Ship Simulation Modeling and Mariner Study of the Maritime Implications of Emergency Self-Arrest of a Tank Vessel in Lower Cook Inlet, Alaska

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Executive Summary:

Purpose: To provide a study of the feasibility of successful crude oil tank vessel self-arrest in Lower Cook Inlet.

Method: To achieve this purpose, this study utilized interviews to explore, ship simulations to diagnose, and a focus group to prescribe recommendations. Tweny confidential interviews were conducted with stakeholders and local subject-matter experts. Thirty-four ship simulations were performed by Southwest Alaska Pilots Association members utilizing three crude oil tank vessel models, at five locations in Lower Cook Inlet using inclement environmental conditions. Only the ship's anchor(s) are used to control the vessel's movements after the loss of propulsion. A focus group including stakeholders and local subject-matter experts prescribed recommendations.

Results: Every simulation was a successful self-arrest. Success means the vessel's motion was arrested, anchored in a temporarily safe position, and that the anchor gear did not break. However, the mariners reported various levels of concern for the self-arrest identifying potential risks in particular at the Nikiski Range location (60 35.6N, 151 24W) in Lower Cook Inlet.

Recommendations: The focus group resulted in various statements of agreement drawing conclusions from the results as well as two recommendations.

The statements conclude that knowledgeable and capable local pilots can utilize anchor gear to self-arrest a crude oil tanker in Lower Cook Inlet. The level of difficulty and concern from the pilot, as well as the process of self-arrest, vary by the location and environmental conditions.

The two recommendations are:

(1) The *Cook Inlet Risk Assessment Final Report* (2015) should be updated based upon this study, per recommendation 6.3 (page 41).

(2) Pilot participation in simulations to familiarize them with self-arrest maneuvers will increase the likelihood of success. Further research should be conducted in terms of developing best practices and the benefit of anchor gear for self-arrest in Lower Cook Inlet.

Note: The opinions expressed in this CIRCAC commissioned report are not necessarily those of CIRCAC.

Acknowledgements

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The Cook Inlet Regional Citizens Advisory Council has demonstrated great support by giving mariners a voice in the viability of self-arresting in Lower Cook Inlet. Their inclusiveness will increase mariners' ability to safely navigate Cook Inlet, and will set a precedent of consultation and cooperation between mariners and the CIRCAC.

We would also like to thank the research assistants that provided critical support and insight on this project: Samantha Garrard, Remington Purnell, Sarah Huffman, and Nicole Schmitt. We appreciate the assistance from Dr. Orson Smith in terms of input about the ice in the AVTEC simulator. Finally, we would like to thank the local subject-matter experts who participated in the interviews and simulations. Their contribution is greatly appreciated.

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Questions, Comments and Requests for More Information

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Acronym List:

AVTEC: Alaska Institute of Technology
CIRCAC: Cook Inlet Regional Citizens Advisory Council
DWT: Dead Weight Ton
NOAA: National Oceanic and Atmospheric Administration
POA: Port of Anchorage
SGM: Safeguard Marine
SWAPA: Southwest Alaska Pilots Association
USCG: United States Coast Guard

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Purpose

The purpose of this report is to better understand the capabilities of crude oil tank vessels (oil tankers) to self-arrest within Lower Cook Inlet. The water depth of Cook Inlet affords tankers the capability to utilize their anchor gear to self-arrest their motion. Due to Cook Inlet's environmental conditions including currents, wind, and ice, this study provides an assessment of the capability of self-arresting an oil tanker successfully during inclement environmental conditions. Previously, The Glosten Associates (2013) completed a report using a literature review to determine the probability and contributing factors of self-arrest in particular for deep draft vessels in Cook Inlet inclusive of crude oil tankers.

The report states,

> In this report, a successful self-arrest scenario is described, and scenarios for commercial, deep draft vessels in Cook Inlet are posed. Their estimated probability of self-arrest is low. Self-arrest has risks, potentially great ones, and variable predictability; consequently, it cannot be considered a reliable risk reduction option (p. 2).

The *Cook Inlet Risk Assessment Final Report* (2015) recommended that research be conducted to determine if self-arrest can be used as a risk reduction method for oil tankers in Cook Inlet. More specifically it recommends:

> Demonstrate or otherwise qualitatively study the ability of a large, deep-draft vessel to self-arrest in different parts of Cook Inlet, including identifying areas where this practice is more or less likely to be successful … identifying best practices for implementation, and estimating the amount of time – and therefore associated vessel drift – that this would take. This effort should also involve large vessel mariners and local pilots, as well as experts in sea ice, ship and ice dynamics, and simulations (p. 41).

This report responds to the previous conclusion drawn by The Glosten Associates (2013) and the recommendation made by the *Cook Inlet Risk Assessment Final Report* (2015) in that it seeks to determine the capability of an oil tanker to self-arrest in Lower Cook Inlet using local pilots. It also identifies the locations that are more or less likely to be successful and provides information about the process of self-arrest.

Background for Self-Arresting a Vessel

The primary purpose of self-arresting a vessel is to control the motion of the vessel after loss of propolusion has occurred. Self-arrest is considered an emergency maneauver, and success is dependent upon the art of deploying dredging anchor(s) to create drag to reduce speed and subsequently move the pivot point of the ship forward (Rowe, 2000). Dredged anchor(s) generate similar results as mooring lines applied by way of a spring line, creating reduction of speed and moving the pivot point to the point of deployment. Reducing speed of a ship by dredging anchor(s) can be performed with one or two anchors. Entangling the two anchor chains will not occur if performed correctly due to the limited amount of anchor chain deployed. Applying one anchor results moving the pivot point to same side of deployment, creating a turning moment for the ship, two anchors moves the pivot point midship, between the two points of deployment.

Managing the scope of the anchor chain is one of the critical prerequisites to successfully self-arrest a large vessel. The scope of anchor chain is the ratio of the amount of chain deployed compared to the 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. Utilizing anchor gear with appropriate scope for the desired effect is an important factor to maximize or minimize the holding power of the anchor gear. Anchor gear holds better when forces are horizontal, when strain increases the anchor chain tends to lift off of the bottom, creating a larger angle and reducing the holding power. Even a slight angle increase results in significantly decreased holding power. For example, a five-degree increase reduces holding power by 25 percent, and a 15-degree increase reduces holding capability 50 percent (Spencer, 2008).

Dredging an anchor for self-arrest requires the anchor chain have a large angle, minimizing the possibility of the anchor digging into the sea bed. The optimum amount of scope (ratio of length of anchor chain to depth of water) for dredging is between 1.5:1 to 2:1. In contrast, for holding a ship in position the minimum scope is 5:1. Dredging an anchor is an accepted practice within the Alaskan maritime community, often referred to as a “poor man’s tug boat”. Western and Southcentral Alaska mariners encounter situations where assist tug boats are not available, and utilize anchor gear as a tool to assist in maneuvering the vessel. A self-arrest maneuver is similar to dredging an anchor for maneuvering purposes with the main difference being the speed of the vessel when the anchor is deployed.

Bottom characteristics are an important aspect of anchoring and dredging an anchor for self-arrest. Generally, bottom characteristics south of Forelands in Cook Inlet is comprised of course sand and gravel, mid Cook Inlet medium to fine grade sand, and southern Cook Inlet fine grained sand, silt and clay (Thurston and Choromanski (US Minerals and Management Service), 1994). Strong tidal currents create a variety of bedforms with variety of sizes and shapes, consisting of sand to pebbling sand in south Cook Inlet and pebbly sand in north Cook Inlet (US Geological Survey, 1978). Simulations were conducted employing a sand bottom, similar bottom characteristics displayed on National Oceanic and Atmospheric Administration (NOAA) charts applicable for the locations of ship failures in Lower Cook Inlet (NOAA, N.D.). A sand bottom is conducive for anchoring and dredging an anchor.

