Temporal overlap amongst all of the seismic and shallow coring programs is limited to the August and September period. During this period, bowhead whales and belugas are expected to be essentially absent from the area and therefore unaffected by the operations, other than Shell's seismic program. During August and September, narwhals are concentrated in and near the Melville Bay Reserve and it is, quite likely that some of these animals will be exposed to noise from each of the seismic survey programs and possibly the shallow coring Check-Shot / VSP array. As discussed above, there have been no quantitative studies of how cumulative sound exposure (over 24 h as modelled) from multiple sources affects marine mammal behaviour, particularly narwhals. However, it is likely that narwhals would respond primarily to the closest seismic operation. Therefore, in most instances the behavioural impacts predicted for a single program would apply to the combined programs. In the uncommon instances when a narwhal is midway between two seismic vessels that are 30 km apart, there may be some additional behavioural responses or effects.

The assessment of Shell's seismic program (see Section 6.7 of this EIA), which involves two seismic vessels operating in the Anu and Napu licenses, predicted that the behavioural residual impacts on narwhals would be *minor* to *moderate*, *short-term*, and in an area of*100–1000* to *1000–10,000 km*^{2} and therefore, *not significant*. It was predicted, based on numerous precautionary steps, that no more than 1.1% of the narwhal population may be exposed to sound levels that might cause behavioural impacts (i.e., avoidance) at a given point in time. An identical assessment approach for narwhals was applied to the shallow coring program (see LGL 2012) and it was predicted that 0.01% of narwhals may exhibit behavioural responses to the VSP array.

Based on the behavioural disturbance criterion for belugas (150 dB rms) used in this assessment and the minimum 30 km separation distance between active seismic programs, it is highly unlikely that the cumulative impact of the three seismic programs and shallow coring program would affect 10% or more (i.e., the criterion for assigning an impact rating of "major") of narwhals in the Melville Bay area. It is far more likely that the combined programs might affect 2-4% of the narwhal population and that impacts would be *not significant*. However, caution is warranted in this situation because it is uncertain if cumulative impacts would be additive or whether habituation would occur and behavioural response distances would decrease.

The other marine mammal VEC of particular relevance in this assessment is the ringed seal given that this species is considered common in the areas proposed for seismic and shallow coring. The assessment of Shell's seismic program (see Section 6.7 of this EIA), predicted that the behavioural residual impacts on ringed seals would be *minor*, *short-term*, and in an area of*100–1000 km*^{2} and therefore, *not significant*. It was predicted, based on numerous precautionary steps, that no more than 0.2% of ringed seals may be exposed to sound levels (assumed 160 dB rms) that could cause behavioural impacts (i.e., avoidance) at a given point in time. Based on this prediction, the combined seismic and shallow coring programs could affect ~1% of the ringed seals in the area and impacts would be *not significant*.

The potential for masking of marine mammal calls and/or important environmental cues is considered quite low from a single seismic program given the short and intermittent nature of airgun pulses (see Section 1.4 of Appendix C for a review of masking). The increased frequency of airgun pulses from up to five airgun arrays increases the potential for masking (as does the number of vessels involved in the seismic and shallow coring programs—see Table 6-5). In most cases, individual animals will only be relatively close to a single seismic operation and significant masking is unlikely. Even for animals that are midway between close (30+ km) seismic operations and with the adjacent vessels alternating shotpoints, there would still be gaps between airgun pulses. Also, this situation would be temporary for any particular animal because the vessels would move away from that animal minimizing the amount of time that pulses from two vessels would be close enough to potentially mask important sounds. Temporary masking of this type is unlikely to negatively affect marine mammals. In addition, masking effects of seismic pulses on small odontocetes like narwhals are considered to be less important because many of the sounds important to them are predominantly at much higher frequencies than are the dominant components of airgun sounds (see Appendix C).

Based on the cumulative acoustic modelling results (see Figures 34 to 39 in Appendix E) for three seismic programs and the shallow coring program and the Southall et al. criterion, the potential for marine mammals to incur permanent hearing impairment (PTS) is limited to a very small area around each of the seismic vessels (see also Section 1.6.2 in Appendix C for a discussion of the potential for incurring PTS). Most marine mammals (particularly narwhals and belugas) are expected to avoid this area around the vessel, especially when airguns are active. With visual monitoring by MMSOs, acoustic monitoring via a PAM system, and mitigation measures in place (ramp ups, ramp up delays for marine mammals within the safety zone, and shut downs for marine mammals within the safety zone), hearing impairment (injury) residual impacts on marine mammal VECs are predicted to be *negligible*. However, caution is warranted in this situation because of the data gaps associated with sound levels and exposure times required to cause hearing impairment, and the absence of any data for narwhals.

The narwhal subsistence hunt in coastal waters of Melville Bay overlaps temporally (August and September) with all three proposed seismic programs and the shallow coring program. Based on acoustic modelling results, the effects of Shell's seismic program on the subsistence harvest were predicted as *minor*, *short-term*, and in an area of *1000–10,000 km*^{2} (Table 6-6). It is assumed that most of the narwhal hunt occurs within a few km of the coast where received sound levels from the combined seismic programs will be less than the 150 dB (rms) level that is predicted to cause behavioural disturbance. Therefore, cumulative impacts from combined seismic and shallow coring programs are not predicted to exceed those predicted for individual programs. The cumulative impacts on subsistence harvesting are predicted to be *not significant*. As noted for other VECs, caution is warranted because of the existing data gaps concerning behavioural responses of narwhals to seismic noise.

6.10.4 Addressing Data Gaps and Uncertainties

It is recognized that data gaps contribute to uncertainty in cumulative impact predictions. Shell and the other Operators are in discussions with BMP regarding the funding for a DCE-led research initiative involving three studies (sound propagation, marine mammal aerial surveys, and subsistence hunting) designed to investigate the potential cumulative impacts assessed here. This program will serve to address data gaps and provide a better basis for mitigation measures in future years. In addition, it will help validate acoustic modelling predictions made in this EIA. The primary objectives of the three studies as provided by DCE are as follows:

Acoustic Measurements.—"*The objective of the proposed study is to obtain detailed information about propagation of sound away from a seismic vessel in Arctic waters and from this create a propagation model usable to make reliable predictions of impact zones for future seismic survey operations*."

Marine Mammal Aerial Surveys.—"*In this study aerial surveys of narwhals in Melville Bay will be conducted before, during and after the seismic activity with the primary purpose of detecting changes in residency of narwhals. A secondary objective is to generate baseline data on narwhal occurrence in the area to be used for assessing future impacts on the population from oil exploration activities*."

