EA 1083

Effects of Offshore Oil Development and Production Activities off Sakhalin Island on Sea Associated Birds and Marine Mammals

by

Denis H. Thomson
LGL Limited, environmental research associates
P.O. Box 280, 22 Fisher Street
King City, Ontario
Canada L7B 1A6

and

Stephen R. Johnson
LGL Limited, environmental research associates
9768 Second St.
Sidney, British Columbia
Canada V8L 3Y8

for

Marathon Upstream Sakhalin Services, Ltd.
P.O. Box 3128
Houston, Texas
United States 77253

15 September 1996

TABLE OF CONTENTS

List of Tables

Introduction

It is not possible to address the potential interactions between every project activity and every component of the natural and human environment. Many of the interactions are impossible, insignificant, or inconsequential. The EA focuses on important Valued Ecosystem Components (VECs). Valued Ecosystem Components include rare or threatened species or habitats; species or habitats that are unique to an area, or are valued for their aesthetic properties; and species that are harvested by people. All marine mammals and most sea associated birds are VECs

It is important that the terminology used to describe potential impacts be clear and easily understood. Words such as minor, moderate, and significant are subjective and their meaning differs depending on the context in which they are used and the experience of the reader. Therefore, precise definitions for the ranking of potential impacts have been used in this EA. The following definitions have been used.

Major Impact - An impact is rated major if it is judged to result in a 10%, or greater, change in the carrying capacity of the environment, size of an animal population, size of a resource harvest or a commercial fishery, or in an attribute of another VEC.

Moderate Impact - An impact is rated moderate if it is judged to result in a 1% to 10% change in the carrying capacity of the environment, size of an animal population, size of a resource harvest or commercial fishery, or in an attribute of another VEC.

Minor Impact - An impact is rated minor if it is judged to result in a less than 1% change in the carrying capacity of the environment, animal population size, resource harvest or commercial fishery, or in an attribute of another VEC.

Negligible Impact - Negligible impacts are those that are judged to have essentially no effects.

Regional Impact - A regional impact is an interaction that is judged to have an impact at the regional level. For the purposes of this EA, the regions are defined as (1) offshore waters of the Sea of Okhotsk (2) the entire nearshore area adjacent to the offshore development and the onshore facilities.

Local Impact - A local impact is an interaction that is judged to have an impact at the local level defined here as the areas within 1 to 10 km from project activities.

Sub-Local Impact - An interaction that is judged to have an impact on the biophysical environment within one km of project activities.

Long-Term - Impacts that last for more than five years.

Medium-Term - Impacts that last for periods of one to five years.

Short-Term - Impacts that last for a period of less than one year.

The terms defined above can be combined, as appropriate, to define an impact. For example, a potential impact can be rated positive, long-term, and regional. The most serious impact (positive or negative) in this rating system is major, regional and long-term; the least serious is negligible. These terms define the level of the potential impacts. However, it is also necessary to define what level of impact constitutes a significant impact.

Not Significant Impact means that an impact is negligible or is minor, short-term, and local or sub-local in nature, and

Significant Impact means that the impact rating is major or moderate or that it is minor with a medium or long term and a regional impact.

Installation of Seabed Components and Underwater Construction

Underwater construction activities will be limited. All drilling and operations will be done from one mobile arctic offshore drilling rig, the *Molikpaq*. The *Molikpaq* will be installed on a berm rising 15 m from the bottom. It will be connected to a Floating Storage and Offloading (FSO) system by a buried subsea pipeline. Installation and construction will include:

- Suction dredging at a borrow site and transport of the material to the berm site,
- Construction of the berm,
- Blasting to densify the berm,
- Armouring the berm with rock,
- Positioning the *Molikpaq* on the berm and filling it with solid ballast,
- Digging a 2 km long trench, laying pipe in the trench and then burying the pipe,
- Installation of a riser and Single Anchor Leg Mooring (SALM) buoy at the end of the pipeline, and

- Mooring a storage tanker to the SALM and connecting it to the riser.

Most effects of construction on marine mammals would be related to effects of noise. These are discussed later under Effects of Noise. The only construction related activity that has the potential for interaction directly with birds and marine mammals is blasting.

Blasting

The core fill and upper berm material will be densified by blasting. Holes will be drilled on a rectangular grid with centre to centre distances of 10 m. There will be 3 to 4 levels of explosives in each hole. Charges will be of 2.7 to 3.6 kg. Densification may require several passes.

Birds and marine mammals may be attracted to the area by fish killed during the first densification pass and then killed or injured by explosions during subsequent densification passes. Explosives can injure or kill fish. The strength of shock wave required to injure or kill these animals varies greatly with type of fish. Fish without swim bladders are very resistant to explosions, while fish with swim bladders are considerably more susceptible.

Fish near the bottom or near a bank will receive a larger impulse and sustain higher mortality than those in open water. The fish kill from a given amount of explosive depends on location, season, and many other factors. Fitch and Young (1948) observed and counted dead fish resulting from detonation of "jet" shots of 9.1 kg each fired below the sea bottom. They estimated mortality at 0.230 kg fish per kg of explosive. They noted that not all dead fish were observed; some sank to the bottom. For larger shots averaging 30 kg of explosives per shot, mortality was 0.47 kg fish/kg explosive. A series of 21 explosions of 114 to 545 kg each set at depths of 5 to 41 m in Chesapeake Bay killed at least 32,658 fish weighing 8,555+ kg (Coker and Hollis 1950). It is possible that only half the kill was recovered. They estimated mortality as 1.25 kg fish/kg explosive.

Young's (1991) equations predict 90% survivability of fish in the 0.4 to 3.6 kg range at distances of about 100 to 150 m from a single blast of 2.7 to 3.6 kg. Thus fish could be killed within 100 to 150 m of the edge of the blasting area and injured within a larger area.

Effects on Birds

Sea associated birds that are close to an explosion can be injured or killed. At a given distance, injury or death is more likely for birds that are below the surface than for those at the surface (Fitch and Young 1948; Yelverton et al. 1973). For birds at the surface, there is apparently little or no risk of injury or death unless the birds are very close to the explosion. Few cases of injury or death from explosions have been reported in the ornithological literature.

Fitch and Young (1948) documented the biological effects of marine seismic programs involving 4½-73 kg high explosive charges. Seabirds were attracted to seismic vessels to feed on fish killed by the explosions. Hockey (1979) observed gannets, cormorants, gulls and terns attracted to fish killed by previous explosions. The gannets fed on these fish by plunge diving, which would take them below the surface.

Effects on Marine Mammals

Intense shock waves, because of their high peak pressures and rapid changes in pressure, can cause severe damage to animals. The most severe damage takes place at boundaries between tissues of different density. Different velocities are imparted to tissues of different densities, and this can physically disrupt the tissues. Gas-containing organs, particularly the lungs and gastrointestinal tract, are especially susceptible (Yelverton et al. 1973; Hill 1978). Lung injuries can include laceration and rupture of the alveoli and blood vessels. This can lead to haemorrhage, creation of air embolisms, and breathing difficulties. Intestinal walls can bruise or rupture, with subsequent haemorrhage and escape of gut contents into the body cavity.

There are only a few published accounts of non-auditory damage to marine mammals exposed to blast. These accounts provide no information about the strengths of blasts that did and did not cause damage:

- Fitch and Young (1948) reported that, on at least three occasions, California Sea Lions were killed during seismic exploration using high explosives. In contrast, Gray Whales "in the region of a blast were seemingly unaffected" Charges in use during the study usually consisted of either 18-36 kg of high explosive detonated "a few feet" underwater, or 9 kg detonated in the bottom sediment.

- Reiter (1981) reported without further details that there was evidence of Northern Fur Seals and birds killed from concussion in the immediate area of demolition when a grounded ship was broken up by about 454 kg of explosive. Again, numbers and distances are unknown.

- Northern Fur Seals have been killed by an 11.4 kg dynamite charge exploded 23 m away (H.F. Hanson 1954; cited in Wright 1982).

- Chinese River Dolphins, Irrawaddy Dolphins, Finless Porpoises and dugongs have been killed by explosions, usually involving use of sticks of dynamite to catch fish (Leatherwood and Reeves 1989; Zhou Kaiya and Zhang Xingduan 1991; Baird et al. 1994).

Several workers have described procedures for calculating safe distances from explosions to marine mammals (Yelverton et al. 1973; Hill 1978; Yelverton 1981; Goertner 1982; Wright 1982; O'Keeffe and Young 1984; Young 1991).

According to the Hill (1978) method, based on Yelverton et al.'s (1973) data from terrestrial mammals, no physical harm would be done to a marine mammal at impulses of 34 Pa.s or less which correspond to distances of >442 m from a 3.2 kg charge detonated at a depth of 15 m if the animal were at depths <15 m. Based on the Yelverton/Hill procedure, moderately severe injuries but no mortality would be expected at 44 m distance.

This procedure does not allow for any relationship between susceptibility and body size. Yelverton (1981) produced new equations for computing safe distances for marine mammals that considered the animal's body mass:

50% Mortality	$\ln(I) = 4.938 + 0.386 \ln(M)$
1% Mortality	$\ln(I) = 4.507 + 0.386 \ln(M)$
No Injuries	$\ln(I) = 3.888 + 0.386 \ln(M)$

where I = impulse in Pa·s and m = body mass in kg. These equations and the other methods are based on data from submerged terrestrial mammals, and they may overstate the severity of injuries to marine mammals adapted for life in the water. The direct applicability of the equations to large marine mammals is particularly questionable, given that the largest animals from which data are available are sheep.

The original Yelverton/Hill procedure assumed that no injuries would occur at impulses of 34 Pa.s or less. For a 3.2 kg charge detonated at a depth of 15 m, an impulse of this magnitude or greater would occur at distances of 315 m or less at depths of 15 m. Based on the Yelverton (1981) equations shown above, an impulse of this level would be safe for a 3 or 4 kg marine mammal, i.e., even for newborn calves of the smallest dolphins in the area. The safe level for a human swimmer near the surface is 14 Pa.s (Yelverton 1981). This could be taken as the magnitude of an absolutely safe impulse for marine mammals. An impulse of this magnitude from a blast of 3.2 kg detonated at a depth of 15 m would occur at a distance of 620 m at 15 m depth and 212 m at a depth of 1 m.

Young (1991) presents a different set of equations, in his case to compute the safe distance for marine mammals given a depth of blast of 200 ft (61 m):

Porpoise Calf	$R = 578\ W_E^{0.28}$
Porpoise Adult	$R = 434\ W_E^{0.28}$
20 ft Whale	$R = 327\ W_E^{0.28}$

In these equations, R = the distance in feet from blast to the mammal, and W_E is the weight of the explosive in pounds. Young also provides the following equation describing the safe range for a human diver at a depth of 50 ft (15 m) and a blast depth of 100 ft (30 m):

Human swimmer $R = 3800\ W_E^{0.18}$.

Units and definitions are as above. For a diver weighing 180 lb (82 kg), the predicted safe range from a 3.2 kg charge would be 1646 m.

When the explosion is near a hard (e.g., rock) bottom, shock waves may attenuate less rapidly than in open water. Hill (1978) and Wright (1982) suggest that calculated lethal ranges or safe distances should be doubled in these circumstances to ensure a conservative safety margin.

The possibility of blast damage to the auditory system is of special concern because the hearing apparatus is adapted to transmit pressure to the inner ear, and the inner ear is sensitive to slight changes in pressure. There is no specific information about the levels of blast necessary to cause temporary or permanent hearing damage in any marine mammal. However, there is some limited information indicating that marine mammal hearing systems are subject to blast damage. This section is taken largely from Richardson et al. (1995a).

Lien et al. (1993) found that Humpback Whales remained in an area where there were repeated large underwater detonations. Two beached humpbacks had damaged auditory organs, consistent with the types of damage caused by explosions (Ketten et al. 1993). It is not known how close they may have been to the explosions.

Bohne et al. (1985, 1986) found that the inner ears of 5 of 11 Weddell Seals that they examined showed evidence of previous damage. The type of damage observed was consistent with exposure to high noise levels. Numerous explosive charges had been detonated in the area the previous summer. There was suspicion but no proof that the auditory damage was caused by those explosions.

The auditory effects of the seal bombs thrown near dolphins during some tuna fishing have not been reported. A similar device killed a human diver when it exploded 15-30 cm from his head (Hirsch and Ommaya 1972). Myrick et al. (1990) concluded that one seal bomb will cause injury when detonated within 0.5-0.6 m of a dolphin. They estimated a safe standoff distance of 4 m or slightly more, depending on explosive type and depth. These conclusions were based partly on tests with dolphin carcasses.

In humans, prolonged or repeated exposure to high sound levels can accelerate the normal process of gradual hearing deterioration with increasing age (Kryter 1985). This deterioration is a permanent threshold shift (PTS). In addition, temporary increases in threshold occur during and shortly after exposure to high noise levels. This temporary threshold shift (TTS) can last from a few minutes to hours or days. Brief exposure to extremely high sound levels, such as those from nearby explosions, can cause discomfort, non-auditory sensory effects, and immediate onset of permanent hearing impairment.

There is no specific information about whether marine mammals are subject to analogous permanent hearing impairment after prolonged or brief exposure to intense sounds either underwater or in the air. It is also not known whether high sound levels cause "discomfort" or non-auditory effects in marine mammals. Thus, any discussion of the radii around explosion sites at which these effects might occur in marine mammals is speculative. It is based almost entirely on analogies with man and other terrestrial mammals, for the most part listening in air rather than underwater. Given the special adaptations of the hearing apparatus of marine mammals, it is uncertain whether information derived from humans or other terrestrial mammals is applicable to marine mammals. Uncertainty about sound conduction paths from water to the inner ears of some marine mammals confounds any assessment of this matter.

In humans, a sound that is about 155 dB above the normal threshold level is high enough to cause some immediate damage and permanent threshold shift (Kryter 1985:272). The hearing thresholds of Baleen Whales are not known. It is reasonable to assume that, at the frequencies of best hearing, they would be no lower than the typical 1/3-octave ambient noise level on a calm day in the absence of man-made noise, e.g., ~50 dB near 100 Hz. If so, and if the "155 dB above threshold" assumption applies, then the received level would need to be above about 205 dB re 1 μPa in order to cause immediate hearing damage. In the case of Toothed Whales, hearing thresholds at 1000 Hz are about 83-102 dB, depending on species. If the "155 Db above threshold" assumption applies, their "immediate damage" threshold would be 238 dB re 1 μPa or above. A level of 238+ dB would be found only within 100 m of a 3.2-kg explosion. At such close distances, non-auditory damage is also possible.

Any interpretation of this information is highly speculative. We assume that the hearing abilities of Baleen and Toothed Whales are very unlikely to be harmed by received pulse levels up to 200 dB and 220 dB re 1 μPa, respectively. These are probably conservative values.

Impacts

Sea Associated Birds: Yelverton (1981) computed underwater blast criteria for birds on the surface and underwater based on earlier work (Yelverton et al. 1973). Based on these calculations the safe distance for birds would be 8 m for birds on the surface, 119 m for birds at 1 m, and 262 m for birds at 15 m depth (Table 1). These distances must be added to the 82 m diameter area within which blasting will occur. Some birds within these ranges are likely to be killed by the blasts, especially if fish killed by the first pass attracts more birds to the area. Impacts are likely to be minor to moderate, sub-local and of short duration and could be significant if large numbers of birds are attracted to the area.

Sea associated birds are not likely to be disturbed sufficiently by the explosions to cause them to leave the area. Even if they were displaced, the effects on individuals and populations would be negligible, given the natural mobility of foraging seabirds, the large extent of the potential foraging area, and the short-term nature of the planned berm densification. Also, any displacement that does occur would have the positive effect of reducing the potential for blast injury.

Table 1. Impulses and corresponding distances from a blast of 3.2 kg detonated at 15 m depth for birds at the surface, 1 m and 15 m depth that would cause various levels of mortality. Computations are based on Yelverton's (1981) criteria for injury in Pa.sec. Distances from the blast at which impulses of the indicated magnitudes would occur were computed from equations provided by Yelverton et al. (1973) for a blast in mid water. N/A means that an impulse of this magnitude will not reach the surface.

