WIND SPEED AND WAVE HEIGHT AT SEAL ROCKS BUOY DURING OUTBOUND TANKER TRANSITS, 2010-2017

PREPARED FOR: PRINCE WILLIAM SOUND REGIONAL CITIZENS' ADVISORY COUNCIL

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ABSTRACT

This study compared outbound tanker transits through Hinchinbrook Entrance in Prince William Sound with conditions reported at Seal Rocks Buoy within an hour of the transit. Eight outbound tankers crossed the Entrance in conditions above wave height closure limits (15 feet) between January 1, 2010 – September 30, 2017. No transits were made in wind conditions above closure limits (45 knots).

This analysis does not identify times when the U.S. Coast Guard's Vessel Traffic Service actually closed Hinchinbrook Entrance, and so should not be construed as demonstrating operator non-compliance with Coast Guard direction. However, it does illustrate the importance of ensuring that escort tugs are capable of saving a tanker in conditions at and above the wave height closure limit (at least) since laden tankers are operating in Hinchinbrook Entrance at least once a year in these conditions. When considered against a September 2017 analysis of conditions during which towing exercises were conducted from 2013-2017, it was determined that 100% of the towing exercises in that time period were conducted in average wave heights of less than 3 feet, while 65% of the outbound tanker transits occurred in wave heights above 3 feet.

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1 Introduction

Nuka Research correlated and analyzed the wind speed and wave height observations from the Seal Rocks buoy taken closest to the time that laden tankers crossed a passage line between Hinchinbrook Light and the buoy. This report describes the analysis and results based on data from January 1, 2010 to September 30, 2017.

The purpose of this report is to identify the met-ocean conditions in which tankers transited Hinchinbrook Entrance during the more than 7-year study period. It does not include information regarding the frequency or timing of port *closures* as this is a decision made by the U.S. Coast Guard's Vessel Traffic Service (VTS) and not something included in the datasets used.

2 Background

Tank vessels operating in Prince William Sound must follow a traffic separation scheme, adhere to inbound and outbound escort zones (when laden), and follow speed limit restrictions for different parts of the Sound. Tank vessels must also follow the directions of the VTS, including closures of Hinchinbrook Entrance.[1]

Closure conditions are stated in the current Prince William Sound Tanker Oil Discharge Prevention and Contingency Plan (Tanker C-plan) and Vessel Escort Response Plan (VERP), each dated 2017. The VERP states:

> *Outbound laden tankers are not allowed to transit Hinchinbrook Entrance when winds exceed 45 knots or seas exceed 15 feet. These conditions are primarily determined from data collected by the weather buoy stationed at Seal Rocks. The VTS will make the decisions on closure after one reading over the maximum limit and will make decisions on reopening based on two consecutive observations. If the buoy is inoperative, observations may be made with the Hinchinbrook Tug in the vicinity of Seal Rocks. . . .*
>
> *Should Hinchinbrook Entrance be closed while the tanker is en route, the Master has the option of anchoring, heaving to, or maintaining a holding pattern as agreed upon between the vessel and the VTS. The tanker must continue to be escorted, whether underway or anchored. One escort may be a Sentinel vessel while the vessel is in the Central Sound (including the anchorage at Knowles Head).*
>
> *Should the tanker be in Hinchinbrook Entrance (past Montague Point) at the time Hinchinbrook Entrance is closed, the Master shall decide the safest course of action (whether to continue through the Entrance or return to the Central Sound), and shall notify SER VS and VTS of their intentions.*

The Tanker C-plan specifies that the Vessel Traffic System run by the U.S. Coast Guard will make closure decisions after one reading over the maximum limit and will make decisions on reopening

[1] Federal regulations require tankers in Prince William Sound to participate in the USCG's Vessel Traffic Service (33 CFR 161.60). These regulations include the stipulation: "A southbound vessel shall remain in Port Valdez east of 146°35′ W. and north of 61°06′ N. until the VTS has granted permission to proceed." [33 CFR 161.60(d)(2)(iii)]

based on two consecutive observations under the limit. If the buoy is inoperative, observations may be made with the Hinchinbrook Tug in the vicinity of Seal Rocks. (RPG, 2017a)

There are different closure conditions for the Port of Valdez and Valdez Narrows that prohibit any tanker traffic (laden or in ballast) when winds exceed 40 knots (RPG, 2017a). Closure does not apply to inbound laden tankers (RPG, 2017b).

3 Data Sources

This analysis utilized two sets of data recorded over the same time period (January 1, 2010 – September 30, 2017).

- Automatic Identification System (AIS) data for Hinchinbrook Entrance transits (captured as passage line data)
- Wind speed and significant wave height data recorded at Seal Rocks buoy.

See Figure 1 for the location of the passage line, buoy, tankers lanes, and the outside boundary of Hinchinbrook Entrance as specified in the VERP (RPG, 2017b).