Subsistence Hunting.— "... *direct observations* [of the narwhal hunt] *together with collection of information on the operations by the hunters will be useful to evaluate any effects that may arise from seismic activity in the area. Furthermore, any changes in whale behaviour will be attributed to seismic activity by the hunters and for evaluation of the impact of noise in relation to hunting success it will be important with direct observations from the area*."

Shell will work closely with BMP, DCE and other Operators to facilitate a successful cumulative impact research program.

6.11 Impact Summary

All of the potential interactions considered between the Project and VECs for Shell's 3-D seismic program result in a predicted residual impact rating of *not significant* after the application of mitigation measures (Table 6-6). The majority of the potential interactions considered have a magnitude rating of *negligible* or *negligible to minor*.

The only potential impact that has a magnitude rating of *moderate* (1–10% change in the size or health of a population) is for the behaviour of the narwhal VEC in relation to airgun array noise (Table 6-6). This potential impact is rated as having this magnitude because it has the potential to affect up to 1.1 % of the Melville Bay narwhal population at the worst-case scenario location (the northeast corner of the northern Optional Seismic Area as modelled; see Appendix E). The potential impacts of all other marine mammal VECs and of the marine mammal subsistence hunt in relation to the airgun array have magnitude ratings of *minor* (<1% change in the size or health of the population; Table 6-6). The level of confidence related to these predictions is considered *medium* because of the lack of information concerning the response of narwhals, and all marine mammals to some extent, to seismic noise and the variable responses of belugas to seismic noise, which is used to predict the residual impact of airgun noise on the narwhal VEC.

Residual impacts of a small fuel spill on seabirds were rated as *minor* (Table 6-6). The typical scenario of an accidental spill during a refuelling operation would result in the potential release of ~1.7 m^3(1700 L) of fuel into the environment. All other potential residual impacts on seabirds considered have a magnitude rating of *negligible*.

The potential interaction of fish and invertebrates, as well as fish and invertebrates eggs and larvae in relation to the airgun array have impact magnitude ratings of *minor* (Table 6-6). All potential residual impacts considered between commercial fisheries and subsistence fishing and project activities have a magnitude rating of *negligible* or *negligible to minor*.

In most cases, the actual numbers of animals exposed the various activities would be expected to be much lower during the majority of the survey. However, considering the limitations associated with the existing baseline data available for these VECs within the Study Area and existing knowledge gaps with regards to the reaction of these VECs to seismic noise, precautionary assumptions were used in the analysis process to predict what should be considered worst-case scenarios.

TABLE 6-6. Summary of potential impacts, proposed mitigation, and predicted residual impacts on VECs from the Shell 3-D seismic program. NA = Not applicable.

VEC / Interaction	Potential Impact	Mitigation Measure(s)	Impact Definition Ratings			Predicted Residual Impact	Confidence Level in Prediction
			Spatial Extent	Magnitude	Duration		
Narwhal, beluga x Airgun array	[1] Hearing damage [2] Disturbance including avoidance	Use MMSOs, ramp up airgun array, delayed start of airguns if marine mammal sighted in safety zone, shut down airguns if marine mammal sighted in safety zone (800 m)	[1] NA [2] 100–1000 km^2 to 1000–10,000 km^2	[1] Negligible [2] Minor to Moderate	[1] NA [2] Short-term	Not significant	[1] High [2] Medium
Bowhead, seals, walrus x Airgun array	[1] Hearing damage [2] Disturbance including avoidance	Use MMSOs, ramp up airgun array, delayed start of airguns if marine mammal sighted in safety zone, shut down airguns if marine mammal sighted in safety zone (800 m whales; 500 m pinnipeds)	[1] NA [2] 100–1000 km^2	[1] Negligible [2] Minor	[1] NA [2] Short-term	Not significant	High
Polar bear x Airgun array	[1] Hearing damage [2] Disturbance including avoidance	Use MMSOs, ramp up airgun array, delayed start of airguns if marine mammal sighted in safety zone, shut down airguns if marine mammal sighted in safety zone (500 m)	NA	Negligible	NA	Not significant	High
Marine mammal subsistence hunt x Airgun array	Reduction in hunt, more effort required by hunters	Avoid temporal overlap with migration activities	1000–10,000 km^2	Minor	Short-term	Not significant	Medium
Narwhal, beluga x Vessel noise	Disturbance including avoidance	Vessels will maintain constant course & speed when possible	10–100 km^2	Negligible to minor	Short-term	Not significant	High
Bowhead, seals, walrus, polar bear x Vessel noise	Disturbance including avoidance	Vessels will maintain constant course & speed when possible	NA	Negligible	NA	Not significant	High
Marine mammal subsistence hunt x Vessel noise	Reduction in hunt, more effort required by hunters.	Avoid sensitive areas and coastal areas when possible	NA	Negligible	NA	Not significant	High

VEC / Interaction	Potential Impact	Mitigation Measure(s)	Impact Definition Ratings			Predicted Residual Impact	Confidence Level in Prediction
			Spatial Extent	Magnitude	Duration		
Narwhal, beluga, bow-head, seals, walrus, polar bear x Vessel presence	Mortality	Avoid sensitive areas and reduce speed when possible.	NA	Negligible	NA	Not significant	High
Marine mammal subsistence hunt x Vessel presence	Reduction in hunt	Avoid sensitive areas and reduce speed when possible	NA	Negligible	NA	Not significant	High
Narwhal, beluga, bow-head, seals, walrus, polar bear x Vessel lights	May attract prey	None	NA	Negligible	NA	Not significant	High
Narwhal, beluga, bow-head, seals, walrus, polar bear x Sanitary/Domestic (S/D) wastes	May attract prey	None	NA	Negligible	NA	Not significant	High
Marine mammal subsistence hunt x S/D wastes	Reduction in hunt, more effort required by hunters	None	NA	Negligible	NA	Not significant	High
Narwhal, beluga, bow-head, seals, walrus, polar bear x Routine accidental spills	Reduced insulation, toxicity if ingested	Spill Prevention Plan, Shipboard Oil Pollution Prevention Plan (SOPEP), crew training and drills, bunkering procedures, Ice Management Plan	NA	Negligible	NA	Not significant	High
Marine mammal subsistence hunt x Routine	Reduction in hunt	Spill Prevention Plan, SOPEP, crew training and drills, bunkering procedures, Ice Management Plan	NA	Negligible	NA	Not significant	High