On Surface		Underwater			
Impulse (Pa.sec)	Dist. (m)	Impulse (Pa.sec)	Dist.(m) at depth		
			1m	15m	Comments
896-1034	N/A	310	25	35	50% mortality, survivors seriously injured and would die.
690-827	N/A	248	32	44	Mortality threshold, survivors had injuries, but would live.
276-414	N/A	138	54	202	No mortality, slight blast injury.
-	N/A	69	96	113	Low probability of lung injury.
207	8	41	119	262	Safe level no injury.

Marine Mammals: Safe ranges for marine mammals can be computed in a number of different ways. The magnitudes of impulses causing no damage and 1% mortality of marine mammals, and the corresponding distances from blasts of various sizes, are shown Table 2. The data used by Yelverton (1981) to derive the equation with which we computed these values did not include large mammals. Therefore, we did not use the equation to estimate safe ranges for animals >1000 kg in weight. Impulse criteria for animals weighing 1000 kg were assumed to apply to all larger mammals. The distances from the blast at which impulses of the indicated magnitudes would occur were computed from equations provided by Yelverton et al. (1973) for a blast in mid water. The proposed blasts will be on the berm and so will be on the bottom but in mid water. We have used these equations to approximate impulses at various distances from the blast.

Table 2. Impulses and horizontal distance from a 3.2 kg charge expected to cause no injury and 1% mortality to marine mammals at depths of 15 and 30 m, assuming that charges are detonated at a depth of 15 m. Impulses were computed according to Yelverton's (1981) equations. The distances from the blast at which impulses of the indicated magnitudes would occur were computed from equations provided by Yelverton et al. (1973).

		No Injury			**1% Mortality**		
	Weight		**Distance (m) at Depth**			**Distance (m) at Depth**	
	(kg)	**Pa.s**	**15 m**	**30 m**	**Pa.s**	**15 m**	**30 m**
Baleen, Sperm & Killer	>>1,000	702	16	<5	1304	9	<5
Steller's Sea Lion (male)	800	644	18	13	1197	10	<5
Bearded Seal	300	441	25	24	819	14	<5
Bottlenose Dolphin	200	377	29	29	701	15	<5
Dall's Porpoise	220	391	28	28	727	15	<5
Spotted Seal	100	289	38	40	536	20	17
Ringed Seal	75	258	43	45	480	23	21
Calves							
Baleen & Sperm	1,000+	702	16	<5	1304	9	<5
Pilot Whale	80	265	42	43	492	23	20
Bottlenose Dolphin	11	123	88	95	229	48	50
Ringed Seal	5.5	94	116	122	175	62	67

Safe ranges for marine mammals computed according to Young's (1991) formulae for a 3.2 kg charge would be:

Porpoise Calf	304 m
Porpoise Adult	228 m
20 ft Whale	172 m

We will use the safe ranges determined using Young's (1991) equations, which are much more conservative than those of Yelverton (1981).

For marine mammals, there are no established criteria for predicting the range within which hearing damage might occur as a result of exposure of marine mammals to impulse noise. Based on extrapolation from humans and other evidence, it is very unlikely that hearing damage could occur at received levels below 200 dB re 1 μPa. At least in Toothed Whales, the threshold for hearing damage likely exceeds 220 dB. Peak levels of 200 and 220 dB would occur within the following distances from charges of the indicated sizes.

Charge (kg)->	1.8 - 4.6
200 dB	3,000 m
220 dB	300 m

The actual threshold for hearing damage may be above 220 dB in both Toothed and Baleen Whales, in which case the safe distance would be less than 300 m from the source.

Marine mammals could be injured or killed if they were within the safe ranges shown on Table 2. Hearing damage could occur if they are within about 300 m of the source. Impacts would depend on the numbers of animals in the area at the time of the blast. The seals tend not to travel in large groups when at sea, but could concentrate at the blast site, if attracted by fish kills from previous blasts. Killer Whales, Dalls Porpoises, White Whales and migrating Gray Whales travel in large groups. Thus, there is the potential for blasting to impact large numbers of animals. Impacts on marine mammals could range from minor to major, sub-local, short term and not significant to significant, depending on numbers involved. The remnant population of Gray Whales which inhabits this area is small and endangered and mortality of one of more of these whales would constitute a significant impact.

Effects of noise associated with blasting and other construction noises are dealt with in the noise section below.

Mitigation

Effects of explosives on marine mammals could be mitigated by conducting the blasting during the daytime, scanning the area visually to detect the presence of seabirds and marine mammals, and delaying the explosions if any were seen. Detonations should be delayed if marine mammals are detected in the area and, especially, if there is a possibility that some of them might be within 400 m of the blast site. Migrating Gray Whales and some of the smaller cetaceans tend to travel in groups, in some cases leaping out of the water, enhancing their detectability. The scans should be done from a work boat by an experienced observer, assisted by other people on watch. It is probably desirable to detonate a few small (5-g) charges at the start of each pass to provide a "warning" to any animals in the area. However, the advisability of using small warning charges is open to debate, on the basis that some seals and dolphins may be attracted to the sites of small explosions if the dolphins have learned to associated blast noise with fish kill.

If birds or marine mammals are attracted to the site by dead or injured fish, the next pass should be delayed until these fish have been consumed and marine mammals have vacated the area.

Insofar as possible, blasting should be avoided at night and in poor visibility (visibility less than 1 mile). However, if a blasting is done during daytime and no marine mammals are seen, it would be reasonably safe to continue blasting into a period of poor visibility or darkness. Once a pass has begun, it is assumed that most marine mammals in the area would avoid the area.

These mitigation measures should reduce impacts of blasting on marine mammals and sea associated birds to negligible.

Other Construction Activities

Dredging and laying pipe will cause an increase in sediment in the water. When underwater, marine mammals rely more on sound than sight to obtain information about their environment. A temporary increase in sediment loads in the water is likely to have negligible impacts on marine mammals and would not interact with sea associated birds.

Most impacts of construction are related to noise which is dealt with below in the section "Effects of Noise".

Drilling and Operations

Presence of Structures

A berm will be built to support the mobile arctic offshore drilling rig. It will rise to a height of 15 m off the seafloor and have an effective top diameter of 84 m. The slope ratio of the sides will be 5:1. The top and sides will be armoured with rocks of various sizes. Because the rocks will be of various sizes, the berm will function as a well designed artificial reef.

A mobile arctic offshore drilling rig, the *Molikpaq*, which will also be the production platform will rest on the berm. A 2 km trenched pipeline will connect the *Molikpaq* with the FSO. There will be a riser at the end of the pipeline where a single anchor leg mooring (SALM) buoy anchored to seafloor with multiple piles will be located. A 120,000 to 140,000 DWT storage tanker will be moored to the SALM. All drilling will be done from the *Molikpaq*, and wellheads will be located within the *Molikpaq*.

Generally, anything that adds to the relief and/or structural diversity of soft bottom marine habitats will attract fish (Polovina 1991). The armoured berm production structures, mounds of cement and debris will create artificial reefs that will be colonized by epifaunal animals and will attract fish (Stanley and Wilson 1990; Dustan et al. 1991; Black et al. 1994). Pelagic fish are also attracted to the structures but are generally found around and near structures and not within them (Gallaway et al. 1981). The fish community found within, very near and around offshore oil and gas structures, to some extent, depends on the nature of the structure (Stanley and Wilson 1991). Studies conducted in the North Sea have shown that cod, haddock and other commercially important species are attracted to and concentrate around production facilities (Picken and McIntyre 1989). The most significant structure on the bottom will be the armoured berm. It will be particularly attractive to fish if the surface is colonized by seaweed, which is likely.

The presence of fish is likely to attract fish-eating marine mammals. These include most of the pinnipeds and small cetaceans. This potential attraction, in some cases, may not be counterbalanced by effects of noise. As shown below, marine mammals habituate to noise and some species are almost totally oblivious to noise when feeding, to the point where it is difficult if not impossible, to scare them away with noise. Thus, marine mammals may be attracted to the production facilities by the presence of fish. Impacts are likely to be negligible.

Migrating birds nearing the end of their migration could be attracted to the drilling platforms and supply boats. In the past, some concern has been expressed that birds nearing the end of their migration could land on structures and die of exhaustion and lack of food and water, and that if the structures had not been present, the birds would have made a landfall.

The Buccaneer oil and gas field is 45 km offshore of the northeastern Gulf of Mexico and within a major migration corridor used by birds migrating across the Gulf of Mexico. Northbound birds which had died of exhaustion were found on the platforms during spring migration (Aumann 1980). The author points out that if the structures had not been present the birds may have made it to land in one hour, but could have died on arrival or before reaching land. Fall migrants were not found on the Buccaneer platforms which were near the start of the autumn trans-Gulf flights. There are very many platforms in the Gulf of Mexico.

Although birds are known to make similar migrations to and from the north coast of the Okhotsk Sea from Sakhalin Island, there will be only one production platform and one FSO present offshore. Thus, impacts on migratory birds should be negligible.

Gulls and terns are known to make extensive use of offshore structures for resting and feeding (Aumann 1980). However, many ships can be found on the Sea of Okhotsk, and many of these are more attractive to seabirds because they provide potential food in the form of fish refuse. The passive use of structures by resting gulls and terns would have negligible effects on the birds.

Overall, impacts on marine and terrestrial birds caused by the presence of structures should be negligible.

Lights and Beacons

The *Molikpaq*, storage tanker, shuttle tankers and supply ships will carry navigation lights and warning lights. Working areas will be illuminated with floodlights. The helideck on the *Molikpaq* will be lit and probably have omnidirectional guidance lights.

Night-migrating birds are attracted to light sources during foggy or overcast conditions and may collide with structures (Avery et al. 1978) or be incinerated by the flare (Bourne 1979; Sage 1979). These types of collisions are infrequent. There are no quantitative data describing the frequency of collisions. Because small numbers of birds would be involved, these collisions would have negligible impact on bird populations.

Discharge of Muds and Cuttings

The *Molikpaq* is designed to drill up to 32 wells at depths of 6,100 m and angles of up to 65°. Drilling fluids are used for lubrication within the well while drilling. Only generic water based drilling fluids and authorized additives will be discharged. The generic drilling fluid types, cuttings and components (specialty additives) authorized for discharge will be consistent with those approved in the US EPA Cook Inlet Permit No. AKG285000 and/or those on the Paris Convention 'List of Substances/Preparations Used and Discharged Offshore'.

Water-based, glycol-based, and low toxicity oil-based drilling muds are of relatively low toxicity (Addy et al. 1984; GESAMP 1993; Hinwood et al. 1994). Their 96 h LC50's to a variety of fish and invertebrates are in the >1,000 to 100,000+ ppm range (Table 3).

Table 3. Acute toxicity of various types of drilling muds.

Mud Type	**96 h LC50**	**Reference**
Low-toxicity Oil	2,000->90,000	GESAMP 1993
Glycol	6,300-9,500	ANCO Product Sheet
Gel Seawater	~100,000	Thomas et al. 1984
PHPA polymer/seawater	10,000 - 100,000+	Thomas et al. 1984
Diesel oil	<100 ppm	GESAMP 1993

This is in contrast to the diesel oil based muds which were used in the past and were highly toxic. Much of the literature dealing with effects of muds and cuttings is based on the use of diesel oil based muds.

Gel/water-based muds are relatively non toxic (Table 4). The mud components are mixed with water prior to use. Concentrations of these individual components in water-based drilling mud approximate their 96 h LC50 values to rainbow trout. This type of water-based mud has 96 h LC50s for fish and invertebrates that are in the 100,000 ppm (10%) range (Thomas et al. 1984).

Table 4. Typical use and toxicity of components in gel/water-based drilling muds.

	Usage		Toxicity[1]
Mud Component	**(g/l)**	**mt/well**	**(g/l)**
Bentonite	57-114	36-71	50
Caustic soda	0.7-1.4	0.4-0.9	0.1
Soda ash	0.7-1.4	0.4-0.9	-
Barite	228-342	143-214	100

[1] 96 h LC50 for rainbow trout (from Mobil 1985).

Components of PHPA polymer/water-based muds are shown in Table 5. Typical 96-h LC50 values for fish and invertebrates exposed to polymer-based muds are a maximum of 10,000 ppm and extend to the hundreds of thousands ppm range (Thomas et al. 1984). They are slightly more toxic than the gel/seawater-based muds. Dilutions to non-toxic levels will occur close to the discharge point.

Table 5. Typical use of components in PHPA polymer/water-based muds.

	Usage	
Mud Component	**(g/l)**	**(mt/well)**
Barite	as required	
DF-VIS	2.9	2.6
Caustic Soda	4.3	3.9
Soda Ash	0.7	0.6
Sodium Bicarbonate	as required	
FLR 100	5.7	5.1
Techniflo	5.7	5.1
Sodium Sulphite	0.7	0.6
Techniguard 7000	1.1	1.0
SS-100	11.4	10.3

Heavy Metal Contamination

Drilling muds and/or the cuttings can contain heavy metals. The kinds and quantities of metals released can be quite variable depending on the composition of the mud and the cuttings. In the Gulf of Mexico, contamination by heavy metals was limited to an area within 100 m of the production platforms (Wheeler et al. 1980). However, Wheeler et al. (1980) believed that some trace elements that they found could have been deposited by produced water rather than by cuttings. The field had been in operation for 20 years at the time of sampling.

High concentrations of heavy metals are toxic, do bio-accumulate, can be passed through the food chain, and have harmful effects on marine biota (Forstner and Wittmann 1983). However, the uptake of metals by marine animals depends on the bio-availability of the metals. Bio-availability is generally low when metals are absorbed onto particles or complexed with organic molecules (Forstner and Wittmann 1983; Leland and Kuwabara 1985; Hinwood et al. 1994). This generally happens in natural waters and total concentrations do not always reflect the availability of metals to animals (Forstner and Wittmann 1983). In addition, drilling activities are unlikely to produce concentrations of heavy metals that are harmful to marine animals (Neff et al. 1980 in Hinwood et al. 1994).

Zone of Influence and Duration of Effects

Most of the data on the fate and effects of drilling muds was generated in the North Sea. There diesel-based or low toxicity-based muds were used. Oil based muds will not be used in the present development area, however, a review of the fate of the oil based muds can yield some information on the zone of influence of drilling muds and cuttings.

Data collected from over 380 sites where single wells were drilled in the North Sea indicate that contamination occurs along the axis of the prevailing current (GESAMP 1993). Theoretically, minor biological effects from single wells could be noted up to 1 km from a single well and oil could be present at distances of 1 to 8 km from the well, depending on prevailing currents (GESAMP 1993).

In areas of the North Sea, sediments initially contaminated with up to 4,300 ppm of diesel oil-based mud from multiple wells showed partial recovery of the benthos one to two years after cessation of drilling (Mair et al. 1987; GESAMP 1993). A summary of the data collected in the North Sea indicates that biological effects and contamination from single wells may not last beyond one season of winter storms (GESAMP 1993). Dustan et al.

(1991) examined individual exploratory drill sites off the Florida Keys and found no cuttings pile near seven exploration wells drilled in 20 to 50 m of water 2 to 30 years previously. The authors found no drill cuttings mounds at all seven sites that they examined. The authors concluded that with modern technology and anti-dumping regulations, exploratory drilling could probably be accomplished without leaving a trace. They caution that these results cannot be extrapolated to the effects of production wells.

In the North Sea, cuttings from 5 wells discharged at one location contaminated with low-toxicity oil-based muds produced only limited effects on the benthos; biological effects were noted only in the immediate vicinity of the platform, were comparatively weak at 250 m and undetectable at 750 m from the platform (Addy et al. 1984).

Davies et al. (1984) examined the distribution of muds and cuttings around nine production platforms where multiple wells were drilled mostly using diesel-based muds. There was a large pile of cuttings around the platform and hydrocarbon concentrations 1000 times background or more to 250 m from the platform. The concentration gradient was very steep and background levels were reached 2,000 to 3,000 m from the platform. Biological effects on the benthos were noted to distances of 400 to 1,000 m. These zones of effect are elliptical in shape with the distances noted above representing maximum distances

Mitigation

Mitigation measures that have been built into the project design include the use of low-toxicity water-based drilling mud and recovery and recycling of the mud.

