Response Gap Methods

Report to Prince William Sound RCAC

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Prepared by:
Nuka Research and Planning Group, LLC.

Research & Planning Group, LLC.

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

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Executive Summary

Sometimes oil is transported in tank vessels at a time when no mechanical oil spill response is possible, due to environmental conditions such as weather and sea state. The term Response Gap is used to refer to such conditions. In Prince William Sound (PWS), Closure Limits preclude outbound laden tanker transits when conditions at Hinchinbrook Entrance exceed 15 foot seas or 45 knot winds. However, these conditions represent safe operating limits for the tankers themselves, and do not necessarily reflect the limits to mechanical oil spill recovery systems. In Prince William Sound, the Response Gap exists for the range of conditions between the upper limits of mechanical recovery systems and the Hinchinbrook Closure Limits.

Prince William Sound (PWS) Regional Citizens' Advisory Council (RCAC) has commissioned a study to determine the frequency and duration of any Response Gap that exists in Prince William Sound. This Methods Report is the first deliverable in this study. RCAC has developed this Methods Report to solicit feedback on the proposed methods, data, and analyses that will be used to quantify the Response Gap. This report describes the data sources and analytical methods to be used in the study. RCAC will consider all input and comments received on these proposed methods before finalizing the methodology.

The proposed methodology is to assemble a historic dataset of the environmental factors that are known to affect the open-water mechanical response system utilized in PWS. For the first phase of this project two datasets will be developed for two of the operating areas in the sound - Central PWS and Hinchinbrook Entrance. Each dataset will contain observations related to four environmental factors - wind, sea state, temperature, and visibility. These datasets will then be used in a "hindcast" to evaluate the frequency and duration of times when environmental condition exceed the maximum response operating limits.

Since there are no universal standards as to what constitutes a response operating limit, establishing the limits necessary to conduct the hindcast is a subjective task. It is proposed that review of published and unpublished literature and reports will aid in this task. After-action reports for drills, exercises, and actual spills will be a focus of this review. Ultimately, the limits used for this will be based on the best professional judgment of the authors of the study. Others might establish different limits.

The methods proposed in this report take into account the interactions between environmental factors and response efficiency losses, to calculate a Response Gap Index (RGI). The RGI will indicate whether the single or combined effect of environmental conditions would exceed the established response limits for any observational period. Once the RGI is computed for each observational period, the dataset can be summarized to produce a realistic estimate of the frequency and duration of the Response Gap.

This report acknowledges and discusses the limitations of this type of study. The proposed methodology for a Response Gap Analysis is not intended to be used to judge compliance of any contingency plan with any regulation. However, it may advance the field of oil spill response science and decision-making by identify environmental parameters for mechanical oil spill recovery systems. A more refined understanding of the Response Gap may also serve to focus risk reduction and oil spill prevention programs.

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Introduction

The Prince William Sound Regional Citizens' Advisory Council (RCAC) has been working with crude oil tanker operators and regulators to promote strong oil spill response and prevention programs since before the Oil Pollution Act of 1990 (OPA 90). [1] In this role, RCAC has been a strong proponent of realistic oil spill contingency planning. The RCAC has also advocated for continual improvement of the Prince William Sound Crude Oil Tanker Oil Discharge Prevention and Contingency Plan (PWS Tanker C-plan) that covers crude oil tankers calling at the Trans-Alaska Pipeline's Valdez Marine Terminal and operating in Prince William Sound (PWS).

Over the past 16 years, technological advancement in oil spill response systems, preparedness programs, and environmental monitoring have contributed to more proficient oil spill response operations in PWS. Yet, there are still times when environmental conditions (wind, waves, temperature, visibility, etc.) preclude effective spill response operations while oil is being shipped through PWS. This window between the point of maximum mechanical response capacity and the established weather-based Closure Limits is the PWS Response Gap.

RCAC has contracted Nuka Research and Planning Group, LLC to quantify the Response Gap in PWS. This is the first of two reports to RCAC under this contract.

Terminology Used in this Report

It is useful to define the following terms for the purpose of this report.

Response Gap RCAC's request for proposals for this project states, *"The Response Gap is the window between the point of maximum capability to mechanically respond to an oil spill in a safe manner, and the point where the conditions reach Closure Limits (15 foot seas or 45 knot winds) at which point Hinchinbrook Entrance is closed to outbound laden tankers."*[2]

Closure Limit The Prince William Sound Vessel Escort Response Plan (VERP) is the port-specific operations plan adopted by the Prince William Sound Owners/Operators. The VERP states, "outbound laden tankers will not be allowed

[1] (http://www.RCAC.org/about/index.html)

[2] RCAC RFP 756-06-01

to transit Hinchinbrook Entrance when winds exceed 45 knots or seas exceed 15 feet." It further states that these conditions will be determined based on the weather buoy at Seal Rocks.[3] Thus, the Closure Limit is the upper limit of environmental conditions where oil is transported through Prince William Sound.

Environmental Factor An environmental factor is an aspect of meteorological or oceanographic conditions that can impede or prevent response operations. Environmental factors include: wind, waves, visibility, temperature, currents, and ice.

Nearshore Oil Spill Recovery System The PWS Tanker Plan describes two types of response systems for the mechanical recovery of oil on water: open-water response and nearshore response. Nearshore response is considered the second tier of response operations after open-water response. Nearshore response consists of free-oil recovery and shoreline protection, and is based mostly on small vessels of opportunity (primarily fishing vessels). The operational limits of the Nearshore Oil Spill Recovery System are less than that of the Open-water Oil Spill Recovery System. Since the open-water oil spill recovery system is the primary response system intended to meet the Response Planning Standard, the nearshore response system is not being considered as part of this analysis.

Observation An observation is a single measurement of an Environmental Factor, such as wind speed or wave height.

Observational Period An observational period is the time covered by an observation. For the purposes of this analysis, an observational period will be one hour; therefore, a wind speed observation will be the average wind speed reported over a particular hour.

