Assessment of Marine Oil Spill Risk and Environmental Vulnerability for the State of Alaska

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September, 2014
Why should we conduct a risk analysis?

- Prioritize our work.
- Use our limited resources well.
- NOAA’s Strategic Plan and NMFS Strategic Plan mandate that we prioritize our work…
Project Objectives

• Conduct a screening-level analysis of the relative risk of oil spills to the marine waters of Alaska

• Study does not attempt to determine the exact size, location, transport, fate, and impacts of a particular future oil spill, nor the potential response technologies applied

• This information can be used to help guide strategic planning and prioritize future research activities
How do we calculate risk for this study?

- Risk = Probability x Consequence
- Risk = (Probability of a Spill) x (Environmental Vulnerability) x (Volume Spilled)

<table>
<thead>
<tr>
<th>Low Probability</th>
<th>High Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Risk</td>
<td>Medium Risk</td>
</tr>
<tr>
<td>Medium Risk</td>
<td>High Risk</td>
</tr>
</tbody>
</table>

- Volume Spilled = Maximum Most Probable Discharge and Worst Case Discharge
- Probability = Actual and Potential spills from Vessels and Facilities
ENVIRONMENTAL VULNERABILITY

OIL SPILL PROBABILITIES

WORST CASE DISCHARGE

MAXIMUM MOST PROBABLE DISCHARGE
Over Arching Factors

• The analysis was done with regard to these three factors.
  • Area
  • Seasonality
  • Oil Type
How to Divide Alaska?

- Decided to use 10 SubAreas and subdivide.
- Maintains common nomenclature within the oil spill response community.
Seasonality

- The risk will change by the season because:
  - Habitat and species sensitivity changes
  - Vessel traffic and facility operations change.
- Six “seasons/periods”
  - December-January
  - February-March
  - April-May
  - June-July
  - August-September
  - October-November
Oil Type

- The analysis was done by oil type because it affects the consequence factor of the equation.
- These characteristics of oil affect the consequence factor:
  - Acute toxicity
  - Mechanical injury
  - Persistence
- Oil type categories:
  - Crude Oils
  - Distillates
  - Light Oils
  - Heavy Oils
Input Data
- Shoreline Habitat
  - Type/Coverage
  - Oil sensitivity
- Bottom Habitat/Submerged Aquatic Vegetation
  - Type/Coverage
  - Oil sensitivity
- Ice Habitat
  - Concentration
  - Coverage
  - Oil sensitivity
- Protected Areas and Essential Fish Habitat
  - Protected marine habitats
  - Protected shorelines
  - Essential Fish Habitat species
- Fish and Invertebrates
  - Abundance
  - Impact Potential
  - Recovery Potential
- Marine Mammals and Sea Turtles
  - Abundance
  - Impact Potential
  - Recovery Potential
- Birds
  - Abundance
  - Impact Potential
  - Recovery Potential

Model Input Parameters
- Shoreline Vulnerability
- Marine Vulnerability
- Protected Area Modifier
- Fish Vulnerability Score (FVS)
- Mammal and Turtle Vulnerability Score (MTVS)
- Bird Vulnerability Score (BVS)
- Habitat Vulnerability Score (HVS)
- Species Vulnerability Score (SVS)

Interim Model Results
- Environmental Vulnerability (EV)
- Oil-Modified Environmental Vulnerability (EVO)
- Relative Risk
- Normalized Spill Volume (MMPD and WCD)
- Normalized Incident Rate (MMPD and WCD)

Oil Effect Scores
- Acute Toxicity
- Mechanical Injury
- Persistence

Spill Volume (MMPD and WCD)
Incident Rate (Frop)
Relative Environmental Vulnerability

- Based on habitats & species present and their vulnerability to oiling
- Includes terms for:
  - Habitat Vulnerability
  - Fish & Invertebrate Vulnerability
  - Marine Mammal Vulnerability
  - Marine Bird Vulnerability

Risk = (Probability of a Spill) \times \text{(Environmental Vulnerability)} \times \text{(Volume Spilled)}
What did we consider in our vulnerability analysis?

