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NAALAKKERSUISUT
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Høringsvar "Offentlig høring af miljøvurdering (EMA), vedrørende indsamling af 2D seismiske data inkl. havbundsprøver fra ca. 120 lokaliteter fra de af forundersøgelsestilladelserne nr. 2009/14 og 2012/41 omfattede områder, Nordøstgrønland"

11. maj 2012
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Dok. Nr. 905532

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Forslaget omhandler udførelsen af 2D seismisk dataindsamling og indsamling af sedimentprøver i Nordøstgrønland udført af TGS-NOPEC Geographical Company ASA. Det foreslåede tidspunkt for undersøgelsen er fra 15. august 2012 til 15. oktober 2012.

Projektet benytter sig en kombination af single og 2 luftkanons opstilling (i alt 16 og 24 luftkanoner i de to opstillinger) som energi kilde med et maksimum kildestyrke af 264 dB re 1 µPa (pp). Der vil være 4 skibe i alt og disse skibe samt sediment prøvetagning vil genere yderligere støj.

Det foreslåede projekt vil blive udført meget tæt på vigtige og kendte hvalros, narhval og grønlandshval beskyttelse områder (protection zones Kyhn et al. 2011). Da der vil være høj sandsynlighed for at møde disse arter under projektet, er det meget vigtigt at maksimere sandsynligheden at finde dyrene.

APNN finder følgende punkter kritisabelt:

- Projektet udføres for tæt på de fastlagte beskyttelsesområder for narhval, grønlandshval og hvalros.

- Den mindste kanon i opstillingen (kaldt mitigation gun) kan i følge bedst procedure i Kyhn et al. 2011 bruges som et afbødning/mitigation værktøj når havpattedyre bliver observeret i 200 m zone fra skibet. Hvad er kildestyrken af de pulser produceret med denne afbødning/mitigation kanon som ifølge tabel 3 har en volumen af 125 in^3? Denne information findes ikke i dokumenterne. En måde at estimere kildestyrke af en kanon med en kendt volumen er at sammenligne det med en kanon med en kendt kildestyrke og kendt volumen. Hvis man antager at den højeste kildestyrke af 241 dB re 1 µPa (rms) (Tabel 9) er produceret af den kanon med den største volumen af 290 in^3 (Table 3) den mindste kanon på 125 in^3 kunne producere lyd med en styrke af ~ 237 dB re 1 µPa (rms)[1]. Ifølge Kyhn

[1] Tryk formindskelse i forhold til en 290 in^3 kanon kan afledes ved at beregne kvadratroden af (290/125), som er 0,6565. Dette betyder, at dB niveau for et lydtryk på en 125 in^3 kanon vil falde med ~ 4 dB (20log [0,6565]) i forhold til 290 in^3 kanonen (Marine Mammal Monitoring and Mitigation Plan for Marine Seismic Surveys, Statoil 2010)

et al. 2011, hvaler og sæler lider permanente hørskader (PTS, permanent threshold shift) hvis kildestyrken af den lyd dyrene bliver udsat for, overgår henholdsvis 230 og 218 dB re 1 µPa (pp) for hvaler og sæler (single puls). Den potentielle kildestyrke af ~ 237 dB re 1 µPa (rms) er alt for høj som afbødning/mitigation værktøj og dermed mister brugen af en mitigation kanon og den 200 m risiko zone sin mening.

Indstillinger

- Et maksimum grænse for lydtryksniveau og kildestyrke for afbødning/mitigation kanon skal sættes. Dette niveau skal være væsentlig lavere end de niveauer, dokumenteret til at være skadeligt for dyr. Dette er især vigtigt i området hvor den kritisk truede Spitsbergen grønlandshval *Balaena mysticetus* kan opholde sig og hvor tabet også af et enkelt individ vil have store konsekvenser til hele populationen.
- PAM (Passiv Akustisk Monitering) skal bruges konstant sammen med visuelle observatør for at maksimere sandsynligheden at lokalisere havpattedyr i området og dermed sikre en fungerende mitigation praksis. Havis, isskosser og isfjelde kan forhindre visuel observation af havpattedyr, også om dagen i godt vejr.

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David Boertmann
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Dato: 15. maj 2012

TGS-NOPEC's EMA on a seismic survey in the Greenland Sea (NEG12) summer 2012

Based on TGS-NOPEC's scope of the project in the Greenland Sea in summer 2012, DCE and GINR assessed the seismic activities and found that no significant impacts on the environment would be expected. TGS-NOPEC should then forward an Environmental Mitigation Assessment (EMA) of the project to BMP.

DCE and GINR raised some questions to the description of the scope of the project: 1/ It should be documented how the safety distance to the well-defined ice edge between Hovgaard Ø and Île de France would be kept and 2/ a description of how the icebreaker would be used is needed.

The EMA description comprises a 2D-regional seismic survey in the region between c. 76° and c. 79° N and between c. 7° and c. 17° W. It is planned to collect data from up to 5000 line km and the survey lines are placed in a network with approx. 20 km between the lines.

The survey also includes seabed sampling with gravity corer and dredge. Samples are to be collected from up to 120 sites.

