cook inlet risk assessment

DRAFT FOR REVIEW

Cook Inlet RISK ASSESSMENT

Consequence ANALYSIS

Report to the Cook Inlet Risk Assessment Advisory Panel

January 25, 2013

RESEARCH & PLANNING GROUP, LLC.
P.O. Box 175
Seldovia, Alaska 99663
tel 907.234.7821
fax 509.278.4406
contact@nukaresearch.com

Front cover photo credit: Kathleen C. George

EXECUTIVE SUMMARY

A Cook Inlet Risk Assessment has been underway since 2011 to assess and recommend risk mitigation options designed to reduce the risk of oil spills from marine operations. The first step of the risk assessment was to identify both historical and forecasted vessel traffic patterns in Cook Inlet. Next, this information was used with historical data on the oil spills from vessels to characterize and forecast potential future spills. This report summarizes the results of the third step of the process: Nuka Research and Planning Group, LLC and Pearson Consulting, LLC convened 15 experts in natural resources, subsistence, fisheries, oceanography, and marine risk assessment to characterize the potential impacts to Cook Inlet's environmental and socioeconomic resources from seven marine oil spill scenarios.

This scenario-based analysis illustrates the types and range of impacts that may occur based on representative spill scenarios. The scenarios were selected by the Cook Inlet Risk Assessment Advisory Panel based on previous analyses of vessel traffic patterns and projections and past incidents and spills. The approach is semi-quantitative.

Subject matter experts selected for their experience with Cook Inlet's environmental and socioeconomic resources, convened for a two-day workshop in Anchorage, AK on October 30-31, 2012. At the workshop, participating experts agreed to use of scores from 1 (very low) to 5 (very high) to characterize the impacts of each spill scenario on: Cook Inlet habitat (pelagic, littoral, and benthic), fish (shellfish and fin fish), birds (waterfowl, shorebirds, and seabirds), mammals (pinnipeds, whales and porpoises, and terrestrial), commercial fishing, subsistence uses, recreation and tourism, general commerce, and oil industry operations.

When considering the scenario outputs, it is important to note that they were chosen based on relative likelihood of occurrence, as compared to the potential high consequence/low probability spill such as a worst-case discharge. The conclusion of the results from workshop is that any of the spills considered would have significant impacts to the environment and socioeconomics of Cook Inlet. All areas of Cook Inlet are vulnerable to significant consequences from marine oil spills of any type in all seasons.

The Alaska Department of Conservation, Cook Inlet Citizens Advisory Council, and the U.S. Coast Guard launched the Cook Inlet Risk Assessment in 2011. The next steps in the project are to identify, analyze, prioritize, and recommend risk reduction options designed to reduce the risk of oil spills to Cook Inlet from marine vessels.

ACRONYMS

Acronym	Translation
AAC	Alaska Administrative Code
ACC	Alaska Coastal Current
ADEC	Alaska Department of Environmental Conservation
ADFG	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
AIRA	Aleutian Islands Risk Assessment
AOOS	Alaska Ocean Observing System
BLM	Bureau of Land Management
BBL	Barrels
CFR	Code of Federal Regulations
CIRA	Cook Inlet Risk Assessment
CIRT	Cook Inlet Response Tool
CISPRI	Cook Inlet Spill Prevention & Response, Inc.
Cook Inlet RCAC	Cook Inlet Regional Citizens Advisory Council
CRREL	Cold Regions Research and Engineering Laboratory
DNV	Det Norske Veritas
EPA	Environmental Protection Agency
ERC	Environmental Research Consulting
ERM	Environmental Resources Management
ESI	Environmental Sensitivity Index
GNOME	General NOAA Operational Modeling Environment
GIS	Geographic Information Systems
HFO	Heavy Fuel Oil
NOAA	National Oceanic and Atmospheric Administration
ROC	Response Options Calculator
RRO	Risk Reduction Options
TRB	Transportation Research Board
TSS	Total Suspended Solids
UAA	University of Alaska Anchorage
USCG	United States Coast Guard
USFWS	United States Fish and Wildlife Services

Table of Contents

This page is intentionally blank.

Cook Inlet Risk Assessment: CONSEQUENCE ANALYSIS

Report to:
Cook Inlet Risk Assessment Advisory Panel

January 25, 2013

DRAFT FOR REVIEW

1. INTRODUCTION

The purpose of this report is to provide a semi-quantitative assessment of potential vessel oil spill impacts to Cook Inlet's marine and coastal environments. This consequence analysis was conducted as part of the Cook Inlet Risk Assessment (CIRA) and is based on expert opinion provided at an October 30-31, 2012 Consequence Analysis Workshop in Anchorage, AK. Subject matter experts in wildlife, fisheries, subsistence use, oceanography, and other related fields used a scale from 1-5 to characterize the potential impacts of seven hypothetical petroleum spills on environmental and socioeconomic receptors in Cook Inlet. The Consequence Analysis Workshop and this summary report represent the third of five steps of the CIRA, underway since 2011. This information will be used to inform the recommendation of options to reduce the risk of marine oil spills in Cook Inlet.

The Cook Inlet Regional Citizens Advisory Council (Cook Inlet RCAC) and the U.S. Coast Guard (USCG) contracted Nuka Research and Planning Group, LLC and Pearson Consulting, LLC to facilitate the project, including preparing this report.

2. BACKGROUND

The Cook Inlet Risk Assessment (CIRA) is a multi-year, multi-stakeholder project designed to assess the risks of oil spills to Cook Inlet from marine vessels and recommend risk mitigation options. The first step of the risk assessment, the Cook Inlet Vessel Traffic Study, identified both historical and forecasted vessel traffic patterns in Cook Inlet. Next, this information was used in a Spill Baseline and Causality Study, which also incorporated historical data on the oil spills from vessels to characterize and forecast potential future spills. The third step of the assessment is to consider the potential consequences of oil spills to Cook Inlet, as described in this report. In steps four and five, CIRA participants and contractors will identify and then evaluate and recommend risk reduction options.

2.1 Risk Assessment Project Scope

This section describes the scope of CIRA in terms of geography, vessels, and incident types.

2.1.1 Geographic Scope

CIRA focuses on the marine waters and coastal areas of Cook Inlet as defined in regulation[1] and shown in Figure 1. Cook Inlet has some of the most extreme tides in the world and is home to commercial and recreational fisheries; petroleum exploration, extraction, and transport; tourism; subsistence use; and both endemic and migratory birds and wildlife. Over 40% of the State's population lives in the Cook Inlet region and the vast majority of the State's commodities and goods are shipped through the ports there. Conditions and activities vary across the three regions, or operating areas, that have been defined within the Inlet: Lower, Middle, and Upper. These are shown in Figure 1.

2.1.2 Vessel and Incident Scope

Cook Inlet Risk Assessment considers potential impacts associated with oil spilled from marine vessels of more than 300 gross tons (excluding military and research vessels for which there are no traffic data to define rates) and smaller vessels with a fuel capacity of at least 10,000 gallons. Tugboats and towboats were included regardless of their gross tonnage and fuel capacity. The following major accident types are considered: collisions, allisions, powered groundings, drift groundings, foundering, structural failures, mooring failures, and fires and explosions. While the accident types

[1] U.S. Coast Guard regulations at 46 CFR 7.165 define Cook Inlet's water boundaries as, "A line drawn from the southernmost extremity of Kenai Peninsula at longitude 151° 44.0 W to East Amatuli Island Light; thence to the northwestern extremity of Shuyak Island at Party Cape; thence to the eastern most extremity of Cape Douglas."

generally present the potential for spillage, not all incidents that occur will result in the spillage of oil.

Operational and intentional discharges from ships are not considered, nor are releases associated with Cook Inlet's petroleum exploration and production operations.[2]

Figure 1. Map of Cook Inlet, including study area boundaries, operating areas, port areas, and cities/towns

2.2 Risk Assessment Project Overview

The Cook Inlet RCAC, Alaska Department of Environment Conservation (ADEC), and the USCG launched the Cook Inlet Risk Assessment in 2011 to examine the risk of oil spills to marine waters from vessels transiting the region. The project is following the basic process recommended by the Transportation Research Board (TRB) of the National Academies, and

[2] Spills from marine vessels associated with oil and gas production infrastructure *are* considered in this study.

consists of five steps: (1) vessel traffic analysis, (2) study of past spills and potential future spills, (3) consequence analysis, (4) identification and analysis of risk reduction options, and (5) recommendation of priority risk reduction options.

2.2.1 Origin of the Project

The safety of maritime transportation in Cook Inlet has been a heightened concern of the Cook Inlet RCAC, ADEC, and the USCG since the grounding of the *M/V Seabulk Pride* in 2006. In 2007, the Cook Inlet RCAC convened the Cook Inlet Navigational Safety Forum, which resulted in a consensus agreement that a more formal risk assessment should be conducted. Cook Inlet RCAC held a similar forum in 1999. The USCG had previously convened a Ports and Waterways Safety Assessment of the region in 2000. These efforts laid the groundwork for the Cook Inlet Risk Assessment.

2.2.2 Transportation Research Board Approach

The CIRA follows the TRB recommendations from the 2008 Special Report 293, "Risk of Vessel Accidents and Spills in the Aleutian Islands: Designing a Comprehensive Risk Assessment." The report recommends a process for conducting a maritime risk assessment and recommending risk reduction options based on both technical analysis and stakeholder input, including studying vessel traffic, analyzing spills and incidents to develop scenarios of likely future incidents, considering the consequences of potential future spills, identifying and evaluating potential risk reduction options, and recommending one or more priority risk reduction options.

The TRB's approach also prescribed a management structure, including a Management Team, Advisory Panel, Peer Review Panel, and contractor team. This structure is being used for the CIRA.

2.2.3 Vessel Traffic Study

The "Cook Inlet Vessel Traffic Study" was delivered to the CIRA Advisory Panel by Cape International, Inc. in January 2012 (Eley, 2012). This study analyzed 2010 data on port calls and transits in Cook Inlet by vessels greater than 300 gross tons, and smaller vessels with at least 10,000 gallons of fuel capacity. Data were compared to a previous study of vessel traffic in 2005-2006. Vessel traffic patterns were not found to have changed since this earlier study, and are not expected to change significantly in the next decade.

In 2010, 15 vessels made 80% of the estimated 480 transits of Cook Inlet by self-propelled vessels large enough to be included in the scope of this study. Most of these were state ferries or non-tank vessels calling at the Port of Anchorage. Most of the oil moving through Cook Inlet was transported via 102 oil barge transits and tank ships calling at Nikiski and Drift River. (Eley, 2012)

2.2.4 Spill Baseline and Accident Causality Study

The "Spill Baseline and Accident Causality Study" was delivered to the Cook Inlet Risk Assessment Advisory Panel by The Glosten Associates and Environmental Research Consulting (ERC) in June 2012. Incident rates were established for tank ships, tank barges, non-tank/non-workboat vessels (ferries, cruise ships, container ships, bulk carriers, general cargo vessels, and gas carriers), and workboats (tugs, offshore supply vessels, and spill response vessels. Overall, the study estimated a spill rate of 3.4 spills (of any size) per year historically, and 3.9 spills per year forecasted for the years 2015 through 2020 in Cook Inlet across all vessel categories due to projected increases in vessel traffic. Historical rates ranged from 0.7 spills per year for tank ships to 1.3 spills per year for non-tank/non-workboat vessels (Glosten and ERC, 2012).

This study assigned a relative probability to more than 2,000 spill scenarios based on projections and a compilation of both historical incidents (16 years of data) and vessel traffic patterns (from the vessel traffic study). The development and application of the scenarios is discussed in Section 5.2.2.

3. FACTORS IMPACTING THE MOVEMENT AND PERSISTENCE OF OIL SPILLS IN COOK INLET

Numerous factors impact the potential consequences of an oil spill to Cook Inlet waters. These factors include the type and quantity of oil spilled, as well as the season and environmental conditions at the time (winds, waves, currents, temperature, tides, and ice). Consequences are also driven by the biological and socioeconomic resources impacted, which are discussed in Section 4.

The factors discussed in this section would also impact the effectiveness of an oil spill response in Cook Inlet, but response effectiveness is not considered as part of this consequence analysis.

3.1 Type of Oil

Different types of oil will behave differently once spilled and will also have varied effects on environmental and socioeconomic receptors. Oils are generally classified as "persistent" or "non-persistent" based on their chemical qualities, or the more specific "low persistent," "medium persistent," or "heavy persistent" classifications used in Table 1.

The TRB Special Report No. 293 summarizes the relationship between type of oil and spill consequences:

> *To illustrate the importance of substance type, spills of persistent oils, such as the heavy fuel oil used for bunkers of large commercial ships, have properties different from those of the diesel oil and marine gas oil used for propulsion of smaller craft, such as fishing boats. The lighter refined products are more volatile, and their evaporation reduces the amount of oil remaining on the surface. Compared with spills of heavy oil, spills of diesel oil and marine gas oil generally have much lower cleanup and socioeconomic costs. Spills of diesel oil and marine gas oil also generally have less impact on seabirds and mammals, cause less shoreline contamination, and have lower cleanup costs than spills of heavier oils. On the other hand, the lighter oils dissolve and disperse more readily into the water column and can be expected to have greater impacts on fish and invertebrates in the water and on demersal fish and invertebrates in the benthic zone.* (TRB, 2008, p. 120)

Table 1 presents a generalized impact scale ranging from Very Low to Very High to portray the relative resource impacts that may be expected based on the anticipated persistence, evaporation, dissolution, toxicity, and coating of four different oil categories (non-persistent, low persistent, medium persistent, and heavy persistent). These generalized impacts were presented in the Spill Baseline and Accident Causality Study (2012).

Table 1. Summary of qualitative risks posed by different types of oil (adapted from Glosten and ERC, 2012)

CATEGORY	TYPES	PERSISTENCE	EVAPORATION	DISSOLUTION	TOXICITY	COATING
Non-Persistent	**Jet Fuel Gasoline**	Very Low	Very High	Medium	High	Very Low
Low Persistent	**Diesel**	Low	High	High	Very High	Low
Medium Persistent	**Crude Lube Oil**	Medium	Medium	Medium	Medium	Medium
Heavy Persistent	**Heavy Fuel Bunkers**	High	Very Low	Very Low	Low	High

According to the vessel traffic study, 13.4 million bbl. of non-persistent oil and 10.7 million bbl. of persistent oil (including oils of low, medium, and heavy persistence) were transported on Cook Inlet waters in 2010. Figures 2 and 3 show the percentages of both non-persistent and persistent oil moved in Cook Inlet by vessel type.

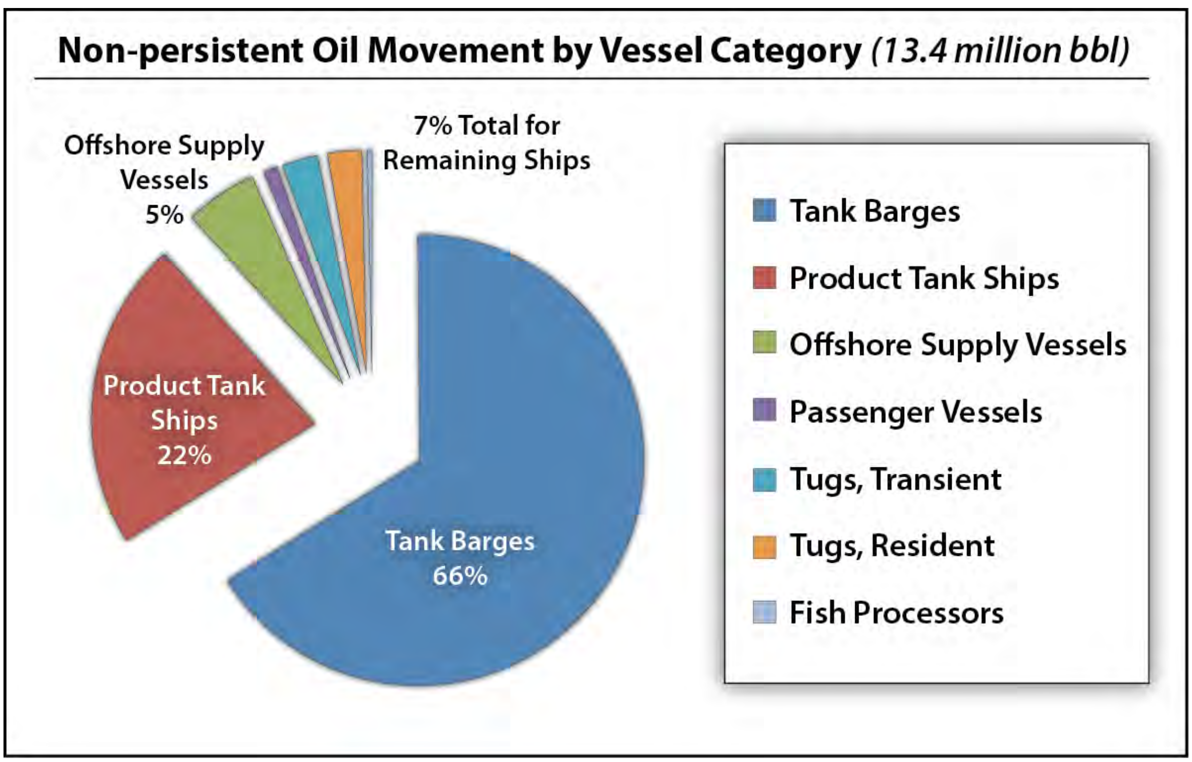

Figure 2. Non-persistent oil movement in Cook Inlet by vessel category in 2010 (total of 13.4 million bbl.) (Eley, 2012)

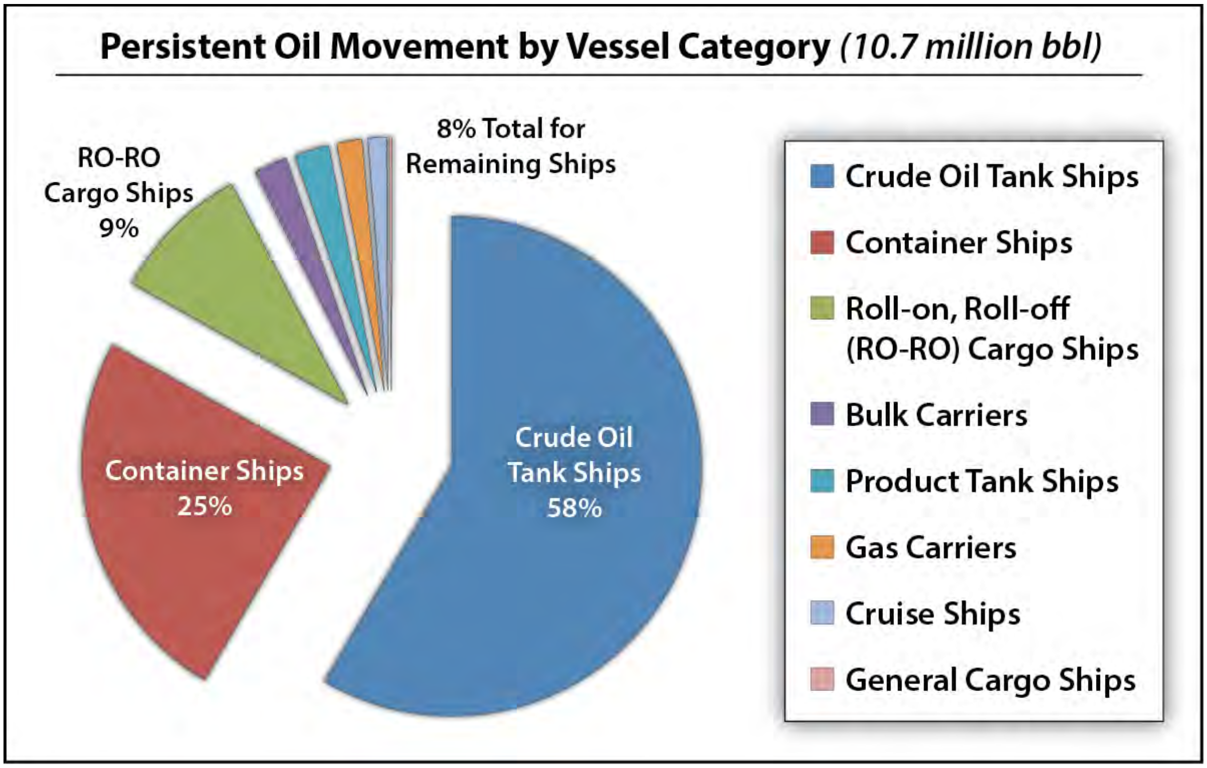

Figure 3. Low, medium, and heavy persistent oil movement in Cook Inlet by vessel category in 2010 (total of 10.7 million bbl) (Eley, 2012)

3.2 Size of Spill

The size of the spill will also impact the resulting consequences because the larger the spill, the greater chance of its encountering or affecting environmental and socioeconomic receptors. The spread of the oil will not be uniform; in addition to mixing in the water column or evaporating, oil on the surface of the water will spread into slicks of different thicknesses and take on different shapes or formations. The presence of ice will also affect the spread of slicks.

The accident type and the vessel involved will determine the range of potential spill volumes. Not all accidents result in spillage of oil and for those that do, there is a range of possible spill volumes from the most likely small volume to the much less likely, but more consequential, very large volume.