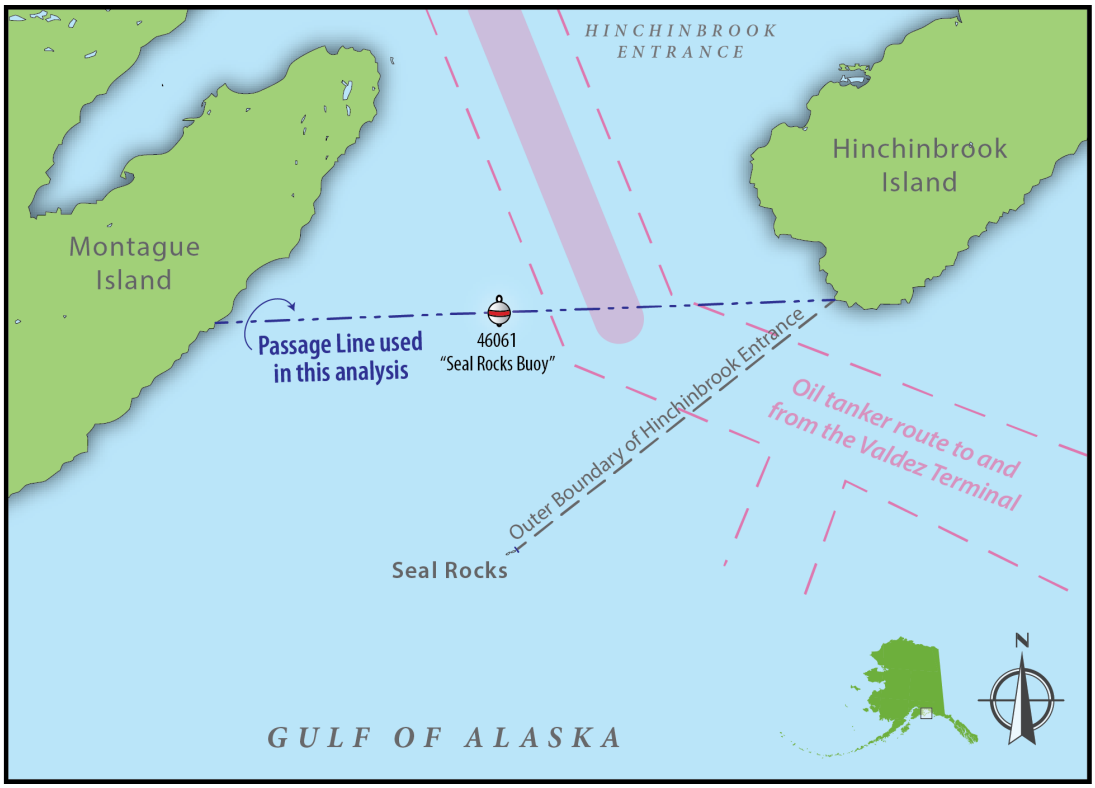

Figure 1. Passage line used for AIS data at Hinchinbrook Entrance and Seal Rocks buoy used for analysis of Hinchinbrook Entrance tanker transit conditions.

Automatic Identification System Data

Passage line data were purchased from the Marine Exchange of Alaska. Passages of Hinchinbrook Entrance were defined as the times when a tanker crossed a line defined as, beginning at Hinchinbrook Light (60.237ºN, 146.646ºW) then passing through the Seal Rocks Buoy (60.230º,

146.843ºW) and continuing to the shoreline of Montague Island, as shown in Figure 1. The passage line was chosen to capture the time of the tanker's closest approach to the Seal Rocks buoy.

The data include the date and time when a vessel equipped with an AIS transmitter crossed the passage line. The data set also includes:

- Ship name
- Location (lat/lon)
- Course over ground
- Speed over ground

This analysis included AIS records from January 1, 2010 to September 30, 2017.

The data were filtered to include only tankers traveling south (outbound). AIS data do not include whether a tanker is laden or in ballast, so this method was used to capture most, if not all, laden tanker transits.

The final dataset included 23 individual tankers making a total of 1,764 southbound transits during the study period. It should be noted that some transits may not have been captured by the Marine Exchange of Alaska's system due to atmospheric conditions or system outages.

BUOY DATA

National Data Buoy Center data from Seal Rocks Buoy (Station #46061) were downloaded for the same time period as the AIS data. Wind speed and significant wave height data (referred to as "wave height" from here on) were used in this analysis. The buoy data also includes information on "wave period" which can be used to determine wave *steepness*. This is noted as a key factor related to a tug's ability to save a laden tanker, but it is not included in the analysis because it is not a metric used in closure conditions.

There were 63,589 hourly wind speed observations in the dataset, representing 93.6% completeness for wind during the time period studied, and 58,992 hourly wave height observations, representing 86.9% completeness for wave height during the time period studied.

Gaps in data were more common in the winter than spring, summer, or fall. Most prominent was the lack of any observations for any parameter in February and March 2014. The lowest completeness for any month across the study period was 79% for wave height for all Februarys combined. While the observations are slightly biased to the non-winter months, we did not consider the bias significant to the analysis.

While the Seal Rocks buoy is widely accepted as the most consistent, reliable source of observational marine data in the Hinchinbrook Entrance area, the National Weather Service recognizes that moored buoys tend to under-report sustained wind speeds when large or steep waves are present. Sustained wind speeds are reported as the average wind over eight minutes. The under-reporting occurs for two reasons: (1) in large waves, the buoy is shielded from wind when in the trough, and (2) in steep waves, the buoy will tip such that the anemometer is no longer perpendicular to the surface wind and reported wind speed is reduced. Both effects are exacerbated the higher or steeper the waves become (Zingone, 2004). Because of these effects, as well as the location of Seal Rocks buoy, which is in a relatively sheltered location, it is estimated that when closure conditions of 45-knot winds or 15-foot seas are recorded at Seal Rocks buoy, actual conditions in the adjacent Gulf of Alaska could be 57-knot winds or 20-foot significant wave height (Robert Allan Ltd., 2016).