The survey is planned to take place in the period Aug. 15th to Oct. 15th.

Besides the acquisition vessel, two more ships are included in the Greenland Sea project: an icebreaker and a support vessel.

Summary

The EMA is in many ways superficial.

The type and use of the required PAM system has not been described, which is required.

The requested modelling of the noise from the seismic survey does not fulfil the requirements.

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The use of heavy fuel oil in one of the ships does not follow the regulation of oil exploration in Greenland.

It should be underlined that the marine gas oil used shall be with low sulphur content (< 1.5 %).

DCE and GINR recommend that a solid streamer is used.

A fishery liaison officer will be superfluous on this survey, as there is no fishery taken place in this part of the Greenland Sea.

DCE and GINR assess that the planned seabed sampling is without significant environmental impacts.

The EMA

The EMA is superficial with regards to effects of airgun noise other than PTS or TTS on marine mammals and the levels obtained by the modelling have not been considered in terms of behavioural changes. There are hardly any references to studies on behavioural changes and effects, despite that it is mentioned, on p. 35, that the most likely effects are to be expected on behaviour. There are no suggestions to mitigation of behavioural or disruptive effects either. This is not satisfactory.

There is no description on how the modelling results will be validated during the seismic survey. This must be clarified.

The EMA contains a section on the biological environment. This is short and largely based on the Strategic Environmental Impact Assessment issued by DCE and GINR in 2009. Nevertheless, some misunderstandings are communicated, as for example, that white whales (belugas) should occur in the area at Ymer Island. This particular information is not correct.

There is also a section on the physical environment. Both this and the section on the biological environment are, strictly speaking, superfluous in an EMA-context. However, if a section on biological information is included, it should focus on relevant species, occurring in the area of potential impact.

Two arrays of airguns will be used, a large, 5025 $inch^3$, and a smaller, 3350 $inch^3$. The intention is to use the small in relatively shallow waters and the large when deep targets are studied. DCE and GINR acknowledge that TGS-NOPEC will apply a smaller array when the large is unnecessary. However, the difference in source level is only 3 dB. TGS-NOPEC is requested to report when and where the two arrays have been in use.

It is mentioned that two MMSOs will be placed on the acquisition vessel and that at least one will be continuously surveying in the pre-shooting search. It is however essential that observations are carried out also during the shooting, as Greenland has a rule of shutdown if seals enter the 200 m injury zone around the airgun array. During reduced visibility PAM-monitoring has to take place.

The type and use of the required PAM system has not been described, which must be clarified, including type of system, place of deployment and how the data will be used. Also, it must be specified under which conditions the system will be used.

One of the ships uses heavy fuel oil (HVO). This type of oil is not allowed for use by oil exploration activities in Greenland waters, primarily because of emissions of SO_x and black carbon, but also because this oil will remain much longer on the sea surface compared to marine gas oil (MGO) in case of a spill.

It is mentioned that the MGO used will be of 'good quality'. However, an assurance that the sulphur content is low is needed (i.e. below 1.5 % by weight).

The streamer planned to be used will be hollow and filled with kerosene-like oil. In case of damage to the streamer (e, g. by ice), there will be a risk for spills to the environment. Although small, due to the segmented streamer, DCE will suggest that a solid streamer is used, especially because of the seaice and because it is Best Environmental Practice (BEP).

A fishery liaison officer will be superfluous on this survey, as no fishery takes place in this part of the Greenland Sea.

DCE assesses that the planned seabed sampling will be without significant environmental impacts.

Finally, the following comments are made to the two questions raised in the DCE-evaluation of the project scope: As the planned lines all are outside the designated protection area for narwhals and bowhead whales, the problem on how to identify the ice edge is irrelevant. Regarding the plans on how to use the icebreaker, a description was provided and as the survey will not take place within the fast-ice, this is also less relevant.

The appendix
The EMA contains an appendix presenting results of the required modelling of the airgun noise from the seismic survey. However, the modelling *does not provide the required parameters* as stated in the 'Guidelines to environmental mitigation assessment of seismic activities in Greenland waters' (Kyhn et al.

2011). It is clearly stated in the guidelines that 'Noise levels to be presented in the model are peak-to-peak sound pressure levels referenced to 1µPa (peak-peak), rms sound pressure levels referenced to 1 µPa (rms measured over 90% of pulse duration, as defined by Malme *et al.* 1986; Blackwell *et al.* 2004; Madsen 2005) and in sound exposure levels referenced to 1 µPa2·s. per pulse. For assessment of cumulative effects also the cumulated sound exposure level (across all airgun pulses and all concurrent surveys in the area) per 24 hours should be presented'.

Furthermore, the model results shall be given as 'Map showing modelled sound pressure levels (rms*), peak-peak and sound exposure level (µPa2s) for the survey area and surroundings (to levels likely to affect marine mammals or nearest land)' (table 6.4.3, page 31).

That means four different measures of received level with range from the air-gun array shall be presented as maps:
SPL (peak-peak),
SPL (rms over 90% pulse duration),
SEL 1 µPa2·s. per pulse,
cSEL 1 µPa2·s. 24 hours.