VEC / Interaction	Potential Impact	Mitigation Measure(s)	Impact Definition Ratings			Predicted Residual Impact	Confidence Level in Prediction
			Spatial Extent	Magnitude	Duration		
accidental spills							
Seabirds x Airgun array	[1] Hearing damage [2] Disturbance including avoidance	Ramp up of airgun array	NA	Negligible	NA	Not significant	High
Seabirds x Vessel noise	Disturbance including avoidance	Avoid sensitive areas and seabird concentrations when possible	NA	Negligible	NA	Not significant	High
Seabirds x Vessel presence and lights	Seabird stranding	Reduce light level while maintaining safe working conditions, daily searches of ship for stranded birds	NA	Negligible	NA	Not significant	High
Seabirds x S/D wastes	May attract prey	None	NA	Negligible	NA	Not significant	High
Seabirds x Routine accidental spills	Reduced insulation, toxicity if ingested	Spill Prevention Plan, SOPEP, crew training and drills, bunkering procedures, Ice Management Plan	<1 km^2 to 1–10 km^2	Minor	Short-term	Not significant	High
Fish, invertebrates x Airgun array	[1] Hearing damage [2] Disturbance including avoidance	Ramp up of airgun array	<1 km^2 to 100–1000 km^2	Minor	Short-term	Not significant	Medium
Fish, invertebrate eggs & larvae x Airgun array	Physical damage	None	<1 km^2	Minor	Short-term	Not significant	Medium
Commercial, subsistence fisheries x Airgun array	Reduction in harvest, more effort required by fishers.	Temporal and spatial avoidance of primary fishing areas, when possible; good communication with fishers	10–100 km^2	Negligible to minor	Short-term	Not significant	High

VEC / Interaction	Potential Impact	Mitigation Measure(s)	Impact Definition Ratings			Predicted Residual Impact	Confidence Level in Prediction
			Spatial Extent	Magnitude	Duration		
Fish, invertebrates x Vessel noise	Disturbance including avoidance	None	<1 km^2 to 100–1000 km^2	Negligible to minor	Short-term	Not significant	High
Commercial, subsistence fisheries x Vessel noise	Reduction in harvest, more effort required by fishers	Temporal and spatial avoidance of primary fishing areas, when possible; good communication with fishers.	NA	Negligible	NA	Not significant	High
Commercial fisheries x Vessel presence	Damage to fishing gear, lost harvesting time.	Temporal and spatial avoidance of primary fishing areas, when possible; good communication with fishers.	NA	Negligible	NA	Not significant	High
Fish, invertebrates x Vessel lights	Attraction	None	NA	Negligible	NA	Not significant	High
Fish, invertebrate eggs & larvae x Vessel lights	Attraction	None	NA	Negligible	NA	Not significant	High
Fish, invertebrates x S/D wastes	Attraction	None	NA	Negligible	NA	Not significant	High
Fish, invertebrate eggs & larvae x S/D wastes	Attraction	None	NA	Negligible	NA	Not significant	High
Commercial, subsistence fisheries x S/D wastes	Attraction of target species, reduction in catch	None	NA	Negligible	NA	Not significant	High
Fish, invertebrates x Routine accidental spills	Local avoidance, toxicity if ingested.	Spill Prevention Plan, SOPEP, crew training and drills, bunkering procedures, Ice Management Plan.	<1 km^2 to 1–10 km^2	Negligible to minor	Short-term	Not significant	High

VEC / Interaction	Potential Impact	Mitigation Measure(s)	Impact Definition Ratings			Predicted Residual Impact	Confidence Level in Prediction
			Spatial Extent	Magnitude	Duration		
Fish, invertebrate eggs & larvae x Routine accidental Spills	Mortality	Spill Prevention Plan, SOPEP, crew training and drills, bunkering procedures, Ice Management Plan	<1 km^2 to 1–10 km^2	Negligible to minor	Short-term	Not significant	High
Commercial, subsistence fisheries x Routine accidental spills	Physical effects on target species, actual and perceived tainting of target species, fouling of gear	Spill Prevention Plan, SOPEP, crew training and drills, bunkering procedures, Ice Management Plan	<1 km^2 to 1–10 km^2	Negligible to minor	Short-term	Not significant	High

7 ENVIRONMENTAL MANAGEMENT PLAN

The Environmental Management Plan (EMP) for Shell's proposed 2012 seismic program in the Anu and Napu licenses describes the measures and management plans that will be put in place to mitigate impacts on the environment. As evidenced in Section 6 of this EIA, the impact of most concern is that of airgun array noise on marine mammals, notably narwhals. The preparation of this EMP focuses on minimizing noise impacts and is based primarily on the best practice mitigation guidelines described in "Guidelines to environmental impact assessment of seismic activities in Greenland waters, 3rd revised edition, December 2011" (Kyhn et al. 2011). However, as recommended in these Seismic EIA Guidelines, mitigations to minimize the impacts of air emissions and discharge of wastes are also included here. The EMP also provides an overview of the plans that will be used to minimize the likelihood of accidental events. In many cases, industry Best Available Technology (BAT) and Best Environmental Practice (BEP) are already incorporated into Shell and Polarcus' standard operating procedures. To ensure that BAT and BEP are applied wherever feasible, other information sources, particularly those specific to arctic operations, were consulted.

7.1 Marine Mammals and Airgun Array Noise

The Seismic EIA Guidelines for minimizing the impacts of airgun array noise are based primarily on the JNCC (Joint Nature Conservation Committee) 2010 Guidelines with some additional mitigation measures that apply to Greenland. Best practice mitigations are provided for the planning (see Section 6.5 in the Seismic EIA Guidelines) and operation phases (Section 6.6 in the Seismic EIA Guidelines) of the proposed seismic program.

7.1.1 Survey Planning

Airgun Array Design and Selection

The 4240-in^3 array provided by Polarcus was selected because it provides sufficient power required to collect seismic data at the deepest geological targets (Cretaceous) of the survey, which are 5–6 km below the seabed. Shell considered the 2940-in^3 array provided by Polarcus and requested that JASCO model the overpressure signature (see Figure 7-1), power spectrum (see Figure 7-2), and estimate the source level for the broadside and endfire directions (Table 7-1); modelling methods were identical to those conducted for the 4240 in^3 (see Appendix E). Results indicate that the 4240-in^3 array planned for use and the smaller volume 2940-in^3 array have similar source level characteristics.