The largest potential vessel spill volumes to Cook Inlet are from crude oil tank ships. The Spill Baseline and Accident Causality Study (2012) estimated potential "moderate" and "large" spill volumes for a range of possible vessel spills in Cook Inlet, including both different vessel and incident types. Estimates were based on data from historical spills (1995-2010). Table 2 shows the results of this analysis for tank ships carrying both crude oil and refined product. The 50th percentile spill ("moderate" spill) is that volume for which half of spills are smaller and half are larger.

The 95th percentile spill volume represents the spill size ("large" spill) for which 95% of spills are smaller and only 5% are larger.

Table 2. Estimated 50th and 95th percentile spill volumes from tank vessels in Cook Inlet (modified from Glosten and ERC, 2012)

VESSEL TYPE	INCIDENT TYPE[3]	50TH PERCENTILE SPILL (BBL)	95TH PERCENTILE SPILL (BBL)
Tank Ship (Product)	Impact Non-impact Transfer Error	119 95 0.24	95,238 3,571 48
Tank Ship (Crude)	Impact Non-impact Transfer Error	476 48 0.24	357,143 190,476 48

3.3 Seasonality and Environmental Conditions

Temperature, currents, tides, winds, and ice will all affect the movement of spilled oil in Cook Inlet. These factors will vary both seasonally and with location: there are differences among the Lower, Middle, and Upper Cook Inlet areas, as well as the east and west sides. Season is also important because wildlife and socioeconomic activities vary widely during the year. These variations are discussed in Section 4.

3.3.1 Temperature

Temperature will affect the evaporation and consistency of spilled oil and whether or not ice will be present. Air temperatures vary dramatically in Cook Inlet, from above 70º F in the summer to less than -30º F in the winter. Figure 4 shows the maximum, minimum, and mean temperatures throughout the year for four locations around Cook Inlet: Anchorage, Nikiski, Flat Island, and East Amatuli (based on shore station data for 2007-2011).

[3] Impact incidents include incidents such as collisions, allisions, or groundings; non-impact incidents include incidents such as structural or equipment failure, or operational error.

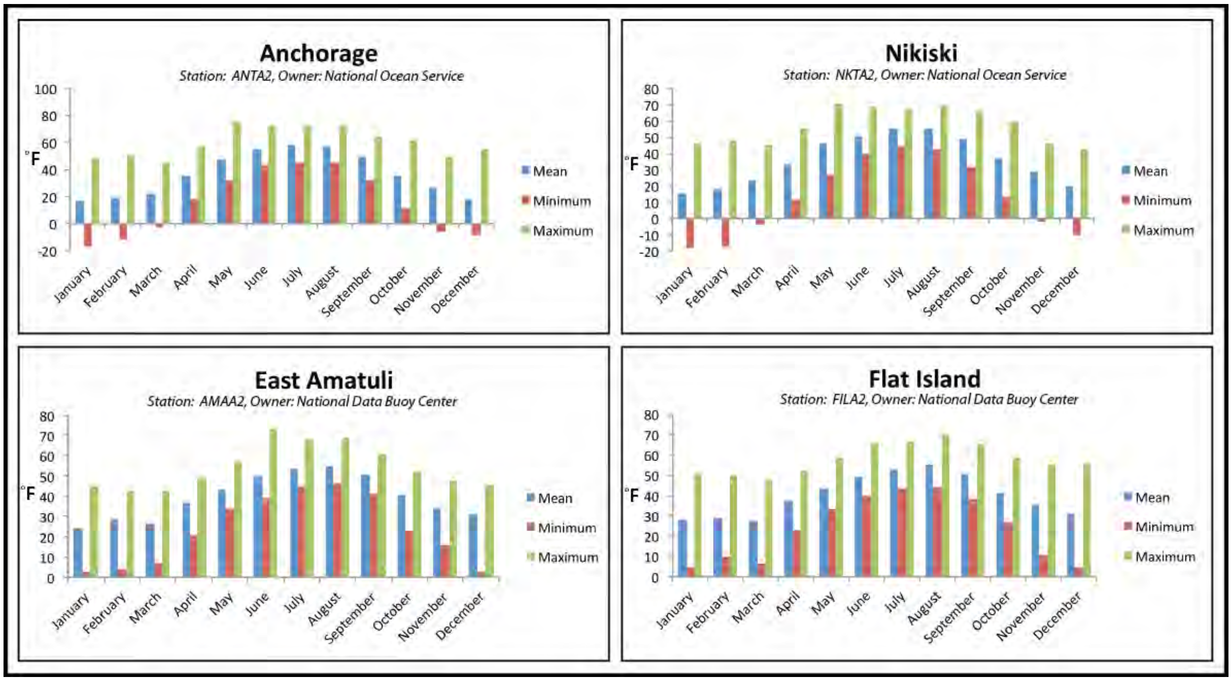

Figure 4. Maximum, minimum, and mean temperatures in Anchorage, Nikiski, Flat Island, and East Amatuli (2007 – 2011 data compiled by Nuka Research from shore stations)

3.3.2 Winds

Wind moves spilled oil across the water at an approximate rate of 3% of the wind speed (NOAA, 2002a). Prevailing wind speed and direction in Cook Inlet vary seasonally as well as in the different regions. The winds are stronger in the winter and tend to be from the north and northeast. During the summer, winds tend to be weaker and from the south and southwest. Table 3 summarizes the historical data on wind speeds for three cities around Cook Inlet (Anchorage, Kenai, and Homer) for each month.

Table 3. Summary of wind observations for Cook Inlet shore stations, 2007 – 2012 (knots) (compiled by Nuka Research for this report)

Location	Month	Mean (knots)	Average Maximum (knots)	Maximum Recorded (knots)
ANCHORAGE Station: ANTA2 Owner: National Ocean Service	Jan	5	24	28
	Feb	5	26	35
	Mar	6	27	32
	Apr	4	20	23
	May	5	20	21
	Jun	5	20	22
	Jul	4	17	20
	Aug	4	18	22
	Sep	4	18	19
	Oct	4	21	25
	Nov	5	25	34
	Dec	5	27	41

Location	Month	Mean (knots)	Average Maximum (knots)	Maximum Recorded (knots)
NIKISKI Station: NKTA2 Owner: National Ocean Service	Jan	8	27	34
	Feb	8	29	36
	Mar	9	27	32
	Apr	8	26	32
	May	8	24	26
	Jun	8	22	25
	Jul	8	26	29
	Aug	7	28	31
	Sep	8	28	31
	Oct	8	26	28
	Nov	9	32	37
	Dec	9	33	38
EAST AMATULI (Barrens Islands) Station: AMAA2 Owner: National Data Buoy Center	Jan	17	46	50
	Feb	16	49	55
	Mar	14	50	57
	Apr	14	44	50
	May	12	39	47
	Jun	10	31	35
	Jul	11	38	45
	Aug	11	34	42
	Sep	13	41	54
	Oct	13	45	52
	Nov	16	49	56
	Dec	17	50	56
HOMER SPIT Station: HMRA2 Owner: National Estuarine Research Reserve	Jan	12	35	37
	Feb	11	33	36
	Mar	9	29	34
	Apr	7	26	33
	May	7	24	26
	Jun	6	22	24
	Jul	6	24	28
	Aug	6	23	24
	Sep	8	30	34
	Oct	9	31	32
	Nov	11	34	40
	Dec	11	31	34
Datasets are for 2007 – 2011. Data for the Homer Spit is from late-2007 – late-2012.				

3.3.3 Currents and Tides

Many factors influence the circulation of water in Cook Inlet: the shape of the Inlet, bathymetry, freshwater input from rivers, the Alaska Coastal Current (ACC), and tides.

The Inlet is long and narrow, with shoals towards its head where it separates into two narrow shallow arms (Knik and Turnagain). The East and West Forelands, a pair of headlands, constrict water flow and influence the movement of water between Central and Upper Cook Inlet. There are also two large embayments. Kachemak Bay, on the east side, has a deep channel and a spit that nearly bisects the bay at its midpoint, and Kamishak Bay, on the west side, is relatively shallow and contains the Augustine Island volcano (Whitney, 2002). These are shown in Figure 5.

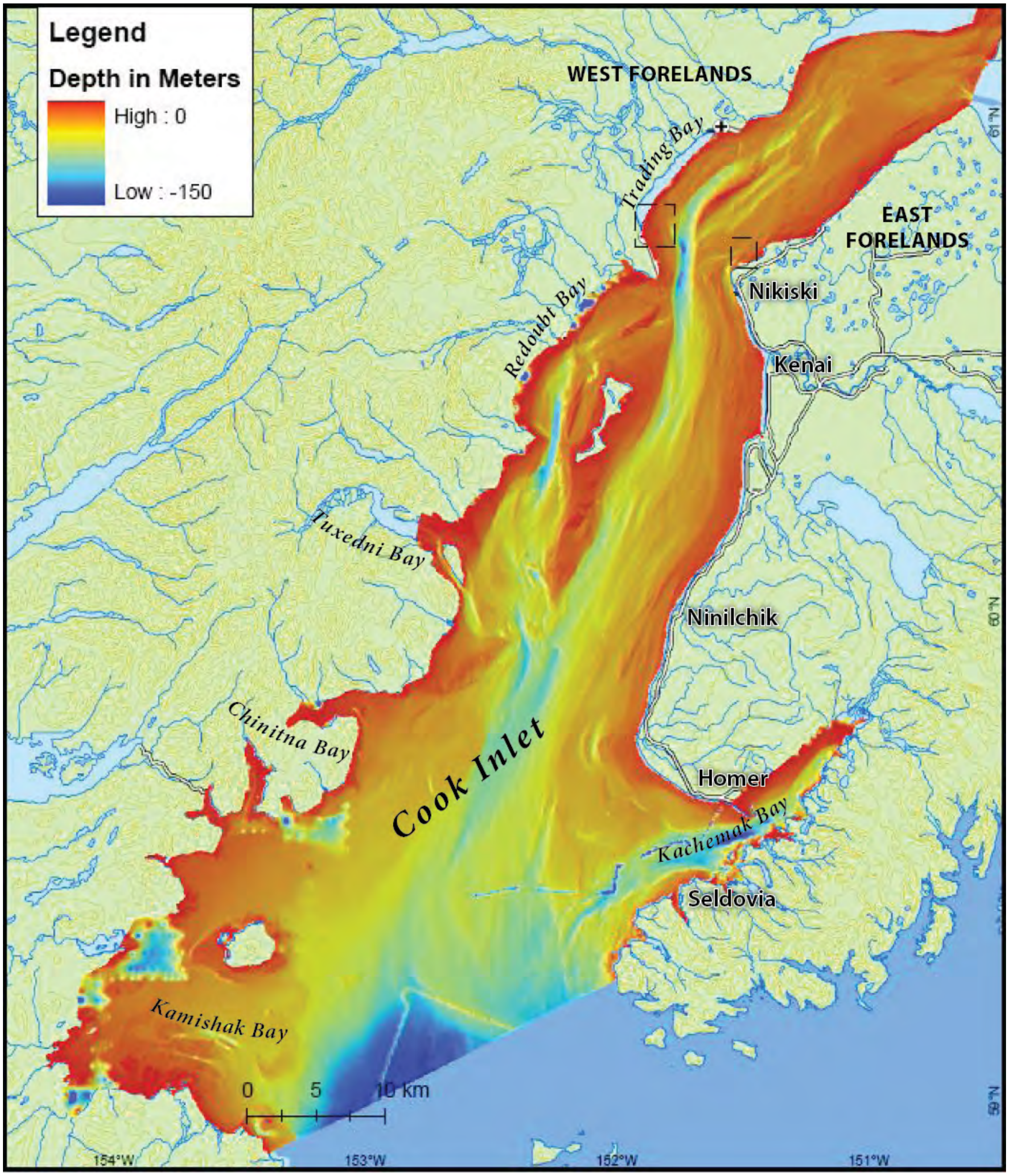

Figure 5. Cook Inlet bathymetry, bays, and East and West Forelands (based on Alaska Map Company)

The major freshwater inputs come from rivers discharging into the Upper Inlet and along the west side. Freshwater inputs, along with the ACC, likely account for most of the non-tidal influence on circulation in Upper and Middle Cook Inlet, except on the west side (Whitney, 2002). As the fresher water from the Upper Inlet flows south along the west side, it eventually meets with the westward-moving ACC near Augustine Island. The northern edge of the ACC commonly follows the 100 m isobath around the mouth of Cook Inlet. ACC water tends to trap the southward flowing water along the western boundary and much of the freshwater flow out of Cook Inlet narrows to a few kilometers in width as it passes Cape Douglas at the southern end of Cook Inlet (Okkonen et al., 2009).

Both tidal and freshwater flows interact with the bathymetry to form convergence zones known as tidal rips. These rips are generally located above rapidly changing bathymetry and often delineate strong gradients in water properties (e.g., temperature, salinity, and total suspended solids) and the speed of the current (Okkonen, 2004; Li et al., 2005). Three main rips are often evident in central Cook Inlet, extending from the vicinity of the Forelands to beyond the southern tip of Kalgin Island. The surface expressions of the rips can change position and strength considerably during the tidal cycle. During the stages of the tidal cycle when the rips are strongest, they are known to accumulate debris, ice, and spilled oil along their axes, where it can become submerged only to resurface downstream. Movement of material from one side of the rip to the other is inhibited. (Whitney, 2002)

The lunar semidiurnal (M2) tide is the principal tidal signal in Cook Inlet. The size, shape, and bathymetry of the Cook Inlet basin are such that a funneling effect and tidal resonance create some of the highest tidal amplitudes in the world. The mean tidal range varies from 11 ft. at the Barren Islands (at the mouth of the Inlet) to more than 27 ft. at Anchorage (NOAA, 2006). The large tidal exchange within Cook Inlet creates the strong tidal currents. While the Inlet as a whole has an average maximum surface current of three knots, local areas can have currents greater than 10 knots due to tides (Li et al., 2005. The constriction between the West and East Forelands accelerates currents to more than six knots during spring tides, with the associated tidal excursions[4] sometimes exceeding 20 miles. Ebb tide excursions can be several miles greater, due to the large freshwater outflow from Upper Cook Inlet Rivers south along the west side of the Inlet. This difference is one cause of the net southerly flow along the west side of Cook Inlet, especially when freshwater input is high.

Figure 6 summarizes the impact of the factors described above on the flows.

[4] The net horizontal distance over which a water particle moves during one tidal cycle of flood and ebb.

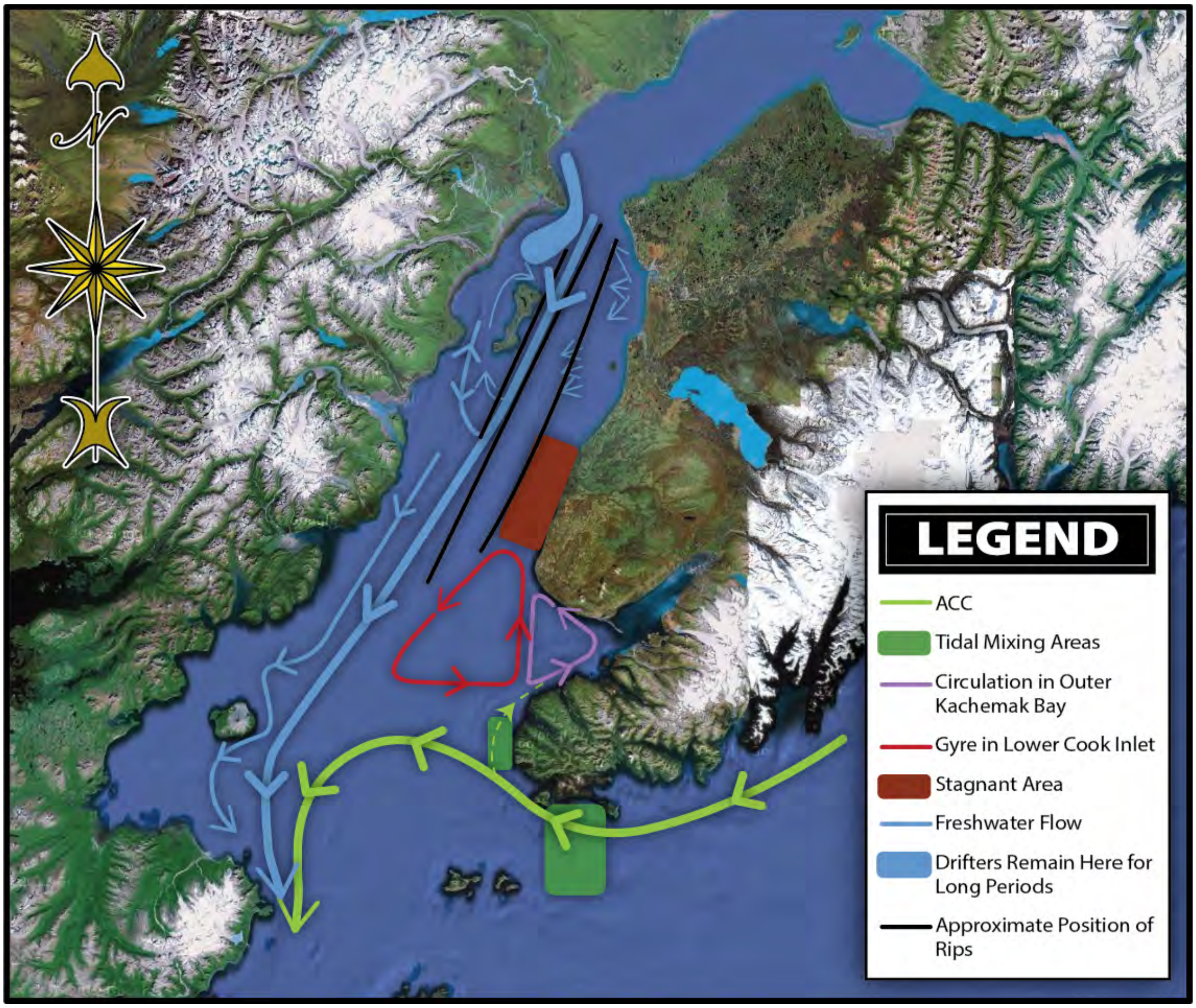

Figure 6. Circulation flows in Cook Inlet (provided by Scott Pegau)

3.3.4 Ice

Ice can be a dominant factor in parts of Cook Inlet during the winter months. While some areas of the Inlet remain ice-free (and ice conditions can vary year-to-year), at least some ice is typically present in all three operating areas of Cook Inlet between December and March. Figure 7 shows the average ice coverage during the first half of March, when the Marine Ice Atlas for Cook Inlet (Mulherin et al., 2001) shows the greatest extent of ice coverage.[5] Figure 8, also based on the Marine Ice Atlas for Cook Inlet, shows the probability of occurrence of ice of any kind in Cook Inlet during this same time period. Workshop participants noted that this data may now be out-of-date, but the data is the best available and the figures remain illustrative of the fact that ice will be a major consideration for safe operations, the movement of spilled oil, and the resource impacts.

[5] The maps in Figures 7 and 8 do not reflect possible heavy ice in Homer harbor.