Merging Datasets

AIS and buoy data were merged to determine the conditions as recorded at Seal Rocks buoy during the time when an outbound tanker crossed the passage line. The following rule was applied:

- If the buoy observation was within one hour of the tanker transit time it was recorded as representing the conditions at the time of the transit.
- If the closest buoy observation was more than one hour from the passage time, then that passage was ignored.

Of the 1,764 outbound tanker transits, 1,688 were associated with a wind speed observation and 1,517 were associated with a wave height observation.

The vast majority of tankers transited within 3-3.5 nm of Seal Rocks buoy as shown in Figure 2.

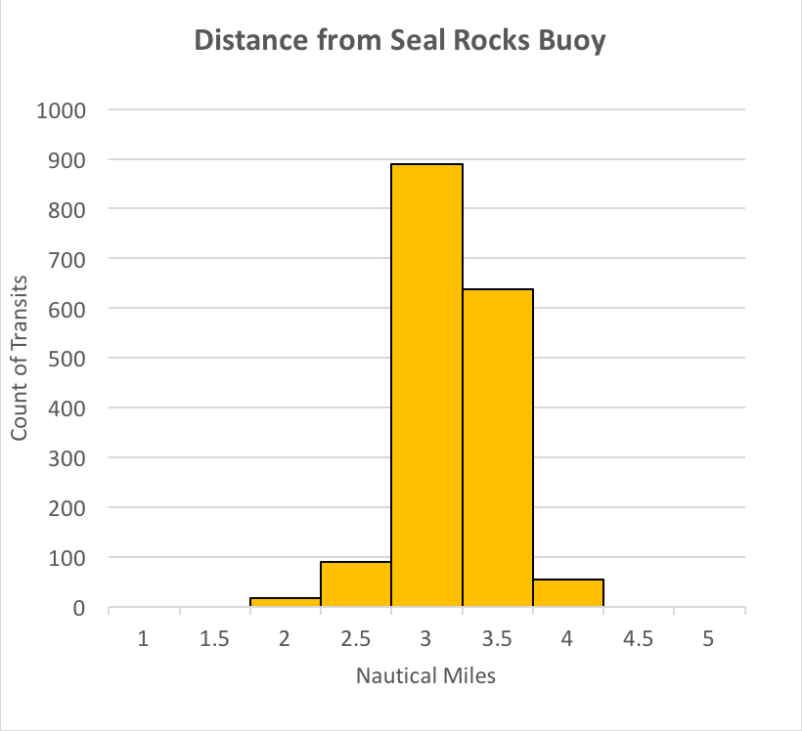

Figure 2. Number of transits recorded by distance from Seal Rocks buoy

Results

This section presents the results of the analysis. Wind speed and wave height are analyzed separately, concluding that several tankers transited at or above closure limits for wave height (though none did so above wind speed limits). These cases are identified and two examples shown in more detail.

Wind Speed

Figure 3 presents distribution of the wind speed readings from Seal Rocks buoy during the study period. Wind reached or exceeded the 45-knot closure cutoff 0.5% of the time (22 out of 63,589 readings). The blue bars show the percentage of time that conditions fell into 2-knot ranges (e.g., 0-

2 knots, as shown on the left), while the orange line presents the cumulative percentage of time captured (on the right). Figure 4 presents information in the same way as Figure 3, but showing the wind speeds *only when an outbound tanker was crossing the passage line*. During more than half of the transits, winds were below 12 knots. The maximum wind speed reported when an outbound tanker was at Hinchinbrook Entrance was around 40 knots. No outbound tankers were recorded at Hinchinbrook Entrance when the winds were at or above closure (45 knots).