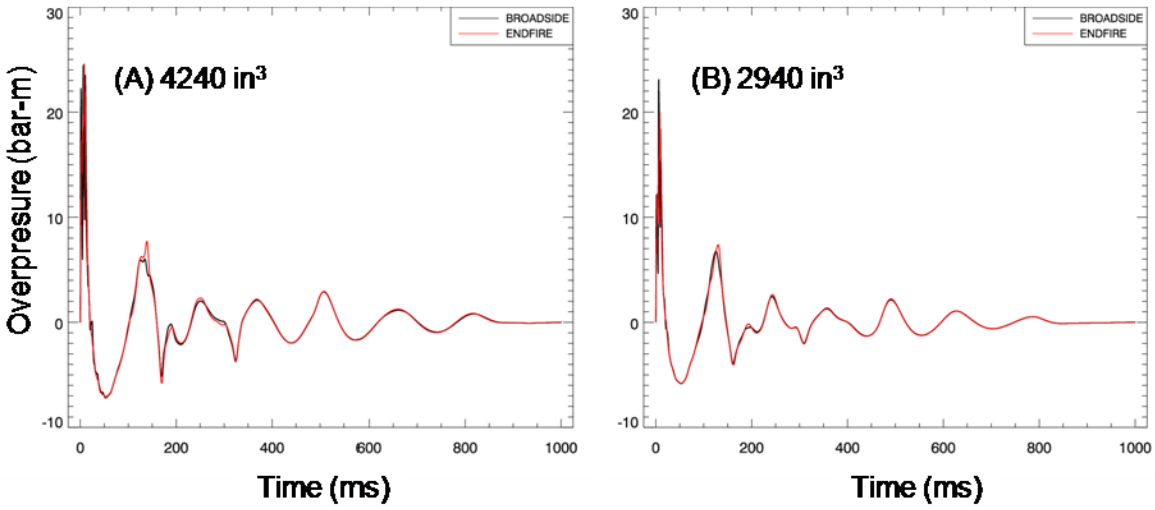

FIGURE 7-1. Predicted overpressure signatures for the (A) 4240-in^3 and (B) 2940-in^3 airgun arrays. Surface ghosts (effects of the pulse reflection at the water surface) are not included in these signatures, as they are accounted for by the MONM propagation model (Appendix E).

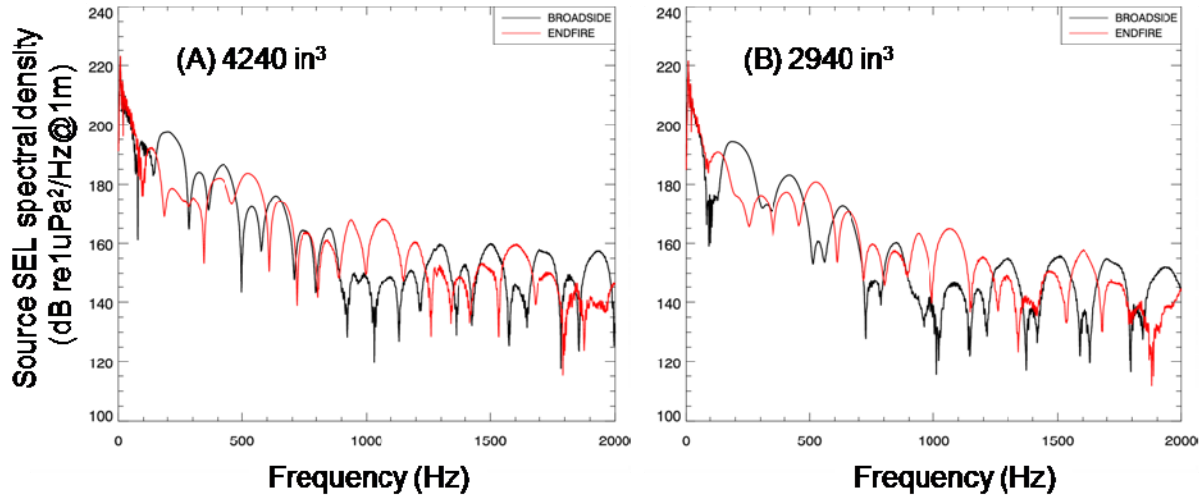

FIGURE 7-2. Predicted power spectrums for the (A) 4240-in^3 and (B) 2940-in^3 airgun arrays. Surface ghosts (effects of the pulse reflection at the water surface) are not included in these signatures, as they are accounted for by the MONM propagation model.

TABLE 7-1. Source level specifications (10–2000 Hz) for the (A) 4240-in^3 and (B) 2940-in^3 airgun arrays at 8-m tow depth computed with AASM in the broadside and endfire directions. Surface ghost effects are not included, as they are accounted for by the MONM propagation model.

Direction	Peak SPL (dB re 1 µPa @ 1 m)	SEL (dB re 1 µPa^2 @ 1 m)		
		Broadband	0–1 kHz	1–2 kHz
(A) 4240 in^3				
Broadside	247.8	229.1	229.1	183.2
Endfire	247.8	229.3	229.3	187.8
(B) 2940 in^3				
Broadside	247.3	227.2	227.2	179.5
Endfire	246.0	227.2	227.2	184.7
(C) Difference [(A) minus (B)]				
Broadside	0.5	1.9	1.9	3.7
Endfire	1.8	2.1	2.1	3.1

Give the similarities in predicted source levels in the broadside and endfire directions between the two airgun arrays, Shell is proposing to use the 4240-in^3 array to meet its operational requirements for the Anu and Napu survey.

The Seismic EIA Guidelines request operators seek methods to reduce and/or baffle unnecessary high-frequency noise and to increase the directionality of the airguns. These potential mitigation measures have been assessed in a Joint Industry Programme study (Spence et al. 2007), and it was determined that the equipment necessary to reduce and/or baffle the airguns is not yet available. Shell has approached Polarcus on these potential mitigation measures. It was determined that changing the 4240-in^3 array configuration proposed for use in the Shell survey is not feasible at this stage in the Project because it will undoubtedly alter the source signature; without proper field testing, this may affect the quality of seismic data collected and render the survey results unusable.

Program Location and Timing

Location

The key marine mammal species of concern as identified in the SEIA (Boertmann and Mosbech 2011) as well as in this EIA, is the narwhal, which is known to concentrate in Melville Bay during summer. There will be no seismic surveying by Shell in Narwhal Protection Zone I; Shell's Seismic Area is at its closest point 31 km from this zone (if the northern optional area is acquired [see Figure 4-1], this distance reduces to 18 km). The main species of interest identified for the seismic survey are the

narwhal, beluga whale, bowhead whale, polar bear, walrus, ringed seal, and bearded seal. Of these species, the ringed seal and bearded seal are the most likely species to be encountered in the Seismic Area, based on available distribution data (as acquired from GINR and DCE) and a recent marine mammal monitoring program in the area (Abgrall and Harris 2011). Seals are not engaged in breeding or pupping during the open-water season.