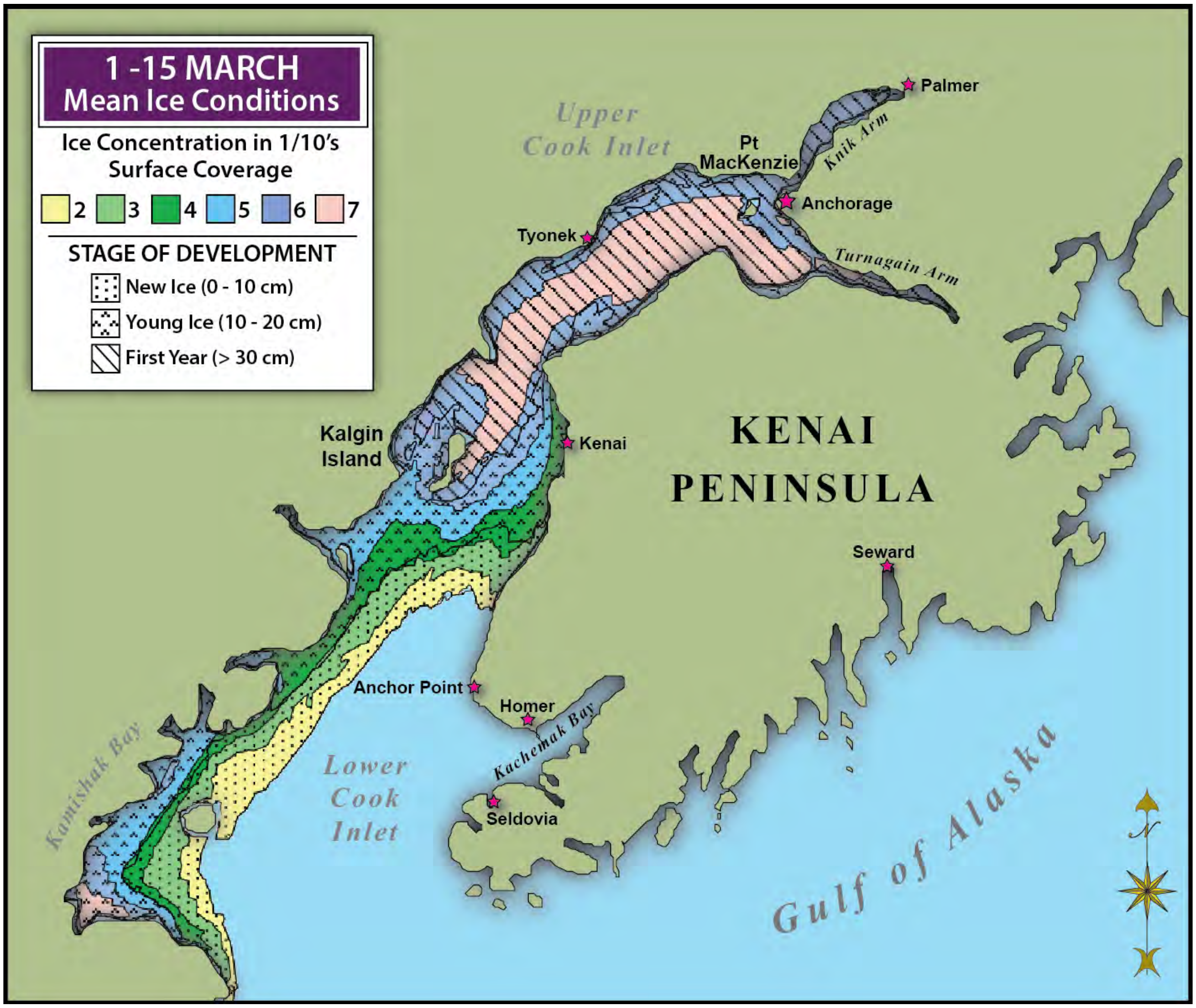

Figure 7. Average Cook Inlet ice coverage for the first half of March (Mulherin et al., 2001)

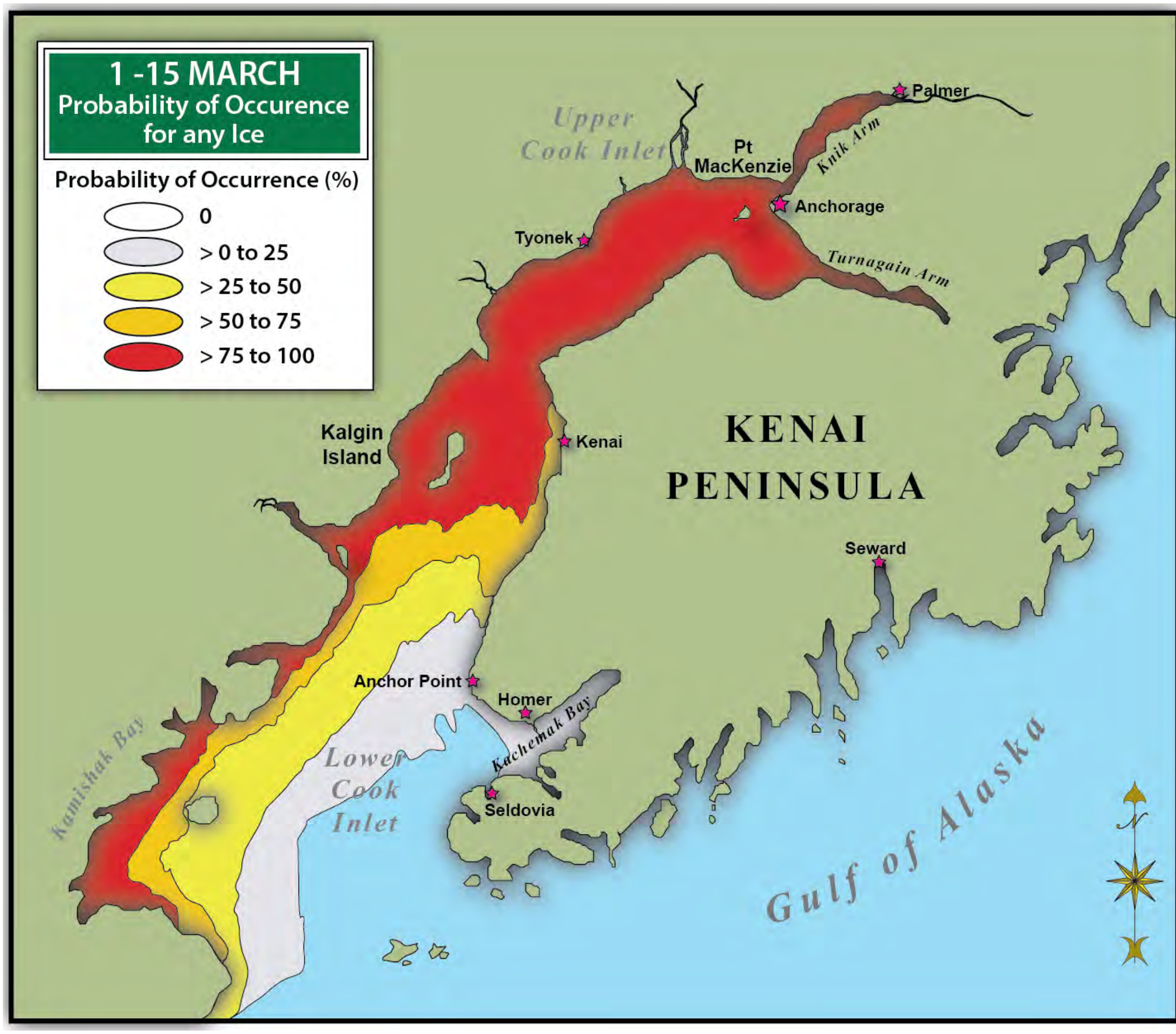

Figure 8. Probability of any type of ice occurrence in Cook Inlet during the first half of March (Mulherin et al., 2001)

3.3.5 Summary of Seasonal Variations

As discussed, the movement of water in Cook Inlet will vary in different seasons. These variations would also affect the movement of spilled oil, and thus the resources that would be impacted by an oil spill. Some factors will influence the movement of water throughout the year, while others are seasonal or local. Even features that may influence the movement of spilled oil throughout the year likely vary in their specific characteristics during different seasons. For example, while prevailing winds will always influence the movement of oil, the direction and speed of prevailing winds will be different in different seasons. At the Consequence Analysis Workshop, subject matter experts identified key influences that would dominate the movement of spilled oil in the Lower, Middle, and Upper Inlet during spring, summer, autumn, and winter (see Figure 9).

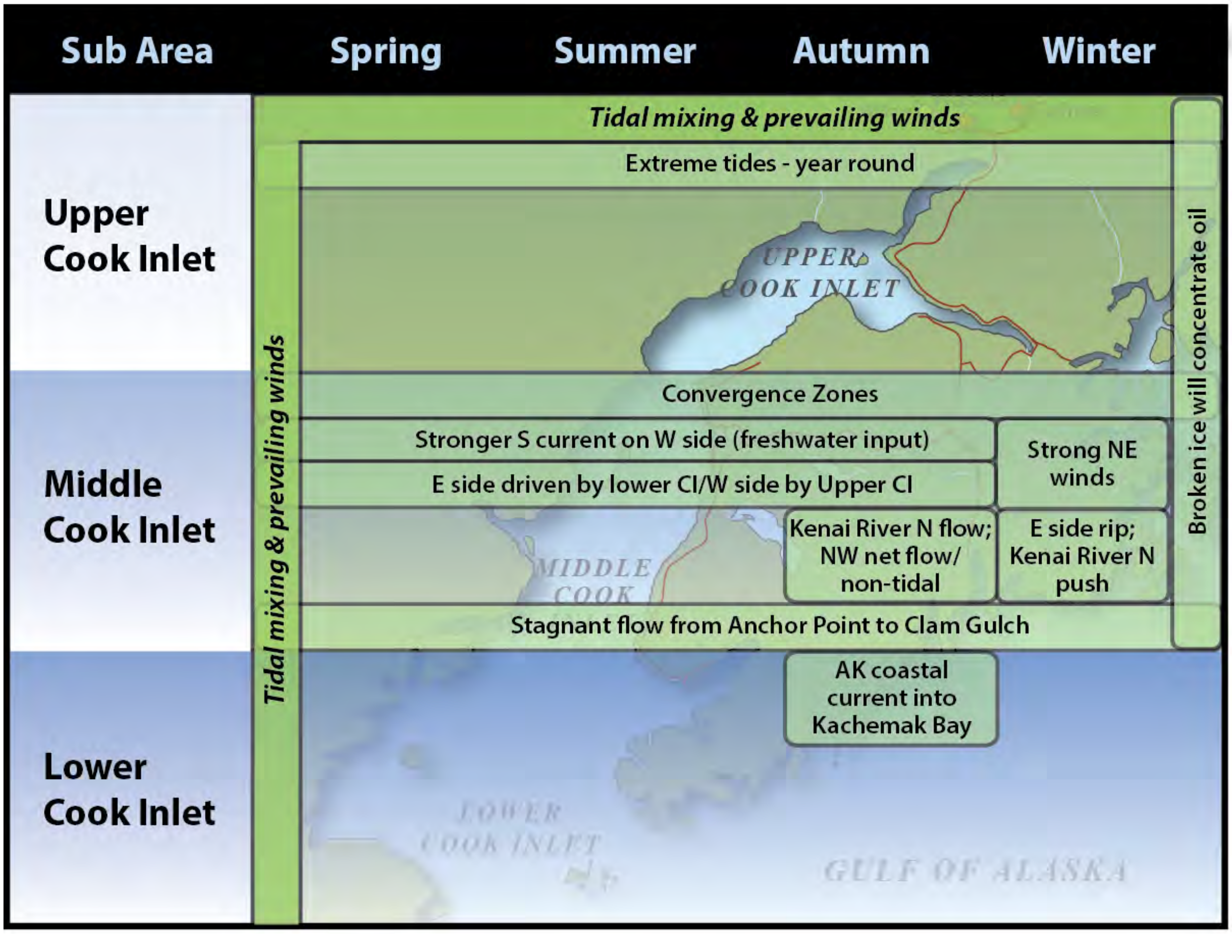

Figure 9. Summary of seasonal variations in wind, tides, and current across the Lower, Middle, and Upper Cook Inlet (based on input provided at the workshop)

4. POTENTIAL IMPACTS OF OIL SPILLS TO COOK INLET

The previous section described factors that will influence how spilled oil is transported and weathered. This section provides a high level overview of the habitat, fish, birds, mammals, and various types of socioeconomic activity that could be impacted by an oil spill to Cook Inlet.

At the Consequence Analysis Workshop, subject matter experts reviewed a proposed list of potential environmental and socioeconomic receptors that could be impacted by an oil spill. With the addition of a category for oil industry operations, the list was approved by the group as appropriate for the purpose of their qualitative analysis of the potential consequences of an oil spill to Cook Inlet. This list is shown in Table 4, below.

Table 4. Potential oil spill receptors in Cook Inlet

ENVIRONMENTAL		SOCIOECONOMIC
Habitat	**Birds**	Subsistence Commercial Fishing Recreation and Tourism General Commerce Oil Industry Operations
Pelagic Littoral Benthic	Waterfowl Sea Birds Shorebirds	
Fish	**Mammals**	
Fin Fish Shellfish	Sea Otters Pinnipeds Whales & Porpoises Terrestrial & Bald Eagles	

Figures 10 and 11 provide generalized depictions of the ways that an oil spill can impact environmental resources and socioeconomic activities, respectively.

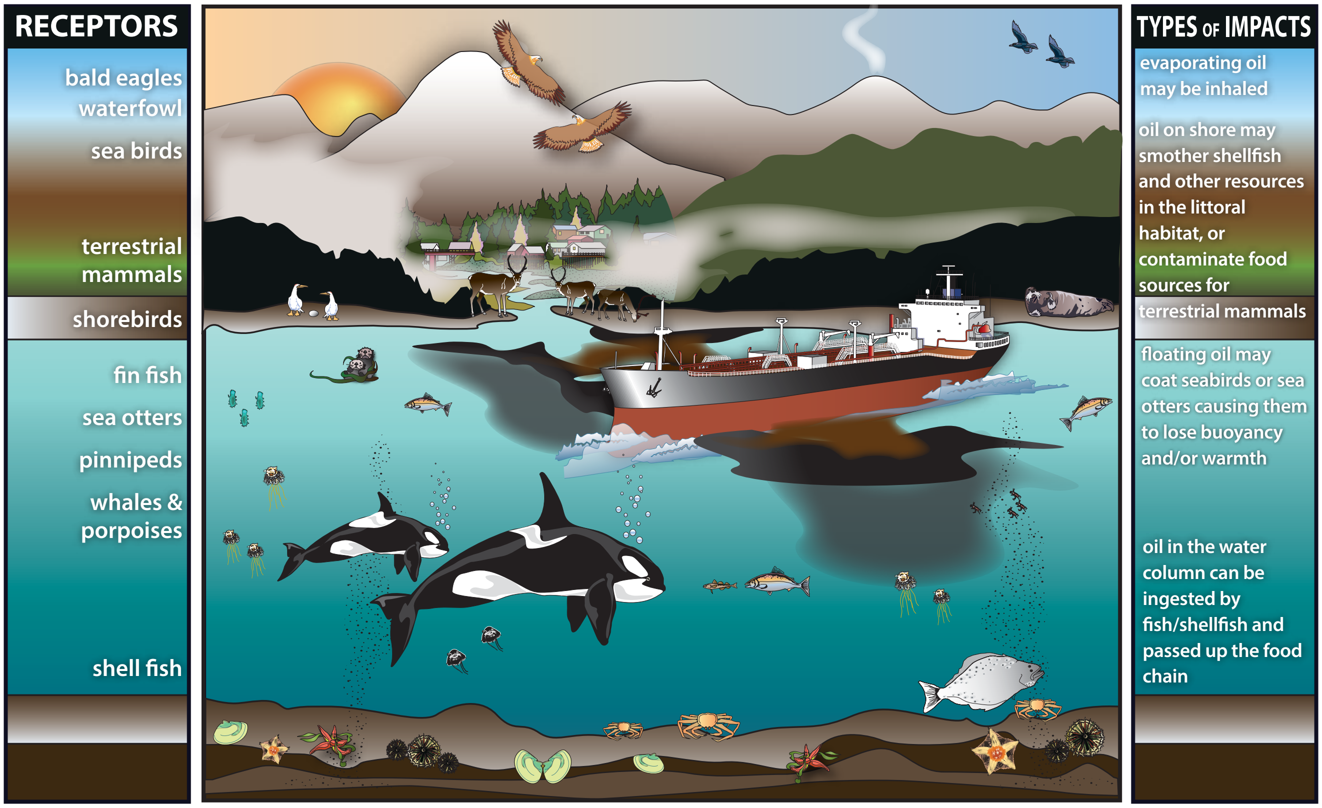

Figure 10. Diagram of select, potential impacts on environmental resources

Figure 11. Diagram of select, potential impacts on socioeconomic resources

4.1 Habitat

Different types of habitat will vary in their susceptibility to the impacts of an oil spill. The type of habitat impacted will also affect the species that depend on that habitat for shelter or food.

4.1.1 Pelagic

The pelagic zone is the water column that is not on the very bottom of the Inlet nor immediate to the shoreline. Oil is in the pelagic zone when it mixes into the water column or moves across the water's surface. Depending on location and season, this zone is likely to be home to fish, sea birds, and marine mammals.

4.1.2 Littoral

The littoral zone is located along the shoreline, including the shallow subtidal zones. In Cook Inlet, littoral habitat may be rocky, sandy, muddy, or icy depending on the season and location. The porosity of the shoreline substrate, which varies around Cook Inlet, is a significant determinant of the extent to which it may be impacted by an oil spill. Upper Cook Inlet has primarily sheltered tidal flats and salt marshes, which are highly sensitive to oil spill impacts, whereas Central Cook Inlet has exposed tidal flats, which are more porous and less sensitive (NOAA, 2002b). Lower Cook Inlet has diverse types of shoreline. Depending on location and season, littoral habitat may provide a significant food source for waterfowl, shorebirds, sea otters, fish, and terrestrial mammals with its abundance of different kinds of shellfish, kelp, sea worms, and other prey. On the west side of Cook Inlet, isolated populations of species have been identified in the littoral zone that are otherwise only found in Arctic regions. Cook Inlet RCAC (2003) provides a summary of the literature on this topic.

4.1.2 Benthic

The benthic zone is at the bottom of Cook Inlet, and is affected when spilled oil sinks. Species that might be impacted by an oil spill in the benthic zone include fin fish, shellfish and sponges. The benthic environment changes seasonally, and the substrate may be either rocky or soft (ADNR, 2009). Bull kelp forests, which can reach 40 ft. tall, grow from the benthic zone in some parts of Cook Inlet. While they may vary in size, kelp forests of more than 11 sq. mi. have been documented in Kachemak Bay, and of more than 6 sq. mi. between Anchor Point and Point Pogibshi (Schoch and Chenelot, 2004).

4.2 Fish

Generally, fish can be impacted by an oil spill if they are exposed to oil or oil components in the water column or if their food becomes contaminated; oil can also be absorbed into fish eggs, larvae, or juveniles (EPA, 1999).

4.2.1 Fin Fish

Many fish spend some or all of their life in Cook Inlet's marine environment. These include, but are not limited to, salmon, Pacific herring, eulachon, Pacific sand lance, pollock, Pacific cod, Sablefish, rockfish, and Pacific halibut. These species may spend time in different parts of Cook Inlet at different times during their lifecycles, including in drainages, nearshore areas, and deep waters. Fish may spawn from spring to fall, depending on the species. Table 5 provides some examples of the diversity of both the timing and location of spawning. Spawning is not the only time that fish are vulnerable to oil spill impacts, but one example of a time period when impacts could be particularly severe.

Table 5. Typical spawning season and locations for Cook Inlet fish (ADNR, 2009)

SPECIES	TIMING OF SPAWNING	LOCATION OF SPAWNING
Eulachon	May	Streams
Pacific herring	Spring	Intertidal and subtidal areas
Pacific sand lance	October	Intertidal and subtidal areas (ADFG, 2013)
Pacific cod	Late winter-early spring	Deep waters
Pacific halibut	Late fall - winter	Deep waters
Salmon	June-September	Streams; some in intertidal areas

Cook Inlet's many anadromous salmon streams are of particular importance to the region's fisheries. Five species of anadromous salmon[6] can be found in Cook Inlet, with most spawning from June – September. While most species spawn far enough upstream that the area is unlikely to be oiled, some pink and chum salmon spawn in intertidal areas. Juvenile salmon will be especially susceptible to oiling when they leave the streams and move to nearshore and offshore waters from mid-April through mid-July (ADNR, 2009). Currently, four Cook Inlet hatcheries are in operation: the Fort Richardson State Hatchery, the William Jack Hernandez Sportfish Hatchery, Trail Lakes Hatchery, and Tutka Bay Lagoon Hatchery. (Two hatcheries, the Elkutna Salmon Hatchery and Port Graham Hatchery, are not in operation.)

4.2.2 Shellfish

Many different kinds of shellfish inhabit Cook Inlet's intertidal and subtidal areas. These include, but are not limited to: clams, mussels, crabs, sea urchins, shrimp, chitons, scallops, limpets, whelks, sea stars, octopus, sponges, sea cucumbers, barnacles, and snails. Many of these species are important resources for consumption by humans as well as by fish and other wildlife.

[6] Chinook, chum, pink, sockeye, and coho

Clams are found in many parts of Cook Inlet. Razor clams are particularly abundant near Polly Creek on the west side of Cook Inlet, and from Anchor Point to the Kasilof River on the east side. Littleneck, butter, and other clams are prominent in Kachemak Bay, while only razor and soft shell clams occur on the west side of the Inlet. Several species of shrimp can be found at different water depths and Tanner crabs are typically found in deep benthic areas in Lower Cook Inlet (ADNR, 2009). Though not currently abundant, King crab and Dungeness crab occur in lower Cook Inlet.

The Alutiiq Pride Shellfish Hatchery in Seward supplements shellfish populations in Cook Inlet.

4.3 Birds

Most of the more than 450 bird species identified in Alaska can be found in Cook Inlet during some part of the year (ADNR, 2009). Birds can be impacted by oil spills if they come into contact with oil on or below the water's surface, or on the shore. Those species with relatively concentrated populations or low reproductive rates will be the most likely to suffer severe impacts. Birds can be harmed by ingesting oil from their food, or during preening; if a bird is oiled, its feathers' may lose buoyancy, insulation, or waterproofing qualities (EPA, 1999).

Bald eagles are considered with Terrestrial Mammals, below; they are potentially susceptible to exposure through consuming oiled carcasses, similar to some mammals.

4.3.1 Waterfowl

Several species of ducks (including eiders), geese, swans, cranes, and can be found nesting, molting, and/or staging in Cook Inlet, depending on the location and season (BLM, 2006 in ADFG, 2009). Migratory waterfowl gather from mid-April through mid-May and again in mid-August through November. Molting takes place from late June through mid-August, during which waterfowl are particularly vulnerable to oil.

The Alaska breeding population of Steller's eiders has been designated as Threatened under the federal Endangered Species Act (50 CFR 17). While the breeding area is elsewhere, Steller's eiders from the designated breeding population can be found in Cook Inlet in the winter, where they mingle to an unknown extent with individuals from the Russian breeding populations. Aerial surveys flown in the winter of 2004 identified flocks of Steller's eiders in Kachemak Bay, along the lower Kenai Peninsula coast to just north of Ninilchik, and in Kamishak Bay (Larned, 2006).