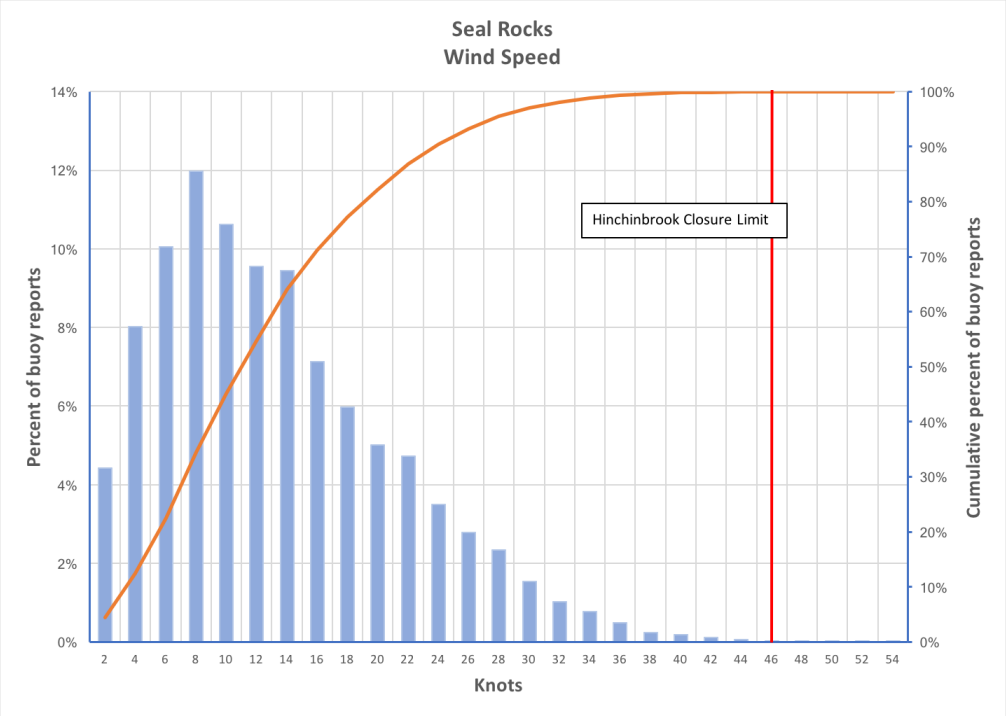

Figure 3. Distribution of wind speed reports from Seal Rocks buoy FOR ENTIRE STUDY PERIOD

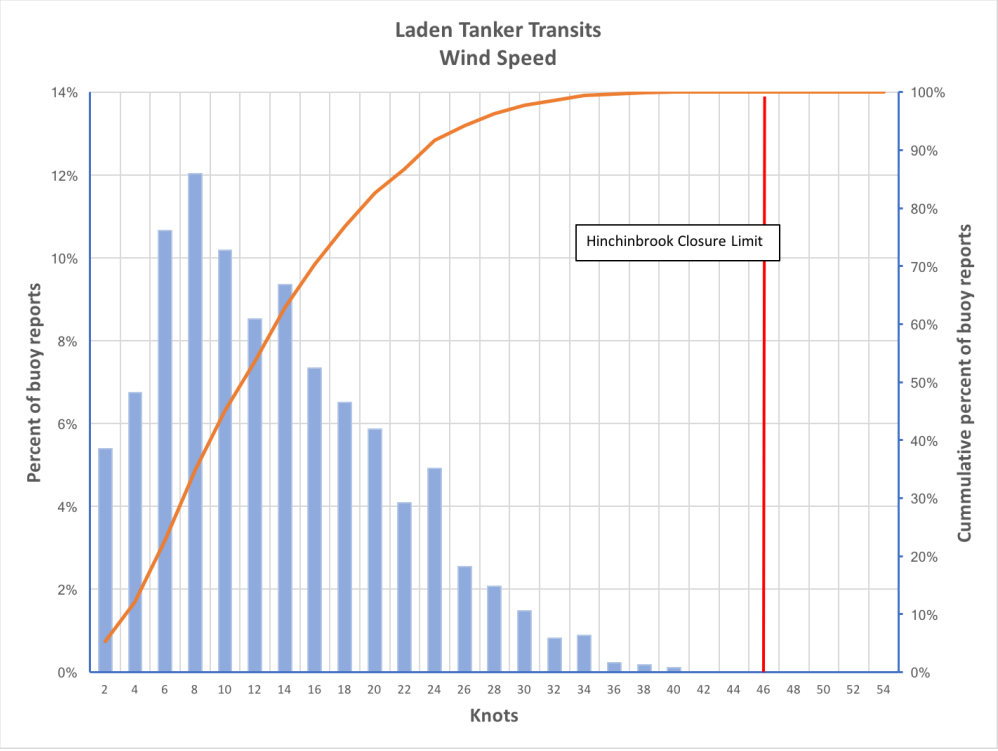

Figure 4. Distribution of wind speed reports from Seal Rocks buoy DURING OUTBOUND TANKER TRANSITS

Another way to consider distribution is percentiles. A percentile is a measure related to a dataset that expresses the percentage of the observations in the dataset that fall below a given value. For

example, if the 20th percentile is 6, then 20% of the observations in the dataset are below the number 6 and 80% of the observations are greater than 6.

Table 1 compares the percentiles of reported wind speeds overall during the study period with wind speeds observed within an hour of an outbound tanker crossing the passage line. Overall the distributions are similar; in both cases, wind speeds are recorded at or below 11 knots 50% of the time, and at or below roughly 17 knots 75% of the time. However, while the maximum reported wind speed during the study period was 53 knots, 39.8 knots was the highest reported wind speed during which an outbound tanker crossed the passage line at Hinchinbrook Entrance.

Table 1. Percentiles of wind speeds January 1, 2010 – September 30, 2017 overall and wind speeds reported during outbound tanker transits

Percentile	Wind Speed (knots) During Study Period	Wind Speed (knots) During Outbound Transit of Hinchinbrook Entrance
Min	0.0	0.0
25th	6.4	6.2
50th	11.1	11.1
75th	17.3	17.5
90th	23.7	23.4
95th	27.4	26.8
98th	31.9	30.4
Max	53.1	39.8

WAVE HEIGHT

Similar to the presentation of results for wind speed, Figure 5 presents the wave height distribution from Seal Rocks buoy during the study period. Figure 6 presents the distribution of wave heights only for the times when an outbound tanker was crossing the passage line near the buoy. In the time period studied (and based on the data available), eight out of the 1,590 transits for which wave height data were available occurred above the 15-foot closure limit.