This has not been provided. Instead figures of tracks of peak-peak values are shown. These figures are of low resolution and are not adequate for a close up around the array to evaluate the highest values. Especially the cSEL values must be modelled and included in the EMA.

The appendix on the noise modelling includes very basic predictions, for example that transmission loss is expected to be higher for higher frequencies. This *is too basic* to be included in such an appendix on noise modelling and brings the results of the modelling to question.

Neither in the appendix nor in the EMA is the low sound velocity surface duct typical of Arctic waters mentioned, despite it is especially called for in the BMP guidelines (Kyhn et al. 2011). If this has not been taken into account in the modelling, *the results cannot be considered conservative*, as argued in appendix 1. This must be clarified.

Specific questions/remarks
EMA
Page 47
"Bowhead and minke whales can be hunted between the 1st of April and 31st of December (Piniarneq 2011)."

This applies to West Greenland. Bowhead whales are not hunted in East Greenland. However, about 12 minke whales are hunted from the East Greenlandic villages each year.

Page 50, table 9
Need to provide duration for the pulse.

Page 54, table 10
Is it source level here?

Page 55
The threshold levels given in the BMP guidelines should be used (Kyhn et al. 2011 based on Southall et al. 2007):
236 peak-peak re 1µPa for cetaceans,
224d Bpeak-peak re 1µPa for pinnipeds.

and not Parvin et al. 2007, which is not stated among the references.

Page 56, table 11
Fine to include Parvin, however the table should be updated to include the above mentioned thresholds (Southall et al. 2007) for PTS and TTS for cetaceans and pinnipeds.

Page 57
It should be modelled how much airgun energy an animal will be exposed to within 24 hours at different ranges to the airgun array. It is fine to make a "top of the head" calculation as presented, but it is a best guess and does not take in to account the increase in background noise in between airgun pulses (Koski et al. 2011) of about 20 dB for a single seismic survey. Besides the calculation presented is not valid for 24 hours.

With a firing rate of 6 shots per minute, the total increase in energy over 24 hours approximates a minimum of 10*log(6*60*24)=39 dB that should be added to the received level at a given range assuming that the animal remains stationary at that spot. The EMA should be updated with a table showing cumulative exposure (cSEL) over 24 hours for different ranges (50 m to 100 km). Preferably, and according to the guidelines, these levels shall be presented as maps, which is clearly specified in the guidelines page 31.

Page 57
"It is usually assumed that an animal present this close to an array at full power has entered the area voluntarily." It is not clear what this

means in terms of exposure to danger for the animal. Therefore the sentence has no meaning in this context.

Page 58
"Narwhals are termed mid-frequency cetaceans by Southall *et al.* (2007) and are understood to have a lower frequency perception limit of around 150 Hz. At the upper end of their hearing range narwhal and other mid and high-frequency cetaceans are understood to be able to perceive sound up to around 160 or 180 kHz."
Please provide the reference for this statement. To the knowledge of DCE and GINR no audiograms have been obtained from narwhals.

Page 58
"Noise modelling stopped at 1 kHz since a test case demonstrated rapid attenuation of higher frequencies (Figure 31)." The modelling should not have stopped at 1 kHz. First of all it is clearly stated in the guidelines that all biologically relevant frequencies should be modelled. Secondly, there are studies showing that higher frequencies from airgun noise can be heard on much greater distances (see DeRuiter el. 2006).

Page 60
"Essentially, through a combination of making use of the lowest power and smallest array possible at any particular time" Will the source level at any time be different to what is stated in the EMA?

Page 61
"For walrus the protection zone is year round but the most sensitive areas are well inshore of the survey (on shallow banks <100m deep) and it is not believed likely that disturbance effects will be significant." Provide reference for this statement and elaborate.

Page 61
"Observations do not need to be continuous throughout the seismic line but provision must be in place to identify marine mammals entering the 200 m injury zone and instruct a reduction in seismic output." How will it be ensured that no seals enter the 200 m zone if there are no one observing? There shall be observers on duty during daylight hours and PAM operators during night or other times of reduced visibility.

Page 61
"A log of all observations (and other required fields) should be kept and submitted as part of the cruise report." The observation methodol-

ogy shall apply the DCE guidelines for observations. This also includes data entry and reports.

Page 62
"..if they enter the injury zone the output of the array should be reduced to a low volume, preferably just a single mitigation gun."
The mitigation gun shall be the airgun of lowest volume and source level within the array, and only a single airgun can be firing for this purpose.
The term *should be* is not appropriate. It *must* be done if a pinniped (i.e. also walrus) enters the injury zone

Page 62
"Guidelines that have also been suggested by BMP for previous surveys stipulate that seismic arrays should not be fired within 2km of bowhead whales. This approach is to be adopted for the NEG12 survey."
DCE acknowledges this approach.

Page 62 Regarding soft start
The soft start should take about 20 minutes. Not longer, not shorter.

Page 63
If soft start for any reason cannot be conducted, it must be ensured that no marine mammals are within at least 500 m before onset, and a full report shall be submitted to BMP.

Page 63
"If airgun testing is required on the entire array at full power a full pre-firing watch and soft start is recommended." If a test is required of the entire array a soft start and pre-firing search is required. See Kyhn et al. 2011.