Vulnerability of Organisms
- Relative abundance
- Recovery potential
- Impact potential

Vulnerability of Habitat
- oil effects on habitat,
- Percent of habitat type in region,
- conservation status,
- Essential Fish Habitat (EFH),
- ice and submerged aquatic vegetation scores.
Species Selection: Species Group Sub-categories

**Fish & Invertebrates**
- Small pelagic fish
- Large pelagic fish
- Semi-demersal fish
- Demersal fish
- Anadromous fish
- Pelagic invertebrates
- Demersal invertebrates

**Marine Mammals**
- Baleen whales
- Toothed whales
- Fur-bearing pinnipeds
- Other pinnipeds (walrus, sea lion, phocids)
- Other fur-bearing marine mammals (polar bear, sea otter)

**Birds**
- Waterfowl
- Seabirds (aerial divers)
- Seabirds (surface divers)
- Shorebirds/wading birds
- Raptors
Environmental Vulnerability (EV) Results

<table>
<thead>
<tr>
<th>Region</th>
<th>Dec-Jan</th>
<th>Feb-Mar</th>
<th>Apr-May</th>
<th>Jun-Jul</th>
<th>Aug-Sep</th>
<th>Oct-Nov</th>
<th>Yearly Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aleutians</td>
<td>1.48</td>
<td>1.44</td>
<td>1.51</td>
<td>1.55</td>
<td>1.49</td>
<td>1.53</td>
<td>1.50</td>
</tr>
<tr>
<td>Norton Sound/St. Lawrence Is.</td>
<td>1.38</td>
<td>1.39</td>
<td>1.46</td>
<td>1.44</td>
<td>1.21</td>
<td>1.27</td>
<td>1.36</td>
</tr>
<tr>
<td>Kodiak/Shelikof Strait</td>
<td>1.27</td>
<td>1.24</td>
<td>1.37</td>
<td>1.36</td>
<td>1.33</td>
<td>1.27</td>
<td>1.31</td>
</tr>
<tr>
<td>Western Alaska</td>
<td>1.24</td>
<td>1.31</td>
<td>1.38</td>
<td>1.36</td>
<td>1.17</td>
<td>1.18</td>
<td>1.27</td>
</tr>
<tr>
<td>Kotzebue Sound/Hope Basin</td>
<td>1.09</td>
<td>1.08</td>
<td>1.30</td>
<td>1.27</td>
<td>1.14</td>
<td>1.10</td>
<td>1.17</td>
</tr>
<tr>
<td>Cook Inlet</td>
<td>1.20</td>
<td>1.21</td>
<td>1.32</td>
<td>1.14</td>
<td>1.09</td>
<td>1.02</td>
<td>1.16</td>
</tr>
<tr>
<td>Aniakchak</td>
<td>1.09</td>
<td>1.10</td>
<td>1.19</td>
<td>1.22</td>
<td>1.17</td>
<td>1.13</td>
<td>1.15</td>
</tr>
<tr>
<td>Chukchi Sea</td>
<td>0.99</td>
<td>0.98</td>
<td>1.19</td>
<td>1.31</td>
<td>1.16</td>
<td>1.06</td>
<td>1.12</td>
</tr>
<tr>
<td>Offshore Kenai Peninsula</td>
<td>1.09</td>
<td>1.04</td>
<td>1.14</td>
<td>1.14</td>
<td>1.11</td>
<td>1.03</td>
<td>1.09</td>
</tr>
<tr>
<td>Prince William Sound</td>
<td>1.02</td>
<td>1.03</td>
<td>1.16</td>
<td>1.05</td>
<td>1.00</td>
<td>0.91</td>
<td>1.03</td>
</tr>
<tr>
<td>Beaufort Sea</td>
<td>0.87</td>
<td>0.87</td>
<td>1.05</td>
<td>1.24</td>
<td>1.13</td>
<td>0.98</td>
<td>1.02</td>
</tr>
<tr>
<td>Southeast Alaska</td>
<td>0.94</td>
<td>0.93</td>
<td>1.08</td>
<td>1.09</td>
<td>1.07</td>
<td>0.98</td>
<td>1.01</td>
</tr>
<tr>
<td>Bristol Bay</td>
<td>1.01</td>
<td>1.05</td>
<td>1.05</td>
<td>0.95</td>
<td>0.88</td>
<td>0.98</td>
<td>0.99</td>
</tr>
<tr>
<td>South-Central Alaska</td>
<td>0.94</td>
<td>0.88</td>
<td>1.03</td>
<td>1.06</td>
<td>1.03</td>
<td>0.92</td>
<td>0.98</td>
</tr>
</tbody>
</table>

Seasonal Average: 1.12 | 1.11 | 1.23 | 1.23 | 1.14 | 1.10
Environmental Vulnerability (EV) Results