Self-arrest maneuvers are executed due to the loss of vessel propulsion, resulting in the propeller not turning. Optimum steering force for a vessel is created when the propeller is turning and forcing water past the rudder, thus the rudder becomes less effective when the propeller is stopped (Murdoch, Dand, and Clarke, 2012).

A recent successful self-arrest in Cook Inlet occurred during ice conditions. The USCG awarded SWAPA pilot Captain Ron Ward a Certification of Appreciation for successfully performing a self-arrest maneuver with the oil tanker *PYXIS THETA* on January 21, 2015. Specifically, the oil tanker lost power with 1.3 million gallons of fuel onboard headed out bound from the Port of Anchorage. By carefully and expertly deploying the ship's anchors, Captain Ward was able to successfully secure the vessel prior to any casualties to the crew or environment.[1]

[1] United States Coast Guard, Certificate of Appreciation, presented to Captain Ron Ward, Feb. 12, 2017, Captain Paul Mehler III, Captain United States Coast Guard, Commander, Coast Guard Sector Anchorage.

Methodology

The methodology utilized in this study includes the triangulation of data and analysis. In practice this means that data is collected on the issue of self-arresting a tanker in Lower Cook Inlet through interviews, vessel simulations including closed-ended interviews, and a focus group. Prior to the collection of data relevant reports and literature are reviewed on the issue such as the review of Cook Inlet vessel traffic by Cape International (2012), the previous report on evaluating a vessel without power being able to self-arrest in Cook Inlet (The Glosten Associates, 2013) and the current Cook Inlet Risk Assessment Final Report (Nuka Research and Planning Group 2015). These reports are used to help provide context,a rich source of information in the development of the interview questions as well as the development of simulation scenarios.

By utilizing multiple approaches of primary data collection and analysis we can best triangulate the results through multiple measurements and assessments of the problem. In addition, each of the forms of data collection and analysis informs the next. Therefore, interviews are utilized to explore the issues and context, simulations are used to diagnose the causes and severity of the problem, and the focus group is used to prescribe how to address the problem.

Phase 1: Interviews

Twenty confidential interviews were conducted with local maritime experts and stakeholders. These interviews included representatives from the shipping industry, tugboats, Southwest Alaska Pilots Association (SWAPA), and CIRCAC. Interviews were designed to meet two primary objectives: (1) to identify issues of concern related to self-arresting in Lower Cook Inlet and provide context about the issue, and (2) provide input for the development of simulations, more speicifically about vessel characteristics and environmental conditions in the Lower Cook Inlet.

Prior to the interviews, participants received information depicting the environmental conditions proposed to be utilized during the simulations. During the interview, participants were asked to verify if the proposed simulation vessel characteristics, locations of engine failures, transit speeds and track lines, wind speed and direction, ice, and current accurately represent environmental conditions in Lower Cook Inlet. This input was essential for establishing simulation parameters and ensuring simulation validity. Participants were also asked to identify challenges, obstacles, and areas of concern when faced with the objective of self-arresting both laden and light tankers. This data provided valuable context for the study, as pilots, captains, tugboat operators, and port personnel (mariners) discussed the nuanced complexities and ramifications of self-arrest maneuvers.

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. These interviews are confidential as per human subjects protocol, identifiable information such as names or organizations are not associated with individual responses. Instead, respondents are associated with a number such as “Interviewee 1”.

Phase 2: Simulations

Simulator

Maritime vessel simulations were created by SGM to replicate inclement environmental conditions that oil tanker may encounter when transiting Lower Cook Inlet. Two automated drift simulations and thirty-four ship simulations were conducted to determine the capability of different size oil tankers, loaded and ballasted, to self-arrest at five locations within Lower Cook Inlet. The simulations provided data on vessel capability to self-arrest by measuring the tonnage exerted on the anchor gear when deployed in an emergency. The various types of environmental conditions in Cook Inlet simulations, as identified and verified by pre-simulation interviews, include maximum flood and ebb currents, elevated sea states, along withwind direction and velocity, as well as ice coverage when appropriate. Simulations evaluated five specific locations, simulating an oil tanker losing propulsion, based upon commonly accepted routes that oil tankers utilize when transiting Lower Cook Inlet.

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 US Coast Guard for instruction and training.[2] The appendix depicts detailed information concerning DNV Class A (NAV) AVTEC Full Mission Ship Bridge Simulators. The simulations were supervised and administered with the assistance of Mike Angove, a maritime simulator technician at AVTEC who has been trained by Kongsberg to operate the simulator.

Personnel

Three active SWAPA members completed the simulated maneuvers, Captain Peter Garay, Captain Josh Weston and Captain Ian Murray and retired SWAPA pilot Captain Karee Elde also participated in the simulations. Table 1 below lists the simulation participants and provides their current title and organizational affiliation.

Table 1. Local Pilots Operating Simulations

Name	Title and Organization
Captain Karee Elde	Retired SWAPA Pilot
Captain Peter Garay	Active SWAPAPilot
Captain Josh Weston	Active SWAPA Pilot
Captain Ian Murray	Active Deputy Pilot SWAPA

[2] 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).

Locations
This study assesses the capability of oil tankers to self-arrest when transiting inbound and outbound to the Nikiski refinery and from the Drift River Terminal to Nikiski. Crude oil tankers transit Cook Inlet south of the Forelands, thus this study did not include transits north of the Forelands. The ship failure locations and speeds utilized in the simulations were based upon commonly utilized transit speed and track lines of oil tankers, and were verified for accuracy in pre-simulation interviews. Furthermore, simulated ship transits were based upon normal transit times coinciding with currents that occur as ship protocol utilizes the flood current at the Nikiski dock, and were reflective of common traffic patterns in the study area. The exact positions where simulated vessels lost power were selected to replicate various requirements in which oil tankers may self-arrest without tug boat assistance. The simulated engine failures occurred at five locations in Lower Cook Inlet. These locations and their latitude and longitude along with the total of number of simulations performed at each location are in Table 2 below.

Table 2. Location of Engine Failure in Lower Cook Inlet, and Number of Simulations

Location Lower Cook Inlet	Latitude and Longitude	Number of Simulations
Nikiski Range	60 35.6N, 151 24W	8
Mid-Inlet Drift Transit	60 37.5N, 151 35W	6
5 Miles from Anchor Point	59 46.40N, 152 02W	6
3 Miles from West Flat Island	59 20N, 152 06W	6
North Kalgin Island	60 35.80N, 151 46.6W	6

Current
To simulate current speed and direction, current maps were created based upon the NOAA current tables of the Pacific Coast of North America and Asia. Interviews indicated that some of the average maximum flood and ebb currents at the five studied locations required greater current values and different directions to be representative of actual currents. It was also noted that vessels predominantly maneuver during flood tides, therefore the majority of simulations utilized a flood tide.

Table 3. Current Speeds and Directions used in Simulations by Location

Current	Nikiski Range	Mid-Inlet Drift Transit	5 Miles from Anchor Point	3 Miles from West Flat Island	North Kalgin Island
Large Floods	2.9 knots, 004	2.6 knots, 055	2.7 knots, 000	3.0 knots, 000	2.6 knots, 055
Small Floods	1.8 knots, 004	1.8 knots, 055	1.7 knots, 000	2.0 knots, 000	1.8 knots, 055
Large Ebbs	2.5 knots, 182	3.1 knots, 232	2.5 knots, 176	3.0 knots, 180	3.1 knots, 232
Small Ebbs	1.5 knots, 182	1.7 knots, 232	1.6 knots, 176	2.0 knots, 180	1.7 knots, 232

Ice

Ice conditions north of the Kenai River were simulated using Vessel Model 1 (smaller tanker) for positions 1) Nikiski flats on range, 2) transiting Drift River to Nikiski, and 5) transiting north Kalgin Island. The ice composition in simulations was 0.25 meters-thick with 30% coverage and large pans. Simulated ice composition is based upon how the model performs within the created ice field, not the specifics of the coverage and thickness. These conditions were found to be realistic by SWAPA pilots during multiple previous simulations conducted by SGM at AVTEC for the Port of Anchorage (POA). In terms of the ice used SGM asked Dr. Orson Smith Professor Emiritus at University of Alaska Anchorage in personal correspondence to provide a comment about the ice used in the Kongsberg simulators at AVTEC. "The simulator is manufactured by Kongsberg and ice program is an additional product purchased separately. The simulator and program are operated by highly trained knowledgable AVTEC personnel, and the simulator is USCG certified for an Ice Navigation course. Simulated ice effects and other maneuvering charactersitics of the ship models are similar to the effect of ice upon ship maneuvers." Therefore, the use of ice in the Kongsberg simulator utilized is sufficient.