Page 63
"During line changes of less than 20 minutes arrays can be continually operated at lower output, preferably a single mitigation gun." During line changes the reduced output shall be to the mitigation gun or entirely shot down to minimise cumulative noise pollution in the area.

Page 64
"Good practice to minimise airgun volume and power output that is planned to reduce impacts to marine mammals will also serve to minimise disturbance effects on fish." Please specify what good practice is planned to be used in such cases.

Page 69
"For this reason it is proposed that Marine Mammal and Seabird Observers (MMSOs) should be present on the ice breaker to conduct visual surveillance and, potentially, to advise on a course of action appropriate to reduce risk of harm or excessive disturbance should animals be encountered"
DCE acknowledges this approach; however advices that potential courses of action are decided upon before the survey commences to avoid any delay of actions.

Appendix 1
Page 9
The frequency spectrums should contain energy up to much higher frequencies, e.g. up to 10 kHz.

Page 10
How is duration defined?
Why is both 0.25 s and 0.4 s used?
Duration must be defined as 90% energy as in Malme *et al.* 1986; Blackwell *et al.* 2004. If this is not the case, provide new calculations for SPL.

New references, not included in the DCE-guidelines

Mellinger, D.K., Nieukirk, S.L., Klinck, K., Klinck, H., Dziak, R.P., Clapham, P.J. & Brandsdóttir, B. 2011. Confirmation of right whales near a nineteenth-century whaling ground east of southern Greenland. *Biol. Lett.* 7: 411–41, doi:10.1098/rsbl.2010.1191

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. 2008. *Eubalaena glacialis*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.

KANUKOKA
Kalaallit Nunaanni Kommunit Kattuffiat • De Grønlandske Kommuners Landsforening

Grønlands Selvstyre
Råstofdirektoratet
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Ulloq/Dato: 14-05-2012
J. nr.: 74.00

Att. Frederik Lynge

Høringssvar til ansøgning vedr. Licens 2009/14, Nordgrønland og 2012/41, Østgrønland om godkendelse af indsamling af 2D seismik og havbundsprøver, v. TGS-NOPEC.

Kommunernes fælles råstofgruppe har gennemgået høringsmaterialet vedr. TGS-NOPEC's aktiviteter i Nord- og Østgrønland.

Ifølge ansøgningen forefindes der kun 2 Marine Mammal Observers (MMO) om bord. Dette kan gøre det vanskeligt at opretholde et beredskab døgnet rundt. I andre lignende projekter er der ofte 4 observatører om bord.

Yderligere bemærker kommunerne at der ikke er nævnt noget samarbejde med Grønlands Naturinstitut (GN) om brug af relevante observationer. Dette kunne vise sig at være brugbart for GN.

I materialet fremgår det at der ikke findes vigtige gydeområder for fisk i det ansøgte område. Dette er efter kommunerne oplysninger ikke korrekt, idet den Østgrønlandske bestand af torsk gyder i området. Se venligst figur 1.
Området er potentielt følsomt overfor seismik, og det bør overvejes hvilke afbødende foranstaltninger der kan foretages.

Yderligere er det danske "ikke tekniske resumé" oversat på et niveau der i nogle sætninger virker uforståeligt og misvisende. Det findes anbefalelsesværdigt at undersøge, om dette også gælder det grønlandske resumé.
Som eksempel kan nævnes overskriften " Menneskelig aktivitet of Områdeøkologien".

Med venlig hilsen
På vegne af kommunernes fælles råstofgruppe

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NNPANs høringssvar vedr. ansøgning om indsamling af 2D seismiske data og havbundsprøver under 2009/14 og 2012/41

11. maj 2012
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Departement for Indenrigsanliggender, Natur og Miljø (NNPAN) modtog den 28. marts 2012 høring vedr. ansøgning om indsamling af 2D seismiske data og havbundsprøver under 2009/14 og 2012/41.

Det ansøgte område er beliggende i Nordøstgrønland. Forventet periode for undersøgelserne er i perioden august-oktober 2011.

Beskyttede områder
Dele af det område hvor der ansøges om at udføre seismiske undersøgelser er nær et beskyttet område for narhval og grønlandshval samt et beskyttet område for hvalros. NNPAN noterer, at dele af den angivne aktivitetsperiode ligger inden for den sårbare periode for narhval, grønlandshval og hvalros (1. juli til 30. september – 1. juni til 30. september). NNPAN henstiller til, at man følger anbefalingerne for at undgå unødig forstyrrelse af de arter, der befinder sig i området.

Kumulative effekter
NNPAN bemærker, at det kunne være relevant at foretage en undersøgelse af de kumulative effekter. NNPAN anbefaler yderligere at der redegøres for effekten ved eventuelle aktiviteter i området i de kommende år. Det vil sige, at der ud over dette års planlagte aktiviteter vurderes hvilke konsekvenser, der kan være, hvis der i de kommende år bliver udført yderligere råstofaktiviteter (herunder seismiske aktiviteter) i og nær de sårbare områder.