- Values for each component of the EV score: habitat vulnerability (HVS), marine mammal & sea turtle vulnerability (MTVS), bird vulnerability (BVS), and fish & invertebrate vulnerability (FVS)

<table>
<thead>
<tr>
<th>Region</th>
<th>Mean HVS</th>
<th>Mean MTVS</th>
<th>Mean BVS</th>
<th>Mean FVS</th>
<th>Mean EV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aleutians</td>
<td>0.63</td>
<td>0.90</td>
<td>0.74</td>
<td>0.97</td>
<td>1.50</td>
</tr>
<tr>
<td>Norton Sound/St. Lawrence Is.</td>
<td>0.89</td>
<td>0.42</td>
<td>0.43</td>
<td>0.56</td>
<td>1.36</td>
</tr>
<tr>
<td>Kodiak/Shelikof Strait</td>
<td>0.62</td>
<td>0.53</td>
<td>0.81</td>
<td>0.73</td>
<td>1.31</td>
</tr>
<tr>
<td>Western Alaska</td>
<td>0.71</td>
<td>0.47</td>
<td>0.47</td>
<td>0.75</td>
<td>1.27</td>
</tr>
<tr>
<td>Kotzebue Sound/Hope Basin</td>
<td>0.83</td>
<td>0.31</td>
<td>0.31</td>
<td>0.39</td>
<td>1.17</td>
</tr>
<tr>
<td>Cook Inlet</td>
<td>0.71</td>
<td>0.25</td>
<td>0.75</td>
<td>0.35</td>
<td>1.16</td>
</tr>
<tr>
<td>Aniakchak</td>
<td>0.58</td>
<td>0.34</td>
<td>0.75</td>
<td>0.63</td>
<td>1.15</td>
</tr>
<tr>
<td>Chukchi Sea</td>
<td>0.79</td>
<td>0.40</td>
<td>0.32</td>
<td>0.26</td>
<td>1.12</td>
</tr>
<tr>
<td>Offshore Kenai Peninsula</td>
<td>0.57</td>
<td>0.34</td>
<td>0.79</td>
<td>0.42</td>
<td>1.09</td>
</tr>
<tr>
<td>Prince William Sound</td>
<td>0.65</td>
<td>0.22</td>
<td>0.58</td>
<td>0.34</td>
<td>1.03</td>
</tr>
<tr>
<td>Beaufort Sea</td>
<td>0.73</td>
<td>0.34</td>
<td>0.30</td>
<td>0.24</td>
<td>1.02</td>
</tr>
<tr>
<td>Southeast Alaska</td>
<td>0.43</td>
<td>0.59</td>
<td>0.68</td>
<td>0.48</td>
<td>1.01</td>
</tr>
<tr>
<td>Bristol Bay</td>
<td>0.56</td>
<td>0.33</td>
<td>0.49</td>
<td>0.45</td>
<td>0.99</td>
</tr>
<tr>
<td>South-Central Alaska</td>
<td>0.51</td>
<td>0.34</td>
<td>0.63</td>
<td>0.42</td>
<td>0.98</td>
</tr>
</tbody>
</table>
Historical Incident Database

10,985 incidents
1995 - 2012

Spills/potential spills
- Vessels
- Facilities
- Geographic location (lat/lon and ADEC region)
- Source type
- Incident cause
- Oil type
- Spill volume

Risk = (Probability of a Spill) x (Environmental Vulnerability) x (Volume Spilled)
## Incident Rate Results

<table>
<thead>
<tr>
<th>Region</th>
<th>Yearly Mean Current/Historical Incident Rate (# per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crude</td>
</tr>
<tr>
<td>Southeast Alaska</td>
<td>0.03</td>
</tr>
<tr>
<td>Aleutians</td>
<td>0</td>
</tr>
<tr>
<td>Beaufort Sea</td>
<td>3.1</td>
</tr>
<tr>
<td>Cook Inlet</td>
<td>2.1</td>
</tr>
<tr>
<td>Prince William Sound</td>
<td>0.6</td>
</tr>
<tr>
<td>Kodiak/Shelikof Strait</td>
<td>0.05</td>
</tr>
<tr>
<td>Western Alaska</td>
<td>0</td>
</tr>
<tr>
<td>Offshore Kenai Peninsula</td>
<td>0.01</td>
</tr>
<tr>
<td>Bristol Bay</td>
<td>0</td>
</tr>
<tr>
<td>South-Central Alaska</td>
<td>0.07</td>
</tr>
<tr>
<td>Norton Sound/St. Lawrence Is.</td>
<td>0</td>
</tr>
<tr>
<td>Aniakchak</td>
<td>0.02</td>
</tr>
<tr>
<td>Kotzebue Sound/Hope Basin</td>
<td>0</td>
</tr>
<tr>
<td>Chukchi Sea</td>
<td>0.01</td>
</tr>
</tbody>
</table>
MMPD Volume