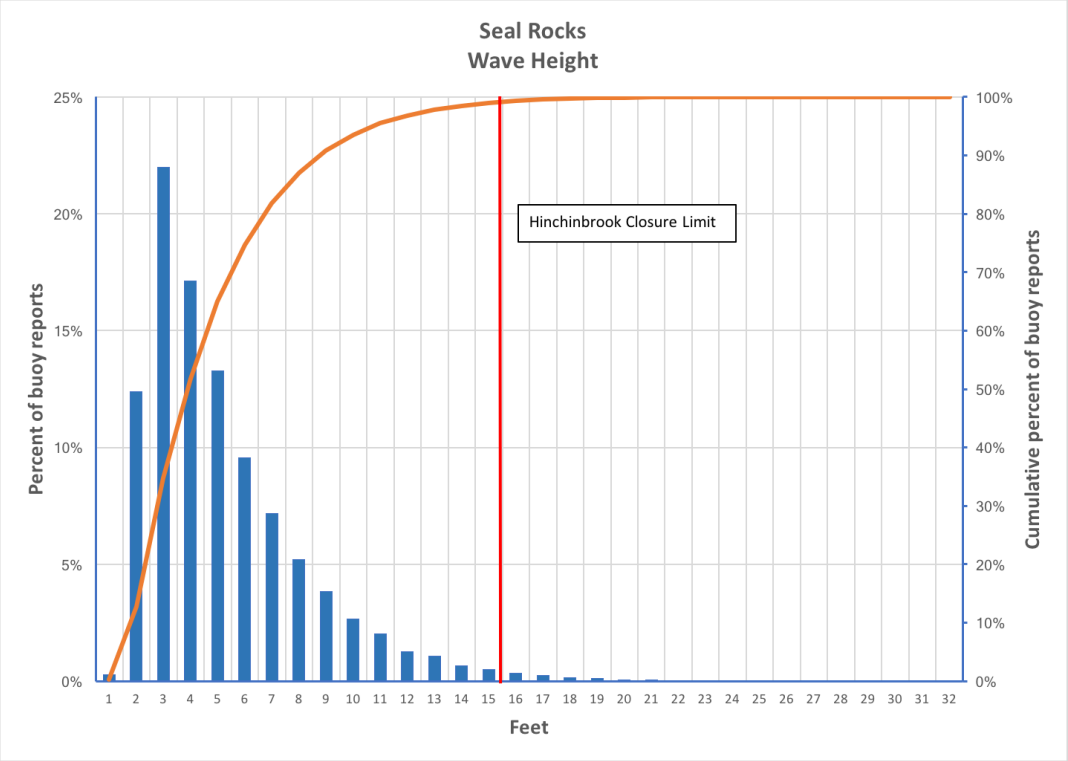

Figure 5. Distribution of wave height reports from Seal Rocks buoy FOR ENTIRE STUDY PERIOD

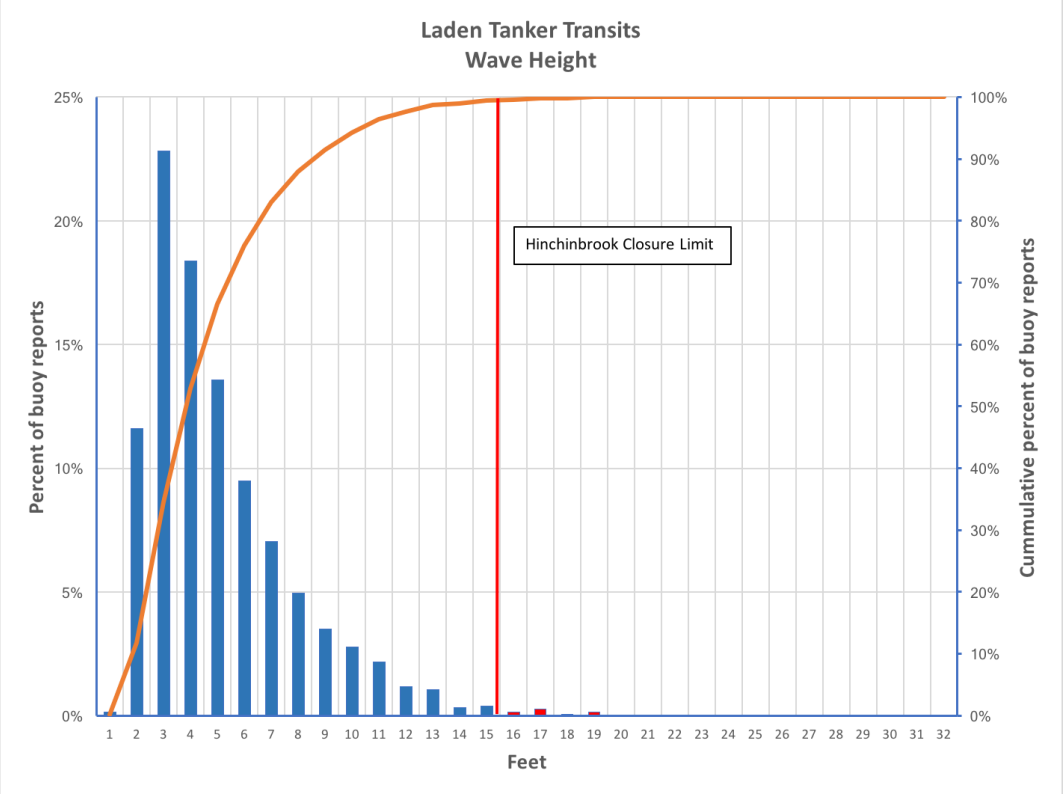

Figure 6. Distribution of wave height reports from Seal Rocks buoy DURING OUTBOUND TANKER TRANSITS