Seismiske aktiviteters effekt på adfærd
I EIAen er der kun i begrænset omfang redegjort for de seismiske aktiviteters effekt på narhvalernes adfærd. Hovedfokus er på hvilke fysiske effekter de seismiske aktiviteter kan have på arterne, herunder specielt på nært afstand. Det oplyses i EIAen, at der er manglende viden om de adfærdsmæssige effekter. NNPAN anbefaler, at der udføres flere undersøgelser på hvilke konsekvenser, der kan være på arternes adfærd ved udførelse af seismiske aktiviteter.

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Regarding marine mammals and proposed seismic surveys in Baffin Bay 2012

DCE - Danish Center for Energy and Environment and Greenland Institute of Natural Resources have received and read the environmental impact assessments (EIAs) submitted with the applications to conduct seismic surveys in Baffin Bay 2012. Based on the EIAs, the available literature regarding effects of seismic surveys on marine life and a draft copy of the report "*Passive acoustic monitoring. measurement of marine sound exposure levels to seismic activity. Baffin Bay 16 August - 24 September 2010*" submitted by Cornell University to Cairn Energy LLC, we have the following general comments to the survey program, in addition to comments specific to the individual EIAs, which has been forwarded separately.

The program, with proposed simultaneous 2D and 3D surveys in four license blocks (Qamut, Anu, Napu and Tooq) is by far the largest proposed program in Greenland. The magnitude of the program coupled with the close proximity to the Melville Bay Nature Reserve and the BMP narwhal protection zones (Kyhn *et al.* 2011) give reason for concern. Several effects of the seismic noise are possible, of which behavioural disturbance of narwhals in Melville Bay is considered the most significant (see further below). For this reason narwhals are the primary focus in our response although some comments on other marine mammals are added when relevant.

A number of factors add to the concern for marine mammals in the area, compared to other areas (in and outside Greenland):

1) The hydrography and associated vertical sound speed profile in the area is typical of Arctic waters, i.e. with a pronounced sound speed minimum close to the surface (30-50 m). This sound speed minimum will act as a waveguide and trap seismic sounds in the upper layers of the water column (see for example figure 29 in appendix D to ConocoPhillips' EIA) and lead to increased sound exposure in the part of

the water column where many marine mammals spend significant amounts of time.

2) The narwhals in Melville Bay are recognized as an isolated stock with little or no exchange with the neighboring stock in Inglefield Bredning. The Melville Bay is the summering ground for this stock and the whales will be in the bay at the same time when surveys are planned (Heide-Jørgensen *et al.* 2010).
3) Although Melville Bay is a very open bay, the seismic operations are distributed across the opening, giving rise to concern that migrating animals (mainly narwhals and belugas) could be prevented from entering the bay or be trapped inside the bay, with few or no alternatives to reallocating to less disturbed areas.
4) In the early fall (from 25 September to 25 October) the West Greenland stock of belugas will pass through coastal areas of Melville Bay. This stock summer in the Canadian High Arctic and winter in West Greenland and it currently numbers around 10,000 whales.

Likely effects of the surveys on marine mammals

There is no knowledge on the effects of seismic surveys on narwhals, very limited knowledge on the effects of seismic surveys on belugas and no studies of effects of seismic surveys in Baffin Bay in general. Previous seismic surveys in the area include prospecting surveys with very long and widely spaced transect lines; a3D seismic survey conducted in the Pitu license block in 2011 and a smaller survey also conducted in 2011 as preparation for the shallow coring program proposed for 2012. Sound entering the Melville Bay from the two 2011 surveys was monitored (Anon. 2012), but the effects on narwhals are unknown.

The lack of knowledge concerning effects of seismic noise on narwhals in particular and marine life in general in combination with the magnitude of the proposed programs calls for caution in evaluating the applications.

Sound levels in Baffin and Melville Bays

The modeling of the four proposed seismic surveys (as described in their EIAs) shows that the air gun sounds will be audible at very long ranges, probably across the entire Baffin Bay Basin and certainly within the whole of Melville Bay. Levels within Melville Bay, including the nature reserve and the narwhal protection zones, are predicted to be sufficiently high to cause behavioural reactions from narwhals and beluga whales, as well as other marine mammals that may occur in the area. Sound levels sufficiently high to be capable of inflicting immediate, acute effects (such as temporary or permanent hearing loss) are only expected in the close vicinity of the air gun arrays (with-

in a few hundred meters or less). Impact on the population from acute effects is not considered likely for the whales.
The predicted noise levels from the models are comparable to the actual noise levels measured during the 2011 seismic survey in the Pitu block (Anon. 2012), taking into account that the program in 2011 was of a magnitude comparable to each of the suggested programs for Qamut and Tooq. Total noise levels are thus predicted to be considerably higher in 2012, compared to 2011. This noise will affect the whole of Melville Bay and therefore result in a temporary habitat degradation, likely to affect marine organisms who depend on sound for vital life functions such as orientation, communication and feeding.

Reduction of impact

Given the very limited experience with effects of seismic sources on narwhals and belugas it is not possible to recommend a safe level for exposure of Baffin and Melville Bays to seismic noise. However, there is probably a connection between sound exposure and magnitude of impact, implying that any reduction in total sound exposure will result in a reduced risk of adverse effects, although not necessarily in direct proportion. DCE and GINR are of the opinion that a precautionary approach should be taken to the proposed program and given the uncertainty about potential effects propose a reduction of the impact along the lines suggested below. There is, however, not sufficient scientific knowledge to provide advice on acceptable levels of exposure and the level of reduction should be a management decision.