- “Maximum Most Probable Discharge”
- Based on USCG definitions:
  - Facility MMPD = the lesser of 1,200 bbl or 10% of the WCD
  - Vessel (<25,000 deadweight tonnage) MMPD = 10% of the WCD
  - Vessel (≥25,000 deadweight tonnage) MMPD = 2,500 bbl
- For each region/period/oil type, the MMPD volumes for all source types were weight-averaged
  - Volumes represented in proportion to their occurrence (i.e., incident rate)
### MMPD Spill Volume - Results

<table>
<thead>
<tr>
<th>Region</th>
<th>Crude</th>
<th>Distillate</th>
<th>Heavy</th>
<th>Light</th>
<th>Sum of All Oil Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaufort Sea</td>
<td>1,200</td>
<td>800</td>
<td>800</td>
<td>1,200</td>
<td>4,000</td>
</tr>
<tr>
<td>Cook Inlet</td>
<td>830</td>
<td>830</td>
<td>830</td>
<td>830</td>
<td>3,320</td>
</tr>
<tr>
<td>South-Central Alaska</td>
<td>670</td>
<td>670</td>
<td>670</td>
<td>670</td>
<td>2,660</td>
</tr>
<tr>
<td>Aniakchak</td>
<td>560</td>
<td>560</td>
<td>560</td>
<td>560</td>
<td>2,240</td>
</tr>
<tr>
<td>Chukchi Sea</td>
<td>560</td>
<td>560</td>
<td>560</td>
<td>560</td>
<td>2,240</td>
</tr>
<tr>
<td>Prince William Sound</td>
<td>520</td>
<td>520</td>
<td>520</td>
<td>520</td>
<td>2,080</td>
</tr>
<tr>
<td>Kotzebue Sound/Hope Basin</td>
<td>0</td>
<td>527</td>
<td>527</td>
<td>790</td>
<td>1,843</td>
</tr>
<tr>
<td>Norton Sound/St. Lawrence Is.</td>
<td>0</td>
<td>650</td>
<td>433</td>
<td>650</td>
<td>1,733</td>
</tr>
<tr>
<td>Western Alaska</td>
<td>0</td>
<td>510</td>
<td>340</td>
<td>510</td>
<td>1,360</td>
</tr>
<tr>
<td>Bristol Bay</td>
<td>0</td>
<td>280</td>
<td>420</td>
<td>420</td>
<td>1,120</td>
</tr>
<tr>
<td>Southeast Alaska</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>230</td>
<td>920</td>
</tr>
<tr>
<td>Aleutians</td>
<td>0</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>750</td>
</tr>
<tr>
<td>Kodiak/Shelikof Strait</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>600</td>
</tr>
<tr>
<td>Offshore Kenai Peninsula</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>150</td>
<td>600</td>
</tr>
</tbody>
</table>
WCD Volume

• “Worst Case Discharge”

• Based on USCG/EPA definitions:
  
  • For onshore/offshore facilities: “the largest foreseeable discharge in adverse weather conditions.” WCDs for facilities are based on the types of facilities present in each region and the known capacities of the facilities (for AK, range from 100 bbl to 200,000 bbl)

  • For offshore wells: defined as 30 days of flow at the daily production rate for wells <10,000 ft, and 45 days of flow at the daily production rate for wells that are >10,000 ft

  • For vessels: total capacity of the cargo and/or bunker fuel tanks of the vessel (for AK, range from 10 bbl to 1.9 million bbl)
### WCD Spill Volume - Results

