October 8, 2012

National Energy Board
444 - 7th Avenue SW
Calgary, AB T2P 0X8

Attention: Ms. Sheri Young,
Secretary to the Joint Review Panel
Enbridge Northern Gateway Project

Dear Ms. Young:

RE: Northern Gateway Pipelines Inc.
    Enbridge Northern Gateway Project Application of 27 May 2010
    Hearing Order OH-4-2011

Please find enclosed for filing with the JRP, the errata for Northern Gateway's Pipeline and Terminal Design and Engineering Panel.

In addition, in Federal Government IR 116, Environment Canada requested further analysis of the effects of oil exposure on marine birds, including consideration of available scientific literature. In response, Northern Gateway is providing "Effects of the Exxon Valdez Oil Spill on Marine Birds: A Literature Review" (Attachment Federal Government IR 116). Northern Gateway is also providing "Update to Marine Birds: Susceptibility to Oil" (Attachment Federal Government IR 2.76 – Updated). These materials have been in the process of review and comment by Environment Canada and are now available for filing.

Yours truly,

Fraser Milner Casgrain LLP

Richard A. Neufeld, Q.C.
Partner
JOINT REVIEW PANEL

Northern Gateway Pipelines Limited Partnership
Enbridge Northern Gateway Project
NEB File OF-Fac-Oil-N304-2010-01 01
Hearing Order OH-4-2011

TO: The Secretary
National Energy Board
444 Seventh Avenue SW
Calgary, AB T2P 0X8

NORTHERN GATEWAY PIPELINES LIMITED PARTNERSHIP

ERRATA

OCTOBER 8, 2012
<table>
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<th>Document Name</th>
<th>Errata</th>
<th>Reason for Change</th>
<th>NEB Reference</th>
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<td>Ecological - Human Health Risk Assessment for Pipeline Spills - TDR 5 of 11</td>
<td>At adobe page 15, Table 3 River Area (KM²) Oiled Above Threshold for Potential Effects to Wildlife. The last column (total) reads as:</td>
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<td>TERM POL Surveys and Studies - Section 3.10 - Site Plans and Technical Data</td>
<td>At adobe page 15, section 2.2.3.2 Underwater Rock Blasting, first sentence reads as follows “An upper limit to the amount of underwater rock material required to be removed is conservatively estimated at 36,000 m³.”  <strong>It should read</strong> “An upper limit to the amount of underwater rock material required to be removed is conservatively estimated at <strong>25,000 m³</strong>.”</td>
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<tr>
<td>Vol 6C - Human Environment ESA (Part 1 of 3)</td>
<td>At adobe page 41, section 2.5.2.2 – Blasting, the second sentence reads as “Based on the preliminary design, total rock blasting (cut) quantities for the berth structures will be approximately 40,000 m³.”  <strong>It should read</strong> “Based on the preliminary design, total rock blasting (cut) quantities for the berth structures will be approximately <strong>25,000 m³</strong>.”</td>
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<td>Vol 6C - Human Environment ESA (Part 1 of 3)</td>
<td>At adobe page 42, section 2.5.4 the third bullet reads as follows “due to the slope of the underlying sea floor, up to 50% (20,000 m³) of the blasted rock will be not be recoverable and will, therefore, remain in the marine environment.”  <strong>It should read</strong> “due to the slope of the underlying sea floor, up to 50% (12,500 m³) of the blasted rock will be not be recoverable and will, therefore, remain in the marine environment.”</td>
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<td>Semi-Quantitative Risk Assessment, revised</td>
<td>At adobe page 19, the last sentence reads as “Under this assumption, the resultant failure likelihood for a full-bore rupture would be $3 \times 10^{-6}$ failures/km-year.”  <strong>It should read as</strong> “Under this assumption, the resultant failure likelihood for a full-bore rupture would be $1.3 \times 10^{-6}$ failures/km-year.”</td>
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<td>At adobe page 104, section 11.2 Control Centers, the first sentence reads as “The safety and integrity of the system will be maintained through the coordination efforts of all support personnel. Personnel will be trained on a computerized simulator at the Edmonton Control Centre.”  <strong>It should read as</strong> “The safety and integrity of the system will be maintained through the coordination efforts of all support personnel. Control Centre personnel for the Edmonton and Kitimat control centres will be trained on computer based simulators, located at their respective centres.”</td>
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<tr>
<th>Northern Gateway Response to K. Izzard IR No. 1</th>
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<td>At adobe page 2, first sentence in response 1 reads as “All Enbridge Liquid Pipelines, including Line 6A, are controlled from the SCADA system at the Enbridge Edmonton Control Centre.” <strong>It should read as</strong> “Enbridge Liquid Pipelines facilities, including Line 6A, are monitored and controlled from the Enbridge Edmonton Control Centre, with the exception of the Enbridge Pipelines Saskatchewan Inc. (EPSI) system, which is controlled from the Estevan Control Centre.”</td>
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<td>Clarification</td>
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<th>Written Reply Evidence of Northern Gateway Pipelines Limited Partnership</th>
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<tr>
<td>At adobe page 46, line 21 reads as “For facility design, seismic load parameters corresponding to a 2 percent probability of exceedance in 50 years will be used, consistent with the provisions of the ASCE 7 standard.” <strong>It should read as</strong>, “For facility design, seismic load parameters corresponding to a 2 percent probability of exceedance in 50 years will be used, consistent with the provisions of the 2010 National Building Code of Canada and ASCE 7 standard.”</td>
</tr>
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<td>The text is changed to reflect designing facilities to the 2010 National Building Code of Canada.</td>
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<td>Written Reply Evidence of Northern Gateway Pipelines Limited Partnership</td>
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<td>Written Reply Evidence of Northern Gateway Pipelines Limited Partnership</td>
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<tr>
<td>Vol 1 – Gateway Application – Overview and General Information (Part 1 of 2)</td>
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<td>---</td>
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</table>
| Vol 1 – Gateway Application – Overview and General Information (Part 1 of 2) | At adobe page 36, the last sentence reads, “The estimate differs from that contained in the Preliminary Information Package (PIP) because there have been:  
  • changes to the project scope  
  • adjustments to material and labour costs  
  • new findings from:  
    o consultation with stakeholders and participating Aboriginal groups  
    o engineering and environmental field studies” **It should read as**, The estimate differs from that contained in the Preliminary Information Package (PIP) because there have been:  
  • changes to the project scope  
  • adjustments to material and labour costs  
  • new findings from:  
    o consultation with stakeholders and participating Aboriginal groups  
    o engineering and environmental field studies  
  • marine infrastructure  
  • design enhancements | The text has been changed to reflect the change in capital costs for the Project due to marine infrastructure and design enhancements. | Exhibit No. B1-2 (A1S9X5) |
| Vol 1 – Gateway Application – Overview and General Information (Part 1 of 2) | At adobe page 37, Table 2-3 – updated. See Attachment 1 to this Errata Document. | The text has been changed to reflect the change in capital costs for the Project due to marine infrastructure and design enhancements. | Exhibit No. B1-2 (A1S9X5) |
Table 2-2  Project Milestones

<table>
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<th>Project Milestone</th>
<th>Start Date</th>
<th>Completion Date</th>
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<tr>
<td>NEB Application submission</td>
<td>–</td>
<td>Q2, 2010</td>
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<td>Detailed design</td>
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<td>Governor in Council (GIC) decision</td>
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<td>Commercial sanction</td>
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<td>Q3, 2012</td>
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<td>Procurement of major material and equipment</td>
<td>Q3, 2012</td>
<td>Q3, 2016</td>
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<tr>
<td>Kitimat Terminal construction</td>
<td>Q2, 2013</td>
<td>Q3, 2017&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
<td>Tunnel construction</td>
<td>Q2, 2013</td>
<td>Q4, 2016</td>
</tr>
<tr>
<td>Oil and condensate pipeline construction</td>
<td>Q4, 2013</td>
<td>Q4, 2016</td>
</tr>
<tr>
<td>Pump station construction</td>
<td>Q3, 2014</td>
<td>Q4, 2016</td>
</tr>
<tr>
<td>Leave-to-open and commissioning</td>
<td>Q3, 2016</td>
<td>Q4, 2016</td>
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<tr>
<td>Project in-service</td>
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<td>Q4, 2016&lt;sup&gt;b&lt;/sup&gt;</td>
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</table>

NOTES:

<sup>a</sup> A limited number of tanks will see construction extend beyond the in-service date to Q3, 2017.

<sup>b</sup> Q4, 2016 is the earliest in-service date. In-service date will depend on various factors, including timing of the regulatory decision, timing of commercial sanction for the Project, detailed engineering and construction progress.

2.8 Project Cost Estimate

The estimated capital cost for the Project is $6.57 billion plus allowance for funds used during construction (AFUDC, see Table 2-3). This estimate is based upon Enbridge and consultant construction experience over the past several years. The estimate differs from that contained in the Preliminary Information Package (PIP) because there have been:

- changes to the project scope
- adjustments to material and labour costs
- new findings from:
  - consultation with stakeholders and participating Aboriginal groups
  - engineering and environmental field studies
  - Marine Infrastructure
  - Design Enhancements

Deleted: 5.54
Deleted: (Q4, 2009 Canadian dollars)
Table 2-3 Estimated Capital Cost for the Project

<table>
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<th>Pipelines ($ millions)</th>
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<th>Kitimat Terminal 5 ($ millions)</th>
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<td>Land 1</td>
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<td>Materials 2</td>
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<tr>
<td><strong>TOTAL</strong></td>
<td><strong>4668</strong></td>
<td><strong>622</strong></td>
<td><strong>1281</strong></td>
<td><strong>7885</strong></td>
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</tbody>
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**NOTES:**
1. Land includes property taxes.
2. Materials include provincial sales tax (PST) in British Columbia.
3. This total includes AFUDC amount of $1,314 million.
4. Goods and services tax (GST) is excluded.
5. Includes Tankage, Metering and Marine Infrastructure.
Effects of the Exxon Valdez Oil Spill on Marine Birds:
A Literature Review

ENBRIDGE NORTHERN GATEWAY PROJECT

Prepared by
Stantec Consulting Ltd.
Burnaby, British Columbia

October 2012

123510694 413.301
Table of Contents

1 Introduction .............................................................................................................. 1-1
  1.1 Literature Review ............................................................................................ 1-1
  1.2 Bird Community of Prince William Sound .................................................... 1-1
  1.3 The Exxon Valdez Oil Spill Event ..................................................................... 1-2

2 Effects of the Exxon Valdez Oil Spill ..................................................................... 2-1
  2.1 Acute Effects ..................................................................................................... 2-1
    2.1.1 Vulnerability ............................................................................................ 2-1
    2.1.2 Mortality ................................................................................................ 2-2
  2.2 Chronic Effects ................................................................................................ 2-3
    2.2.1 Changes to Habitat Use .......................................................................... 2-4
    2.2.2 Other Measures of Chronic Effects ......................................................... 2-5
    2.2.3 Biomarkers of Oil Exposure ..................................................................... 2-6
    2.2.4 Indirect Effects ....................................................................................... 2-7

3 Species Population Recovery .............................................................................. 3-1
  3.1 Recovered Populations ...................................................................................... 3-1
    3.1.1 Common Loon ....................................................................................... 3-1
    3.1.2 Bald Eagle ............................................................................................. 3-2
    3.1.3 Common Murre ..................................................................................... 3-2
    3.1.4 Glaucous-winged Gull .......................................................................... 3-2
    3.1.5 Black-legged Kittiwake ........................................................................ 3-3
  3.2 Recovering Populations .................................................................................... 3-3
    3.2.1 Barrow’s Goldeneye ............................................................................. 3-3
    3.2.2 Harlequin Duck ..................................................................................... 3-4
    3.2.3 Black Oystercatcher ............................................................................. 3-5
  3.3 Other Populations ............................................................................................ 3-5
    3.3.1 Pigeon Guillemot .................................................................................. 3-6
    3.3.2 Marbled Murrelet ............................................................................... 3-6
    3.3.3 Kittlitz’s Murrelet ............................................................................... 3-6

4 Application to the Northern Gateway Project .................................................... 4-1
  4.1 Response Planning ......................................................................................... 4-1
  4.2 Comprehensive Baseline Monitoring ............................................................ 4-1

5 Conclusions .......................................................................................................... 5-1

6 References ........................................................................................................... 6-1
  6.1 Personal Communications ............................................................................. 6-8
List of Tables

Table 1  Marine Bird Carcasses Collected during Beach Surveys after the Exxon Valdez Oil Spill, April - September 1989                      2-2
Introduction

Northern Gateway Pipelines Limited Partnership (Northern Gateway) was formed to design, construct, operate and decommission the Enbridge Northern Gateway Project (the Project). The Project includes the oil and condensate pipelines and associated terrestrial infrastructure, the Kitimat Terminal, and the marine shipping routes, which are the Confined Channel Assessment Area (CCAA) and the Open Water Area (OWA).