Bottom Characteristics

The bottom characteristics used for Lower Cook Inlet during the simulations were sand, for all five locations. This bottom characteristic was selected and held constant for multiple reasons. While the simulator can vary the gradation of the bottom such as rock and pebbly sand, sand is valid as it is consistent with multiple sources including NOAA and US Geological Survey (see above in the background section), and this bottom type was found to be realistic by SWAPA pilots that operate and dredge anchors in Cook Inlet. In addition to its validity, sand is also used because according to SWAPA pilots it is the most conducive bottom characteristic for dredging an anchor, and was used throughout to increase the reliability for comparing between locations.

Wind

The wind speed and direction parameters for this study were also based on data from NOAA, and were verified for accuracy in pre-simulation interviews.

Table 4. Wind Speed and Directions used in Simulations by Location

Position of Failure	NOAA wind Station Location	Low Wind from North	High Wind from North	Low Wind from South	High Wind from South
Nikiski Range	NKTA2/ Tesoro Pier	10 knots, 035	25 knots, 035	10 knots, 225	25 knots, 225
Mid-Inlet Drift Transit	NKTA2/ Tesoro Pier	10 knots, 000	25 knots, 345	10 knots, 180	25 knots, 215
5 Miles from Anchor Point	46108 / SW Anchor Point	10 knots, 020	25 knots, 040	10 knots, 180	25 knots, 225
3 Miles West of Flat Island	FILA2 / Flat Island	10 knots, 000	25 knots, 000	10 knots, 180	25 knots, 180
North Kalgin Island	NKTA2/ Tesoro Pier	10 knots, 000	25 knots, 345	10 knots, 180	25 knots, 215

Sea States
Sea states such as swell and wind chop were implemented for the higher wind simulation objectives for two locations: 5 miles west of Anchor Point and 3 miles from West Flat Island. Five miles West Anchor Point Swells were 1.5 meters including wind chop of 0.5 meter with 4 seconds between swells, representing a sea height of approximately 6 feet. Three miles West Flat Island ocean swell was 7 meters and wind chop of 2 meters with 8 seconds between swells, representing significant total sea height of approximately 30 feet.

Vessels
There are two vessels utilized for simulations. The Tank Model PRODC07L is a loaded oil tanker that is consistent with the smaller oil tankers that currently operate in Lower Cook Inlet (Cape International, 2012). As per the results of the interview process suggesting a second larger oil tanker also be used, a 115K Tank Model is also utilized both ballast and loaded. A vessel of this size cannot be fully loaded as tankers operating in Cook Inlet are limited by contingency planning to a total capacity of 500,000 barrels of oil. Therefore, even if such an oil tanker were to operate in Cook Inlet it could not be fully loaded. However, for this research a fully loaded 115,000 ton tanker is utilized in the simulation due to programming limitations of the Kongsberg simulator at AVTEC, only a full loaded tanker could be simulated. The smaller tanker was only tested as loaded and not ballast. The rationale is that the 115K tanker model when ballast is much more difficult to maneuver and if simulations were able to self-arrest the ballasted larger vessel it would be unnecessary to simulate the smaller vessel in ballast.

Table 5. Vessel Charateristics and Vessel Models Utilized for Self-Arrest Simulations

Model/ Ship	#SIM Model	LOA	Beam	Depth/ Draft	Displacement Dead Weight	Gross Tons	Anchor Break Tons
Overseas Group Loaded		601’	105’	43’	60,000	29,242	
Tank Model PRODC07L	1	600’	105’	43’	64,330	Approx. 30,000	441 TONS 12 SHOTS
Ross Sea 114 K Ballast		801’	139’	28’	36,771 54,530	59,180	
Tank Model 115K 16B	2	820’	144’	28’	61,320 115,000	Approx. 62,000	772 TONS 26 Shots
Ross Sea 114K Loaded		801’	139’	40’	81,695 99,454	59,180	
Tank Model 115K 16 L	3	820’	144’	49’	61,320 133,900	Approx. 62,000	772 Tons 26 shots

Table 5 depicts the vessel characteristics as well as the models in the simulator. Larger tankers (models 2 and 3) were simulated in both ballasted and loaded conditions. The ballasted model, 115K 16B, portrayed an empty tanker with the following characteristics: Length 820’ and beam 144’ and 28’ draft. The loaded model, 115K 16L, was portrayed as a fully loaded tanker with the following characteristics: Length 820’ and beam 144’ and draft 49’, 115,000 deadweight ton (DWT). A smaller tanker was simulated with 64,000 DWT model from AVTEC library. This model PRODC07L, has the following characteristics: Length 600' and beam 105' loaded with 44' draft. It should be noted that the anchor gear breaking metrics, or failure tonnages, are provided for each model.

Simulation Protocol

The simulations occurred over a period of two days, during December 15 – 16, 2016. Simulations were supervised and administered with the assistance of Mike Angove, a maritime simulator technician trained by Kongsberg to operate the simulator. Prior to the simulations, SGM conducted pretests of the simulations to help determine the most effective starting points and other objecitves to ensure the validity of the simulations in collaboration with AVTEC simulator technician Mike Angove.

Two simulators were used simultaneously, with each maneuver performed by two highly qualified mariners and one AVTEC simulator technician. One research assistant was present in each simulator to document mariners' reactions, and process during the exercise. A SWAPA pilot would have command and would be assisted by a second mariner. During the simulation, the pilot was encouraged to communicate his process throughout the manuever to the research assistant for documentation. The second mariner was there to assist in the bridge simulator actions as needed by the pilot, and to increase the reliability of the exit interview such as clarify details or provide additional input as needed.

Pilots were tasked with completing a self-arrest maneuver due to the loss of propulsion as the vessel was underway at anticipated normal speeds of advance for specific locations. All simulations were initiated with vessel speed over the ground of either 10 or 12 knots. Anchor(s) deployment was controlled by the pilot within the simulator. An anchor gear tonnage indicator was located within each of the simulators to monitor the tons of force applied and if tonnage exceeded the documented breaking strength. The breaking strengths are 441 tons' simulator model 1 and 772 tons for simulator model 2 and 3.

Pilots had the objective to safely self-arrest the vessel, given various environmental conditions, vessel characterisitcs, and location. Simulations varied in the amount of time they took to complete, but were approximately 30 minutes from beginning to end.

After each simulation, pilots completed an exit interview while consulting a video monitor that showed a screen shot capturing the vessel movement during every three minutes of the simulation. The exit interview questions and scales of responses analyzed are listed below:

1) The simulation represented realistic environmental conditions.
   1 = Strongly Disagree, 2 = Disagree, 3 = Neither Disagree nor Agree, 4 = Agree, 5 = Strongly Agree
2) The simulation represented realistic attributes and maneuverability of the vessel.
   1 = Strongly Disagree, 2 = Disagree, 3 = Neither Disagree nor Agree, 4 = Agree, 5 = Strongly Agree
3) After the performing the emergency self-arrest maneuver, the vessel is now in a temporarily safe position.
   1 = Strongly Disagree, 2 = Disagree, 3 = Neither Disagree nor Agree, 4 = Agree, 5 = Strongly Agree

4) Taking into consideration this is an emergency maneuver, what was your level of concern when attempting to arrest the vessel?
   1= Not at all, 2 = Slightly, 3 = Somewhat, 4 = Moderately, 5 = Extremely
5) How many anchors were utilized in performing this maneuver?
   One or two
6) Did anchor strain exceed breaking strength of anchor gear?
   0 = No, 1 = Yes
7) The anchor(s) provided sufficient arresting capability for disabled vessel.
   1 = Strongly Disagree, 2 = Disagree, 3 = Neither Disagree nor Agree, 4 Agree, = 5 Strongly Agree

Phase 3: Focus Group

A focus group was conducted on February 3, 2017 in Anchorage, Alaska. The purpose of the focus group is to facilitate an open discussion between mariners and stakeholders about the results of the simulations. The primary objectives are: verify and help interpret the results of the simulations; identify the causes of concern from pilots and stakeholders related to self-arrest; provide recommendations on how to mitigate issues related to self-arrest.