Open-water Oil Spill Recovery System The PWS Tanker Plan describes two types of response systems for the mechanical recovery of oil on water: open-water response and nearshore response. Open-water response is considered the first tier of response operations followed by nearshore response. Open-water response consists of containment and removal of oil floating on the water, and is based mostly on large, dedicated response vessels. Some vessels of opportunity (primarily fishing vessels) are used in open-water response to tow oil containment boom. The operational limits of the Open-water Oil Spill Recovery System are greater than that of the Nearshore Oil Spill Recovery System. *Since the Open-water Oil Spill Recovery System is the primary response system intended to meet the Response Planning Standard, it is the focus of this study.*

Operating Area An operating area is a geographic zone where oil spill response operations might occur. Since the Prince William Sound region is large and diverse, it is being subdivided into operating areas where similar environmental conditions are expected to occur. For instance, environmental factors in Valdez Arm can be very different from Central Prince William Sound. The term *operating area* is analogous to the response "zones" used in the PWS Tanker C-plan.

[3] National Data Buoy Center buoy 46061.

Operating Environment The operating environment is the anticipated environmental context where an oil spill response might occur. Examples include: open-water, protected-water, and calm-water. There are at least two different classification schemes for operating environments. For this study, we are using the scheme established by the American Society for Testing and Materials (ASTM).

Realistic Maximum Response Operating Limitation (RMROL) This term is coined in the Alaska Department of Environmental Conservation's (ADEC) Oil and Hazardous Substance Pollution Control Regulations as "the upper limit of a combination of environmental factors that might occur at a facility or operation beyond which an operator would be unable to mount a mechanical response to a discharge event."[4]

Response Planning Standard (RPS) Response Planning Standard (RPS) is defined in the ADEC regulations as a planning standard against which the adequacy of an oil discharge prevention and contingency plan will be judged by ADEC. It does not constitute a cleanup standard that must be met by the holder of a contingency plan.[5]

Response Gap Index (RGI) The Response Gap Index is a derived barometer/index used in this study to combine multiple environmental factor observations into a single indication that the maximum operational limit has been exceeded for the observational period.

Purpose of this Report

Defining the Response Gap is a complex task, as the maximum response capability of the open-water oil spill recovery system in PWS is subject to many environmental factors. The task is also limited to the environmental data available for analysis. The purpose of this Methods Report is to establish the methods and data to be used to quantify the Response Gap. Once the methods have been approved by RCAC, the data will be complied and analyzed and a final Results Report will be produced.

This report is not intended to imply anything about PWS Tanker C-plan compliance with any law or regulation. The scope of the report is limited to the open-water response system currently described in the PWS Tanker C-plan and the selected operating areas. The report does not consider the nearshore response capability described in the same plan.

Goal and Objectives

The goal of this study is to quantify frequency and duration of the Response Gap in PWS. This Response Gap exists when the realistic maximum response operating limits for the existing spill response technologies occur at conditions below the closure limits.

[4] Alaska Regulations 18 AAC 75.990(56).

[5] Alaska Regulations 18 AAC 75.990(57).

Achieving this goal is complicated by the following facts:

- There are multiple, diverse operating areas in PWS and the environmental conditions may be very different at any given time. Environmental conditions can even vary considerably within operating areas.
- RMROL is affected by a number of environmental factors that interact with each other.
- Environmental factor data is sparse and not readily available for all operating areas in PWS.

A number of different approaches could be used to achieve the project goal, but we propose to use a "hindcast" to estimate the probable distribution of environmental factors and the RGI over time. To that end, the objective is to work with a large data set of environmental factors, preferably a five-year data set from 2000 to 2005. This method assumes that past weather patterns (and therefore environmental factors) will reflect future ones. It also assumes that the limitations of open-water oil spill recovery systems remain constant over time.

The following objectives will facilitate achieving the study's goal:

1. Establish the typical operating areas for open-water mechanical recovery systems in PWS.
2. Establish the environmental factors that might limit oil spill response.
3. Assess the availability of data for each environmental factor.
4. Determine which operating environments and environmental factors will be used for the purposes of this analysis.
5. Assemble available environmental factor data into datasets that represent selected operating areas.
6. Characterize the datasets of environmental factors using histograms and joint-probability distributions and correlate conditions within PWS to conditions at Hinchinbrook Entrance up to the closure threshold.
7. Flag data observations for the time when Hinchinbrook Entrance was closed and ignore these observations in subsequent analyses.
8. Review C-plans, published research, and oil spill response drill/exercise/spill after-action reports to asses the operational limits of each environmental factor on open-water oil spill response systems.
9. Based on the review in Objective 8 and best professional judgment, establish operational limits for each environmental factor.
10. Apply the operational limits to the datasets and characterize the results as frequency of occurrence distributions over time.
11. Based on best professional judgment, establish a rule to create a Response Gap Index representing the interaction between all environmental factors for a single observational period.

12. Apply the rule to the datasets and characterize the results as frequency of occurrence distributions over time.

Background on Response Gap Issues

Legal and Regulatory Framework

This section of the report considers the legal and regulatory framework for the project, as well as the contents of the PWS Tanker C-plan.

STATE LAWS AND REGULATIONS

The possibility of a Response Gap has been established in Alaska State Laws and Regulations and the PWS Tanker C-plan since the early 1990s. State law requires anyone operating a tank vessel to have an Oil Discharge Prevention and Contingency Plan approved by ADEC.[6] Plan approval requires a demonstration of sufficient resources to meet the Response Planning Standard (RPS) for the planholder's operations.

RESPONSE PLANNING STANDARDS

The State of Alaska Response Planning Standard that applies to the PWS Tanker C-plan requires the planholders to have sufficient oil discharge containment, storage, transfer, and cleanup equipment, personnel, and resources to contain or control, and clean up a 300,000 barrel discharge within 72 hours.[7] The law is silent on the environmental conditions under which this standard must be met, but gives ADEC the authority to establish such details in regulation.[8]

ADEC's Oil and Hazardous Substance Pollution Control Regulations contain oil discharge prevention and contingency plan approval criteria that state that the contingency plan must demonstrate that:

- The response system can be deployed in time to meet the RPS and state what conditions were assumed for response operations.[9]
- The RPS can be met under the conditions that might reasonably be expected to occur at the discharge site.[10]

Still ADEC recognizes that the RPS cannot be met under all environmental conditions and further establishes the concept of operating limitations in their regulations.

