ALEUTIAN ISLANDS RISK ASSESSMENT

Minimum Required Tug for the Aleutian Islands

PREPARED FOR:	BY:
Nuka Research Seldovia, Alaska	Garth Wilcox, P.E. PROJECT MANAGER
	CHECKED: K. V. Sultani-Wright, P.E. OCEAN ENGINEER
THE GLOSTEN ASSOCIATES 1201 Western Avenue, Suite 200, Seattle, WA 98101-2921 TEL 206.624.7850 FAX 206.682.9117 www.glosten.com	APPROVED: Justin M. Morgan, P.E. PRINCIPAL-IN-CHARGE

Digitally Signed 02-May-2014

DOC:	REV:	FILE:	DATE:
12127.03.1	-	12127.03	1 May 2014

References

1. *Minimum Required Tugs*, The Glosten Associates, Inc., File No. 12127.02, Report No. 12127.02.1-2b, Rev. A, 14 January 2013.
2. *Environmental Data Tables*, Nuka Research & Planning Group, LLC, March 2013.
3. 33 CFR §155.4030(e), *Ensuring the proper emergency towing vessels are listed in your VRP*, 2013.
4. *Aleutian Islands Risk Assessment Project– Advisory Panel Webinar Summary*, Aleutian Islands Risk Assessment, April 2013.
5. *Aleutian Islands Risk Assessment Project- Phase A Summary Report*, Aleutian Islands Risk Assessment, August 2011.
6. *Reassessment of the Marine Salvage Posture of the United States*, National Research Council, The National Academies Press, 1994.

Introduction

As part of the Aleutian Islands Risk Assessment, a minimum tug was sized based on rescuing two given vessels in 40 knots of wind and a matching sea state, as reported in Reference 1. The environmental conditions of that study were based on the marine salvage regulations, Reference 3. The vessels were chosen based on the traffic analysis in the Aleutian Islands Risk Assessment Phase A, Reference 5.

The purpose of this study is to extend Reference 1 with environmental conditions that suit the Aleutian Islands, Reference 2, and vessels that match a newer traffic analysis, Reference 4.

Vessels

While it was recognized that a tug could not be sized to meet the every possible combination of weather condition with the largest possible vessels, it was intended that the rescue tug be sized adequately for the majority of possible rescue scenarios. The vessels to be rescued were specified by the advisory committee based on new vessel traffic analysis, Reference 4. The specific vessels for this study are a 600,000 BBL tanker and an 85,000 DWT container ship. They were selected by the committee to be the 75th percentile, by size, in their category.

Actual vessels were found to match the given requirements. This study uses the same tanker as Reference 5 but a larger container ship. The vessel particulars are summarized in Table 1.

Table 1 Vessel Particulars.

	Tanker	Container Ship
Type	NASSCO 675,930 BBL	HHI 7,500 TEU Class
Name	*Overseas Ohio*	*Hong Kong Express*
Length Overall (m)	272(est.)	321
Length Between Perpendiculars (m)	261	304
Beam (m)	32.2	42.8
Deadweight (MT)	90,000	82,800
Design Draft (m)	15	14
Depth (m)	18(est.)	24.5
Block Coefficient	0.82	0.65(est.)
Frontal Windage Area (m^2)	552	1,551
Lateral Windage Area (m^2)	1,888	8,639

Environmental Conditions

For this study, observation data made from weather buoys and airports in the Aleutians was collected. The data, as collected and processed by Nuka Research & Planning Group, is presented in Reference 2.

As reported by Nuka:

> Wind speeds, wave heights, and modal periods are 6-hour averages, where a 6-hour block is available. Where data is missing, the average of all readings present during the 6-hour period is used. Hourly wind directions are used (as opposed to 6-hour averages of bearings) as it was presumed that, for design purposes, the direction of the wind at a given time, with respect to the seas, is the important measurement. Hourly wind directions were checked for similarity, and it was found that, on average, a given hour's wind direction is the same as that of at least 4 of the 5 previous hours.

Reference 1 demonstrated that the largest part of the tug force comes from the windage of the vessel. This study began by selecting a wind speed and proceeded to match the wave height and period to that wind speed. The 98th percentile wind speed for the worst case location during the worst case month was chosen for the design condition to represent all but extreme conditions. Table 2 shows the wind speeds for the various weather buoys in the data set during the worst month in that location.

Table 2 Weather Buoy Steady Wind Speeds (Uncorrected).

Buoy Location	Sensor Height (m)	Worst Month	Monthly Readings	Monthly Average (kt)	Monthly Max (kt)	Monthly Min (kt)	Monthly 98th % (kt)	Monthly Standard Deviation (kt)
SW Bearing Sea	5	Feb	2340	18	42	0	**37**	8
SE Bearing Sea	10	Jan	4067	22	51	0	**40**	9
NE Pacific / Shumagin Is.	5	Dec	4416	20	45	0	**38**	9
North Pacific / Central Aleutians	5	Dec	3717	19	44	0	**37**	8

The data as originally analyzed and reported by Nuka was not corrected for sensor height. To compare the data, wind speeds for buoys with sensors at 5m were adjusted upward to account for the wind speed gradient typically found near the earth's surface. The standard exponential formula was used with an exponent of 0.11 as recommended by the National Data Buoy Center. Table 3 shows the corrected wind speeds for the various weather buoys

Table 3 Weather Buoy Steady Wind Speeds with Height Correction.