Table 2 compares the distribution of reported wave heights overall during the study period with wave heights reported during times within an hour of an outbound tanker crossing the Hinchinbrook Entrance passage line. As with wind speed, the distributions are again fairly similar. Half the time, waves are just under 4 feet. Wave heights are 6 feet or less 75% of the time. However, unlike with winds, in the case of wave height the data do identify eight transits that occurred above 15-foot waves as reported at Seal Rocks buoy. The maximum wave height reported within an hour of an outbound tanker crossing the passage line was 18.8 feet.

Table 2. Distribution of wave heights January 1, 2010 – September 30, 2017 overall and wave heights reported during outbound tanker transits

Percentile	**Wave Height (feet) During Study Period**	**Wave Height (feet) During Outbound Transit of Hinchinbrook Entrance**
Min	0.5	0.7
25th	2.5	2.6
50th	3.9	3.8
75th	6.0	5.9
90th	8.8	8.6
95th	10.7	10.2
98th	13.2	12.2
Max	26.7	18.8

TRANSITS ABOVE WAVE HEIGHT CLOSURE LIMIT

Eight outbound tankers crossed the passage line within one hour of the Seal Rocks buoy reporting wave heights that exceeded 15 feet (Table 3). The eight transits above closure conditions were spaced across the study period with one or two a year, including two in the first nine months of 2017. They occurred in the months of January (2), February (2), April (2), June (1), and November (1).

Table 3. Outbound tankers reported at Hinchinbrook Entrance passage line in wave heights greater than 15 feet, from highest to lowest reported wave height above 15 feet

Date	Vessel	Wind Direction (degT)	Wind Speed (knots)	Wave Height (ft)	Dominate Wave Period (sec)
04/04/17 09:42	EVERGREEN STATE	108.0	33.2	18.8	12.9
01/26/17 16:46	ALASKAN NAVIGATOR	103.0	39.9	18.3	10.8
04/26/10 05:02	POLAR ENDEAVOUR	83.0	28.6	17.6	12.9
02/21/16 03:35	ALASKAN FRONTIER	96.0	35.2	16.9	10.8
01/24/11 01:44	OVERSEAS NIKISKI	109.0	30.7	16.5	10.0
02/09/12 04:56	OVERSEAS NIKISKI	101.0	31.3	16.3	8.3
11/01/10 05:30	POLAR ADVENTURE	72.0	19.2	16.1	12.9
06/17/14 09:14	OVERSEAS MARTINEZ	104.0	37.9	15.3	9.1

CASE STUDIES

Two of the cases were examined in more detail: T/V Evergreen State and T/V Alaskan Frontier.

Evergreen State

On April 4, 2017 the T/V Evergreen State, a 49,000 DWT crude oil tanker, crossed the passage line in the highest waves reported during a transit at 18.8 feet, following the timeline below.

Time (UTC)	***Event***
09:42*	Evergreen State crosses passage line 3.25 nm from Cape Hinchinbrook, heading south at 6.2 knots
09:43	Escort vessel *Nanuq* crosses passage line south bound**
09:44	Escort vessel *Attentive* crosses passage line south bound**
09:50	Seal Rocks buoy reports: Winds = 33 knots from the SE (108º) Gusts = to 42 knots Wave height = 18.8 feet Dominant wave period = 12.9 seconds (a very steep wave) Tide ebbing with tidal current predicted at 0.2 knots at 180º

** 00:40 Alaska Standard Time (6 hours before daylight that day)*

*** Both escorts crossed back over the passage line 30 minutes later at 10:12*

Seal Rocks buoy began reporting wave heights above 15 feet two hours before the tanker crossed the passage line, following on several hours over which wave heights built steadily. Figure 7 shows the wave height observation for several hours before, during, and after the transit, as well as the closure wave height of 15 feet (red line).