Drilling mud will be recycled and reused. Sand and drill cuttings will be separated from the mud and disposed of over the side and below the water surface. Some mud will remain on the disposed cuttings and in the water used in the process.

The use and discharge of drilling fluids, cuttings, and other effluents will comply with and be consistent with:

- past drilling discharge experiments in the Sakhalin Region,
- U.S. Environmental Protection Agency (EPA) Oil and Gas Offshore Effluent Guidelines (40 CFR Part 435),
- Paris Commission "Guidelines Regarding Harmonization of Procedures of Approval, Evaluation and Testing of Offshore Chemicals and Drilling Muds, and
- Accepted good industry practice.

The continuation of the experimental discharge, in combination with intensive environmental monitoring will allow a more complete evaluation of discharge impacts on the Sakhalin environment.

The best available and well proven processing equipment will be utilized on the *Molikpaq* to insure that these conditions can be met, and training and awareness programs will be implemented to maximize the utility of the protocol.

For all drilling fluid systems, additives, and other chemicals proposed for discharge from the rig, a chemical inventory will be kept. All chemicals used and discharged during drilling, well completion or treatment will be approved in advance by Russian authorities. Approval of chemicals for discharge will be based on evidence of their low potential for harmful effects. Data on the chemical will be submitted in advance in order to obtain discharge approval.

The discharge of drilling fluids containing any additive (or component) not permitted under the above legislation shall require authorization from the Sakhalin Island Ecological Committee prior to discharge. Discharge approval for additional chemicals will be based on toxicity and fate consistent with the Paris Commission Guidelines.

Discharge of Produced Water

Oil bearing formations usually contain water as well as oil. Gas and/or water are injected into wells to maintain reservoir pressure and to enhance the recovery of oil. Preliminary development plans call for gas injection to be followed by water injection. Water injection will be up to 8.12 million t/yr (140,000 B/D). The injection water will be filtered and an oxygen scavenger added. A membrane sulphate removal system may be used to remove sulphate from the injection water.

Formation water and injection water will be recovered with the oil and gas. This produced water will be separated from the oil in a hydro-cyclone. The oil will be returned to the oil processing cycle and the water will be passed through a precipitator for polishing and degassing. The water will then be discharged at a depth of 7 m below the surface. The produced water will be processed such that the average monthly concentration of hydrocarbons is 40 mg/l or less. Monitoring will be conducted to ensure that this oil in water concentration is not exceeded. The average produced water discharge rate from the *Molikpaq* for the first 10 years will be approximately than 800 m^3/day and produced water output for each year is estimated to be:

Year 1	< 80 m^3/D
Year 2	< 160 m^3/D
Year 3	< 160 m^3/D
Year 4	< 160 m^3/D
Year 5	< 160 m^3/D
Year 6	< 160 m^3/D
Year 7	< 160 m^3/D
Year 8	< 1120 m^3/D
Year 9	< 2400 m^3/D
Year 10	< 4000 m^3/D

Zone of Influence

The reservoir temperature is about 60°C. The produced water will be less dense than the receiving seawater and, if discharged at the surface, would form a plume at the sea surface. To enhance dispersion of the produced water, it will be discharged 7 m below the sea surface. When discharged at these depths, the plume will tend to rise, but in so doing, it will be mixed with the receiving water so that the temperature approaches that of the receiving water within a few 10's of metres of the discharge (Black et al. 1994).

Modelling done for the Hibernia (off Newfoundland) development scenario for discharge above the thermocline, predicted dilution by a factor of 170 near the discharge, by a factor of 1,000 at a distance of 500 m and 10,000 at 5 km downstream (Mobil 1985). It

(PAHs). All but the PAHs, evaporate quickly and pose only a very localized threat to marine organisms (Black et al. 1994). The PAHs are more persistent and are probably responsible for biological effects near produced water outfalls (Black et al. 1994). Some of the chemicals added to the injection water are toxic, however, there is little information on their concentrations in produced water (Black et al. 1994).

Produced water is generally considered to be non-hazardous with 96 h-LC50 values for invertebrates and fish of 1,000 to > 10,000 ppm (GESAMP 1993). Acute toxicity is unlikely at dilutions of 100 fold (Sommerville et al. 1987). As shown above, dilutions of 100 fold will occur near the discharge point.

The concentrations of toxic chemicals, that originate in the formation, in most produced waters are less than the 96 h LC50 levels for most species and are not of ecotoxicological concern, so there should be no acute toxicity beyond a few 10's of meters of the discharge (Sommerville et al. 1987; GESAMP 1993).

A few ml of oil on the plumage of a seabird will cause death within a few days (Peakall et al. 1987). Seabirds survive external oiling with 0.1 ml of oil, but show decreased reproductive success (Butler et al. 1988). Oily water will be treated before discharge. Concentrations of oil in the discharge will average 40 mg/l (ppm). Dilution by a factor of 1,000 would occur within 50 m downstream of the discharge (Sommerville et al. 1987). In addition the oily water will be discharged below the surface. Thus, it is very unlikely that birds at the surface will contact enough oil to cause direct effects on themselves or on their reproductive success.

Most of the marine mammals of the Sakhalin Island region rely on blubber rather than fur for insulation; thus, they can withstand some degree of external oiling with no serious damage (Richardson et al. 1989). The quantities of oil causing sublethal effects are greater than those resulting from discharge of produced water.

Chronic releases of oily water are likely to have negligible impacts on birds and marine mammals

Discharge of Other Fluids and Solids

Well Completion and Treatment fluids

Components of well completion and treatment fluid should be approved in advance for discharge. In addition, the following regulations will apply:

		Monitoring Requirements		
Effluent Characteristics	**Discharge Limitation**	**Measurement Frequency**	**Sample Type/Method**	**Reported Value(s)**
Volume	No limit	Monthly	Estimate	Monthly Average
Toxic substances and/or chemicals not approved for discharge	No discharge	Chemical Inventory	Record of Chemicals and their disposition	Material Tracking Logs
Free oil	No discharge	Daily		Visual observation of receiving water Number of sheens observed

Completion, packer and workover fluids are pumped into the well after drilling to prepare the well for production. Workover fluids are similar in composition to completion fluids. About 200 m^3 of fluids containing about 0.7 tons of calcium chloride as well as

The *Molikpaq* will not have internal storage for oil, oil will be pumped to the FSO. The FSO and shuttle tankers will have independent ballast tanks, so there will be no possibility of oil-contaminated ballast water being discharged over the side.

Impacts of this uncontaminated cooling and ballast water should have negligible impacts on marine mammals and birds.

Deck Drainage

The *Molikpaq* will have three separate drainage systems.

1. Drainage from the drill floor, mud pump room, drill cellars, and drilling cuttings will be routed to a hazardous drain and discharged over the side

2. Oily drains will be routed to and oil/water separator and the oil will be burned in the flare boom and water discharged over the side. There will be separate drains from equipment catchment trays that will be routed to a slop oil tank and then to the oil/water separator.

3. Non-hazardous 'clean' drains that will discharge over the side.

No free oil will be discharged.

Effects of discharge of deck drainage should be similar to that of discharge of produced water and this should result in negligible impacts on marine mammals and birds.

Sanitary and Domestic Waste

The *Molikpaq* will have accommodation for 105 people. Grey and black water will be routed to a sewage treatment plant where it will undergo grinding, aeration, recycling and settling. The supernatant liquid will undergo Ultra Violet sterilization prior to being discharged. The sludge will be burned in and incinerator.

Discharged sterilized treated sewage will be quickly diluted. It should have negligible impact on marine mammals and seabirds.

Garbage and Other Waste

Solid type process waste will be packaged and shipped to shore and so, will not interact with marine mammals or birds.

Chronic Spills and Small Accidental Spills of Oil

Fuel and other chemicals will be transported by supply boat from onshore facilities to the *Molikpaq*. There could be routine spillage or small accidental spills of these materials while they are in transit, during transfer to the *Molikpaq*, or while they are stored on the *Molikpaq*.

Small oil spills could occur because of human error during production, during transfer to the FSO or the shuttle tanker, a pipeline leak, malfunction of the oil/water separator, misdirection of oil waste to direct discharge, or any number of other means. Most of these spills would be small and could be dealt with on site.

When warned of a threat, personnel on the FSO will perform a controlled disconnect. All sub-sea facilities, including the pipeline will be shutdown. Little, if any, crude oil would be released during a controlled disconnect. However, if an emergency disconnect is required, there would be an emergency shutdown and a loss of crude oil.

Impacts.--As shown in the 'Effects of Oil' section below, marine mammals usually sustain little serious damage from large spills. Impacts of small spills on marine mammals are likely to be negligible.

Impacts of oil spills on birds are often unrelated to the size of the spill. (see "Effects of Oil" below). Large spills can kill few birds and small spills can kill many birds. Mortality depends on the kinds of birds present and their numbers. If large numbers of seabirds or waterfowl are present at the time of a small spill and are oiled, then large numbers could be killed. Impacts on seabirds could be minor to moderate, sub-local and short-term to medium term and, thus, significant.

Mitigation.--All crude oil transfers, fuel, chemical and waste handling activities will be carried out in a manner designed to minimize or eliminate chronic inputs and accidents. An Environmental Protection Plan will provide details of safe crude oil transfer, and fuel, chemical, and waste handling and storage procedures. Workers will be trained in these proper procedures.

Shutdown systems and routines will minimize environmental effects from accidental damage to the *Molikpaq* and FSO by isolating systems and equipment. Shutdown routines will be developed in the detailed design phase.

The *Molikpaq* will be equipped with appropriate accidental oil spill equipment and supplies. This material will be sufficient to deal with small accidental releases. The UPCO will ensure that rig supervisors and personnel are trained in spill response and are familiar with the requirements of the emergency plans for small spills. Rapid and effective deployment of oil spill response measures could reduce impacts on seabirds.

Spills of Other Material

The *Molikpaq* will have storage facilities for:

2,000 m^3 barite and cement
390 m^3 mud in tanks
70 m^3 drill water
5,000 m^3 fuel
500 m^3 potable water
2,200 t pipe and casing

In addition, oxygen scavengers, BOP fluid, drilling mud additives and many other chemicals used in drilling operations could be accidentally spilled. Spills of other materials that do not contain hydrocarbons are likely to have negligible impacts on marine birds and mammals

Effects of Noise

Marine animals, particularly mammals, are very dependent upon the underwater acoustic environment. Thus, there is concern about potential negative effects caused by the introduction of man-made noise into the marine environment. The reactions of marine animals to underwater noise can be variable and depend on the characteristics of the noise source, the species involved, and the behavior of the animal at the time of disturbance.

Because underwater noise propagates for long distances, the potential zone of influence around a particular vessel can be many tens of km in radius. The zone of influence of underwater noise includes the development/production area, shipping routes between the supply base and the drilling/production rig, and the route that the helicopters will fly between the airport and the *Molikpaq*.

In this section, information on the reactions of marine animals to noises of the kind that will be associated with the development and operation of an oil field will be used to make impact predictions. This section is lengthy because the subject matter is complicated. Reactions of marine animals to underwater noise are extremely variable. Thus, much background material must be evaluated and presented in order to justify impact predictions.

The sea is a naturally noisy environment. Natural ambient noise is often related to sea state. Ambient noise tends to increase with increasing wind speed and wave height (Table 6). In many areas, shipping is a major contributor to ambient noise.

Table 6. Broadband underwater ambient noise levels and noise levels at dominant frequencies produced by various activities associated with offshore oil and gas development. Noise associated with other activities is included for comparison. From Richardson et al. (1995a).

Source	**Source Levels**		
	Broadband	**At Dominant Frequencies**	
	dB re 1 µPa	**Hz**	**dB re 1 µPa[1]**
Ambient Noise, wind < 1 kt		100	60
wind 11-16 kts		100	97
wind 22-27 kts		100	102
heavy shipping		50	105
light shipping		50	86
remote shipping		50	81
TNT explosion - 0.5 kg at 60 m	267	21	
Seismic Airguns	216-259	50-100	
Depth Sounder	180+	12,000+	
Semisubmersible Drilling Rig - working	154	7-14, 29, 70	
Drillship - working, 20 m water depth	174-185	to 600	
Supply Boats	170-180	20-100	
with propeller nozzles	-10		
with bow thrusters operating	+11		
Large Tanker	186	100+, 125	177
Supertanker	190 - > 205	70	175
S. Puma Helicopter at 300 m asl. Received level at sea surface		20,50	105-110
Received level at 3-18 m depth			65-70

[1]1/3 Octave band level

Construction

Stationary dredges may cause limited avoidance of the area by marine mammals. White Whales approached within 400 m of stationary dredges (Ford 1977; Fraker 1977a,b). Bowhead Whales approached within 800 m of the site of construction for an artificial island where a suction dredge was operating (Richardson et al. 1985a,b,c 1990a). Dredge sounds were above ambient for several km from the site. During playback experiments with Bowhead Whales, whales stopped feeding at distances of 800 m and moved away to distances > 2 km of the simulated dredge sounds (Richardson et al. 1985c; 1990a). Gray Whales abandoned a wintering lagoon during years with much shipping and the constant dredging operations required to keep the shipping channel open: they reoccupied the lagoon after shipping subsided (Bryant et al. 1984).

Construction activities may cause some temporary displacement of whales and some seals for distances of a few km. Impacts on behavior are likely to be minor, local, and short-term. Impacts on populations are likely to be negligible.

Drilling

Self contained concrete drilling rigs such as the *Molikpaq* are relatively quiet when not drilling (Hall and Francine 1990, 1991). When drilling, total received sound levels were about 112 dB at 1.4 km. Most of the energy is infrasonic, below 20 Hz. There are few data on noises produced by self contained concrete drilling rigs or on reactions of marine mammals to them. The deck of the *Molikpaq* will be 14 m above mean sea level. The drilling platform and all necessary support equipment is on the deck in modular buildings. The noise levels produced by these rigs is comparable to those produced by semisubmersible drill rigs. Generally, noise levels produced by semisubmersible drill rigs are lower than those produced by drillships or other types of caisson rigs where some machinery is below the waterline (Richardson et al. 1995a; Table 6). Noise from a semisubmersible drilling rig working in 114 m water depth in the Bering Sea did not exceed ambient noise levels beyond a range of 1 km (Greene 1986). Support boats were also present at the time these measurements were taken. In contrast, noise produced by working drillships did not decline to ambient levels until distances beyond 10 km from the source (Richardson et al. 1995a).

Development activities may produce intermittent low frequency sounds. Specific information about the reactions of some Baleen Whales to low-frequency noise pulses has been obtained by observing their responses to pulses from airguns and other non-explosive methods of marine seismic exploration. Humpback, Gray, and Bowhead Whales all seem quite tolerant of noise pulses from marine seismic exploration (e.g., Malme et al. 1984, 1985, 1988; Richardson et al. 1986; Ljungblad et al. 1988; Richardson and Malme 1993). The same may be true of Fin and Blue Whales (Ljungblad et al. 1982; McDonald et al. 1993). These species usually continue their normal activities when exposed to pulses with peak received pressures as high as 150-160 dB re 1 μPa, and sometimes even higher. Such levels are 50-60 dB or more above typical 1/3-octave ambient noise levels. However, subtle behavioral effects are suspected to occur at least some of the time at lower received levels, at least in Bowheads and possibly Gray Whales.

Gray Whales exposed to underwater playbacks of drilling noises while migrating off the California coast showed responses to all noise types, including reduced swimming speed, and slight seaward or shoreward diversions in course (Malme et al. 1984). Reaction distances for semisubmersible and relatively quiet types of platforms were 4 to 20 m. Reaction distances for inherently noisier drillships were 1.1 km. Tests on the Gray Whale summering grounds in the northern Bering Sea indicate that the results obtained off California may be applicable to that area as well (Malme et al. 1986, 1988).