4.3.2 Seabirds

Seabirds in Cook Inlet include murres, gulls, kittiwakes, cormorants, murrelets, petrels, shearwaters, and puffins. They can be found in Cook

Inlet in large concentrations during summer and winter (feeding) and fall (staging). The east side of Lower Cook Inlet is a particularly important habitat for seabirds (Piatt and Harding, 2007 in ADNR, 2009), though important nesting sites have been identified not just in Kachemak Bay (Gull Island), but other locations as well, including Chisik Island, Duck Island, the Barren Islands, and Shuyak Island (Denlinger, 2006).

4.3.3 Shorebirds

More than two dozen shorebird species use Cook Inlet during some part of the year, including dunlin, sandpipers, plovers, godwits, yellowlegs, whimbrel, and dowitchers. Cook Inlet is an important stopover site for migrating shorebirds, which tend to appear in large numbers during the month of May (73 percent of them are found at Southern Redoubt Bay during that month). Tuxedni Bay also has important shorebird habitat in the spring.

In summer, relatively few shorebirds use Cook Inlet for breeding. An exception is the Hudsonian godwit, for which the Cook Inlet drainage may be a critical breeding ground for a significant percentage of the continental population.

In winter, the Susitna Flats is an important area, with an estimated 82 percent of the shorebirds present in Cook Inlet at that time. Mudflats located in Trading Bay, Tuxedni Bay, Kachemak Bay, south of Redoubt Bay, and in the Homer Spit area are also important winter habitat for shorebirds. (Gill and Tibbetts, 1999 in ADNR, 2009). Rock Sandpipers, which spread throughout Cook Inlet and the Alaska Peninsula during the breeding season, inhabit Upper Cook Inlet in the winter by the thousands, representing a significant portion of this subspecies' population (USGS, 2013).

4.4 Mammals

Mammals can be affected by oil spills if they inhale oil or ingest it either through grooming or by eating contaminated food. Furred marine mammals also rely on clean fur to stay warm. (EPA, 1999)

4.4.1 Sea Otters

Sea otters forage for shellfish, other marine invertebrates, and fish in Kamishak and Kachemak Bays in Lower Cook Inlet, along the south shore of the Kenai Peninsula, and on the coast of the Alaska Peninsula through Shelikof Strait (ADNR, 2009). Sea otters in Cook Inlet come from two different stocks in Alaska waters, including the Southwest Alaska stock, which is listed as Threatened under the Endangered Species Act (USFWS, 2012). Sea otters are highly susceptible to impacts from oil spills including hypothermia and injuries resulting from inhaling or ingesting oil (EPA, 1999).

4.4.2 Pinnipeds

Cook Inlet has both harbor seals and Steller sea lions (ADFG, 2006), including one of twelve distinct stocks of harbor seals (Allen and Angliss, 2011). Harbor seal pupping takes place during June and July in the same places used for haulout.

Steller sea lions breed during June and July, after which the adults and young tend to congregate at rookery sites through October before joining non-breeding individuals at haulout locations. Steller sea lions in and around Cook Inlet have been federally designated as Endangered since 1997 (62 FR 30772). Rookeries are protected by no-entry buffer zones of three nautical miles, per federal regulations (50 CFR 227.12). In addition, critical habitat for Steller sea lions has been designated, including part of Lower Cook Inlet. This designation expands protective measures around rookeries and haulouts west of 144 degrees West Longitude (50 CFR 226.202).

Pinnipeds are most susceptible to oiling during haulout and pupping.

4.4.3 Whales and Porpoises

Cook Inlet is home to a year-round population of Beluga whales, with Humpback and Minke whales present throughout the summer and Gray and Killer whales migrating through the area. Cook Inlet also has Dall's and harbor porpoises.

Harbor porpoises are found in harbors, bays, and river mouths throughout the Inlet and are part of the Gulf of Alaska stock (ADNR, 2009).

Beluga whales tend to concentrate near Upper Cook Inlet's river mouths and mudflats during the summer, but are believed to disperse further south in the Inlet in winter (Angliss and Outlaw, 2006). In 2008, Cook Inlet Beluga whales were designated as an Endangered Species under the federal Endangered Species Act (NOAA, 2008). Cook Inlet's Beluga whales comprise the smallest of five distinct population segments of this species found in Alaska. In 2011, the National Marine Fisheries Service designated 3,013 sq. mi. of Cook Inlet as critical habitat for the Beluga whale (see Figure 12) (50 CFR 226; 76 FR 20180).

Humpback whales are also designated as an Endangered Species under both federal law and State of Alaska law (AS 16.20.190). Humpback whales are primarily seen moving through Lower Cook Inlet (Allen and Angliss, 2011). Fin whales are rare in Cook Inlet, but they have also been designated as Endangered under federal law in 1970 (35 FR 18319).

While whales may be able to avoid spilled oil in the water, a spill may harm whales if they ingest or inhale oil (EPA, 1999).

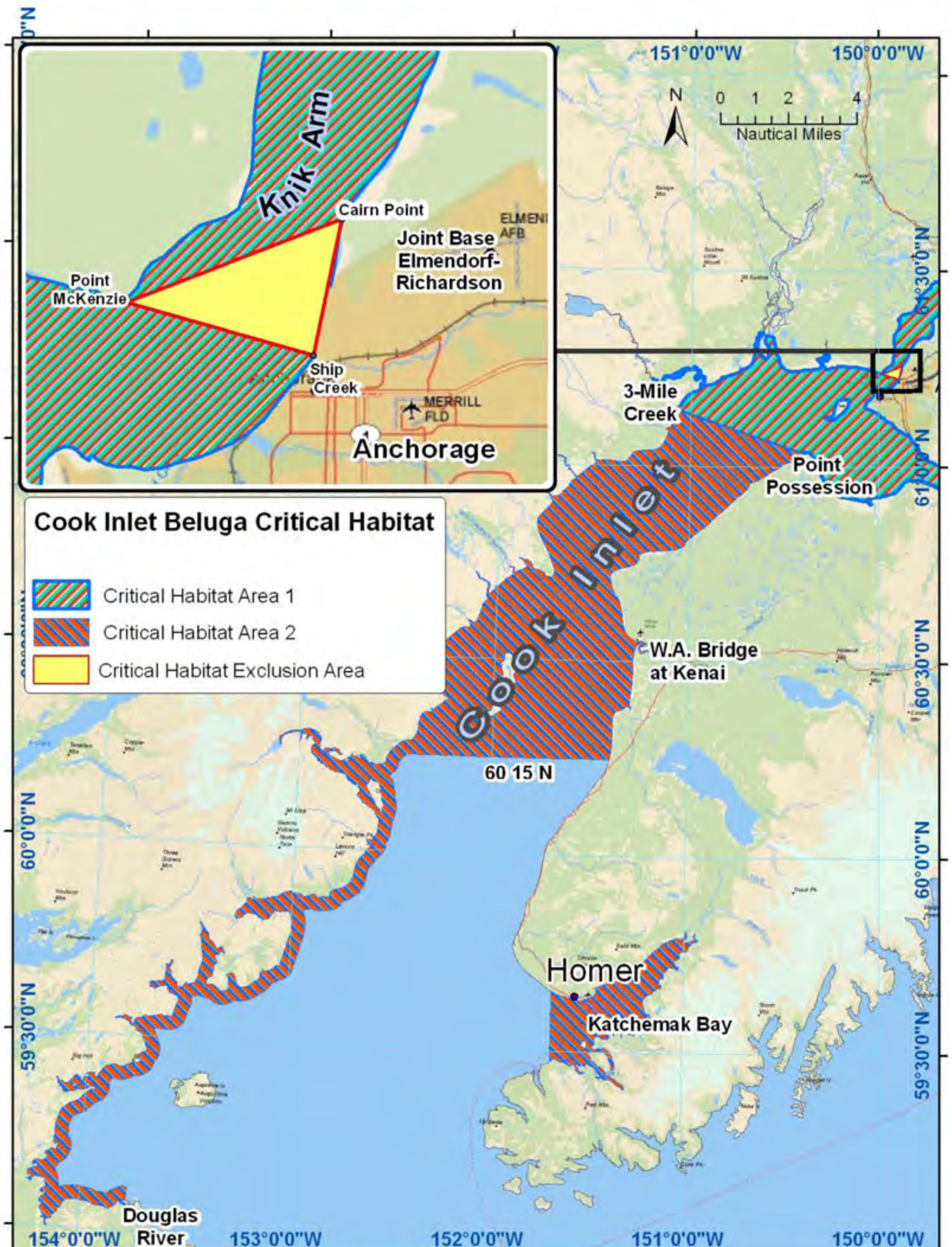

Figure 12. Critical habitat for Beluga whales in Cook Inlet (NOAA, 2011)

4.4.4 Terrestrial Mammals and Bald Eagles

Terrestrial mammals in the Cook Inlet area that could come in contact with an oil spill include brown and black bear, coyotes, moose, wolves, wolverines, fox, and river otters. Terrestrial mammals are less likely to be affected by an oil spill than mammals that spend most of their time in the water, though would be affected if they scavenge oiled carcasses or consume oiled shellfish. Although not mammals, bald eagles may also be impacted this way.

4.5 Socioeconomic Receptors

The socioeconomic activities and resources considered at the Consequence Analysis Workshop were: subsistence, commercial fisheries, recreation and tourism, general commerce, and the oil industry.

4.5.1 Subsistence

Subsistence use of fish and other resources is defined in Alaska statute[7] as "non commercial, customary and traditional uses," whether for personal or family consumption, customary trade, barter, or sharing with other individuals or families for their consumption. Subsistence uses of natural resources play an important role in the economy and culture of many communities in the Cook Inlet region. All residents of Alaska may participate in subsistence activities. The subsistence lifestyle and diet are of great importance to the self-definition, self-determination and overall health and well being for Alaskans, particularly within Native Alaskan communities.

Subsistence fishing can only take place outside of *non*-subsistence areas. Non-subsistence areas are designated by the Joint Board of Fisheries and Game and are generally more urban areas where subsistence is less common.[8] Areas around Alaska's major cities, including Anchorage, have been designated as non-subsistence areas. Figure 13 shows the Anchorage *non*-subsistence area, which encompasses much, though not all, of the land and nearshore areas around Cook Inlet. (Personal use fishing may still take place within non-subsistence areas).

Subsistence fisheries designated by the State's Board of Fisheries in Cook Inlet include salmon, halibut, herring, bottomfish, Tanner crab, clams, Dolly Varden, and smelt, depending on location, season, stock levels, and gear. There are state-managed subsistence fisheries for salmon at Tyonek, Seldovia, Port Graham, and Nanwalek, and federally managed salmon fisheries for residents of Hope, Copper Landing, and Ninilchik. (ADFG, 2012a)

[7] AS 16.05.940(32)

[8] AS 16.05.258(c)

Figure 13. Anchorage non-subsistence use area (yellow boundary)

There are also federally designated subsistence harvests in Cook Inlet that take place on federal lands and waters under the Federal Subsistence Management Program. Additional harvests are managed under other federal agencies, sometimes in partnership with Alaska Natives, including halibut (National Marine Fisheries Service); seals, sea lions, and some whales (National Marine Fisheries Service and Alaska Natives), and sea otters, waterfowl, and other migratory birds (U.S. Fish and Wildlife Service and Alaska Natives).

Oil spills may reduce the quantity and diversity of subsistence harvests, resource sharing, and the teaching of knowledge and skills (Fall, 1999). Severely limiting the consumption of traditional foods may have negative health effects on the population if they replace their consumption of relatively healthy food from subsistence harvests with foods that have potential health risks.

4.5.2 Commercial Fishing

Commercial fishing in Cook Inlet targets five species of salmon, halibut, Pacific cod, eulachon/smelt and razor clams. Economically speaking, the salmon fishery is the most important commercial harvest activity. The Upper Cook Inlet sockeye drift net fishery generally brings the greatest cash return. Set net and pink salmon seine harvests are also economically significant. The salmon fishery brought in more than 6.2 million fish in 2011 for a total ex-vessel value greater than $55.2 million.[9]

The Port of Homer sees some of the largest landings of commercial halibut in the world, with more than 4.4 million pounds landed there in the 2012 season, which lasted from March 17 – November 7[10] (NOAA, 2012).

Table 6 shows select, annual catch and ex-vessel values reported by the state and federal agencies for either 2010, 2011, or 2012 in Cook Inlet (depending on the year for which reports were available).

Table 6. Commercial fisheries in Cook Inlet: select catch and ex-vessel values[11]

	STATE-MANAGED (2011)				STATE- & FEDERALLY-MANAGED (2010)	FEDERALLY-MANAGED (2012)
	Salmon	Pacific herring	Eulachon/ Smelt	Razor clams	Pacific cod	Halibut
Catch	6.2 million fish	16.2 tons	100.8 tons	94.5 tons	180 tons	2200 tons
Estimated ex-vessel value	$55.2 million	$32,000	$200,000	$122,000	$1 million	$28 million

[9] Ex-vessel value is the average price of the catch sold off the boat in a particular location and with a particular gear type. Catches and ex-vessel values shown here were totaled from Alaska Department of Fish and Game reports for Upper and Lower Cook Inlet (Shields and Dupuis, 2012 and Hollowell et al., 2012).

[10] Not all halibut landed at Homer were *caught* in Cook Inlet, but data on catch location is not publicly reported.

[11] Salmon, herring, Eulachon, and razor clam data are compiled from reports on the 2011 fisheries (Shields and Dupuis, 2012 and Hollowell et al., 2012). Halibut figures are based on individual fishing quota landings at Homer in 2012 (NOAA, 2012). Pacific cod data is from 2010, combining both the state waters and federal parallel fisheries (Trowbridge et al., 2011).

Clams are harvested commercially in Kachemak Bay and Tuxedni Bay. Beaches that have been approved for the commercial harvest of shellfish include: Polly Creek, Crescent River, Chugachik Island, Halibut Cove Lagoon, Jakolof Bay, Kasitsna Bay, and Tutka Bay.

Commercial aquaculture sites include both blue mussel and oyster farms and are concentrated in the Kachemak Bay area. Aquaculture sites are vulnerable to spill damage on a year-round basis since the shellfish are typically suspended from anchored rafts and are continuously submerged in the water column (ARRT, 2010).

Fisheries are subject to oil spill impacts above and beyond the way that the actual fish may be impacted. The State of Alaska has a “zero tolerance” policy for oil contamination of commercial fish products (ADEC, 2004). Requirements for fishing vessel operators, tenders, buying stations, and processors in the event of an oil spill are outlined in state regulations at 18 AAC 34 Article 6. Fisheries in the area of a spill may be closed even before any known oiling occurs in order to ensure that high standards are maintained. An oil spill may also reduce demand for product from a fishery even after it has reopened based on perception in the marketplace. Missed days on the water and/or reduced catch will impact not only the fishing vessel owners and crew, but also processors and other businesses that rely in full or in part on income associated with commercial fishing operations or their catch. Loss of income will also translate into reduced tax revenue to local governments.

4.5.3 Recreation and Tourism

Recreation and tourism in Cook Inlet include a wide range of activities, such as sport and personal use fishing, wildlife viewing, tours, boating, camping, and kayaking, which are undertaken by Alaska residents and visitors.

Data collected for the summer of 2011 indicate that 166,000 people visited Kenai/Soldotna; 152,000 visited Homer, and 784,000 visited Anchorage. That summer an estimated 77% of visitors came to Alaska for vacation or pleasure. (McDowell Group, 2012)

Table 7 shows the number of cruise and tour boats transiting the Inlet in 2010 (according to the Vessel Traffic Study).[12] Of visitors to the Kenai Peninsula in the summer of 2011, 19% came by cruise ship and 36% used the Alaska Marine Highway System or ferry (McDowell Group, 2012).

[12] Alaska Marine Highway System ferries are included in Section 4.5.4 General Commerce.

Table 7. Estimate of vessel activity directly related to tourism, 2010 (Eley, 2012)

Vessel Type	Calls to Cook Inlet	Underway Operating Days
Cruise Ships	13	6
Small Cruise Ships	2	0.25
Tour Boats	N/A	153

Sport and personal use fishing are significant economic activities with other associated benefits (including fresh food, recreation and exercise, and culture/community). In 2007, the Alaska Department of Fish and Game estimated that anglers engaged in sport fishing for salmon, herring, halibut, cod, rockfish, and crab in Cook Inlet, spent about $733 million that year. This, in turn, supported more than 8,000 jobs and generated $63 million in state and local tax revenue (Southwick et al., 2007). As just one example of the significance of personal use fisheries around Cook Inlet, the estimated dip net harvest of sockeye salmon on the Kenai River was more than 500,000 fish in 2011 (ADFG, 2012b)[13]. Clamming is also popular, particularly the razor clam fishery between Homer and Kenai (ADFG, 2012c).

Similar to commercial fisheries, recreation and tourism can suffer significantly in the event of an oil spill. While recreational areas may not be directly oiled, the perception that the place is unsafe or unpleasant to visit may deter visitors for an unknown period of time. This may be more likely to deter the high percentage of visitors coming strictly for vacation, as they are more apt to seek other options than those traveling to visit friends or family, or for business purposes.

Some parts of the tourism sector may experience a short-term increase in business during a spill by providing rooms, food, or transportation to out-of-town personnel responding to the spill. However, guides, gift shops, and other services for tourists that are not required by spill response personnel may suffer from lost revenue during and/or after the spill (Picou et al., 2009).

4.5.4 General Commerce

General commerce in Cook Inlet includes shipping to and from the Port of Anchorage and Port MacKenzie, and the movement of people and goods via the Alaska Marine Highway System. The Port of Anchorage is a "major hub for the movement of goods by rail, road, and air cargo connections to all regions of the state, except Southeast Alaska" for goods and raw materials. Port MacKenzie, across Knik Arm from Anchorage, moves wood chips, coal, limestone, cement, mineral concentrates, and other commodities. (Eley, 2012). Table 8 shows the commercial vessel traffic in Cook Inlet. (The

[13] Other estimated harvests in recent years were: 389,552 (2010); 339,993 (2009); 234,109 (2008); and 291,270 (2007).

tourism and oil industries are considered separately).

In addition to the movement of goods in and out of Alaska, Cook Inlet's vessel traffic is also engaged in moving people, goods, and fuel among Alaskan communities. The movement of people and goods could be disrupted by an oil spill in Cook Inlet if vessel traffic was curtailed.

Table 8. Estimate of vessel activity associated with general commerce, 2010 (Eley, 2012)

Vessel Type	Calls to Cook Inlet	Operating Days Underway
Container Ship	108	111
RO-RO	104	81
Gas Carrier	12	9
General Cargo	5	1.16
Alaska Marine Highway System Ferries	114	38

4.5.5 Oil Industry

Cook Inlet has extensive oil and gas activity, including exploration, production from both on and offshore wells, storage, pipelines, and shipping via tank barge and tank ship. The Drift River Marine Terminal is the transfer point for crude oil from the Cook Inlet Pipeline to tank vessels berthed there (Eley, 2012). Tank vessels then move the oil to the Kenai Pipeline refining facility at Nikiski. Nikiski also has docks for other types of vessels engaged in oil industry operations (Eley, 2012). Table 9 summarizes the findings from the vessel traffic study related to oil and gas operations (for vessels greater than 300 GT or with more than 10,000 gallons of fuel).

Vessels also transit the Inlet to service the production platforms around the Inlet. In the event of a spill, vessel traffic servicing platforms or moving oil via ship or barge could be disrupted.

Table 9. Estimate of vessel activity directly related to oil and gas industry, 2010 (Eley, 2012)

Vessel Type	Calls to Cook Inlet	Underway Operating Days
Crude oil tank ships	76	88
Bulk carriers	21	22.80
Gas carrier	12	9
Product tank ships	18	18
Offshore supply and spill response vessels	N/A	730

5. OVERVIEW OF APPROACH AND WORKSHOP PREPARATION

This section describes the overall approach used to develop this consequence analysis, including steps taken prior to the Consequence Analysis Workshop by the contractor team, Advisory Panel, and Management Team, and the process used by the subject matter experts at the Workshop on October 30-31, 2012.

The following steps were taken in preparation for the Consequence Analysis Workshop:

1) The Glosten Associates and ERC completed the Spill Baseline and Accident Causality Study, which included 2,112 potential scenarios with a probability and preliminary estimate of consequence assigned to each. This study included information from the Cook Inlet Vessel Traffic Study, which was the first deliverable of the Cook Inlet Risk Assessment.
2) The Advisory Panel reviewed the Spill Baseline and Accident Causality Study and identified six scenarios to be used at the Consequence Analysis Workshop. Their selections are discussed in greater detail in Section 5.1. (The seventh scenario was developed at the Workshop.)
3) The Advisory Panel and Management Team provided input to Nuka Research and Pearson Consulting as they identified subject matter experts to be invited to the Consequence Analysis Workshop. Experts were invited based on their familiarity with Cook Inlet's physical, biological and socioeconomic knowledge of the region. Fifteen experts were able to attend (see Section 5.2); some of the experts invited were unable to participate due to conflicting schedules.
4) The Management Team reviewed and approved the agenda for the Consequence Analysis Workshop. (See Appendix C.)

At the two-day Consequence Analysis Workshop, the participating subject matter experts followed the steps below as a group. These steps are described in more detail in Sections 6 - 8.

1) Refined scenarios, including estimating the spill area using oil spill trajectory models and persistence based on product spilled. A seventh scenario was added to represent an example of a higher consequence/lower probability event. See Section 6.1.
2) Defined environmental impact scale. See Section 6.2.
3) Defined socioeconomic impact scale. See Section 6.3.
4) Reviewed preliminary analysis of scenarios, including toxicity and persistence (both based on product type). See Section 6.4.

