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Assessment of impacts and potential mitigation for icebreaking vessels transiting pupping areas of an ice-breeding seal

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Supplementary material: Appendix D

Development of integrated mitigation measures for icebreaker impact on breeding seals in the Caspian Sea

The potential exists for vessel-related impact on the survival of Caspian seal pups and breeding adults, and these may cause avoidable pressures on the population. Therefore a Mitigation Hierarchy is recommended, together with measurable indicators to evaluate mitigation success. Operators should determine what level of vessel-seal interactions are compatible with their Company environmental policies and environmental law of the country of operations. The measurable indicators can be used to quantify success of compliance.

1. Primary mitigation – Reduce and eliminate requirements for icebreaker transits through seal breeding areas during critical periods

One of the main drivers of icebreaker traffic in the north-east Caspian is removal of sewage and other waste from manned installations. This arises from Kazakh environmental legislation requiring zero discharge of waste water. The need for icebreaker operations during the sensitive pupping period could be reduced by changes in legislation to allow recycling/discharge of water from sewage treated *in-situ*, or reinjection of treated slurry into wells (Wilkerson and Wallace 1999), and storage of solid waste until the end of the ice season. Other supply logistics could also be planned in advance to reduce need for icebreaker transits during the seal pupping season.

The aim of primary mitigation should be to avoid vessel traffic during the Caspian seal pupping period, which is approximately from the last week in January to the 2nd week in March. In most years the peak extends from the end of the first week in February to the end of the month (Wilson et al., 2017). This means that there are young pups throughout the season which will be vulnerable to hypothermia or to 'extra' energy expenditure over the norm in undisturbed conditions. Older pups with a blubber layer and shedding lanugo will be less prone to hypothermia, but may still be compromised by 'extra' energy expenditure or maternal separation. Pups of all developmental stages, even in late season, are slow to move away from the vessel and are therefore vulnerable to vessel collision.

2. Secondary mitigation – Advanced route planning to avoid seal aggregations

If transits through the seal breeding ice cannot be suspended during the breeding season, planning vessel routes with the aim of avoiding seal colonies should be the next level in the mitigation hierarchy. The pup distribution in seven surveyed years (Dmitrieva, 2013) suggests that high densities of seal pups occur in the Saddle area (Fig. A1) most years, and that therefore a default strategy would be to avoid passing through that area. Instead, vessels could be routed to the northwest of the Saddle from late January to the beginning of March. The seal areas to avoid could be fine-tuned during each season by aerial surveys to determine in real time the location and approximate densities of seal colonies in the potential vessel corridor area. The necessary data can be obtained from aerial survey transects over the navigation corridor (see Figure D1a. for an example). Aerial surveys are required since vessel-based observations cannot identify areas clear of seals away from the vessel track suitable for alternative routing. Vessel routing will also be constrained by bathymetry, international borders, ice conditions, and safety related operating procedures. Operators may also have economic considerations such as transit time and fuel costs, which they would wish to balance against their environmental policies.

To facilitate rapid dissemination of aerial survey results to navigation planners, seal occurrence can be recorded on a qualitative basis, since precise population counts are not necessary for this purpose. Using this approach, results can be sent for route planning the same day as the survey after minimal processing. Results can be time sensitive for navigation use since dynamic ice conditions mean that seal aggregations can drift significant distances in short periods.

Approximate seal densities are reported in four 'seal index value' categories (Figure D1b) which are colour-coded and combined with navigation and speed advisories, i.e. green – transit with caution; yellow – extreme caution, max. speed 3.5kn (based on the risk of collision at different cruising speeds); amber – avoid if possible, max. speed 3.5kn; red – avoid completely. Such charts can further be used for optimum seal-avoidance route-planning, taking into consideration navigation constraints.

