NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

April 3, 2018

Group Chairman's Factual Report

METEOROLOGY

DCA17FM006

Table Of Contents

A. ACCIDENT

Location: Near St. George Island, Alaska
Date: February 11, 2017
Time: 0610 Alaska standard time
1510 Coordinated Universal Time (UTC)
Vehicles: *F/V Destination*

B. METEOROLOGY GROUP

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NOAA/National Weather Service

C. DETAILS OF THE INVESTIGATION

The National Transportation Safety Board's (NTSB) Meteorologist travelled for this investigation to the United States Coast Guard (USCG) Commandant Marine Board Public Hearing (MBI) in Seattle, Washington, held between August 7, and August 17, 2017. In addition, the NTSB meteorologist gathered the weather data for this investigation from official National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) sources including the National Centers for Environmental Information (NCEI). All times are Alaska standard time (AKST) on February 11, 2017, and are based upon the 24-hour clock, where local time is -9 hours from UTC, and UTC=Z (unless otherwise noted). Directions are referenced to true north and distances in nautical miles. Heights are above mean sea level (msl) unless otherwise noted. Visibility is in statute miles and fractions of statute miles.

The approximate accident site and last known location was latitude 56.6496° N, longitude 169.8327° W.

D. FACTUAL INFORMATION

1.0 Synoptic Situation

The synoptic or large scale migratory weather systems influencing the area were documented using standard NWS charts issued by the National Center for Environmental Prediction, the Ocean Prediction Center (OPC), and the Weather Prediction Center, located in College Park, Maryland. These are the base products used in describing synoptic weather features and in the creation of forecasts and warnings for the NWS. Reference to these charts can be found in the joint NWS and Federal Aviation Administration Advisory Circular "Aviation Weather Services", AC 00-45H[1].

1.1 Surface Analysis Chart

The OPC Surface Analysis Charts for 0300 and 0900 AKST are provided as figures 1 and 2 with the approximate location of the accident site marked within the red circle. The charts depicted two surface high pressure centers over the Kamchatka Peninsula and eastern Russia with a surface pressure of 1020- and 1039-hectopascals (hPa), respectively. Those surface high pressure centers remained nearly stationary between 0300 and 0900 AKST. South of the Aleutian Islands in the northern Pacific Ocean there were three surface low pressure centers indicated (figure 1) with surface pressures of 975-, 973-, and 968-hPa, respectively. The surface low pressure centers south of the Aleutian Islands also remained relatively stationary between 0300 and 0900 AKST. The station models around the accident site depicted air temperatures of -5° Celsius (C) at 0300 AKST that cooled to -9° C by 0900 AKST, a northeast wind of 20 knots, cloudy skies, and light snow.

1 https://www.faa.gov/regulations_policies/advisory_circulars/index.cfm/go/document.information/documentID/1030235