As part of the review of the Project, Environment Canada has requested a comprehensive review of the effects of the Exxon Valdez Oil Spill (EVOS) on marine birds. Northern Gateway has committed to providing the requested information and the following literature review summarizes the effects of the EVOS on marine birds from available information resources.

1.1 Literature Review

This review encompasses more than 20 years of studies and information collected on oil spill effects, oil vulnerabilities, and marine bird species and guild sensitivities specific to the EVOS. The information was compiled from government and non-government resources, peer-reviewed journal articles, published literature, and regional consulting reports. Additional information was contributed by the following scientists with expertise in the field of oil spill risk, assessment, management, and wildlife species population recovery:

- Moore, J. 2012. Senior Marine Ecologist and Environmental Consultant, owner of Coastal Assessment, Liaison & Monitoring, Pembrokeshire, UK.
- Pearson, W. 2012. Formerly Staff Scientist, Battelle/Marine Sciences Laboratory, Sequim, Washington; Currently owner and chief scientist of Peapod Research addressing natural resource and environmental issues in marine and aquatic systems. Allendale, MI

1.2 Bird Community of Prince William Sound

Temperate marine coastal environments support high seasonal avifaunal species richness and abundance (Weins 1995). The Gulf of Alaska (GOA), including Prince William Sound (PWS), is home to large numbers of marine and coastal birds (Piatt et al. 1990; Harrison 1982), with abundance varying seasonally. In summer, up to 40 million birds are present in the gulf with more than nine million individuals breeding during the nesting period (Day 2006; DeGange and Sanger 1986; Gould et al. 1982). In winter, the numbers are lower (Gould et al. 1982). The environment and avifaunal composition of Prince William Sound are relatively similar those in the proposed Project area in terms of proximity, environmental conditions and migratory bird species.
Within PWS, over 92 species of marine birds have been confirmed utilizing coastal and marine environments, 79 of which were present during the three years following the EVOS (Weins et al. 1996). Numbers in 2007 were estimated to be 181,883 ± 38,808 during winter, increasing to 256,299 ± 72,058 in summer (McKnight et al., 2008).

### 1.3 The Exxon Valdez Oil Spill Event

On March 24 1989, the bulk oil carrier T/V Exxon Valdez ran aground in Alaska’s south-central Prince William Sound within the Gulf of Alaska. The state and federal agency consortium, the Exxon Valdez Oil Spill Trustee Council (EVOSTC), the National Oceanic and Atmospheric Administration (NOAA) and various academic sources reported that the amount of oil that spilled into PWS was approximately 41.5 million liters (EVOSTC 2009; Peterson et al. 2003; Esler et al. 2002; Paine et al. 1996). Based on observed distributions of the oil (Alaskan North Slope Crude Oil), slicks moved through and affected portions of approximately 28,000 km$^2$ of the gulf waters (Hostettler et al. 1999b, Murphy et al. 1997). Due to the remoteness of the region, the ambient winter conditions within PWS, and the state of readiness of the spill response team and equipment, the emergency spill response measures were not deployed in a timely manner or on a scale necessary to effectively address the extent of the EVOS$^1$ (EVOSTC 2009). Response operations were conducted from 1989 through the summers of 1990 and 1991, with continued remediation efforts in 1992.

Directly following the spill, a relatively smooth liquid-oil coated sections of beaches and shorelines. A storm in the Gulf of Alaska on April 10 and 11 1989 rapidly emulsified much of the remaining surface slicks into smaller patches, which then developed into an emulsification or mousse that washed up on long shore sections (Wolfe et al. 1994; Galt et al. 1991). An estimated 40% of spilled oil settled on beaches within PWS (Galt et al. 1991). By July 1989, observations indicated only “small patches of mousse, sheen, and tar balls” were visible on the ocean surface (Piatt et al. 1990).

The vast majority of visible oceanic surface oil had dissipated by August 1, 1989, a date used as the direct spill–indirect spill transition for quantifying marine bird mortality (Piatt et al. 1990; Piatt and Ford 1996). Sub-surface oil along some shoreline segments was much less weathered and still in a liquid state. Approximately 20% to 30% of the total oil spill dispersed through evaporation, dissolution, biodegradation, or photo-oxidization during the initial weeks (Harwell and Gentile 2006; ITOPF 2002; Paine et al. 1996; Wolfe et al. 1994). Natural weathering of the residual oil has continued since 1992 with a small proportion of oil persisting within the subsurface sediments of some beaches.

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$^1$ As a result of the EVOS spill, timelines for spill response and requirements for spill response capacity in Alaska were increased.
2 Effects of the Exxon Valdez Oil Spill

Once an oil spill has occurred, marine birds in the area may be affected through four different routes of exposure (Leighton 1993):

- Direct Contact – with fresh oil, which is the most visible route of exposure to an observer. Direct contact can result in varying degrees of plumage oiling depending on a range of conditions and extent of oil spill (Piatt et al. 1990).
- Ingestion – through direct ingestion (when a bird eats food coated with oil or when a bird attempts to clean oil from its feathers) and indirect ingestion (when a bird eats food that contains oil or oil constituents) (Khan and Ryan 1991).
- Inhalation – of the volatile fractions of freshly spilled crude oil. This type of exposure is of more concern for causing acute effects than chronic effects because the volatile fractions evaporate relatively quickly.
- Absorption – through the skin. Absorption rates through skin are much slower than those through ingestion or inhalation pathways.

The effects from direct contact, inhalation, and absorption are primarily acute. Ingestion can result in both acute and chronic exposures (EVOSTC 2010).

The following sections describe the known effects of the EVOS on marine birds that were directly or indirectly linked to aspects of the spill.

2.1 Acute Effects

2.1.1 Vulnerability

The three main pathways by which oil can result in acute effects or mortality of marine birds include:

- External oiling causing hypothermia or asphyxiation (Camphuysen 2007; Stephenson 1997; Leighton 1993)
- Reduced egg and chick survival (Velando et al. 2005; Fry et al. 1986; Albers 1983)
- Direct ingestion of oil from preening or contaminated prey (Weins 1995; Leighton 1993; Ainley et al. 1981).

A more detailed description of these pathways is provided in Northern Gateway’s 2010 Application, Volume 7C, Section 7.8.2; and Northern Gateway’s supplemental report, Marine Birds: Susceptibility to Oil (Enbridge Northern Gateway Project 2012).

Acute effects following the EVOS were primarily attributed to direct oiling of individual birds on the water surface; the most vulnerable species being those that spend the most time on the water (Wiens...
1995). Some species guilds—such as geese, swans, cranes and herons—may therefore be somewhat more resistant to the acute effects of oil because of their foraging strategies and life history traits.

Additional uncertainty surrounding vulnerability (Piatt and Ford 1996) also includes but is not limited to the following factors:

- Life history traits resulting in delayed oil exposure in some species
- Difficulty in accounting for long-term population trends for some species
- Shifting climatic regimes (Agler et al. 1999).

### 2.1.2 Mortality

Acute effects of oil spills on marine birds are generally defined by direct mortality occurring in the weeks following a spill event. To investigate the extent of acute effects from the spill on marine wildlife populations, shore-based beach surveys and marine-based drift surveys (Piatt and Ford 1996) were conducted. An estimated 30,000 to 52,330 carcasses from 90 bird species were reportedly retrieved from the spill area between early April and late September 1989 (Piatt and Ford 1996; Wiens 1995; Piatt et al. 1990). The majority of all bird carcasses retrieved in the two months following the EVOS included murres (74%), other alcids (7%) and diving ducks (5%) (Table 1).

**Table 1** Marine Bird Carcasses Collected during Beach Surveys after the Exxon Valdez Oil Spill, April - September 1989

<table>
<thead>
<tr>
<th>Marine Bird Groups</th>
<th>Reported Carcasses Retrieved*</th>
</tr>
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<tbody>
<tr>
<td>Geese and swans</td>
<td>9</td>
</tr>
<tr>
<td>Diving and dabbling ducks</td>
<td>1,561</td>
</tr>
<tr>
<td>Loons and grebes</td>
<td>857</td>
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<tr>
<td>Tubenoses</td>
<td>4,269</td>
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<tr>
<td>Cormorants</td>
<td>836</td>
</tr>
<tr>
<td>Herons</td>
<td>1</td>
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<tr>
<td>Coastal Raptors</td>
<td>138</td>
</tr>
<tr>
<td>Cranes</td>
<td>2</td>
</tr>
<tr>
<td>Shorebirds</td>
<td>49</td>
</tr>
<tr>
<td>Gulls, jaegers, terns, and kittiwakes</td>
<td>1,925</td>
</tr>
<tr>
<td>Alcids (excluding murres)</td>
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<td>Murre (Uria spp.)</td>
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<td>Corvids</td>
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<td>Other</td>
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<td><strong>TOTAL</strong></td>
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</table>

**NOTE:**

Survey data indicated that a portion of the carcasses recovered after August 1989 had become oiled after mortality from other undetermined causes (Piatt and Ford 1996; Piatt et al. 1990). Statistical models completed by Ford et al. (1991) estimated the mortality as 375,000 birds. Other scientists estimated mortality from alternative models (Piatt and Ford 1996; Heinemann 1993; Piatt et al. 1990) that yielded numbers ranging from 100,000 to 690,000 birds. In addition, Weins (1995) indicated that a range of factors could interrupt the process between bird mortality at sea and the eventual washing up of the carcass on the shoreline. These factors include birds lost in harsh weather and wave action, ocean currents moving birds away from survey areas, birds sinking before being beached, beached birds swept back out to sea, birds that remain undetected in oiled detritus, or birds that are scavenged by other wildlife at sea and on land. For this reason, post-EVOS carcass counts, that have formed the basis of reported marine bird mortalities, represent an unknown portion of the actual mortality at the time of the spill.