5) Calculated preliminary spill severity based on spill area, volume, toxicity, and persistence. See Section 6.5.

6) Assigned scores to each scenario for socioeconomic receptors. See Section 7.

7) Assigned scores to each scenario for biological receptors. See Section 7.

8) Considered combined scores for each scenario and scenario consequences relative to each other. See Section 8.

5.1 Selection of Six Scenarios by the Advisory Panel

Risk is the product of the probability of an event occurring and the consequences of that event. The Spill Baseline and Accident Causality Study (2012) developed and categorized 2,112 scenarios based on historical and forecasted data for vessel traffic and reported incidents. The return period was calculated for each scenario based on historical spill rates. The return period of a spill describes how likely it is that a spill of equal or greater size will occur in a given year, but expresses this likelihood using an inverse probability; therefore, a 1000 year return period for a spill has a 0.001 or 0.1% chance of happening in any given year. Each scenario was also given a preliminary estimate of consequence (based solely on the type and amount of oil spilled). The scenarios were categorized in a matrix shown in Table 10 (for 2010-2014) and Table 11 (for 2015-2020).

As described below, a seventh scenario was added at the Consequence Analysis Workshop. All seven scenarios are summarized in Section 6.

Table 10. Number of scenarios at each risk level, 2010-2014 (based on Glosten and ERC, 2012)

CONSEQUENCE LEVEL	PROBABILITY LEVEL (SPILL RETURN PERIOD IN YEARS)				
	Very Low >10,000	Low <10,000	Medium <5000	High <1000	Very High <500
Very High	23	0	1	0	0
High	104	9	7	0	0
Medium	249	31	28	1	5
Low	146	7	10	2	1
Very Low	953	64	121	40	46

Table 11. Number of scenarios at each risk level, 2015-2020 (based on Glosten and ERC, 2012)

CONSEQUENCE LEVEL	PROBABILITY LEVEL (SPILL RETURN PERIOD IN YEARS)				
	Very Low	Low	Medium	High	Very High

	>10,000	<10,000	<5000	<1000	<500
Very High	24	0	0	0	0
High	100	9	5	0	0
Medium	267	28	14	1	0
Low	137	5	12	0	0
Very Low	972	65	124	43	38

After reviewing the results of the Spill Baseline and Accident Causality Study, and based on their experience and knowledge of Cook Inlet, the Advisory Panel chose six scenarios to provide a representative set of possible events and resulting ecological and socioeconomic impacts. The elements of the scenarios are:

- Vessel type based on the vessel traffic study
- Region of Inlet (Lower, Middle, Upper)
- Specific locations that threaten valuable resources
- Oil type that is transported in the region and spill volume based on the vessel capacity and realistic outflow
- Moored/Transit
- Season (Ice/non-ice)
- Month of year since climatic conditions and natural resource presence/abundance vary with seasonal conditions.

5.1.1 Purpose and Limitations of this Scenario-based Analysis

The TRB recommends that the consequence analysis component of the risk assessment should focus on understanding the impact of a series of hypothetical spill scenarios on different environmental and socioeconomic receptors. The scenarios should be developed based on previous study of vessel traffic in the region, as well as an analysis of spill history and causality. The scenarios developed for the consequence analysis should reflect the key factors influencing the consequences of a spill, including the product spilled, size of the spill, season, and geographic location. (TRB, 2008)

A scenario is a description of the circumstances and events that lead to an accident and, in this case, the resulting oil outflow from that accident. The scenarios essentially establish the spatial and temporal parameters of the risk analysis. The purpose of this scenario-based analysis is to understand the different possible impacts to biological or socioeconomic receptors that may result from a small but diverse set of potential spill events. This will inform decisions that will be made by the Advisory Panel and Management

Team of the Cook Inlet Risk Assessment when they consider potential risk reduction measures. Knowing the possible consequences may inform the selection and prioritization of risk reduction options to prevent or respond to a spill; for example, if a spill at a certain location during a certain season could devastate a significant portion of an endangered species, it may be prudent to avoid shipping large quantities of oil through that area during that season, if feasible.

Scenario analysis is not meant to be predictive, nor is it meant to portray all possible events and outcomes. The seven spill scenarios considered at the Consequence Analysis Workshop do not in any way represent all possible spills from marine vessels that could occur in Cook Inlet. Even the 2,112 scenarios developed in the Spill Baseline and Causality Report do not represent all possible spill events and their associated consequences. Thus, areas of Cook Inlet that are *not* included in the scenarios considered at the workshop should not be deemed safe from the impacts of spills. It is also possible for much larger spills to occur than those that are included in the seven scenarios considered here. Even the consequences of the spill scenarios that were considered may be different if a spill were to occur during a different season, for example, or involve a different product. The consequences of a spill are very dependent on variables such as wind direction and weather at the time of the event, as well as the presence of sensitive resources, such as migratory species. The subject matter experts at the Consequence Analysis Workshop acknowledged that many other types of spills are possible, including much larger ones.

The scenarios selected notably do not include a worst-case discharge (a total loss of oil cargo and bunker fuel from a tank vessel), although it is theoretically feasible for such an event to occur.[14] In this context, studying impacts from extreme worst-case spills is not instructive, because all receptors would likely receive the highest impact scores, thus providing no differentiation among receptors. Consideration of such scenarios does not inform selection or prioritization of risk reduction measures. As discussed in Section 6, the addition of the seventh scenario at the Workshop sought to include a potentially higher consequence spill even if it had a lower probability, but even this scenario fell far short of a worst-case event.

Finally, this consequence analysis does not consider any mitigation or reduction in consequences due to effective oil spill response: spill response planning is governed by state and federal statute and is not part of this stage of the Cook Inlet Risk Assessment.[15] Spill scenarios are often used to inform the efforts of spill responders to identify the tactics and resources that would be needed to respond to an oil spill in a certain region or from a

[14] A worst case discharge did not occur in the U.S. from 1985-2000, though two such incidents did occur prior to 1985 and worst case discharges did occur outside U.S. waters between 1985-2001. (Glosten and ERC, 2012)

[15] It is possible that improved response capability may be considered as a risk reduction option at a later stage in the project, but this is not relevant to the consequence analysis.

certain type of vessel or facility. When using scenarios to plan for a spill response, it can be instructive – or required by regulation – to consider the resources that would be needed to respond to a worst-case spill or a spill of a certain size. In the case of spill response planning, scenarios may be used to challenge spill responders to ensure that they can address the full gamut of possible spill events. In the context of the risk assessment process, however, the goal is not to be prepared for the full range of possible spill events, but to identify risk reduction options that are most likely to minimize spill consequences; thus, the scenarios chosen for this analysis were selected to focus on spill events that are more likely to occur and their associated consequences.

5.2 Subject Matter Experts and Other Participants

The Consequence Analysis Workshop convened 15 subject matter experts (see Table 12) in fields including natural resource management, subsistence, fisheries, oceanography, and marine risk assessment. See Appendix A for brief subject matter expert bios. Members of the Cook Inlet Risk Assessment Advisory Panel, Management Team, and interested members of the public also attended the workshop and are listed in Appendix B.[16]

Table 12. Subject matter experts participating in the workshop

FIRST NAME	LAST NAME	ROLE	AFFILIATION
Catherine	Berg	Land/Resources	U.S. Fish and Wildlife Service
Jim	Butler	Fisheries	Baldwin & Butler, LLC
Jack	Harrald	Risk Assessment	Retired
Heather	Coletti	Biology	US National Park Service
Brad	Dunker	Fisheries & Habitat	Alaska Department of Fish and Game
Gary	Fandrei	Fisheries	Cook Inlet Aquaculture Association
Tahzay	Jones	Biology/Habitat	National Park Service
Robbin	La Vine	Subsistence	Alaska Department of Fish & Game
Steve	Okkonen	Oceanography	University of Alaska Fairbanks
Scott	Pegau	Oceanography	Prince William Sound Oil Spill Recovery Institute
Bud	Rice	Biology/Habitat	National Park Service
Sue	Saupe	Oceanography/General	Cook Inlet RCAC
Carl	Schoch	Oceanography/General	Coastwise Services - Private
Orson	Smith	Oceanography and Marine Ecology	University of Alaska, Anchorage

[16] Many comments from the audience were accepted and discussed, but only the subject matter experts scored the impacts.

FIRST NAME	LAST NAME	ROLE	AFFILIATION
John	Whitney	Oceanography	National Oceanic and Atmospheric Administration

5.2.1 Considerations Related to the Use of Expert Opinion

Expert opinion was utilized to characterize the likely impacts and consequences of the seven scenarios considered at the Consequence Analysis Workshop. The use of expert opinion for evaluating risk has grown – and been refined – since the mid-20th century (Cooke, 1991). While expert opinion has an inherent level of uncertainty, as compared to "fact," it provides a means of gaining information in an uncertain context. As discussed in this report, the context in which the consequences of an oil spill would unfold in Cook Inlet is very uncertain: consequences depend on the movement, persistence, and toxicity of the spilled oil (which will vary depending on many factors) and also on exactly what comes in contact with it, when, and how.

Eliciting the opinion of multiple experts, as was done in the Consequence Analysis Workshop, is considered to yield more accurate results than using just one expert (TRB, 2008). In this case, the multiple experts represented experience with different Cook Inlet resources and characteristics.

This section describes the process undertaken by the subject matter experts at the Consequence Analysis Workshop, as summarized in Section 5.

6. PRELIMINARY SCENARIO ANALYSIS

6.1 Refining Scenarios and Addition of a Seventh Scenario

Table 13 summarizes the scenarios used in the Consequence Analysis Workshop. This includes the six scenarios selected by the Advisory Panel prior to the Workshop, as well as a seventh scenario added during the workshop (see below). Additional information on each scenario is included in Section 7.

Table 13. Seven spill scenarios used in Consequence Analysis Workshop

No.	Scenario	Region	Oil Type	Spill Vol. (bbl)	Incident Type	Ice?[17]
1	Crude Oil Tanker at Drift River Terminal	Middle	Med. Persistent	30,000	Structural	No
2	Oil Barge at Nikiski Loading Facility	Middle	Low Persistent	1,000	Operational Error	No
3	Product Tanker containing Jet Fuel at Knik Shoal	Upper	Non Persistent	48,000	Powered Grounding	No
4	Container Ship at Anchorage Dock	Upper	Heavy Persistent	1,000	Equip. Failure	Yes
5	Tug and Oil Barge at Barren Islands	Lower	Low Persistent	20,000	Drift Grounding	No
6	Work Boat in Homer Harbor	Lower	Low Persistent	100	Operational Error	No
7	Work Boat and Tanker at Anchor Point	Lower	Low Persistent	1000	Collision	No

Before considering what resources may be impacted by a particular spill, the subject matter experts had to agree first on the areas likely to be oiled in each scenario. As noted above, Cook Inlet has many unique features that will influence the behavior of spilled oil, many of which are not included in the best available spill trajectory models. Subject matter experts considered outputs from both the General NOAA Operational Modeling Environment (GNOME) modeling tool[18] and the Response Options Calculator's (ROC)[19]

[17] Whether or not ice is present at the time of a spill is only one aspect of the way that seasonal variations will affect the movement of spilled oil and the consequences of a spill.

[18] The GNOME tool was developed by NOAA's Office of Response and Restoration to assist oil spill response planning and implementation by modeling the way that spilled oil will move in different locations and conditions, as well as how it will weather over time. More information and the tool itself can be found here:

oil weathering model with different wind conditions appropriate to the season applied in order to estimate a rough footprint for each trajectory. The group modified the scenario footprints in cases where they agreed that the influence of tides or currents not considered in the model(s) would significantly impact the spill behavior. Figure 13 shows the footprints established for all seven scenarios. Each scenario is described in greater detail in Section 7.

After reviewing these scenarios, the subject matter experts added the seventh scenario, also shown in Table 13 and Figure 13, to represent a low probability/high consequence event. The addition of this scenario made the resulting analysis more inclusive of the potential for high consequence events, although, as noted in Section 5, much higher consequence spills could still occur.

As the purpose of the consequence analysis is to provide a high level illustration of potential impacts based on a subjective scale, and because all agreed that while the spill trajectory modeling represents the best available tool it remains imperfect, no attempt has been made to describe or imply precision in the way that the spilled product may move in each scenario. Scenario footprints also assumed a uniform distribution of the spilled product within the area outlined in order to simplify the assignment of the impact scores. In reality, the oil slick would be patchy and not necessarily cover the entire footprint at all times.

http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/response-tools/gnome.html.

[19] The Response Options Calculator (ROC) is a modeling tool created by NOAA that is based on the Mechanical Equipment Calculator (MEC) / Spill Tools method but also considers oil spread and weathering by incorporating the Automated Data Inquiry for Oil Spills (ADIOS) model, which was also developed for NOAA (NOAA, 2012).

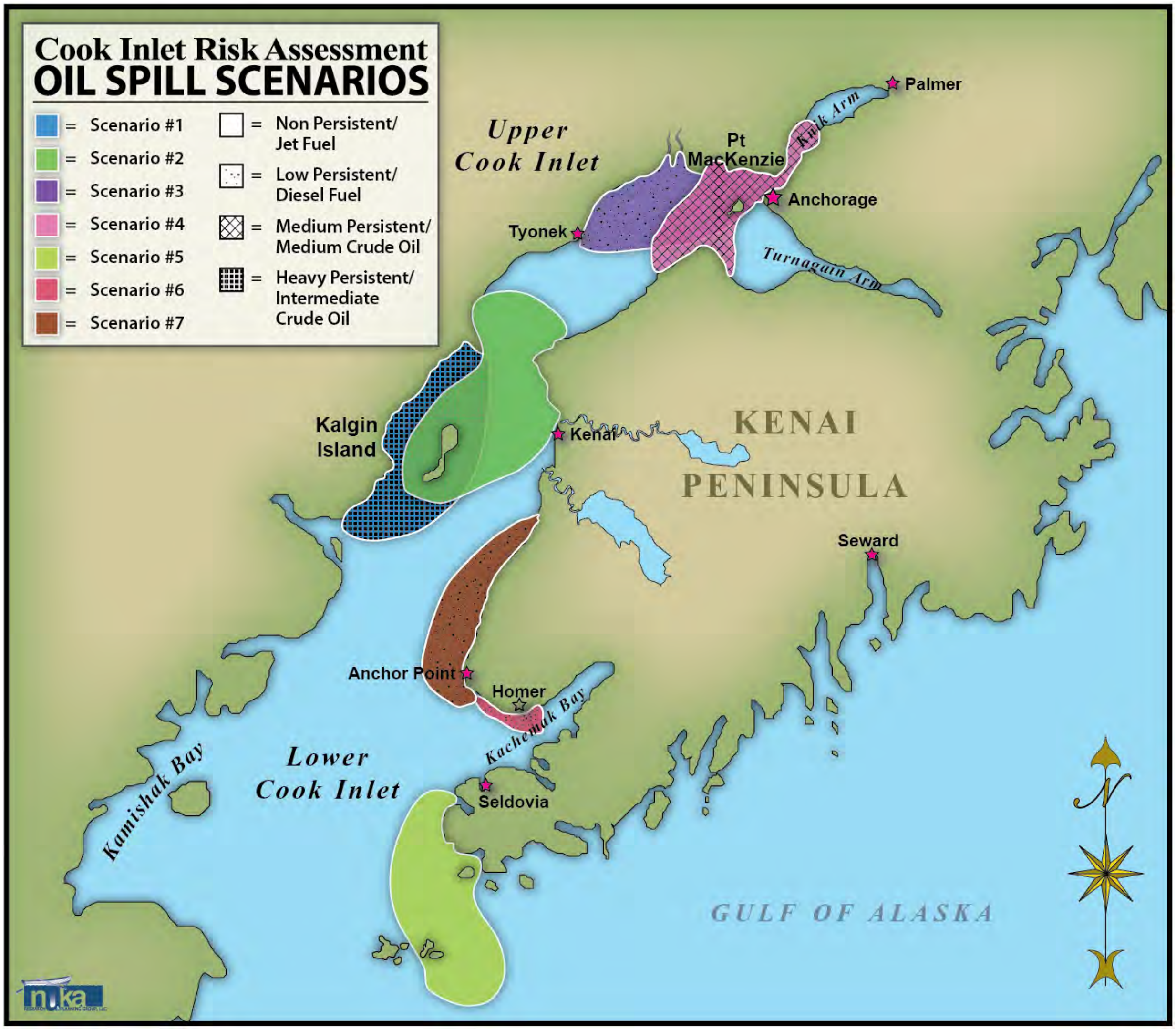

Figure 13. Spill footprints established for seven scenarios

6.2 Defining the Environmental Impact Scale

The subject matter experts used categories on an interval scale from 1-5 to describe the environmental impacts of the seven spill scenarios. The five categories were characterized with terms (very low, low, moderate, high, and very high) and given a point value from 1-5, with one point given to the category of very low impacts and five points given to the category of very high impacts. Zero points would be used if no impact was anticipated; however, this was never the case for the spill scenarios considered.

The categories used in the impact scale are essentially descriptive and the relationship between them is nonlinear. The points assigned to them allow for the comparison of the overall consequences of different scenarios but do not reflect a specific, quantifiable relationship among the different categories. For example, it is meaningless, and in no way implied, that a *very high* impact to shorebirds, for example, which would be five points, is "five times worse than" a *very low* impact (one point).

A similar scale was used by The Glosten Associates (Glosten and ERC, 2012) and used in their initial presentation of the scenarios generated by the Spill Baseline and Causality Study. The scales were used to rate the relative impacts by season (including ice), location, oil type, and spill volume. The point system used in the study were based on the length of time impact to recovery that would be anticipated for ecosystems and wildlife species, the degree of impact with respect to populations and ecosystems, the general area of coverage of those impacts, and whether or not threatened or special-management species were significantly impacted.

The Aleutian Islands Risk Assessment, generally concurrent with the Cook Inlet Risk Assessment, used a 1-5 scale with points from 1-5 assigned. In this latter example, different scales were developed for each type of receptor and then combined (ERM and DNV, 2011). At the Consequence Analysis Workshop, experts used a combination of these approaches: they used a generic scale of descriptive categories that could be applied across the environmental receptors being considered and including points from 1-5 assigned to the five categories ranging from very low to very high.

The five categories in the environmental impact scale describe environmental impacts based on three generic elements: (1) the duration of impact, (2) size of the area affected, and (3) expected time it will take for recovery of the affected population or ecosystem. As shown in Table 14, these elements are distributed across the five categories as follows:

- **Duration of impact:** Shorter term (< 2 years), Moderate term (2-5 years), and Long term (> 5 years)
- **Size of area affected:** Specific areas (localized area in which species nest, gather, or otherwise are known to concentrate either year-round or seasonally), Small parts of Cook Inlet (<15% of one Cook Inlet operating area), Large part of Cook Inlet (>15% of one Cook Inlet operating area) or Alaskan waters outside Cook Inlet.
- **Time for population/ecosystem recovery:** Less than 2 years, 2-5 years, and more than 5 years.

The 1-5 scale was proposed to the group of subject matter experts and discussed and agreed to at the Consequence Analysis Workshop.

The only change that the subject matter experts made to the proposed scale was to refine the definition of "smaller" parts of Cook Inlet when referring to the size of the area affected. They agreed that the term "smaller parts" of Cook Inlet would be applied if less than 15% of one of the three Cook Inlet operating areas was affected. This change is included in the summary of the point scale used to assign environmental impacts shown in Table 14.

Table 14. Point scale used to assign environmental impacts

IMPACT	POINTS	DESCRIPTION OF ENVIRONMENTAL IMPACTS
Very Low	**1**	Significant shorter-term impacts (< 2 years) to smaller parts (< 15% of a Cook Inlet operating area) of Cook Inlet or low impacts to larger areas of the Inlet. Recovery of populations and ecosystems in less than 2 years.
Low	**2**	Significant shorter-term impacts (< 2 years) to a large part of Cook Inlet or moderate impacts to specific areas of the Inlet. Recovery of populations and ecosystems in less than 2 years.
Moderate	**3**	Moderate-term impacts (2 - 5 yrs.) anticipated over smaller part of Cook Inlet (< 15% of a Cook Inlet operating area) or significant (high) impacts to specific areas of Inlet. Recovery of populations and ecosystems in 2 to 5 years.
High	**4**	Moderate-term impacts (2 - 5 yrs.) anticipated over large part of Cook Inlet or very significant (high) impacts to specific areas of Inlet. Recovery of populations and ecosystems in 2 - 5 years.
Very High	**5**	Long-term impacts (>5 yrs.) anticipated over large part of Cook Inlet and potentially in other areas of Alaskan waters and coastal areas and/or significant impacts to threatened species or species indicated for special management. Recovery of populations and ecosystems will take > 5 years and/or threatened or special-management species will be very significantly impacted at population level.

6.3 Defining the Socioeconomic Impact Scale

The subject matter experts also used an interval scale of five categories to describe the impacts to socioeconomic receptors for each scenario. The scale represents a nonlinear set of categories, which are each described by both a term and a point value, as was the case with the environmental impacts.