Reduction of impact in 2012 can be obtained by:

- Postponing substantial parts of the effort to 2013 or beyond. Postponing some of the survey efforts until 2013 might reduce the impact in 2012. However, the efficiency of splitting the effort over two years relies on an unproven assumption that the combined effect of the effort spread over two seasons is less than the effect of all efforts taking place during one season.
- Substantially reducing the time period in which surveys can be conducted. With respect to beluga whales in particular, an end of season earlier that 1 October will benefit the southward migration of belugas.
- Decrease output of air guns and/or changes to survey size/layout/design to substantially reduce total radiated energy.
- Avoiding two consecutive years with seismic surveys in the Baffin Bay area. This would in practice mean restraining from seismic activity in Baffin Bay in 2013, but it is however unknown if the effects of disturbance in one year will be restored in subsequent years. This measure by itself will not prevent high levels of sound from reaching the Melville Bay Nature Re-

serve and narwhal protection areas, and therefore will be more effective if applied together with one or more of the measures suggested above.

The monitoring program proposed for the 2012 season, consisting of aerial surveys, independent observers accompanying narwhal hunters and monitoring of noise in the Melville Bay will provide additional information to be taken into consideration when evaluating such mitigating and/or compensatory actions.

Monitoring of potential population effects

Seismic activities may cause demographic effects, such as abandonment of the stock area, decrease in reproduction or survival and these potential demographic effects will eventually manifest themselves as population trends in surveys. It is therefore important to monitor the population of narwhals in Melville Bay at regular intervals for as long as there are seismic surveys in the area.

Currently, narwhals in Melville Bay are managed with a catch quota for subsistence harvest designed to allow for a high probability (70%) for population growth over the 5-yr quota period. This is based on assessments reviewed by an international expert panel (JCNB/NAMMCO).The management system allow for adjustments of quotas as a response to measured population trends. Detrimental effects of seismic surveys are expected to be detected in future narwhal surveys and will eventually be compensated by changed catch quotas. It is therefore recommended that the population trends of narwhals in the Melville Bay stock area should be monitored annually in the coming years.

Appendices

Three appendices are found below. Appendix A describes possible effects of the surveys on marine mammals in Baffin and Melville Bays, with emphasis on narwhals. Appendix B outlines a possible long-term strategy for reduction of acoustic impact on ecosystems in Greenland and appendix C provides information on each of the three proposed surveys for comparison.

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Appendix A. Summary of the potential effects of high sound levels on marine mammals

Acute effects (injury)

Acute effects include exposure to dangerously high sound pressures, which may cause tissue damage and possibly even death in extreme cases (Gray and Waerebeek 2011) and at lower levels cause temporary or permanent hearing impairment (TTS and PTS; Southall *et al.* 2007). Sound levels are only sufficiently intense to inflict these types of damage at close range to the airgun array, within few hundred meters to 1 kilometer. Acute effects are considered to be mitigated in appropriate ways by following the procedures for soft start, marine mammal and seabird observers, passive acoustic monitoring etc, as described in the EIAs. While these procedures do not eliminate the risk of accidental injury to individual animals, they greatly reduce this risk. Effects of a magnitude affecting population size or vital rates are very unlikely.

Hearing loss due to prolonged exposure to noise

It is well known from humans that prolonged exposure to high levels of sound leads to TTS and subsequently PTS. No information is available on narwhal hearing and susceptibility to noise, but the closely related beluga whale is well studied. Studies with noise exposure in captivity have indicated a threshold for eliciting TTS to single pulses in beluga of 186 dB re. 1 uPa^2*s (Finneran *et al.* 2002). Little is known about the cumulative effect of repeated exposure to pulses, although experience from humans indicate that acoustic energy accumulated over several hours should be added when assessing potential impact on hearing (reflected in work place and community noise criteria, which require total accumulated sound exposure over the entire working day to be considered).
From maps of the cumulative sound exposure over 24 hours, weighted for mid-frequency cetaceans (e.g. figure 26 in ConocoPhillips EIA, appendix D) the level sufficient to elicit TTS in narwhals is very local around the survey track lines. A narwhal thus must remain stationary very close to a passing survey ship, in order to be exposed to sound capable of inducing TTS and this is presumably mitigated by the procedures mentioned above under acute effects.
Seals both have a lower threshold for eliciting TTS: 171 dB re. 1 uPa^2*s (Finneran *et al.* 2002), and a better low frequency hearing than narwhals. Looking at the map of predicted sound exposure weighted according to pinniped hearing (e.g. figure 28 in ConocoPhillips' EIA, appendix D) it is evident that the zone where seals could be exposed to levels above 171 dB re. 1 uPa^2*s over 24 hours is extending out to distances more than 100 km from the survey ships. However, the estimated exposure is an absolute worst case

scenario: all four ships operating continuously for 24 hours and maximum values in the vertical water column are used. Ships cannot operate 24 hours at a time (they will shut down during line turns) and seals will not be in the part of the water column with highest sound levels (deeper than 50 m) continuously. Although they might spend considerable time at these depths, they will spend time at the surface and hauled out on ice. Nevertheless, it cannot be ruled out that a significant number of seals will experience TTS, if they remain in the affected offshore waters inside and surrounding the license blocks. However, this being said, it appears unlikely that this TTS possibly inflicted on seals could have significant effects on the population vital parameters.

