouse gas emissions. The Conservation Management

Plan also calls for specific “on-the-ground” management measures, that will contribute to the survival of polar bears in the interim (until effective greenhouse gas mitigation is in place). The exploration and development actions described in the DEIS, however, conflict directly with stated objectives of protecting polar bears on the ground. The developments and associated activities described in the DEIS are sure to accelerate ongoing declines in the Southern Beaufort Sea polar bear population.

The most serious inadequacies in the DEIS include: failure to describe the intensive seismic exploration that will precede any on-the-ground developments and the impacts of that exploration on denning polar bear families; failure to recognize the shortcomings of past mitigation measures; failure to recognize the additional complications working in the more complex habitat of the Arctic Refuge will present; failure to fully consider how ongoing climate change will increase uncertainties and complicate impacts associated with proposed operations; and failure to acknowledge the cumulative impacts of expanding oil and gas activities into the undeveloped Arctic Refuge.

Impacts of seismic testing—Information presented in this DEIS (Vol 1, 1-128) and available information on polar bear breeding rates and cub survival, indicate that between 20 and 29 bears are currently denning on the Arctic Refuge Coastal Plain each year, and that this number is likely only to increase as sea ice continues to deteriorate. The DEIS proposes to avoid denning bears by conducting forward-looking infrared (FLIR) surveys. Historically, however, FLIR surveys, proposed to detect and protect denning bears, have been only about 50% effective. Therefore, between 10 and 15 dens would not be detected by the proposed methods. ***As proposed***, the seismic

testing necessary to guide development activities would cover 88% of maternal denning habitat and depending on how many occupied dens occur on the Refuge in any given year, have up to a 36% chance of running over one or more dens. ***As actually conducted*** (if the survey is accomplished in similar fashion to other 3D seismic surveys recently performed west of the Arctic Refuge), it would cover more than 92% of identified maternal denning habitats and have a 90% chance of actually running over and crushing one or more occupied den. On average such a survey would disturb up to 14 denning mother bears and run over 2 dens (see Table 2, above). The high probability of fatal encounters from seismic testing is inconsistent with management directives to protect polar bears on the ground and can only worsen the ongoing decline in this population.

Shortcomings of past mitigation and new complications—In over 45 years of oil and gas activity on Alaska's North Slope, neither exploration nor development have occurred where polar bears and their maternal denning habitat are as abundant as they are on the Arctic Refuge Coastal Plain. The more deeply incised and complicated denning habitat of the Arctic Refuge, the higher density of dens and greater numbers of free-ranging polar bears, are certain to complicate mitigation attempts. In addition to population level effects on maternal denning bears, polar bear/human conflicts are virtually certain to occur at higher levels than in the past. With climate change bringing more bears to shore for longer periods (hence reducing food available to those bears) interactions between polar bears and oil-field workers will be more frequent, and more severe. Greater numbers of emaciated bears are likely to threaten workers, and such interactions are more likely to lead to the killing of bears in defense of life and property.

With this population already in severe decline, additional mortalities can only add to declining numbers.

Failure to fully consider complicating factors of climate change—The DEIS repeatedly states that ongoing sea ice loss and other climate change symptoms of global warming will exacerbate impacts of the exploration and development activities that are proposed. Without explanation, however, the DEIS also concludes that impacts still will be negligible. Numbers of polar bears on land and visiting the bone pile at Kaktovik, are almost certain to increase as sea ice continues to decline. Numbers of maternal dens and their importance to population welfare are likely to increase at the same time activities proposed in the DEIS will increasingly impact them. Negative polar bear/human interactions are sure to increase in number, with no serious discussion of how these increasing conflict situations will be handled. Even if mitigation measures applied in the past have been successful, all of these changes mean that challenges will be more difficult in the future, and that severity of outcomes is likely to increase. Despite the fact that uncertainties prevail in strategizing future mitigation measures to handle more frequent and more complicated challenges, the DEIS maintains past practices will keep impacts negligible. In addition to the small number of past deaths recorded in Alaska's oilfields, knowledge of the fate of mother bears and cubs that left dens in oil field areas is absent. When the polar bear population of the Southern Beaufort Sea was thriving, these events may not have been important. Now, every requirement for additional energy expenditure and every additional mortality can accelerate the declining welfare of this population. Although acknowledging these facts, the DEIS offers no remedies, and fails to explain its conclusions in light of those facts.