The elements of the socioeconomic impact scale are based largely on the availability of the resource and alternatives (for example, whether a resource targeted by a fishery is present, or whether there are alternative sources of a particular species harvested for subsistence uses), the effects on people and portion of the population affected, and the time expected until recovery. As shown in Table 15, these elements are distributed across the five categories as follows:

- **Availability of resources/alternatives:** Resources are common and alternatives are available; Resources are regionally significant and alternatives are not feasibly available; Resources are of national value and alternatives are not available.
- **Population affected:** Small portion of population affected; Large numbers of people affected; and Sensitive economies/communities are totally reliant.
- **Time expected until recovery:** 1-2 months; 6 months – 1 year; greater than one year.

This scale was modified from the one used in the AIRA analysis (ERM and DNV, 2011). The scale descriptions developed for the AIRA analysis were tailored to regionally specific concerns, so not all of the socioeconomic factors fit well with the Cook Inlet region's socioeconomic concerns. Subject matter experts at the Consequence Analysis Workshop for Cook Inlet accepted the proposed scale and general descriptions found in Table 15.

Table 15. Point scale used to assign socioeconomic impacts

IMPACT	POINTS	DESCRIPTION OF SOCIOECONOMIC IMPACTS
Very Low	**1**	No specific socioeconomic activity other than communications.
Low	**2**	Resource is locally important but widespread and common. Alternatives are available. Small proportion of population reliant on affected resources. Recovery likely to be complete and effective within 1 to 2 months. Effects on people will be localized and short-lived.
Moderate	**3**	Resource is regionally significant, widespread but relatively high value. Alternative not feasibly available. Recovery likely to be complete and effective within 6 months to 1 year.
High	**4**	Resources are of high (national) value and not widely distributed. Alternatives are not available and large numbers of people are reliant. Recovery likely to be greater than 1 year.
Very High	**5**	Resources are of national value upon which very sensitive economies and communities are totally reliant. Impacts are likely to be difficult to mitigate.

6.4 Preliminary Analysis of Scenarios

Subject matter experts also considered a preliminary analysis of each spill based on oil type (toxicity and persistence) and the size of the spill (spill area and volume remaining on water at 72 hours[20]) when applying the 1-5 impact scale to the environmental and socioeconomic receptors in each scenario. The preliminary analysis is described here.

Nuka Research applied the ROC to each of the spill scenarios to provide a preliminary characterization of the total area likely to be impacted and the spill volume at 72 hours. The results are shown in Table 16.

Table 16. Preliminary characterizations of spill scenarios based on ROC

SCENARIO	SPILL VOLUME REMAINING ON WATER (BBL @ 72 HRS.)	SPILL AREA (SQ. MI. @ 72 HRS.)

[20] Need footnote here.

#1 (30,000 bbl crude at Drift River in July)	17,773	7
#2 (1,000 bbl diesel at Nikiski in November)	676	3
#3 (48,000 bbl Jet A at Knik Shoal in June)	11,153	11
#4 (1,000 bbl HFO at Anchorage in February)	951	2
#5 (20,000 bbl No. 2 fuel oil at Barrens in May)	18,033	6
#6 (100 bbl diesel at Homer in July)	49	0.9
#7 (1,000 bbl crude at Anchor Point in September)	561	4

6.5 Calculating Preliminary Spill Severity

The ROC outputs were scaled to a 1-5 ranking to create an Area Scale and Volume Scale. The Area Scale and Volume Scale were then combined with the scores assigned in the Spill Baseline and Accident Causality Study to create a combined scale, or preliminary ranking of the scenarios based on oil type (for persistence and toxicity), area covered, and volume. This Combined Scale was based on adding the Area Scale and Volume Scale values and normalizing the results to a maximum of five and minimum of zero in order to stay within the general context of the 1-5 scale being used (See Table 17).

Table 17. Preliminary scoring of scenarios for toxicity and persistence (based on Glosten and ERC, 2012), scales for area and volume (based on ROC), and a preliminary combined scale and ranking

SCENARIO	TOXICITY	PERSISTENCE	AREA SCALE (BASED ON ABOVE)	VOLUME SCALE (BASED ON ABOVE)	COMBINED SCALE	RANK
#1 (30,000 bbl crude at Drift River in July)	3	4	3.18	4.93	4.59	2
#2 (1,000 bbl diesel at Nikiski in November)	5	3	1.36	0.19	0.09	6
#3 (48,000 bbl Jet A at Knik Shoal in June)	4	2	5	3.09	3.02	3
#4 (1,000 bbl HFO at Anchorage in February)	2	5	0.91	0.26	0.06	5
#5 (20,000 bbl No. 2 fuel oil at Barrens in May)	5	3	2.73	5	5	1
#6 (100 bbl diesel at Homer in July)	5	3	0.41	0.01	0	7
#7 (1,000 bbl crude at Anchor Point in September)	5	5	1.82	0.16	0.18	4

7. SCENARIOS #1-7 AND IMPACT SCORES ASSIGNED

This section provides an overview of each scenario and the impact scores assigned for both biological and socioeconomic receptors for that scenario. Appendix D shows the scores for each scenario in one table to facilitate comparison.

As a group, the subject matter experts consulted several key references when considering the potential spill impacts. Individuals also drew on their past experiences and knowledge, and may have consulted other resources as well. The references consulted by the group of experts include:

- **Environmental Sensitivity Index (ESI) maps.** The National Oceanographic and Atmospheric Administration (NOAA) produces these maps showing the coastal resources that are at risk in an oil spill. The maps are color-coded to show the relative sensitivity to oil of different species or populations, and are also produced for different seasons, as well as ta classification of shoreline type.

- **Cook Inlet Response Tool (CIRT).** The Cook Inlet RCAC has commissioned the development of a data integration and visualization product being developed with the Alaska Ocean Observing System (AOOS) and NOAA. The tool incorporates Geographic Information Systems (GIS) spatial data layers; real time observations; model and forecasted winds, waves, and ocean circulation; and ShoreZone video and imagery. A beta version of the program was used during the workshop.

- **Marine Ice Atlas for Cook Inlet, Alaska.** The U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory (CRREL) and the University of Alaska Anchorage (UAA) collaborated on this 2001 report documenting the type, location, and movement of ice typical to Cook Inlet. (Whether or not ice is present will play a role in determining which shoreline areas are impacted).

- **ShoreZone.** The Alaska ShoreZone Coastal Inventory and Mapping Project has both imagery and habitat and biological resource data for the Cook Inlet coastline available at: http://conserveonline.org/workspaces/shorezone/ and on NOAA's website at: http://mapping.fakr.noaa.gov/szflex/.

- **Technical papers related to subsistence use in Cook Inlet.**
  - Technical Paper 32: "Natural Resource Harvests at Port Graham and English Bay: An Interim Report." Ron Stanek, 1982.
  - Technical Paper 34: "Subsistence Shellfish Uses in Three Cook Inlet Villages." Stanek et al., 1982.
  - Technical Paper 104: "Patterns of Wild Resource Use in English Bay and Port Graham, Alaska." Ron Stanek, 1985.
  - Technical Paper 105: "The Use of Fish and Wild Resources in Tyonek, Alaska." Fall et al., 1984.
  - Technical Paper 232: "The Subsistence Use of Beluga Whale in Cook Inlet by Alaska Natives, 1993." Ron Stanek, 1994.
  - Technical Paper 252: "Subsistence Harvest and Uses in Eight Communities Ten Years After the 'Exxon Valdez' Oil Spill." Fall et al., 1999.

7.1 Scenario #1

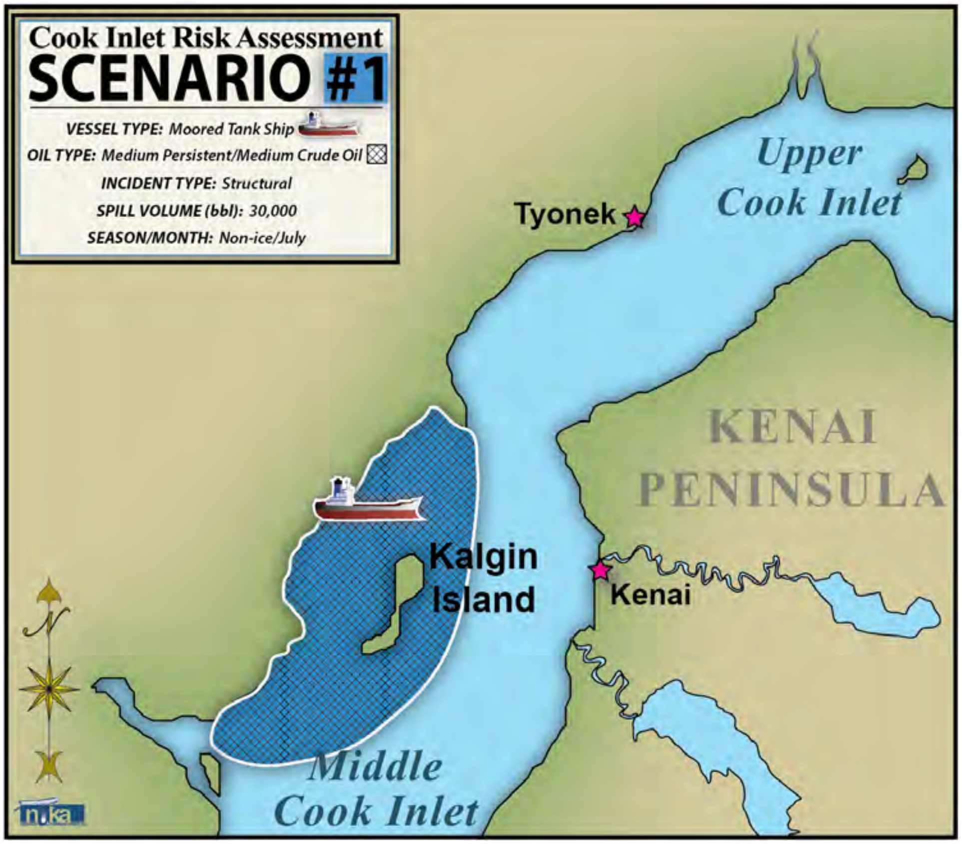

Figure 14. Scenario #1 footprint

Figure 14 summarizes Scenario #1; the tables below show the impact scores assigned by subject matter experts at the workshop. Scenario #1 is a crude oil spill from a moored tank ship at Drift River. A structural incident results in the release of 30,000 bbl of oil during the month of July (no ice present).

Table 18. Socioeconomic Receptor Scores for Scenario #1

Subsistence	Commercial Fishing	Recreational/ Tourism	General Commerce	Oil Industry
4	5	3	1	4

Table 19. Environmental Receptor Scores for Scenario #1

Habitat			Fish		Birds			Mammals			
Pelagic	Littoral	Benthic	Fin Fish	Shellfish	Waterfowl	Seabirds	Shorebirds	Sea Otters	Pinnipeds	Whales	Terrestrial
2	4	2	3	4	4	4	5	1	4	4	3

7.2 Scenario #2

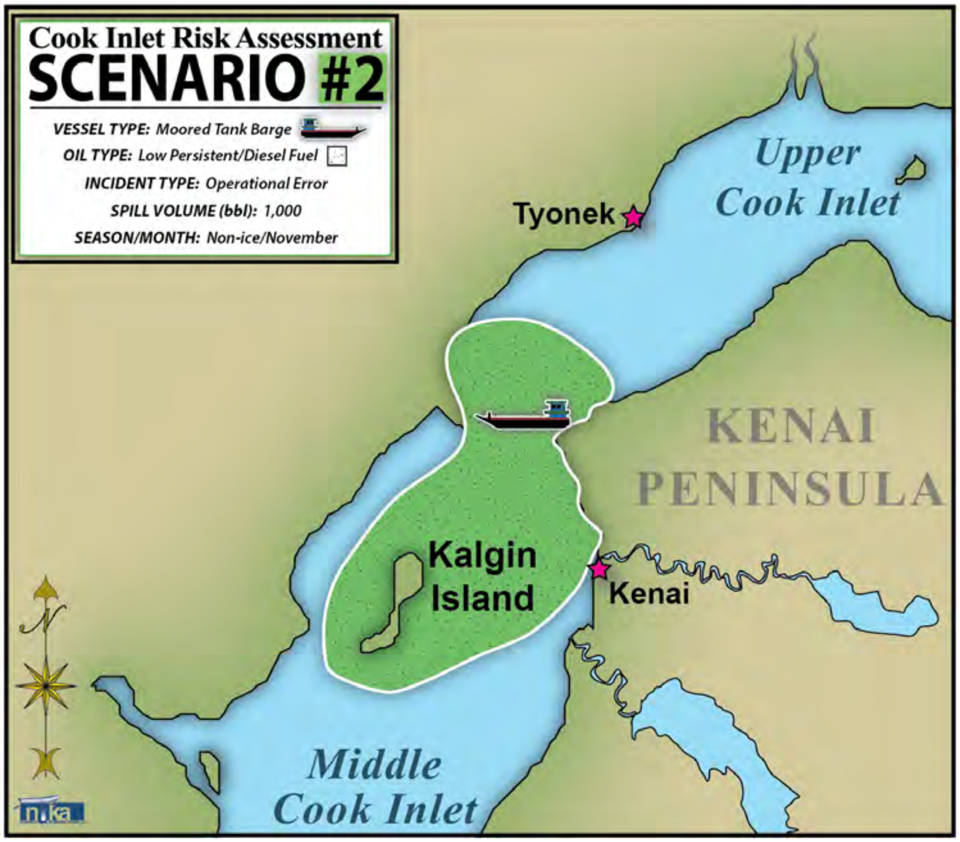

Figure 15. Scenario #2 footprint

Figure 15 summarizes Scenario #2; the tables below show the impact scores assigned by subject matter experts at the workshop. Scenario #2 is a diesel fuel spill from a tank barge moored at Nikiski. An operational error results in the release of 1,000 bbl of oil during the month of November (no ice present).

Table 20. Socioeconomic Receptor Scores for Scenario #2

Subsistence	Commercial Fishing	Recreational/ Tourism	General Commerce	Oil Industry
1	1	1	1	2

Table 21. Environmental Receptor Scores for Scenario #2

Habitat			Fish		Birds			Mammals			
Pelagic	Littoral	Benthic	Fin Fish	Shellfish	Waterfowl	Seabirds	Shorebirds	Sea Otters	Pinnipeds	Whales	Terrestrial
2	1	1	1	1	1	1	1	0	1	3	1

7.3 Scenario #3

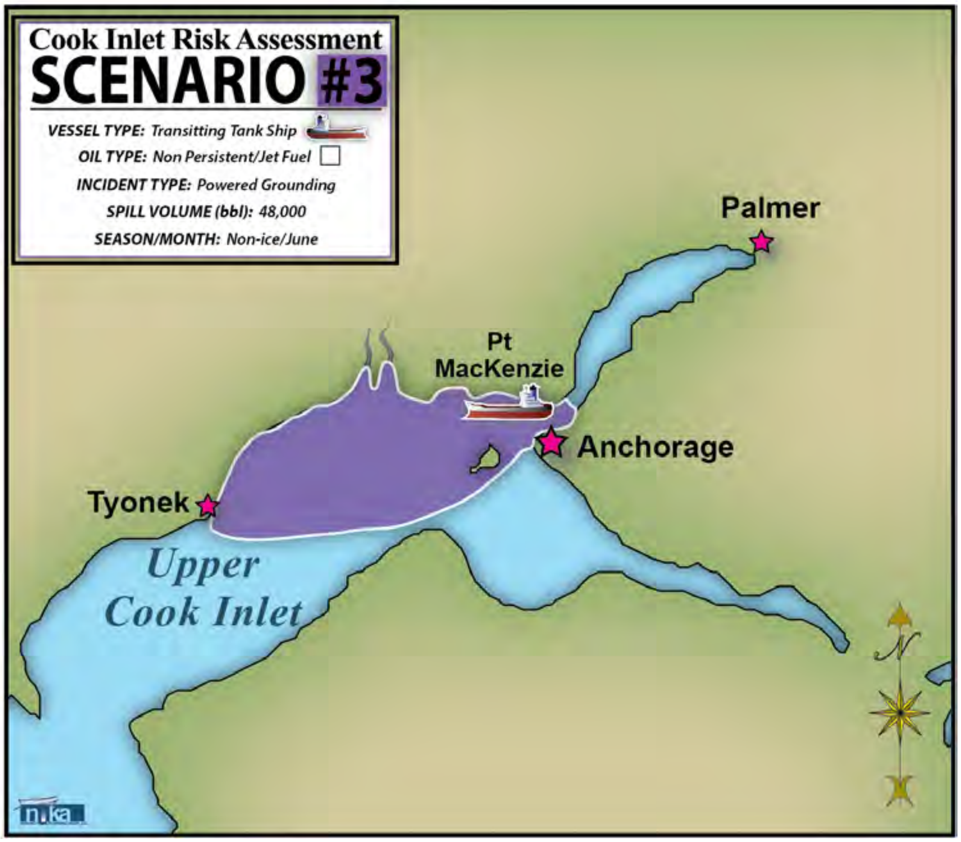

Figure 16. Scenario #3 footprint

Figure 16 summarizes Scenario #3; the tables below show the impact scores assigned by subject matter experts at the workshop. Scenario #3 is a jet fuel spill from a tank ship in transit near Knik Shoal. A powered grounding results in the release of 48,000 bbl of jet fuel during the month of June (no ice present).

Table 22. Socioeconomic Receptor Scores for Scenario #3

Subsistence	Commercial Fishing	Recreational/ Tourism	General Commerce	Oil Industry
2	2	2	1	1

Table 23. Environmental Receptor Scores for Scenario #3

Habitat			Fish		Birds			Mammals			
Pelagic	Littoral	Benthic	Fin Fish	Shellfish	Waterfowl	Seabirds	Shorebirds	Sea Otters	Pinnipeds	Whales	Terrestrial
2	2	1	4	3	2	2	3	0	2	5	1

7.4 Scenario #4

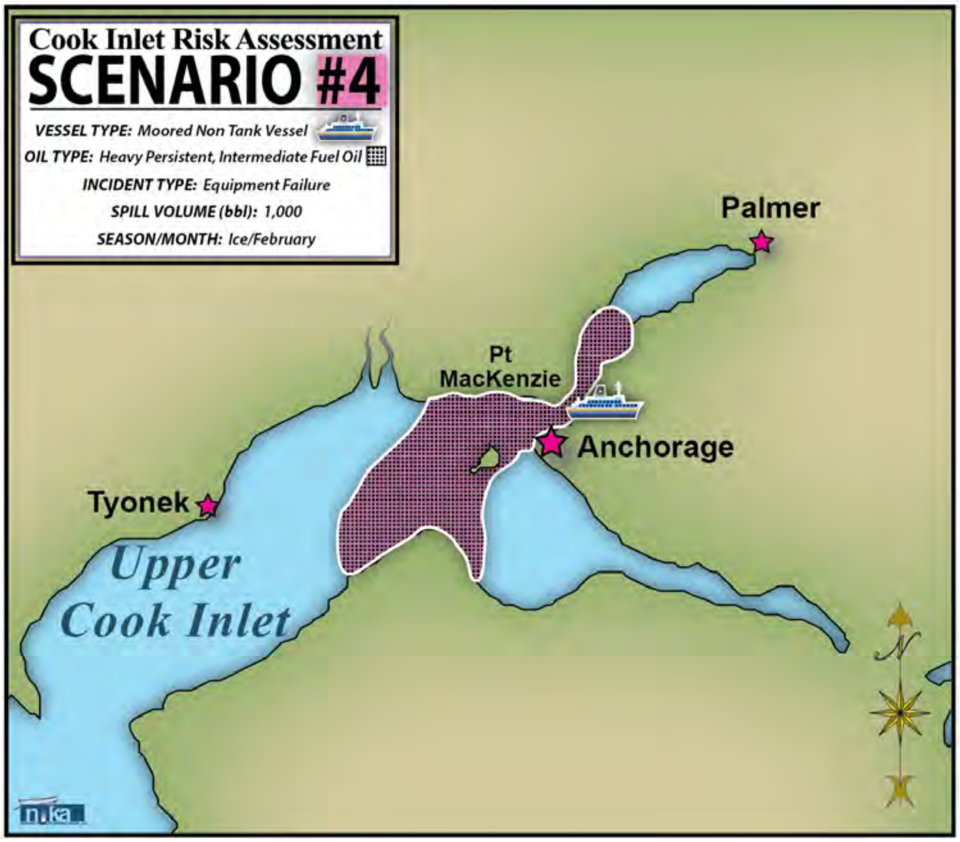

Figure 17. Scenario #4 footprint

Figure 17 summarizes Scenario #4; the tables below show the impact scores assigned by subject matter experts at the workshop. Scenario #4 is an intermediate fuel oil spill from a non-tank vessel moored at the Port of Anchorage. An equipment failure results in the release of 1,000 bbl of oil during the month of February (ice present).

