Ship Simulation and Mariner Study of the Maritime Implications for Tank Vessels Utilizing Potential Places of Refuge, Mid-Prince William Sound Alaska

Prepared by:

Captain Jeff Pierce
Jonathan Pierce, Ph.D.
Safeguard Marine LLC
January 17, 2017

Prepared for Prince William Sound Regional Citizens' Advisory Council

Contract No. 8560-15-01

Executive Summary

Purpose: The purpose of this study is to assess the capability of tank vessels (tanker) in distress utilizing Mid–Prince William Sound Potential Places of Refuge (PPOR) that were determined in the Prince William Sound Subarea Contingency Plan. This study does not examine PPOR Knowles Head Anchorage, because it is currently utilized as an anchoring site for tankers. North Smith Island, Outside Bay, and McPherson as identified by the Contengency Plan are all examined.

Methods: This study utilized 16 interviews with local subject-matter experts and stakeholders, as well as 34 ship bridge simulations under the operation of professional mariners. Interview questions focused on three Mid-Prince William Sound PPOR, and simulations included a fourth alternative PPOR in the proximity to North Smith Island.

Recommendation 1. Both North Smith Island and the alternative location at North Smith Island should not be considered a viable PPOR as simulations of tankers consistently grounded.

Recommendation 2. Outside Bay should not be considered a viable PPOR for tankers as it is too close to a ten fathom curve, and does not provide a safe swing area for tankers at anchor.

Recommendation 3. McPherson Bay is a viable PPOR for tankers. The site allows enough swing area for tankers at anchor, and provides some protection from the majority of environmental conditions.

Recommendation 4. The PPOR identified in the Prince William Sound Subarea Contingency Plan in North and South Prince William Sound should be similarly assessed for their capability to provide potential refuge for tankers in distress.

Acknowledgements

We want to acknowledge the support provided by the following individuals and organizations: Mike Angove, an Alaska Institute of Technology (AVTEC) maritime simulator engineer, provided insightful knowledge and assistance concerning PPOR simulations. AVTEC's Maritime Training Center and Department Head Captain Terry Federer provided important support in the completion of the simulations conducted for this report.

The Prince William Sound Regional Citizens' Advisory Council has demonstrated great support by giving mariners a voice in the viability of PPOR for tankers in Mid-Prince William Sound. Their inclusiveness will increase mariners' ability to safely utilize PPOR, and will set a precedent of consultation and cooperation between mariners and the PWSRCAC.

We would also like to thank the research assistants that provided critical support and insight on this project: Katherine Hicks and Nicole Schmitt.

Finally, we would like to thank the local subject-matter experts who participated in the interviews and simulations. Their contribution is greatly appreciated.

Citing this Report: Pierce, Jeffrey D., and Jonathan J. Pierce. 2016. "Ship Simulation and Mariner Study of Maritime Implications for Tankers Utilizing Possible Ports of Refuge Mid-Prince William Sound". Prepared for Prince William Sound Regional Citizens' Advisory Council.

Questions, Comments and Requests for More Information

Captain Jeff Pierce
President Safeguard Marine
17321 Yellowstone Dr.
Eagle River, AK 99577
907-240-2149
safeguardmarinellc@gmail.com

http://www.safeguardmarinealaska.com/

Acronym List

ACP: Prince William Sound Sub-Area Contingency Plan

ADEC: Alaska Department of Environmental Conservation

ADF&G: Alaska Department of Fish and Game

AIS: Automatic Identification System

AVTEC: Alaska Institute of Technology

BRM: bridge resource management

CPA: Approximate Closest Point of Approach

ECDIS: Electronic chart display information systems

GPS: Global Positioning System

Mid PWS: Mid Prince William Sound

NMFS: National Marine Fisheries Services

PPOR: Potential Places of Refuge

PWS: Prince William Sound, Alaska

PWSRCAC: Prince William Sound Regional Citizens' Advisory Council

SERVS: Alyeska Ship Escort Response Vessel Service

SGM: Safeguard Marine

TAPS: Trans-Alaska Pipeline System

TSS: Traffic Separation Scheme

USCG: United State Coast Guard

US DOI: Department of the Interior

VTS: Vessel traffic services

Table of Contents

I. Introduction

The Trans-Alaska Pipeline System (TAPS) transports crude oil to the Valdez marine terminal in Prince William Sound, Alaska (PWS). Tank vessels (tankers) that transit PWS empty inbound and loaded outbound, provide an essential link for the transportation of crude oil from Alaska. Throughout this process, tankers transiting within PWS may be stricken, requiring a Potential Place of Refuge (PPOR) to await and accept assistance. A PPOR is defined by the Prince William Sound Subarea Contingency Plan as, "a location where a vessel needing assistance can be moved to, and where actions can then be taken to stabilize the vessel, protect human life, reduce a hazard to navigation, and/or protect sensitive natural resources and other uses of the area."[1] The Contingency Plan contains a list of PPOR to reference in an emergency. While a PPOR may include constructed harbors, ports, natural embayments, potential grounding sites, or offshore waters, the actual designation of a PPOR is an incident and circumstance-specific decision made by the US Coast Guard Captain of the Port for Prince William Sound, and may not be a pre-identified PPOR. To determine the maritime feasibility of tankers anchoring at proposed sites, Safeguard Marine performed a maritime analysis of three PPOR within Mid-Prince William Sound. These PPOR are North Smith Island identified by the ADEC as A36 and in this report as PPOR 1, Outside Bay identified by the ADEC as A37 and in this report as PPOR 2, and McPherson Bay is identified by the ADEC as A38 and in this report as PPOR 3. In addition, we identified an alternative PPOR at North Smith Island and we identify this alternative PPOR as PPOR 1 SGM North Smith Island.

Two different forms of data collection were used to assess three PPOR in Mid-PWS identified for analysis. Safeguard Marine conducted 16 interviews with local maritime experts and stakeholders regarding PPOR and maritime conditions within PWS. Additionally, expert mariners conducted 34 ship bridge simulations to anchor stricken tanker models in various environmental conditions at various PPOR. Results of the simulations, which include semi-structured interviews with the mariners who operated simulations, were compiled to determine the feasibility of each PPOR to provide refuge for stricken tankers.

This report provides information regarding the (1) background (2) pre-simulation interview methodology and results (3) simulation information (objectives, methodology, vessel characteristics, environmental conditions, and physical characteristics of studied PPOR), (4) simulation results, (5) conclusion, and (6) two appendixes with further information on simulated PPOR sites and exit interviews.

[1] United States, State of Alaska, Department of Environmental Conservation. (July, 1997). *Prince William Sound Subarea Contingency Plan*.

II. Background

The objective of this study is to analyze the maritime implications for TAPS tankers under distress anchoring at Mid-PWS PPOR. Responding to an emergency such as a fire, a vessel losing power, or a structurally damaged tanker requires immediate action. The U. S. Coast Guard Captain of the Port Prince William Sound has jurisdiction over approving temporary mooring or anchoring locations for leaking or damaged vessels within the PWS subarea. The actual designation of a PPOR will always be an incident-specific decision made by the US Coast Guard Captain of the Port for PWS.

The waters of PWS are very deep, limiting the number and availability of safe anchorages for large deep draft tankers.[2] Anchorage locations for large tankers frequenting PWS require (1) adequate water depth and swinging room, (2) suitable holding ground and (3) protected from weather. These three criteria related to anchorage locations within Mid-PWS are difficult to accommodate because water depth is not commonly conducive for anchoring without being too close to shore lines.

Some PPOR within Mid-PWS have been identified in the Prince William Sound Subarea Contingency Plan, last updated in 2014 and authored by members of the Prince William Sound Subarea Committee as part of the Alaska Department of Environmental Conservation (ADEC). Authors included numerous federal government, state government, local government, tribal, local subject matter and industry participants.[3] The report identifies 21 PPOR for vessels greater than 20,000 gross tons. Six of the 21 identified PPOR are not relevant to this study because they are located in western PWS, outside of normal tanker traffic lanes. An additional seven PPOR do not require examination because they are regularly frequented by tankers, and their limitations and capabilities are already well known to mariners. Eight possible PPOR have been identified for further study and have been divided by geographical locations of North, Mid, and South-PWS. This study focuses on three identified PPOR for Mid-PWS. They are: North Smith Island Anchorage, Outside Bay, and McPherson Bay Anchorage. After simulating anchorage at the North Smith Island location identified in the Contingency Plan, Safeguard Marine identified an alternative location in the North Smith Island area, and simulated anchorage at that site, referenced as PPOR SGM 1.The charts for these PPOR are located in the attachments, identified as Figure 1. PPOR 1 North Smith Island Anchorage, Figure 2. PPOR 1 SGM North Smith Island Anchorage, Figure 3. PPOR 2 Outside Bay Anchorage, and Figure 4. PPOR 3 McPherson Bay Anchorage.

Safeguards for Tankers Transiting Mid-PWS

Safeguarding PWS from maritime emergency is of the utmost importance to all public, private, and government stakeholders operating in the region. Ship technology, design, operations, emergency response processes, and traffic control systems contribute to this effort.

Multiple technological tanker movement safeguards have been implemented within PWS in the last twenty-five years, including electronic upgrades such as Global Positioning System (GPS), and Differential GPS (minimizes error within GPS receivers PWS). The United States Coast

[2] National Oceanic and Atmospheric Administration. (2010). Chapter Four. *Coast Pilot 9.*
[3] United States, State of Alaska, Department of Environmental Conservation. (1997, July). *Prince William Sound Subarea Contingency Plan*.

Guard (USCG) Vessel Traffic Service (VTS) monitoring capabilities have updated their radar and communications network, and also utilized shore based ice radar. Automatic Identification System (AIS) automatic tracking systems are used aboard ships and by VTS for identifying and locating vessels by electronically exchanging data with other nearby ships and VTS. Electronic chart display information systems (ECDIS) creates electronic display of nautical charts, providing real time data of a ship's position, heading, and speed. Radar system upgrades including advanced collision avoidance systems and the ability to integrate ECDIS information into a radar systems provide navigators a radar picture and nautical chart overlay with actual speed and course of ships over ground. Additionally, communication capabilities have improved and expanded to include cell phone networks and satellite telephone systems. Ship construction has also improved to safeguard crew and cargo with double hull tank design, providing significant protection from penetration of oil laden tanks. Finally, ship operators have dramatically increased crew training, and have implemented extensive bridge resource management (BRM) techniques among other safety training.