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[6] Alaska Statutes: AS 46.04.030(c)

[7] Alaska Statutes: AS 46.04.030(k)(1)(3)(b). This applies to tank vessels having a cargo volume of 500,000 barrels or more. Not all tank vessels operating in PWS are this large, but most are, so the PWS Tanker C-plan must meet the most stringent RPS.

[8] Alaska Statutes: AS 46.04.030(e)

[9] ADEC Regulations: 18 AAC 75.445(c)

[10] ADEC Regulations: 18 AAC 75.445(d)(5)

REALISTIC MAXIMUM RESPONSE OPERATING LIMITATIONS

ADEC regulations require that the contingency plan must provide a description of the Realistic Maximum Response Operating Limitations (RMROL) that might be encountered during response operations. The plan must include an analysis of the frequency and duration of limitations that would render mechanical and other response methods ineffective. The RMROL, expressed as a percentage of time, must be defined through an analysis of the following environmental factors:

- Weather, including wind, visibility, precipitation and temperature,
- Sea states, tides, and currents,
- Ice and debris presence,
- Hours of daylight, and
- Other known environmental conditions that might influence the efficiency of the response equipment or the overall effectiveness of a response effort.[11]

FEDERAL LAWS AND REGULATIONS

The Oil Pollution Act of 1990 (OPA-90) specifies that an operator of a tank vessel must have a contingency plan called a Vessel Response Plan (VRP)[12], not to be confused with VERP which is the port operations plan. The planning standard for a VRP is "to remove to the maximum extent practicable a worst case discharge (including a discharge resulting from fire or explosion)." Worse case discharge is further defined as "in the case of a vessel, a discharge in adverse weather conditions of its entire cargo."[13]

Federal law sets additional standards for tankers loading at the Valdez Marine terminal. These vessels must have "oil spill removal organization at appropriate locations in Prince William Sound, consisting of trained personnel in sufficient numbers to immediately remove, to the maximum extent practicable, a worst case discharge or a discharge of 200,000 barrels of oil, whichever is greater."[14]

The US Coast Guard has established regulations for these federal laws. These regulations define adverse weather: "the weather conditions that will be considered when identifying response systems and equipment in a response plan for the applicable operating environment. Factors to consider include, but are not limited to, significant wave height, ice, temperature, weather-related visibility, and currents within the Captain of the Port (COTP) zone in which the systems or equipment are intended to function."[15]

These regulations set a general planning standard for tank vessels carrying oil as a primary cargo, and specific planning standards for tank vessels loading at the Valdez Marine Terminal. In general, the VRP must provide for response resources

[11] ADEC Regulations: 18 AAC 75.425(e)(3)(D)

[12] United States Code: 33 USC Chapter 26 Subchapter III Section 1321(j)(5)

[13] United States Code: 33 USC Chapter 26 Subchapter III Section 1321(a)(24)

[14] United States Code: 33 USC Chapter 40 Subchapter II Section 2735(a)(2)

[15] Federal Regulations: 33 CFR Part 155 Subpart D Section 155.1020

that are suitable for a specified operation environment. Operating environments are broken into four categories with the characteristics shown in Table 1. While most of the waters in the PWS region are considered inland waters, the COPT has classified PWS as an ocean operating environment.

Additional criteria to be evaluated include the following environmental factors:

- Ice conditions,
- Debris,
- Temperature ranges, and
- Weather related visibility.[16]

However, the federal regulations clearly state that "(t)hese criteria reflect conditions used for planning purposes to select mechanical response equipment and are not conditions that would limit response actions or affect normal vessel operations." [17]

Table 1. Operating environment and characteristics set out in federal regulations.[18]

Operating Environment	Significant Wave Height	Sea State
Rivers and Canals	≤ 1 feet	1
Inland	≤ 3 feet	2
Great Lakes	≤ 4 feet	2-3
Ocean	≤ 6 feet	3-4

Note: Sea States descriptions may be found at:
http://www.msc-smc.ec.gc.ca/msb/manuals/manmar/app6_e.html

ASTM Operating Environment Classifications

The American Society for Testing and Materials (ASTM) has established another scheme for classifying operating environments in order to determine if oil spill response equipment is appropriate.[19] ASTM states that "(t)hese classifications may be used in formulating standards for design, performance, evaluation, contingency and response planning, contingency and response plan evaluation, and standard practice for spill control systems." Table 2 shows the ASTM classifications. This classification system is also used in the World Catalog of Oil Spill Response Products[20] and the Spill Tactics for Alaska Responders manual.[21]

[16] Federal Regulations: 33 CFR Part 155 Subpart D Section 155.1050(a)(2)

[17] Federal Regulations: 33 CFR Part 155 Subpart D Section 155.1050(a)(1)(ii)

[18] Federal Regulations: 33 CFR Part 155 Appendix B Table 1

[19] American Society for Testing and Materials. 2000. Standard practice for classifying water bodies for spill control systems. F625-94.

[20] Potter, Steve, ed. 2004. World Catalog of Oil Spill Response Products. Ottawa, Ontario, Canada: SL Ross Environmental Research Ltd. http://www.slross.com/WorldCat/WorldCatcontent.php

[21] Alaska Department of Environmental Conservation. 2006. Spill Tactics for Alaska Responders, DRAFT. http://www.dec.state.ak.us/spar/perp/star/index.htm

We have chosen to use this classification scheme for this study. The Open-water class in the ASTM scheme corresponds to the Ocean class in the USCG scheme, which is the operating environment specified for PWS.

Table 2. ASTM F625 water body classifications.