Physiological effects of prolonged exposure

It is well known from humans that prolonged exposure to noise at levels below thresholds for acute effects can produce hearing loss and also induce other physiological effects, such as elevated stress hormone concentrations in the blood (Evans and Johnson 2000),increased blood pressure, heart problems and reduced learning capabilities among others (Passchier-Vermeer and Passchier 2000).Two studies on belugas have showed that blood stress hormone levels increased in response to noise exposure (water guns), and that levels increased with increasing noise levels. (Thomas et al. 1990, Romano *et al.* 2004). A recent study on northern right whales showed that they have elevated levels of stress hormones likely as a consequence of intense ship noise in the waters off New England (Rolland *et al.* 2012).These effects may be relevant for narwhals in Melville Bay. The long term consequences of such elevated stress hormone levels are unknown for marine mammals and the risk cannot be assessed.

Masking effects

Increasing the background noise will make it more difficult for animals to detect other sounds in the same frequency band (masking). Due to scattering, multi-path propagation and other factors the background noise between seismic impulses is increased by up to 20 dB (Koski *et al.* 2011) for a single survey. This masking will occur in a wide frequency band close to the seismic array but as higher frequencies are attenuated substantially with distance masking will only be relevant for low frequency signals at longer distances, such as inside Melville Bay. As the echolocation signals of narwhals and other odontocetes contains most energy at ultrasonic frequencies (above 20 kHz), their echolocation signals are unlikely to be masked by seismic noise, but low frequency communication signals (whistles) as well as passive listening for acoustic cues for orientation may be affected.

Since communication calls of baleen whales and pinnipeds overlap in frequency with seismic noise, they are prone to masking from the noise. The impact of such a masking cannot be assessed as very little is known about the general importance of underwater calls in these species and the distances over which they depend on being able to communicate. What can be estimated however, is the so-called range reduction factor (Møhl 1981). Elevating the general noise level by 20 dB (an underestimate, as up to four ships will operate simultaneously) corresponds to a range reduction factor of 10. This means that whatever maximum distance two animals can communicate across without the seismic noise, this maximum distance will be reduced to 1/10 when the noise is present.

Disturbance of behaviour

The most significant effect of the elevated noise levels in Melville Bay, in particular for the narwhals, will be behavioural reactions to the noise and in particular the long-term consequences of these reactions. There are hardly any studies of narwhal reactions to underwater noise, but one study (Finley *et al.* 1990) demonstrated reactions to underwater noise of icebreakers at very low received levels of noise (120 dB re. 1 μPa rms for persistent reactions and down to 94 dB re. 1 μPa rms for initial startle reactions). Although the noise was very different from seismic impulses and the context different, the low threshold of reaction is indicative of sensitivity towards noise disturbance. A second study (Miller *et al.* 2005), on beluga whales, showed pronounced avoidance reactions from a seismic survey in shallow waters at distances of 10-20 km, consistent with sound levels of 140 dB re. 1 μPa rms or lower. Both studies indicate that narwhals inside Melville Bay are likely to react to the seismic noise. However, with the current knowledge it is not possible to predict how the animals will react.

Appendix B. *Long term strategy for reduced acoustic impact*

Marine mammals are notoriously difficult to study and in particular in large and remote areas such as Baffin and Melville Bays. It is not likely that we in the foreseeable future will be able to determine the actual impact on population size or population vital parameters for species such as the narwhal. However, the proposed monitoring program for 2012 includes aerial surveys before and during seismic surveys, independent observers participating in the narwhal hunt and measurements of the actual sound exposure to Melville Bay. Together these studies will form the basis of a long term double-legged strategy. One part of the strategy should include continued monitoring of marine mammals in the Baffin Bay/Melville Bay area coupled with direct studies of impact of seismic noise, through controlled exposure experiments and studies conducted in connection to actual seismic surveys. The second part of the strategy is aimed at reducing the overall risk of impact, along the precautionary lines suggested above, i.e. under the assumption that noise can never do anything good to the animals, and thus that less noise can only be better. It is suggested that an overall strategy is adopted wherein all companies working in the same geographical area (such as the Baffin Bay license blocks) are required to work towards a continuous reduction of the overall acoustic impact of their operations. Work must be undertaken to establish relevant and operational indicators of acoustic exposure.

Appendix C: Comparison of proposed surveys

It is difficult to compare the three proposed programs directly. However, some key figures are shown in table 1. Included is a very rough estimate of the noise energy radiated into Melville Bay by each of the surveys summed up over the entire program. To estimate this quantity, the energy flux density was integrated for each survey over the entire duration of the program. The energy flux density was estimated at the border of narwhal protection zone I, i.e. reflecting the amount of energy radiated into Melville Bay.