Emergency response is also paramount in PWS safeguard policies. Alyeska created a Ship Escort Response Vessel Service (SERVS) to provide extensive oil spill response capabilities throughout PWS. This service also includes an oil tanker escort system, in which loaded tankers are escorted by two large horsepowered tug boats throughout their transits of PWS.[4] To account for this process, this study required two large tug boats to be within close escort of loaded tankers at all times during simulations.

Tankers transiting Mid-PWS operate within a Traffic Separation Scheme (TSS), where traffic lanes indicate the general direction of the ships in that lane, and ships navigating within a TSS all sail in the same direction. When crossing lanes, vessels cross in an angle as close to 90 degrees as possible. Mid-PWS traffic lanes are a significant distance from shore and other known hazards. Approximate Closest Point of Approach (CPA) for outbound loaded tankers operating within the outbound traffic lanes to shore are: Glacier Island 2.3 miles; Bligh Reef 3.5 miles; Naked Island and Smith Island 8.5 miles. Approximate CPA for inbound tankers operating within the inbound traffic lanes to shore are: 2.0 miles Bligh Reef; Goose Island 6.0 miles. Ice from Columbia Glacier within TSS has significantly declined due to the distance is has to travel to enter the lanes. Valdez VTS monitors the TSS and provides updates pertaining to one-way zones that may have been implemented due to ice in the area.

Scope of Anchor Chain and Swinging room

The scope of the anchor chain is the ratio of the amount of chain deployed at anchorage compared to depth of water. Scope is determined by the following equation, S= L/D, in which S= scope; L=Length of anchor chain; D= Depth of water. Anchoring with appropriate scope for the specific situation is an important factor to maximize holding power of the anchor gear. Anchor gear holds better when forces are horizontal, for when strain increases, the anchor chain tends to lift off the bottom, creating a larger angle and reducing the holding power. Even a slight angle increase results in significantly decreased holding power; a five degree increase reduces holding power by 25 percent, and a 15 degree increase reduces holding capability 50 percent.[5] The

---

[4] Mitchell, V., Carney, P., Randall, G., Jones, T., Hyce, L. (2001). *Escort Tug Analysis for Oil Tankerships in Prince William Sound and the Gulf of Alaska.*

[5] Spencer, C. (2008). Standard Safety. *The Standard, Anchoring- Special Edition*.

optimum amount of scope is dependent upon several factors, including environmental conditions, wind and current, length of time to remain at the anchor, holding ground, and swinging room for the vessel.

The scope of chain compared to water depth, plus ship length creates the swing area where the tanker may swing around the anchor depending upon environmental conditions. Tankers seeking a refuge at a PPOR will deploy a significant amount of scope to assure that the vessel maintains the anchor position. Research suggests that a scope of less than five or six to one is adequate, but the recommended scope ranges from 7:1 to as great as 10:1.[6] [7] [8] Other research suggests that the required scope is 3.5 to 4 times the depth, 5 times if possible.[9]

Multiple prerequisites or guide lines concerning a PPOR were established by the Alaska Regional Response Team to consider the type and size of the vessel seeking refuge and their required "swing room" relative to specific PPOR. Considerations include weather limitations, adequate water depth at mean low tide, navigational approach, vessel traffic and associated risks, pilotage requirements, anchoring depth and ground, and suitable docking facilities.[10] Designated tanker anchorage sites within PWS, Knowles Head Anchorage, and south of Knowles Head provide sufficient water depths of 15 to 26 fathoms, and provide good holding ground with a mud bottom, adequate swinging room for several ships at anchor, and shelter from northerly weather. This study does not examine Knowles Head Anchorage, because it is currently frequently utilized as an anchoring site for TAPS tankers.

---

[6] Ibid.

[7] Burden, T. (n.d.). Selecting an Anchor Rode. In *West Marine*.

[8] Irons, J. (2013, March 13). The Most Critical Factor in Anchoring? Scope!

[9] McDowall, C. A. (2000). *Anchoring large vessels: A new approach*.

[10] United States, Alaska Regional Response Team. (2013, September). *Guidelines for Places of Refuge Decision-Making*.

III. Pre-Simulation Interview Methodology and Results

Interview Methodology

Prior to conducting simulations, Safeguard Marine conducted 16 interviews to assure accurate ship simulations, and better understand the capabilities of pre-identified PPOR to provide refuge for stricken tankers. Interviews were conducted via the telephone by the co-primary investigators, and notes were taken by designated recorders. The interview notes were then emailed to the interviewees to verify their accuracy and invite further comment. Safeguard Marine conducted confidential interviews with individuals from the following organizations Southwest Alaska Pilots Association, ADEC, active and retired TAPS industry representatives, active TAPS ship captains, retired ship captains from TAPS trade, retired PWS assist tugboat operators, US Department of Interior, Prince William Sound Regional Citizens' Advisory Council representatives, previous PPOR study facilitators, Alaska Fish and Game, and National Oceanic and Atmospheric Administration (NOAA). Representatives from Alyeska and SERVS and shipping companies involved with TAPS and Crowley (tug boat assist) refused to participate in this study. These interviews are confidential as per human subjects protocol, so identifiable information such as names or organizations are not associated with individual responses. Instead, respondents are associated with a number such as "Respondent 1". This is the case except for the USCG, who requested that their written responses to interview questions explicitly be associated with the organization.

More than five active and retired mariners involved with TAPS trade shipping were also consulted. After reviewing the interview documentation from interview participants, these local subject matter experts provided feedback on the study, and contributed important maritime perspective. This was not a formal interview, but rather provided background information. These interviews were aggregated and identified below in the results as Respondent 13.

Interview Results

The key finding from the interviews was that the proposed simulations were sufficient to determine the capability of TAPS tankers in their utilization of Mid-PWS pre-identified PPOR. In addition, respondents agreed that the mariners chosen to take part in the simulations were appropriate experts for this research. Interviewees also provided important information about concerns and context regarding the PPOR that were assessed in this study.

Interview responses are summarized, by interview question, below.

Question 1: Would you anticipate a stricken vessel to utilize the PPOR identified? If not, why?

Responses to this question were highly diverse. Five mariners and the group of consulted experts responded that they would *not* anticipate a stricken vessel to utilize the North Smith Island PPOR, and the majority also responded "no" for PPORs Outside Bay, and McPherson Bay Anchorage. Mariners identified various reasons for their rationale, including the concern that the area had minimal sea room available for maneuvering, especially compared to the designated anchorage for PWS and Knowles Head (Respondents 1, 2, 5, 6, 8, and 13). "Why would I risk my ship further by entering confined waters?" responded one interviewee, "the personnel aboard may be endangered if we were to flounder with restricted maneuverability in confined waters."

Another interviewee stated that they did not anticipate vessels using any of the PPOR because they have “never been used before,” and because Knowles Head Anchorage is “superior.” Another respondent said they would, “strive to make it to Knowles Head unless there is absolutely no chance of making it there. It's all [they] have ever known, and Knowles Head is the designated anchorage in PWS. Assist boat or no assist boat, [they] would avoid anchoring in bays of Naked Island or near Smith Island unless there is a pilot to assist. An anchorage area which is more wide open would be possible if there is no chance of getting to Knowles Head.” Another respondent who answered “no” elaborated that, “Outside Bay is the only one that should be identified as a possible port of refuge for Mid-PWS.” Finally, one respondent noted that they are, “more in favor” of taking a vessel to Knowles Head Anchorage, or further out into the ocean than a PPOR in order to avoid the spread of a spill; “unless a leak is severe, a PPOR should not be used.”

Respondents 9, 10, 11, 12, 14, 15, and 16 responded that they *did* anticipate usage of the pre-identified PPOR. The USCG summarized this sentiment by stating, **“**Yes, the PPOR list is the product of a significant amount of research and coordination with numerous involved agencies and stakeholders. There is a great deal of value in this information that mariners take very seriously and consult as a starting point for planning where to position a stricken vessel. Please bear in mind that there are a wide variety of factors (e.g. wind, seas, tide, currents, vessel condition, location, time of year, etc.) that the mariner would consider before deciding where and how to position a vessel, which might not be at a place identified as a PPOR.”

Question 2: Can you recommend other PPOR that may be adequate for Mid-PWS that are not identified?

The majority of respondents stated that they did not have an alternative PPOR for Mid-PWS (Respondents 1, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16). Knowles Head Anchorage was mentioned as a possibility, however the site is not within the scope of this study due to the frequency with which tankers already utilize the anchorage. Some of the respondents did mention specific sites other than the three identified, such as the Two Arm Bay/Port Fidalgo, the area east of Goose Island in the old steam ship channel between Goose Island and Bligh Island, and a site south of Rocky Point. The USCG responded that, “At this time, [they] could not recommend a PPOR that isn't listed in the Prince William Sound Sub-Area Contingency Plan (ACP) without discussing the decision with stakeholders and partner agencies…the PPOR identified in the ACP is a product of much research and stakeholder coordination. Additionally, the prevailing conditions (wind, seas, tide, currents, etc.) in the maritime environment are quite dynamic. Depending on the situation, the Coast Guard would coordinate with the same stakeholders/partner agencies to consider using a PPOR that is not listed in the ACP.”

Question 3: Utilizing PPOR as portrayed within the attachment, do you foresee any difficulty maneuvering ships to any of the specific PPOR? If yes, please specify.

Three respondents did not foresee any difficulty maneuvering the ships into the PPOR (Respondents 1, 9, and 10), but most of the respondents stated that maneuverability depended upon the circumstances of the specific situation, especially during high winds (Respondents 2, 3, 4, 5, 6, 7, 8, and 13). One repsondent stated they, “do not foresee difficulty at low wind speed, but [they] do see a variety of difficulty at high wind speed due to a variety of environmental factors. This all depends on the causality of the ship.” Another respondent also noted that PPOR

1 (North Smith Island) is, "a little close for comfort" to jagged rocks. The USCG summarized the majority of respondent sentiment by stating that maneuverability depends on a number of factors, including, but not limited to the weather conditions at the time of the incident, and vessel propulsion and/or steering capabilities**.**

Question 4: If a ship required grounding to prevent sinking, which of the PPOR would be recommended?