Type[a]	Wave Height[b] meters (feet)	Examples of General Conditions
Calm-water	0 to 0.3 (0 to 1)	Small, short, non-breaking waves
Protected-water	0 to 1 (0 to 3)	Small waves, some whitecaps
Open-water	0 to 2 (0 to 6)	Moderate waves, frequent whitecaps
Open-water (rough)	>2 (>6)	Large waves, foam crests and some spray

a. If current is significant, approximately 0.4 m/s (0.8 knots) or more, append "C" to the descriptor type, as" I-C".
b. Significant wave height throughout. May include breaking waves. The ratio of wave height to wave length should also be considered. The orientation of waves to current direction should also be considered.

PWS Tanker PWS Tanker C-plan

OPEN-WATER MECHANICAL RECOVERY SYSTEM

SERVS' current open-water oil spill recovery system for Prince William Sound is comprised of four barge-based recovery and storage systems and one dynamic inclined-plane skimming vessel.[22] The recovered fluid storage capability of the barges range from 137,000 to 191,000 barrels. Each barge has three high-volume weir skimming systems for recovering oil concentrated with a gated U-boom array and contained in a standard U-boom. Each barge is part of a Task Force that contains: a tug to control the barge and four workboats or fishing vessels to handle the boom.[23] This Task Force is thus a system that requires each of its parts to function in order for the system to accomplish the recovery tactic. *If any component of the system (people, vessels, booms, barges, and skimmers) fails, then the system is precluded from collecting oil.* Therefore, the effect of every environmental factor on every component of the system must be considered when determining operational limits.

Since the four barge-based open-water mechanical recovery systems account for 87% of the response capability[24] necessary to meet the 300,000 bbl RPS, it will be the focus of this study.

REALISTIC MAXIMUM RESPONSE OPERATING LIMITATIONS

As required by State Regulation, the PWS Tanker C-plan has a section on Realistic Maximum Response Operating Limitations in each of their last three plan review submittals (1995, 1998, 2002).[25] The plan writers acknowledge the regulations discussed above and recognize the difficulty of determining the RMROL. They recognize that the interactions between environmental factors make it very difficult to set a hard and fast response limit. With many caveats, the operational

[22] PWS Tanker C-Plan, 2002, Part 3, SID 1, Section 1

[23] PWS Tanker C-Plan, 2002, Part 3, SID 1, Section 2

[24] ANVIL Engineering, March 1994, HB567 Compliance Study, Chapter 4 Process Engineering.

[25] The 1998 and 2002 sections are identical.

limits for the mechanical response system in Table 3 are reported in the RMROL section of the C-plan.

Table 3. RMROL Reported in the 1998 and 2002 PWS Tanker C-plan for Mechanical Response Operations

Environmental Factor	Conditions that Could Preclude a Response
Wind	Winds > 30 to 40 knots, but depending on other variables. The negative impact of winds on the effectiveness of a response is realized when winds approach a range of 30 to 40 knots or greater. Temperature, sea state, visibility, and perception may make the effect of a specific wind speed variable. In some circumstances, a response may be possible in 30- to 40-knot winds, while in other circumstances a response may not be effective in winds less than 20 knots.
Sea State	Seas greater than 3m (10 ft) with strong tides and currents. A rule-of-thumb RMROL for wave height is 3 meters (10 feet). This limitation may be affected by ambient temperature, visibility and precipitation. The impact of tides and currents can only be determined on a case-by-case basis.
Visibility	Depending on other environmental factors, the visibility limitation may be <0.5 nautical miles (nm) for vessels tracking oil. If wind, sea state, temperature, visibility and/or precipitation cause the response to be inefficient, the additional factor of darkness may actually preclude a response. Limitations for flight surveillance operations, based on visual flight rules for rotary- and fixed-wing aircraft are: 500 foot ceiling and 1-mile visibility if in sight of land, or 500 foot ceiling and 3-mile visibility if over open-water and land is not in sight. For booming and skimming vessels, the visibility limitation varies between 0.125 nautical miles (200 meters) and 0.5 nautical miles (800) meters, depending on temperature, sea state, wind, and precipitation. A realistic maximum response operating limitation for visibility affects response vessel differently depending or whether they are already engaged in oil recovery or seeking oil to recover. For vessels actively booming and skimming in oil, limits would be set by the master of the vessel based on safety and operational efficiency. For vessels not in oil and which may require aircraft surveillance, the limitations would likely be for the aircraft described above. A realistic maximum response operation, based solely on hours of daylight, can only be determined on a case-by-case basis.
Temperature	Long-term temperatures below freezing combined with high winds could preclude a response. Sustained temperatures below freezing, in conjunction with high winds, severe sea states, poor visibility, and/or heavy precipitation, will significantly reduce the effectiveness of the response. At temperatures below 15ºF and winds of 24 to 28 knots, wind chill becomes a factor in response operations.

Environmental Factors Limiting Mechanical Response

A number of environmental factors affect the efficiency of a mechanical oil spill response systems. There are interactions between these factors, and response efficiency does not decline in a linear fashion as environmental conditions deteriorate.

WIND

Wind is a common phenomenon that affects any marine environment. Wind is the primary driver of ocean waves, but sea state will be considered as a separate factor. Wind alone can impede or prevent mechanical response operations in the following ways:

- Inability of vessels to keep on station,
- Crew unable to work on deck,
- Equipment and workboat deployment and retrieval impeded, and
- Boom failure.

SEA STATE

Sea state refers to both wave height and wave period (frequency). When wave height is small, wave period has little effect on response operations. As wave height increases, waves of a short period have greater effect on response operations than waves of a longer period. Short choppy waves have a greater effect than long ocean swells. Waves can impede or prevent mechanical response operations in the following ways:

- Boom failure,
- Inability of vessels to keep on station,
- Skimmer failure,
- Crew inability to work on deck,
- Equipment and workboat deployment and retrieval impeded,
- Oil becoming submerged and thus not available to recovery, and
- Inability to track and encounter oil.