When exposed to sounds from a drillship, some White Whales altered course to swim around the source, increased swimming speed, or reversed direction of travel (Stewart et al. 1982). Reactions to semisubmersible drillship noise were less severe than were reactions to motorboats with outboards. Dolphins and other Toothed Whales show considerable tolerance of drillrigs and their support vessels.

Bowhead Whales did react to drillship noises within 4 to 8 km of a drillship when received levels were 20 dB above ambient or about 118 dB re 1 μPa (Greene 1985, 1987; Richardson et al. 1985a,c, 1990a). Reaction was greater at the onset of the sound (Richardson et al. 1995a). Thus, Bowhead Whales migrating in the Beaufort Sea avoided an area with radius 10 km around a drillship which corresponded to received noise levels of 115 Db re 1 μPa (Richardson et al. 1990a). Some whales are less responsive and habituation may occur, so that in time, Bowheads may be seen within 4 to 8 km of a drillship (Richardson et al. 1985a,c 1990a). Sound attenuates less rapidly in the shallow Beaufort Sea where these experiments were conducted than in temperate waters of greater depth. Off California, the reaction zone (120 dB re 1 μPa) around a semisubmersible drill rig was much less than 1 km for Gray Whales (Malme et al. 1983, 1984). Humpback Whales showed no clear avoidance response to received drillship broadband noises of 116 dB re 1 μPa (Malme et al. 1985). Baleen Whales may show behavioral changes to received broadband drillship noises of 120 dB re 1 μPa or greater. Broadband source levels produced by a working semisubmersible drilling rig may be about 154 dB re 1 μPa at 1 m (Table 6). Assuming spherical spreading, received levels at 100 m distance would be about 114 dB re 1 μPa. Thus, behavioral reactions could be limited to a very small area around the drilling rig.

Sea Otters showed little or no reaction to drilling noises (Riedman 1983; 1984). When their heads were above water they would not hear the sounds. Sea Otters continued to dive and feed at distance of 400 m+ from the source.

Ringed and Bearded Seals have been observed swimming and diving within 50 m of an underwater projector that was broadcasting drilling noises (Richardson et al. 1990b, 1995). However, springtime densities of ringed Seals were reduced within 3.7 km of an artificial island on which drilling operations were being conducted (Frost and Lowry 1988).

Impacts of drilling operations on marine mammals may be negligible to minor, local, and short to medium-term, depending on the species and duration of drilling. Impacts would not be significant. However, if drilling activities are continuous, some habituation may occur, thereby reducing impacts.

Blasting

Death and injury resulting from underwater explosives were dealt with on page 4 -- Blasting. This section deals with the effects of noise generated by blasting activities. The noise pulses from 3.2 kg blasts will be well above the usual ambient sound levels out to a distance of many tens of kilometres (Richardson et al. 1995a, b). It is assumed that Baleen Whales are well adapted for hearing low frequency sounds, and thus that their hearing sensitivity is limited by ambient noise rather than their absolute hearing thresholds. If so, Baleen Whales at long ranges will hear the pulses as brief transient sounds, faint in the case of very distant whales and stronger in the case of whales within a few kilometres of the berm site.

Toothed Whales (or at least the smaller species whose hearing has been measured) have rather poor hearing sensitivity at the low frequencies. However, they are expected to detect the signals from the charges at distances exceeding 50 km. For example, at 1000 Hz, thresholds of White Whales, Harbor Porpoises and Bottlenose Dolphins range from about 83 to 102 dB re 1 μPa. The expected Sound Exposure Level (SEL) of noise from the charges in the 1/3-octave band centred at 1000 Hz could be 215 to 222 dB (Richardson et al. 1995a). Transmission loss at 1000 Hz could be about 95 dB at a distance of 50 km from the source (Richardson et al. 1995a). Animals detect peak pressure and SEL underestimates peak pressure by a large amount. SEL will be well above 102 dB at range 50 km and so detection distances for the charges will be well beyond 50 km.

The Baleen Whales that have been studied show some avoidance of areas where there are noise pulses with received peak pressures exceeding 160-170 dB re 1 μPa (SEL near 156 dB re 1 μPa). Overall broadband pulse levels from the charges are may diminish to 160-170 dB peak pressure at distances of about 100 km (Richardson et al. 1995a). There is the possibility that Baleen Whales within this distances might show some avoidance. Avoidance reactions near the outer edge of this 100 km zone are likely to be minor if they occur at all. Whales closer to the berm site would be expected to swim away from the area. Whales are expected to reoccupy the area after the blasting ends. In the case of migrating animals, any that bypass the area upon hearing the pulses are expected to resume use of the usual migration corridor through the area during the next migration season. Any avoidance reactions that do occur will be short-term and of negligible consequence to marine mammal individuals or populations. Avoidance reactions will have the benefit of reducing the likelihood that any marine mammals will be close enough to a blast site to be injured.

The reaction threshold of dolphins and other Toothed Whales to noise pulses has not been determined. Given their rather poor hearing sensitivity at low frequencies (Richardson et al. 1995a), it is reasonable to assume that they are less sensitive to explosion noise than are Baleen Whales. Therefore, effects are predicted to be less than those discussed in the preceding paragraph for Baleen Whales. Again, any avoidance that does occur will serve to reduce the likelihood of close approach to berm site, and thus to reduce the likelihood of physical injury or mortality.

Transient sounds are common in the ocean as a result of various natural phenomena as well as human activities. The mere detection of a faint noise pulse from a distant source, explosion or otherwise, is not expected to have any negative effects on marine mammals. Impacts on behavior would be minor, sub-local to local and short-term.

Operations

The deck of the *Molikpaq* will be 14 m above mean sea level. A production module will be added to the structure. It will be supported by the *Molikpaq's* caisson. All production related and drilling machinery will be well above the waterline. Self contained concrete drilling rigs such as the *Molikpaq* are relatively quiet when not drilling (Hall and Francine 1990, 1991). When production operations are underway, there will be the additional noise of production machinery.

There are very few data on noises associated with production activities (Richardson et al. 1995a). The few measurements that do exist were made from bottom standing metal platforms or artificial islands. Man-made islands are very quiet when compared to those produced by metal-legged production platforms (Gales 1982). He attributed the quietness of the islands to the poor sound conduction of sound through the rock and fill island. It should be noted that the artificial islands mentioned above relied on shore power. The *Molikpaq* is made of concrete and will be filled with solid ballast. Thus, conduction of production noise to the water will be poor. However, the *Molikpaq* will have onboard power generators.

The *Molikpaq* will be in the same position for at least 10 years. Hence, the effects on marine mammals are predicted to be very localized. Habituation is likely, especially if the mammals find food in the vicinity. Overall, the effects of the stationary platform on behavior are likely to be negligible to minor, sub-local, and long term. This should translate into negligible impacts on populations.

Ships and Boats

There will be a supply base at Nabil Bay near Katangli. Korsakov Kohlmsk will be the supply port from which supply boats will carry material to the *Molikpaq*. A one-way trip will require 3 to 4 d.

Broadband source levels (at 1 m) for most small ships are in the 170-180 dB re 1 μPa range (Richardson et al. 1995a). Broadband underwater sounds from the supply ship *Robert Lemeur* were 130 dB re 1 μPa at a distance of 0.56 km (Greene 1987). Some ships use bow thrusters to aid in manoeuvring. Broadband underwater sounds from the *Robert Lemeur* were 11 dB higher when bow thrusters were operating than when they were not (Greene 1985, 1987). The *Robert Lemeur* has nozzles around the propellers. Broadband noise levels from ships lacking nozzles or cowlings around the propellers can be about 10 dB higher than those from ships with the nozzles (Greene 1987).

Marine Mammals

Reactions of Baleen Whales to boat and other noises include changes in swimming direction and speed, blow rate, and the frequency and kinds of vocalizations (Richardson et al. 1995a). Baleen Whales may approach or avoid boats (Watkins 1986). Avoidance was strongest when boats approached directly or when vessel noise changed abruptly (Watkins 1986; Beach and Weinrich 1989). Humpback Whales responded to boats at distances of at least 0.5 to 1 km and avoidance and other reactions have been noted in several areas at distances of several km (Jurasz and Jurasz 1979; Bauer 1986; Dean et al..1985; Bauer and

Herman 1986). During some activities and at some locations, Humpbacks exhibit little or no reaction to boats (Watkins 1986). Right Whales also show variable response to boats. There may be an initial orientation away from a boat, followed by a lack of observable reaction (Atkins and Swartz 1989). A slowly moving boat can approach a Right Whale, but an abrupt change in course or engine speed will elicit a reaction (Goodyear 1989; Mayo and Marx 1990; Gaskin 1991). When approached by a boat, Right Whale mothers will interpose themselves between the vessel and calf and will maintain a low profile (Richardson et al. 1995a). The closely related Bowhead Whale will begin avoiding diesel powered boats at distances of 4 km; they first attempt to flee and then swim perpendicular to the boat (Richardson et al. 1985b,c; Koski and Johnson 1987). They may be displaced by a few km when fleeing, although some Bowheads may return to the area within a day. Bowheads show strong reactions to boats and will flee, change dive profiles or exhibit other changes in behavior when approached by boats (Richardson et al. 1995a). Effects are transitory.

While on their southern summering grounds, Gray Whales show little response to slow moving or anchored vessels, but do show short-term escape reactions to fast moving and/or boats that follow an erratic course (Reeves 1977; Swartz and Cummings 1978; Swartz and Jones 1978, 1981). The whales appear to habituate to the presence of whale watching boats over the course of the winter. Gray Whales may not be seriously disturbed by noises from small boats, but change calling behavior to compensate for masking effects of the noise (Dahlheim 1987). Heavy ship traffic may cause Gray Whales to abandon a specific wintering ground (Rice and Wolman 1971; Gard 1974; Reeves 1977).

While migrating, Gray Whales may change course when within 15 to 300 m of a ship (Schulberg et al. 1989). However, many collisions have been reported (Patten et al. 1980; Schulberg et al. 1989). Off the west coast of North America, there is a possibility that they Gray Whale migration route has been displaced offshore by nearshore vessel traffic and other human disturbance (Rice 1965; Wolfson 1977). However, the change in route may have occurred for other reasons and there is no clear evidence implicating shipping. Overall, most of the range of the eastern population of Gray Whales is used by vessels and is subject to noise and disturbance by other human activities and the population has recovered from over harvesting. This would indicate little or no overall impacts of disturbance at the population level.

Dolphins may tolerate and often approach boats of all sizes and ride the bow and stern waves (Shane et al. 1986). At other times, dolphin species that are known to be attracted to boats will avoid them. This avoidance is often linked to previous boat-based harassment of the animals (Richardson et al. 1995a). Other species avoid boats. Generally, small cetaceans avoid boats when they are approached within 0.5 km to 1.5 km, with some species showing avoidance at distances of 12 km (Richardson et al. 1995a).

In summary, whales may show little reaction or slow, inconspicuous avoidance reactions to boats that are moving slowly on a steady course. If the vessel changes course and/or speed, whales likely will swim rapidly away. Avoidance is strongest when the boat travels directly towards the whale. The potential impacts on behavior of Baleen and Toothed Whales of individual passages by supply vessels during life of the project are likely to be minor, long-term and sub-local to local. Impacts on populations would be negligible. Impacts on mammals can be reduced if the boats maintain a steady course and speed, whenever possible. The Environmental Protection Plan will document locations of nearshore areas that are extensively used by seals and whales. These areas will be avoided by ships and boats reducing potential impacts to negligible.

Sea Associated Birds

The normal offshore activities of ships are likely to have inconsequential effects on sea-associated birds. Some species will be attracted to drill rigs and boats. Direct effects on other species are unlikely because seabirds are highly mobile and can easily avoid ships by flight or by diving. Energy expended in these infrequent evasive movements would be trivial and would have no effect on an individual bird's daily energy budget.

Noise and disturbance from the ship itself are unlikely to affect birds in the area. Birds have adapted to ship traffic throughout the world. Some species, such as Northern Fulmar and gulls, are actually attracted to ships and often follow them for extended periods (Wahl and Heinemann 1979; Brown 1986). Thus, noise and disturbance from normal offshore ship operations will not affect sea-associated birds in offshore waters. Impacts would be negligible.

There is a concern that ships could disturb seabird colonies if they passed nearby. Cliff-nesting species are susceptible to panic responses caused by man-induced activities. Temporary abandonment of colonies by adult birds can also lead to increased predation on unguarded eggs and young by gulls and ravens. Helicopter traffic is the main concern, but the ships themselves could cause minor to moderate, local, medium-term significant impacts when the colony is occupied. The Environmental Protection Plan will identify colonies and their timing of use by birds. Avoidance of colonies will lead to negligible impacts. Prudent seamanship dictates that the supply vessels will maintain adequate distances from any seabird colonies.

Helicopters

Personnel will be transported by helicopter from Nogliki to the Molikpaq. Two helicopters will be chartered year-round during the operational phase and an additional one will be chartered during drilling operations.

Helicopters are quite noisy compared to fixed-wing aircraft. Source levels in air for helicopters can be about 150 dB re 1 μPa (Richardson et al. 1995a). Sound does not transfer well between air and water. In the upper water column (3 to 18 m water depth), received noise levels depend on the altitude of the aircraft above the water (Richardson et al. 1995a), as follows:

Altitude (m)	dB re 1 μPa
152	109
305	107
610	101

At angles >13° from the vertical, most sound is reflected from the sea surface. Thus, noise from aircraft is audible mainly within a 13° cone under the aircraft. The area of potential audibility increases with increasing depth, but the sound also attenuates with increasing water depth. Thus, a Bell 214ST was audible to a hydrophone at 3 m depth for 38 s, but only for 11 s at 8 m depth (Richardson et al. 1995a). Some airborne sounds will enter the water column at angles >13° from the vertical when seas are rough.

Marine Mammals

Pinnipeds hauled out for pupping or molting are very sensitive to aircraft disturbance (Richardson et al. 1995a). Fixed-wing aircraft flying at low altitudes below 60 to 120 m and helicopters flying below 305 m, may cause panic among adult Harbor Seals and mortality of young at haul-out beaches (Johnson 1977; Bowles and Stewart 1980; Osborn 1985). Not all Harbor Seals react in this way. Seals that have become habituated to aircraft may show little or no reaction (Johnson et al. 1989). Northern Fur Seals and Northern Sea Lions are usually frightened into the water by low flying aircraft (Calkins 1979; Withrow et al. 1985; Herter and Koski 1988; Johnson et al. 1989). In some cases, the flight into the water may be a stampede. There are few observations of the reactions of seals in the water to aircraft. Overflights at low altitudes may cause some animals to dive (Richardson et al. 1995a).

Toothed Whales show variable reactions to aircraft. Some White Whales ignored aircraft at flying at 500 m altitude but dove for longer periods and some times swam away when it was at 150-200 m (Bel'kovich 1960; Kleinenberg et al. 1964). Lone animals sometimes dove in response to flights at 500 m. Off Alaska, some White Whales showed no reaction to airplanes or helicopters at 100 - 200 m altitude, while others dove abruptly or swam away in response to overflights at altitudes up to 460 m (Richardson et al. 1991). Narwhals dove in response to helicopters flying at altitudes of below 244 m and, to a lesser degree, at 305 m (Kingsley et al. 1994). Some Sperm Whales showed no reaction to helicopters and airplanes flying over at altitudes of 150 m but some dove immediately (Clarke 1956; Mullin et al. 1991). Dall's Porpoise and Spinner Dolphins reacted abruptly to overflights at 215 to 300 m (Withrow et al. 1985; B. Wursig in Richardson et al. 1995a).

Minke, Bowhead and Right Whales reacted to aircraft overflights at altitudes of 150 to 300 m by diving, changing dive patterns or leaving the area (Leatherwood et al. 1982; Watkins and Moore 1983; Payne et al 1983; Richardson et al 1985b,c). Helicopter disturbance to Humpback Whales is a concern off Hawaii and helicopters are prohibited from approaching Humpbacks within a slant range of 305 m (Tinney 1988; Atkins and Swartz 1989; NMFS 1987).