The primary commercial fishery of concern, as noted in Boertmann and Mosbech (2011), is for the Greenland halibut, which generally occurs along the shelf break, with some overlap with the western side of the Project Area. Based on information provided in the SEIA, the Project Area is north of area where shrimp are harvested.

Timing

The timing of the survey is designed to reduce the likelihood of encounters with marine mammals, while operating during a period that allows for safe operations (the open-water period). The survey is planned to commence ~15 July and end before 15 October, primarily to minimize any potential interactions with the narwhal migration. The distributions of bowhead whales, beluga whales, and walruses generally do not overlap temporally with the open-water season; if they do, it is only for a short period in late fall (October and November).

Number and Qualifications of MMSOs

The Seismic EIA Guidelines require that at least two MMSOs should be onboard seismic vessels. At present, it is planned to place four MMSOs on the *Polarcus Amani* and two MMSOs on the *Polarcus Samur*. In addition, two ship's crew on the *Polarcus Samur* will assist with marine mammal watches; these crew members will be trained in marine mammal identification, data collection procedures, and mitigation protocols before the start of the seismic program. Two MMSOs will also be placed on each of the support vessels. The MMSOs will possess the necessary observation qualifications and training (or equivalent experience) required by DCE, and will possess suitable and up-to-date offshore medical and safety training. They will be trained and/or familiar with the DCE marine mammal and seabird observation procedures and recording forms. As required in BMP (2011), the names and CVs of MMSOs will be submitted to BMP for approval at least 40 days before the anticipated start of the seismic program.

PAM

Shell will implement a Passive Acoustic Monitoring (PAM) program in order to allow the start up of seismic acquisition during periods of darkness and low visibility, or during periods when the sea state impedes visual monitoring (BMP Guidelines assume sea state >3). The PAM system will be provided by MSEIS Ltd.; technical specifics of the PAM system to be used during the seismic survey are provided in Section 4.2.7 and Appendix A. MMSOs aboard both vessels will be trained to operate the PAM systems. The PAM system uses PAMGUARD, software that has been validated with field trials (Gillespie et al. 2008).

7.1.2 Operations

Marine Mammal Monitoring and Mitigation

General

Marine mammal (and seabird; see "Seabirds" below) observations will be performed from the seismic vessels (and the support vessels) on an elevated platform allowing an unobstructed view of the waters around the vessel. Whenever possible, the MMSOs will conduct observations from an outdoor platform. During periods of poor weather (high winds, rain/snow, or extreme cold temperatures), the MMSOs will continue monitoring for marine mammals and seabirds from the bridge for safety reasons. MMSOs aboard each of the seismic vessels will monitor for the presence of marine mammals (and seabirds) during all daylight hours as required in the Seismic EIA Guidelines and the guidelines for MMSOs *Manual for seabird and marine mammal survey on seismic vessels in Greenland* (Johansen et al. 2011a). At all times, MMSOs will have access to a direct communication line with the survey room and the operator of the airguns. A safety zone of 800 m from the centre of the airgun array will be implemented for cetaceans and 500 m for other marine mammals (see Ramp up and Line Shooting below). The 800 m safety zone for cetaceans is determined by the maximum modelled 180 dB re 1 μPa (rms) at the broadside $R_{95\%}$ (i.e. the maximum range at which the sound level was encountered in the modelled sound field after exclusion of the farthest 5%) plus a safety margin of 10%. For other marine mammals a 500 m safety zone is applied, which is based on international best practice. A radius of 190 dB re 1 μPa (rms) at the broadside $R_{95\%}$ was considered but the 500 m was determined to be more conservative.

Table 7-2 summarizes the operational monitoring and mitigation measures proposed for Shell's seismic program. A MMSO Plan will be submitted by Shell to BMP as part of the remaining project documentation to be submitted 40 days before the start of the seismic program. As part of this MMSO Plan, flow-charts will be developed that clearly outline the decision-making process for implementing mitigation and monitoring procedures.

TABLE 7-2. Summary of operational monitoring and mitigation measures for Shell's 2012 Baffin Bay 3-D seismic survey.

MMSOs
MMSO observations will be performed from the seismic vessels (and the support vessels) on an elevated platform allowing an unobstructed view of the waters around the vessel. Whenever possible, the MMSOs will conduct observations from an outdoor platform.
MMSOs aboard each of the seismic vessels will monitor for the presence of marine mammals during all daylight hours.
MMSOs will have access to a direct communication line with the survey room and the operator of the airguns.
A safety/shut-down zone of 800 m from the centre of the airgun array for cetaceans and 500 m for other marine mammals will be implemented and monitored for the presence of marine mammals during all daylight hours.

Shutdown [a]
If any marine mammal is observed within the 800 or 500-m safety zone for cetaceans and other marine mammals, respectively, the airgun array will be reduced to the mitigation gun.
A precautionary shutdown will be applied if a marine mammal is observed to be on a course that will result in its entering the shut down zone.
Pre-shooting search
A pre-shooting search of 30 min (60 min in water depths of >200 m) will be conducted before the start of any airgun operations.
During periods of poor visibility, PAM will be used during the pre-shooting watch period to monitor for vocalizing marine mammals within the safety zone.
If any marine mammal is visually or acoustically detected within the safety zone during the pre-shooting watch period, the ramp-up will be delayed until the animal has been observed outside of the safety zone or 20 min has passed since the animal was last detected.
Ramp-up
The ramp-up or soft start procedure will occur over a minimum period of ~20 min.
The ramp-up procedure will be planned such that the start of the survey line begins immediately following the ramp-up.
Ramp ups will not exceed 40 min in duration and to the extent possible will be initiated during daylight hours.
During periods of poor monitoring visibility, PAM will be used during the ramp-up procedure to monitor vocalizing marine mammals within the safety zone.
If any marine mammal is detected within the safety zone during the ramp-up procedure, the airgun array will be reduced to the mitigation gun and a new ramp-up procedure will be initiated once the animal has been detected outside of the safety zone or 20 min has passed since the animal was last detected.
If any marine mammal is detected within the safety zone while on the transect line, the airgun array will be reduced to the mitigation gun and a new ramp-up procedure will be initiated if the silent break (period between shut-down and start-up) exceeds 5 minutes or 20 min has passed since the animal was last detected. If the animal is observed outside the safety zone within 5 minutes after shut-down, the airgun array can be started at full power without ramp-up.
If the airgun array is shut down for any reason other than marine mammals while on the transect line, the airgun array can be re-initiated at full power given that the silent break is not longer than 5 min. Otherwise, a 20-min pre-shooting search and full ramp-up procedure will need to be initiated.