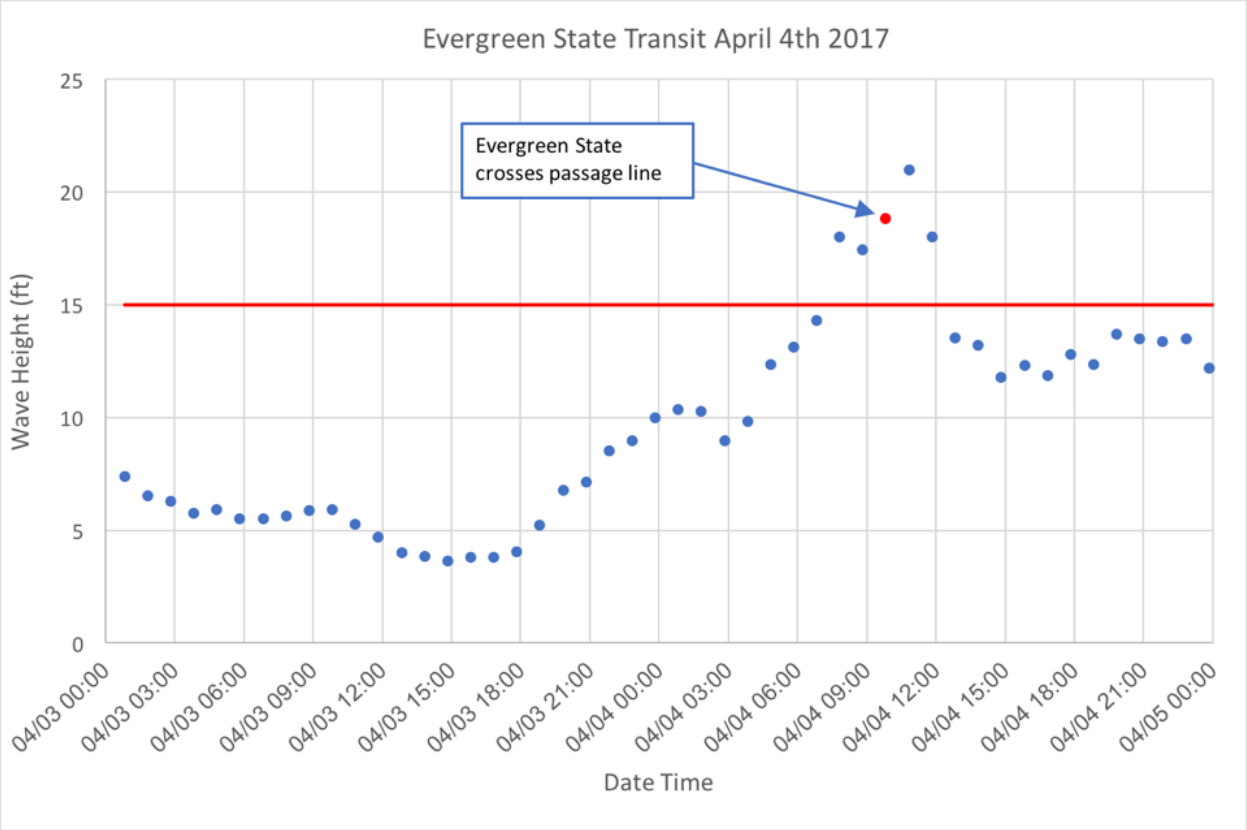

Figure 7. Timeline of Seal Rocks buoy wave height reports as the T/V Evergreen State approaches, transits, and departs Hinchinbrook Entrance on April 4, 2017 (all times in UTC), with closure wave height shown in red

The T/V Evergreen State crossed the passage 5.7 nm directly upwind from the shoreline of Montague Island. Based on an estimated drift rate of 8% of the wind speed for a laden tanker (Holder, et. al., 1981), if the Evergreen State lost propulsion at this location, it would ground within 2 ½ hours,[2] if the escort vessels were not able to execute an emergency tow.

[2] 5.7 nm / (33 knots x 8%) = 2.2 hours

Alaska Frontier

On February 21, 2016, the T/V Alaskan Frontier, a 193,000 DWT crude oil tanker, crossed the passage line in 16.9 ft. seas, following the timeline below. The drift conditions for the T/V Alaska Frontier were similar to the T/V Evergreen State, but the tanker is three times larger and the sea state remained above or near 15 feet for 24 hours after the crossing.

Time (UTC)	***Event***
03:35*	Alaskan Frontier crosses passage line 2.25 nm from Cape Hinchinbrook, heading south at 8.4 knots
03:33	Escort vessel *Nanuq* crosses passage line south bound**
03:34	Escort vessel *Alert* crosses passage line south bound**
03:50	Seal Rocks buoy reports: Winds = 35 knots from the E (96º) Gusts = to 43 knots Wave height = 16.9 feet Dominant wave period = 10.8 seconds (a very steep wave) Tide ebbing with tidal current predicted at 0.2 knots at 180º