Buoy Location	Sensor Height (m)	Worst Month	Monthly 98th % (kt)	Standard Height (m)	Corrected Monthly 98th % (kt)
SW Bearing Sea	5	Feb	37	10	**40**
SE Bearing Sea	10	Jan	40	10	**40**
NE Pacific / Shumagin Is.	5	Dec	38	10	**41**
North Pacific / Central Aleutians	5	Dec	37	10	**40**

The design condition of 41 knots occurs in December in the NE Pacific near the Shumagin Islands.

In addition to wind data, Reference 2 also has data for the significant wave heights and periods but has no information on how the wave heights correspond to the wind speeds and modal wave periods. In an attempt to correlate the wind speed with wave height and period, joint probability plots were made. Figure 1 shows the joint occurrences of wind speed verses wave height and wave height verses modal period for each of 4 wind direction quadrants, all for the NE Pacific Ocean location. The data was broken into directional quadrants to ensure that the wave data in the grouping is related in reality to the wind speeds. The northwest quadrant, for instance, contains all the buoy readings for which the wind direction is anywhere from north to west.

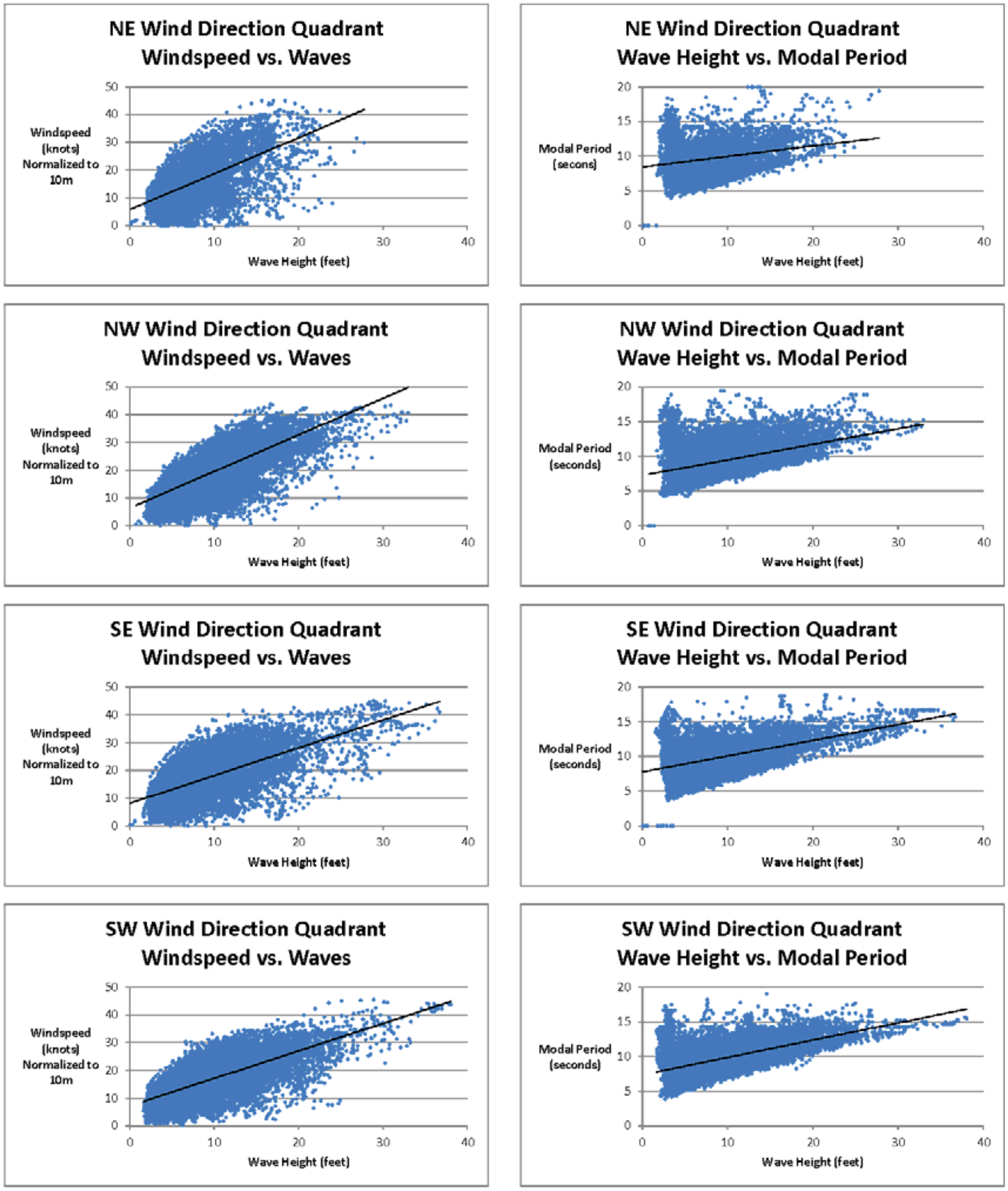

Figure 1 Wave Height vs. Wind Speed and Period - NE Pacific Ocean

Table 4 shows the data taken on the trend lines for the above plots. Note the buoy location is somewhat sheltered to the north and that wave heights are higher from the southerly quadrants with better fit to the trend lines.

Table 4 Wave Height vs. Wind Speed and Period - NE Pacific Ocean

	NE		NW		SE		SW		All Southerly	
Wave Height	Wind Speed	Modal Period	Wind Speed	Modal Period	Wind Speed	Modal Period	Wind Speed	Modal Period	Sig. Wave Speed	Modal Period
ft	kt	s	kt	s	kt	s	kt	s	kt	s
5.0	12.2	9.2	13.0	10.0	13.1	10.1	12.2	9.9	**12.7**	**10.0**
10.0	18.7	10.0	19.6	11.5	18.1	11.2	17.2	11.0	**17.6**	**11.1**
15.0	25.2	10.7	26.2	13.0	23.1	12.3	22.1	12.1	**22.6**	**12.2**
20.0	31.7	11.5	32.7	14.5	28.1	13.4	27.1	13.2	**27.6**	**13.3**
25.0	38.2	12.2	39.3	15.9	33.1	14.5	32.0	14.3	**32.6**	**14.4**
30.0	44.6	13.0	45.9	17.4	38.1	15.7	36.9	15.4	**37.5**	**15.5**
33.5					**41.6**	**16.4**	**40.4**	**16.2**	**41.0**	**16.3**

Using the average of the southerly quadrants, we deduce that the design condition, a 41 knot wind speed, corresponds to a wave height of 33.5 feet and a modal period of approximately 16.3 seconds.

Analysis Methods

In this study, tug forces were computed using the methods outlined in Reference 1, with different inputs for vessel sizes and environmental conditions.