Representatives from CIRCAC, mariners who took part in the simulations, and Tesoro participated in the focus group. The focus group was moderated by Safeguard Marine personnel. Notes were taken by a research assistant, but recorded comments were not attributed to any individual speaker.

Table 6: Focus Group Participants

Individual	Organization
Captain Pete Garay	SWAPA Pilot
Captain Josh Weston	SWAPA Pilot
Captain Ian Murry (telephonic)	SWAPA Deputy Pilot
Captain John Schneider	Tesoro Marine Operations
Mike Munger (telephonic)	Executive Director CIRCAC
Steve “Vinnie” Catalano (telephonic)	Director of Operations CIRCAC
Captain Jeff Pierce	SGM President
Dr. Jonathan Pierce	SGM Vice President
Sarah Huffman	SGM Research Assistant

Results

Results: Interviews

Interviews were conducted over a two-week period in November 2016. These interviews are semi-structured using open ended questions in a similar manner and order for all participants. The interviews are confidential as per federal laws for using human subjects. However, all interview participants are local subject-matter experts or stakeholders involved with Cook Inlet maritime sector. Twenty interviews were conducted, seventeen of these were with local maritime subject matter experts and three with stakeholders. The local subject matter experts provided information about the locations of the self-arrest, environmental conditions, vessel attributes, as well as the process of self-arrest including input on developing the vessel simulations. One interview was removed from interview data upon request of interviewee prior to simulations.

Nineteen of the twenty respondents interviewed stated that self-arrest of a crude oil tanker in lower Cook Inlet was a feasible maneuver based upon reducing speed prior to deployment of anchor(s). Specific locations for engine failures to occur were recommended, based upon excepted track lines of crude oil tankers. Also, specific environmental conditions in combination with specific ship models were suggested. Finally, multiple respondents stated their appreciation for conducting this study.

1. **Do you believe self-arresting a crude oil tanker within Cook Inlet is feasible?**

Nineteen of the twenty respondents interviewed stated that it is feasible. Multiple respondents commented that feasibility depended on the personnel involved.

“Personnel is the crucial variable for successful outcome” (Interviewee 1).

“Yes however, it’s not so much whether the tanker is capable as much as it depends on the operator, depending on experience and training. A well trained/experienced pilot/captain could do it under difficult conditions, however without experience/training could be unsuccessful in good conditions. I think it’s more than feasible, I’ve seen the results and think it’s an important tool for pilots to have” (Interviewee 16).

2. **Among the four designated positions for ship casualty (loss of power) selected, which position, if any, will pose the greatest difficulty for self-arrest capabilities?**

Responses from interviewees resulted in multiple locations being identified. However, the Nikiski Range location had a majority of responses and was specified as the most dangerous position due to proximity to shallow waters and possibility of grounding.

The Flat Island location was also mentioned due to depth of water, resulting in difficulty of self-arresting at this location. Some respondents provided multiple responses and provided comments associated with their choice, some of these are depicted with results listed. Two respondents did not comment on this question. Thirteen of the eighteen respondents indicated Nikiski Range location as the most difficult location to perform self-arrest maneuver successfully. Examples of responses are below.

“Nikiski would be the most difficult because the proximity of shallow areas, need react a lot faster than you would for the others, keeping in the channel before losing control” (Interviewee 9).

Other interviewess called Nikiski Range the “most potentially hazardous” (Interviewee 14), “if something goes wrong there is a lot of shallow water, better chance of going a ground” (Interviewee 15).

Four respondents indicated that three miles west of Flat Island would present the most difficult position to perform a successful self-arrest maneuver. Some comments concerning this location were: Flat Island because it is deeper than the other locations (Interviewees 4, 6, and 9), and it is hard to get the anchor to dredge (Interviewee 15).

Drift River Transit (mid Cook Inlet) positon was identified by four interviewees due to the depth of water, and four interviewees included 5 miles West of Anchor Point also citing the depth of water.

3. Conversely, which of the four designated positions do you think will be the least difficult position for performing self-arrest of tankers within Cook Inlet?

Fifteen interviewees indicated 5 Miles West of Anchor Point would be the least difficult position for performing a self-arrest maneuver. The majority of the responses cited the amount of sea room available, and lack of immediate hazards to the ship. Some respondents answered with multiple locations, such as Drift Transit Mid Cook Inlet and Anchor Point also citing the lack of navigational hazards, and sea room to perform a self-arrest maneuver. Two respondents stated Nikiski Flats, due to shallow water for dredging an anchor.

4. **NOAA stations closest to the four designated positions are referenced for wind and currents, do you have recommendations for alternative values to utilize for simulations?**

Sixteen of the interviewees responded in negative, no further recommendations for stated winds and currents. The majority stated the currents and winds were adequate to test environmental conditions associated with Cook Inlet. Most of the respondents agreed that the environmental conditions represented the conditions in Cook Inlet about 80% of the time. There was no dissent about the wind speed or direction.

Several interviewees commented concerning Flat Island that the current velocity should be increased (Interviewees 2, 12, and 15). Utilizing large southernly swell height and wind chop at Flat Island was also recommended. These concerns were addressed, resulting in an increase of current velocities to 3 knots for both flood and ebb currents, also swell height for Flat Island was simulated at 7 meters and wind chop an additional 2 meters with 8 second period. Anchor Point was simulated with 1.5 meter swell and 1 meter wind chop at 4 second period.

5. **After loss of headway, will current or wind have greater effect upon ships being simulated?**

The majority of interviewees referenced the condition of the ship, whether it was loaded or empty. If loaded, the current would have the largest effect, but if light or empty, the wind would have greatest effect upon ship. Also noted was the velocity of the wind in contrast to the speed of the current.

Respondents commented that “If it’s loaded the current will have the most effect, if it’s in ballast the wind is going to have more of an effect” (Interviewee 1).

“If loaded it will be the current, if its light the wind is going to affect it more. Current could offset the wind even if the ship is light, depending on its strength” (Interviewee 2).

“Laden tankers will be more affected by current, wind will affect ballasted tankers more” (Interviewee 12).

One respondent quoted a rule of thumb utilized for estimating environmental effects upon ships, “20 knots of wind equals 1 knot of current, path dependency, and time related” (Interviewee 4).

6. Do you think tonnages applied to anchor gear will result in exceeding breaking strengths?

If anchor gear (combination of anchor and anchor chain) breaks, the possibility of performing a self-arrest is eliminated. Only one respondent stated that they expected the anchor gear to break, the remaining nineteen respondents stated that the anchor would not break. Respondents cited local knowledge, training and experience utilizing anchor gear as essential requirement for capabilities of mariners to perform a successful self-arrest maneuver. Breaking of anchor gear was directly associated with minimizing amount of anchor chain utilized and speed of vessel at time of deployment, requiring the mariner to exhibit great skill and patience. Examples of responses are below.

“Yes, and no. I think you’re going to have some broken chains and others will be able to self-arrest without breaking the chain. Depends on ship speed and tide (ebb and flood), how much chain is let out, if the dredging anchor is left out, how much momentum is picked up, depends on how good the mariner is. You would have to turn the ship to get it slowed down. You will see broken chains on a regular anchoring procedure, but that doesn’t mean this can’t be done correctly, it just means that to not break the chain training and experience is necessary” (Interviewee 2).