Additional uncertainty surrounding bird mortality estimates (Piatt and Ford1996) also includes but is not limited to the following factors:

- Timing, frequency, technique and thoroughness of beach surveys
- Distribution patterns of slicks associated with EVOS.

A substantial portion of carcasses retrieved between August and September 1989 (approximately four months post-spill) displayed no external or internal indications of oil contamination, or physical evidence to suggest there was postmortem exposure to oil. The majority of these recovered carcasses were shearwaters, storm-petrels, gulls, black-legged kittiwakes (*Rissa tridactyla*) and recently-fledged puffins (Piatt et al. 1990). Necropsies and contaminant analyses indicated probable deaths were from starvation; thus, not all mortality may have been attributable to the EVOS. It was suggested by several scientists (McKnight et al.2006; Irons et al. 2000; Houghton et al. 1997) that the EVOS introduced a variety of short-term adverse effects to marine bird prey bases that diminished bird foraging opportunities and, in turn, resulted in starvation and increased compensatory predation on nesting colonies.

Specific conclusions regarding the relationships between 1) the extent, timing, and distribution of mortality associated with the EVOS and 2) the susceptibility of birds to oil also require consideration for the seasonal fluctuations in species abundances (Piatt et al. 1990). For example, the delayed observation of tufted puffin (*Fratercula cirrhata*) and horned puffin (*Fratercula corniculata*) mortality was likely due to the seasonal influx of these species to the Gulf of Alaska during the spring of 1989.

### 2.2 Chronic Effects

One of the outcomes of the EVOS was the creation of an unprecedented volume of published literature addressing the effects of chronic oil exposure, including the long-term ecological effects of oil spills (Peterson et al. 2003). Research has identified toxicological effects from chronic oil contamination (Leighton 1993) or indirect effects involving disruptions in trophic interactions (Peterson et al. 2003). However, chronic effects associated with exposure to residual Exxon Valdez oil have been difficult to quantify due to a lack of baseline data on the ecological conditions prior to the spill. Two decades later, issues that continue to be the subject of research and debate include the extent of exposure and pathways
of exposure by which marine birds continue to be affected by EVOS residual oil, including the degree to which the suppressed recovery of some species can be attributed to exposure to EVOS residual oil.

Following the EVOS, risk of direct exposure decreased as the spilled oil weathered (Boehm et al. 2007). Lighter fractions volatilized, while the water-soluble and emulsifiable fractions entered the water column and settled onto submerged substrates (Sterling Jr. et al. 2003; Wolfe et al. 1994; Galt et al. 1991). Shoreline sediments (i.e., fine gravels, sands, clays) were the primary repository for hydrocarbons as a consequence of their lipophilic and hydrophobic nature (Latimer and Zheng 2003). Oil of sufficiently low viscosity (e.g., less than 1,000 centipoise (cP)) percolated down through interstices left by seawater as the tide fell and might consequently have been sequestered (Li and Boufadel 2010; Xia et al. 2010; Short et al. 2004). As the water table rose with the incoming tide, capillary forces near the sediment grain contact points prevented most of the oil from refloating (Short et al. 2004) and left the residual oil protected from photo-oxidation and bacterial degradation. As a result of these processes, the sediments in PWS might have become exposure routes by which residual oil could be introduced into the food web, though the potential extent and effects through this pathway of exposure has been debated (Neff et al. 2006).

More than 20 years after the spill, there continues to be an ongoing debate in peer-reviewed literature as to whether marine birds in PWS are exposed to residual oil, whether residual exposure has caused effects at the individual or population level, and whether recovery is occurring or has occurred for distinct marine bird species (Esler et al. 2011; Wiens et al. 2010; Boehm et al. 2007; Peterson et al. 2003; Esler et al. 2002; Short et al. 1999; Day et al. 1997a). While it appears there has been a general recovery of marine bird diversity and numbers (e.g., Day et al. 2003; Day et al. 1997b; Wiens et al. 1996), there has been longer-term population depressions observed in some vulnerable taxa (e.g., Esler et al. 2010; Esler et al. 2002; Trust et al. 2000).

### 2.2.1 Changes to Habitat Use

The EVOS had immediate implications for habitat availability and habitat use for approximately half of all bird species studied (Irons et al. 2000; Day et al. 1997a; Murphy et al. 1997; Wiens et al. 1996; Wiens et al. 1995; Murphy et al. 1995). This was especially apparent in year-round resident species and species that use nearshore, intertidal and shoreline habitats (Lance et al. 2001). For example, taxa such as loons, cormorants, harlequin ducks, goldeneyes, mergansers, black oystercatchers, murres and pigeon guillemots displayed lower densities in oiled areas versus unoiled reference areas (Irons et al. 2000; Irons et al. 2001). Additional detailed information on the vulnerability of marine birds to oil in relation to habitat use is provided in the Northern Gateway’s Marine Birds: Susceptibility to Oil (Enbridge Northern Gateway Project 2012).

Habitat use has been used to examine chronic effects of oil spills. Research by Day et al. (2003; 1997a and 1997b) related the abundance of individual species occupying habitats in PWS to the oiling gradient (level of initial oiling) over space and time. They reported substantial initial effects in 19 of the 42 species examined, but found evidence of recovery within 2.5 years among 13 of the 19 species (Day et al. 1997a). Wiens et al. (2004) reported on marine bird studies in PWS for 12 years following the EVOS. They compared occupancy and habitat use in ten bays, within the spill zone, that exhibited a range of oil
exposure from unoiled to heavily oiled. Of the 25 bird species surveyed, 12 (48%) exhibited no evidence of spill effects, ten (40%) exhibited adverse effects that disappeared within seven years post-spill, and three (12%) exhibited positive effects that disappeared within two years post-spill. They reported no explicit evidence in any species to suggest delayed chronic effects resulting from habitat use.

These and other studies (Day and Murphy 2003; Irons et al. 2000) suggested that there was substantial recovery in habitat conditions and subsequent habitat use in the PWS intertidal zone during the years following the EVOS (Day et al. 2003). The authors concluded that the rate of recovery paralleled the rapid recovery seen following other spills (Day et al. 1997a). For example, some species may possess evolutionary adaptations to large-scale environmental perturbations (e.g., immense storms). Also, oil may have been physically dispersed by high-energy wave action along exposed rocky intertidal areas (Day et al. 1997a; Wiens et al. 1996).

It is important to note that the term ‘recovery’ in these studies was defined as the absence of a relationship between the abundance of a species and oiling levels, while others have defined recovery as an increase in post-spill populations of marine birds within PWS (McKnight et al. 2008). Other researchers have indicated that habitat occupancy does not necessarily indicate population recovery because it may, in fact, reflect high site fidelity expressed by some species or that the area is acting as a population sink (Monson et al. 2011; Esler et al. 2002).

### 2.2.2 Other Measures of Chronic Effects

Measures at the community-level, such as quantifying species richness and combined abundance of all species, have indicated that local effects on marine birds were transitory and that recovery of the bird community as a whole was relatively rapid (Day et al. 2003; Wiens et al. 1996). In many cases, however, studies have been criticized for being based on one of the following:

- Presence/absence data (Day et al. 2003; Day et al. 1997a; Wiens et al. 1996), which may not be informative about the health of populations
- Inappropriate temporal or spatial scales for some species (Day et al. 1997a)
- Summer data (Murphy et al. 1997) used, despite the fact that some species mainly overwinter in PWS (Esler et al. 2002).

The winter survival of female harlequin ducks (*Histrionicus histrionicus*) was examined in an attempt to understand long-term chronic effects. Decreased female survival in winter was observed by Esler et al. (2000b) between 1995 and 1998. Data from 2000 to 2003 indicated that there was no longer a difference in female winter survival between oiled and unoiled areas of PWS, suggesting that it took ten years for female survival to return to the levels observed in unoiled areas (Esler and Iverson 2010). Based on the proposition that female survival is the key attribute constraining population recovery following the EVOS, Esler and Iverson (2010) estimated that direct effects on harlequin ducks abated in PWS approximately 11 to 14 years following the spill.
2.2.3 Biomarkers of Oil Exposure

Biomarkers can be useful indicators of exposure to xenobiotics (chemical substances foreign to the biological system) that do not bioaccumulate or are rapidly metabolized (Prichard et al. 1997). Anderson and Lee (2006) provided a review of biomarkers used to assess petroleum exposure, including their usefulness and potential shortcomings. For example, in vertebrates, the cytochrome P4501A (CYP1A) enzyme system is responsible for the Phase I biotransformation of compounds such as polycyclic aromatic hydrocarbons (PAHs) and dioxin-like compounds (e.g., polychlorinated biphenyls [PCBs]) (Bucheli and Fent 1995; Stegeman and Hahn 1994).

In the ten years following the EVOS, harlequin ducks, pigeon guillemots (*Cepphus columba*), and Barrow’s goldeneyes (*Bucephala islandica*) using oiled areas of Prince William Sound were found to have elevated levels of CYP1A compared to birds from unoiled areas (Trust et al. 2000). A follow-up study from 2005 to 2009 revealed that CYP1A levels measured in harlequin ducks from oiled areas continued to be higher than in ducks from unoiled areas. This result suggested that up to 20 years after the initial spill, harlequin ducks in PWS continued to be exposed to oil from the EVOS, a time period that is much longer than conventional assumptions about the duration of the bioavailability of oil (Esler et al. 2010).

The prolonged exposure of harlequin ducks contrasts with data collected for Barrow’s goldeneye (Esler et al. 2011), which indicated no differences in ethoxyresorufin-O-deethylase (EROD; a proxy for CYP1A activity) expression in Barrow’s goldeneyes from oiled areas compared to unoiled areas in 2009 (though exposure was indicated previously through to 2005). These differences may result from variations in environmental factors, and/or life history characteristics or physiology traits among species. For example, harlequin ducks feed on various invertebrates that inhabit intertidal sediments while Barrow’s goldeneyes feed almost exclusively on blue mussels in the intertidal zone, which have been shown to accumulate lower concentrations of oil than other invertebrates (Payne et al. 2008). Additionally, there may be species differences in CYP1A response to PAH exposure.

Elevated CYP1A activity in pigeon guillemots from oiled areas compared to unoiled areas of PWS indicated that in the ten years following the EVOS, adult guillemots—like harlequin ducks and Barrow’s goldeneyes—were exposed to residual oil (Golet et al. 2002). A strong relationship between CYP1A and aspartate aminotransferase (AST) further suggested that exposure caused organ damage. Caution should be exercised in the interpretation of these results because AST was significantly elevated in only one of the two study years (Golet et al. 2002). Also, while adult guillemots exhibited elevated CYP1A levels, chicks did not, indicating oil exposure occurred only in adults (Golet et al. 2002). The authors attributed this to differences in diet: while adults consume both fish and benthic invertebrates, chicks feed almost exclusively on fish. Unlike invertebrates, fish can effectively metabolize hydrocarbons; thereby, decreasing the hydrocarbon burden delivered to the chicks (Meador 2003).