Different components of the required force were computed for waves, wind, and current. No actual current was applied; the current loadings were used to represent smooth water towing resistance. One knot was used as a tow speed to allow hydrodynamic forces on the vessels to help with steering and control. All forces were added together and assumed to be aligned.

The towing force was calculated as the worst case of the straight ahead pull or the forward yawing force represented as the maximum turning force at approximately +/- 40 degrees. The towing force for the container ship was dominated by the yawing force due to the high windage while the towing force for the tanker was maximum in the straight ahead condition.

The turning force is the maximum required to turn the vessel from its drifting attitude to head to wind assuming the tug is pulling transversely on the bow.

The towing force is converted to a tug rated bollard pull by applying a tug efficiency factor. The tug efficiency factor used in the previous study is used here as well. See Reference 6 for the factors and Reference 1 for a discussion of what this factor represents.

Analysis Results

The tables below show the tug forces in metric tonnes (MT) required to handle the container ship and tanker for a range of wind speeds in knots. At higher wind speeds the wind forces dominate the solution which makes the container ship the limiting case for sizing the rescue tug.

Table 5 Tug Forces for Container Ship

Wave Hs (ft)	Wind (kt)	Modal Period (s)	Towing Speed (kt)	Towing Force (MT)	Turning Force (MT)	Tug Efficiency	Tug Rated Bollard Pull (MT)
5	13	10.0	1	7	8	0.80	10
10	18	11.1	1	15	15	0.80	19
15	23	12.2	1	26	24	0.78	34
20	28	13.3	1	38	35	0.76	50
25	33	14.4	1	45	50	0.74	68
30	38	15.5	1	44	67	0.74	91
33	41	16.3	1	52	80	0.74	109

Table 6 Tug Forces for Tanker

Wave Hs (ft)	Wind (kt)	Modal Period (s)	Towing Speed (kt)	Towing Force (MT)	Turning Force (MT)	Tug Efficiency	Tug Rated Bollard Pull (MT)
5	13	10.0	1	4	2	0.8	5
10	18	11.1	1	10	3	0.8	12
15	23	12.2	1	18	5	0.78	23
20	28	13.3	1	26	7	0.76	34
25	33	14.4	1	29	11	0.74	39
30	38	15.5	1	25	16	0.74	34
33	41	16.3	1	30	19	0.74	41

Discussion

There are two notable differences between the minimum tug study performed in Reference 1 and this new study.

2. The wave heights are larger in the Aleutians than the average conditions used in the original study. The increased wave heights affect both vessels but tend to be more noticeable for the tanker. The design condition for the tanker has almost doubled the tug rating from 24 MT to 41 MT.