Gray Whales sometimes react to aircraft overflights at altitudes below 400 m (Ljungblad et al. 1983; SRA 1988; Clarke et al. 1989). Reactions included abrupt turns, dives, a mother covering the calf with her body or the calf swimming under the mother.

Low flying helicopters could cause minor, short-term, and sub-local impacts on marine mammals in the water and minor to moderate, local, long-term, significant impacts on seals at terrestrial haul-out sites. Helicopters will fly at a minimum altitude of 600 m whenever possible. Beaches used by seals will be identified in an Environmental Protection Plan and avoided by overflying project aircraft. Aircraft will be prohibited from flying low over wildlife in order for passengers to 'get a better look' or for photography. These measures will reduce impacts on marine mammals, including seals on land, to negligible.

Sea Associated Birds

Most sea-associated birds flush or dive in response to low-flying aircraft (e.g., Polar Gas Project 1977; LGL Ltd., unpubl. data). The significance of these disturbances is probably low, if the flights are infrequent. In one of the few systematic studies of aircraft disturbance, Ward and Sharp (1974) found that molting sea ducks in the Beaufort Sea showed no detectable reactions to helicopter overflights at 300 m asl. Overflights at 100 m had no apparent influence on overall feeding activity or population size, although the ducks did show short-term avoidance reactions.

Studies of other species in other situations have shown a variety of responses to overflying aircraft (Davis and Wisely 1974; Gollop et al. 1974a,b; Schweinsburg 1974; Koski 1975, 1977; Barry and Spencer 1976; Fyfe and Oldenorff 1976; Platt and Tull 1977; Fletcher and Busnel 1978; Webb 1980). In general, these studies support the contention that birds respond most to low level flights and the effects of these responses are generally transitory. Nonetheless, project helicopters will be operated (minimum altitudes, routing restrictions) to minimize even these responses.

Of most concern are large colonies of nesting birds. A helicopter flying near a colony is capable of causing a panic response by the birds, which can result in loss of eggs and flightless young. Impacts would be moderate to major, local and long-term and significant.

The helicopters will fly at minimum altitudes of 600 m whenever possible and pilots will be instructed to avoid repeated overflights of concentrations of birds and/or important bird habitats. Impacts on birds in open water would be negligible. Guidelines for avoiding major bird colonies should be based on Nettleship (1980) or some other rigorous protocal. These Canadian Wildlife Service guidelines recommend that aircraft not approach closer than 8 km seaward and 3 km landward of a seabird colony from 1 April to 1 November. The Environmental Protection Plan will document the locations of seabird colonies and other areas where sea-associated birds congregate. Use of these mitigation measures will insure that potential impacts on birds will be negligible.

Effects of Oil Spills

Oil will be processed on the *Molikpaq* and then transferred to the FSO by buried pipeline. At any given time, the pipeline will contain 147 m^3 of oil. Oil will be stored on the FSO. The FSO will be a 150,000 DWT low ice rating tanker with storage for 120,000 to 140,0000 T or about 10 to 12 days of production. The FSO will have emergency weather disconnect capability. Oil will be transferred from the FSO to shuttle tankers for shipment to port. Oil spills could occur through a blowout, pipeline rupture, an accident involving the FSO or shuttle tanker or through human error while transferring oil.

The following sections deal with potential impacts of oil spills on sea associated birds and marine mammals of the Sakhalin Island region.

Sea Associated Birds

Seabirds rely on air trapped within and between feathers for insulation. Oil mats the feathers, destroying their insulative and water repellent properties (Mansfield 1971; Clark

1984). A few ml of oil on the plumage of a seabird will cause death within a few days. The underlying skin becomes wet, and the birds cannot compensate for the heat loss. In cold water, oiled birds die.

An oil spill at sea can kill tens of thousands of birds (Clark 1984; Piatt et al. 1990). Not all dead birds are washed ashore, so many estimates of mortality are actually underestimates (Burger 1993). The UK Royal Society for the Protection of Birds estimates that 46,000 birds died over 9 years around the UK because of the unreported and illegal dumping of oil by ships (Anon 1980). Vermeer and Vermeer (1975) have compiled other estimates indicating that 14,000 to 50,000 birds perished as a result of routine pollution around the British coast in a four month period. Clark (1984) estimates that 150,000 to 450,000 birds die annually in the North Sea and North Atlantic from oil pollution of all sources (Clark 1984). Thomson et al. (1990) estimated that 21,000 birds die annually from operational spills on the Atlantic coast of Canada and that 72,000 birds die annually from all operational spills in Canada.

Brown et al. (1973) estimated that 12,000 birds died from contact with oil spilled by the *Arrow* and *Irving Whale*. Total amount of oil spilled was 10,000,000 litres. A 100,000 to 200,000 litre spill killed 40,000 birds off Holland and relatively small discharges from two ships killed 30,000 birds off Denmark (Baker 1983). Mystery spills killed an estimated 18,000 seabirds in Placentia Bay, Canada (Anon 1990). Piatt et al (1990) reported that between 100,000 and 300,000 were killed by the *Exxon Valdez* which spilled 260,000 barrels of crude oil into Prince William Sound, Alaska. Even small spills can cause mass mortality of seabirds (Joensen 1972; Campbell et al. 1978). A major spill that persisted for several days near a nesting colony (see Shuntov et al. 1996) could kill a high proportion of the pursuit-diving birds (e.g., Murres) within it (Cairns and Elliot 1987).

In contrast to the above, relatively low mortalities have been recorded from some huge spills. The *Amoco Cadiz* spilled 230,000 tonnes of crude oil and caused the recorded deaths of only 4,572 birds (Clark 1984). The *Arco Anchorage* spilled about 1,000,000 liters of oil into Port Angeles Harbor (Strait of Juan de Fuca) and killed only 2,000 seabirds (Lindstedt-Siva et al. 1987). Burger (1993) found no clear correlation between the size of the spill and numbers of seabirds killed. The density of birds in the spill area, wind velocity and direction, wave action, and distance to shore may have a greater bearing on mortality than size of the spill (Burger 1993).

Nesting seabirds that are contaminated with oil, and survive, can contaminate their eggs with oil (Albers and Szaro 1978). Seabirds survive external oiling with 0.1 ml of oil, but show decreased reproductive success. When eggs are contaminated with diesel oil, the young may die soon after hatching (Harfenist et al. 1990). Hatching and fledging success of young is related to the internal or external dose received by adults. Oil spills can also cause indirect reproductive failure. Eppley and Rubega (1990) suggest that exposure to an Antarctic oil spill caused changes in normal parental behavior of south polar skuas which exposed young to increased predation and caused total reproductive failure in that population. In another case, abandonment of nesting burrows by oiled adult Leach's Storm Petrels may have caused reproductive failure in that population (Butler et al. 1988). Thus, a spill that occurred during the reproductive period could cause mortality of young, even if the adults survived exposure to oil.

Oiling that does not cause immediate death can cause serious and/or eventually fatal, anatomical and physiological changes in birds (Khan and Ryan 1991). These include emaciation, renal tubular degeneration, necrosis of the duodenum and liver, anemia, electrolytic imbalance and interference with growth and reproduction. Because of these delayed effects, attempted rehabilitation of birds through external cleaning is most often not successful (Khan and Ryan 1991).

Simply put, oiled birds die and any oil spill is likely to cause at least some, and at worst, extensive, bird mortality. Oil and fuel spills have the greatest impacts on seabirds and marine waterfowl if the spill occurs at a time and place where birds are concentrated, e.g., near nesting colonies or feeding/staging aggregation areas. A spill could have moderate to major, regional, long-term significant impacts on bird populations.

Marine Mammals

In general, marine mammals are less susceptible to oiling than are sea associated birds. Whales and pinnipeds rely on a layer of blubber for insulation and oiling of the external surface does not appear to have any adverse thermoregulatory effects (Kooyman et al. 1976, 1977; St. Aubin 1990; Geraci 1990). Sea Otters, Polar Bears, Fur Seals and new-born seal pups rely on their fur for insulation.

<u>Seals</u>

Reports of the effects of oil spills have shown that some mortality of seals may have occurred as a result of oil fouling, however, large scale mortality has never been observed (St. Aubin 1990). The largest impact of a spill was on young Hair Seals in cold water (St. Aubin 1990). Brownell and LeBeouf (1971) fond no marked effects of oil from the Santa Barbara oil spill on California Sea Lions or on the mortality rates of new-born pups.

Effects on marine mammals were not well studied at most spills because of lack of baseline data and/or the brevity of the post-spill surveys. Intensive and long-term studies were conducted after the *Exxon Valdez* spill in Alaska. There may have been a long-term decline of 36% in numbers of molting Harbor Seals at oiled haul-out sites in Prince William Sound, following the *Exxon Valdez* spill (Frost et al. 1994). The seals were probably not displaced and the decline probably represents mortality. Harbor Seal pup mortality at oiled beaches was 23 to 26%, which may have been higher than natural mortality (Frost et al. 1994). There were no data that provided conclusive evidence of spill effects on Steller's Sea Lions (Calkins et al. 1994). Oil did not persist on Sea Lions themselves as it did on Harbor Seals nor on their haul-out sites and rookeries (Calkins et al. 1994). Sea Lion rookeries and haul-out sites, unlike those used by Harbor Seals, had steep sides and were subject to high wave energy (Calkins et al. 1994).

Contact with oil on the external surfaces can cause increased stress and can irritate the eyes of ringed Seals (Geraci and Smith 1976; St. Aubin 1990). These effects seemed to be temporary and reversible, but continued exposure to eyes could cause permanent damage (St. Aubin 1990).

Marine mammals can also ingest oil if their food is contaminated. Oil can also be absorbed through the respiratory tract (Geraci and Smith 1976; Engelhardt et al. 1977). Some of the ingested oil is voided in vomit or faeces but some is absorbed and can cause toxic effects (Engelhardt 1981). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt 1978, 1982, 1985). Nevertheless, seals exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin 1980, 1982).

One notable behavioral reaction to oiling, is that oiled seals are reluctant to enter the water, even when intense cleanup activities are conducted nearby (St. Aubin 1990; Frost et al. 1994).

Seals that are under some type of natural stress, such as lack of food, or a heavy infestation by parasites, could die as a result of the additional stress of oiling (Geraci and

Smith 1976; St. Aubin 1990). Seals that are not under natural stress (e.g., starvation) would most likely survive oiling.

Seals exposed to heavy doses of fuel oil for prolonged periods of time could die. This type of prolonged exposure could occur if fuel oil were spilled in or reached a bay or was spilled in a lead in the ice used by seals. Seals residing in these habitats may not be able to avoid prolonged contamination and some would die.

Although seals may have capability to detect and avoid oil, they apparently do so only to a limited extent (St. Aubin 1990). Seals may abandon the area of an oil spill because of human disturbance associated with cleanup efforts, but they are most likely to remain in the area of the spill.

In general, seals do not exhibit large behavioral or physiological reactions to limited surface oiling, incidental exposure to contaminated food or to vapours (St. Aubin 1990; Williams et al. 1994). Effects can be severe if seals surface in heavy oil slicks in ice leads or if oil accumulates near rookeries and haul-out sites (St. Aubin 1990). Impacts of an oil spill in open water is likely to have minor, local, short-term impacts on seals. If a spill reached rookeries, haul-out sites or breeding beaches used by Largha or Spotted Seals, then impacts could be moderate, local to regional medium-term and significant.

Sea Otters

Sea Otters do not have a layer of blubber for insulation. They rely on their fur and a high metabolic rate supported by a prodigious rate of food consumption to cope with cold water. Contamination with oil mats the fur and destroys its insulative capacity. Oiled otters attempt to remove the oil by grooming. A Sea Otter could not survive oiling of the entire body (Geraci and Williams 1990). When the pelage is fouled, otters will spend a great deal of time attempting to remove the oil by grooming. In addition to the heat loss, caused by the oiled portion of the pelt, the otters lose valuable feeding time while grooming. Oil causes severe internal damage such as pulmonary emphysema, stress induced gastric erosions and internal haemorrhage (Lipscomb et al. 1994). Eventually these stresses overwhelm the otters, they go into shock and die (Lipscomb et al. 1994).

About 4,000 Sea Otters are estimated to have died following the *Exxon Valdez* spill (Ballachey et al. 1994). Otters that were oiled but survived, and otters that escaped oiling had higher than normal mortality rates possibly because their pelts became oiled through contact with oil-contaminated food and/or ingestion of oil with food (Ballachey et al. 1994). Sea Otters that had been oiled, rehabilitated and released also showed abnormally high mortality rates and low reproductive rates (Ballachey et al. 1994).

The Sea Otter is the marine mammal most likely to suffer immediate and long-term injury and death from oil (Geraci and Williams 1990). One can assume that most of the otters that come into contact with a spill are likely to die, if not immediately, then at some time later. Although Sea Otters have not been recorded in recent years near Sakhalin Island, if an oil spill reached the Kurile Islands, an area where Sea Otters are common, impacts could be major, local to regional, long-term and significant.

Whales

Whales rely on a layer of blubber for insulation and oil would have little if any effect on thermoregulation. Effects of oiling on cetacean skin appear to be minor and of little significance to the animal's health (Geraci 1990).

There is no concrete evidence that implicates recorded and studied oil spills, including the much studied Santa Barbara and *Exxon Valdez* spills with the death of cetaceans (Geraci 1990).

Migrating Gray Whales were apparently not greatly affected by the Santa Barbara spill. There appeared to be no relationship between the spill and mortality of marine mammals. The higher than usual counts of dead marine mammals recorded after the spill represented increased survey effort (Geraci 1990). The conclusion was that whales were either able to detect the oil and avoid it or were unaffected by it (Geraci 1990).

There may have been a significant decrease in the size of a Killer Whale pod resident in the area of the Exxon Valdez spill, but no clear cause and effect relationship between the spill and the decline could be established (Dahlheim and Matkin 1994). There were no evident effects on Humpback Whales in Prince William Sound after the *Exxon Valdez* spill (von Ziegesar et al. 1994). There was some temporary displacement of Humpback Whales out of Prince William Sound, but this could have been caused by oil contamination, boat and aircraft disturbance or displacement of food sources.

Some cetaceans can and sometimes do avoid oil, but others enter and swim through slicks without apparent effects (Geraci 1990; Harvey and Dahlheim 1994).

It can be assumed that if oil contacted the eyes, effects would be similar to that observed in Ringed Seals and that continued exposure to eyes could cause permanent damage (St. Aubin 1990).

Whales could ingest oil if their food is contaminated or it could be absorbed through the respiratory tract. Some of the ingested oil is voided in vomit or faeces but some is absorbed and can cause toxic effects (Smith 1980). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt 1978, 1982). Whales exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin 1980, 1982).

In Baleen Whales, crude oil could coat the baleen and reduce filtration efficiency, however, effects may be reversible within a few days (see Richardson et al. 1989 and Geraci 1990 for reviews). Effects of oiling of the baleen on feeding efficiency appear to be only minor (Geraci 1990). Fuel oil is not likely to cause much reduction in efficiency of the baleen.

Effects on whales in open water are likely to be negligible, but there could be minor, local, short-term effects on whales oiled in nearshore waters or at ice edges where they cannot escape (Geraci 1990). Effects may be most severe for White Whales using traditional estuarine summering areas. They continue to enter these estuaries in the face of disturbance by power boats, ships, and in some cases intense hunting pressure.

Mitigation

The *Molikpaq* will be equipped with appropriate accidental oil spill equipment and supplies. The UPCO will ensure that rig supervisors and marine personnel are trained in spill response and are familiar with the requirements of the emergency plans. Additional equipment and materials will also be identified which can be called out as required through the appropriate agencies and other operating companies.

The initial oil spill response support will be from the *Molikpaq*, support vessels and onshore supply bases. Additional support for a major emergency is available through the UPCO's membership in numerous oil spill response cooperatives.

The UPCO will have access to experienced oil spill containment and cleanup advisors as well as marine operations and environmental advisors through its headquarters. UPCO will also have access to other consortium emergency response expertise throughout the Pacific Rim.