** 18:35 Alaska Standard Time on February 20*

*** Both vessels crossed back across the passage line 18 minutes later at 03:53*

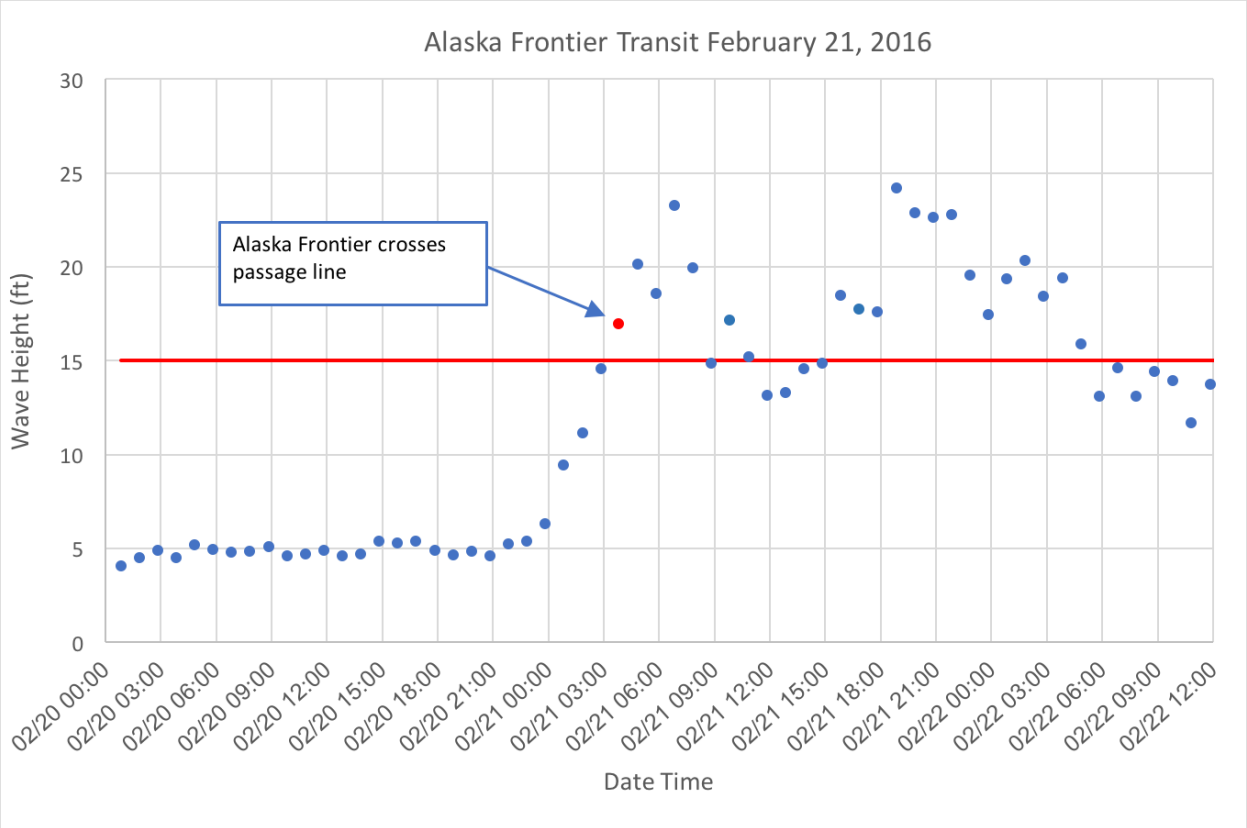

Figure 8. Timeline of Seal Rocks buoy wave height reports as the Alaskan Frontier approaches, transits, and departs Hinchinbrook Entrance on February 21, 2016 (all times in UTC), with closure wave height shown in red

4 Discussion

While the maximum *wind speed* reported at Seal Rocks buoy as an outbound tanker passed through Hinchinbrook Entrance was five knots below the wind closure limit, at least eight tankers made the transit when *wave height* exceeded the 15-foot closure limit during the study period. Because closure is actually dependent on the U.S. Coast Guard determining that the port is closed, this does not necessarily indicate that the tankers were in violation of any requirements. However, it does highlight the importance of readiness to respond to an incident at or above closure limits for wave height, as laden outbound tankers are transiting the Hinchinbrook Entrance at or above these conditions.

We do not have data on the times during the study period when the VTS closed Hinchinbrook Entrance to outbound laden tanker transits. However, it is possible to calculate how potential reductions in closure limits may have affected the tankers that did transit Hinchinbrook Entrance during the 7.75-year study period.

- Reducing the closure limits to 35 knots and 13 feet would have affected 26 transits or 3 per year, if the VTS closed the Entrance.
- Reducing the closure limits to 30 knots and 10 feet would have affected 109 transits or 14 per year, if the VTS closed the Entrance.

It is also possible to compare the sea state conditions when tanker towing exercises have been conducted with the conditions that outbound tankers actually transit Hinchinbrook Entrance. A recent memorandum documented the average wave height conditions reported at the West Orca Bay buoy (Station #46060) at the times emergency towing exercises were conducted in central Prince William Sound (Nuka Research and Planning Group, 2017). Table 4 compares the distribution of wave heights during emergency towing exercises with the wave height distribution during outbound tanker transits reported above. The maximum average wave height reported during emergency towing exercises was 2.8 feet, while the maximum wave height reported during an outbound tanker transit was 18.8 feet. One hundred percent (100%) of the towing exercises were conducted in average wave heights of less that 3 feet, while 65% of the outbound tanker transits occurred in wave heights above 3 feet.

Table 4. Comparison of the distributions of wave height reports during emergency towing exercises with the wave height observation during outbound tanker transits.

Wave Height (ft)	Tanker Towing Exercises (2013 to 2017)	Outbound Tanker Transits (2010 to 2017)
0 to 1	35.3%	0.1%
1 to 2	52.9%	11.6%
2 to 3	11.8%	22.8%
3 to 4	0.0%	18.4%
4 to 5	0.0%	13.6%
5 to 6	0.0%	9.5%
6 to 7	0.0%	7.1%
7 to 8	0.0%	4.9%
8 to 9	0.0%	3.5%
9 to 10	0.0%	2.8%
10 to 11	0.0%	2.2%
11 to 12	0.0%	1.2%
12 to 13	0.0%	1.1%
13 to 14	0.0%	0.3%
14 to 15	0.0%	0.4%
15 to 16	0.0%	0.1%
16 to 17	0.0%	0.3%
17 to 18	0.0%	0.1%
18 to 19	0.0%	0.1%
19 to 20	0.0%	0.0%

5 References

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