The majority of respondents did not recommend PPOR 1 North Smith Island, but did endorse the possibility of grounding in PPOR 2 or 3. One respondent noted that PPOR 1 would "not work" for this scenario. The other two sites were mentioned as possibilities for grounding, depending on the specific situation at the time. Utilizing Outside Bay (PPOR 2) was recommended, as long as the vessel was moved "further to the south of the designated PPOR site" (Respondents1, 3, 5, 9, and 10). One respondent wanted to know if the vessel would be loaded or light, but reflected that, either way, the vessel should likely "shoot for the south portion PPOR 2." This respondent also said that context, such as environmental conditions, could "affect their answer." Another respondent stated that PPOR 2 could be feasible, as long as the vessel is "pushed further in." Respondents 2, 3, 5, 6, 8, and 10 mentioned the possibility of grounding a stricken vessel in McPherson Bay (PPOR 3), particularly on the south end because it, "provides the most shelter" and could most effectively contain an oil spill.

Overwhelmingly, respondents reflected that a grounding decision must consider an array of conditional factors, and that a PPOR in "lee of the wind and weather" would be preferable. Put most comprehensively by the USCG, "wind, seas, current and tides would impact the decision. In addition, time of year, presence of protected or endangered species, and spawning, nesting, migratory patterns of mammals, fish, birds, and other wildlife would have to be considered when making this critical decision. It should be noted that information would be sought from US DOI/NOAA/ ADF&G/ NMFS regarding all of the above concerns to assist with the PPOR decision."

Question 5: Which ship type or casualty type do you think simulations should be concentrated upon to best determine the capability of the selected PPOR to provide adequate refuge?

The majority of all the respondents desired that the simulations model anchoring a holed tanker or a disabled tanker in a variety of environmental conditions. Respondents particularly encouraged simulations of vessels "involved in a collision or holed in any way", vessels experiencing a "loss of power and loss of steering", and vessels with a "gash across the side or bottom of a ship in which a leak would be fast moving and destabilizing, thus forcing the ship to run aground." Respondents 4, 5, 6, 8, 9, 10, 11, and 13 all stated that the most common casualty type would be a disabled tanker, and should thus be a focal point of the simulations. Respondents 3, 4, 5, 6, 7, 8, 9, 10, and 11 also stated that they would like to simulate a "total failure in which towing is required to get ship into PPOR."

Question 6: In the simulations, we will be comparing single propeller with twin propeller capabilities (reference Table 2), what do you expect will be the results?

A vast majority of respondents stated that vessels with two propellers will have more maneuverability than single propeller because of redundancy and the availability of one propeller for maneuvering. One respondent expected “superior maneuvering capability” from twin propellers, noting that redundancy is helpful if one propeller becomes dysfunctional. Other respondents echoed this sentiment, stating that “with two propellers, losing one would still mean that one would be operational because of redundancy,” and “twin propellers result in fewer issues because one is still useable in the event of the failure of the other.” Respondents 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, and 13 all expected twin propeller capabilities to have a higher success rate of reaching the PPOR in simulations.

Question 7: Do you believe that more than two assist tugboats will be required to maneuver any of the stricken vessels being simulated into the identified PPOR? What about during high wind conditions?

The majority of all respondents believed that a third tug boat assist should be available, depending on mariner input, and that they would wait for sufficient tug boat assist prior to entering a PPOR. Many respondents believed that larger sized tankers were more likely to require three tug boats, just as they require three tug boats for maneuvering at TAPS terminal. One interviewee responded that more than two tug boats would “not be required” for a ship of smaller size, but that three tug boats should be used for larger ships, especially for “higher winds or large laden ships.” Another respondent stated that three tug boats should be used for “anything over 150,000 tons.” Participants repeatedly stated that the mariners directly involved in the process should determine the number of tugboats. One interviewee noted that the power of the vessels is a big deciding factor, considering that “sometimes more tugboats can get in the way.” Mariners also reflected that the need and number of tug boat assist depends on whether the vessel is laden or light. Regardless, one interviewee encouraged “a lot of sail” in either of these situations. Respondents also considered currents, and requested that the most extreme current situations be simulated. Respondents 2, 3, 4, 5, 6, 7, 8, 9, 10, and 11 wished to see a simulation in which two tug boats are used until they fail, in order to see if a third is needed.

Question 8: Based upon the category of high wind direction and velocity (reference Table 5) would you recommend a stricken ship not use any of the identified PPOR to be simulated?

Multiple respondents recommended not using any of the identified PPOR during high winds (Respondents 1, 2, 6, 8, and 13). Among their comments, respondents stated that “none of the PPOR are to be used in high wind,” and that “any ship not under tight control should stay in the traffic lane or head to Knowles Head Anchorage rather than use any of the three PPOR.”

PPOR 1, North Smith Island, was specifically identified by respondents 3, 5, 7, and 13 as being problematic during high winds because of the site’s close proximity to rocks and limited swinging room. Respondents described PPOR 1 as being “inadequate”, “not recommended in high wind situations”, and having high “general exposure to the elements.”

Question 9: Depicted winds for specific PPOR result in windward shoreline anchoring. Is this appropriate or should alternative PPOR or leeward shoreline be utilized?

The majority of respondents believe that windward shoreline anchoring to be undesirable, and recommend instead that the leeward shore should be utilized. Respondents described the windward shore as “inappropriate”, and overwhelmingly recommended that leeward anchoring “always be used” (Respondents 1, 2, 5, 6, 7, 8, 9, 10, 11, and 13). One respondent elaborated to say that shoreline anchoring depends on level of control, but that a windward shoreline is “not recommendable either way.”

Other respondents answered that a specific PPOR is inadequate, such as PPOR 1. One respondent reflected that “a PPOR needs to be a place where a ship can be anchored safely with minimal damage. In light of this, PPOR 1 is unacceptable.” One interviewee requested a survey of the bottom be completed to determine the anchoring capabilities of each PPOR, and another requested that higher winds to be utilized in the simulation to test extreme docking conditions.

Question 10: Do you have any specific simulations you wish to see performed based upon the specific three proposed POR?

Many of the respondents did not identify specific simulations. Some respondents requested that the vessel conditions of sinking ships that require grounding be analyzed (Respondents 3, 6, and 8). One of these respondents reflected that, though they would like to see a sinking ship grounded in PPOR 3, they were skeptical that, “any of the PPOR would be used in reality.” That being stated, the respondent expressed a strong interest in knowing how and where to ground a ship if an emergency situation were to occur. The only specific recommendations were simulations in which the whole length of a ship’s side is open, and a situation in which a rudder is jammed hard over.

Question 11: Based upon information provided, do you have any input concerning best practices to be performed during simulations?

Respondents answered with various recommendations, ranging from specific environmental inputs to the type of causality for ships and the number and types of tugboats utilized. Regarding environmental inputs, respondents requested “higher winds and reduced visibility as a result of conditions such as severe fog and other environmental factors,” and grounding in a “variety of conditions.” Many respondents also commented on casualty type for ships, with requests to simulate the “most extreme conditions” and a “variety of casualties” involving a sinking ship. One respondent suggested the possibility of a ship on fire, or a vessel influenced by an act of terrorism that may cause marine casualties. The respondent reflects that these “out of the box situations” are exactly the situations in which a Contingency Plan is used. Finally, regarding tugboats, respondents reflected that, if a vessel was truly stricken, “all tugboats in the area not otherwise engaged would come to help anyway.” Another interviewee requested that the study include “three yellow boats, and no conventional tugboats.”

Additional Questions for Regional Stakeholders

In addition to the simulation specific questions above asked to mariners, SGM also conducted interviews with representatives from stakeholder organizations listed in the Prince William Sound Subarea Contingency Plan, which include: US DOI, NOAA, ADEC Prevention and Emergency Response Program, Alaska Department of Fish and Game, and the PWSRCAC.

What is the role of your agency in relation to PPOR?

All five respondents provided concise answers concerning their agency's involvement in determining PPOR for stricken vessels. Emphasis was placed upon the term "possible" places of refuge, stipulating that any place may be designated as a PPOR depending on the specific situation and pertinent circumstances. One respondent summarized this point by emphasizing that, "the actual location of a PPOR is not limited to the pre-identified PPOR listed in the Contingency Plan. The pre-identified sites are *potential*, not predesignated, and the unified command is not bound to use a pre-identified location in the case of an emergency."

Each respondent stated that multiple agencies would be involved and consulted prior to the designated place of refuge being determined. These agencies include the Alaska Department of Fish and Game, NOAA, US Forest Service, Citizen Advisory Councils, Native Corporation(s) and Federally Recognized Tribes in the area, as well as the Coast Guard and the ADEC. The ADEC works with the Captain of the Port and resource trustees to, "determine the sensitivity of a proposed PPOR location with regards to impacts on the environment, wildlife, local, cultural, and the economy." If a spill was to occur, the environmental unit of the unified planning command would, "invite [resource trustees] to review PPOR closely, and comment/recommend sites for minimal environmental damage." In the event of an emergency, the state onsite coordinator works with the USCG Captain of the Port to, "determine the specific needs of the incident, such as the safety of the crew, safety of the vessel, state of the vessel, and what activities will need to take place in the PPOR to address the problem." Another respondent seconded this sentiment, noting that, "the state onsite coordinator is very involved with the Captain of the Port to determine these needs, and to weigh them against the environmental, cultural, and economic sensitivities of the area."

Ultimately, each respondent identified the Unified Command as the highest authority in determining a PPOR. "All POR are in state waters," states one respondent, "and ultimately the Unified Command has the final decision on where a vessel should go in the case of an emergency." Another respondent reflected that, "under international maritime law, the Captain of the Port has the authority to direct a vessel operating in their area of responsibility to go anywhere in their jurisdiction…ultimately, the state onsite coordinator supports the Captain of the Port's decision to relocate a vessel to the determined location." While one respondent expressed interest in a process whereby marine mammal and habitat experts could conduct an in-depth review of many PPOR prior to a spill event, the agency can only, "logistically assess a handful of PPOR at a time." Therefore, agencies await consultation from the Unified Command in an emergency, and provide information on the "many variables" impacting where a vessel should seek refuge.

In terms of research, what should SGM focus on from a maritime standpoint? What information would you like to see in SGM's final report?

One respondent provided specific maritime conditions they wished to be researched, which included loss of power, reduced maneuverability, and hull damage to a vessel that results in hull and/or cargo space flooding.

Two respondents wished to see a focus on the environmental impacts of specific PPOR. One respondent stated that, "the environmental implications are extremely important and, though they may not be simulated in this project, they should be considered in assessing the PPOR." This respondent also suggested that environmental issues be considered by involving the various natural and cultural specialist organizations in research interviews. When determining PPOR, pre-identified or otherwise, one respondent noted that it is important to assess known consistent pinniped haul out and rookery haul outs for harbor seals, and critical habitat and rookeries for stellar sea lions. Additionally, the agencies that oversee federal fisheries should be consulted to ensure they are protected.