A number of studies have provided counter evidence that the EVOS was the source of the hydrocarbons since there are other contaminants in PWS that could stimulate biomarker enzymes (Boehm et al. 2004; Page et al. 2006). They point to the numerous locations associated with past human activity that still provide a low-level source of PAHs and to various geological sources of oil, including oil seeps and coal.
(Short et al. 1999). Other reviewers have suggested that the statistical evidence for greater CYP1A activity in oiled areas, compared to unoiled areas, is weak. Wiens (2007) noted that the highest level of CYP1A activity in harlequin ducks observed in 2000 came from an unoiled area and maintained that interpretation of the statistical differences is not straightforward.

### 2.2.4 Indirect Effects

Longer-term interactions, due to chronic exposure to oil, have been proposed as mechanisms by which marine birds that inhabit rocky shorelines may be delayed in recovering from oil spills (Peterson et al. 2003; Peterson 2001). Ongoing research has shifted toward an ecosystem approach when assessing the long-term effects of oil spills. Many parameters, which cannot either be measured in a laboratory setting or observed immediately following a spill, may have produced effects on PWS ecosystems that were not previously understood (Esler et al. 2010). For example, the weeks and months following the EVOS were formerly believed to have the greatest population-level effects; however, indirect effects on particular species (e.g., harlequin ducks), resulting from subsequent chronic oil exposure, may actually have exceeded the mortality resulting from acute exposure to oil (Monson et al. 2011; Iverson and Esler 2010; Peterson et al. 2003).

In pigeon guillemot nestlings, decreased survival observed at oiled sites was attributed to reduced availability of high-lipid forage fishes such as Pacific sand lance (*Ammodytes hexapterus*), Pacific herring (*Clupea pallasii*), capelin (*Mallotus villosus*), and smelt (*Osmeridae*) (Golet et al. 2002; Peterson 2001); see Piatt and Anderson (1996) for a similar discussion involving common murres. These findings were based on analysis of chick diets and were related to differences in reproductive performance at oiled sites compared to unoiled sites (Golet et al. 2002). Consumption of high-lipid forage fishes has been positively related to chick growth rates, nestling survival, and overall productivity (Golet et al. 2000). Conversely, no differences were observed in harlequin duck prey availability or consumption or body mass between oiled and unoiled sites during the overwintering period of study (Holland-Bartels 2002). For this species, evidence from several lines of investigation points to direct exposure to residual oil in constraining population recovery, as opposed to the indirect effects of food availability or demographic processes (Holland-Bartels 2002).
3 Species Population Recovery

The EVOS Trustee Council (EVOSTC) indicates that assessing, planning for and active management of, species recovery are based on a goal of a “return to conditions that would have existed had the spill not occurred” (EVOSTC 2010). Defining what those conditions would have been is difficult to assess in the absence of detailed baseline data. Many scientists have based their definition of recovery on statistical criteria, defining recovery “as the disappearance over time of a previously significant relationship [of the bird species] with oiling” (Wiens et al. 2004; Murphy et al. 1995). This latter view has received criticism for undervaluing factors such as pre-existing demographics (e.g., age structure), species composition, and population densities (Paine et al. 1996).

Defining a state of recovery and determining if the current limited, or lack of, recovery observed in some species (e.g., pigeon guillemots and Kittlitz’s murrelets [Brachyramphus brevirostris]) are attributable to the EVOS is a subject of significant debate (Wiens et al. 2004). The limited recovery of some species may actually be attributed to a complex interaction of both natural and anthropogenic factors and not necessarily to chronic effects of the EVOS (EVOSTC 2010). For example, a study in PWS found that significant declines in the populations of marine bird species which rely on fish (wholly or in part) for their diet, such as surf scoter and pigeon guillemot, might be linked to reduced fish prey abundance, which is due to a climatic regime shift (Agler et al. 1999).

The following subsections highlight the recovery status of several marine bird species that have been the focus of post-EVOS scientific and governmental focus, some with conflicting evidence and views on status of population recovery. Vulnerability to oil varies across marine bird groups due to diverse life history traits, among other ecological factors. For more information on specific vulnerabilities, see Northern Gateway’s Marine Birds: Susceptibility to Oil (2011).

3.1 Recovered Populations

3.1.1 Common Loon

Common loons (Gavia immer) occur in the Gulf of Alaska primarily in winter and as spring and fall migrants. They are generally uncommon to rare, ranging from a few hundred to a few thousand individuals annually (Day 2006). There were 216 common loon carcasses collected (of 395 carcasses of Gavia spp.) after the EVOS; however, direct mortality was estimated by the EVOS Trust Council (2010) as 720 to 2,160 individuals.

Although common loon populations were reported to have declined immediately following the oil spill event (Irons et al. 2000), long-term surveys conducted from 1989 to 2007 found winter populations were increasing to pre-spill levels. Loon populations appeared to begin recovering in 1991 and are now at, or have exceeded, historical numbers (EVOSTC 2010; Day et al. 1997b).
3.1.2 Bald Eagle

PWS provides year-round and seasonal habitat for approximately 6,000 bald eagles (*Haliaeetus leucocephalus*) (EVOSTC 2010). Bald eagles are common residents of marine and estuarine shorelines throughout the oil spill area and are known to breed in PWS.

Following the EVOS, bald eagle mortality was estimated at 250 individuals; with 151 carcasses recovered (Wiens 1995). In oiled areas of PWS in 1989, productivity was reduced to 30% nest success and 0.39 young per active nests compared to control areas were 54% of nests were successful and 0.96 young per active nest (Bernatowicz et al. 1996). Aerial surveys confirmed productivity had returned to normal by 1990 and 1991 (Bowman 1999; Day et al. 1997b), with more than 0.8 young per active nest (Bernatowicz et al. 1996). By 1995, reproductive success and (or) recruitment was estimated to have returned the population to or exceeding its pre-spill numbers (EVOSTC 2010).

3.1.3 Common Murre

Approximately 74% of seabird mortality in PWS was common murres (*Uria aalge*) and thick-billed murres (*Uria lomvia*). Indirect effects of oiling on common murres included disrupted metabolism and liver damage leading to disability and mortality (Khan and Ryan 1991). Short-term, lethal and sublethal effects were observed until 1993, including reduced breeding success, lower chick weight and survival, poorer body condition and delayed breeding phenology (Golet et al. 2002; Piatt and Anderson 1996). Although the timing and success of breeding at murre nesting colonies within the Gulf of Alaska was reportedly disrupted, pre-spill population abundances were re-establishing during 1993 to 1997, which suggested that recovery took approximately four to seven years (EVOSTC 2010). It has been suggested, by some studies, that large numbers of previously non-breeding common murres might have filled the newly available nesting opportunities, which may have obscured numerical declines based on colony counts (Boersma and Clark 2001; Parrish and Boersma 1995).

3.1.4 Glaucous-winged Gull

The glaucous-winged gull (*Larus glaucescens*) is a year-round resident that breeds in PWS. As a group, gulls accounted for 25% of living birds observed in PWS during surveys conducted in the weeks following the EVOS (Piatt et al. 1990), which suggested gulls might have reduced susceptibility to oiling.

Results of the EVOS carcass surveys conducted in early summer of 1989 indicated that direct mortality to gulls was lower than for other marine bird guilds. Gulls comprised 2% of the total number of retrieved carcasses. However, late summer surveys in that same year showed an increase in gull mortality (21% of retrieved carcasses) (Piatt et al. 1990). The glaucous-winged gull is a surface feeder and delay in mortality may be due to chronic oil exposure during time spent on the ocean surface ingesting oiled prey (Piatt et al. 1990).

The recovery status of glaucous-winged gull was uncertain in the first few years following the EVOS. Day et al. (1997b) determined that the species initially showed adverse effects with no evidence of recovery. Subsequent publications indicated substantial population increases in PWS, which may partially
be attributed to the indirect effects of vessel clean-up activities, which tend to provide sustenance to foraging gulls (Irons et al. 2000; Murphy et al. 1997). Overall, the populations of glaucous-winged gull in PWS are now considered to have re-established to pre-spill levels (Irons et al. 2000).

3.1.5 Black-legged Kittiwake

The black-legged kittiwake occurs in PWS during summer months with known breeding colonies within PWS and nearby Barren Islands and the Kenai Coast (USFWS 2006; Piatt et al. 1990).

The primary mechanisms for acute effects from the EVOS included contact with oiled areas of the ocean surface and ingestion of contaminated prey (USFWS 2006). Because kittiwakes are colonial breeders, contaminated adults could potentially transfer oil to breeding sites which, in turn, could decrease reproductive success if hydrocarbon compounds persisted at nest sites for multiple generations (Piatt et al. 1990).

Multiple studies following the EVOS documented black-legged kittiwake population declines in PWS (Irons et al. 2000; Day et al. 1997b; Piatt et al. 1990). These studies indicated that observed population declines might potentially have been related to changes in foraging behavior, with a large number of individuals selecting habitat outside of the spill zone (Irons et al. 2000). It was unknown whether the changes in foraging distribution reflected normal feeding cycles or if kittiwakes were avoiding oiled areas (Irons et al. 2000). In addition, species decline was, in part, attributed to natural breeding failures at nesting colonies and unrelated to the spill event (Day et al. 1997b; Piatt et al. 1990). Similar breeding failures were documented at kittiwake colonies in the area in the years prior to the EVOS and these breeding failures were strongly influenced by availability of food supply (USFWS 2006; Piatt et al. 1990).

Recent studies suggest that breeding colonies in the PWS have since recovered and increased 1.6% since the 1970s (USFWS 2006). Therefore, it is expected that black-legged kittiwake has recovered to pre-EVOS levels (USFWS 2006).

3.2 Recovering Populations

3.2.1 Barrow’s Goldeneye

Approximately 20,000 to 50,000 Barrow’s goldeneyes commonly winter in protected near shore marine waters in PWS.

This marine bird species is particularly vulnerable to oil exposure because of its preference for diving and foraging on invertebrates in shallow near shore and subtidal habitats (Trust et al. 2000; Irons et al. 2000). Acute mortality following the EVOS was estimated in the low thousands (EVOSTC 2010). Studies on Barrow’s goldeneyes indicated this species might have also experienced chronic effects from residual oil, although it’s unclear for how long or whether adverse effects were observable at the population or regional level (Esler et al. 2011; Irons et al. 2000).
The population of Barrow’s goldeneye in the Gulf of Alaska was considered by some scientists to have recovered from the EVOS by 1996 to 1998 (Wiens et al. 2001). Others considered the population to be increasing and still recovering from the effects of the oil spill (EVOSTC 2010).

### 3.2.2 Harlequin Duck

The harlequin duck is a common winter resident foraging in the shallow subtidal and near shore habitats of the Gulf of Alaska. PWS is prime wintering habitat supporting an estimated 14,000 to 15,000 harlequin ducks (EVOSTC 2010; Esler et al. 2002; Lance et al. 1999).

The harlequin duck’s preference for foraging in shallow marine areas, strong site fidelity and limited capacity to withstand increase in energy costs may have increased its vulnerability to both acute and chronic effects of the EVOS because of the potential exposure to residual oil deposits (Esler and Iverson 2010; Esler et al. 2002; Esler et al. 2000b; Trust et al. 2000). Harlequin duck mortality was estimated at 1,000 individuals with 150 carcasses collected after the EVOS. Population densities were reported to be lower in oil-affected areas than unaffected areas in 1990 and 1991 (Irons et al. 2000), and in the winters from 1995 to 1997 (Esler et al. 2000a); however, other contradictory studies have indicated no significant effect of oiling on harlequin duck populations following the EVOS (Day et al. 1997a).