“I think if you’re controlling the drift as you put it out (the anchor) even if there is a strong current and ice and if you’re in deep water and you’re tracking yourself, if you are arresting the ship then a controlled drift isn’t a bad thing” (Interviewee 3).

“It would not exceed if done correctly” (Interviewee 5).

“Not if the anchor is applied properly” (Interviewee 7, 11, 12).

“I think if done carefully and properly then no, it will not break” (Interviewee 8).

“If deployed correctly and the speed is down and you’re monitoring it then no, it won’t exceed the breaking strength if done correctly” (Interviewee 10).

"Not if the anchor is deployed dredging. It could if you put out too much chain and are going too fast, if it's not done correctly" (Intervieweee 15).

7. Do you think you will have rudder capability even if the ship lost propulsion?

If a vessel loses propulsion, it does not mean a loss of steering will occur for a prolonged period as vessel has multiple backup rudders. All interviewees agreed that the rudder would still be able to steer the vessel even after the loss of propulsion. Therefore, simulations were performed with the vessels rudder system operating based upon responses to this question, however there was a loss of propulsion in every simulation. Examples of responses are below.

"The actual down time of a rudder I have experienced in the last 40 years is approximately 30-60 seconds. You don't have the need to anchor in this span because of multi system backups. Normally the need is eliminated when you go non-follow up. In the one minute of steering failure, or even 3-5 minutes of down time, the vessel is unlikely to be in congested waters in Cook Inlet and the time is used to naturally slow the vessel down in preparation to self-arrest. If the rudder is the issue and stuck hard over, the turn will assist slowing the vessel speed. If it is an engine issue you still have steering and time to self-arrest or just anchor normally" (Interviewee 1).

"It depends on the nature of the failure. Generally, there are several ways to get it back? Should be able to get it back in minutes. Should switch to an alternate source if you've got a good crew/mechanics. A rudder has multiple backup systems, should be able to count on getting the rudder back quickly, so you can use it to steer to the spot where you want to anchor" (Interviewee 2).

"There are back up systems for the rudder, even if there are not back up systems for the engine" (Interviewee 3).

8. Self-arresting procedure utilizing three distinct procedures describe your input for each:

8A. Reducing speed of ship prior to deploying an anchor;
The speed of the vessel must first be reduced in order to deploy an anchor(s). If vessel speed is not reduced, then the forces may break the anchor gear or prevent its optimal use. Reducing vessel speed can be done by using multiple approaches as depicted by the interviewees. A majority of responses were focused upon the time factor required prior to immediate responses and location of the ship relative to nearby dangers. If feasible, allowing the ship to diminish speed without action was recommended, immediate action requirements were turning the ship to reduce speed and dredging of anchor(s) prior to full deployment. Some examples of the responses are:

"Reducing the speed prior to deploying the anchor is critical part of the maneuver. There are very few places in the world where pilots have the skill and experience to do this in current. You must keep in mind the speed in the water verses the speed over the ground. If you're controlling your speed, utilizing the current and the speed over the ground is critical to a successful save. Depending on the nearest obstruction/ danger. If ship is close proximity to danger, one might have to bring the vessels head into the current early. It is a matter of timing and experience. The general process would be to bring the bow into the current with a residual speed, reducing speed over the ground until it's below a knot and a half, two knots over the ground prior to full deployment of anchor" (Interviewee 1).

"Walk back two or three shots while in gear in a controlled manner if you can and it's not too sudden (depends on how much time you have, based upon ship location). You can let anchor go and make no progress because it will break. Walking the anchor back, dredging the anchor, or if you have the time and your off shore, walk out a couple shots and put the break on, but don't let the anchor free fall" (Interviewee 2).

Other respondents were not as detailed: "cycle the rudder, do a round turn depending if you're going with or against the current. A round turn is the quickest way to slow down, if you have the sea room" (Interviewee 11). "I would cycle the rudder to act as a break or make a big turn to reduce headway" (Interviewee 12). "Use the rudder, and turn the ship into the current to stem the tide" (Interviewee 14).

8B. At what speed would you deploy the anchor, and when would this commence? Also, please describe the process?

A vast majority of interviewees stated that the ship speed should be three knots or less for deploying the anchor(s) except three respondents stated either five or six knots. The response of three knots is consistent with the finding of The Glosten Associates (2013) which states, "In our judgment, the upper speed limit above which there is near zero probability of self-arrest is around 5 knots (p. 4)". Several comments related to ships speed and deployment of anchors are listed.

"Depending on the nearby dangers you would alter course at the right time to keep a good CPA from dangers, stem the current, reduce ground speed to 2 knots or under, and then deploy the anchor. In an emergency, a skilled deployment in stages of the anchor chain can and has been done at much higher speeds. An example might be dredging the vessel to reduce the set and headway while all the time slowing down and paying out scope of chain until the vessel catches" (Interviewee 1).

"Not above 4 or 5 knots. Below 4 or 3 is preferable. I would walk back a shot depending on depth until I know it's close to the bottom and then I would let it get 1.5 times the water depth and let the anchor dredge. You should know the depth of water to dredge the anchor, and this will slow the ship down. Once you're slow enough you can deploy the rest of the anchor (speed around 1-.5 knots)" (Interviewee 2).

"Probably do it at 3-5 knots, letting out 1 or 2 shots to start with, until the speed goes down and then you can let out more" (Interviewee 11).

8C. Full deployment of anchor(s) describe procedure and how many shots of chain?

The scope of the anchor chain was emphasized by multiple respondents. Dredging anchor to slow the vessel down was recommended to be veered out to a greater scope or utilizing the second anchor for deployment. Procedurally multiple respondents identified the use of walking the anchor(s) out instead of letting the anchor free fall on the brake. Multiple respondents also emphasized utilizing only one anchor for ultimately anchoring the ship. Some specific responses are below.

"I would put a little more chain out until I'm below a knot. I'd leave the dredging anchor out and put the other anchor out, I'd go in line with the anchor so that I'm in line with the current, until I have control, and then I would put the anchor out another shot or two. I wouldn't finish deploying the anchor until I'm below a half a knot" (Interviewee 2).

"If you can minimize the scope of chain and avoid the anchors grabbing the bottom until the speed is reduced, then you may have a better chance. Again, depending on the amount of sea room in the area" (Interviewee 10).

"Once the anchor gently touches the bottom the ship will start slowing down. Once you're dead in the water you can let it out more, up to 8 shots" (Intervieee 14).

9. Based upon the information provided, do you have any input concerning best practices to be performed during simulations?

Responses to this question were varied. A majority of interviewees stated what was presented already is sufficient and they were interested in the results of this research (4, 8, 9, 10, 11, 12, 14, 15, 19). A couple interviewees identified the need for exposure or training in order to effectively perform a self-arrest maneuver. Respondents 2 and 3 stated that experience and training are necessary to stabilize and slow the ship down, that a pilot or captain needs to know where you want to drop the anchor and where you want the ship to be after the anchor is dropped**.**

Ship board personnel capabilities were also mentioned as their needs to be a person on the bow capable of operating the anchor and good communication between the bridge and the bow. This means good bridge resource management by the pilot or captain. Examples of responses are below.

"Someone needs to be on the bow to handle the anchor. Good seamanship is important when letting the anchor go and being able to control the release on the break, if you have a problem as the pilot about the speed of chain being let out by the brake, or competency of person on bow paying out the chain, you can ask the person on the bow to engage and walk out the remaining scope of chain as the last resort" (Interviewee 1).

"A conflict between the master and the pilot may occur because captains are going to be reluctant to do something extreme out of fear of damaging the vessel. The pilots are going to have to make those decisions, and have persuasive leadership, especially since it's likely that the captain will have a more conservative position" (Interivewee 16).

10. Do you have any specific simulations you wish to see performed based upon the four positions or ships involved?

A majority of respondents did not identify specific simulations. Engine failures or self-arrest locations were depicted at four separate locations during the interviews. Interviewees 5, 11, and 15 requested a fifth position of North of Kalgin Island. Therefore, North Kalgin Island was added as a positon for self-arrest simulations.