Respondents also focused on the process for determining a PPOR in an emergency situation. One respondent stressed that the Alaska Unified Plan has “Places of Refuge Guidelines” that outlines the process for determining where a vessel seeks refuge. There are pre-identified places, but depending on the vessel, product, time of year, operational needs, and other conditions, a vessel may consider a place that is not on the pre-identified list. The respondent acknowledged that this planning process may be outside the scope of this project, but that the process for identifying a place of refuge— pre-identified or not—should also be considered when discussing PPOR in PWS. This respondent offered to provide environmental information for the simulations, and emphasized that it would be helpful to have a summary of the criteria for deciding a PPOR. In real events, the respondent noted that sometimes a place that is not listed on the pre-identified list of PPOR may be the most environmentally safe and reasonable PPOR. There are also different levels and priorities of critical habitat, which would be considered in-depth during the unified planning process.

Respondents varied in their opinions on the importance of vessel maneuverability and docking feasibility in determining a PPOR. For example, one respondent noted that, “some PPOR are chosen almost exclusively for their protective environmental factors, such as natural wind shelter, etc”, and another stated that, “the original process for determining pre-identified PPOR started from a feasibility perspective and then expanded to consider environmental implications through the involvement of natural and cultural resource specialist agencies.” This suggests that the vessel's maneuverability is thoroughly considered when determining a POR, and was at the forefront of the process at its inception.

However, a different respondent noted that, “though the simulations have various vessel configurations, redundant propulsion systems, redundant steering, etc, there is no discussion of how those variables would impact a PPOR in the PPOR guidelines.” In this sense, the respondent reflected that the simulations may not be answering a valid question because the variables that the simulations are testing are not considered in the PPOR determination process. The respondent also questioned simulation protocol in utilizing assist tug boats, because they are only available in Cook Inlet and PWS. “The concept of as assist vessel is unique to PWS and the Cook Inlet,” said the respondent. However, the majority of respondents, including the USCG, noted that the feasibility of docking at a PPOR *is* an important consideration when determining a POR (see response to question three above).

Do you have any additional context or information about the PPOR you would like to include? Do you have any additional comments or questions that we should be aware of?

Each respondent reflected on the process for determining PPOR under the unified plan, and emphasized the importance of considering environmental implications in this process. Respondents consistently emphasized that, though the Unified Plan lists *potential* POR, vessels are not limited to these specific locations. “The Alaska Unified Plan Places of Refuge is a process,” stated one respondent, “a vessel may not use a pre-identified PPOR if circumstances warrant an exception." Ultimately, the Subarea committee drives and determines the PPOR for a region. "The damage, timing, and accessibility of the situation all factor into the determination of where you should go to have a safe fix," concludes one respondent. Interviewees also consistently referenced the environmental implications of utilizing a PPOR. "The environmental impact should be a strong consideration when assessing PPOR in the region," stated one respondent, and another was "happy to hear" that multiple agencies were consulted in this process, especially state and federal agencies operating in PWS. One respondent encouraged a, "public and agency review of the PPOR determination process" to ensure that all relevant variables are considered when assigning a PPOR.

IV. Simulation Information

Objective

The objective of the simulations was to assess three PPOR in Mid-PWS for their ability to harbor stricken TAPS tanker vessels.

Simulation Methodology

Thirty-four simulations were conducted with two simulators from Kongsberg's "Polaris Ship's Bridge Simulator" at the Alaska Vocational Technical Center (AVTEC) Marine Training Center in Seward, Alaska. These simulators have been certified by the U.S. Coast Guard for instruction and training.[11] The simulations occurred over a period of two days, between October 14th and 15th, 2016. The simulations were supervised and administered with the assistance of Mike Angove, a maritime simulator technician who has been educated by Kongsberg to operate the simulator. Prior to the simulations being run, a pre-test of the simulations was conducted by Safeguard Marine on October 6th, 2016. This pre-test is used to determine the most effective and efficient process for conducting the simulations. For example, it helped determine the starting position for the simulations at 0.5 miles from the PPOR, the amount of line out from the forward and aft tug boats, and the approximate amount of time it would take to complete each simulation. The pre-test was conducted by Captain Jeff Pierce in collaboration with AVTEC technician Mike Angove.

Captain Pete Garay and Captain Jeff Pierce conducted the simulations. Both are active Southwest Alaska Pilots possessing extensive ship handling experience in operating TAPS trade ships and other vessels. Captain Garay graduated from the California Maritime Academy and has gained experience as a sailing captain and mate on the Alaskan West Coast since 1981. He has been piloting in Alaska for 25 years. Captain Pierce has a BS Nautical Industrial Technology from California Maritime Academy. Captain Pierce holds instructor certificates from USCG and Standards of Training, Certification and Watchkeeping, and is a licensed maritime pilot holding federal licenses for all Puget Sound and South Central and Western Alaskan waters. Captain Pierce has been an Alaskan State licensed pilot for South Central Alaska for over thirty years. Over fifty-five years of combined Alaska maritime experience was represented during the simulation process.

In total, 34 simulations were performed utilizing two different simulators. Each pilot acted as the operator for each simulator, and a simulator engineer monitored each simulator from within a control room. A recorder took notes during some of the simulations on an experimental basis, and exit interviews were conducted immediately after each of the specific simulations were completed. The pilots were shown a screenshot capturing the vessel's position every three minutes in the debrief room. After the ship anchor was deployed, each simulation was accelerated to ten times real time. This was done to display the ship's movement after anchor deployment for one hour of real time. This was shown in the screenshots to ascertain the ship's location after swinging and surging on its anchor.

[11] For more information about the simulator, please see the website for Kongsberg Maritime AS (http://www.km.kongsberg.com/). For more information about the specific simulator used in this study, please see Alaska Vocational Technical Center (http://www.avtec.edu/AMTC-Sim.aspx).

Both pilots were asked multiple questions concerning the completed simulations using the screenshots as a reference. An interview protocol and simulation information sheet was created for every simulation. The pilots were always asked the following question.

1) What is your level of concern for the completed simulation?
The scale is: 1 = not at all concerned, 2 = slightly concerned, 3 = somewhat concerned, 4 = moderately concerned, and 5 = extremely concerned.

Additional closed-ended questions were asked based upon specific simulations:

1) Were the assigned assist tugs adequate for this ship maneuver? 1= Yes 2= No
2) Does anchor position provide safe refuge for the disabled vessel? 1=Yes 2=No
3) Does this PPOR anchor position provide adequate swinging room for ship to maintain position? 1=Yes 2=No
4) Was simulation realistic? 1=Yes 2=No
5) Did the listing of the ship have an effect upon maneuverability of ship into PPOR? 1=Yes 2=No
6) Did the availability of engine and rudder provide greater maneuverability? 1=Yes 2=No
7) Did the availability of engine and rudder reduce risk maneuvering disabled ship? 1=Yes 2=No

An additional four simulations were performed to portray swing area for each of the designated PPOR, with eight shots of chain deployed (720 feet).[12] These four simulations did not require an exit interview as they were conducted only in the control room under the direction of the pilot.

Simulations were equally distributed between the two pilots to mitigate fatigue. Performing ship simulations such as these require high levels of concentration for the entire length of the simulation. Therefore, an equal distribution of simulations was essential. Captain Garay's simulations were performed utilizing simulator C, while Captain Pierce used simulator B. Table 1 below outlines the simulations performed by each pilot with the various ship models.

Table 1. Simulation Operator by Ship Model

Ship Type	Ship Model	Captain Garay	Captain Pierce
Overseas Group Loaded	(1) PRODC07L	3	
SeaRiver 115 K Ballast	(2) VLCC14B		3
SeaRiver 115 K Loaded	(3) VLCC14L	3	5
Polar Tankers 141 K Ballast	(4) VLCC15B	1	2
Polar Tankers 141 K Loaded	(5) VLCC15L	5	2
Alaska Tanker Ballast	(6) GAS06L	3	4
Tanker 220 K Ballast	(7) VLCC05B	3	
	Total	18	16

[12] A single shot of anchor chain is equal to 90 feet.

Vessels

Throughout simulations, pilots assessed the capability of stricken tank vessels to safely maneuver into the determined Mid-PWS PPOR. The ship characteristic variables included: varying dead weight tonnage, empty versus fully loaded vessels, and single propeller and twin propeller capabilities. Two azimuth drive ten thousand horsepower assist tug boats were utilized to maneuver the stricken vessel. The two assist tug boats, one forward and one aft, were deployed in simulations to tow the ship to designated anchorage locations specified for each PPOR. Assist tug boats were simulated as vector tug boats; the force exerted upon vessels were applied by simulator operators based upon predetermined tonnages and pilot direction.

Vessels utilized within the simulations were representative of the tankers presently operating for TAPS. Approximately 14 tank vessels operate at TAPS ranging in overall length, from 600 feet to 941 feet, with dead weight tonnage from 46,000 metric tons to more than 200,000 metric tons. Tankers are operated by four different companies, each with different class, size, and number of ships as represented Table 2.

Table 2. TAPS Vessel Deadweight and Operators

Polar Tankers	Overseas Group	Alaska Tanker Co	SeaRiver
141,000 Deadweight	60,000 Deadweight	195,000 Deadweight	115,000 Deadweight
Adventurer	*Boston*	*Alaskan Explorer*	*Eagle Bay*
Endeavour	*Nikiski*	*Alaskan Navigator*	*Liberty Bay*
Resolution	*Martinez*	*Alaskan Legend*	
Enterprise		*Alaskan Frontier*	
Discovery			

Vessel models representing TAPS tankers were selected from the AVTEC library based upon their ship particulars and block coefficients. Vessel models are specific replicas of their originals, and include exact hydrodynamic characteristics of the specific vessel they are modeling. Vessel models and actual vessel particulars of four different class of vessels within TAPS trade are listed below, in Table 3. Exact models of Overseas Group and SeaRiver tank vessels were available for the simulations, but the Polar and Alaska Tanker ship exact replicas were not. However, these vessels are represented by two similar vessel models, also listed in Table 3.