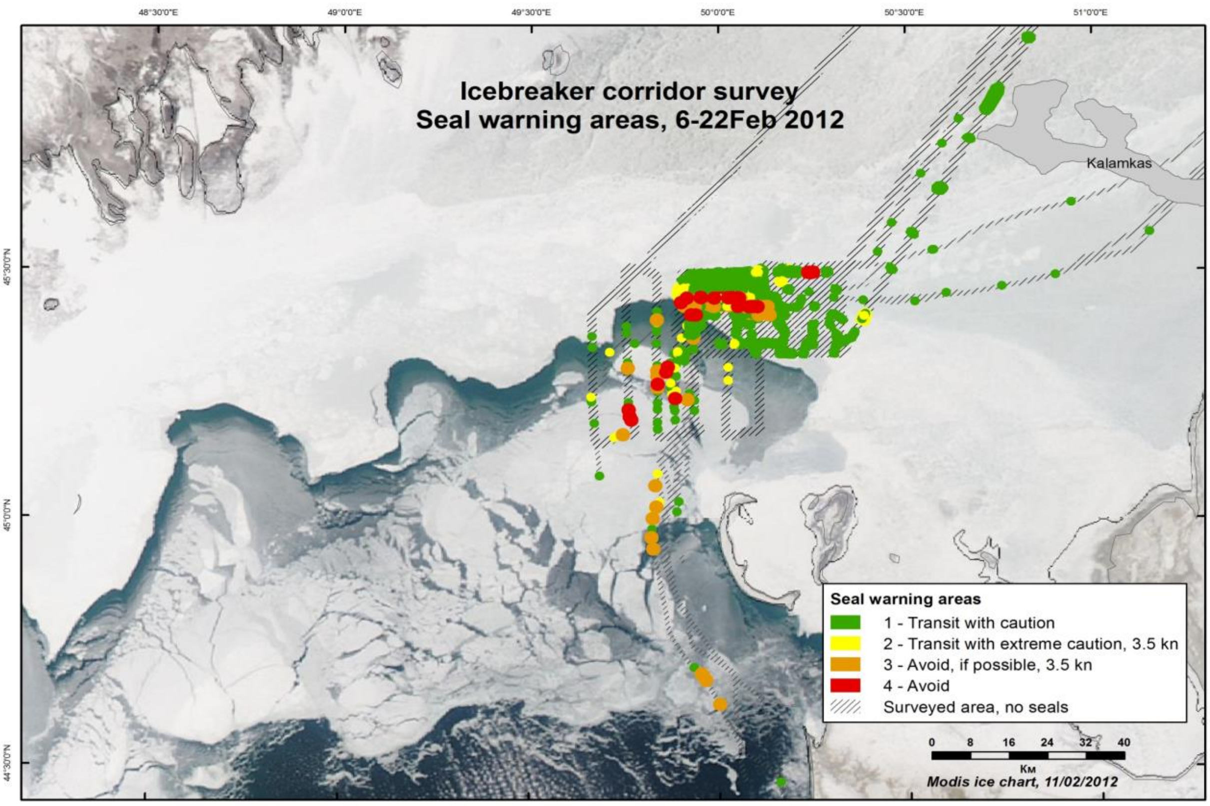
Reactive mitigation – On board responses at the discretion of vessel crew with advice from Seal Observers

Onboard mitigation may include 'micro' route planning to circumnavigate entire seal groups spotted ahead of the vessel. This study considered that a realistic 'safe' distance for passing Caspian seals without causing significant disturbance is ~250m. Maintaining a 250m distance should be feasible for vessels breaking new ice and watching out for groups of seals ahead, but would not be feasible where already-broken channels, where the channel edges have been colonised by breeding seals, are being re-used by vessels. In the latter case a decision to re-route vessel traffic away from colonised channels may be advisable.

This study found that the maximum flight distance for Caspian seal mothers and pups ahead of the vessel in daylight was less than 100m, averaged only ~42m, and was often almost zero distance at night. This short flight distance means that the onus of collision avoidance rests with the vessel captain. For the scenario of a vessel arriving in the middle of a seal breeding area, this would entail maintaining a slow speed of <4kn and preparing to slow further to ~2kn to manoeuvre around seals, or stop completely to allow mothers and pups to escape.

However, navigating through a seal colony with stopping and maneuvering should only be a last resort. Our analysis of the limited dataset thus far suggests that although slowing vessel speed to enable manoeuvring around seals may successfully reduce actual collisions, the risk of indirect mortality will still arise due to nursery habitat breakage and increased risk of mother-pup separation. In the circumstances of a vessel breaking fresh ice in a seal pupping area, there is no humane alternative to adopting a slow speed and manoeuvring around seals. However, in the circumstances of travelling along a pre-existing channel which is largely ice-free, the most sensitive approach is probably to maintain a moderate speed (e.g. 5 kn) so as to pass seals along the side of the channel quickly while still being able to stop for any pups stranded ahead in the channel.

Since our analysis of the dataset on collisions found that the risk of collision in the dark was >7x that in daylight, effective thermal imaging equipment should be mandatory for night transits when daylight navigation is not possible.



Observation criteria from aerial survey	Seal value index	Colour code transfer to chart and interpretation	Description of the area
1 or more Lone Adults (LAs), 1 Lone Pup (LP), Mother-pup pair (MP), water access hole or sitting eagles	1	**Transit with caution**	Area where seals may give birth. Pups are sparsely distributed.
Small breeding groups (<10 LPs or MPs)	2	**Transit with extreme caution Max speed 3.5 kn**	Starting new breeding colony. Pups are sparsely distributed or clustered in small groups.
Large breeding groups (>10 LPs or MPs)	3	**Avoid if possible Max speed 3.5 kn**	Breeding groups may extend to several km, passage without serious disturbance is difficult.
Countless numbers of seals with pups extending beyond good visibility range	4	**Avoid completely**	Established dense breeding colony, impossible to navigate through safely

Figure D1. Example of qualitative aerial survey results to generate seal density indexes to aid routing of vessels away from high seal density areas. Aerial surveys were carried out using a modified version of the method described in Dmitrieva et al. (2015), with the same aircraft and flight parameters (altitude, speed). Observation strip width was 500m-1km depending on inter-transect distance, and seal numbers were recorded using the qualitative criteria in the table above. A dedicated manual for seal reconnaissance aerial surveys was developed for the icebreaker seal mitigation training package. a) Upper: Sample map of icebreaker corridor showing transects flown and colour-coded seal warning areas from aerial and vessel-based surveys; b) Lower: Table giving seal index zone criteria and colour-coded vessel speed advisories.