Total energy was estimated by two methods, either from sound exposure levels (SEL) of single shots or from sound exposure levels cumulated over 24 hours (cSEL) and the mean of the two estimates is given in table 1.

From SEL of single shots:

$$E_1 = SEL_{\text{single shot}} + 10\log_{10}\left(\frac{sr \cdot L}{v}\right) - 182\,\text{dB re.1J}\cdot\text{m}^{-2}\cdot\mu\text{Pa}^{-2}\cdot s^{-1}$$

$$e_1 = 10^{\frac{E_1}{10}}$$

where SEL is the energy of a single shot (in dB re. 1 upa^2*s), sr is shot rate, L is total length of transect lines and v is ship speed (in m/s). The 182 dB is the conversion factor from uPa^2*s to Joule/m^2.

From cSEL$_{24h}$:

$$E_2 = SEL_{24\text{h}} + 10\log_{10}\left(\frac{L}{v\cdot 24\cdot 60^2}\right) - 182\,\text{dB re.1J}\cdot\text{m}^{-2}\cdot\mu\text{Pa}^{-2}\cdot s^{-1}$$

$$e_2 = 10^{\frac{E_2}{10}}$$

A) Qamut (ConocoPhillips)
Total length 3000 km. Survey speed 5 knot = 2.6 m/s. Shot interval 10 s, 0.1 shot/s. Total estimated 116,000 shots. SEL of single shot = 130 dB re. 1 uPa^2*s (estimated from figure 10, 13 and 16 in EIA appendix D).
E_1= -1 dB re. 1 J/m^2; e_1 = 0.8 J/m^2.
cSEL 24 hours = 165 dB re. 1 uPa^2*s (estimated from figure 19 in EIA appendix D).
E_2= -6 dB re. 1 J/m^2; e_2= 0.3 J/m^2.
E_{mean} = 0.5 J/m^2.

B) Anu + Napu (Shell)
Two ships. Total length14.400 km. Survey speed 8 km/h = 2.2 m/s. Shot interval 11 s, 0.09 shot/s. Total estimated 583,000 shots. SEL single shot = 127 dB re. 1 uPa^2*s (EIA appendix E table 17, R1 (Melville Bay, S3 (Anu) and S4 (Napu)).
E_1= 3 dB re. 1 J/m^2; e_1 = 1.9 J/m^2.
cSEL 24 hours = 165 dB re. 1 uPa^2*s (estimated from figure 30 in EIA appendix E).
E_2= 2 dB re. 1 J/m^2; e_2= 1.5 J/m^2.
E_{mean} = 1.7 J/m^2.

C) Anu + Napu (Shell) - option
2900 km, otherwise as above.
E_1= -4 dB re. 1 J/m^2; e_1 = 0.4 J/m^2.
E_2= -5 dB re. 1 J/m^2; e_2= 0.3 J/m^2.
E_{mean} = 0.3 J/m^2.

D) Tooq (Mærsk) 2012
Total length 3000 km (estimated from figure # in EIA). Survey speed 4.5 knots = 2.3 m/s. Shot interval 10 s, = 0.1 shots/s. Total estimated 130,000 shots.
SEL of single shot = 127 dB re. 1 uPa^2*s (from table 32, R1 (Melville Bay)+ S2 (Tooq)).
E_1= -4 dB re. 1 J/m^2; e_1 = 0.4 J/m^2.
cSEL 24 hours = 160 dB re. 1 uPa^2*s (guesstimated from figure 28 in EIA appendix #).
E_2= -10 dB re. 1 J/m^2; e_2= 0.1 J/m^2.
E_{mean} = 0.3 J/m^2.

Table 1. Comparison of 2D seismic survey conducted in 2011 and proposed 2D and 3D surveys for 2012. Proposal for Anu and Napu license blocks contains a core program plus an optional program. Information found or inferred from EIAs. As many inputs to the calculation of total energy was roughly estimated from maps and tables, the uncertainty on the figures is considerable and should only serve for a rough comparison between programs.

Licence Block		Qamut	Anu+Napu	Anu+Napu Option	Anu+Napu total	Tooq	Total
Company		COP	Shell	Shell	Shell	Mærsk	
Total line length	(km)	3000	14400	2900	17300	3000	
On effort	(hours)	324	1800	363	2163	360	2848
Array size	$inch^2$	3940	2 x 4240	2 x 4240	2 x 4240	4240	
Source factor	dB re. 1 Pa*m pp	262	263	263	263	263	
Total no. of shots		120000	583000	120000	603000	130000	
Total energy[5]	J/m^2	0.5	1.7	0.3	2.0	0.3	2.8
Percent excl. optional program		22%	68%			10%	100%
Percent incl. Opional program		19%			72%	9%	100%

While comparing the three surveys and their expected impact on Melville Bay it is apparent that the 3D program proposed by Shell will contribute with the major part of the impact (given that the program can be completed within the allocated time), followed by ConocoPhillips (Qamut) and then Mærsk (Tooq). The two latter surveys are very comparable in extent (about 3000 km on effort), but impact on narwhals from the Qamut block is expected to be larger due to its closer proximity to Melville Bay.

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