Table 24. Socioeconomic Receptor Scores for Scenario #4

Subsistence	Commercial Fishing	Recreational/ Tourism	General Commerce	Oil Industry
1	1	1	3	0

Table 25. Environmental Receptor Scores for Scenario #4

Habitat			Fish		Birds			Mammals			
Pelagic	Littoral	Benthic	Fin Fish	Shellfish	Waterfowl	Seabirds	Shorebirds	Sea Otters	Pinnipeds	Whales	Terrestrial
1	1	1	1	1	1	1	1	0	1	2	1

7.5 Scenario #5

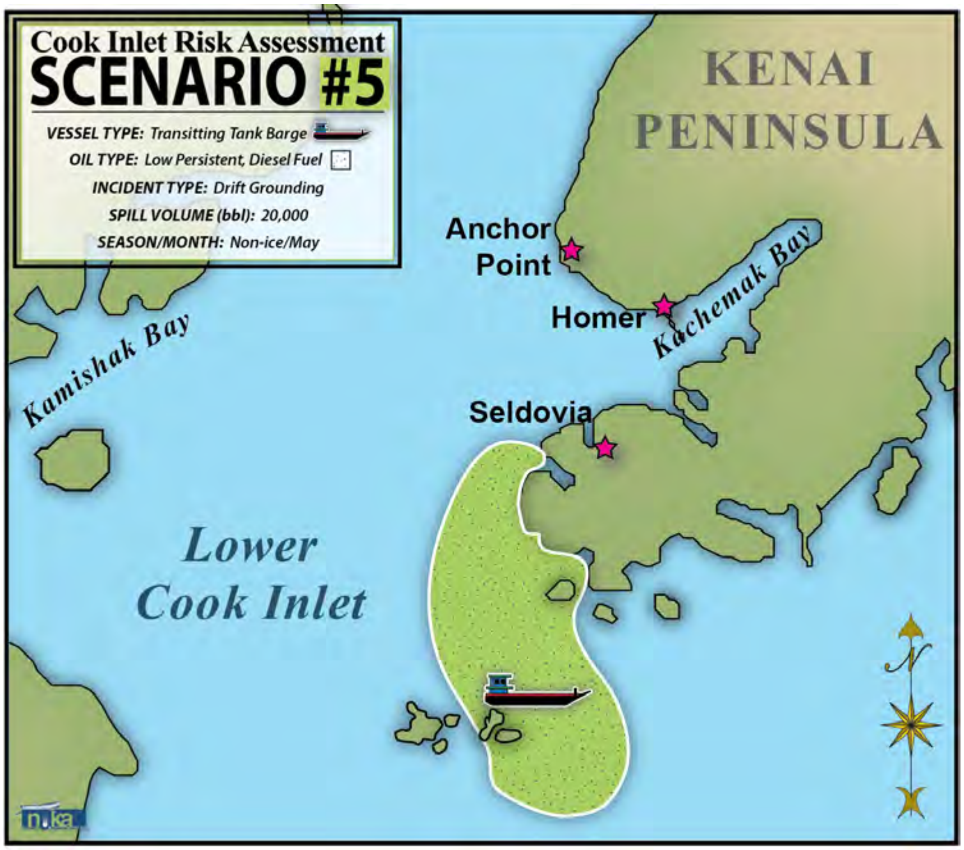

Figure 18 summarizes Scenario #5; the tables below show the impact scores assigned by subject matter experts at the workshop. Scenario #5 is a diesel fuel spill from a tank barge in the Barren Islands. A drift grounding results in the release of 20,000 bbl of oil in the month of May (no ice present).

Figure 18. Scenario #5 footprint

Table 26. Socioeconomic Receptor Scores for Scenario #5

Subsistence	Commercial Fishing	Recreational/ Tourism	General Commerce	Oil Industry
5	2	2	2	0

Table 27. Environmental Receptor Scores for Scenario #5

Habitat			Fish		Birds			Mammals			
Pelagic	Littoral	Benthic	Fin Fish	Shellfish	Waterfowl	Seabirds	Shorebirds	Sea Otters	Pinnipeds	Whales	Terrestrial
2	3	1	3	2	2	5	3	4	3	3	2

7.6 Scenario #6

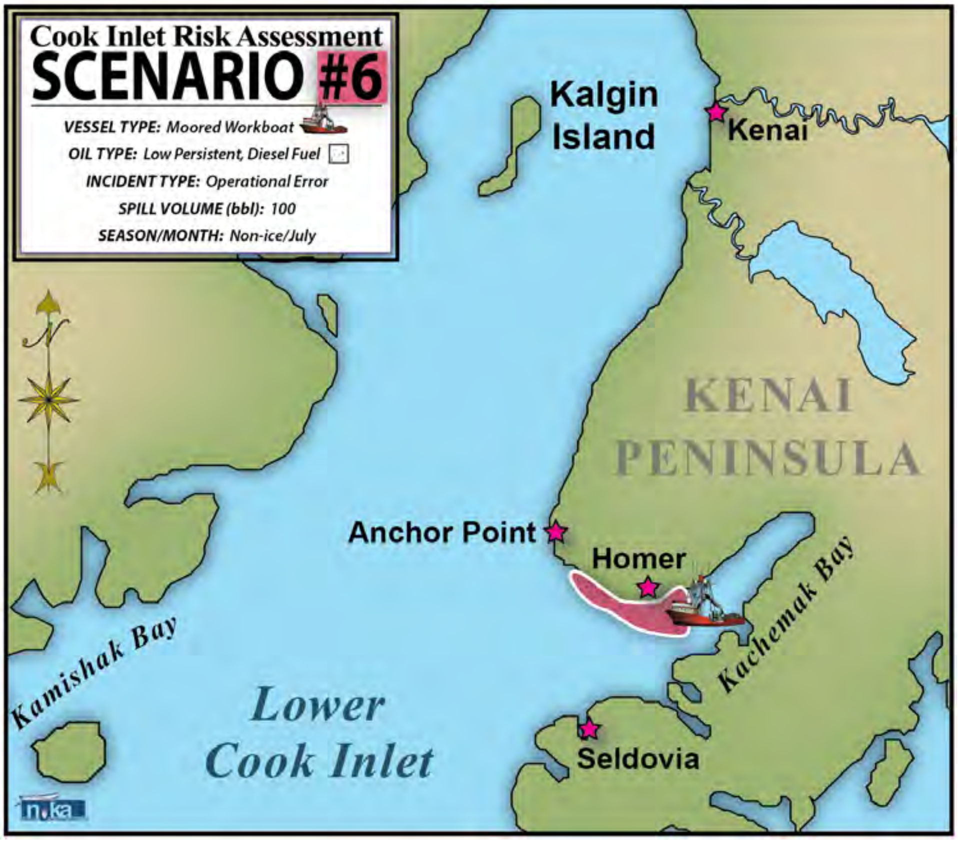

Figure 19. Scenario #6 footprint

Figure 19 summarizes Scenario #6; the tables below show the impact scores assigned by subject matter experts at the workshop. Scenario #6 is a diesel fuel spill from a moored workboat at the Port of Homer. An operational error results in the release of 100 bbl of spilled oil during the month of July (no ice present).

Table 28. Socioeconomic Receptor Scores for Scenario #6

Subsistence	Commercial Fishing	Recreational/ Tourism	General Commerce	Oil Industry
1	3	3	2	0

Table 29. Environmental Receptor Scores for Scenario #6

Habitat			Fish		Birds			Mammals			
Pelagic	Littoral	Benthic	Fin Fish	Shellfish	Waterfowl	Seabirds	Shorebirds	Sea Otters	Pinnipeds	Whales	Terrestrial
1	2	1	1	1	1	3	2	2	2	1	2

7.7 Scenario #7

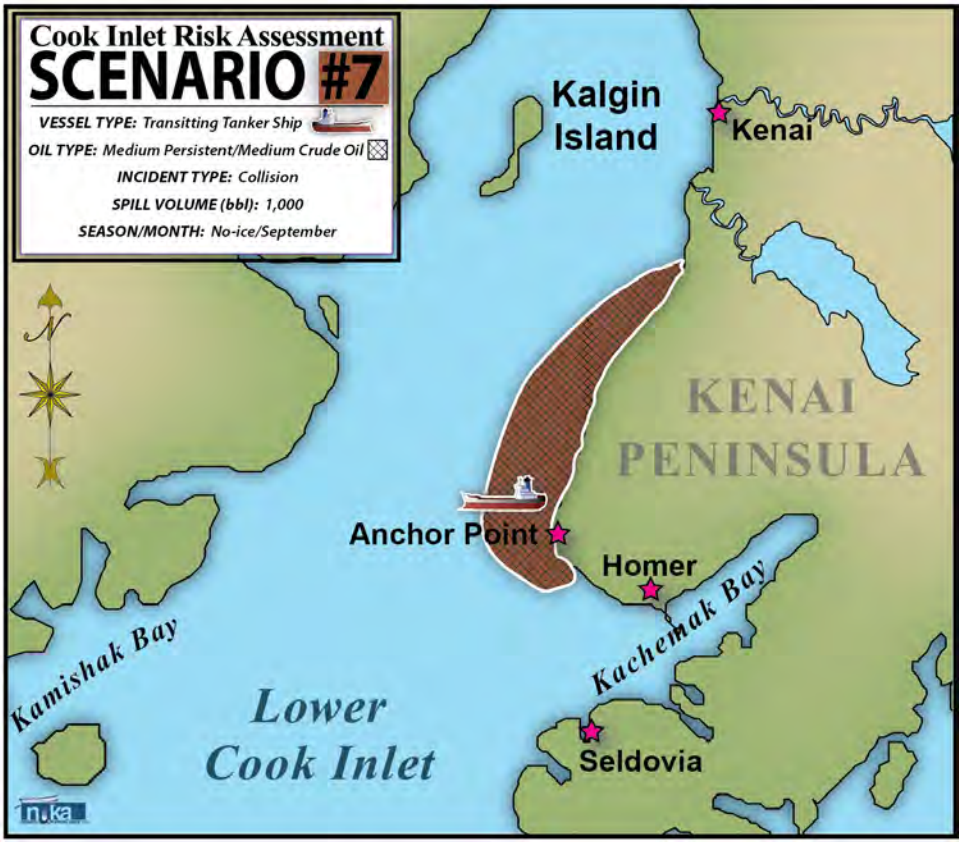

Figure 20. Scenario #7 footprint

Figure 20 summarizes Scenario #7; the tables below show the impact scores assigned by subject matter experts at the workshop. Scenario #7 is a crude oil spill from a tank ship in transit near Anchor Point. A collision results in the release of 1,000 bbl of spilled oil during the month of September (no ice present).

Table 30. Socioeconomic Receptor Scores for Scenario #7

Subsistence	Commercial Fishing	Recreational/ Tourism	General Commerce	Oil Industry
3	1	3	1	1

Table 31. Environmental Receptor Scores for Scenario #7

Habitat			Fish		Birds			Mammals			
Pelagic	Littoral	Benthic	Fin Fish	Shellfish	Waterfowl	Seabirds	Shorebirds	Sea Otters	Pinnipeds	Whales	Terrestrial
2	3	2	2	4	5	2	2	2	1	1	1

8. DISCUSSION

8.1 Comparison of Scenario Consequences

A key purpose in assigning points to the categories in the impact scales used is to allow for comparison of the anticipated consequences from each scenario. Table 32 shows the average and maximum assigned scores for each scenario's 12 environmental and five socioeconomic factors. The ranking shown in the right-hand columns (one for environmental factors and one for socioeconomic factors) represents the ranking of the scenarios where one is the scenario with the greatest consequences in that category. When environmental and socioeconomic factors are considered entirely separately, the ranking of the scenarios varies only slightly, primarily due to the fact that Scenario #3 and Scenario #7 are expected to result in slightly greater environmental impacts than socioeconomic ones.

Table 32. Summary of scenario ranking by environmental and socioeconomic factors based on subject matter expert input

Scenario	Environmental Factors			Socioeconomic Factors		
	Average	**Max**	**Rank**	**Average**	**Max**	**Rank**
1	3.33	5	1	3.40	5	1
2	1.17	3	6	1.20	2	6
3	2.25	5	3	1.60	2	5
4	1.00	2	7	1.20	3	6
5	2.75	5	2	2.20	5	2
6	1.58	3	5	1.80	3	3
7	2.25	5	3	1.80	3	3

Of course, environmental and socioeconomic consequences do not exist in separate spheres, so it is instructive to combine them and develop an overall ranking of the scenarios. Table 33 shows the average score assigned to each scenario across all receptors, essentially giving greater weight to environmental factors because there are 12 of them and only 5 socioeconomic factors (Column A); the average score for the scenario if the average scores for environmental and socioeconomic receptors are *then* averaged, which treats environmental and socioeconomic factors equally (Column B); the highest score assigned to a scenario across all factors (Column C), and the ranking of the scenarios, which is the same regardless of the treatment given in Columns A-C (Column D). These scores are all based on the input provided by the subject matter experts. (Note that in the ranking, one represents the spill with the *worst* consequences, as opposed to the scores used in the 1-5 consequence scales where a score of five is used for the worst impacts.)

Table 33. Ranking scenario consequences based on subject matter expert input (1 = worst impact)

Scenario	Scores Assigned by Experts at Workshop			
	Column A	**Column B**	**Column C**	**Column D**
	Average: Each Factor Equal	**Average: Env'l and Socio Equal**	**Highest Score (Env'l or Socio)**	**Ranking** (1= worst impact)
#1 *(30,000 bbl crude at Drift River in July)*	3.35	3.37	5	1
#2 *(1,000 bbl diesel at Nikiski in November)*	1.18	1.18	3	6
#3 (48,000 bbl Jet A at Knik Shoal in June)	2.06	1.93	5	4
#4 *(1,000 bbl HFO at Anchorage in February)*	1.06	1.10	3	7
#5 *(20,000 bbl No. 2 fuel oil at Barrens in May)*	2.59	2.48	5	2
#6 *(100 bbl diesel at Homer in July)*	1.65	1.69	3	5
#7 *(1,000 bbl crude at Anchor Point in September)*	2.12	2.03	5	3

There are differences in the rankings that resulted from the subject matter experts' input and the preliminary analysis based on modeling, but there are still four scenarios that appear to be the most likely to result in the greatest impacts: Scenarios #1, #3, #5, and #7. In the preliminary analysis, Scenario #5 (20,000 bbl of No. 2 fuel oil at the Barrens) was expected to have the most significant consequences, followed by Scenario #1 (30,000 bbl of crude at Drift River) and Scenario #3 (48,000 bbl of Jet A at Knik Shoal). When subject matter experts considered the list of environmental and socioeconomic receptors, Scenario #1 emerged with the greatest consequences, followed by Scenario #5 and Scenario #7 (1,000 bbl of crude at Anchor Point). Scenarios #1 and #5 were anticipated to have the greatest impacts in both the preliminary analysis and based on the subject matter experts' input at the Workshop, likely due to the persistence of the oil spilled and the relatively large size of the spills in these scenarios.

While Scenario #4 (1,000 bbl HFO at Anchorage in February) has the least consequences of all the chosen scenarios, the Experts noted that this persistent oil product would likely not be recovered and could present unknown consequences during the spring break of the ice pack.

Table 34 shows both the scenario ranking that resulted from the subject matter experts' input at the Consequence Analysis Workshop and the scenario ranking that was assigned to the scenarios from the *preliminary* analysis, which considered only the scenarios' spill volume, spill area, toxicity, and persistence. The input elicited from the experts took into consideration a wider range of factors than those in the preliminary analysis, including which resources would be present during certain seasons, the influence of Cook Inlet oceanography that is not included in spill trajectory models, and whether not ice would be present.

Table 34. Comparison of rankings from subject matter expert input at Workshop and preliminary analysis (1= worst impact)

Scenario	Ranking Based on Subject Matter Expert Input	Ranking based on Preliminary Analysis[21]
#1 *(30,000 bbl crude at Drift River in July)*	1	2
#2 *(1,000 bbl diesel at Nikiski in November)*	6	5
#3 (48,000 bbl Jet A at Knik Shoal in June)	4	3
#4 *(1,000 bbl HFO at Anchorage in February)*	7	6
#5 *(20,000 bbl No. 2 fuel oil at Barrens in May)*	2	1
#6 *(100 bbl diesel at Homer in July)*	5	7
#7 *(1,000 bbl crude at Anchor Point in September)*	3	4

[21] Based on information for spill volume, area covered, toxicity, and persistence based on Combined Scale shown in Table 16.

8.2 Conclusion

When considering the full range of potential direct impacts from an oil spill to Cook Inlet, it is clear that even relatively small spills may have significant negative impact, as with the 100 bbl diesel spill in Scenario #6 to which experts gave a mid-level impact score of '3' for Commercial Fishing and Recreation/Tourism. Each of the scenarios considered resulted in a significant (maximum score of three or above) impact to at least one of the receptors considered. Four of the seven scenarios resulted in a major impact (maximum score of five) to at least one of the receptors considered.

When considering the scenario outputs, it is important to note that they were chosen based on relative likelihood of occurrence, as compared to the potential high consequence/low probability spill such as a worst-case discharge. The conclusion of the results from workshop is that any of the spills considered would have significant impacts to the environment and socioeconomics of Cook Inlet. All areas of Cook Inlet are vulnerable to significant consequences from marine oil spills of any type in all seasons.

Transferring risk from one area to another would have little or no benefits in terms of potential consequences. Transferring risks between spring, summer, or fall would have no benefits in terms of potential consequences. Transferring risks from spring, summer, or fall to winter could potentially reduce *immediate* biological and socioeconomic consequences if ice "protects" the shoreline at the time of the spill, but there remains potential for impacts the following spring when the ice melts and spilled oil that is contained within it is released to the surrounding waters.

When considering Risk Reduction Options, the Advisory Panel should focus on measures with the potential to reduce oil outflows and/or quickly contain and remove the oil outflow. Reducing potential spill volume, particularly of persistent oil, will minimize consequences to the greatest extent.

8.3 Next Steps for Cook Inlet Risk Assessment

The next steps in the Cook Inlet Risk Assessment are to elicit recommended risk reduction options (RRO) to mitigate the risk of oil spills from vessels in Cook Inlet. These options will be considered by the Advisory Panel based on a preliminary assessment of their feasibility, cost, effectiveness, and the extent to which they would reduce the likelihood of consequences such as the ones discussed in this report. For priority RRO, the Analysis Team and Management Team will commission a more detailed study in order to develop their final recommendations at the conclusion of the project.

References

Alaska Department of Environmental Conservation . (2004). *The State of Alaska's "zero tolerance" regulations for preventing oil contamination of seafood products* (Fact Sheet). Retrieved from ADEC website: http://www.state.ak.us/local/ akpages/ ENV.CONSERV/spar/perp/response/ sum_fy05/041207201/fact/ 041207201_fact_zero.pdf

Alaska Department of Fish and Game. (2012a). *Cook Inlet area fishing information.* Retrieved from ADFG website: http://www.adfg.alaska.gov/index.cfm?adfg=ByAreaSubsistenceCookInlet.fishingInfo

Alaska Department of Fish and Game. (2012b). *Cook Inlet salmon fisheries: Salmon fishery harvest and effort estimates (sockeye salmon harvest).* Retrieved from ADFG website: http://www.adfg.alaska.gov/index.cfm?adfg=PersonalUsebyAreaSouthcentralKenaiSalmon.harvest

Alaska Department of Fish and Game. (2012c). *Cook Inlet personal use clam fishery: Overview.* Retrieved from ADFG website: http://www.adfg.alaska.gov/index.cfm?adfg=PersonalUsebyAreaSouthcentralCookInletClams.main

Alaska Department of Fish and Game. (2013). *Fish species information: Pacific sand lance.* Retrieved from ADFG website: http://www.adfg.alaska.gov/index.cfm?ADFG=animals.listfish

Southwick Associates, Inc. and Romberg, W.J., Bingham, A.E., Jennings, G.B., & Clark, R.A. (Rev. Ed). (2007). *Economic impacts and contributions of sportfishing in Alaska.* Retrieved from the ADFG website: http://www.adfg.alaska.gov/FedAidpdfs/PP08-01.pdf

Alaska Department of Fish and Game. (2006). *Our wealth maintained: A strategy for conserving Alaska's diverse wildlife and fish resources.* Retrieved from ADFG website: http://www.adfg.alaska.gov/static/species/wildlife_action_plan/cwcs_main_text_combined.pdf

Alaska Department of Natural Resources. (2009). *Cook Inlet area wide oil and gas lease sale: Final finding of the director.* Retrieved from: http://dog.dnr.alaska.gov/Publications/CookInlet.htm

Alaska Regional Response Team. (2010). *Cook Inlet subarea contingency plan.* Retrieved from ADEC website: http://dec.alaska.gov/spar/perp/plans/scp_ci.htm

Allen, B.M. & Angliss, R.P. (2011). *Alaska marine mammal stock assessments. Alaska Fisheries Science Center* (NOAA Technical Memorandum NMFS-AFSC-206). Retrieved from NOAA website: http://www.nmfs.noaa.gov/pr/pdfs/sars/ak2009.pdf

Angliss, R.P. & Outlaw, R.B. (2006). *Beluga whale (Delphinapterus leucas): Cook Inlet stock* (NOAA Technical Memorandum NOAA-TM-AFSC-168). Retrieved from: http://www.nmfs.noaa.gov/pr/pdfs/sars/ak2006whbg-ci.pdf

Bureau of Land Management. (2006). *Ring of fire: Proposed resource management plan and final environmental impact statement*. Retrieved from BLM website: http://www.blm.gov/ak/st/en/prog/planning/ring_of_fire_plan/ring_of_fire_proposed.html

Cook Inlet Spill Prevention & Response, Inc. (2012). *CISPRI technical manual*. Nikiski, AK. Retrieved from CISPRI website: http://www.cispri.org/members/documents/01CISRPItm_cover.pdf

Clark, J.H., McGregor, A., Mecum, R.D., Krasnowski, P. & Caroll, A.M.. (2006). The commercial salmon fishery in Alaska. *Alaska Fishery Research Bulletin*, 12:1-146.