3. Quantitative assessment of impacts and mitigation success

Quantitative impact assessment and evaluation of mitigation measure effectiveness requires an evidence-based Seal Observer (SO) monitoring and reporting system for vessels traversing Caspian seal breeding ice. One role of SOs should be to watch for seals ahead of the vessel and advise captains on reactive measures; the effectiveness of such observers has been demonstrated in the case of whales in the path of ferries (Weinrich et al. 2010). However, the use of SOs alone is not sufficient for effective mitigation without the primary and secondary mitigation strategies described above.

An additional vital role of SOs on icebreakers would be to both document and report on impacts and avoidance of impact, so that the success of measures such as route planning can be assessed quantitatively. Such a programme should have defined targets with measurable indicators for reducing the number of icebreaker transits during sensitive pupping periods, successful seal-avoidance route-planning, reduction of breeding seal encounters and equipping vessels with the means for minimising impact. In the case of Kazakhstan, these measures are specified in Kazakh national law (the Ecocode; Republic Kazakhstan 2007).

SOs should report back to the client Company and the regulatory authority on vessel-seal encounters. For the purpose of such reporting, a trial was carried out in 2012 of classifying all encounters as 'Major', 'Medium' or 'Minor' according to standard operational criteria (Table D1). These criteria relate to the wide range of vessel-seal encounters and outcomes recorded in the study in relation to distance and speed of vessel and impact on seal survival. SOs should also record the vessel speed immediately prior to and during each encounter, the number and GPS locations of pups seen within 200m of the vessel path, and category of vessel encounter impact. In order to provide further feedback on seal densities to shipping logistics, SOs should also report regularly on the approximate numbers of seals visible at any distance from the vessel, to be recorded in seal index values similar to that from the aerial surveys. The measurable indicators are the numbers of each encounter class and type, together with the documentary data of distance from vessel, vessel speeds etc. These data can be used to produce quantitative reports on success of mitigation measures, progress towards Company impact minimization targets, and compliance with environmental legislation.

The SO role is therefore quite complex, requiring specific training to criteria of competence levels. A dedicated training package specific to icebreakers and ice-breeding seals has been developed by the present authors for use by SOs and shipping management in the Caspian. Government-regulated monitoring by trained MMOs has been recommended for the O&G industry in the NE Caspian, but the legal framework for implementation of such a system remains unclear. Monitoring and reporting of vessel-seal interactions currently remains at the discretion of operating companies.

Table D1: Criteria that will be used by SOs to record 'Major', 'Medium' and 'Minor' encounters

Encounter Class	Criteria	Impact Type
MINOR **Criteria: encounters which cause repeated unnecessary energy expenditure and stress, with a cumulative effect on survival with repeated exposure**	Mother and pup are 50-200m from side of vessel or ship's path	Causing alert response and moving location and/or mother entering water
	Other adults on ice are 10-100m from side of vessel or ship's path	Causing alert response, moving away from vessel and/or entering water
MEDIUM **Criteria: encounters which cause greater unnecessary energy expenditure and stress due to the close proximity of the vessel and increased avoidance behavior from seals**	Mother and/or pup are 10-50m from side of vessel or ship's path	Causing alert response, moving away from vessel and/or mother entering water
	Mother and pup are separated by ≥20m	Separation
	Either M or P are displaced by ≥20m	Displacement
	Other adults on ice are <10m from side of vessel or ship's path	Causing alert response, moving away from vessel and/or entering water
MAJOR **Criteria: encounters which cause direct mortality or are an imminent threat to survival**	Mother or pup are struck or run over by vessel	Collison
	White-coat pup is dragged under ice, forced into water or covered in brash ice	Pup wetting
	Birthing and/or newborn pup and mother disturbed, separated or displaced by ≥5m	disruption and risk to mother-pup neonatal bonding, stress, energy loss
	Mother and/or pup are ≤10m from side of vessel or ship's path	Alert response, rapid moving away from vessel and/or entering water
	Vessel breaking new ice passes ≤10m from mother and/or pup (thus breaking nursery habitat)	Habitat destruction
	Mother and pup are displaced or separated by ≥100m	Displacement/ Separation
	Either M or P are displaced by ≥100m	Displacement/ Separation

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