<table>
<thead>
<tr>
<th>Region</th>
<th>Current Theoretical WCD (bbl)</th>
<th>Sum of All Oil Types</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crude</td>
<td>Distillate</td>
</tr>
<tr>
<td>Cook Inlet</td>
<td>1,900,000</td>
<td>523,000</td>
</tr>
<tr>
<td>Kodiak/Shelikof Strait</td>
<td>1,900,000</td>
<td>523,000</td>
</tr>
<tr>
<td>Prince William Sound</td>
<td>1,900,000</td>
<td>523,000</td>
</tr>
<tr>
<td>Southeast Alaska</td>
<td>1,900,000</td>
<td>523,000</td>
</tr>
<tr>
<td>South-Central Alaska</td>
<td>1,900,000</td>
<td>348,667</td>
</tr>
<tr>
<td>Beaufort Sea</td>
<td>3,900,000</td>
<td>348,667</td>
</tr>
<tr>
<td>Chukchi Sea</td>
<td>2,200,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Aniakchak</td>
<td>523,000</td>
<td>523,000</td>
</tr>
<tr>
<td>Offshore Kenai Peninsula</td>
<td>523,000</td>
<td>523,000</td>
</tr>
<tr>
<td>Aleutians</td>
<td>0</td>
<td>523,000</td>
</tr>
<tr>
<td>Bristol Bay</td>
<td>0</td>
<td>108,667</td>
</tr>
<tr>
<td>Norton Sound/St. Lawrence Is.</td>
<td>0</td>
<td>163,000</td>
</tr>
<tr>
<td>Western Alaska</td>
<td>0</td>
<td>163,000</td>
</tr>
<tr>
<td>Kotzebue Sound/Hope Basin</td>
<td>0</td>
<td>108,667</td>
</tr>
</tbody>
</table>
Modeling Approach: 2025 Projections

• Study also included an assessment of future relative risk for the year 2025, based on expected changes in vessel traffic, oil exploration/production, and the regional economy.
• Only incidents rates and MMPD/WCD spill volumes were projected into the future.
• No future projections of environmental vulnerability were calculated for this project.
Modeling Approach: 2025 Incident Rates

- Assumptions based on a literature review of studies related to future spillage risk
- Assumptions relate to:
  - Factors that reduce the probability of an incident becoming a spill event (e.g., risk mitigation practices, use of double-hulled tanks)
  - Changes in vessel traffic patterns
  - Marine engineering advances and ice coverage reductions, allowing for year-round activity
  - Changes in the distribution of oil types
  - Increases in oil exploration/production activities
  - Economic growth
MMPD Risk Results

![Graph showing relative risk for different areas](image)

- **MMPD Current Risk**
- **MMPD Future Risk**

Areas listed include:
- Southeast Alaska
- Aleutians
- Kodiak/Shelikof Strait
- Cook Inlet
- Prince William Sound
- Aniakchak
- Beaufort Sea
- Offshore Kenai Peninsula
- Chukchi Sea
- South-Central Alaska
- Norton Sound/St. Lawrence Is.
- Western Alaska
- Bristol Bay
- Kotzebue Sound/Hope Basin
WCD Risk Results
Conclusions

- Environmental vulnerability, incident rate, and relative risk scores are typically higher in the summer months than during the winter
  - Due to presence of migratory species and greater vessel traffic activities during the warmer months
- Light and heavy oils are the biggest contributors to risk for the current MMPD, current WCD, 2025 MMPD, and 2025 WCD scenarios on average
Conclusions

- Top 3 highest relative risk regions for each model scenario:

<table>
<thead>
<tr>
<th>Relative Risk Rank</th>
<th>MMPD Current Risk</th>
<th>WCD Current Risk</th>
<th>MMPD 2025 Risk</th>
<th>WCD 2025 Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Southeast Alaska</td>
<td>Southeast Alaska</td>
<td>Beaufort Sea</td>
<td>Beaufort Sea</td>
</tr>
<tr>
<td>2</td>
<td>Aleutians</td>
<td>Kodiak/Shelikof Strait</td>
<td>Aleutians</td>
<td>Aleutians</td>
</tr>
<tr>
<td>3</td>
<td>Kodiak/Shelikof Strait</td>
<td>Cook Inlet</td>
<td>Southeast Alaska</td>
<td>Southeast Alaska</td>
</tr>
</tbody>
</table>

- These regions are recommended for further study to investigate various aspects of the factors constituting risk:
  - spill volume and location
  - location of species and habitats within a region
  - fate and transport of spilled oil
Conclusions

• Benefits of the risk model approach:
  • The various inputs, assessment criteria, and assumptions are explicitly stated and analyzed in a quantitative manner
  • Transparent
  • Objective, repeatable results

• Despite the inherent limitations of such a broad-scale assessment effort, this study provides valuable information to guide the prioritization of risk planning and further study in Alaska
What next?

• The report, appendices, database and query tool should be available in November 2014.

• If funding were available, it would be ideal to determine trajectories in high risk areas.
Alaska Spill Risk Calculator

- Simple interface to allow user to generate tables of various results
- Can export to text, shapefile, or kml
Questions?

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