VISIBILITY

Visibility can be hampered by darkness, fog, snow, heavy precipitation, or low clouds. Visibility can impede or prevent spill response operations in the following ways:

- Inability to track and encounter oil, and
- Inability of vessels to keep on station.

TEMPERATURE

Temperature extremes (both high and low) can adversely affect oil spill response operations, but in PWS low temperatures are more likely to cause problems. Low temperature can impede or prevent response operations in the following ways:

- Crew inability to work on deck due to ice or hypothermia,
- Mechanical equipment failure due to icing, and
- Vessel instability due to icing.

CURRENTS

Currents can significantly impact oil spill response operations, but ocean currents have less effect compared to the currents found in rivers or in narrow embayments. This is because ocean currents occur over a broad area. The entire response system is captured in the current and there is little or no relative movement between the various components of the response system. However currents can cause problems in areas where eddies or tide rips occur and when the current sets the response system into shoal waters. Currents can impede or prevent response operations in the following ways:

- Boom failure,
- Oil becoming submerged and thus not available to recovery, and
- Inability to keep vessels on station.

Because only ocean currents are likely to be encountered by the Open-water Response Systems operating in PWS, and there is no way to measure local currents such as tide rips, currents are not considered for the purposes of this study.

ICE

When ice is present it can impede or prevent response operations in the following ways:

- Failure of skimming systems,
- Inability to keep vessels on station,
- Boom failure, and
- Inability to track and encounter oil.

Ice is not a common phenomenon in Prince William Sound: significant amounts occur only near Columbia Bay. Ice is not considered for this phase of this study, because ice is not a common phenomena in Central PWS or Hinchinbrook Entrance.

OTHER ENVIRONMENTAL FACTORS

Other environmental factors such a precipitation, debris, and tides can conceivably have an affect on oil spill response operations, but are not considered significant to this study.

Interactions Between Environmental Factors

Interactions between environmental factors have a big effect on response operating limits. For example, low temperatures and strong winds cause freezing spray that can impede or prevent response operations much sooner than either temperature or wind alone. Likewise, waves of a certain height are much more limiting in the presence of a strong wind or in times of low visibility. We will account for these interactions by developing a simple set of rules that develop a Response Gap Index for each observational period.

Response Capability Degradation

The degradation of response does not occur at a single point, nor is it necessarily linear in nature. For instance, response efficiency does not go from 100 percent to zero percent as wind increases from 29 to 30 knots. Likewise, a wind of 15 knots does not indicate that the response efficiency is one half that at 30 knots. The degradation curve is probably different for each environmental factor. This further complicates the task of setting discreet operational limits. We will account for capability degradation by establishing categories of limitations for each environmental factor. These categories are further explained below.

Methods

We propose the following methods to conduct the hindcast of the Response Gap probabilities in Prince William Sound.

Selecting Operating Areas

Prince William Sound is a large inland sea formed between the glaciated Chugach Mountains and the northern coastline of the Gulf of Alaska. Many factors influence the weather and sea conditions in PWS. Weather and sea conditions are markedly different between winter and summer. At any one time, conditions can be very different in different parts of PWS. On any single day, conditions may change dramatically. We propose to divide PWS into operating areas, where environmental conditions might be similar across the entire area. We balance the recognition that micro-climates still exist in any operating environment against the need to define an area that has similar environmental conditions and observations available.

The 1995 PWS Tanker C-plan describes the following four response zones in the Prince William Sound Subarea:

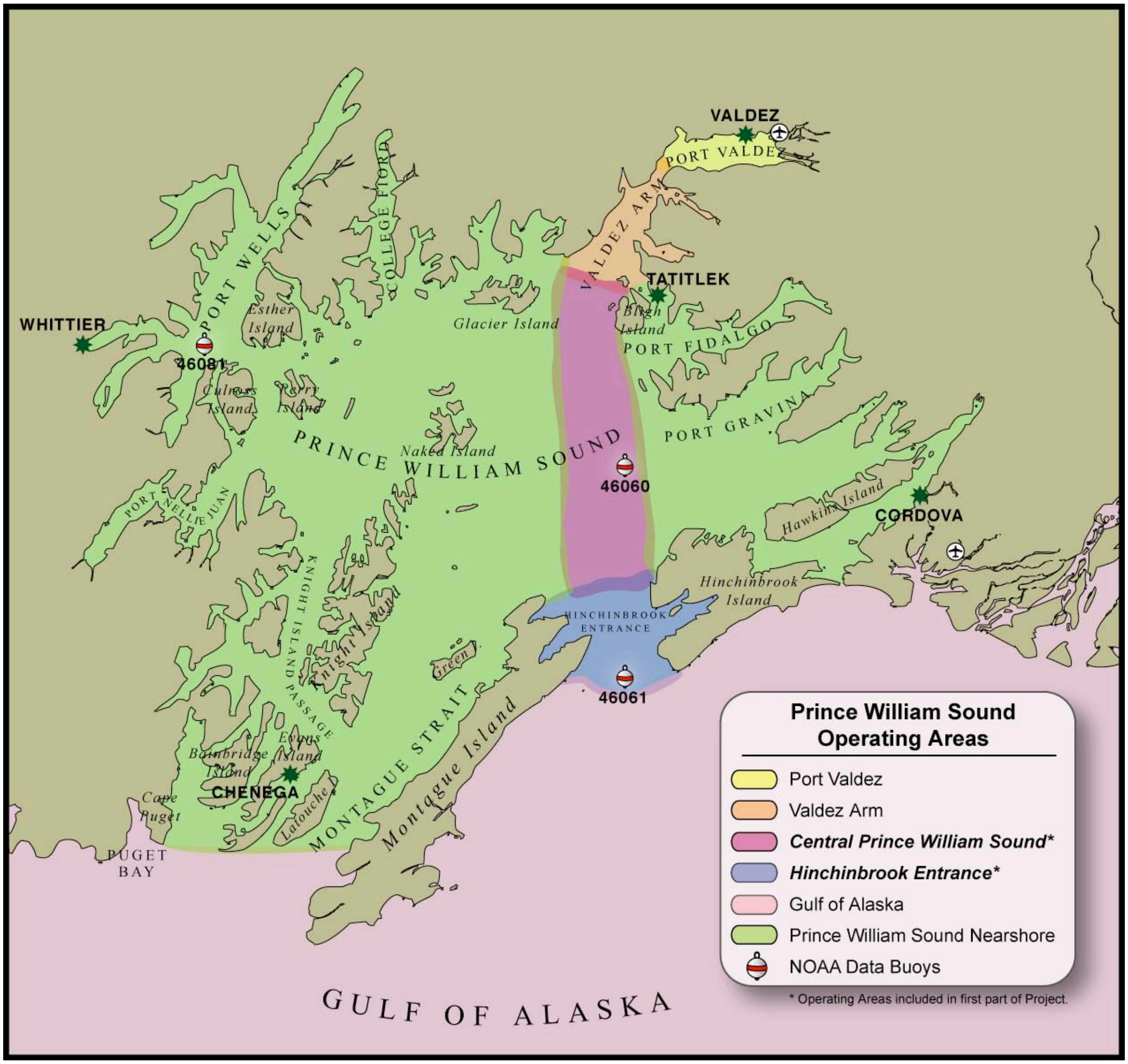
- Port Valdez,
- Valdez Arm,
- Central Prince William Sound, and
- Hinchinbrook Entrance.