Cook Inlet RCAC. (2003). *Comments on Cook Inlet oil and gas lease sales 191 & 199, draft environmental impact statement* (OCS EIS/EA MMS 2002-2006). Letter to John Goll, Minerals Management Service from James E. Carter, Cook Inlet RCAC. February 10.

Cooke, R.M. (1991). *Experts in Uncertainty: Opinion and Subjective Probability in Science*. New York, NY: Oxford University Press.

Denlinger, L. (2006). *Alaska seabird information series*. Unpublished Report. Retrieved from US Fish & Wildlife Service website: http://alaska.fws.gov/mbsp/mbm/seabirds/pdf/asis_complete.pdf

Eley, D.W. (2012). *Cook Inlet vessel traffic study*. Retrieved from CIRA website: http://www.cookinletriskassessment.com/documents/120206CIVTSvFINAL.

ERM-West, Inc. & Det Norske Veritas (U.S.A.), Inc. (2011). *Consequence analysis report*. Retrieved from AIRA website: http://www.aleutiansriskassessment.com/documents/2011_7_7_AIRAPhaseACAReportFINALwCovLtr.pdf

Environmental Protection Agency, Office of Emergency and Remedial Response.. (1999). *Understanding oil spills and oil spill response*. Retrieved from EPA website: http://www.epa.gov/osweroe1/content/learning/pdfbook.htm Washington, DC: Author.

Fall, J.A. (1999). *Restoration notebook: Subsistence.* Retrieved from Exxon Valdez Oil Spill Trustee Council website: http://www.evostc.state.ak.us/Universal/Documents/Publications/RestorationNotebook/RN_subsist.pdf

Gill, R.E., Jr. & Tibbitts, T.L.. (1999). *Seasonal shorebird use of intertidal habitats in Alaska* (OCS Study MMS 99-0012). Retrieved from USDOI, USGS, MMS website : http://alaska.usgs.gov/science/biology/shorebirds/pdfs/GillTibbitts_Shorebird%20use%20CookInlet_MMS99

Hollowell, G., Otis, T., & Ford, E. (2012). *2011 Lower Cook Inlet area finfish management report* (Fishery Management Report No. 12-30). Retrieved from ADFG website: www.adfg.alaska.gov/FedAidpdfs/FMR12-30.pdf

Larned, W.W. (2006). *Winter distribution and abundance of Steller's eiders (Polysticta stelleri) in Cook Inlet, Alaska*, 2004-2005 (OCS Study, MMS 2006-066). Retrieved from U.S. Fish and Wildlife Service website: http://alaska.fws.gov/mbsp/mbm/waterfowl/surveys/pdf/cistei_report.pdf

Li, X., Li, C., Pichel, W.G., Clemente-Colón, P., & Friedman, K.S. (2005). Synthetic aperture. *IEEE Journal of Oceanic Engineering* 30(3): . 543-551.

McDowell Group. (2012). *Alaska visitor statistics program VI: Summer 2011.* Retrieved from Alaska Office of Tourism Development website: http://www.commerce.state.ak.us/ded/dev/toubus/research.

Mulherin, N.D., Tucker, W.B. Smith, O.P., Lee, W.J. (2001). *Marine ice atlas for Cook Inlet, Alaska* (TR-01-10). Retrieved from US Army Corps of Engineers website: http://www.crrel.usace.army.mil/library/technicalreports/TR-01-10.pdf

National Oceanic and Atmospheric Administration. (2002a). *Trajectory analysis handbook.* Retrieved from the NOAA website: response.restoration.noaa.gov /sites/default/files/Trajectory_Analysis_Handbook.pdf

National Oceanic and Atmospheric Administration. (2002b). *Environmentally sensitive index summary maps for Cook Inlet and Kenai Peninsula.* Retrieved from NOAA website: http://response.restoration.noaa.gov/sites/default/files/esimaps/gisdata/CookInlet_2002_Meta.pdf

National Oceanic and Atmospheric Administration. (2006). *Tidal station locations and ranges.* Retrieved from NOAA website: http://tidesandcurrents.noaa.gov/tides07/tab2wc2b.html#154

National Oceanic and Atmospheric Administration. (2008). *NOAA lists Cook Inlet Beluga whales as endangered*. Retrieved from: http://www.noaanews.noaa.gov/stories2008/20081017_belugawhale.html

National Oceanic and Atmospheric Administration. (2011). *Beluga whale critical habitat*. Retrieved from: http://www.nmfs.noaa.gov/pr/pdfs/criticalhabitat/belugawhale_cookinlet.pdf

National Oceanic and Atmospheric Administration. (2012). *Total IFQ landings & pounds by port for fishing year 2012 (halibut and sablefish)*. Retrieved from NOAA website: https://alaskafisheries.noaa.gov/ram/12ifqport.pdf

Nuka Research and Planning Group, LLC (Nuka Research). (2012). Cook Inlet Risk Assessment Advisory Panel meeting summary. August 23.

Okkonen, S.R. (2004). *Observations of hydrography and currents in Central Cook Inlet, Alaska during diurnal and semidiurnal tidal cycles* (OCS Study MMS 2004-058).. Retrieved from University of Alaska website: http://www.arlis.org/docs/vol1/70265562.pdf

Okkonen, S., Pegau, S. & Saupe, S., (2009). *Seasonality of boundary conditions for Cook Inlet, Alaska* (OCS Study MMS 2009-041). Retrieved from University of Alaska website: http://www.arlis.org/docs/vol1/C/505869646.pdf

Piatt, J.F. & Harding, A.M.A.. (2007). Population ecology of seabirds in Cook Inlet. In R. Spieds, (Ed.), *Long-term Ecological Change in the Northern Gulf of Alaska*. Amsterdam: Elsevier.

Picou, J.S., Formichella, C., Marshall, B.K., & Arata, C. (2009). Community impacts of *Exxon Valdez* oil spill: A synthesis of social science research (OCS Study Number 2009-006). In S. R. Braund and J. Kruse, (Eds.), *Synthesis: Three Decades of Research on Socioeconomic Effects Related to Offshore Petroleum Development in Coastal Alaska.*

Schoch, G.C. & Chenelot, H. (2004). The role of estuarine hydrodynamics in the distribution of kelp forests in Kachemak Bay, Alaska. *Journal of Coastal Research* 45: 179-195.

Shields, P., & Dupuis, A. (2012). *Upper Cook Inlet commercial fisheries annual management report, 2011* (Fishery Management Report No. 12-25). Retrieved from ADFG website: http://www.sf.adfg.state.ak.us/fedaidpdfs/FMR12-25.pdf

The Glosten Associates, Inc. & Environmental Research Consulting .(2012). *Spill baseline and accident causality study*. Retrieved from Nuka Research website: http://www.nukaresearch.com/projects/cira/documents/CIRC_Task4RiskAssessmentRptRev-.pdf

Transportation Research Board. (2008). *Risk of vessel accidents and spills in the Aleutian Islands: Designing a comprehensive risk assessment.* (Special Report 293). Retrieved from TRB website: http://onlinepubs.trb.org/onlinepubs/sr/sr293.pdf

Trowbridge, C.E., Russ, E. & Russ, C. (2011). *Annual management report for Pacific cod fisheries in the Prince William Sound and Cook Inlet management areas, 2010* (Fishery Management Report No. 11-47). Retrieved from ADFG website: http://www.adfg.alaska.gov/FedAidPDFs/FMR11-47.pdf

U.S. Fish and Wildlife Service. (2012). *Threatened and endangered species: Northern sea otter (Southwest Alaska Distinct Population Segment)* (Fact Sheet). Retrieved from US Fish & Wildlife website: http://alaska.fws.gov/fisheries/endangered/pdf/Nseaotter_factsheet_v2.pdf

U.S. Geological Survey. (2013). *Winter ecology of Rock Sandpipers*. Retrieved from USGS website: http://alaska.usgs.gov/science/biology/shorebirds/rosa_winter_ecology.html

Whitney, J. S. (2002). *Cook Inlet, Alaska: oceanographic and ice conditions and NOAA's 18-year oil spill response history 1984-2001,* (HAZMAT report 2003-01). Anchorage, Alaska: National Ocean Service, Hazardous Materials Response and Assessment Division. TD427.P4 W61 2002

This page is intentionally blank.

Appendix A: Subject Matter Expert Bios

Catherine Berg, Regional Spill Response Coordinator, U.S. Fish and Wildlife Service. Catherine has worked for the U.S. Fish and Wildlife Service in Alaska for 26 years. Her current position as the Regional Spill Response Coordinator with Division of Environmental Contaminants combines her extensive experience in Alaska sub-area contingency planning with her considerable endangered species background. Catherine is involved at the Advisory Panel level in both the Aleutian Islands Risk Assessment and the Cook Inlet Risk Assessment.

Jim Butler, Advisory Panel Fishing, Baldwin & Butler LLC. A 34-year resident of the Cook Inlet area, Jim is a commercial fisherman and has a law practice focusing on incident management and marine casualties. His professional background has led him to a role as an incident management trainer and responder for the last 20 years.

Heather Coletti, National Park Service. Heather is the National Park Service project leader for marine-related vital signs. She has worked in the field of biology for federal agencies in Alaska for more than a decade and has a M.S. in Natural Resources: Environmental Conservation and a B.S. in Zoology.

Brad Dunker, Alaska Department of Fish and Game. Brad is a habitat biologist at the Izembek State Game Refuge located on the northern shore of the Alaskan Peninsula. This refuge supports one of the largest eelgrass beds in the world and annually hosts millions of waterfowl and shorebirds on their way to and from nesting grounds to the north. Brad works to ensure that the vegetation and wildlife remain protected and pollutant free.

Gary Fandrei, Cook Inlet Aquaculture Association. Gary is the Executive Director of the Cook Inlet Aquaculture Association, a position he has held since 1996. CIAA operates 2 hatcheries producing sockeye, coho and pink salmon and is involved with a broad spectrum of salmon monitoring and enhancement programs throughout the Cook Inlet drainage. Gary worked on lake studies and water quality issues prior to his employment with CIAA. He holds a B.S. degree in Ecosystems Analysis from the University of Wisconsin and an M.S. degree in Environmental Biology from the University of Minnesota.

Jack (John) Harrald, Ph.D., Retired USCG Captain, Virginia Tech. Jack's Alaska expertise began with his USCG service and continued with academic research in association with the Prince William Sound risk assessment post-Exxon Valdez response. Currently Jack is working with Virginia Tech University to establish a new Center for Community Security and Resilience and serves as the Chair of the Disaster Roundtable of National Research Council.

Tahzay Jones, National Park Service. Tahzay is a marine ecologist and coastal researcher working with the National Park Service and the Center for Marine and Environmental Analyses over the past 15 years. He has worked on the development of long term monitoring plans for physical, chemical, and biological coastal ecosystem components for environmental change analyses.

Robbin La Vine, Subsistence Resource Specialist II Alaska Department of Fish and Game. Robbin is the south-central area specialist for the Southern Region, based in Anchorage. She has extensive experience partnering in research and capacity building activities with tribal, state, and federal entities in Alaska. Robbin has conducted research on the subsistence way of life since 2002.

Dr. Steve Okkonen, University of Alaska Fairbanks. Steve is currently a professor at the University of Alaska. He has done extensive research in a variety of fields including mesoscale eddies, shelf-slope exchange, polar/sub-polar oceanography, and frontal dynamics. With ten years of experience and a Ph. D, Steve is an expert in Oceanography, and has published more than twenty books.

Dr. Scott Pegau, Prince William Sound Oil Spill Recovery Institute. Scott received his Ph.D. in physical Oceanography from Oregon State University in 1996. He worked at the Kachemak Bay Research Reserve in Homer from 2002 to 2007 where he studied oceanographic conditions and circulation in lower Cook Inlet. He currently works at the Oil Spill Recovery Institute, but maintains an interest in the oceanographic conditions of Cook Inlet.

Bud Rice, National Park Service. Bud is an Environmental Protection Specialist who has worked for the U.S. National Park Service (NPS) in Alaska since 1976 as a seasonal Park Ranger, Natural Resources Specialist, and Chief of Resources at Kenai Fjords National Park during the Exxon Valdez Oil Spill, before he moved to Anchorage in 1992 to serve in the NPS Alaska Regional Office. He works on National Environmental Policy Act projects, both internally and externally generated, and as an oil spill and natural resource damage assessment point of contact for Alaska Region NPS areas. Bud was recently involved in the Northwest Alaska Ecological Risk Assessment and reviews subarea contingency plans and geographic response strategies involving any NPS areas around the state of Alaska.

Sue Saupe, Cook Inlet RCAC. Sue has worked in Alaska's marine environment for over 25 years, focusing on oceanography, coastal habitats, stable isotopes in marine food webs, and contaminants. She is currently Director of Science and Research for Cook Inlet RCAC, applying her experience gained from working in the Bering, Chukchi, and Beaufort seas, on *Exxon Valdez* oil spill damage assessment studies, and on salt marsh estuary studies out of Woods Hole, MA.

Dr. Carl Schoch, Coastwise Services (private). Carl is an independent research scientist based in Homer, AK focused on marine and estuarine ecology in arctic, temperate, and tropical systems. He is a visiting researcher at the UCLA/Joint Institute for Regional Earth System Science and Engineering and an affiliate research professor at the University of Alaska School of Fisheries and Ocean

Sciences. Carl's studies include how physical processes affect plant and animal recruitment and modify competition and predation force changes in biological diversity and community structure at local and regional scales.

Dr. Orson Smith, University of Alaska – Anchorage. Orson is the Interim Dean of the University of Alaska School of Engineering in Anchorage, where he has been a professor since 2003, Chair of the Civil Engineering Department from 2006-2010, and led development of graduate programs in Arctic Engineering and Coastal, Ocean, and Port Engineering. In addition to many other accomplishments in the fields of engineering and oceanography, Orson has dealt with coastal and civil engineering issues in Alaska ranging from Ketchikan to Barrow and Prudhoe Bay.

John Whitney, National Oceanographic and Atmospheric Administration. A member of the Emergency Response Division in Anchorage, Alaska, John is part of an interdisciplinary scientific team that responds to oil and chemical spills in U.S. waters. John leads the team at spills, drawing on the team's spill trajectory estimates, chemical hazards analyses, and assessments of the sensitivity of biological and human-use resources. Using his expertise, John assists the Federal On-Scene Coordinator in making timely operational and planning decisions.

This page is intentionally blank.

Appendix B: Workshop Participants

The tables below list participants who attended the workshop in the role of Advisory Panel, Management Team, Facilitation Team, or the public. Some subject matter experts, listed in Table 10, are also on the Advisory Panel. Not all participants were present for the whole two-day workshop.

ADVISORY PANEL

First Name	Last Name	Role	Affiliation
Catherine	Berg	Land/Resources	U.S. Fish and Wildlife Service
Owen	Boyle	Mariner	Retired
Jim	Butler	Fisheries	Baldwin & Butler, LLC
David	Devilbiss	Marine Salvor	Global Diving & Salvage, Inc.
Gregory	Duggin	Oil Platforms	XTO Energy
Jack	Harrald	Risk Assessment	Retired
Bryan	Hawkins	Ports & Harbors	Port of Homer
Ron	Long	NGO	Port of Seward
George	Lowery	Mariner – Freight Ship	Totem Ocean Trailer Express
Greg	Pavellas	Mariner – Tug	Crowley Marine
Bob	Pawloski	NGO	Alaska Legislature
Jack	Rasmussen	Mariner – Freight Ship	Lynden Transport
Stephen	Ribuffo	Ports & Harbors	Port of Anchorage
Mike	Stone	Marine Pilot	Southwest Pilots' Association
Marc	Van Dongen	Ports & Harbors	Port Mackenzie
Richard	Wilson	Mariner – Other	Offshore Systems Inc.

MANAGEMENT TEAM

First Name	Last Name	Role	Affiliation
LT Kion	Evans	Management Team	USCG
Lynda	Giguere	Public Outreach	Cook Inlet RCAC
CDR Scott	Johnson	Management Team	USCG
Steve	Russell	Management Team	ADEC

PUBLIC/OTHER INTERESTED PARTIES

First Name	Last Name	Affiliation (if noted)
Brenda	Ahlberg	Kenai Peninsula Borough
Diane	Dunham	
Bob	Klieforth	
Tom	Lakosh	
Steve	Lewis	Prince William Sound Regional Citizens' Advisory Council
Walt	Parker	
Linda	Swiss	Prince William Sound Regional Citizens' Advisory Council

FACILITATION TEAM

First Name	Last Name	Affiliation
Amy	Gilson	Nuka Research
Sierra	Fletcher	Nuka Research
Leslie	Pearson	Pearson Consulting
Tim	Robertson	Nuka Research

Appendix C: Consequence Analysis Workshop Agenda

Cook Inlet Risk Assessment – Consequence Analysis Workshop

University Alaska Anchorage
Lee Gorsuch Commons, Room 106
3700 Sharon Gagnon Lane #602
Anchorage, Alaska
Tuesday, October 30 – 2012
9:00 AM – 4:30 PM

PURPOSE: The purpose of this two-day workshop is to bring together subject matter experts in the field of oceanography, geology, biology, subsistence use, socioeconomics, fisheries and resource management to discuss impacts to resources in the region from oil spills.

ATTENDEES: Subject Matter Experts, Cook Inlet Risk Assessment Management Team, Advisory Panel, Project Managers and the Public.

Agenda

9:00 AM	**Welcome and Introductions**	CIRA Project Team
	Meeting Purpose, Goal and Process	CIRA Project Team
	Project Overview and Status	CIRA Project Team
	Consequence Categories and Matrix	CIRA Project Team
10:30	**Morning Break**	
	Discussion on Consequence Categories and Matrix	Attendees
	Spill Scenarios	CIRA Project Team
Noon	**Lunch** (Provided)	
1:00 PM	**Review Spill Trajectories, Sensitivity Analysis, Impact zones**	CIRA Project Team/Attendees
3:00 PM	**Afternoon Break**	
	Spill Trajectory, Sensitivity Analysis, Impact zone discussion	CIRA Project Team/Attendees
	Review of Key Items and Decisions	CIRA Project Team
	Public Comments	CIRA Project Team
4:30 PM	**Adjourn**	

Project Website: http://www.cookinletriskassessment.com

Contact person for additional information: Leslie Pearson 907.947.2316 or Amy Gilson 907.234.7821

Cook Inlet Risk Assessment – Consequence Analysis Workshop

University Alaska Anchorage
Lee Gorsuch Commons, Room 106
3700 Sharon Gagnon Lane #602
Anchorage, Alaska
Wednesday, October 31 – 2012
9:00 AM – 4:30 PM

PURPOSE: The purpose of this two-day workshop is to bring together subject matter experts in the field of oceanography, geology, biology, subsistence use, socioeconomics, fisheries and resource management to discuss impacts to resources in the region from oil spills.

ATTENDEES: Subject Matter Experts, Cook Inlet Risk Assessment Management Team, Advisory Panel, Project Managers and the Public.

Agenda

9:00 AM **Welcome and Introductions**.......... CIRA Project Team
Meeting Purpose, Goal and Process.......... CIRA Project Team
Overview of Day One .... CIRA Project Team
Review of Consequence Categories and Matrix .... CIRA Project Team
10:30 **Morning Break**
Discussion on Resource Impacts for each Scenario.......... CIRA Project Team/Attendees

Noon **Lunch** (Provided)

1:00 PM **Continue discussion on Resource Impacts for each Scenario**.......... CIRA Project Team/Attendees
3:00 PM **Afternoon Break**
Continue discussion on Resource Impacts for each Scenario .... CIRA Project Team/Attendees
Review of Key Items and Decisions .... CIRA Project Team
Public Comments .... CIRA Project Team
4:30 PM **Adjourn**

Project Website: http://www.cookinletriskassessment.com

Contact person for additional information: Leslie Pearson 907.947.2316 or Amy Gilson 907.234.7821

This page is intentionally blank.

Appendix D:
Summary of Scenario Scores

	HABITAT			FISH		BIRDS			MARINE MAMMALS			OTHER	SOCIO-ECONOMIC				
	Pelagic	Littoral	Benthic	Fin Fish	Shellfish	Waterfowl	Seabirds	Shorebirds	Sea Otters	Pinnipeds	Whales	Terrestrial Wildlife	Subsistence	Commercial Fishing	Recreation /Tourism	General Commerce	Oil Industry
SCENARIO 1 **30K, Crude, Drift River, JULY**	2	4	2	3	4	4	4	5	1	4	4	3	4	5	3	1	4
SCENARIO 2 **1K, Diesel, Nikiski, NOVEMBER**	2	1	1	1	1	1	1	1	0	1	3	1	1	1	1	1	2
SCENARIO 3 **48K, Jet A, Knik Shoal, JUNE**	2	2	1	4	3	2	2	3	0	2	5	1	2	2	2	1	1
SCENARIO 4 **1K, HFO, Anchorage, FEBRUARY**	1	1	1	1	1	1	1	1	0	1	2	1	1	1	1	3	0
SCENARIO 5 **20K, No. 2 Fuel Oil, Barrens, MAY**	2	3	1	3	2	2	5	3	4	3	3	2	5	2	2	2	0
SCENARIO 6 **0.1K, Diesel, Homer, JULY**	1	2	1	1	1	1	3	2	2	2	1	2	1	3	3	2	0
SCENARIO 7 **1K, Crude, Anchor Pt., SEPTEMBER**	2	3	2	2	4	5	2	2	2	1	1	1	3	1	3	1	1

This page is intentionally blank.