Table 3. Vessel Model Attributes

Model/ Ship	SIM Model	LOA	Beam	Depth/Draft	Displacement	Gross Tons	Props Rudders	Thruster
Overseas Group Loaded		601’	105’	43’	59,000	29,242	ONE	NONE
Tank Model PRODC07L	1	600’	105’	43’	64,330	Approx. 30,000	ONE	NONE
SeaRiver 115K Ballast		823’	144’	Approx. 28’	Approx. 61,000	62,318	ONE	NONE
Tank Model 115K VLCC14B	2	820’	144’	28’	61,320	Approx. 62,000	ONE	NONE
SeaRiver 115K Loaded		823’	144’	49’	134,352	62,318	ONE	NONE
Tank Model 115K VLCC14L	3	820’	144’	49’	133,900	Approx. 62,000	ONE	NONE
PolarTankers 141K Ballast		892’	151’	Approx. 30’	Approx. 68,000	85,387	TWO	ONE
Tank Model 127K VLCC15B	4	859’	138’	27’	60,000	Approx. 68,000	TWO	ONE
PolarTankers 141K Loaded		892’	151’	Approx. 50’	Approx. 160,000	85,387	TWO	ONE
Tank Model 127K VLCC15L	5	859’	138’	49’	153,100	Approx. 68,000	TWO	ONE
AlaskaTanker Ballast		941’	164’	Approx. 36’	Approx. 90,000	110,693	TWO	NONE
210 Q FLEX GAS 06L	6	1033’	164’	36’	142,700	Approx. 125,000	TWO	NONE
Ballasted 220K Tanker VLCC05B	7	960’	143’	36’	92,960	Approx. 100,000	ONE	NONE

The attributes of vessel models are as follows:

Overseas Group Tankers were simulated by employing a PRODC07L Kongsberg library model with the following specific attributes: length 600’, beam (width) 105’, draft (depth) 43’, gross tonnage approximately 30,000 tons, diesel engine single propeller. This model is an exact replica of three loaded Overseas Group ships, with same block coefficient as present ships, and therefore similar handling characteristics.

SeaRiver was simulated using two different models, one representing loaded conditions and other for ballast conditions. Both were exact models of two Sea River ships involved TAPS trade, and were available in the AVTEC library. The ballasted model was a 115K VLCC 14B, while the loaded condition model was a 115K VLCC14L. Model dimensions were identical with the exception of draft; light model of 28' draft, and loaded of 49'. Model dimensions include: length 820', beam 144', gross tonnage approximately 62,000, single diesel engine with same block coefficient as present ships, thus yielding similar handling characteristics.

Polar Ships were simulated using two different models, one representing loaded condition and other for ballast condition. Both models were available within the AVTEC library. The ballast model 127K VLCC 15B, and the loaded model 127K VLCC 15L had similar block coefficients as actual ships, but were not exact replicas. Model dimensions between ballast and loaded models are the same, except for draft; light model of 27' draft, and loaded 49'. Model dimensions include: length 859', beam 138', gross tonnage approximately 68,000, two diesel engines and rudders with bow thruster. Mechanical and handling characteristics were similar compared to five actual Polar ships involved TAPS trade.

Alaska Tanker Ships were simulated using two different models, both representing ballasted or light conditions. Both models were available within the AVTEC library. The models were 210 Q FLEX GAS 06L and the 220K VLCC05B. The first model had two diesel powered propellers and two rudders. The second contained only one diesel powered propeller and rudder. The loaded model representing these ships wasn't available within AVTEC library. Dimensions of the 210 Q flex are: length 1033', beam 164', draft 36', approximate gross tonnage 135,000 tons. Dimensions of the 220K VLCC05B are: length 960', beam 143', draft 36', approximate gross tonnage 100,000 tons. Block coefficients of both ship models are similar to four Alaska tankers involved TAPS trade.

Assist Tug Boats were simulated as vector tugs, requiring simulator engineer apply power at direction of pilot, utilizing model TUG03, azimuth drive approximately 10,000 horsepower with 150 tons' bollard pull. The dimensions of this model are: length 140', beam 41' and draft 16'. Tug boat models are representative of tug boats presently utilized for TAPS trade ship maneuvers.

Two simulators were operating simultaneously with different vessels being operated within each simulator. Each simulator had separate and distinct objectives, as well as distinct ship models, assist tug boats, and environmental conditions. The tonnage applied for vector tug boats was reduced 15% and the various commands with tonnage applied are listed in Table 4.

Table 4. Horsepower for Vector Tug Boats

Tug Order	150 Ton Assist Tug Boat	15% Applied Power
Hang	15 tons	13 Tons
Dead Slow	22 Tons	19 Tons
Slow/ Easy	38 Tons	32 Tons
Half	75 Tons	64 Tons
Two Third	100 Tons	85 Tons
Full	150 Tons	128 Tons

Simulations commenced a half mile from the desired anchor location with three knots headway and tug boats made up on the bow chalk and stern chalk of the vessel. All vessels with two propellers had Starboard propeller and rudder failures with Port side remaining operational. Listing vessels were all simulated with approximately seven-degree Port side list. Anchor control was maintained in the control room, performing anchor procedures at the direction of the pilot. Upon completion of a simulation with tanker models at anchor, fast time simulations were implemented (ten times real time) to obtain a good plot of anchor swing. Vessel movements were captured utilizing three minute plots, including fast time simulations. Each plot was immediately forwarded to the debrief room, allowing the pilot to comment on the simulation and utilize it as reference to complete the interviews.

Wind

Mid-Sound winds with significant velocities are typically from the eastern quadrant, which effect the three simulated PPOR. Multiple studies have assembled and analyzed the meteorological and oceanographic data in PWS, so that oil shipping corporations may “identify those environmental and operational conditions that limit the effectiveness of the chosen response tactics in the event of an oil spill in PWS.[13]” The PWSRCAC directed SGM to utilize wind data provided by the Alaska Experimental Forecast Facility for the simulations. PPOR SGM 1utilized same wind as PPOR 1 North Smith Island. The wind data is available in Table 5. High Wind Velocity and Direction are used for all simulations, except for simulation 19 which was PPOR 2, vessel 6, and utilized Low Wind of 4 knots and Direction of 55 degrees.

Table 5. Wind Speed and Direction[14]

PPOR	Low Wind Velocity/ Direction	Medium Wind Velocity/ Direction	High Wind Velocity/ Direction
North Smith Island 60º 31.90N 147º 22.67W	2 knots 31 Degrees	33 knots 26 Degrees	30 knots 105 Degrees
Outside Bay 60º 38.26N 147º 29.48W	4 knots 55 Degrees	8 knots 340 Degrees	34 knots 106 Degrees
McPherson Bay 60º 40.65N 147º 21.79W	3 knots 24 Degrees	24 knots 24 Degrees	36 knots 111 Degrees

[13] Kumar, A., & Gray, D. (2007, January). *Analysis of Meteorological and Oceanographic Data for Prince William Sound, Alaska*
[14] Ibid.

Current

Mid-Prince William Sound current is insignificant in comparison to other regions of PWS. One knot of current was utilized for all simulations, either flooding or ebbing depending on the specific simulation. One knot of current would be considered an insignificant force for southcentral maritime operators, however this current vector resulted in creating a force which required significant compensation for deeply laden tankers. One knot of current applies force upon the loaded tanker that is at times greater than the high wind forces acting upon the vessel.

Characteristics of Simulated PPOR

The physical characteristics of the three simulated PPOR, as depicted by ADEC, are listed in Table 6.

Table 6. Physical Characteristics of PPOR 11

PPOR	**N Smith Island A36**	**Outside Bay A37**	**McPherson Bay A38**
Vessel Size	Greater 20,000 Tons	Greater 20,000 Tons	Greater 20,000 Tons
Navigational Approach	From E, W, N	From W	From E
Minimum water depth	25 Fathoms	10 Fathoms	19 Fathoms
Maximum water depth	50 Fathoms	60 Fathoms	33 Fathoms
Maximum vessel draft	65’	50’	65’
Swing room	1,900’	1,750’	1,750’
Bottom Type	Mud	Mud	Mud
Position Anchorage	60º 31.90N 147º 22.67W	60º 38.26N 147º 29.48W	60º 40.65N 147º 21.79W
Grounding Sites	Outside Bay/ 16 mi.	Outside Bay/ 1 mi.	Outside Bay/ 24 mi.
Prevailing Winds	NE. (Oct-April), SW. (May-Sept.)	NE. (Oct-April), SW. (May-Sept.)	NE. (Oct-April), SW. (May-Sept.)
Currents	Negligible	Negligible	Negligible
Tides	MHW 11.2 MLW 1.2	MHW 11.2 MLW 1.2	MHW 11.2 MLW 1.2
Sea Conditions	Exposed swell N	Exposed swell W	Exposed swell NW
Shelter severe storms	Exposed to storms	Exposed from W	Sheltered

Data for the North Smith Island PPOR indicates a minimum water depth of 25 fathoms, and a maximum water depth of 50 fathoms with swing room of 1,900’. The Latitude and Longitude of this PPOR is located 7.5 fathoms of water (45 feet) deep, which grounds most loaded TAPS tanker models because their drafts are greater than the depth of water. Swing room is not available because the vessels are grounded in this PPOR. Photos of nautical charts in relation to these PPOR are included in Attachments 1-4.

Safeguard Marine performed fewer simulations on the DEC’s location for PPOR 1 because of continued grounding. Safeguard Marine identified an alternative PPOR location near the ADEC’s location for simulation purposes. The PPOR location SGM designated for this purpose meets ADEC guidelines for determining a PPOR because it allows the tankers to remain afloat and provides sufficient sea room for them to swing at anchor and avoid grounding (see Appendix 1). This location is referred to as PPOR 1 SGM North Smith Island. PPOR 1 SGM North Smith Island is located 0.6 miles from all obstructions at a depth of 25 fathoms, 60 º 32.080, 147 º 24.36. Information regarding the locations of Mid-PWS PPOR is available in Table 7.

Table 7. Scope Compared to Depth of Simulated Designated Anchorages

PPOR	PPOR 1 North Smith Island	PPOR 1 SGM North Smith Island	PPOR 2 Outside Bay	PPOR 3 McPherson Bay
Latitude & Longitude	60º 31.90 N 147º 22.67W	60º 32.31 N 147º 24.22 W	60º 38.26 N 147º 29.48 W	60º 40.65 N 147º 21.79 W
Approximate Depth of Water	45 feet	150 feet	150 feet	150 feet
Scope of Chain	NA	5:1/ 8 shots (720 feet)	5:1/ 8 shots (720 feet)	5:1/ 8 shots (720 feet)
Total Available Swing Room	NA	3,000 feet	1,750 feet	1,750 feet

Simulation Charts

The following charts provide information about the physical characteristics of PPOR during simulations.