In the interview protocol, two ships were identified for simulations. Multiple respondents suggested a third, loaded 115,000-ton ship. According to Cape International (2012), a tanker of this size has not previously been in operation in Cook Inlet. In addition, a vessel of this size cannot be fully loaded as tankers operating in Cook Inlet are limited by contingency planning to a total capacity of 500,000 barrels of oil. Therefore, even if such a tank vessel were to operate in Cook Inlet it could not be fully loaded. However, for this research a fully loaded 115,000 ton tanker is utilized in the simulation this is because the simulation vessel models can only be set to loaded or unloaded.

11. Will proposed simulations provide enough data to determine if self-arresting tankers in Cook Inlet is feasible?

Nineteen of the twenty respondents agreed that simulations would provide enough data to determine the feasibility of self-arresting a tanker in Cook Inlet. Examples of responses are below.

"Yes, the background experience of people that have had to do this is the past will be helpful. Cook Inlet is shallow, allowing for self-arresting as risk mitigation possibility, this is helpful (Interviewee 3).

"Yes, because it will be comprehensive" (Interviewee 5).

"All of us have already done anchor work (self-arrest) in strong current and ice in Cook Inlet. We have done it for years at Nikiski and are very familiar with how to deploy without overloading the anchor chain, also with how to use the anchor as a brake and to get better control of the vessel. Most of us, at one time or another, have had to anchor in non-standard anchorages under emergency conditions. We already know the effects of current and ice on the process but it is always good to run things through the simulator. There is always more to learn" (Interviewee 13).

"I think this is good, especially since I've seen self-arrest in Cook Inlet be accomplished. Self-arresting is an important and critical tool for pilots to have to navigate Cook Inlet because of the extreme tides and currents. It's an important tool and it gives them the ability to work out in their heads and have plans to utilize within the Inlet, without this we miss an important opportunity" (Interviewee 16).

12. Do you have any further comments or is there further relevant information that we should consider?

Three respondents requested ice simulations to be performed (Interviewees 11, 13, and 16). These were performed and were depicted within the interview protocol for the shuttle tanker simulations. Simulations in ice were not conducted for the 115,000-ton class ship, as it previously had not been used in lower Cook Inlet during significant ice prior to winter 2016. Thus, this class of ship was not simulated performing self-arresting simulations during ice conditions.

In addition, several respondents raised the issue of training.

“I’ve handled ships in busy ports where tethering is necessary, but it’s not in Cook Inlet, because the width and depth in Cook Inlet is very conducive for self-arrest where other ports are not. The pilots are experienced at utilizing this technique in an emergency, so we need continual training. This includes master/pilot training, training for pilots is assured that this is the best solution compared to alternative methods. Self-arrest may also never be needed because of this large body of water. One could find themselves slowing the ship down naturally until a normal anchor operation would occur” (Interviewee 1).

“You’ve asked good questions and picked good spots/conditions to get a lot of different information. Very little training is given to pilots with anchoring. Anchoring is a complex procedure, while it may appear simple. Most of the time pilots are only trained to anchor in specific conditions. To get good at self-arresting you would have to practice. You need to know when to drop it, how much chain to put out – you don’t want to leave these things to chance when you’re trying to be successful in your outcome. It’s important to be familiarized with the process and procedures that go into anchoring” (Interviewee 2).

“Pilots should have familiarization or training in self- arresting, when arresting a ship w/out a tug is a practical practice within Cook Inlet and should be an important part of training for Cook Inlet” (Interviewee 3).

Some additional comments are below.

“No, In the past we have proven that this maneuver is successful, maybe we could document some of those experiences to provide further evidence for simulation” (Interviewee 5).

“No, in general, the water is shallow in Cook Inlet, so you can anchor anywhere” (Interviewee 7).

“Not at all. It is well-designed, and interested in seeing the results” (Interviewee 9).

Results: Simulations

The following simulation results are grouped by exit interview questions, and are reported using median scores.[3]

Determining realistic environmental conditions, vessel attributes, and vessel maneuverability

Exit interview results conclude that the simulations presented realistic environmental conditions, vessel attributes, and vessel maneuverability in all position of failure sites.

Table 7. Median Level of Agreement for Simulation Conditions (1= Strongly Disagree, 5= Strongly Agree)

Exit Interview Question	Nikiski Range (n=8)	Mid-Inlet Drift Transit (n=6)	5 Miles from Anchor Point (n=6)	3 Miles from West Flat Island (n=6)	North Kalgin Island (n=6)
Realistic Environmental Conditions	5	5	5	5	5
Realistic Vessel Maneuverability	5	5	5	5	5

Determining if the vessel was in a temporarily safe position after performing an emergency self-arrest maneuver

Pilots in all locations concluded that the exercise ended with the vessel in a temporarily safe location. Pilots were instructed that temporary meant up to approximately six hours for a response. This amount of time is consistent with the range of times provided by the *Cook Inlet Risk Assessment Final Report* (2015) for a tugboat response in the Lower Cook Inlet region.

Table 8. Median Level of Agreement that Vessel Reached a Temporarily Safe Location (1= Strongly disagree, 5= Strongly Agree)

Exit Interview Question	Nikiski Range (n=8)	Mid-Inlet Drift Transit (n=6)	5 Miles from Anchor Point (n=6)	3 Miles from West Flat Island (n=6)	North Kalgin Island (n=6)
Vessel in Temporary Safe Position	5	5	5	5	5

[3] The simulation sample size does not provide enough statistical validity for results to be reported as an average (mean). Thus, results are reported using the median, which is a more accurate representation given the sample size and the ordinal nature of the data.

Level of Concern for Completing an Emergency Self-Arrest Maneuver

The median level of concern varied by location. There is a high level of concern (4.5 out of 5) on the Nikiski Range and a low level of concern (2) in the Mid-Inlet Drift Transit. While most of the point of failure sites yielded a slight to moderate concern, pilots were notably more concerned about self-arresting on the Nikiski Range.

Table 9. Median Level of Concern for the Completion of the Maneuver (1= Not at All, 5= Extremely)

Exit Interview Question	Nikiski Range (n=8)	Mid-Inlet Drift Transit (n=6)	5 Miles from Anchor Point (n=6)	3 Miles from West Flat Island (n=6)	North Kalgin Island (n=6)
Level of Concern	4.5	2	3.5	3	2.5

The level of concern also varied between the first and second day of simulations. Overall, the median level of concern for self-arrest declined during the second day of simulations, as pilots became more familiar with the maneuver. It cannot be determined if this decline is significant as there are not enough simulations. However, this issue is further addressed in the focus group discussion.

Table 10. Comparison of Day One and Day Two Median Level of Concern (1=Not at All Concerned, 5=Extremely Concerned)

Level of Concern	Nikiski Range	Mid-Inlet Drift Transit	5 Miles from Anchor Point	3 Miles from West Flat Island	North Kalgin Island
Day One Median / # Observations	4.5 / n=4	3 / n=3	3.5 / n=6	3.5 / n=2	4 / n=3
Day Two Median / # Observations	4 / n=4	2 / n=3	NA / n=0	2.5 / n=4	2 / n=3
Difference (Day 2 – Day One)	-0.5	-1	NA	-1	-2

Frequency of Multiple Anchor Use and Anchor Breaks by Location

Pilots had two anchors available during the simulations. If the pilot utilized two anchors, the simulation was recorded as one that required “multiple anchors.” The frequency with which pilots utilized multiple anchors varied by location. The Nikiski Range simulations required multiple anchors in 75% (6/8) of the simulations, while simulations at the Mid-Inlet Drift Transit only required multiple anchors during 33% (2/6) of the simulations. None of the simulations concluded in an anchor break. Also, the use of multiple anchors was not associated with anchor gear breaks.