We agree that these zones describe distinct operating areas and we would add two more:

- Gulf of Alaska outside PWS, and
- Nearshore areas in PWS that are away from the tanker lanes.

Figure 1 depicts the operating areas to be used in this study.

Figure 1. Prince William Sounds operating areas.

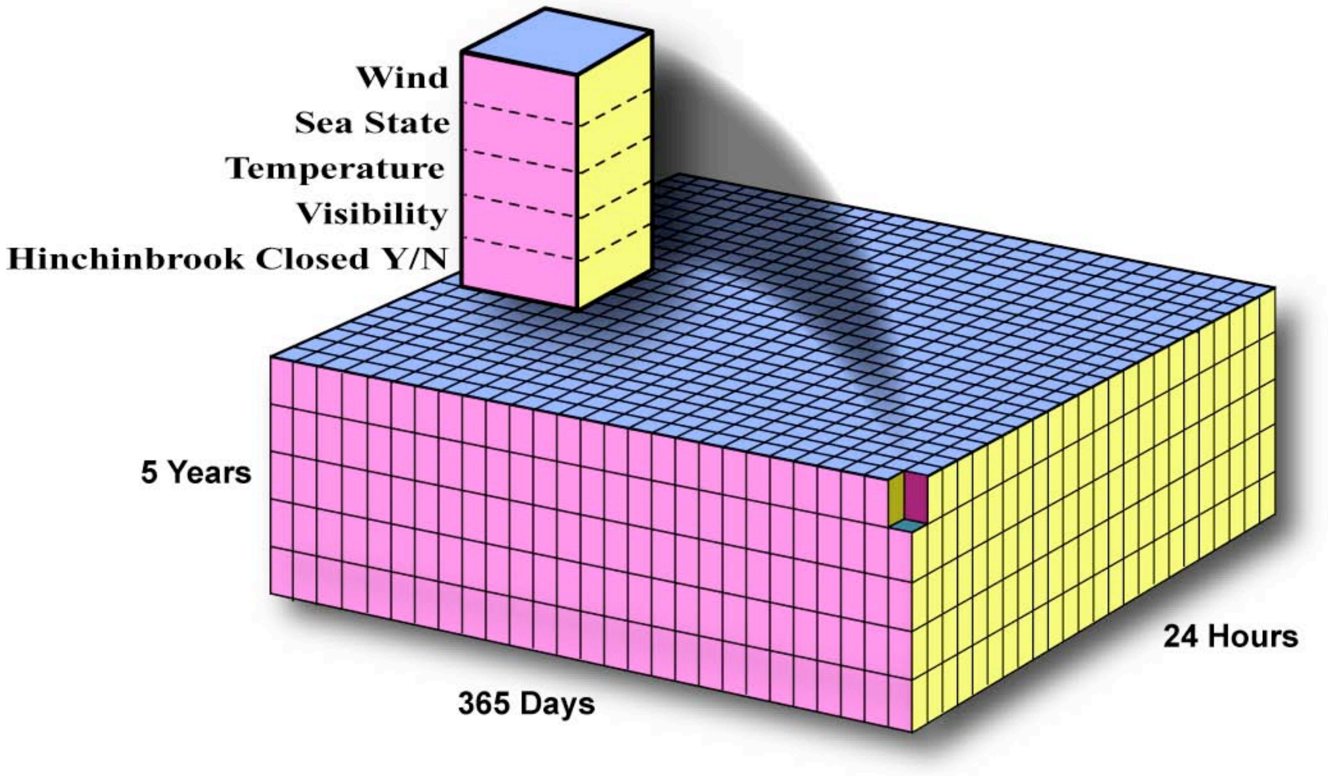


Of the six operating areas defined for Prince William Sound, only two have sufficient data readily available for analysis: Central Prince William Sound and Hinchinbrook Entrance. Data from the National Data Buoy Center's buoys 46060 (West Orca Bay) and 46061 (Seal Rocks) gives readily-available, accurate observations for wind speed, wave height, wave period, and temperature. Some visibility data is also available for these areas. We propose to limit the analysis to these two operating areas for this first phase of the project, then expand into other operating areas in subsequent phases.

Assembling a Dataset of Environmental Factors for Each Operating Environment

A dataset of environmental factors will be assembled for both of the selected operating areas. The temporal scope of the dataset will include the years 2001 through 2005. The dataset will consist of 5 years x 365 days x 24 hourly periods, for a total of 43,800 observational sets per dataset. Figure 2 depicts the size of the matrix for each dataset: 43,800 cells per dataset. Each cell of the matrix will contain observations for four environmental factors (whenever observations are available): wind, sea state, air temperature, and visibility.