These individuals are available on a call out basis for an oil spill and to participate in simulated oil spill exercises. UPCO, through affiliated companies, is also a member of:

- The Petroleum Association of Japan
- East Asia Response Limited (EARL), in Singapore
- Oil Spill Response Centre in Southhampton, England

These resources are available for use in a large scale emergency. UPCO participates in worldwide insurance programs to ensure funding associated with well control and pollution clean-up costs are in accordance with and in excess of any legislative requirements.

An oil spill response plan will be developed specifically for the *Molikpaq* deployment and utilization (see Section 9.6.1 of the POD). The plan will list procedures, personnel and organizations which will be utilized in response to releases. Spill response equipment to be maintained on the platform, on shore, and available from other sources will be listed. Response activities for offshore platforms and pipelines are reviewed in Section 7.5.2 of the FSR.

The oil spill response plan will document important nearshore areas used by marine mammals and seabirds. These will be mapped and prioritized according to their relative importance. Spill containment and other spill response measures would be rapidly deployed at any of these areas threatened by an oil spill according to their priority ranking. Rapid deployment of oil spill response measures could reduce impacts on birds and seals at their breeding beaches and haul-out sites.

Literature Cited

Addy, J.M., J.P. Hartley and P.J.C. Tibbetts. 1984. Ecological effects of low toxicity oil-based mud drilling in the Beatrice oilfield. Mar. Poll. Bull. 15:429-436.

Albers, P.H. and R.C. Szaro. 1978. Effects of No. 2 fuel oil on common eider eggs. Mar. Pollut. Bull. 9:138-139.

Anon. 1980. Oiled birds poll. Mar. Poll. Bull. 11:11.

Anon. 1990. Protecting our waters. Public Review Panel on Tanker Safety and Marine Spills Response Capability. Final Report. Ministry of Supply and Services.

Atkins, N. and S.L. Swartz (eds.). 1989. Proceedings of the workshop to review and evaluate whale watching programs and management needs/November 14-16, 1988, Monterey, CA. Cent. Mar. Conserv., Washington, DC. 53 p.

Aumann, G. 1980. The effect of structures on migratory and local marine birds. p 209-221 In: B.S. Middleditch (ed.), Environmental effects of offshore oil production: The Buccaneer gas and oil field study. Marine Science. Vol. 14. Plenum Press, New York.

Avery, M.L. P.F. Springer, and N.S. Dailey. 1978. Avian mortality at man-made structures: an annotated bibliography. U.S. Dep. Interior, Fish and Wildlife Service, Washington, FWS/OBS-78/58. 108 p.

Baird, I.G., B. Mounsouphom and P.J. Stacey. 1994. Preliminary surveys of Irrawaddy Dolphins (*Orcaella brevirostris*) in Lao PDR and northeastern Cambodia. Rep. Int. Whal. Comm. 44:367-369.

Baker, J.M. 1983. Impact of oil pollution on living resources. The Environmentalist 3 (Suppl. 4):1-48.

Ballachey, B.E., J.L. Bodkin and A.R. DeGrange. 1994. An overview of sea Otter studies. p 47-59 *In*: T.R. Loughlin (ed.), Marine mammals and the *Exxon Valdez*. Academic Press, San Diego.

Barry, T.W. and R. Spencer. 1976. Wildlife response to oil well drilling. Can. Wildl. Serv., Prog. Note 67. 15 p.

Bauer, G.B. 1986. The behaviour of Humpback Whales in Hawaii and modifications of behaviour induced by human interventions. Ph.D. Thesis, Univ. Hawaii, Honolulu. 314 p.

Bauer, G.B. and L.M. Herman. 1986. Effects of vessel traffic on the behaviour of Humpback Whales in Hawaii. Rep. from Kewalo Basin Mar. Mamm. Lab., Univ. Hawaii, Honolulu, for U.S. Natl. Mar. Fish. Serv., Honolulu, HI. 151 p.

Beach, D.W. and M.T. Weinrich. 1989. Watching the whales: Is an educational adventure for humans turning out to be another threat for endangered species? Oceanus 32(1):84-88.

Bel'kovich, V.M. 1960. Some biological observations on the White Whale from the aircraft. Zool. Zh. 39(9):1414-1422 (Transl. NOO-T-403. U.S. Naval Oceanogr. Off., Washington, DC. 14 p. NTIS AD-693583).

Black, K.P., G.W. Brand, H. Grynberg, D. Gwyther, L.S. Hammond, S. Mourtikas, B.J. Richardson and J.A. Wardrop. 1994. Production facilities. p 209-407 *In*: J.M. Swan, J.M. Neff and P.C. Young (eds.), Environmental implications of offshore oil and gas development in Australia - the findings of an independent scientific review. Australian Petroleum Exploration Society, Sydney.

Bohne, B.A. J.A. Thomas, E.R. Yohe and S.H. Stone. 1985. Examination of potential hearing damage in Weddell Seals (*Leptonychotes weddelli*) in McMurdo Sound, Antarctica. Antarctic J. 20:174-176.

Bohne, B.A., D.G. Bozzay and J.A. Thomas. 1986. Evaluation of inner ear pathology in Weddell Seals. Antarctic J. 21:208.

Bourne, W.R.P. 1979. Birds and gas flares. Mar. Poll. Bull. 10:124-125.

Bowles, A. and B.S. Stewart. 1980. Disturbances to the pinnipeds and birds of San Miguel Island, 1979-1980. p. 99-137 *In*: J.R. Jehl, Jr., and C.F. Cooper (eds.), Potential effects of space shuttle sonic booms on the biota and geology of the California Channel Islands: Research reports. Tech. Rep. 80-1. Rep. from Cent. Mar. Stud., San Diego State Univ., and Hubbs/Sea World Res. Inst., San Diego, CA, for U.S. Air Force, Space Div. 246 p.

Brown, R.G.B. 1986. Revised atlas of eastern Canadian seabirds: 1. Shipboard Surveys. Can. Wildl. Serv., Dartmouth, N.W. 111 p.

Brown, R.G.B., D.I. Gillespie, A.R. Lock, P.A. Pierce and G.H. Watson. 1973. Bird mortality from oil slicks off eastern Canada, February - April 1970. Can. Field Nat. 87:225-234.

Brownell, R.L.J. and B.J. Le Boeuf. 1971. California Sea Lion mortality: natural or artifact. p 287-306 *In*: Biological and oceanographical survey of the Santa Barbara Channel oil spill 1969 -1970. Vol. 1, Biology and bacteriology. Allan Hancock Foundation, University of Southern California.

Bryant, P.J., C.M. Lafferty and S.K. Lafferty. 1984. Reoccupation of Laguna Guerrero Negro, Baja California, Mexico, by Gray Whales. p. 375-387 *In*: M.L. Jones, S.L. Swartz and S. Leatherwood (eds.), The Gray Whale *Eschrichtius robustus*. Academic Press, Orlando, FL. 600 p.

Burger, A.E. 1993. Estimating the mortality of seabirds following oil spills: effects of spill volume. Mar. Pollut. Bull. 26:140-143.

Butler, R.G., A. Harfenist, F.A. Leighton and D.B. Peakall. 1988. Impact of sublethal oil and emulsion exposure on the reproductive success of Leach's Storm-Petrels: short and long-term effects. J. Appl. Ecol. 25:125-143.

Cacchione, D.A., D.E. Drake, M.E. Field and G.B. Tate. 1987. Sea-floor gouges caused by migrating Gray Whales off northern California. Cont. Shelf Res. 7:553-560.

Cairns, D.K. and R.D. Elliot. 1987. Oil spill impact assessment for seabirds: the role of refugia and growth centres. Biol. Conserv. 40:1-9.

Calkins, D.G. 1979 [publ. 1983]. Marine mammals of Lower Cook Inlet and the potential for impact from outer continental shelf oil and gas exploration, development, and transport. Environ. Assess. Alaskan Cont. Shelf, Final Rep. Princ. Invest., NOAA, Juneau, AK 20:171-263. 650 p. NTIS PB85-201226.

Calkins, D.G., E. Becker, T.R. Spraker and T.R. Loughlin. 1994. Impacts on Steller Sea Lions. p 119-139 *In*: T.R. Loughlin (ed.), Marine Mammals and the *Exxon Valdez*. Academic Press, San Diego.

Campbell, L.H., K.T. Sandring and C.J. Cadbury. 1978. Firth of Forth oil pollution incident, February 1978. Mar. Poll. Bull. 9:335-339.

Clark, R.B. 1984. Impact of oil pollution on seabirds. Environ. Pollut. 33:1-22.

Clarke, R. 1956. Marking whales from a helicopter. Norsk Hvalfangst-Tid. 45(6):311-318.

Clarke, J.T., S.E. Moore and D.K. Ljungblad. 1989. Observations on Gray Whale (*Eschrichtius robustus*) utilization patterns in the northeastern Chukchi Sea, July-October 1982-1987. Can. J. Zool. 67(11):2646-2654.

Coker, C.M. and E.H. Hollis. 1950. Fish mortality caused by a series of heavy explosions in Chesapeake Bay. J. Wildl. Manage. 14:435-444.

Dahlheim, M.E. 1987. Bio-acoustics of the Gray Whale (*Eschrichtius robustus*). Ph.D. Thesis, Univ. British Columbia, Vancouver, B.C. 315 p.

Dahlheim, M.E. and C.O. Matkin. 1994. Assessment of injuries to Prince William Sound Killer Whales. p 163-171 *In*: T.R. Loughlin (ed.), Marine Mammals and the *Exxon Valdez*. Academic Press, San Diego.

Davies, J.M., J.M. Addy, R.A. Blackman, J.R. Blanchard, J.E. Ferbrache, D.C. Moore, H.J. Somerville, A. Whitehead and T. Wilkinson. 1984. Environmental effects of the use of oil-based drilling muds in the North Sea. Mar. Pollut. Bull. 15:363-370.

Davis, R.A. and A.N. Wiseley. 1974. Normal behaviour of snow geese on the Yukon-Alaska North Slope and the effects of aircraft-induced disturbance on this behaviour, September 1973. Arctic Gas. Biol. Rep. Ser. 27(2):1-85.

Dean, F.C., C.M. Jurasz, V.P. Palmer, C.H. Curby and D.L. Thomas. 1985. Analysis of Humpback Whale (*Megaptera novaeangliae*) blow interval data/Glacier Bay, Alaska, 1976-1979. Rep. from Univ. Alaska, Fairbanks, for U.S. Natl. Park Serv., Anchorage, AK. 224 p. (vol. 1) + diagrams (vol. 2).

Dustan, P., B.H. Lidz and E.A. Shinn. 1991. Impact of exploratory wells, offshore Florida - a biological assessment. Bull. Mar. Sci. 48:94-124.

Eppley, Z.A. and M.A. Rubega. 1990. Indirect effects of an oil spill: reproductive failure in a population of South Polar skuas following the '*Bahia Paraiso*' oil spill in Antarctica. Mar. Ecol. Progr. Ser. 67:1-6.

Engelhardt, F.R. 1978. Petroleum hydrocarbons in arctic ringed Seals, *Phoca hispida*, following experimental oil exposure. p. 614-628 *In*: Proc. Conf. on Assessment of Ecological Impacts of Oil Spills, 14-17 June 1978, Keystone, CO. Am. Inst. Biol. Sci.

Engelhardt, F.R. 1981. Oil pollution in polar bears: exposure and clinical effects. p. 139-179 *In*: Proc. 4th Arctic Marine Oilspill Program technical seminar, Edmonton Alta. Envir. Protect. Serv, Ottawa. 741 p.

Engelhardt, F.R. 1982. Hydrocarbon metabolism and cortisol balance in oil-exposed ringed Seals, *Phoca hispida*. Comp. Biochem. Physiol. 72C:133-136.

Englehardt, F.R. 1985. Effect of petroleum on marine mammals. p 217-243 *In*: F.R. Englehardt (ed.), Petroleum effects in the arctic environment. Elsevier Applied Science Publishers, London.

Engelhardt, F.R., J.R. Geraci and T.G. Smith. 1977. Uptake and clearance of petroleum hydrocarbons in the ringed Seal, *Phoca hispida*. J. Fish. Res. Board Can. 34:1143-1147.

Fitch, J.E. and P.H. Young. 1948. Use and effect of explosives in California coastal waters. Calif. Fish & Game 34(2):53-70.

Fletcher, J.L. and R.G. Busnel (eds.). 1978. Effects of noise on wildlife. Academic Press, New York, N.Y. 305 p.

Ford, J. 1977. White Whale-offshore exploration acoustic study. Rep. from F.F. Slaney & Co. Ltd., Vancouver, B.C., for Imperial Oil Ltd., Calgary, Alb. 26 p. + fig., tables.

Forstner, U. and G.T.W. Wittmann 1983. Metal pollution in the aquatic environment. Springer-Verlag, Berlin. 486 p.

Fraker, M.A. 1977a. The 1976 White Whale monitoring program, Mackenzie Estuary, N.W.T. Rep. from F.F. Slaney & Co. Ltd., Vancouver, B.C., for Imperial Oil Ltd., Calgary, Alb. 76 p. + maps, tables, append.

Fraker, M.A. 1977b. The 1977 whale monitoring program/Mackenzie Estuary, N.W.T. Rep. from F.F. Slaney & Co. Ltd., Vancouver, B.C., for Imperial Oil Ltd., Calgary, Alb. 53 p. + maps.

Frost, K.J. and L.F. Lowry. 1988. Effects of industrial activities on ringed Seals in Alaska, as indicated by aerial surveys. p. 15-25 *In*: W.M. Sackinger et al. (eds.), Port and ocean engineering under arctic conditions, vol. II. Geophys. Inst., Univ. Alaska, Fairbanks. 111 p.

Frost, K.J., L.F. Lowry, E.H. Sinclair, J. Ver Hoef and D.C. McAllister. 1994. Impacts on distribution, abundance and productivity of Harbor Seals. p 97-118 *In*: T.R. Loughlin (ed.), Marine Mammals and the *Exxon Valdez*. Academic Press, San Diego.

Fyfe, R.W. and R.R. Olendorff. 1976. Minimizing the dangers of nesting studies to raptors and other sensitive species. Can. Wildl. Serv. Occ. Pap. 23. 16 p.

Gales, R.S. 1982. Effects of noise of offshore oil and gas operations on marine mammals--an introductory assessment. NOSC Tech. Rep. 844. Rep. from Naval Ocean Systems Center, San Diego, CA, for U.S. Bur. Land Manage., New York, NY. 79 + 300 p. 2 volumes.

Gallaway, B.J., L.R. Martin, R.L. Howard, G.S. Boland and G.D. Dennis. 1981. Effects on artificial reef and demersal fish and macrocrustacean communities. p 237-299 *In*: Middleditch (ed.), Environmental effects of offshore oil production. Plenum Publishing Corp., NY.

Gard, R. 1974. Aerial census of Gray Whales in Baja California lagoons, 1970 and 1973, with notes on behavior, mortality and conservation. Calif. Fish & Game 60(3):132-143.

Gaskin, D.E. 1991. An update on the status of the Right Whale, *Eubalaena glacialis*, in Canada. Can. Field-Nat. 105(2):198-205.

Geraci, J.R. 1990. Physiologic and toxic effects on cetaceans. p. 167-197 *In*: Geraci, J.R. and D.J. St. Aubin (eds.). Sea mammals and oil: Confronting the risks. Academic Press, San Diego. 282 p.

Geraci, J.R. and T.G. Smith. 1976. Direct and indirect effects of oil on ringed Seals (*Phoca hispida*) of the Beaufort Sea. Can. J. Fish. Aquat. Sci. 33:1976-1984.

Geraci, J.R. and D.J. St. Aubin. 1980. Offshore petroleum resource development and marine mammals: a review and research recommendations. Mar. Fish. Rev. 42:1-12.

Geraci, J.R. and D.J. St. Aubin. 1982. Study of the effects of oil on cetaceans. Final report. Rep. from University of Guelph for U.S. Bur. Land Manage., Washington, DC. 274 p. NTIS PB83-152991.

Geraci, J.R. and T.D. Williams. 1990. Physiologic and toxic effects on sea Otters. p 211-221 *In*: J.R. Geraci and D.J. St. Aubin (eds.), Sea mammals and oil: confronting the risks. Academic Press, San Diego.