Table 11. Frequency of Multiple Anchors Used and Anchor Breaks by Location

Exit Interview Question	Nikiski Range (n=8)	Mid-Inlet Drift Transit (n=6)	5 Miles from Anchor Point (n=6)	3 Miles from West Flat Island (n=6)	North Kalgin Island (n=6)
Multiple Anchors	75% (6)	33% (2)	50% (3)	66% (4)	83% (5)
Anchor Break	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)

In addition, the results demonstrate that the level of concern is not associated with the number of anchors used at the location. Nikiski Range has the highest level of concern and multiple anchors are frequently used (6/8), but North Kalgin Island has a low level of concern and multiple anchors are also used frequently (5/6). In addition, Mid-Inlet Drift Transit had a low level of concern and did not frequenty require multiple anchors (2/6). Overall, the number of anchors and level of concern are independent and instead are associated with the specific location.

Table 12. Median Level of Concern and Frequency of Multiple Anchors Used (1=Not at All Concerned, 5=Extremely Concerned)

Exit Interview Question	Nikiski Range (n=8)	Mid-Inlet Drift Transit (n=6)	5 Miles from Anchor Point (n=6)	3 Miles from West Flat Island (n=6)	North Kalgin Island (n=6)
Level Concern	4.5	2	3.5	3	2.5
Multiple Anchors	75% (6)	33% (2)	50% (3)	66% (4)	83% (5)

Determining if Anchors are Sufficient for Self-Arrest

At all locations, pilots reported that the anchors available during the simulations were sufficient for the self-arrest maneuver.

Table 13. Median Level of Agreement with Sufficiency of Anchor for Self-Arrest (1=Strongly Disagree 5=Strongly Agree)

Exit Interview Question	Nikiski Range (n=8)	Mid-Inlet Drift Transit (n=6)	5 Miles from Anchor Point (n=6)	3 Miles from West Flat Island (n=6)	North Kalgin Island (n=6)
Anchor Sufficient for Self-Arrest	5	5	5	5	5

The simulations performed by the mariners were all extreme cases involving emergency scenarios. The above simulations did not allow for pilot miscalculations. Pilots used ship anchors to control vessel movements after the loss of propulsion. The pilots had control over the anchor in the simulator this means that they determined when it was deployed, and how much chain was used. In practice, walking the anchor back in gear was the preferred method of deployment, in order to control the amount of anchor chain utilized. The initial scope of anchor chain was never greater than approximately 2:1 ratio. This creates a large angle between anchor chain and ship, preventing the anchor from fetching up on the bottom.

Overall, the simulations resulted in the following observations:

Simulations were realistic both in terms of environmental conditions and vessel maneuverability. At all five locations in Lower Cook Inlet, the vessel was in a temporarily safe location after the emergency self-arrest maneuver.

In all five locations, the anchor was sufficient for the vessel to self-arrest.
The median level of concern for the maneuver varied by location, with the Mid-Inlet Drift Transit yielding the lowest level of concern (2/5) and the Nikiski Range yielding the highest level of concern (4.5/5) based on multiple simulations.

Self-arrest maneuvers of the vessels never led to the breaking of the anchor gear, including in ice conditions.

The number of anchors used varied between 1 and 2 depending on location.

The level of concern for self-arresting maneuvers was not assoicated with the number of anchors used during the maneuver, rather they are independent and level of concern and the number of anchors is dependent on the location.

The median level of concern for self-arrest declined during the second day of simulations. This result occurred even though there was no decline in the difficulty of the simulations involved in terms of location or environmental conditions being less extreme. The results indicate that the level of concern decreases after mariners complete multiple self-arrest maneuvers.

In addition to the piloted simulations, four automated drifts of using Tank Model PRODC07L (the small loaded tanker) were performed from two locations. Two were conducted 3 miles West of Flat Island and two simulations for Mid-Inlet Drift Transit. Each of these were conducted utilizing fast time simualtions, resulting in accelerating time lapse to 36 times actual time. Each of the two locations were tested. One simulation used a six hour drift depicting an ebb current, and the other simulation a 12 hour drift depicting both ebb and flood currents. All four simualtions resulted in the vessel drifing south and north within Cook Inlet without any casualities to the vessel.

Results: Focus Group

A focus group was conducted to verify, interpret and provide recommendations based on the completed simulations. It provided an opportunity for discussion about the results of the simulations including various stakeholders. Participants involved in the focus group are identified in Table 6 above, and includes the pilots involved in the simulation as well as stakeholders. A power point was used to present an overview of the study and the results from the simulations. The results of the simulations were also sent to CIRCAC and the pilots participating in the focus group a month prior. This provided ample time for attendees to be aware of the results of the simulations.

The pilots verified the results from the simulations. Including that environmental conditions and simulator models were representations of real-world experiences.

The focus group discussed the results of the simulations. Experience, exposure, and local knowledge were discussed as important aspects for successful completion of a self-arrest maneuver. The loss of a ships' propulsion at full speed necessitated the pilots' make a decision dependent upon the location of the failure and environmental conditions.

Some simulations did not require immediate action due to the specific locations involved. This was further portrayed with four automated fast time extended drifts of disabled tankers during simulations. Nikiski Range and North Kalgin Island required immediate action to be taken because of cross currents and limited sea room available for the ship.

During the focus group, the pilots discussed how local knowledge and pilots' perception of imminent danger to the ship may be different than a captain resulting in different reactions to the loss of propulsion. A pilot will have greater comfort level and confidence utilizing all of the tools available to safely maneuver the vessel including anchor gear. Ultimately what actions are taken in an emergency should not create greater consequences for the ship but rather mitigate them. The actions of a pilot or a captain on a vessel that has lost propulsion may aggrevate the level of risk to the vessel and the environment rather than mitigate.

There was also a discussion concerning vessels near Flat Island not advancing to the Homer pilot station in a timely manner. The discussion was that tankers should proceed to the pilot station in a timely manner for several reasons including changing environmental conditions, exposing themselves to greater risk, and possible direct conflict with state regulations.

The results of the focus group are nine statements of agreement and three recommendations. These statements have been revised for greater clarity and correct grammar, but the content, intent and purpose has not been changed. The statements of agreement are the following:

1) Results indicate that self-arrest is a viable risk mitigation procedure.
2) Anchors are an effective tool and should be used for self-arrest in Lower Cook Inlet.
3) Knowledge of anchor equipment and capabilities are necessary for a succesful self-arrest.
4) Ice and other environmental conditions may assist a vessel and mitigate the level of concern.
5) If the current is running parallel to the bathymetry, the level of concern is significantly less.

6) The process of self-arrest is location dependent. The most immediate concern and primary task is to reduce the speed by turning the tanker and balancing vectors of environmental elements. Utilizing an anchor for self-arrest is an art dependent upon many factors, including the human factor.
7) Different locations require different processes and practices for self-arrest, and success is dependent upon the level of experience of the mariner involved.
8) Cook Inlet Harbor Safety Committee should address and discuss ships operating outside of Kachemak Bay awaiting arrival at the Homer Pilot Station.
9) Pilot level of concern decreased during the second day of simulations. This was due to exposure and practice of performing the self-arrest maneuvers. The greater the amount of exposure a mariner has to self-arrest maneuvers, the more likely they will be successful in performing self-arrest.

The two recommendations by the focus group and this report are the following:

1) The Cook Inlet Risk Assessment should be updated based upon this study, per recommendation 6.3.[4]
2) Pilots should participate in simulation familiarization of self-arrest maneuvers as this will increase the likelihood of success. Further research should be conducted in terms of developing best practices and the benefit of anchor gear use for self-arrest.