Table 8. Number of Simulations in Day or Night Conditions: (D) or Night (N)

Ship Model	PPOR 1 (n=6)	PPOR 1 SGM (n=8)	PPOR 2 (n=10)	PPOR 3 (n=10)
(1) PRODC07L	N		N	N
(2) VLCC14B		D	D	D
(3) VLCC14L	N, N, N	D	D, N	D, N
(4) VLCC15B		N	N	N
(5) VLCC15L	N	D, N	D, N	D, N
(6) GAS06L	N	D, N	D, N	D, N
(7) VLCC05B		N	N	N
Totals	6 Nights	4 Nights, 4 Days	6 Nights, 4 Days	6 Nights, 4 Days

Table 9. Visibility in Miles

Ship Model	PPOR 1 (n=6)	PPOR 1 SGM (n=8)	PPOR 2 (n=10)	PPOR 3 (n=10)
(1) PRODC07L	10		3	1
(2) VLCC14B		1	10	3
(3) VLCC14L	10, 10, 3	1	1, 1	10, 10
(4) VLCC15B		10	3	1
(5) VLCC15L	10	1, 1	10, 1	3, 3
(6) GAS06L	3	3, 3	10, 1	1, 10
(7) VLCC05B		7	3	1
Mean Miles of Visibility per PPOR	7.7	3.4	4.3	4.3

Table 10. Precipitation

Ship Model	PPOR 1 (n=6)	PPOR 1 SGM (n=8)	PPOR 2 (n=10)	PPOR 3 (n=10)
(1) PRODC07L	Rain		Rain	Snow
(2) VLCC14B		Snow	None	Rain
(3) VLCC14L	Snow, None, None	Snow	Snow, Rain	None, None
(4) VLCC15B		None	Rain	Snow
(5) VLCC15L	None	Snow, Snow	None, Snow	Rain, Rain
(6) GAS06L	Rain	Rain, Rain	None, Snow	Snow, None
(7) VLCC05B		None	Rain	Snow
Percentage with Precipitation	50%	75%	60%	80%

Table 11. Currents All One Knot, Direction Degrees (Toward)

Ship Model	PPOR 1 (n=6)	PPOR 1 SGM (n=8)	PPOR 2 (n=10)	PPOR 3 (n=10)
(1) PRODC07L	45		30	180
(2) VLCC14B		180	225	45
(3) VLCC14L	45, 45, 45	180	30, 225	180, 45
(4) VLCC15B		45	30	180
(5) VLCC15L	45	180, 45	30, 225	180, 45
(6) GAS06L	45	180, 45	30, 225	180, 45
(7) VLCC05B		45	30	180

Table 12. Listing: All Ships to Port Seven Degrees

Ship Model	PPOR 1 (n=6)	PPOR 1 SGM (n=8)	PPOR 2 (n=10)	PPOR 3 (n=10)
(1) PRODC07L	1		1	1
(2) VLCC14B		1	1	1
(3) VLCC14L	1, 0, 0	0	0, 0	0, 0
(4) VLCC15B		1	1	1
(5) VLCC15L	0	1, 0	1, 0	1, 0
(6) GAS06L	0	0, 0	0, 0	0, 0
(7) VLCC05B		0	0	0
Percentage Listing	33%	38%	40%	40%

Table 13. Propeller and Rudder Available, Port Side Only

Ship Model	PPOR 1 (n=6)	PPOR 1 SGM (n=8)	PPOR 2 (n=10)	PPOR 3 (n=10)
(1) PRODC07L	0		0	0
(2) VLCC14B		0	0	0
(3) VLCC14L	0, 0, 0	0	0, 0	0, 0
(4) VLCC15B		1	1	1
(5) VLCC15L	1	1, 1	1, 1	1, 1
(6) GAS06L	1	1, 1	1, 1	1, 1
(7) VLCC05B		0	0	0
Percentage with Propeller and Rudder	33%	63%	50%	50%

V. Simulation Results

The results of the simulations are based on interviews after the completion of the simulation and aided by using a screenshot of the vessel's movement. Both pilots were asked multiple questions concerning the completed simulations. One debrief sheet was created for each simulation taking into consideration the mariners' input for the specific simulations. Pilots were first asked a closed-ended question about their level of concern for the completed simulation.

1) What is your level of concern for the completed simulation?

Scale: 1= not at all concerned, 2 = slightly concerned, 3 = somewhat concerned, 4 = moderately concerned, and 5 = extremely concerned.

Pilot responses were collected and synthesized by PPOR. The results of each simulation are reported below, including median score for each PPOR. Median score is reported because ordinal data was collected.

Table 14. Level of Concern for Anchoring at each Simulated PPOR (Scale 1-5)

Ship Model	PPOR 1 (n=6)	PPOR 1 SGM (n=8)	PPOR 2 (n=10)	PPOR 3 (n=10)
(1) PRODC07L	5		2	2
(2) VLCC14B		1	3	2
(3) VLCC14L	5, 5, 5	2	4, 4	1, 1
(4) VLCC15B		2	4	1
(5) VLCC15L	5	1, 2	2, 4	1, 1
(6) GAS06L	5	2, 2	2, 4	1, 1
(7) VLCC05B		1	1	3
Median Level	5	2	3.5	1

Additional closed-ended questions were asked based upon specific simulations. The results of every simulation for each question are reported. The scale utilized was Yes/No, and the aggregate percentage for each PPOR are reported as a percentage of Yes.

1) Were the assigned assist tugs adequate for this ship maneuver?
2) Does anchor position provide safe refuge for the disabled vessel?
3) Does this PPOR anchor position provide adequate swinging room for ship to maintain position?
4) Was simulation realistic?
5) Did the listing of ship have an effect upon maneuverability of ship into PPOR?
6) Did the availability of engine and rudder provide greater maneuverability?
7) Did the availability of engine and rudder reduce risk maneuvering disabled ship?

Table 15. Question 1: Were assigned assist tugboats adequate for this ship to maneuver?

Ship Model	PPOR 1 (n=6)	PPOR 1 SGM (n=8)	PPOR 2 (n=10)	PPOR 3 (n=10)
(1) PRODC07L	Yes		Yes	Yes
(2) VLCC14B		Yes	Yes	Yes
(3) VLCC14L	Yes, Yes, Yes	Yes	Yes, Yes	Yes, Yes
(4) VLCC15B		Yes	Yes	Yes
(5) VLCC15L	Yes	Yes, Yes	Yes, Yes	Yes, Yes
(6) GAS06L	Yes	Yes, Yes	Yes, Yes	Yes, Yes
(7) VLCC05B		Yes	Yes	Yes
Percentage of Yes	100%	100%	100%	100%

Table 16. Question 2: Does anchor position provide safe refuge for the disabled vessel?

Ship Model	PPOR 1 (n=6)	PPOR 1 SGM (n=8)	PPOR 2 (n=10)	PPOR 3 (n=10)
(1) PRODC07L	No		No	Yes
(2) VLCC14B		Yes	No	Yes
(3) VLCC14L	No, No, No	Yes	Yes, No	Yes, Yes
(4) VLCC15B		Yes	No	Yes
(5) VLCC15L	No	Yes, Yes	No, No	Yes, Yes
(6) GAS06L	No	Yes, Yes	No, No	Yes, Yes
(7) VLCC05B		Yes	Yes	Yes
Percentage of Yes	0%	100%	20%	100%

Table 17. Question 3: Does this anchor position provide adequate swinging room for the ship to maintain position?

Ship Model	PPOR 1 (n=6)	PPOR 1 SGM (n=8)	PPOR 2 (n=10)	PPOR 3 (n=10)
(1) PRODC07L	No		No	Yes
(2) VLCC14B		Yes	No	Yes
(3) VLCC14L	No, No, No	Yes	Yes, No	Yes, Yes
(4) VLCC15B		Yes	No	Yes
(5) VLCC15L	No	Yes, Yes	No, No	Yes, Yes
(6) GAS06L	No	Yes, Yes	No, No	Yes, Yes
(7) VLCC05B		Yes	Yes	Yes
Percentage of Yes	0%	100%	20%	100%

Table 18. Question 4: Was the Simulation Realistic?

Ship Model	PPOR 1 (n=6)	PPOR 1 SGM (n=8)	PPOR 2 (n=10)	PPOR 3 (n=10)
(1) PRODC07L	Yes		Yes	Yes
(2) VLCC14B		Yes	Yes	Yes
(3) VLCC14L	Yes, Yes, Yes	Yes	Yes, Yes	Yes, Yes
(4) VLCC15B		Yes	Yes	Yes
(5) VLCC15L	Yes	Yes, Yes	Yes, Yes	Yes, Yes
(6) GAS06L	Yes	Yes, Yes	Yes, Yes	Yes, Yes
(7) VLCC05B		Yes	Yes	Yes
Percentage of Yes	100%	100%	100%	100%

Table 19. Question 5: Did the Listing of the Ship have an Effect on the Maneuverability of the Vessel into PPOR?

Ship Model	PPOR 1 (n=2)	PPOR 1 SGM (n=3)	PPOR 2 (n=4)	PPOR 3 (n=4)
(1) PRODC07L	Yes		Yes	Yes
(2) VLCC14B		Yes	Yes	Yes
(3) VLCC14L	Yes			
(4) VLCC15B		Yes	Yes	Yes
(5) VLCC15L		Yes	Yes	Yes
(6) GAS06L				
(7) VLCC05B				
Percentage of Yes	100%	100%	100%	100%

Table 20. Question 6: Did the Availability of Engine and Rudder Provide Greater Maneuverability of the Ship into PPOR?

Ship Model	PPOR 1 (n=2)	PPOR 1 SGM (n=5)	PPOR 2 (n=5)	PPOR 3 (n=5)
(1) PRODC07L				
(2) VLCC14B				
(3) VLCC14L				
(4) VLCC15B		Yes	Yes	Yes
(5) VLCC15L	Yes	Yes, Yes	Yes, Yes	Yes, Yes
(6) GAS06L	Yes	Yes, No	Yes, Yes	Yes, Yes
(7) VLCC05B				
Percentage of Yes	100%	80%	100%	100%

Table 21. Question 7: Did the Availability of Engine and Rudder Reduce the Risk of Manuevering the Disabled Ship?