Extensive research has endeavored to quantify the chronic effects related to long-term exposure of harlequin ducks to residual oils (Wiens 2007; Esler et al. 2002; Trust et al. 2000). For example, studies indicated that chronic effects were responsible for the decreased survival rates of female harlequin ducks, and that it was approximately a decade before survival rates returned to normal levels (Esler and Iverson 2010, Esler et al. 2000b) and 11 to 14 years before the population began to show signs of recovery (Esler et al. 2010, EVOSTC 2010). Debate remains as to whether the EVOS is a source of chronic contamination because trace oil detections might potentially be from other sources. The sources of chronic contamination currently identified in PWS include:

- Oil slicks and sheens from routine vessel traffic and discharge (Taft et al. 1995)
- Oil from old canneries and other abandoned industrial sites (Page et al. 1995)
- Trace in subtidal sediment from oil spilled during earthquakes
- Trace in sediments from natural oil seeps to the east of PWS (Bence and Burns 1995; Page et al. 1995; Irons et al. 2000)
- Trace in sediments from the EVOS (Bence and Burns 1995)
- Oil residues (sub-surface oil) beneath the beaches (Short et al. 1999; Hostettler 1999a).

In addition, Neff et al. (2006) indicates that oil buried on shorelines as a result of the EVOS is located on 0.1% of the entire PWS shoreline and has low bio-availability due to its sequestration from normal weathering processes. It is their view that the low concentrations of EVOS PAH found at some oiled shoreline sites in PWS do not represent a health risk to populations of marine birds and mammals that forage on intertidal organisms. Therefore, although it is known from studies that oil sequestered on some
beaches in PWS is associated with the EVOS, it remains unknown whether this is the source of oil contamination detected in CYP1A trials of harlequin ducks.

Constraints to, or variations in, population recovery may be attributable to several factors, including for example:

- Direct exposure while foraging in the subtidal sediments due to the presence of residual oil
- Limited food resources due to oil-related prey mortality
- Intrinsic demographic lags related to the effects of the EVOS (Rice et al. 2007; Esler et al. 2002; Trust et al. 2000)
- Climatic regime shifts in food abundance (Agler et al. 1999).

Other scientists have concluded there are “no detectable ecologically significant effects” of the EVOS on harlequin ducks (Harwell and Gentile 2006). Harlequin duck populations that winter in PWS remain below pre-EVOS levels and are still recovering (EVOSTC 2010; Trust et al. 2000).

### 3.2.3 Black Oystercatcher

An estimated 700 black oystercatchers (Haematopus bachmani) are present within PWS (Agler et al. 1999), with an additional 800 to 1,300 resident individuals along the south-central coast of Alaska (EVOSTC 2010). Black oystercatchers spend their entire life cycle in or near intertidal habitats foraging exclusively on invertebrate species and are, thus, highly vulnerable to oil pollution (Andres 1999).

Only nine black oystercatcher carcasses were recovered following the EVOS, with direct mortality estimates ranging from 50 to 280 individuals (Harwell and Gentile 2006). However, some studies indicate black oystercatchers exhibited no significant population declines following the EVOS from 1989 to 1991 (Day et al. 1997a). Population estimates were reported to be significantly lower in affected areas than unaffected areas during post-spill surveys in 1990, 1991 and 1998 (Irons et al. 2000).

Studies using biomarkers as a method of detecting oil in oystercatchers indicated continued exposure to oil up to 2004 (EVOSTC 2010). It is unclear what effect, if any, the EVOS may have had on black oystercatcher breeding and foraging success (Murphy and Mabee 2000; Andres 1999).

Black oystercatcher population numbers are considered by some scientists to have recovered (Murphy and Mabee 2000; Agler et al. 1999), while other scientists have reported population trend estimates that indicate numbers have not returned to pre-spill levels (EVOSTC 2010).

### 3.3 Other Populations

The following bird species populations appear to be in decline; although, it is uncertain to what degree the EVOS may have contributed.
3.3.1 Pigeon Guillemot

Pre-spill estimates of pigeon guillemot breeding populations in PWS varied between 20,000 and 40,000 birds (EVOSTC 2010).

Reported indirect effects of oil include disruption to forage fish abundance and increased nest predation on incubating adults and chicks following the EVOS (Golet et al. 2002). In addition, predators, such as river otters, shifted away from their primary prey (i.e., shellfish and fish), which were less abundant due to oiling and subsequent clean-up efforts, to prey on birds (Golet et al. 2002).

Weins (1996) indicated that studies suggested there were no spill-related effects to pigeon guillemot reproduction. Studies in 2002, however, indicated that pigeon guillemots present in PWS were exposed to residual oil, as evidenced by levels of the biomarker enzyme, CYP1A, in the livers of adult birds collected from oiled areas (Peterson et al. 2003; Golet et al. 2002). Thus, there might have been sublethal chronic effects at the population-level, as well as indirect effects from reduced foraging fish stocks during breeding efforts (Golet et al. 2002).

Pigeon guillemot populations were reportedly declining in the ten years preceding the EVOS, which suggests there are likely additional factors effecting population stability (Wiens 1996). The status of pigeon guillemot populations is considered as not recovering by the EVOS Trust Council (2010); however, the factors that are adversely influencing the survival of pigeon guillemots in PWS are uncertain (Golet et al. 2002).

3.3.2 Marbled Murrelet

Population estimates of marbled murrelet (Brachyramphus marmoratus) in the Gulf of Alaska prior to the EVOS ranged from 50,000 to 120,000 birds (EVOSTC 2010; McKnight et al. 2006).

There were 1,100 murrelet (Brachyramphus spp.) carcasses retrieved following the EVOS, and approximately 90% of these were identified as marbled murrelets. Mortality from exposure to oil was estimated at 8,400 birds, representing approximately 7% of the population living in the spill zone (McKnight et al. 2006). Foraging activity and breeding behavior might also have been disrupted during oil spill clean-up activities (EVOSTC 2010).

Marbled murrelet survival and distribution have reportedly been declining in the Gulf of Alaska and PWS since the 1970s. Marbled murrelet populations in PWS declined by 50% between 1972 and 1992, from the cumulative effects of oil pollution, logging of old-growth forests, gill netting and anthropogenic alterations to the marine environment (Piatt and Naslund 1995). A lack of pre-spill baseline ecological data in these areas makes it difficult to determine whether more recent population declines can be attributed to the EVOS. Based on available data and scientific opinion, the recovery status of the marbled murrelets population remains unknown (EVOSTC 2010).

3.3.3 Kittlitz’s Murrelet

The size and distribution of Kittlitz’s murrelet in PWS was estimated at 2,080 individuals in 2009, a significant decline from 91,162 reported in 1972 (Kuletz et al. 2011).
Of the 1,100 murrelet carcasses recovered after the EVOS, a small portion was identified as Kittlitz’s murrelets. Direct mortality estimates ranged from 255 to 2,000 individuals, which represented approximately 5 to 10% of the world’s population of Kittlitz’s murrelet (EVOSTC 2010). This reduction was significant because the shelf of the northern Gulf of Alaska, generally, and PWS, more specifically, are important wintering and breeding areas for Kittlitz’s murrelet (Kuletz et al. 2011; Day 2006; Day et al. 1999).

Population estimates have remained uncertain until recently due to several factors: the prohibitive expense of studying the naturally small population within the Gulf of Alaska, incorrect identification of similar-looking species, and a lack of information on the source(s) of pre-spill and post-spill population declines (EVOSTC 2010; Day and Nigro 2003). The rate of population declines were estimated at 13% from 1989 to 2007 (Kuletz et al. 2011).

The recovery status of Kittlitz’s murrelet in PWS is uncertain and the factors contributing to the continued decline of the population remain unresolved (EVOSTC 2010).
4 Application to the Northern Gateway Project

Northern Gateway has committed to a comprehensive, world-class marine safety program for the Project to minimize the risk of hydrocarbon spills. This includes the following:

- Using of modern double-hulled tankers
- Committing to Independent BC pilots and International Maritime Organization (IMO) certified tanker crews on all vessels
- Vetting of all tankers by a third-party agency before gaining entry to port
- Using escort tugs with all tankers within the CCAA
- Using an additional tethered tug for all laden vessels within the CCAA
- Reducing vessel speeds (8 - 12 knots) within the CCAA
- Augmenting the automatic identification system by installing a radar system along coastal routes.

Additional mitigation measures are provided below.

4.1 Response Planning

Northern Gateway has committed to developing an integrated tier of emergency response plans well in advance of the start of marine operations, which include the General Oil Spill Response Plan, a Marine Oil Spill Response Plan and detailed Geographic Response Plans. A Responsible Organization will be selected to acquire and maintain equipment, and to identify and train response teams. In addition, a range of baseline environmental surveys will be completed (e.g., marine birds, environmental effects monitoring) to establish the existing condition of environmental quality, as well as species abundance and diversity. Details are provided in Northern Gateway Application Volume 8C, Section 2.1 Vessel Operations and Environmental Protection, the General Oil Spill Response Plan (GOSRP), and the operational Marine, Terminal and Pipeline Oil Spill Response Plans (OSRP). All plans will be finalized six months prior to the commencement of marine operations.

4.2 Comprehensive Baseline Monitoring

Strategic components of Northern Gateway pre-operational baseline and post-operational environmental monitoring programs will include systematic sampling of marine birds within a larger Marine Environmental Effects Monitoring Program to document environmental quality in specific areas throughout the CCAA and parts of the OWA (e.g., vessel approaches to the CCAA, critical marine habitat areas). The intent will be to supplement existing baseline data, and will focus on an ecosystem-based approach with some site-specific tailoring to the ecology of appropriately selected indicator species. This approach will reduce the potential for future uncertainties with regard to species trends, populations, environmental quality and habitat use, and ecological sustainability.
The design of the marine bird baseline and monitoring surveys will be developed through discussions with Canadian Wildlife Service and participating Aboriginal groups. For more detailed information on the commitments of the Project’s marine programs, see Northern Gateway’s 2010 Application, Volume 7C, Section 7.8.5, supplemental report: Framework for the Marine Environmental Effects Monitoring Program, and supplemental marine bird reports. Information on mitigation measures and monitoring program commitments are provided in Northern Gateway’s 2010 Application, Volumes 7C and 8C.
5 Conclusions

The EVOS contributed to a variety of non- or partially-mitigated acute and chronic effects. The acute and short-term effects of the EVOS on many marine bird species have been thoroughly documented across multiple studies: external oiling to the bodies of marine birds, direct ingestion of oil, sublethal effects, and reduced productivity and survivorship. Issues associated with long term and chronic effects to marine birds, including residual oil exposure, bioavailability of the oil, potential ecological effects and the effects on marine bird health (at individual and population levels), are less understood and have generated considerable debate in the literature.

While many marine bird populations appear to have recovered from the effects of the EVOS, some species—either through a complex set of environmental factors, life history characteristics (e.g., harlequin ducks), or as a result of indirect effects (e.g., pigeon guillemots)— are considered by the EVOSTC as having not recovered. Some species within the alcid and diving duck guilds appear to have experienced greater acute and longer term chronic effects than those in other guilds. Some species populations were declining prior to the EVOS for reasons that are unclear. Gaining an understanding of the acute and chronic ecological effects that are attributable to the EVOS remains problematic primarily because of the lack of knowledge regarding:

- Pre-spill marine ecological conditions
- Sources and ranges of natural variability in these systems
- Abundances, habitat use and thresholds of marine bird populations in the marine areas affected by the EVOS.