Not recognizing potential for cumulative effects— Development of the Arctic Refuge Coastal Plain would extend the development corridor on Alaska's North Slope approximately 90 more kilometers to the vicinity of Barter Island. This expansion would mean that essentially half of the Arctic Coast of Alaska has some form of industrial development, and more of the previously pristine coastline that pregnant polar bears visit each autumn would be fragmented by human development. Assessing cumulative impacts is difficult and studies have not been done to estimate whether the expansion of oil-field activity in Alaska may have contributed to trends in polar bear welfare. We do know, however, that polar bears and all animals operate on an energy budget. They are constantly trying to bring in more energy and nutrients than they consume. If successful they increase body mass and females can successfully reproduce. We also know that unnatural and hence unnecessary movements and activities add to the energy costs animals normally face. The greater the number of novel and unnecessary energy expenditures a polar bear needs to make, the greater the likelihood of going into a negative energy balance. Polar bears in the Southern Beaufort Sea are increasingly in negative energy balance, as reflected in declining survival of cubs and reduced population size. Although these negative trends can largely be attributed to warming temperatures and declining sea ice availability, we cannot overlook a possible contribution from the expanding footprint of oil and gas developments in coastal areas of northern Alaska. The negative trends in the Southern Beaufort Sea population have coincided with major expansion of developments. The extra energy polar bears must expend as they encounter foreign objects or activities may not mean much in a stable

environment with healthy bears. With energy balance and reproduction declining, however, potential effects from a 90-kilometer expansion of coastal infrastructure cannot be ignored.

Polar bears are a designated threatened species. The Arctic National Wildlife Refuge Coastal Plain has been designated critical habitat to prevent having on-the-ground activities compound the negative impacts of ongoing habitat loss. If allowed to proceed, the exploration and development of the Arctic Refuge Coastal Plain described in this DEIS will have population level negative effects on polar bears of the Southern Beaufort Sea. Exploration is nearly certain to disturb multiple females from their dens and mortalities of mother bears and their cubs seem virtually assured. Increased numbers of conflicts between humans and the greater numbers of hungrier bears on land are unlikely to be avoided. These conflicts are increasingly likely to result in fatalities as hungry bears become more desperate. The developments and activities proposed in this DEIS are contradictory to the goals for which the Arctic Refuge and the critical habitat it contains were established. Those developments and activities can only worsen the already declining conditions facing polar bears as they go through their normal life cycle, and they are virtually certain to accelerate the ongoing decline in the Southern Beaufort Sea polar bear population. The likelihood of negative population level effects from these combined influences makes it clear that exploration and development of the Arctic National Wildlife Refuge Coastal Plain should not proceed unless and until there are assurances that these negative impacts can be eliminated—not just mitigated.

Literature cited

Amstrup, S. C. 1993. Human disturbances of denning polar bears in Alaska. Arctic 46:246–50.

Amstrup, S. C. 1995. Movements, Distribution, and Population Dynamics of Polar Bears in the Beaufort Sea. Ph. D. Dissertation, University of Alaska, Fairbanks. 299 pp.

Amstrup, S.C. 2003. Polar bear, Ursus maritimus. Chapter 27 In Wild mammals of North America: biology, management, and conservation. Edited by G.A. Feldhamer, B.C. Thompson, and J.A. Chapman. John Hopkins University Press, Baltimore. pp. 587-610.

Amstrup, S. C., and C. Gardner. 1994. Polar bear maternity denning in the Beaufort Sea. Journal of Wildlife Management 58:1–10.

Amstrup, S. C., I. Stirling, and J. W. Lentfer. 1986. Past and present status of polar bears in Alaska. Wildlife Society Bulletin 14:241–54.

Amstrup, S. C., I. Stirling, T. S. Smith, C. Perham, and G. W. Thiemann. 2006. Recent observations of intraspecific predation and cannibalism among polar bears in the Southern Beaufort Sea. Polar Biology 29(11):997-1002.

Amstrup, S. C., G. York, T. L. McDonald, R. Nielson, and K. Simac. 2004. Detecting denning polar bears with forward looking infra-red (FLIR) imagery. BioScience 54(4):337-344.

Atwood, T. C., K. Simac, S. W. Breck, G. York, and J. Wilder. 2017. Human-polar bear interactions in a changing Arctic: existing and emerging concerns. Pages 397-418 in A. Butterworth, editor. Marine mammal welfare: Human induced change in the marine environment and its impacts on marine mammal welfare. Springer International Publishing.

Belikov, S. E. 1976. Behavioral aspects of the polar bear, *Ursus maritimus*. International Conference on Bear Research and Management 3:37–40.

Bromaghin, J.F., T.L. Mcdonald, I. Stirling, A. E. Derocher, E.S. Richardson, E.V. Regehr, D. C. Douglas, G.M. Durner, T. Atwood, and **S.C. Amstrup**. 2015. Polar bear population dynamics in the Southern Beaufort Sea during a period of sea ice decline. Ecological Applications, 25(3), 2015, pp. 634–651.