GESAMP 1993. Impact of oil and related chemicals and wastes on the marine environment. GESAMP Reports and Studies No. Vol. 50. IMO/FAO/UNESCO/WMO/WHO/IAEA/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution, London. 180 p.

Goertner, J.F. 1982. Prediction of underwater explosion safe ranges for sea mammals. NSWC/TR 82-188. Naval Surf. Weap. Cent., White Oak Lab., Silver Spring, MD. 25 p. NTIS AD-A139 823.

Gollop, M.A., J.E. Black, B.E. Felske and R.A. Davis. 1974a. Disturbance studies of breeding black brant, common eiders, glaucous gulls and Arctic terns at Nunaluk Spit and Phillips Bay, Yukon Territory, July 1972. Arctic Gas Biol. Rep. Ser. 14(4):153-201.

Gollop, M.A., J.R. Goldsberry and R.A. Davis. 1974b. Aircraft disturbance to molting sea ducks, Herschel Island, Yukon Territory, August 1972. Arctic Gas Biol. Rep. Ser. 14(5):202-231.

Goodyear, J. 1989. Feeding ecology, night behaviour, and vessel collision risk of Bay of Fundy Right Whales. p. 24 *In*: Abstr. 8th Bienn. Conf. Biol. Mar. Mamm., Pacific Grove, CA, Dec. 1989. 81 p.

Greene, C.R. 1985. Characteristics of waterborne industrial noise, 1980-84. p. 197-253 *In*: W.J. Richardson (ed.), Behaviour, disturbance responses and distribution of Bowhead Whales *Balaena mysticetus* in the eastern Beaufort Sea, 1980-84. OCS Study MMS 85-0034. Rep. from LGL Ecol. Res. Assoc. Inc., Bryan, TX, for U.S. Minerals Manage. Serv., Reston, VA. 306 p. NTIS PB87-124376.

Greene, C.R. 1985. Characteristics of waterborne industrial noise, 1980-84. p. 197-253 *In*: W.J. Richardson (ed.), Behavior, disturbance responses and distribution of Bowhead Whales *Balaena mysticetus* in the eastern Beaufort Sea, 1980-84. OCS Study MMS 85-0034. Rep. from LGL Ecol. Res. Assoc. Inc., Bryan, TX, for U.S. Minerals Manage. Serv., Reston, VA. 306 p. NTIS PB87-124376.

Greene, C.R. 1986. Underwater sounds from the semisubmersible drill rig SEDCO 708 drilling in the Aleutian Islands. Sect. 1 *In*: API Publ. 4438. Am. Petrol. Inst., Washington, DC. 69 p.

Greene, C.R. 1987. Acoustic studies of underwater noise and localization of whale calls. Sect. 2 *In*: Responses of Bowhead Whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986. Rep. from LGL Ltd., King City, Ont., and

Greeneridge Sciences Inc., Santa Barbara, CA, for Shell Western E & P Inc., Anchorage, AK. 128 p.

Hall, J.D. and J. Francine. 1990. Underwater sound production of a bottom founded drilling platform (Concrete Island Drilling Structure) located in the Alaskan Beaufort Sea (Camden Bay). p. 181-183 *In*: Ext. Abstr., 5th Conf. Biol. Bowhead Whale, *Balaena mysticetus*, April 1990, Anchorage, AK. North Slope Borough, Barrow, AK. 244 p.

Hall, J.D. and J. Francine. 1991. Measurements of underwater sounds from a concrete island drilling structure located in the Alaskan sector of the Beaufort Sea. *J. Acoust. Soc. Am.* 90(3):1665-1667.

Harfenist, A., A.P. Gilman and K.L. Maus. 1990. The effects of exposure of incubating adult and young herring gulls to a simulated no-2 fuel oil slick. Arch. Environ. Contam. Toxicol. 19:902-906.

Harvey, J.T. and M.E. Dahlheim. 1994. Cetaceans in oil. p 257-264 *In*: T.R. Loughlin (ed.), Marine Mammals and the *Exxon Valdez*. Academic Press, San Diego.

Herter, D.R. and W.R. Koski. 1988. The effects of airport development and operation on waterbird and northern fur Seal populations: A review from the perspective of the St. George airport project. Rep. from LGL Alaska Res. Assoc. Inc., Anchorage, AK, for Alaska Dep. Transp. & Public Facil., Anchorage, AK. 201 p.

Hill, S.H. 1978. A guide to the effects of underwater shock waves on arctic marine mammals and fish. Pacific Mar. Sci. Rep. 78-26. Inst. Ocean Sciences, Patricia Bay, Sidney, B.C. 50 p.

Hinwood, J.B., A.E. Potts, L.R. Dennis, J.M. Carey, H. Houridis, R.J. Bell, J.R. Thomson, P. Boudreau and A.M. Ayling. 1994. Drilling activities. p 123-207 *In*: J.M. Swan, J.M. Neff and P.C. Young (eds.), Environmental implications of offshore oil and gas development in Australia - the findings of an independent scientific review. Australian Petroleum Exploration Society, Sydney.

Hirsch, A.E. and A.K. Ommaya. 1972. Head injury caused by underwater explosion of a firecracker. J. Neurosurg. 37(1):95-99.

Hockey, P.A.R. 1979. Reactions of seabirds to an underwater explosion in Saldanha Bay. Cormorant 1:6.

Joensen, A.H. 1972. Studies on oil pollution and seabirds in Denmark 1968-1971. Danish Rev. Game Biol. 6:1-32.

Johnson, B.W. 1977. The effects of human disturbance on a population of harbor Seals. Environ. Assess. Alaskan Cont. Shelf, Annu. Rep. Princ. Invest., NOAA, Boulder, CO, 1977(1):422-432. 708 p. NTIS PB-280934/1.

Johnson, S.R., J.J. Burns, C.I. Malme and R.A. Davis. 1989. Synthesis of information on the effects of noise and disturbance on major haul-out concentrations of Bering Sea pinnipeds. OCS Study MMS 88-0092. Rep. from LGL Alaska Res. Assoc. Inc., Anchorage, AK, for U.S. Minerals Manage. Serv., Anchorage, AK. 267 p. NTIS PB89-191373.

Jurasz, C.M. and V.P Jurasz. 1979. Ecology of Humpback Whale. Draft report for U.S. Natl. Park Serv. (Contr. No. CX-9000-7-0045). 118 p. + fig., tables.

Khan, R.A. and P. Ryan. 1991. Long term effects of crude oil on common murres (Uria-aalge) following rehabilitation. Bull. Environ. Contam. Toxicol. 46:216-222.

Ketten, D.R., J. Lien and S. Todd. 1993. Blast injury in Humpback Whale ears: evidence and implications. J. Acoust. Soc. Am. 94.

Kingsley, M.C.S., H.J. Cleator and M.A. Ramsay. 1994. Summer distribution and movements of narwhals (*Monodon monoceros*) in Eclipse Sound and adjacent waters, north Baffin Island, N.W.T. Medd. Grønl., Biosci. 39:163-174.

Kleinenberg, S.E., A.V. Yablokov, B.M. Bel'kovich and M.N. Tarasevich. 1964. White Whales (*Delphinapterus leucas*) investigation of the species. Transl. from Russian by Israel Program Sci. Transl., Jerusalem, 1969. 376 p.

Kooyman, G.L., R.L. Gentry and W.B. McAlister. 1976. Physiological impact of oil on pinnipeds. Unpubl. Final Rep., Res. Unit 71, to Outer Cont. Shelf Envir. Assess. Program, BLM/NOAA. 26 p.

Kooyman, G.L., R.W. Davis and M.A. Castellini. 1977. Thermal conductance of immersed pinniped and sea Otter pelts before and after oiling with Prudhoe Bay crude. p. 151-157 *In*: D.A. Wolfe (ed.), Fate and effects of petroleum hydrocarbons in marine ecosystems and organisms. Pergamon Press, Oxford.

Koski, W.R. 1975. Continuing surveys of terrestrial bird populations on the Yukon-Alaskan North Slope: June and July 1974. Chapt. 3. 100 p. *In*: W.W.H. Gunn, R.E.

Schweinsburg, C.E. Tull and T.D. Wright (eds.), Ornithological studies conducted in the area of the proposed gas pipeline route: Northwest Territories, Yukon Territory and Alaska, 1974. Arctic Gas Biol. Rep. Ser. Vol. 30.

Koski, W.R. 1977. Distribution of peregrine falcons and other raptors in the McConnell Range, Northwest Territories: May 1977. Rep. by LGL Ltd. for Northern Engineering Services Co. Ltd., Calgary. 17 p.

Koski, W.R. and S.R. Johnson. 1987. Behavioral studies and aerial photogrammetry. Sect. 4 *In*: Responses of Bowhead Whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Shell Western Expl. & Prod. Inc., Anchorage, AK. 371 p.

Kryter, K.D. 1985. The effects of noise on man, 2nd ed. Academic Press, Orlando, FL. 688 p.

Lindstedt-Siva, J., D.W. Chamberlain and E.R. Mancini. 1987. Environmental aspects of the *Arco Anchorage* oil spill, Port Angeles, Washington. Proc. 10th Bien. Oil Spill Conf. (Prevention, Behaviour, Control and Cleanup). American Petroleum Institute, Washington.

Lipscomb, T.B., R.K. Harris, A.H. Rebar, B.E. Ballachey and R.J. Haebler. 1994. Pathology of sea Otters. p 265-279 *In*: T.R. Loughlin (ed.), Marine mammals and the *Exxon Valdez*. Academic Press, San Diego.

Lien, J., S. Todd, P. Stevick, F. Marques and D. Ketten. 1993. The reaction of Humpback Whales to underwater explosions: orientation, movements and behavior. J. Acoust. Soc. Am. 94. in press.

Leatherwood, S. and R.R. Reeves (eds.). 1989. Marine mammal research and conservation in Sri Lanka 1985-1986. Mar. Mamm. Tech. Rep. 1. United Nations Environ. Prog., Oceans & Coastal Areas Prog. Activ. Cent., Nairobi, Kenya. 138 p.

Leatherwood, S., F.T. Awbrey and J.A. Thomas. 1982. Minke Whale response to a transiting survey vessel. Rep. Int. Whal. Comm. 32:795-802.

Leland, H.V. and J.S. Kuwabara. 1985. Trace metals. p 374-415 *In*: G.M. Rand and S.R. Petrocelli (eds.), Fundamentals of aquatic toxicology. Taylor and Francis.

Ljungblad, D.K., S.E. Moore, D.R. Van Schoik and C.S. Winchell. 1982. Aerial surveys of endangered whales in the Beaufort, Chukchi, & northern Bering Seas. NOSC Tech. Doc. 486. Rep. from Naval Ocean Systems Center, San Diego, CA, for U.S. Bur. Land Manage., Washington, DC. 406 p. NTIS AD-A126 542/0.

Ljungblad, D.K., S.E. Moore and D.R. Van Schoik. 1983. Aerial surveys of endangered whales in the Beaufort, eastern Chukchi, and northern Bering seas, 1982. NOSC TD 605. U.S. Naval Ocean Systems Cent., San Diego, CA. 382 p. NTIS AD-A 134772/3.

Ljungblad, D.K., B. Würsig, S.L. Swartz and J.M. Keene. 1988. Observations on the behavioral responses of Bowhead Whales (*Balaena mysticetus*) to active geophysical vessels in the Alaskan Beaufort Sea. Arctic 41(3):183-194.

Mair, J.McD., I. Matheson and J.F. Applebee. 1987. Offshore macrobenthic recovery in the Murchison field following the termination of drill-cuttings discharge. Mar. Poll. Bull. 18:628-634.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack and J.E. Bird. 1983. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating Gray Whale behaviour. BBN Rep. 5366. Rep. from Bolt Beranek & Newman Inc., Cambridge, MA, for U.S. Minerals Manage. Serv., Anchorage, AK. Var. pag. NTIS PB86-174174.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack and J.E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating Gray Whale behaviour/Phase II: January 1984 migration. BBN Rep. 5586. Rep. from Bolt Beranek & Newman Inc., Cambridge, MA, for U.S. Minerals Manage. Serv., Anchorage, AK. Var. pag. NTIS PB86-218377.

Malme, C.I., P.R. Miles, P. Tyack, C.W. Clark and J.E. Bird. 1985. Investigation of the potential effects of underwater noise from petroleum industry activities on feeding Humpback Whale behaviour. BBN Rep. 5851; OCS Study MMS 85-0019. Rep. from BBN Labs Inc., Cambridge, MA, for U.S. Minerals Manage. Serv., Anchorage, AK. Var. pag. NTIS PB86-218385.

Malme, C.I., B. Würsig, J.E. Bird and P. Tyack. 1986 [publ. 1988]. Behavioral responses of Gray Whales to industrial noise: Feeding observations and predictive modeling. BBN Rep. 6265. Outer Cont. Shelf Environ. Assess. Progr., Final Rep. Princ. Invest., NOAA, Anchorage, AK 56:393-600. 600 p. OCS Study MMS 88-0048; NTIS PB88-249008.

Malme, C.I., B. Würsig, J.E. Bird and P. Tyack. 1988. Observations of feeding Gray Whale responses to controlled industrial noise exposure. p. 55-73 *In*: W.M. Sackinger, M.O. Jeffries, J.L. Imm and S.D. Treacy (eds.), Port and ocean engineering under arctic conditions, vol. II. Geophysical Inst., Univ. of Alaska, Fairbanks, AK. 111 p.

Mansfield, A.W. 1971. Occurrence of the Bowhead or Greenland Right Whale (*Balaena mysticetus*) in Canadian arctic waters. Can. J. Fish. Aquat. Sci. 28:1873-1875.

Mayo, C.A. and M.K. Marx. 1990. Surface foraging behaviour of the North Atlantic Right Whale, *Eubalaena glacialis*, and associated zooplankton characteristics. Can. J. Zool. 68(10):2214-2220.

McDonald, M.A., J.A. Hildebrand, S. Webb, L. Dorman and C.G. Fox. 1993. Vocalizations of Blue and Fin Whales during a midocean ridge airgun experiment. J. Acoust. Soc. Am. 94(3, Pt. 2):1849.

Mobil 1985. Hibernia Development Project Environmental Impact Statement Volume IIIb Biophysical Assessment. Mobil Oil Canada, Ltd. (Operator), Gulf Canada Resources Inc., Petro-Canada Inc., Chevron Canada Resources Limited, and Columbia Gas Development of Canada Ltd. 238 p.

Mullin, K., W. Hoggard, C. Roden, R. Lohoefener, C. Rogers and B. Taggart. 1991. Cetaceans on the upper continental slope in the north-central Gulf of Mexico. OCS Study MMS 91-0027. Rep. from U.S. Natl. Mar. Fish. Serv., Pascagoula, MS, for U.S. Minerals Manage. Serv., New Orleans, LA. 108 p.

Myrick, A.C., Jr., E.R. Cassano and C.W. Oliver. 1990. Potential for physical injury, other than hearing damage, to dolphins from seal bombs used in the yellowfin tuna purse-seine fishery: results from open-water tests. Admin. Rep. LJ-90-07. Nat. Mar. Fish. Serv., Southwest Fish. Cent., LaJolla, CA. 28 p.

Nettleship, D.N. 1980. A guide to the major seabird colonies of eastern Canada - identity, distribution and abundance. Can. Wildl. Serv. MS Rep. 133 p.

NMFS (U.S. Natl. Mar. Fish. Serv.). 1987. Endangered fish and wildlife; approaching Humpback Whales in Hawaiian waters. Fed. Regist. 52(225, 23 Nov.):44912-44915 [50 CFR Part 222].

Olsgard, F. and J.S. Gray. 1995. A comprehensive analysis of the effects of offshore oil and gas exploration and production on the benthic communities of the Norwegian continental shelf. Mar. Ecol. Progr. Ser. 122:277-306.

O'Keeffe, D.J. and G.A. Young. 1984. Handbook on the environmental effects of underwater explosions. NSWC TR 83-240. Naval Surf. Weap. Cent., Silver Spring, MD. 207 p. Def. Tech. Info. Cent. AD-B093 885.