Ship Model	PPOR 1 (n=2)	PPOR 1 SGM (n=5)	PPOR 2 (n=5)	PPOR 3 (n=5)
(1) PRODC07L				
(2) VLCC14B				
(3) VLCC14L				
(4) VLCC15B		Yes	Yes	Yes
(5) VLCC15L	No	Yes, Yes	Yes, Yes	Yes, Yes
(6) GAS06L	No	Yes, No	Yes, Yes	Yes, Yes
(7) VLCC05B				
Percentage of Yes	0%	80%	100%	100%

PPOR 1: North Smith Island

PPOR 1 was simulated in two locations around North Smith Island. The first round of simulations modeled the designated PPOR in North Smith Island, as described in the Subarea Contingency Plan. Six simulations were conducted at this location. An additional unmanned simulation was used to demonstrate vessel swing. Of the six anchoring simulations, all six resulted in vessel grounding either upon approach to the designated anchor position, or after the vessel anchored and was settling upon its anchor. Two of the six simulated vessels were listing, and two had one engine and a rudder available. Tug boat assists for all six simulations were found to be adequate, however the anchor position did not offer safe refuge and did not provide adequate swing room for simulated vessels. All six of these simulations were ranked with extremely concerned (5), and all six simulations were ranked as being realistic.

The seventh simulation was performed to assess swing. In this simulation, the ship had eight shots of chain (720 feet) with 360 degree swing. This simulation showed the vessel passing through shallow waters and land, due to the close proximity of the anchor position to shore.

The post simulation interviews concerning this specific location were very negative, and raised unanimous concern in utilizing the site as a PPOR. Participants noted that their vessels "went aground" when approaching the anchor position with a loaded ship. Another post simulation interview concluded that the anchoring maneuvers were "going fine" until the vessel ran aground because there was, "not enough water at the location." Finally, the pilots stated in the post simulation interview that mariners should, "not go near Smith Island," and that the site should not have been selected because there is, "not enough water for these size ships." Therefore, this PPOR should not be used by tank vessels.

PPOR 1 SGM: North Smith Island

Due to the repeated grounding of PPOR 1, Safeguard Marine identified an alternative location in North Smith Island, with 150 feet of water and approximately 3,000 feet of swing room to simulate anchorage. Nine simulations were conducted at this location, eight of which demonstrated anchorage, while the ninth simulated the ship rotating around 360 degrees to determine vessel swing.

The median level of concern for anchoring at this location is 2, representing slight concern. All eight simulations at PPOR 1 SGM were reported to be realistic, and the anchor position was reported to provide adequate swinging room for ships to maintain position. Participants also reported that the assigned assist tug boats were adequate for the ship to maneuver. Three of the eight ships were listing, and all three had an effect upon the maneuverability of the ship. Five of the eight simulations had twin screw vessels with operational port propeller and rudder. Four of the five simulations reported that the availability of engine and rudder function provided greater maneuverability and reduced risk when maneuvering a disabled ship. The use of assist tug boats, and the availability of engine and rudder assisted a disabled ship.

Comments concerning the maneuverability at this PPOR were greatly varied by environmental conditions, namely current and wind. Light tankers experienced a larger wind effect, reflecting that, "the current pulls one way and the wind pushes the other way," and, though the current, "definitely has an effect" on maneuverability, the wind is the "predominant factor." Larger ships however, experienced an inverse affect; current effected loaded ships to a larger extent, at times greater than the wind. "Ebb current effected the vessel more than the wind, because the vessel was loaded". I "started out with easterly heading with wind 30 knots from east, but the current was going at 1 knot, and overpowered the 30 knot wind. We ended up crabbing with wind on the beam, and then we're going into the wind sideways, all due to the current because the ship has minimal surface area above the water compared to under water." Simulation participants also reported that tug boat assists were extremely helpful in mitigating ship swing. "The current really effects us. Even 1 knot really effects us, but the tug was there mitigating. When our speeds are low, it allows the current to have a stronger effect." Pilots "need to use tugs" to get the ship moving, even if the vessel has the port propeller and rudder.

Regarding the viability of this location as a PPOR, simulation results report predominantly negative reviews of this site due to a lack of protection from hazardous environmental conditions. This location is exposed to wind and seas from all directions, except the southern quadrants. The anchor location found by SGM is a pinnacle, surrounded on three sides by significantly deeper water. If the vessel started to drag anchor, retaining this position is unlikely and would result in an inadequate anchor location. The only positive comment about this PPOR is that, when environmental conditions are from the south, this location offers a leeward shore for anchoring. Therefore, this PPOR should not be used by tank vessels.

PPOR 2: Outside Bay

Ten anchoring simulations were performed at this site. A separate unmanned simulation was performed rotating a ship 360 degrees at anchor on the designated position with eight shots of chain out (720 feet), demonstrating the swing area of the ship. The swing area is based upon scope of 5:1, and was determined to be within 190' of the ten fathom curve to the north of the anchor location. This close proximity to the ten fathom curve, or 60' depth, is inappropriate, considering that a large tank ship may prefer 6:1 scope, which eliminates the sea room between an anchored vessel and the ten fathom curve. Vessels approaching anchor point came from the southwest area on true course of 045 degrees, with open water available for vessel to maneuver. All ten simulations were reported to be realistic. Nine of the simulations had maximum wind: 34 knots from 106 degrees. The other simulation modeled low wind, with 4 knots from 55 degrees. The current was at one knot toward 225 or 30 degrees depending upon flood or ebbing. Results concluded that two assigned assist tug boats were adequate for this ship maneuver for all ten simulations. Four of the ten ships were listing and all four had an effect upon the maneuverability of the ship. Five of the ten simulations had twin screw vessels with an operational port propeller and rudder. All five of these simulations concluded that the availability of engine and rudder function provided greater maneuverability and reduced risk when maneuvering a disabled ship.

The median level of concern for the ten simulations is 3.5. Responses varied from not at all concerned (1) to moderately concerned (4). Mariners were most prominently concerned about the proximity to the ten fathom curve and the impact of current on vessel anchorage. One mariner commented that he was able to drive the ship within a ship length of the anchorage without using tug boats, but that the anchor location was "too close" to the ten fathom curve. Another reflected that he was able to use tug boats to maneuver the vessel into anchor position, but the anchor position is, "too close to shallow water." Mariners also commented on the impacts of wind and current. "Wind had minimal effect on the ship," stated one mariner, "but the vector of the current force turned the ship around completely." Outside Bay appear to be "friendlier environmentals," they actually harbor a "more hazardous situation." This can be more dangerous, as the PPOR "lulls the mariner into a sense of false security." In summation, the conditions at Outside Bay are, "beyond the complexity of what a master is expected to deal with." If the ship were loaded, the vessel would move faster and, with current pushing the vessel around, tension on the chain would increase dramatically. Adding those factors to the disabilities of a stricken vessel, anchoring at this specific PPOR would be "even more complex." Therefore, this PPOR should not be used by tank vessels.

PPOR 3: McPherson Bay

Ten simulations were conducted for PPOR 3, McPherson Bay. The approach to the anchor point was executed from northeast area of McPherson Bay on true course of 225 degrees, with open water available for the vessel to maneuver. All ten simulations were reported to be realistic. All of the simulations had maximum wind: 36 knots from 111 degrees. The current was one knot toward 180, or 45 degrees, depending upon flood or ebbing. All vessels were simulated starting one half mile from designated anchor position making three knots over ground course 225. All ten simulations ranked the two assigned assist tug boats as adequate for this ship maneuver. Four of the ten ships were listing, and all four were found to have an effect on the maneuverability of the ship. Five of the ten simulations had twin screw vessels with an operational port propeller and rudder. All five of these simulation reported that the availability of engine and rudder function provided greater maneuverability and reduced risk when maneuvering the disabled ship.

An additional swing simulation was also performed, in which the ship swung completely around the area of the anchorage. The swing area simulation demonstrated sufficient swing room from the ten fathom curve for a ship at anchor with 5:1 scope; eight shots of chain (720 feet). This position allowed for another two shots of chain to be used (160 feet), increasing scope to 6:1 while still allowing for sufficient swing room.

The median level of concern for the ten simulations is 1. Responses varied from not at all concerned (1) to somewhat concerned (3). Majority of comments concerning this PPOR were favorable, however there is concern about the impact of wind. Anchoring a ship at PPOR 3 is subject to wind forces due to velocity and direction because it is, "empty and very large, so the wind sail area is enormous." The anchoring maneuvers generally went "very well" with "minimal problems" even when listing greatly affected steering. However, after the anchor was set, high winds put, "too much strain on the anchor chain." Anchoring a large ship in the simulated high wind conditions at PPOR 3 may not be an issue, but that mariners may encounter problems holding it there. Therefore, PPOR 3 should be utilized by tank vessels, but only temporarily due to potential exposure to high winds.

VI. Conclusions

PPOR 1, North Smith Island was determined to be inadequate for TAPS tank vessels frequenting Prince William Sound, as all of the simulated anchorages resulted in grounding. PPOR SGM 1 is more feasible, however the location is exposed to challenging environmental elements from all directions except the south. The anchor location at this site is atop a bottom uprising surrounded by deep water on three sides, which is considered a poor anchor location due to the high probability of dragging the anchor off the uprising. PPOR 2 Outside Bay was also inadequate for stricken tankers due to the close proximity to the ten fathom curve. PPOR 3 McPherson Bay did provide adequate accommodation for stricken tanker vessels, but this location should be used with caution due to the strain on an anchor that may be caused by high winds.

Twin propeller and rudder ships, with one disabled, provided greater maneuverability than ships without. Vessels with two propellers and rudders, that had one disabled, reported reduced risk associated with the stricken vessel. Mariners were able to maneuver these vessels without the assistance of assist tug boats when approaching designated anchorages. In comparison, single propeller and rudder ships without propulsion required assist tug boats, and were found to be less maneuverable than larger vessels with available propeller and rudder function.

As expected, wind had greater effect on ballasted vessels compared to loaded vessels. However, current forces, even at one knot, overcame high wind forces on all vessels. Mariners used the wind to assist during maneuvers to counter the force vectors from current. Reduced or low wind velocity required the use of assist tug boats to maneuver.