Figure 2. The dataset matrix.



WIND

Wind observations for the two operating areas can be obtained from instruments operated by the National Weather Service (NWS), the National Data Buoy Center (NDBC), the Prince William Sound Science Center, and other sources. For this phase of the study, we will use wind speed (WSPD) observations from the NDBC buoys 46060 and 46061. Wind observations will be reported in knots.

SEA STATE

Reliable wave height and period observations for the two operating areas can be obtained from NDBC buoys 46060 and 46061. Significant wave height (WVHT) is calculated as the average of the highest one-third of all of the wave heights during the sampling period. Average wave period (APD) is the average of all waves during observational period. Because the short period waves are most detrimental to response operations, we will also record the Wind Wave Height (WWH) and Wind Wave Period (WWP) observations derived from the buoy data. Wind Wave Height is the vertical distance between any wind wave crest and the succeeding wind wave trough (independent of swell waves). Wind Wave Period is the time that it takes successive wind wave crests or troughs to pass a fixed point. Wave height will be reported in feet and wave period will be reported in seconds.

TEMPERATURE

Air temperature observations for the two operating areas is also readily available from instruments operated by the NWS, the NDBC, the Prince William Sound Science Center, and other sources. For this study, air temperature will be taken from NDBC buoys 46060 and 46061. Air temperature observations will be reported in degrees Fahrenheit.

VISIBILITY

Reduced visibility due to daylight/darkness can be computed from civil twilight tables. Reliable observations of visibility during daylight hours are difficult to obtain, so the only visibility restriction considered for this phase of the study will be due to darkness. Using only daylight/darkness visibility restrictions will result in a conservative estimate of the RG. Future phases of the project may account for visibility restrictions due to weather.

HINCHINBROOK STATUS

Each hourly set of observations in the matrix will include another piece of data. A flag will indicate if Hinchinbrook Entrance was opened or closed at the time of the observation. This information will be obtained from actual closure records obtained from the USCG. Observations for times when Hinchinbrook Entrance was closed will not be considered when determining the response limits.

Characterization of Environmental Factor Datasets

Once assembled, datasets will be analyzed to provide insight to the various environmental conditions found in the two operating areas. The following results will be presented in the final report:

- Histograms and cumulative-distribution plots of significant wave height (WVHT), average wave period (APD), wind speed (WSPD), wind wave height (WWH), wind wave period (WWP), and air temperature from buoys 46060 and 46061.
- Joint-probability-distribution plots of wind wave height (WWH), wind wave period (WWP): annual, winter, and summer.
- Analysis of buoys 46060 and 46061 as above when Hinchinbrook Entrance is closed.
- Histograms, cumulative-distribution plots, and statistical analyses of visibility based on the final visibility dataset.

Literature Review

It will be useful to review published and un-published reports concerning the operating limits of various response systems. Prior to establishing limits for this study, we will review relevant published literature and reports and assemble an annotated bibliography.

We are also interested in un-published reports, especially after-action reports from oil spill drills, exercises, trainings, and actual responses. Actual observations of the conditions where response systems become limited are much more valuable than tests on a single component of the system. We have made inquiries with the following organizations and requested information from after-action reports that would be useful in establishing response operating limits:

- Alaska Chadux,
- Alaska Clean Seas (ACS),
- Alaska Department of Environmental Conservation (ADEC),
- Alyeska Pipeline Service Company,
  Ship Escort and Response Vessel Service (SERVS),
- Australian Marine Oil Spill Centre,
- Briggs Marine Environmental Services, Ltd.,
- Burrard Clean Operations,
- California Department of Fish and Game,
- Canadian Coast Guard,
- Cook Inlet Spill Prevention and Response Inc. (CISPRI),
- East Asian Response Limited,
- Environmental Protection Agency (EPA),
- Global Salvage & Diving,
- Marine Spill Response Corp. (MSRC),
- National Ocean and Atmospheric Administration (NOAA), HazMat
- National Response Corp (NRC),
- Ocean Advocates,
- OHMSETT,
- Oil Spill Response Limited (OSRL),
- Oregon Department of Environmental Quality,
- PWS Regional Citizens' Advisory Council (RCAC),
- PWS Response Plan Group (RPG),
- Southeast Alaska Petroleum Response Organization (SeaPro),
- Shoreline Environmental Research Facility,

- SL Ross,
- US Coast Guard (USCG), and
- Washington Department of Ecology.

To date some of the organizations have indicated that they will not provide their reports or data on response limitations. Many more do not have their after-action reports organized in a fashion that allows them to provide any information on response limitation. We will continue to pursue after-action information on response operating limitations to assist in establishing response limits for this study.

Establishing Response Operating Limits

The most subjective part of this analysis is determining the response operating limits. Ultimately, the limits will be established based on the best professional judgment of the authors of this report.[26] Others may very well support other limits. However, we will attempt to base the limits on the most complete review of the published literature, existing contingency plans, regulatory standards, and after-action reports, with the objective of establishing realistic limits for the existing Open-Water Response System.

We propose to apply rules to sort each observation into one of four categories described in Table 4.

Table 4. Categories for observation analysis with examples for wind speed

Color Category	Criteria	Example
Green	Response operations not impeded	WSPD ≤ 19
Yellow	Response operations impaired	WSPD ≥ 20 but ≤ 28
Red	Response operation not possible or effective	WSPD ≥ 29
White	No observation for this period, ignore in further analysis	

The results of applying these rules to each observation in the dataset will be presented in the final report as histograms, cumulative-distribution plots, and joint probability distribution plots for each environmental factor.

Creating a Response Gap Index

Finally, a Response Gap Index (RGI) will be computed for each observational period based on an additional rule that will address the interaction of the environmental factors. RGI will be recorded as either Green (response possible) or Red (response not possible/effective). *Since an RGI will only be computed for observational periods when Hinchinbrook Entrance is open, the tabulation and analysis of the Red RGI will result in a reasonable estimate of the Response Gap.*

[26] The Glosten Associates will not be part of determining operational limits; they will be established by Nuka Research and Planning Group.