These deficiencies also constrain efforts to assess the extent of the known effects to marine birds. Research studies continue to investigate short and long-term effects of the EVOS, along with the success of remediation efforts, and the recovery of bird populations.

The EVOS, and other large spills in recent history, have led to major and important changes in the regulation and operation of hydrocarbon tankers world-wide. Such incidents have also led to improvements in the approaches used for managing and responding to spills including:

- Improved timelines, capabilities and capacity for oil spill response
- Use of Net Environmental Benefit Analysis (NEBA) to determine most appropriate spill response and clean-up techniques
- New or improved containment, recovery and clean-up methods and tools (e.g., use of dispersants and controlled burning), as well as better definitions of appropriate uses
- Structured approaches to spill response planning, management and implementation (i.e., adoption of Incident Command Structure [ICS], Geographic Response Plans)
- Advanced methods for tracking spills, and protecting coastal and marine sensitivities, including using environmental sensitivity and operation atlases to support spill response and clean-up actions
Innovative rehabilitation of affected areas.

In combination, these regulatory and operational improvements may now limit the amount of oil that could be released following a grounding incident, such as the EVOS, while management and response improvements may reduce the amount and persistence of oil following a release. The collective developments with regard to the integrity and safety of tankers, and the management and techniques of spill response since the EVOS, have the potential to reduce the effects of an oil spill on marine birds.

The EVOS event created valuable research-based recommendations that will be considered for incorporation into the oil spill risk assessments, oil spill response plans and pre- and post-construction monitoring plans for the Northern Gateway Project. These recommendations include, but are not limited to establishing baseline conditions, predetermining oil susceptibility for species within the project area, developing robust monitoring strategies, and preparing comprehensive oil spill response plans. This will reduce environmental uncertainties and contribute to an existing base of local and regional knowledge.

Of note, Northern Gateway has committed to the conduct of additional baseline surveys of marine bird abundance and distribution for three years prior to the start of operations. The Marine Environmental Effects Monitoring Program will provide information on baseline environmental quality in the CCAA. This information, together with other published information and data sources, and Aboriginal traditional knowledge, will be used to update the environmental sensitivity and operation atlases. In combination with stochastic spill modeling, this information will be used in the development of the Marine Oil Spill Response Plan and the associated Geographic Response Plans. Environment Canada, BCME and participating Aboriginal groups will be engaged in the development of these response plans and the finalization of the environmental atlases.
6 References


Section 6: References


6.1 Personal Communications


Moore, J. 2012. Senior Marine Ecologist and Environmental Consultant, owner of Coastal Assessment, Liaison & Monitoring, Pembrokeshire, UK.

Pearson, W. 2012. Formerly Staff Scientist, Battelle/Marine Sciences Laboratory, Sequim, Washington; Currently owner and chief scientist of Peapod Research addressing natural resource and environmental issues in marine and aquatic systems. Allendale, MI
Marine Birds: Susceptibility to Oil

ENBRIDGE NORTHERN GATEWAY PROJECT

Prepared by
Stantec Consulting Ltd.
Burnaby, British Columbia

October 2012

123510694 413.301
1 Introduction

Northern Gateway Pipelines Limited Partnership (Northern Gateway) was formed to design, develop, construct, own and operate the Enbridge Northern Gateway Project (Project). The Project includes the construction, operations and decommissioning of oil pipelines and associated infrastructure, and the Kitimat Terminal. The marine environment is comprised of the Confined Channel Assessment Area (CCAA) and the Open Water Area (OWA).

As part of the review of the Project, Environment Canada requested a comprehensive assessment of region-specific effects of oil spills. To address this request, Northern Gateway prepared this report and tabular summary that describes the following information for each major group of marine birds:

- Sensitivity to oil spills
- Vulnerability to oil spills relative to distribution and occurrence in the CCAA and the OWA
- Summary of observed effects in the published literature
- Potential mitigation measures.

Northern Gateway has committed to providing the requested information and the following report addresses those commitments.
2 Major Marine Bird Groups and Susceptibility to Oil Spills

2.1 Introduction

The northern coast of British Columbia provides year-round, high-value wildlife habitat for a large diversity and abundance of marine birds including pelagic species, alcids, waders, shorebirds, dabbling and diving ducks, and marine-associated raptors. These coastal areas provide important nesting areas for many seabird species and are extensively used wintering and staging areas with some species spending up to 10 months here. Many sheltered bays, lagoons, channels and estuaries are important components of the coastal migratory route for a wide variety of shorebirds and waterfowl.

Two key elements determine susceptibility: the relative sensitivity of marine birds to oil (i.e., anatomy, life stage) and their vulnerability to exposure to oil (i.e., seasonal abundance, distribution, foraging and breeding behaviour, likelihood of exposure (proportion of time spent on water)). Vulnerability is also expected to vary among seasons because marine bird communities differ in their composition.

This report provides a comprehensive summary of major marine bird groups present within the CCAA and OWA, and describes marine bird sensitivity and vulnerability to oil spills (i.e., susceptibility to interaction with an oil spill). For each marine bird group, the tabular summary describes associated species within each group, the relative distribution and occurrence of taxa across all seasons of the year, their specific susceptibility to the effects of a potential oil spill, and mitigation measures to reduce susceptibility (Table 1).

2.2 Methodology

2.2.1 Literature Review

To populate Table 1, information was compiled from government and non-government resources, peer-reviewed journals, published literature and local environmental and consulting reports to provide background data on marine and coastal bird occurrence and abundance, oil vulnerability, and species and/or species group sensitivities to oil spills.

Additional information was contributed by the following scientists with expertise in the field of oil spill risk, assessment, management, and wildlife species population recovery and from literature on the effects of the Exxon Valdez Oil Spill (EVOS):

- Moore, J. 2012. Senior Marine Ecologist and Environmental Consultant, owner of Coastal Assessment, Liaison & Monitoring, Pembrokeshire, UK.
Pearson, W. 2012. Formerly Staff Scientist, Battelle/Marine Sciences Laboratory, Sequim, Washington; Currently owner and chief scientist of Peapod Research addressing natural resource and environmental issues in marine and aquatic systems. Allendale, MI

Information pertaining to species occurrence, species abundance, and measures to mitigate the effect of oil on marine birds is available in Northern Gateway’s 2010 Application from the following documents:

- Volume 6B: Environmental and Socio-economic Assessment – Marine Terminal
- Volume 7C: Risk Assessment and Management of Spills – Kitimat Terminal
- Volume 8B: Environmental and Socio-economic Assessment – Marine Transportation
- Volume 8C: Risk Assessment and Management of Spills – Marine Transportation

### 2.2.2 Oil Vulnerability Indices

The vulnerability of marine birds to oil spills depends not only on the numbers of individuals present but also on the behaviour and other life history characteristics of each species. In Europe and North America, several studies have quantitatively assessed these characteristics in relation to marine bird sensitivity to oil pollution using bird vulnerability indices, such as the Oil Vulnerability Index (OVI) (Camphuysen 2006; King and Sanger 1979) or the Bird Oiling Indices (BOI) (Speich et al. 1991). These indices, which include factors affecting the survival of a species, use scoring systems (e.g., 0, 1, 3, or 5) that rank sensitivity to oil spills, from relatively no sensitivity (OVI close to zero) to relatively high sensitivity (OVI close to 100) (Camphuysen 2006). The scores assigned to any given factor are summed to provide an overall OVI for each species. Another similar approach has been used by Speich et al. (1991) to assess oil spills in the Puget Sound Area through development of a Bird Oiling Index (BOI); however, this ranking system uses an index rated out of 1,000 points, as opposed to that of 100 points used in the OVI referred to by Camphuysen.

Overall oil vulnerability of each marine bird group in Table 1 quotes species-specific OVI values from published literature (e.g., Camphuysen 2006) as indicative values for similar-grouped species that may share morphological or life history traits. In some instances, an OVI value for a non-regional, but analogous species (such as Atlantic Puffin), is presented as a representative index where an OVI is otherwise unavailable from literature sources. For consistency in interpretation of Table 1, the BOI index was not included because it is not comparable with the OVI.

### 2.3 Results and Discussion

#### 2.3.1 Tabular Summary of Marine Bird Groups and Oil Susceptibility

Table 1 summarizes the relative oil spill susceptibility of six marine bird groups representing 124 marine bird species known to occur in the CCAA and/or OWA. The tabular summary is based on two main components of information used to describe overall susceptibility:
1. Species richness, abundance and distribution of each marine group

2. Oil spill sensitivities of each marine bird group, based on life history traits that may contribute to exposure.

These inputs are described in detail in the following sections.

### 2.3.1.1 Marine Bird Groups and Associated Species

In the tabular summary, marine birds are classified by major bird group, associated species diversity within each group, and the abundance and expected distribution within the CCAA and the OWA. The arrow on the left side of the table indicates relative susceptibility to oil spills. Species groups are thus ranked from highest to lowest in accordance with known sensitivities to oil. However, within each marine bird group, some species may be more vulnerable than others; hence, there are some limitations to outlining vulnerability at the higher taxon level.

The occurrence of each bird species is based on data currently available for known or potential occurrences within the Project area, and the larger region or province, and has been refined, wherever possible, with newly available information. Population estimates for individual species are provided as context for assessing vulnerability. For example, within the group “Gulls, Terns, Jaegers, and Skuas”, the breeding population of Glaucous-winged Gull is estimated at 50,000 individuals in BC. In contrast, the South Polar Skua is considered a rare visitor to the CCAA and OWA and, as such, is expected to be reported less than annually.
Table 1  Major Marine Bird Groups and Susceptibility to Oil