Line changes
The airgun array output will be shutdown when the transit time to the next survey line is expected to be greater than 20 min.
A 20-min pre-shooting search and full ramp-up procedure will be initiated prior to the start of the next survey line.
If a transit between survey lines is expected to last less than 20 min, the airgun array can remain operational during transit, but preferably at a reduced power output (mitigation gun). No ramp-up procedure will be required at the start of the next survey line.

[a]Although called a "shutdown" here (and elsewhere), this shutdown to a mitigation gun is often referred to as a power down.

Pre-shooting Search

A pre-shooting search of 30 min (60 min in water depths of >200 m) will be conducted before the start of any airgun operations. During periods of poor visibility (when the 800/500-m safety zone for cetaceans and other marine mammals, respectively cannot be monitored because of darkness or poor sighting conditions such as fog, rain, snow, or sea states >3), PAM will be used during the pre-shooting watch period to monitor for vocalizing marine mammals within the safety zone. The safety zone monitored by the PAM system will be determined in the field to ensure it extends beyond 800 m to compensate for the system's accuracy.

If any marine mammal is visually or acoustically detected within the safety zone during the pre-shooting watch period, the ramp-up will be delayed until the animal has been observed outside of the safety zone or 20 min has passed since the animal was last detected.

Ramp-up

The ramp-up or soft start procedure will occur over a minimum period of ~20 min. Ramp up will start with the smallest volume airgun and incrementally increase the number of airguns activated.

The ramp-up procedure will be planned such that the start of the survey line begins immediately following the ramp up (i.e., unnecessary airgun firing will be avoided). Ramp ups will not exceed 40 min in duration, and to the extent possible will be initiated during daylight hours. During periods of poor monitoring visibility (when the 800/500-m safety zone for cetaceans and other marine mammals, respectively cannot be monitored because of darkness or poor sighting conditions such as fog, rain, snow, or sea states >3), PAM will be used during the ramp-up procedure to monitor vocalizing marine mammals within the safety zone (to be determined in the field to ensure it extends beyond 800 m to compensate for the accuracy of the PAM system).

If any marine mammal is visually or acoustically detected within the safety zone during the ramp-up procedure, the airgun array will be reduced to the mitigation gun (smallest airgun in the array) and a new ramp-up procedure will be initiated once the animal has been detected outside of the safety zone or 20 min has passed since the animal was last detected.

Line Shooting

When the airgun array is shut down, either because of marine mammals within the safety zone or for other reasons, the mitigation gun will continue to be used. If a marine mammal is observed within the 800/500-m safety zone for cetaceans and other marine mammals, respectively, the airgun array will be reduced to the mitigation gun until the animal has left the safety zone. When this situation occurs, the airgun array can return to shooting at full power without requiring a ramp-up procedure in cases where (i) the animal is observed to have left the safety zone and (ii) the maximum time of the silent break (period between shut down and start up) is 5 min. If this period is longer than 5 min or the animal is not observed leaving the 800 / 500-m safety zone for cetaceans and other marine mammals, respectively, a 20-min pre-shooting search period followed by a 20-min ramp-up procedure will be used before line shooting can resume. The use of a 800 / 500-m safety zone for cetaceans and other marine mammals, respectively, versus the 200-m injury zone recommended in the Seismic EIA Guidelines is considered precautionary.

If the airgun array is shut down while on a transect line for any reason other than a marine mammal shutdown, the airgun array can be re-initiated at full power given that the shutdown is not longer than 5 min. Otherwise, a 20-min pre-shooting search and full ramp-up procedure will need to be initiated.

When a marine mammal is observed to be on a course that will result in its entering the safety zone, a precautionary shutdown of the airgun array will be implemented.

Line Changes

The airgun array output will be shut down when the transit time to the next survey line is expected to be greater than 20 min (the amount of time it would take to conduct a full ramp-up procedure). A 20-min pre-shooting search and full ramp-up procedure will be initiated before the start of the next survey line. This is expected to occur in most line changes during the 2012 program.

If a transit between survey lines is expected to last less than 20 min, the airgun array can remain operational during transit, but preferably at a reduced power output (mitigation gun). No ramp-up procedure will be required at the start of the next survey line.

7.1.3 Acoustic Modelling and Acoustic Field Program

Acoustic modelling of the 4240-in^3 array has been conducted according to BMP's requirements, and the findings have been incorporated into the EIA. Shell does not, at this time, intend to conduct its own acoustic field measurements to verify the accuracy of the modelled sound propagation. Discussions are in progress with BMP that would arrange for a DCE field monitoring program to examine cumulative impacts of Shell's seismic program, as well as two other seismic programs and a shallow coring program in the region (see below). As part of the sound propagation portion of the field program, noise will be monitored at selected locations near Shell's seismic survey and also in the Melville Bay Reserve. The specific locations and methodology have not yet been finalized. Information from this acoustic propagation study will address data gaps that contribute to uncertainty in impact predictions. The primary objective of the propagation study as provided by DCE is as follows:

"The objective of the proposed study is to obtain detailed information about propagation of sound away from a seismic vessel in Arctic waters and from this create a propagation model usable to make reliable predictions of impact zones for future seismic survey operations."

7.1.4 Cumulative Impacts of Other Geophysical Programs

As assessed in Section 6.10, in addition to Shell's proposed 3-D seismic survey, ConocoPhillips and Maersk are proposing to acquire seismic data, and there is also a proposed shallow coring program in and near the Anu and Qamut licenses. Shell has been in regular communication with these oil and gas exploration companies that have operations planned for Baffin Bay in 2012, and will continue to communicate with these groups leading up to and throughout the 2012 survey program. Operators will coordinate their geophysical programs to maintain spatial separation (minimum of ~30 km) with each other. A cumulative acoustic modelling report was prepared (see Appendix E), and a cumulative impact assessment based, in part, on the modelling results, was prepared (see Section 6.10) in an attempt to predict the impacts of three seismic programs and a shallow coring program on VECs, notably narwhal. As noted above, Shell is in discussions with BMP regarding the funding for a DCE-led research initiative involving three studies (sound propagation, marine mammal aerial surveys, and subsistence hunting) designed to investigate potential cumulative impacts from three seismic programs and a shallow coring program. This will serve to address data gaps and provide a better basis for mitigation measures in future years.