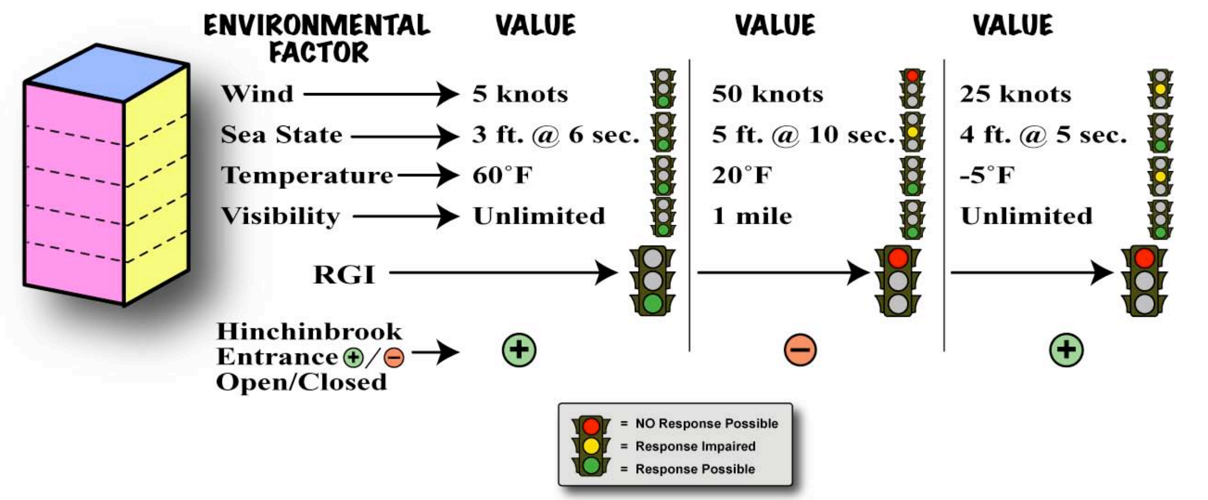
An example of such a RGI rule follows:

1. If any environmental factor is ruled Red, RGI = Red,
2. If all environmental factors are ruled Green, RGI = Green,
3. If only one environmental factor is ruled Yellow and the remainder are ruled Green, RGI = Green, and
4. If two or more factors are ruled Yellow, RGI = Red.

Other more specific rules might consider the interactions of specific environmental factors. Such as, if wind is Yellow and temperature is Yellow, RGI = Red; but if temperature is Yellow and visibility is Yellow, RGI = Green.

Figure 3 shows how this process might work.

Figure 3. An example of how a RGI rule might be applied.



Once the rule is applied, the RGI results will be summarized and presented as statistics, histograms, and plots: annual, winter, and summer. Additional analysis of the RGI data will indicate the frequency and duration of the events where RGI is Red.

Discussion

Accurately quantifying the Response Gap is a challenge because of data scarcity and the subjective nature of determining response limitations. We have chosen to use a hindcast of observations from known data sources that reflect actual conditions in two of the operating areas in PWS.

We are conducting a full review of literature and un-published reports, as well as interviewing key personnel. This data, combined with our actual field experience, will be used to establish operational limits that we believe to be realistic. However, we acknowledge that the limits are subjective and based largely on best professional judgment. This study should not be used to judge anyone's compliance with any law, regulation or rule. The purpose of the study should be solely to elucidate the Response Gap. Hopefully, this study will support efforts to reduce the gap or insure that adequate prevention measures are in place to minimize the risk of having an oil spill when no response is possible/effective.

We propose computational methods in an attempt to account for the interactions between environmental factors, the capability degradation curve, and provides an overall indication of the response capability for any observational period.

One finding from our work to date is that the environmental data is sparse in many areas. There have been many improvements in environmental monitoring in the past few years with the advent of relatively cheap telemetry systems. Still, more data is needed, particularly on waves and visibility. Observations from vessels promise to provide valuable information, especially in operating areas where no NDBC buoy exists. However, we have not yet been allowed to access the observation logs from the participants of the vessel escort system.

Another finding is that no one in the public arena seems to be collecting the kind of information that would allow quantitative evaluations on response operating limits. Given the large number of drills, exercises, and actual responses that have been conducted in the past 15 years, very little data has been collected on the effect of weather, sea state, and other factors on the response system. Such data are extremely valuable in conducting response gap analyses. Yet, this type of information has been difficult to find.

References

Alaska Department of Environmental Conservation. 2006. “Spill Tactics for Alaska Responders, DRAFT.”

American Society for Testing and Materials. 2000, “Standard practice for classifying water bodies for spill control systems. F625-94.”

ANVIL Engineering. March 1994. “HB567 Compliance Study.” Chapter 4 Process Engineering.

Arctic Environmental Information and Data Center and NCDC. 1988. “Climatic Atlas of the Outer Continental Shelf Waters and Coastal Regions of Alaska.”

DNV, George Washington University, and Rensselaer Polytechnic Institute and Le Moyne College. December 1996. “Prince William Sound Risk Assessment Study.”

Potter, Steve, ed. 2004. “World Catalog of Oil Spill Response Products.” SL Ross Environmental Research Ltd., Ottawa, Ontario, Canada.

Prince William Sound Tanker Owners/Operators. 2001. “Vessel Escort and Response Plan.”

Prince William Sound Tanker Plan Holders. 2002. “Prince William Sound Tanker Oil Discharge Prevention and Contingency Plan, Volumes I and II.”

The Glosten Associates. July 1994. “Prince William Sound: Disabled Tanker Towing Study.” prepared for the Disabled Tanker Towing Study Group, Anchorage, Alaska.

U.S. National Climatic Center. June 1978. “Summary of Synoptic Meteorological Observations (SSMO): Alaska Coastal Marine Area – Valdez Marine Area, Valdez, Cape Hinchinbrook.” Asheville, North Carolina.

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