The exact point for anchoring at a PPOR in this study was determined by the latitude and longitude of PPOR as listed in the Subarea Contingency Plan, or by SGM's internal analysis of PPOR 1. Surrounding areas of a PPOR may be considered as viable locations for a stricken vessel, however this study did not explore this potential aside from PPOR 1. This study of Mid-PWS PPOR also indicates the need for further study of PWS PPOR. The list of pre-identified PPOR is, "the product of a significant amount of research and coordination with numerous involved agencies and stakeholders," states the USCG in their written response for this study. "There is a great deal of value in this information that mariners take very seriously, and consult as a starting point for planning where to position a stricken vessel." A maritime review of PPOR within all regions of PWS would confirm anchorage feasibility in an emergency, support the effectiveness of the PPOR Contingency Plan, and increase the safety of the maritime community. This research demonstrated the viability of using PPOR in Mid-PWS for a stricken tank vessel. Not all possible locations, conditions, vessels or type of mariners were analyzed. Instead, this research demonstrated based on interviews with mariners who operate tank vessels in Mid-PWS and stakeholders identified by the Subarea Contingency Plan, as well as over thirty ship bridge simulations performed by experienced TAPS pilots that PPOR 1 North Smith Island (and alternative PPOR SGM 1) as well as PPOR 2 Outside Bay may not be viable locations for tank vessels in distress. In addition, PPOR 3 McPherson Bay is the most viable location in Mid-PWS for a tank vessel in distress, but this location should be used with caution due to high winds.

References

Alaska Regional Response Team. (2014, January 29). *Meeting Summary*. Anchorage Federal Building, Anchorage, AK.

Burden, T. (n.d.). Selecting an Anchor Rode. In *West Marine*. Retrieved from http://www.westmarine.com/WestAdvisor/Selecting-An-Anchor-Rode

Irons, J. (2013, March 13). The Most Critical Factor in Anchoring? Scope! Retrieved from http://commutercruiser.com/the-most-critical-factor-in-anchoring-scope/

Kumar, A., & Gray, D. (2007, January). *Analysis of Meteorological and Oceanographic Data for Prince William Sound, Alaska* (Rep.). Retrieved http://www.pws-osri.org/publications/Met_ocn_2007.pdf

McDowall, C. A. (2000). *Anchoring large vessels: A new approach*. Retrieved from http://mariners.narod.ru/ANCHORING_LARGE_VESSELS.pdf

Mitchell, Vince, Patrick J. Carney, George Randall, Tim Jones, and Lynda Hyce. (2001). *Escort Tug Analysis for Oil Tankerships in Prince William Sound and the Gulf of Alaska.* (801.107.010414)

National Oceanic and Atmospheric Administration. (2010). Chapter Four. In *Coast Pilot 9* (28th ed.). Retrieved from http://www.nauticalcharts.noaa.gov/nsd/coastpilot/archive/9/CP9-28ed-2010-reduced.pdf

NUKA Research & Planning Group, LLC. (n.d.). *Places of Refuge* [Map]. Retrieved from https://dec.alaska.gov/spar/ppr/pwspor/pwsppormap05.pdf

Spencer, C. (2008). Standard Safety. *The Standard, Anchoring- Special Edition*. Retrieved from http://www.nauticalplatform.org/docs/files/Standard Club Anchoring procedures.pdf

United States, Alaska Regional Response Team. (2013, September). *Guidelines for Places of Refuge Decision-Making*. Retrieved from http://dec.alaska.gov/spar/PPR/pwspor/040927arrtplacesofrefuge.pdf

United States, State of Alaska, Department of Environmental Conservation. (1997, July). *Prince William Sound Subarea Contingency Plan*. Retrieved from http://dec.alaska.gov/Spar/ppr/plans/scp_pws/PWS_SCP_H-PPOR.pdf

Appendix 1. Figures of Simulated PPOR

The following figures depict the PPOR simulated in this study.

Figure 1. PPOR 1 North Smith Island Anchorage

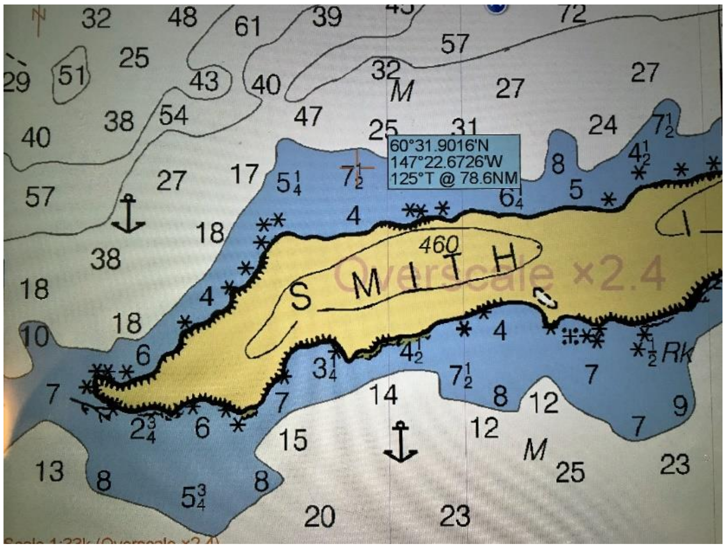

Figure 2. PPOR 1 SGM North Smith Island Anchorage

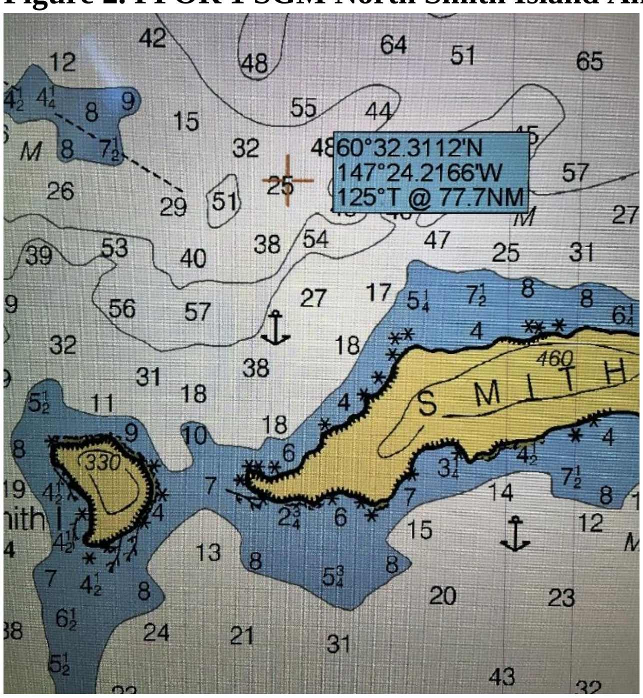

Figure 3. PPOR 2 Outside Bay Anchorage

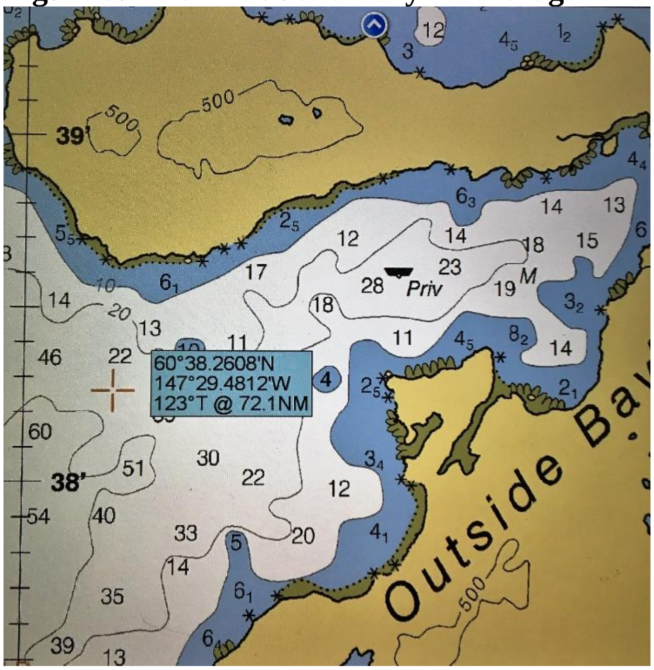

Figure 4. PPOR 3 McPherson Bay Anchorage

Appendix 2. Interview and Simulator Questions

Interview Questions for Local Subject Matter Experts

1. Would you anticipate a stricken vessel to utilize the PPOR identified? If not, why?
2. Can you recommend other PPOR that may be adequate for Mid-PWS that are not identified?
3. Utilizing PPOR as portrayed within the attachment, do you foresee any difficulty maneuvering ships to any of the specific PPOR? If yes, please specify.
4. If a ship required grounding to prevent sinking, which of the PPOR would be recommended?
5. Which ship type or casualty type do you think simulations should be concentrated upon to best determine the capability of the selected PPOR to provide adequate refuge?
6. In the simulations, we will be comparing single propeller with twin propeller capabilities what do you expect will be the results?
7. Do you believe that more than two assist tugboats will be required to maneuver any of the stricken vessels being simulated into the identified PPOR? What about during high wind conditions?
8. Based upon the category of high wind direction and velocity would you recommend a stricken ship not use any of the identified PPOR to be simulated?
9. Depicted winds for specific PPOR result in windward shoreline anchoring. Is this appropriate or should alternative PPOR or leeward shoreline be utilized?
10. Do you have any specific simulations you wish to see performed based upon the specific three proposed POR?
11. Based upon information provided, do you have any input concerning best practices to be performed during simulations?

Interview Questions for Stakeholders

1. What is the role of your agency in relation to PPOR?
2. In terms of research, what should SGM focus on from a maritime standpoint? What information would you like to see in SGM's final report?
3. Do you have any additional context or information about the PPOR you would like to include?
4. Do you have any additional comments or questions that we should be aware of?

Questions for Mariners after Completion of Simulation

1. What is your level of concern for the completed simulation?
The scale is: 1 = not at all concerned, 2 = slightly concerned, 3 = somewhat concerned, 4 = moderately concerned, and 5 = extremely concerned.
2. Were the assigned assist tugs adequate for this ship maneuver? 1= Yes 2= No
3. Does anchor position provide safe refuge for the disabled vessel? 1=Yes 2=No
4. Does this PPOR anchor position provide adequate swinging room for ship to maintain position? 1=Yes 2=No
5. Was simulation realistic? 1=Yes 2=No
6. Did the listing of the ship have an effect upon maneuverability of ship into PPOR? 1=Yes 2=No
7. Did the availability of engine and rudder provide greater maneuverability? 1=Yes 2=No
8. Did the availability of engine and rudder reduce risk maneuvering disabled ship? 1=Yes 2=No