The primary objectives of the aerial survey and subsistence hunting studies as provided by DCE are as follows:

Marine Mammal Aerial Surveys.—"*In this study aerial surveys of narwhals in Melville Bay will be conducted before, during and after the seismic activity with the primary purpose of detecting changes in residency of narwhals. A secondary objective is to generate baseline data on narwhal occurrence in the area to be used for assessing future impacts on the population from oil exploration activities*."

Subsistence Hunting.— "... *direct observations* [of the narwhal hunt] *together with collection of information on the operations by the hunters will be useful to evaluate any effects that may arise from seismic activity in the area. Furthermore, any changes in whale behaviour will be attributed to seismic activity by the hunters and for evaluation of the impact of noise in relation to hunting success it will be important with direct observations from the area*."

Shell will work closely with BMP, DCE and other Operators to facilitate a successful cumulative impact research program.

7.2 Seabirds

7.2.1 Systematic Surveys

Shell recognizes the importance of acquiring systematic and scientifically credible seabird data in its survey area and the role the data will play in addressing data gaps for the region. As such, systematic seabird surveys will be conducted to the maximum extent possible and by experienced seabird observers (MMSOs). Seabird observations will be undertaken using the Tasker count method and follow the protocol outlined in the *Manual for seabird and marine mammal survey on seismic vessels in Greenland* (Johansen et al. 2011a) on all project vessels that include MMSOs.

7.2.2 Lighting and Stranded Birds

Deck lighting will be minimized (especially upward and horizontal-projecting light) to the extent that it is safe and practical to reduce the likelihood of birds stranding on Project vessels. Daily searches of Project vessels will be conducted for stranded birds. Project personnel will be made aware of bird attraction to the lights on offshore structures. However, some degree of lighting is required for safe work practices, and seismic surveying is conducted around the clock. The MMSOs will conduct daily searches of the ship, and the ship's crew will also be notified to contact the MMSOs if a bird is found. Procedures developed by the Canadian Wildlife Service and Petro-Canada (now Suncor) will be used to handle stranded birds and release them (Williams and Chardine, n.d.).

7.3 General Ship Operations

The impacts of vessel traffic (seismic and support vessels) on marine mammals will be reduced by vessels steering a straight course and maintaining constant and moderate speed whenever possible. Shell is committed to these mitigation measures to the extent that is possible and practical for their operations. Maintaining a constant and moderate speed will reduce changes in sound levels and frequencies of engine and propeller sounds that disturb marine animals. The Polarcus vessels have a Det Norske Veritas (DNV) notation, COMF-V(3) or Comfort Class 3 which, because of the Ulstein X-Bow vessel design, minimizes vibration and noise. This vessel design minimizes the interaction of waves and water on the hull, resulting in reduced noise in the immediate environment.

Project vessels will operate in accordance with all applicable laws, standards and conditions while in Greenland waters, including:

- MARPOL 73/78 (the International Convention for the Prevention of Pollution from Ships).
- International Convention for the Safety of Life at Sea (SOLAS), 1974.
- Requirements attached to the authorisation from the Greenland Government or any associated conditions required by the authorities.
- 'E&P Forum Health, Safety and Environmental Schedules for Marine Geophysical Operations' (Report No. 6.34/206).

- IAGC 'Marine Geophysical Operations Safety Manual' published by the International Association of Geophysical Contractors (10th edition).
- IAGC 'Environmental Guidelines for Worldwide Geophysical Operations' (most recent edition).
- DCE's 'Guidelines to Environmental Impact Assessment of Seismic Activities in Greenland Waters'.
- OGP Guideline: Managing HSE in a geophysical contract (report No. 432).

7.3.1 Fisheries Interactions

The 2011 Application Guidelines state (Section 7.6) that "The licensee shall, upon BMP request, include one or more Fishery Liaison Officers (FLO) in the operation. The FLO must be approved by the BMP and shall serve as an advisory observer and communicator in matters related to fishery. BMP may impose specific requirements on the FLO's qualifications, including, for example that he must be speaking Greenlandic in order to communicate with local fishery actors." However, it is not anticipated that a FLO will be required considering the location of Shell's Seismic Area. Nevertheless, it is understood that Shell will place a FLO onboard a seismic vessel if so requested and will bear all associated costs. If a FLO is required, a logbook of observations will be kept using the template in Appendix J of the Application Guidelines, and will be submitted to the BMP (with a copy to Shell) within two weeks of the termination of the exploration activity.

Project vessel crews will keep a log of sightings and contacts with fishing (and other) vessels. In addition, a log will be kept of any fishing or other equipment removed from the sea for the purpose of clearing a path for the survey vessels. The log will include location, date, type of equipment, and any identifying marks. No hunting or fishing will be permitted from Project vessels or from in-going or out-going individuals while on land during crew change operations.

7.3.2 Simultaneous Operations

A Simultaneous Operations (SIMOPs) Plan is typically implemented as a "best practice" by companies during concurrent offshore seismic surveys occurring in the same region. The quality and integrity of seismic data can be impaired or degraded if the survey ships are too close to each other when airgun arrays are being operated and seismic data is being acquired. In practice, the SIMOPs plan is established by the respective companies and is coordinated at sea by the company representatives aboard the seismic vessels.

Shell intends to maintain a nominal separation distance of 30 km between vessels. The details of this process will be included in the Project Plan document to be submitted with the permit application.

At the present time, SIMOPs planning has been discussed internally but not in detail between Shell and the other Baffin Bay operators for the 2012 season. Shell will engage with Maersk and ConocoPhillips to evaluate possible options for a common SIMOPs plan and assess the possibility of its application as an additional seismic noise mitigation.

7.4 Emissions, Discharges, and Waste Management

7.4.1 Waste Management

Polarcus has a Garbage Management Plan in place that meets or exceeds MARPOL requirements (MARPOL 73/78, Annex V). As part of this plan:

- Food waste will be burned onboard in the DNV approved incinerator. Polarcus has a 'nothing overboard policy' while on project.
- Sufficient and adequate facilities will be available on vessels to store solid wastes to the extent required.
- All solid wastes are segregated as per the onboard garbage segregation plan with products that are not incinerated kept either on the Polarcus or support vessels until the end of the project. There will be no disposal of waste ashore. Polarcus vessels are equipped with a compactor, so volume of waste can be kept to a minimum. All manner of waste management will be fully described in the project documentation.
- Records of waste produced, segregated, and stored during the program will be managed by Polarcus via the Garbage Record and Oil Record Book.