<table>
<thead>
<tr>
<th>Marine Bird Group</th>
<th>Number of Species</th>
<th>Main Distribution</th>
<th>Abundance</th>
<th>Example Population Estimates</th>
<th>Oil Vulnerability Index (OVI)</th>
<th>Sensitivities to Oil Spills</th>
<th>Highest Seasonal Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Alcids</strong></td>
<td>9</td>
<td>CCAA and OWA</td>
<td>Common Murre: Y; Thick-billed Murre: w; Pigeon Guillemot: Y; Marbled Murrelet: Y; Ancient Murrelet: Y; Cassin's Auklet: y; Rhinoceros Auklet: PSfw; Horned Puffin: ws; Tufted Puffin: s</td>
<td>Marbled Murrelet: 54,700 to 77,700 in BC (BC MWLAP 2004). Ancient Murrelet: 512,000 Canada and BC (BC MWLAP 2004)</td>
<td>Atlantic Puffin: 80, Common Murre: 82</td>
<td>- Form large aggregations to breed or feed. - Breeding resident: reduced breeding, hatching success and offspring through oil transfer to eggs or direct oil ingestion. - Disturbance avoidance through diving. - Diving forager. - Breeding constraints (delayed maturity, small clutch size, long lifespan); hence, populations are vulnerable and could potentially take a long time to recover. - Winter resident: higher physiological stress may be increased by longer oil persistence in cold temperatures. - Intertidal foragers (Pigeon Guillemot) are particularly susceptible to both acute and chronic effects of oil, and indirect effects due to disruption of nearshore food webs.</td>
<td>Winter aggregations and summer breeding colonies/cliff nesters (Common Murre and Ancient Murrelet). Large concentrations of summer foraging (Cassin’s Auklet) (EC 2012).</td>
</tr>
<tr>
<td>Loons, Cormorants and Grebes</td>
<td>12</td>
<td>CCAA and OWA</td>
<td>Red-throated Loon: Y; Pacific Loon: PsFW; Common Loon: Y; Yellow-billed Loon: y; Pied-billed Grebe: r; Horned Grebe: FWP; Red-necked Grebe: FWP; Western Grebe: M; Eared Grebe: r; Brandt's Cormorant: M; Double-crested Cormorant: y; Pelagic Cormorant: Y;</td>
<td>Double-crested Cormorant: 49,094 in BC (Moul and Gebauer 2002). Western Grebe: 118,000 in North America with &lt;200 breeding pairs in BC (Burger 1997). Highest abundances of many species, and highest bird-days recorded, occur during nonbreeding periods of the year (EC 2012).</td>
<td>Red-throated Loon: 68, Common Loon: 67, Red-necked Grebe: 54</td>
<td>• Breeding resident: reduced breeding, hatching success and offspring through oil transfer to eggs or direct oil ingestion. • Long nonbreeding period of residence. • Disturbance avoidance through diving. • Diving foragers.</td>
<td>Breeding season as species (e.g., Red-throated Loon) nest along the terrestrial shoreline in OWA and CCWA and provision young by diving for small fish, though, are present throughout the nonbreeding period as well.</td>
</tr>
</tbody>
</table>
## Table 1  Major Marine Bird Groups and Susceptibility to Oil (cont’d)

<table>
<thead>
<tr>
<th>Marine Bird Group</th>
<th>Number of Species</th>
<th>Main Distribution</th>
<th>Abundance</th>
<th>Assessed Vulnerability to Oil γ</th>
<th>Oil Vulnerability Index (OVI)*†</th>
<th>Sensitivities to Oil Spill†</th>
<th>Highest Seasonal Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diving Ducks</strong></td>
<td>16</td>
<td>CCAA and OWA</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Common Goldeneye: 1,000,000 in North America (SDJV 2004a)</td>
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<td></td>
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<td></td>
<td>Barrow's Goldeneye: 200,000 to 250,000 in western North America (SDJV 2003)</td>
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<td></td>
<td></td>
<td></td>
<td>Surf Scoter: 600,000 to 1,000,000 in North America (SDJV 2004b)</td>
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<td></td>
<td></td>
<td></td>
<td>Harlequin Duck: 150,000 to 250,000 in western North America (SDJV 2004c)</td>
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<td></td>
<td></td>
<td></td>
<td>• Disturbance avoidance through diving.</td>
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<td></td>
<td></td>
<td></td>
<td>• Diving forager.</td>
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<td></td>
<td></td>
<td></td>
<td>• Winter resident: higher physiological stress may be increased by longer oil persistence in cold temperatures.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Many species forage in nearshore, subtidal and intertidal habitats.</td>
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<tr>
<td><strong>Pelagic</strong></td>
<td>11</td>
<td>OWA</td>
<td>Laysan Albatross: s; Black-footed Albatross: psf; Short-tailed Albatross: r; Northern Fulmar: Y; Pink-footed Shearwater: r; Flesh-footed Shearwater: r; Buller's Shearwater: r; Sooty Shearwater: Psf; Short-tailed Shearwater: w; Leach's Storm Petrel: sf; Fork-tailed Storm Petrel: PSf**</td>
<td>Short-tailed Albatross: 1,600 (COSEWIC 2003) and a conservative estimate of just over 3,000 (IEC 2012) in global population. Black-footed Albatross: global population 278,000 to 300,000 with 2,500 occurring seasonally in BC (COSEWIC 2007).</td>
<td>Northern Fulmar: 65, Leach's Storm-petrel: 49, Sooty Shearwater: 47</td>
<td>• Form large aggregations to breed or feed.</td>
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<td></td>
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<td></td>
<td>• Shearwaters are pursuit-diving foragers.</td>
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<td></td>
<td></td>
<td></td>
<td>• Breeding resident: reduced breeding, hatching success and offspring through oil transfer to eggs or direct oil ingestion.</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>• Natural breeding constraints (delayed maturity, small clutch size, and long lifespan).</td>
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<td></td>
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<td>• Winter resident: higher physiological stress may be increased by longer oil persistence in cold temperatures.</td>
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</tbody>
</table>

*Assessed Vulnerability to Oil γ: Assessing degree of risk of exposure to oil spills.  
†Oil Vulnerability Index (OVI): Quantification of vulnerability.  
‡Sensitivities to Oil Spill: Specific impacts associated with exposure.  
§Highest Seasonal Vulnerability: Seasonal changes in vulnerability.
### Table 1  Major Marine Bird Groups and Susceptibility to Oil (cont’d)

<table>
<thead>
<tr>
<th>Marine Bird Group</th>
<th>Number of Species</th>
<th>Main Distribution</th>
<th>Abundance</th>
<th>Oil Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>General Occurrence</td>
<td>Example Population Estimates</td>
</tr>
<tr>
<td>Gulls, Terns, Jaegers and Skuas</td>
<td>20</td>
<td>CCAA and OWA</td>
<td>Black-legged Kittiwake: PF; Sabine's Gull: r; Bonaparte's Gull: wM; Heermann's Gull: r; Mew Gull: sWM; Ring-billed Gull: s; Western Gull: wM; California Gull: Sfw; Herring Gull: y; Thayer's Gull: W; Glaucous-winged Gull: Y; Glaucous Gull: w; Caspian Tern: S; Black Tern: r; Common Tern: r; Arctic Tern: s; South Polar Skua: r; Pomarine Jaeger: m; Parasitic Jaeger: m; Long-tailed Jaeger: m</td>
<td>Glaucous-winged Gull: 50,000 breeding individuals in BC (Campbell et al. 1990).</td>
</tr>
</tbody>
</table>
## Table 1: Major Marine Bird Groups and Susceptibility to Oil (cont’d)

<table>
<thead>
<tr>
<th>Marine Bird Group</th>
<th>Number of Species</th>
<th>Main Distribution</th>
<th>Abundance</th>
<th>Example Population Estimates</th>
<th>Oil Vulnerability Index (OVI)</th>
<th>Sensitivities to Oil Spill</th>
<th>Highest Seasonal Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shorebirds</strong></td>
<td>28</td>
<td>CCAA and inlet channels of the OWA</td>
<td>Black-bellied Plover: W; American Golden Plover: s; Semipalmated Plover: s; Killdeer: Y; Black Oystercatcher: y; Spotted Sandpiper: SwM; Solitary Sandpiper: m; Wandering Tattler: w; Greater Yellowlegs: M; Lesser Yellowlegs: M; Whimbrel: w; Ruddy Turnstone: w; Black Turnstone: w; Surfbird: W; Red knot: r; Sanderling: M; Semipalmated Sandpiper: M; Western Sandpiper: M; Least Sandpiper: w; Baird’s Sandpiper: m; Pectoral Sandpiper: M; Rock Sandpiper: M; Dunlin: W; Short-billed Dowitcher: w; Long-billed Dowitcher: M; Wilson’s Snipe: Y; Red-necked Phalarope: r; Red Phalarope: r;</td>
<td>Black Oystercatcher: global population estimated at 6,900 to 10,800, approximately 40-50% located in BC (Pacific Wildlife Foundation 2011). Red-necked Phalarope: 37; European Oystercatcher: 30; Dunlin: 32</td>
<td>Breeding resident: reduced breeding, hatching success and offspring through oil transfer to eggs or direct oil ingestion. Forage in intertidal areas. Critical pre-breeding foraging habitat where species forage on fish beds (Pacific herring, sea lances, surf smelt) in spring.</td>
<td></td>
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</tr>
</tbody>
</table>
### Table 1  Major Marine Bird Groups and Susceptibility to Oil (cont’d)

<table>
<thead>
<tr>
<th>Marine Bird Group</th>
<th>Number of Species</th>
<th>Main Distribution</th>
<th>Abundance</th>
<th>Example Population Estimates</th>
<th>Oil Vulnerability Index (OVI)†</th>
<th>Sensitivities to Oil Spill‡</th>
<th>Highest Seasonal Vulnerability</th>
</tr>
</thead>
</table>
| Dabbling Ducks    | 10                | CCAA and OWA      |           | Cinnamon Teal: 260,000 to 300,000 in North America (Gammonley 2012). Northern Shoveler: 265,000 in Alberta and Northeastern BC (Dubowy 1996) | Northern Shoveler: 30, Mallard: 29, Northern Pintail: 27 | • Breeding resident: reduced breeding, hatching success and offspring through oil transfer to eggs or direct oil ingestion.  
• Forage in intertidal areas.  
• Winter resident: higher physiological stress may be increased by longer oil persistence in cold temperatures. | Majority of species known to utilize salt marshes and shallow bays as wintering grounds. |
### Table 1  Major Marine Bird Groups and Susceptibility to Oil (cont’d)

<table>
<thead>
<tr>
<th>Marine Bird Group</th>
<th>Number of Species</th>
<th>Main Distribution</th>
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<th>Sensitivities to Oil Spill‡</th>
<th>Highest Seasonal Vulnerability</th>
</tr>
</thead>
</table>
| Geese and Swans         | 7                 | CCAA and OWA                       | Tundra Swan: wm; Trumpeter Swan: sW; Greater White-fronted Goose: r; Snow Goose: WM; Brant: WM; Canada Goose: Y; Cackling Goose: pw | Trumpeter Swan: 17,551 individuals (EC 2004) and approx. 26,000 (S. Boyd, pers. Comm. 2010) in the Pacific Coast Population. | Mute swan: 28; Brant Goose: 42; White-fronted goose:17 | • Form large seasonal aggregations.  
  • Brant are strongly associated with intertidal areas. | Spring and fall where species generally can be found in large seasonal aggregations. |
| nonconforming           | 6                 | CCAA and OWA                       | American Bittern: S; Great Blue Heron: SW; American Coot: Y; Sandhill Crane: Y; Belted Kingfisher: Y; Common Raven: Y | Great Blue Heron, fannini subspecies: 3626 breeding adults in BC (300 outside of the Strait of Georgia) (BC MWLAP 2004). | Grey heron: 20; Eurasian Coot: 19 | • Breeding resident: reduced breeding, hatching success and offspring through oil transfer to eggs or direct oil ingestion.  
  • Forage in intertidal areas.  
  • Winter resident: higher physiological stress may be increased by longer oil persistence in cold temperatures. | Majority of species known to use portions of the CCAA and OWA throughout the year. |
| Raptors                 | 5                 | CCAA and inlet channels of the OWA | Osprey: Sw; Bald Eagle: Y; Merlin: y; Peale’s Peregrine Falcon: Y; Sharp-shinned Hawk: O | Bald Eagle: 28,500 in BC (Blood and Anweiler 1994) | | • Breeding resident: reduced breeding, hatching success and offspring through oil transfer to eggs or direct oil ingestion.  
  • Breeding constraints (delayed maturity, small clutch size, long lifespan); hence, populations are vulnerable and could potentially take a long time to recover.  
  • Forage in intertidal areas. | Winter residents and summer breeding individuals. |
| Total # Species         | 124               |                                    |           |                             |                                |                               |                               |
## Table 1  Major Marine Bird Groups and Susceptibility to Oil (cont’d)

| Abundance | Definition                                                                 | W,w | Winter (approx. December - February) | Y,y | Yearlong | P,p | Spring (approx. March - May) | M,m | Migratory (spring and fall) | S,s | Summer (approx. June - August) | R,r | Rare | F,f | Fall (approx. September - November) | O | Unknown |
|-----------|---------------------------------------------------------------------------|-----|-------------------------------------|-----|----------|-----|---------------------------|-----|-----------------------------|-----|-----------------------------|-----|------|-----|--------------------------------------| | |
| Uppercase letter | common, very common, abundant                                             |     |                                     |     |          |     |                           |     |                             |     |                             |     |      |     |                                         | | |
| Lowercase letter | rare, scarce, uncommon, scattered and sporadic                           |     |                                     |     |          |     |                           |     |                             |     |                             |     |      |     |                                         | | |