Osborn, L.S. 1985. Population dynamics, behaviour, and the effect of disturbance on haul-out patterns of the harbor seal *Phoca vitulina richardsi*/Elkhorn Slough, Monterey Bay, California. B.A. Thesis, Dep. Environ. Stud. & Dep. Biol., Univ. Calif., Santa Cruz. 75 p.

Payne, R., O. Brazier, E.M. Dorsey, J.S. Perkins, V.J. Rowntree and A. Titus. 1983. External features in southern Right Whales (*Eubalaena australis*) and their use in identifying individuals. p. 371-445 *In*: R. Payne (ed.), Communication and behaviour of whales. AAAS Sel. Symp. 76. Westview Press, Boulder, CO. 643 p.

Peakall, D.B., P.G. Wells and D. Mackay. 1987. A hazard assessment of chemically dispersed oil spills and seabirds. Mar. Environ. Res. 22:91-106.

Patten, D.R., W.F. Samaras and D.R. McIntyre. 1980. Whales, move over! Whalewatcher, J. Am. Cetac. Soc. 14(4):13-15.

Piatt, J.F., C.J. Lensink, W. Butler, M. Kendziorek and D.R. Nysewander. 1990. Immediate impact of the '*Exxon Valdez*' oil spill on marine birds. The Auk 107:387-397.

Picken, B. and A.D. McIntyre. 1989. Rigs to reefs in the North Sea. Bull. Mar. Sci. 44:782-788.

Platt, J.B. and C.E. Tull. 1977. A study of wintering and nesting gryfalcons on the Yukon North Slope during 1975 with emphasis on their behaviour during experimental overflights by helicopters. Arctic Gas Biol. Rep. Ser. 35(1):1-90.

Polar Gas Project. 1977. Application to National Energy Board. Vol. 5, Part A. Environmental Statement. Prepared by Polar Gas Project, Toronto.

Polovina, J.J. 1991. Fisheries applications and biological impacts of artificial habitats. p 153-176 *In*: W. Seaman and L.M. Sprague (eds.), Artificial habitats for marine and freshwater fisheries. Academic Press, Inc., San Diego.

Reeves, R.R. 1977. The problem of Gray Whale (*Eschrichtius robustus*) harassment: At the breeding lagoons and during migration. MMC-76/06. U.S. Mar. Mamm. Comm. 60 p. NTIS PB-272506.

Reiter, G.A. 1981. Cold weather response F/V *Ryuyo Maru* No. 2 St. Paul, Pribiloff Islands, Alaska. p. 227-231 *In*: Proc. 1981 oil spill conf., March 1981, Atlanta, GA. Am. Petrol. Inst., Washington, DC.

Rice, D.W. 1965. Offshore southward migration of Gray Whales off southern California. J. Mammal. 46(3):504-505.

Rice, D.W. and A.A. Wolman. 1971. The life history and ecology of the Gray Whale (*Eschrichtius robustus*). Am. Soc. Mammal., Spec. Publ. 3. 142 p.

Richardson, W.J. and C.I. Malme. 1993. Man-made noise and behavioral responses. p. 631-700 *In*: J.J. Burns, J.J. Montague and C.J. Cowles (eds.), The Bowhead Whale. Spec. Publ. 2. Soc. Mar. Mammal., Lawrence, KS. 787 p.

Richardson, W.J., R.A. Davis, C.R. Evans and P. Norton. 1985a. Distribution of Bowheads and industrial activity, 1980-84. p. 255-306 *In*: W.J. Richardson (ed.), Behaviour, disturbance responses and distribution of Bowhead Whales *Balaena mysticetus* in the eastern Beaufort Sea, 1980-84. OCS Study MMS 85-0034. Rep. from LGL Ecol. Res. Assoc. Inc., Bryan, TX, for U.S. Minerals Manage. Serv., Reston, VA. 306 p. NTIS PB87-124376.

Richardson, W.J., M.A. Fraker, B. Würsig and R.S. Wells. 1985b. Behaviour of Bowhead Whales *Balaena mysticetus* summering in the Beaufort Sea: Reactions to industrial activities. Biol. Conserv. 32(3):195-230.

Richardson, W.J., R.S. Wells and B. Würsig. 1985c. Disturbance responses of Bowheads, 1980-84. p. 89-196 *In*: W.J. Richardson (ed.), Behaviour, disturbance responses and distribution of Bowhead Whales *Balaena mysticetus* in the eastern Beaufort Sea, 1980-84. OCS Study MMS 85-0034. Rep. from LGL Ecol. Res. Assoc. Inc., Bryan, TX, for U.S. Minerals Manage. Serv., Reston, VA. 306 p. NTIS PB87-124376.

Richardson, W.J., B. Würsig and C.R. Greene, Jr. 1986. Reactions of Bowhead Whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. J. Acoust. Soc. Am. 79(4):1117-1128.

Richardson, W.J., C.R. Greene, J.P. Hickie, R.A. Davis and D.H. Thomson. 1989. Effects of offshore petroleum operations on cold water marine mammals: A literature review. 2nd edition. American Petroleum Institute Publication No. 4475, Washington, D.C. 385 p.

Richardson, W.J., B. Würsig and C.R. Greene, Jr. 1990a. Reactions of Bowhead Whales, *Balaena mysticetus*, to drilling and dredging noise in the Canadian Beaufort Sea. Mar. Environ. Res. 29(2):135-160.

Richardson, W.J., C.R. Greene, Jr., W.R. Koski, C.I. Malme, G.W. Miller, M.A. Smultea and B. Würsig. 1990b. Acoustic effects of oil production activities on Bowhead and White Whales visible during spring migration near Pt. Barrow, Alaska—1989 phase. OCS Study MMS 90-0017. Rep. from LGL Ltd., King City, Ont., for U.S. Minerals Manage. Serv., Herndon, VA. 284 p. NTIS PB91-105486.

Richardson, W.J., C.R. Greene, Jr., W.R. Koski and M.A. Smultea, with G. Cameron, C. Holdsworth, G. Miller, T. Woodley and B. Würsig. 1991. Acoustic effects of oil production activities on Bowhead and White Whales visible during spring migration near Pt. Barrow, Alaska-1990 phase. OCS Study MMS 91-0037. Rep. from LGL Ltd., King City, Ont., for U.S. Minerals Manage. Serv., Herndon, VA. 311 p. NTIS PB92-170430.

Richardson, W.J., C.R. Greene, C.I. Malme and D.H. Thomson 1995a. Marine Mammals and Noise. Academic Press, San Diego. 576 p.

Richardson, W.J., S. Davis, R. Harris, D.W. Owens, N.J. Patenaude, D.H. Thomson, R.C. Atkinson and W.J. Marshall 1995b. Assessment of potential impacts of small explosions in the Korea Strait on marine animals and fisheries. Rep. by LGL Limited and BBN Systems and Technologies, Cambridge, MA for Maritime Systems Technology Office, Advanced Projects Research Agency, 128 p.

Riedman, M.L. 1983. Studies of the effects of experimentally produced noise associated with oil and gas exploration and development on sea Otters in California. Rep. from Cent. Coastal Mar. Stud., Univ. Calif. Santa Cruz, CA, for U.S. Minerals Manage. Serv., Anchorage, AK. 92 p. NTIS PB86-218575.

Riedman, M.L. 1984. Effects of sounds associated with petroleum industry activities on the behavior of sea Otters in California. p. D-1 to D-12 *In*: C.I. Malme, P.R. Miles, C.W. Clark, P. Tyack and J.E. Bird, Investigations of the potential effects of underwater noise from petroleum industry activities on migrating Gray Whale behavior/Phase II: January 1984 migration. BBN Rep. 5586. Rep. from Bolt Beranek & Newman Inc., Cambridge, MA, for U.S. Minerals Manage. Serv., Anchorage, AK. Var. pag. NTIS PB86-218377.

Sage, B. 1979. Flare up over North Sea birds. New Scientist 81:464-466.

Schulberg, S., I. Show and D.[R.] Van Schoik. 1989. Results of the 1987-1988 Gray Whale migration and Landing Craft Air Cushion interaction study program. U.S. Navy Contr. N62474-87-C-8669. Rep. from SRA Southwest Res. Assoc., Cardiff, CA, for Naval Facil. Eng. Comm., San Bruno, CA. 45 p.

Schweinsburg, R.E. 1974. Snow geese disturbance by aircraft on the North Slope, September 1972. Chapt. 7. 21 p. *In*: W.W.H. Gunn and J.A. Livingston (eds.), Disturbance to birds by gas compressor noise simulators, aircraft and human activity in the Mackenzie Valley and the North Slope, 1972. Arctic Gas Biol. Rep. Ser., Vol. 14.

Shane, S.H., R.S. Wells and B. Würsig. 1986. Ecology, behaviour and social organization of the bottlenose Dolphin: A review. Mar. Mamm. Sci. 2(1):34-63.

Shuntov, F., V. Zykov and N. Poyarkov. 1996. Review of Literature/Information Regarding Sea-Associated Birds in the Vicinity of Sakhalin Island, Okhotsk Sea, Russia. Rep. for Marathon Oil Company, Littleton, Colorado, US. Translations and editorial contributions by LGL Limited environmental research associates, Sidney, BC, Canada.

Sommerville, H.J., D. Bennett, J.N. Davenport, M.S. Holt, A. Lynes, A. Mahieu, B. McCourt, J.G. Parker, R.R. Stephenson, R.J. Watkinson and T.G. Wilkinson. 1987. Environmental effects of produced water from north sea oil operations. Mar. Poll. Bull. 18:549-558.

SRA. 1988. Results of the 1986-1987 Gray Whale migration and landing craft, air cushion interaction study program. U.S. Navy Contr. N62474-86-M-0942. Rep. from SRA Southwest Res. Assoc., Cardiff by the Sea, CA, for Naval Facil. Eng. Comm., San Bruno, CA. 31 p.

Smith, T.G. 1980. Polar bear predation of ringed and bearded Seals in the land-fast sea ice habitat. Can. J. Zool. 58:2201-2209.

St. Aubin, D.J. 1990. Physiologic and toxic effects on pinnipeds. p 103-127 *In*: J.R. Geraci and D.J. St. Aubin (eds.), Sea mammals and oil confronting the risks. Academic Press, Inc., San Diego.

Stanley, D.R. and C.A. Wilson. 1990. A fishery-dependent based study of fish species composition and associated catch rates around oil and gas structures off Louisiana. Fish. Bull. (U.S.) 88:719-730.

Stanley, D.R. and C.A. Wilson. 1991. Factors affecting the abundance of selected fishes near oil and gas platforms in the northern Gulf of Mexico. Fish. Bull. (U.S.) 89:149-159.

Stewart, B.S., W.E. Evans and F.T. Awbrey. 1982. Effects of man-made water-borne noise on behaviour of Belukha Whales (*Delphinapterus leucas*) in Bristol Bay, Alaska. HSWRI Tech. Rep. 82-145. Rep. from Hubbs Sea World Res. Inst. San Diego, CA for U.S. Natl. Oceanic and Atmospheric Admin., Juneau AK. 29 p.

Swartz, S.L. and W.C. Cummings. 1978. Gray Whales, *Eschrichtius robustus*, in Laguna San Ignacio, Baja California, Mexico. MMC-77/04. Rep. from San Diego Nat. Hist. Museum for U.S. Mar. Mamm. Comm., Washington, DC. 38 p. NTIS PB-276319.

Swartz, S.L. and M.L. Jones. 1978. The evaluation of human activities on Gray Whales, *Eschrichtius robustus*, in Laguna San Ignacio, Baja California, Mexico. MMC-78/03. U.S. Mar. Mamm. Comm., Washington, DC. 34 p. NTIS PB-289737.

Thomas, D.J., G.D. Greene, W.S. Duval, K.C. Milne and M.S. Hutcheson. 1984. Offshore oil and gas production waste characteristics, treatment methods, biological effects and their application to Canadian regions. Final Report (IP-4). Water Pollution Control Directorate, Environmental Protection Service, Environment Canada, Ottawa.

Thomson, D.H. and L.R. Martin. 1984. Feeding ecology of Gray Whales in the Chirikof Basin. p 209-460 *In*: D.H. Thomson (ed.), Feeding ecology of Gray Whales in the Chirikof Basin, summer 1982. NOAA, OCSEAP Final Report. 43. U.S. Dep. Commer., Anchorage.

Tinney, R.T., Jr. 1988. Review of information bearing upon the conservation and protection of Humpback Whales in Hawaii. Rep. for U.S. Mar. Mamm. Comm., Washington, DC. 56 p. NTIS PB88-195359.

Vermeer, K and R. Vermeer. 1975. Oil threat to birds on the Canadian west coast. Can. Field Nat. 89:278-298.

Wahl, T.R. and D. Heinemann. 1979. Seabirds and fishing vessels: co-occurrence and attraction. Condor 81:390-396.

Ward, J.G. and P.L. Sharp. 1974. Effects of aircraft disturbance on molting sea ducks at Herschel Island, Yukon Territory, August 1973. Arctic Gas Biol. Rep. Ser. 14(2):1-54.

Watkins, W.A. 1986. Whale reactions to human activities in Cape Cod waters. Mar. Mamm. Sci. 2(4):251-262.

Watkins, W.A. and K.E. Moore. 1983. Three Right Whales (*Eubalaena glacialis*) alternating at the surface. J. Mammal. 64(3):506-508.

Webb, R. 1980. Norman Wells goose survey. Report prep. by R. Webb Environmental Services Ltd., for Esso Resources Canada Limited. Norman Wells Project. Calgary, Alta. 39 p. + 100.

Wheeler, R.B., J.B. Anderson, R.R. Schwarzer and C.L. Hokanson. 1980. Sedimentary processes and trace metal contaminants in the Buccaneer oil/gas field, northwestern Gulf of Mexico. Environ. Geol. 3:163-175.

Williams, T.M., G.A. Antonelis and J. Balke. 1994. Health evaluation, rehabilitation and release of oiled Harbor Seal pups. p 227-241 *In*: T.R. Loughlin (ed.), Marine Mammals and the *Exxon Valdez*. Academic Press, San Diego.

Withrow, D.E., G.C. Bouchet and L.L. Jones. 1985. Response of Dall's Porpoise (*Phocoenoides dalli*) to survey vessels in both offshore and nearshore waters: Results of 1984 research. Int. N. Pacific Fish. Comm. Doc. U.S. Natl. Mar. Mamm. Lab., Seattle, WA. 16 p.

Wolfson, F.H. 1977. Gray Whale behavior [letter to editor]. *Science* 195(4278):534-535.

Wright, D.G. 1982. A discussion paper on the effects of explosives on fish and marine mammals in the waters of the Northwest Territories. Can. Tech. Rep. Fish. Aquatic Sci. 1052. 16 p.

Yelverton, J.T. 1981. Underwater explosion damage risk criteria for fish, birds, and mammals. Unpubl. manuscr., presented at 102nd Meet. Acoust. Soc. Am., Miami Beach, FL, Dec. 1981. 32 p.

Yelverton, J.T., D.R. Richmond, E.R. Fletcher and R.K. Jones. 1973. Safe distances from underwater explosions for mammals and birds. Rep. from Lovelace Found. Med. Educ. Res., Albuquerque, NM, for Defense Nuclear Agency, Washington, DC. 67 p.

Young, G.A. 1991. Concise methods for predicting the effects of underwater explosions on marine life. NSWC MP 91-220. Naval Surf. Weap. Cent., Silver Spring, MD. 13 p. Def. Tech. Info. Cent. AD-A241 310.

von Ziegesar, O., E. Miller and M.E. Dahlheim. 1994. Impacts on Humpback Whales in Prince William Sound. p 173-191 *In*: T.R. Loughlin (ed.), Marine Mammals and the *Exxon Valdez*. Academic Press, San Diego.

Zhou Kaiya and Zhang Xingduan. 1991. Baiji/The Yangtze river Dolphin and other endangered animals of China. Stone Wall Press and Yilin Press, Washington, DC, and Nanjing, China. 129 p.