7.4.2 Emissions and Discharges

All Project vessels will only use diesel and gasoil with a sulphur content of less than 1.5% (weight). Both the *Polarcus Samur* and *Polarcus Amani* are newly built (2011 and 2012, respectively), environmentally advanced vessels that have diesel-electric propulsion, high specification catalytic convertors, and advanced ballast water treatment and bilge water cleaning systems. Other details relevant to emissions and discharges for the seismic vessels are provided below.

- Polarcus practices the Nothing Overboard policy while on project, which exceeds MARPOL guidelines. The Polarcus seismic vessels will meet the stringent Det Norske Veritas (DNV) CLEAN-DESIGN and BWM-T notations that regulate emissions to air and water. All Polarcus vessels are equipped with an SCR catalytic reactor unit, which assists in the reduction of harmful emissions.
- The Polarcus seismic vessels carry an IMO Green Passport ensuring that minimal harmful products are used during production of the vessel.
- Records of water and fuel use by the vessel will be managed by Polarcus. DNV sampling is carried out on Polarcus vessel to verify quality of product.
- Records of all discharges, including gray and black water discharges, bilge and ballast water, and dirty oil, will be managed by Polarcus. Bilge water separators reach values of <5 ppm, whereas the regulatory requirement is 15 ppm. (It is noteworthy that values of 2 ppm are regularly recorded.) Ballast water is treated with chemical-free products to ensure proper treatment of water and sediments as per International Convention of the Control of Ships Ballast Water and Sediments.

- Equipment onboard the vessels will be maintained according to manufacturer's instructions in order to ensure optimal functional and minimal risk of discharges into the environment. Records of equipment maintenance will be managed by Polarcus. Polarcus uses a PMS (Planned Maintenance System) to ensure that the ship and equipment is maintained accordance with the relevant rules and regulations and requirements identified by Polarcus. Maintenance is carried out at specified intervals in order to maintain a satisfactory operational status. Components critical to safety and production are identified in the PMS.

7.5 Other Environmental Conditions

The BMP's Application Guidelines (BMP 2011; Section 7.8) also note requirements related to other environmental conditions and considerations:

- When acquiring seismic data, the operation shall be conducted in accordance with the Best Practices listed in NERI Report No. 785, Chapter 5, concerning acquisition of seismic data.
- All non-degradable materials and structures shall be removed upon termination of the operation, unless BMP approves otherwise.
- Discharge of wastewater and kitchen waste shall be in compliance with the provisions of Annex IV and Annex V of the MARPOL Convention (see Section 7.4.1, above).
- Hunting and fishing is not permitted in connection with exploration activities, unless specific permission is given by the Greenland Government. [Note that hunting and fishing from Project vessels will not be permitted by Shell.]
- BMP may, when approving specific exploration activities, require the licensee to perform further impact studies and/or limit the operation to certain periods or from certain areas.
- Vessels engaged and machinery used in the exploration activities should only use diesel and gasoil with a sulphur content less than 1.5 % (weight). Heavy fuel oil and oil with a sulphur content >1.5 % should not be used (see Section 7.4.2, above).

Shell will comply with each of these requirements (as described above) and will brief Project personnel about these and all other environmental commitments and requirements during in-person start up meetings before data acquisition (during early July 2012).

7.6 Unplanned Events

7.6.1 Health, Safety, Security and Environmental Management Systems

Shell and Polarcus will submit to BMP a description of the safety management system and bridging documents for the health, safety, security, and environmental management systems in a separate document to this EIA, no later than 40 days prior to the anticipated survey start. These documents will include roles and responsibilities of all parties in the event of an emergency or accident during the 2012 program, including an Emergency Response Plan, Spill Response Plan that will include bunkering procedures to be used, and an Ice Management Plan. The following measures will also reduce the likelihood of an unplanned event.

- Polarcus and the support vessel contractors will be made aware of relevant national legislation and guidelines, as outlined in Sections 3.1 and 7.3, as well as follow International Maritime Organization best practices and guidelines such as *Guidelines for Ship Operating in Polar Waters*.
- Oil spill drills are a regulatory requirement and are carried out at regular intervals during which the oil spill response kit is checked. These oil spill drills encompass bunkering in port and at sea and machinery leaks, and form a part of the emergency onboard drills matrix.
- None of the seismic vessel fuel tanks are in contact with the outer skin of the vessel.
- Solid streamers will be used on the seismic vessels to reduce the risk of accidental spills.

Shell and BMP shall be notified immediately of any significant accidental event, including loss of life, missing persons, serious injury, fire onboard, oil spill, and any threat to the personnel or the safety of the survey vessel. Any spills or unplanned releases will also be recorded and reported to appropriate authorities.

7.7 Communications

Good communication with local stakeholders and regulatory authorities is key to the success of the proposed seismic program. Shell has already held initial meetings with local stakeholders in northwest Greenland and Nuuk to provide information about the Project and to ascertain concerns stakeholders may have. Further engagement with local communities will take place before, during, and after the seismic operations to ensure that community concerns are heard and acted upon wherever possible. Other aspects of Shell's communication approach are provided below.

- Shell will publish and disseminate a non-technical summary of this document in Greenlandic, Danish, and English, to encourage feedback from stakeholders.
- Project team members will visit those communities that may be directly or indirectly impacted by the activities to invite feedback on the project and the contents of the EIA.
- Notification of the seismic survey details will be provided to BMP, Royal Greenland A/S, appropriate shipping and harbour authorities, and local hunter associations before the start of the survey.
- Shell staff will be present in Greenland to maintain close relationships with stakeholders and to respond to potential issues.
- A grievance mechanism will be established, offering various ways (e.g., telephone, email, personal contact) to enable local stakeholders to contact Shell directly to ensure timely resolution of concerns and complaints.
- Shell will continue to communicate with other operators during the planning and operation phases of its seismic program to avoid interactions and minimize impacts.
- Shell will contact the DCE prior to survey start to ensure that its monitoring and mitigation plan for marine mammals and seabirds meets DCE protocols.
- Shell will be available to meet with local stakeholders after the proposed seismic program to present the findings of the marine mammal and seabird monitoring program.

- To make sure that all Project personnel are aware of the environmental issues and mitigation measures that will be applied for the 2012 survey, Shell environmental and Project management personnel will hold a meeting with the seismic survey and support vessel crews and managers before the start of the seismic program to ensure full compliance.

7.8 Reporting

Marine mammal and seabird observation databases, along with a monitoring report, will be submitted to BMP and DCE within two months of completion of the seismic program.

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