Derocher, A. E., Stirling, I., and Andriashedk. 1992. Pregnancy rates and serum progesterone levels of polar bears

in western Hudson Bay. Can. J. Zool. 70: 561 -566.

Durner, G.M., **S.C. Amstrup** and K. Ambrosius. 2006. Polar bear maternal den habitat on the Arctic National Wildlife Refuge, Alaska. ARCTIC VOL. 59, No. 1. P. 31–36.

Durner, G.M., Fischbach, A.S., **Amstrup, S.C**., and Douglas, D.C., 2010, Catalogue of polar bear (*Ursus maritimus*) maternal den locations in the Beaufort Sea and neighboring regions, Alaska, 1910–2010: U.S. Geological Survey Data Series 568, 14 p

Durner, G., J. Whiteman, H. Harlow, **S. C. Amstrup**, E. Regehr, and M. Ben-David. 2011. Consequences of long-distance swimming and travel over deep-water pack ice for a female polar bear during a year of extreme sea ice retreat. Polar Biology 34:975-984.

Fischbach, A. S., **S. C. Amstrup**, and D. C. Douglas. 2007. Landward and eastward shift of Alaskan polar bear denning associated with recent sea ice changes. Polar Biology 30(11):1395-1405.

Olson, J. W., K. D. Rode, D. Eggett, T. S. Smith, R. R. Wilson, G. M. Durner, A. Fischbach, T. C. Atwood, D. C. Douglas. 2017. Collar temperature sensor data reveal long-term patterns in Southern Beaufort Sea polar bear den distribution on pack ice and land. Mar Ecol Prog Ser 564: 211–224, 2017.

Owyhee Air Research, Inc. 2018. Aerial Infrared Detection Survey for polar bear maternal dens in the Coastal Plain of the Arctic National Wildlife Refuge, Alaska.

Report prepared for Marine Mammals Management, U.S. Fish and Wildlife Service, Anchorage, Alaska. 12pp.

Pagano, A. M., G. M. Durner, **S. C. Amstrup**, K. S. Simac, and G. S. York. 2012. Long-distance swimming by polar bears (*Ursus maritimus*) of the Southern Beaufort Sea during years of extensive open water. Canadian Journal of Zoology 90:663-676.

Ramsay, M. A., and I. Stirling. 1988. Reproductive biology and ecology of female polar bears (*Ursus maritimus*). J. Zool. Lond. 214, 601-634.

Ramsay, M. A., and R. L. Dunbrack. 1986. Physiological constraints on life history phenomena: The example of small bear cubs at birth. American Naturalist 127:735–43.

Richardson, E.S. and D. Andriashek. 2006. Wolf (Canis lupus) Predation of a Polar Bear (Ursus maritimus) Cub on the Sea Ice off Northwestern Banks Island, Northwest Territories, Canada. Arctic 59(3):322-324.

Robinson, R., T. S. Smith, R. T. Larsen, and BJ Kirschhoffer. 2014. Factors influencing the efficacy of forward-looking infrared in polar bear den detection. BioScience 64(8):735-742.

Rode, K. D., J. Olson, D. Eggett, D. C. Douglas, G. M. Durner, T. C. Atwood, E. V. Regehr, R. R. Wilson, T. Smith, and M. St. Martin. 2018. Den phenology and reproductive success of polar bears in a changing climate. J. Mammal. 99(1):16-26.

Smith, T. S., **S. C. Amstrup**, and others. In Prep. Operational effectiveness of forward-looking infrared imagery for locating polar bear maternal dens.

Towns, L., A. E. Derocher, I. Stirling, N. J. Lunn, and D. Hedman. 2009. Spatial and Temporal Patterns of Problem Polar Bears in Churchill, Manitoba. Polar Biology 32:1529-1537.

U.S. Fish and Wildlife. 2016. Polar Bear (*Ursus maritimus*) Conservation Management Plan, Final. U.S. Fish and Wildlife, Region 7, Anchorage, Alaska. 104 pp.

Walker, D. A., M. T. Jorgenson, M. Kanevskiy, A. K. Liljedahl, M. Nolan, M. K. Raynolds, and M. Sturm. 2019. Likely impacts of proposed 3D-seismic surveys to the terrain, permafrost, hydrology, and vegetation in the 1002 Area, Arctic National Wildlife Refuge, Alaska. Alaska Geobotany Center Publication AGC 19-01. University of Alaska Fairbanks, Fairbanks, Alaska, USA.

York, G. **S. Amstrup**, and K. Simac. 2004. Using forward looking infrared (FLIR) imagery to detect polar bear dens operations manual. OCS Study, MMS 2004-062. 62 pp.