[4] Cook Inlet Risk Assessment Final Report, January 27, 2015, Nuka Research and Planning Group, LLC and Pearson Consulting, LLC, www.cookinletriskassesment.com page 41

Conclusion

This report identifies issues related to the capabilities of oil tankers to self-arrest in Lower Cook Inlet as recommended in the *Cook Inlet Risk Assessment Final Report* (2015). It finds that self-arresting a tanker after the loss of power is a viable option in Lower Cook Inlet. The interviews with local-subject matter experts indicate that self-arresting a tanker in Lower Cook Inlet has been performed and successfully accomplished in the past. During simulations, five locations in Lower Cook Inlet were tested during inclement environmental conditions using three different tank vessels of various sizes and cargo status. In total, thirty-two simulations were conducted using normally accepted track lines for tankers transiting Lower Cook Inlet. The simulations resulted in no groundings. All of the oil tankers simulated including the loaded 115,000-ton tanker were capable of being arrested utilizing the ship's anchor(s) without incurring anchor gear failures. There is variation in terms of the amount of concern, process, and number of anchors used depending on the location in Lower Cook Inlet.

Previously, The Glosten Associates (2013) completed a report on self-arrest of deep draft vessels in Cook Inlet inclusive of oil tankers. They utilized a literature review to determine that the "estimated probability of self-arrest is low … [and] it cannot be considered a reliable risk reduction option" (p. 2). This research using interviews with local subject matter experts and stakeholders, vessel simulations of oil tankers in Lower Cook Inlet using local pilots, and a focus group with local subject matter experts and stakeholders finds that oil tankers, which are a type of large, deep-draft vessel, are able to self-arrest in Lower Cook Inelt. The probability of self-arrest is high given the conditions and local pilots used in this study. It is outside the scope of this research to determine if self-arrest is a raliable reduction option. In order to determine if the practice is reliable, additional research is necessary.

The results of the self-arrest in all of the locations in Lower Cook Inlet were a success. This means the vessel after it lost power was able to self-arrest in a temporarily safe location using only its anchor gear that did not break. However, the level of concern by the pilots performing the manuever did vary by location. The locations in Lower Cook Inlet that had the least amount of concern and where the practice is most likely to be successful are Mid-Inlet Drift Transit (60 37.5N, 151 35W) and North Kalgin Island (60 35.80N, 151 46.6W). The locations that had medium levels of concern and higher levels of caution should be used are three miles from West Flat Island (59 20N, 152 06W) and five miles from Anchor Point (59 46.40N, 152 02W). The location that had the highest level of concern and should have the highest level of caution is Nikiski Range (60 35.6N, 151 24W).

Finally, in terms of best practices to implement self-arrest, the practice of self-arrest depends on many factors including the location, environmental conditions, vessel attributes, and human factors. In terms of human factors, the local pilot's ability and local knowledge concerning wind, currents and ice forces acting upon the ship are paramount to successfully executing self-arrest. During simulations, the ship's movement was controlled or steered with anchor(s) dredging with minimal scope deployed and constant small adjustments being made varying the amount of anchor chain deployed. Successfully self-arresting requires understanding the art of piloting, specifically deploying the correct amount of anchor chain to reduce the speed of the ship, while also preventing excessive forces being applied. An excessive amount of force on the anchor gear will result in it breaking. Self-arrest requires dredging the anchor(s) until the ship's speed is reduced and then deploying more chain incrementally to obtain a sufficient amount to fully arrest or securely anchor the ship.

Multiple maritime instances have been documented with self-arrest maneuvers failing due to breaking anchor gear (see The Glosten Associates, 2013 and Spencer, 2008). Excessive amounts and rapid deployment of anchor chain, may result in an anchor fetching on the bottom and lead to anchor gear failure. This study reflects the positive results of utilizing self-arrest as a risk mitigation maneuver for crude oil tankers in Lower Cook Inlet. This research finds that local pilots are able to and with a high probability of success, can self-arrest oil tankers in Lower Cook Inlet even during inclement weather conditions and at various locations.

The self-arrest of an oil tanker has been shown to be a valuable tool when performed by highly skilled and proficient local pilots. The level of concern expressed by the pilots decreased during a second day of simulations, emphasizing the recommendation that even highly trained and knowledgeable pilots would benefit from self-arrest maneuver simulations.

This research has multiple limitations. Primarily, only thirty-two simulations are utilized testing many different variables including location, environmental conditions, bottom characterisitcs, vessel attributes, and various human factors. To better understand and determine the overall benefits and reliability of using anchor gear to self-arrest, additional simulations are necessary. In addition, the practice of self-arrest was only simulated with a limited number of SWAPA pilots. The external validity of these results to other SWAPA pilots, as well as other mariners such as oil tanker captains is limited. Therefore, the results should not be generalized to any personnel beyond those who participated in these simulations. In order to determine the probability and reliability of other mariners performing self-arrest of an oil tanker in Lower Cook Inlet, additional research is required, and using the simulator by other mariners to practice self-arrest is recommended. Ultimately, this research shows that self-arrest of an oil tanker in Lower Cook Inlet is possible. Using properly trained and capable local pilots self-arrest has a high probability of success, but this research does not find that other mariners could engage in such practices with the same reliable success unless properly trained.

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Appendix. AVTEC Full Mission Ship Bridge Simulators Description

Alaska's Institute of Technology (AVTEC) upgraded their ship simulation capabilities 2016, increasing number of LED screens, new computers with newly installed data cables for simulators B and C. Specific details of three ship simulators for this study are listed below:

Specific Details	**Simulator A**	**Simulator B**	**Simulator C**
DNV Rating	DNV Class A (NAV)	DNV Class A (NAV)	DNV Class A (NAV)
Projected Visual Horizontal Field View	290 Degrees:	300 Degrees	300 Degrees
Projected Visual Vertical Field of View	31 Degrees	31 Degrees	31 Degrees
Projectors and LED Displays	7 Projectors forward 4 LED Displays Astern	14 LED Displays Forward 6 LED Displays Aft	14 LED Displays Forward 6 LED Displays Aft
Throttle Control	Console	Console	Console
Joy Stick Steering	Console	NA	NA
Steering Wheel	Separate Stand	Console	Console
Polaris Software	Yes	Yes	Yes
VHF radios	1 on Console	1 on Console	1 on Console
Internal ship phone	Yes	Yes	Yes
RADAR/ARPA	Yes	Yes	Yes
ECDIS	Yes	Yes	Yes
Conning Display	Yes	Yes	Yes
Anchor Control	Yes	Yes	Yes
Winch Control	Yes	Yes	Yes
Hawser	Yes	Yes	Yes
Tension/length display	Yes	Yes	Yes
Doppler, Gyro Compass	Yes	Yes	Yes
DGPS, AIS	Yes	Yes	Yes
Depth Sounder	Yes	Yes	Yes
Auto Pilot	Yes	Yes	Yes
Thruster Control	Yes	Yes	Yes
Pilot Plugs	Yes	Yes	Yes
Alarm/ fault display	Yes	Yes	Yes
Lights, Sound signals	Yes	Yes	Yes
Binocular view	Yes	Yes	Yes
Chart Table with light	Yes	Yes	Yes

Instructor Stations include following controls and capabilities: Interactive or separate exercises, target vessel routing, Wind, waves, current, weather, tide, faults, alarms, offsets, hawsers for tugging/towing/mooring, operator controlled tugs (vector tugs), audio and video monitoring, playback for debrief with multiple variables available. Ice context includes bergs, brash, hummocked, first year, multi-year ice.

Modeling Capability includes custom built area database based on NOAA chart with capability to modify area database for research projects. Research projects include editing capabilities of adding docks, buildings, land features, buoys, depth, current, wind.

Other features include: User-controlled viewing angle with 360-degree horizontal and 180-degree vertical capabilities. Additional smaller screens show the views from the stern of the vessel, through a binocular channel display and control panels. Virtual Ship model calculates ship response to the variety of forces that can be exerted upon a vessel, including changed topography, channel depth and width effects, and ship motion. 30 geographic area databases with visual, coastline, landmass, radar and depth files. 46 ship and tow model databases including inland waterways barges and towboats, bulk ship, cruise ships and variety tanker types. **S**hip-to-ship interaction; vessel responses to currents, waves and winds; vessel-to-vessel towing simulation; and interactive ability to maneuver and control a tow boat. First United States simulator awarded USCG certification teach ice class required for IMO certification.