**NOTES:**

- Arrow indicates relative susceptibility to oil spills, species groups are thus ranked from highest to lowest in accordance with known sensitivities to oil (Camphuysen 2006; Leighton 1993; Al Maki, pers comm.).
- Source From: Andes 1999; Volier et al. 2008; Wiens 1995; Wiens et al. 2004
- OVI is sourced from C.J. Camphuysen’s method (Camphuysen 1989; Camphuysen 1998; Camphuysen et al. 1999.)
- OVI is based on 14 factors:
  - RANGE (1 - Breeding, 2 - Migration, 3 - Wintering, 4 - Marine Orientation)
  - BEHAVIOUR (5 - Roosting, 6 - Foraging, 7 - Reaction to disturbance, 8 - Flocking, 9 - Nesting density, 10 – Specialization)
  - EXPOSURE (11 - Spring, 12 - Summer, 13 - Fall, 14 - Winter)
- Phalaropes may be one of the more sensitive shorebird species as they “winter on the open ocean where they behave more like diving pelagic seabirds” (Michel 2000).
- Fork-tailed Storm Petrel are not reportedly found on the north coast in winter (Kenyon et al. 2009)
- Wood ducks forage primarily in wetlands and other riparian areas on aquatic vegetation and insects, diving relatively less than dabbling (Hepp et al. 1995)

**MITIGATION MEASURES**

Please refer to:

- Volume 6B ESA - Marine Terminal,
- Volume 7C Risk Assessment and Management of Spills - Kitsimat Terminal,
- Volume 8B ESA - Marine Transportation,
- Volume 8C Risk Assessment and Management of Spills - Marine Transportation
2.3.2 Oil Susceptibility

2.3.2.1 Marine Bird Morphological Susceptibility to Oil Spills

The mechanisms by which direct contact with oil causes mortality of marine and coastal birds falls into three categories: external contamination of feathers, avian embryonic mortality due to contact with oiled adults, and the ingestion of oil (Wiens 1995; Leighton 1993). Following contact with oil, marine birds may experience decreased buoyancy, compromised ability to feed, increased risk of hypothermia, and limited ability to thermoregulate (Camphuysen 2007; Leighton 1993).

The long-term effects of oil ingestion can be difficult to quantify because the ingestion of oil predominantly occurs concurrently with external exposure to the body (Leighton 1993). Sublethal effects such as retarded growth rate, weight loss, histopathological changes, suppressed immunity and abnormal blood chemistry may occur but determinations of long-term sublethal effects can be obscured by direct mortality (for a full discussion see Leighton 1993).

Physiological constraints (e.g., moulting) can further contribute to oil spill susceptibility during particular seasons. Table 1 describes a range of life history traits that are expected to contribute to the sensitivity of each marine bird group (or species within) and would be considered in assessments of relative vulnerability.

Research has identified toxicological effects from contaminant exposure as a consequence of either the chronic persistence of oil or indirect effects associated with trophic interaction cascades (Peterson et al. 2003; Leighton 1993). The harlequin duck, for example, has a preference for foraging in shallow marine areas, which may increase its vulnerability to both acute and chronic effects of oil, such as during and after the EVOS, because of its potential exposure to residual oil deposits (Esler and Iverson 2010; Esler et al. 2002; Trust et al. 2000).

Indirect effects from chronic exposure to oil have been proposed as mechanisms by which marine birds inhabiting rocky shorelines experience delayed recovery from oil spills (Peterson et al. 2003; Peterson et al. 2001). For example, decreased survival in pigeon guillemot nestlings has been observed at sites oiled as a result of the EVOS, which was attributed to the reduced availability of high-lipid forage fishes, such as Pacific sand lance (Ammodytes hexapterus), Pacific herring (Clupea pallasii), capelin (Mallotus villosus), and smelt (Osmeridae) (Golet et al. 2002; Peterson 2001). Piatt and Anderson (1996) provide a similar discussion involving common murres.

2.3.2.2 Susceptibility to Oil Relative to Distribution and Occurrence

Across species groups, the species known to form large seasonal assemblages, such as colonial breeders, appear more vulnerable to a potential oil spill than those species remaining in small groups or as dispersed individuals. Resident breeders and wintering species that may spend up to 10 months in coastal habitats (e.g., harlequin ducks) are similarly more vulnerable than migrant species, species that occur rarely, or species that occur in relatively low densities, within the CCAA and/or the OWA. However, any species travelling through, or foraging, or both within an oiled area may be at risk for oil exposure.
Though marine birds have the potential to experience effects due to oil exposure, vulnerability to oil spills is influenced, where they occur within the CCAA and OWA, by life history traits, such as foraging strategy. Birds that forage by diving, or by searching the intertidal zones, or that are dietary specialists (e.g., bivalve harvesters), are expected to have increased risk and also may experience delayed recovery subsequent to exposure versus marine birds that are generalist foragers. Surface feeders, depending on the species, may or may not avoid sitting or feeding on the water surface during an oil spill event, which may be a factor in determining vulnerability. Alcids, for example, are believed to be at higher risk of exposure due to the tendency to forage in congregations by repeated diving and surfing.

Each species’ global status is an important consideration when assessing the susceptibility of marine birds to oil. Seabirds are more vulnerable than a number of other bird groups. Among seabirds, the pelagic birds, especially albatrosses and large petrels, have declined globally faster than coastal species and are threatened for a variety of reasons, including pollution, invasive species, overfishing, and habitat loss (Croxall et al. 2012). Some globally-vulnerable species, such as black-footed and short-tailed albatross (IUCN 2012), have been shown to congregate to the north, east and south of Haida Gwaii (Kenyon et al. 2009). Species with small global populations persist within the constraints of a limited pool of recruitment; therefore, any potential effects following an oil spill event are of particular concern. The rarer a species may be globally, the lower is the probability of one or more individuals being present in an area where an oil spill has occurred; however, any mortality has a substantial effect on the population.

2.3.2.3 Observed Effects of Oil Spills in Relevant Literature Sources

Northern Gateway has committed to providing Environment Canada with a detailed literature review of observed effects of the EVOS on marine birds, including long-term effects. This review is provided in a separate report.

2.3.2.4 Mitigation Measures to Reduce Susceptibility

In addition to the protection of human health and safety, the priorities for spill response are, 1) stopping the source of the leak, and 2) containing and removing released hydrocarbons. However, as noted in the environmental assessment (Northern Gateway’s 2010 Application, Volumes 7C and 8C), and supporting documents on spill response planning, mitigation and environmental protection measures for environmentally sensitive areas and species will be a focus of the Marine Oil Spill Response Plan and the associated Geographic Response Plans.

Northern Gateway will work collaboratively with Environment Canada, the British Columbia Ministry of Environment, and participating Aboriginal groups will be engaged in the development of oil spill response plans and the finalization of environmental atlases. This will include the development of mitigation and environmental protection strategies specific to marine birds. Such planning will be initiated following Project approval and will be completed at least six months prior to the start of operations of the Project. A Net Environmental Benefits Analysis (NEBA) would play an important role in the final identification and selection of specific measures for species areas. Measures and strategies that would be considered include:
Enbridge Northern Gateway Project
Marine Birds: Susceptibility to Oil
Section 2: Major Marine Bird Groups and Susceptibility to Oil Spills

- Deflection and exclusion booms to protect important habitat or concentration areas
- Scaring techniques and devices to keep birds away from oiled areas
- Dispersants in offshore areas to minimize effects on marine birds and habitat
- Rapid removal of stranded oil from shoreline areas and cleanup
- Recovery and rehabilitation of oiled wildlife, as directed by CWS.

As discussed in Northern Gateway’s response to Federal Government IR 1.116 and 2.66, Northern Gateway will undertake a comprehensive Marine Environmental Effects Monitoring Program (EEMP) in the CCAA to:

- Document baseline environmental conditions (i.e., quality, distribution, abundance and diversity)
- Measure and confirm effects of routine operations
- Monitor the success of mitigation and environmental protection measures.

The Marine EEMP will also provide a basis for post-spill monitoring, should this ever be required. Northern Gateway also will undertake additional surveys of marine birds. For example, knowledge of the location and timing of breeding efforts by colonial nesters, and the seasonal use of intertidal areas by migratory shorebirds, can guide the placement of oil spill response equipment. Mapping habitat use by marine bird groups to facilitate the completion of the coastal sensitivity atlases also will contribute directly to geographic response plans and inform the placement of response equipment storage locations.

2.4 Key Findings

As described in Table 1, there are a variety of mechanisms through which marine and coastal birds are susceptible to the effects of oil spill events. Vulnerability and sensitivity across taxa are associated with factors such as habitat use, life history, behaviour and seasonal fluctuations in occurrence. Although multiple combinations of environmental factors can influence the trajectory and environmental consequences of a hydrocarbon spill, certain groups of marine birds exhibit greater vulnerability than others. Table 1 provides a foundation for future considerations, including focal species for future studies, mitigation strategies and planning to reduce the potential for oil spill effects. This information also is of value in developing geographic oil spill response planning (i.e., focal species groups, habitat mapping, coastal sensitivity atlases).

Northern Gateway acknowledges that marine birds are vulnerable to oil through several vectors (e.g., contact, direct or indirect ingestion, loss of habitat). Regardless of the documented and debated acute and chronic effects of oil on the environment, and the ability of cold-water ecosystems to recover following an oil spill, oil spills must be prevented. The safe operations of vessels and of the marine terminal are essential aspects of the Project. Northern Gateway has devoted a substantial effort to addressing the prevention of marine oil spills during marine transportation, as well as at the Kitimat Terminal.
2.4.1 Data Limitations

Assessing the vulnerability of marine bird species, or species groups relative to one another, is limited by at least two factors. First, the availability of information on the long-term regional, provincial, and often national abundance of marine birds is limited, especially for more remote regions such as the north coast of British Columbia. It is, therefore, challenging to assess habitat use, regional importance and natural variability in population numbers for all species. Second, the availability of background sources of oil vulnerability indices for relevant species and species groups in the region is limited.

2.5 Literature Cited


Enbridge Northern Gateway Project
Marine Birds: Susceptibility to Oil
Section 2: Major Marine Bird Groups and Susceptibility to Oil Spills


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