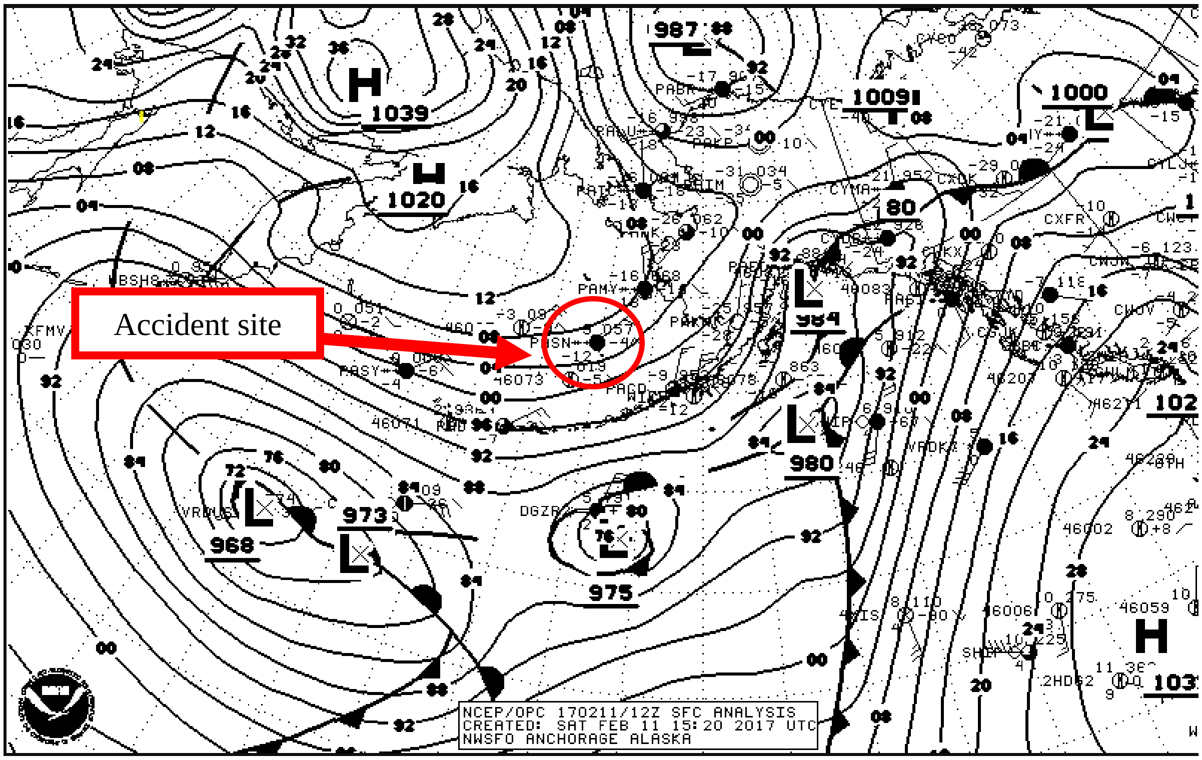

Figure 1 – OPC Surface Analysis Chart for 0300 AKST

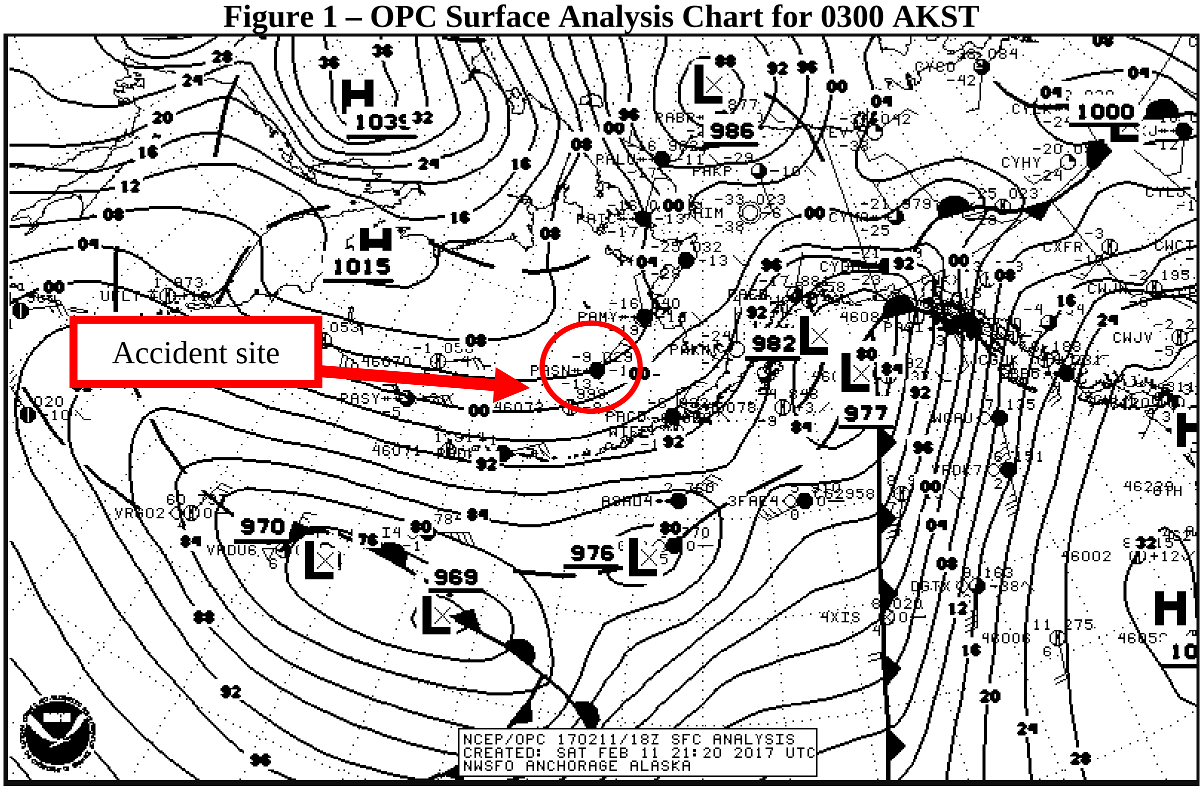

Figure 2 – OPC Surface Analysis Chart for 0900 AKST

1.2 Upper Air Charts

The OPC 500-hPa Constant Pressure Charts for 1500 AKST on February 10, and 0300 AKST and 1500 AKST on February 11 are presented in figures 3 through 5. A mid-level trough[2] moved southeastward away from the accident site between 1500 AKST on February 10 and 1500 AKST on February 11. The mid-level trough was located along the Aleutian Islands, oriented southwest through northeast, by 1500 AKST on February 11. The OPC 500-hPa analysis indicated northerly winds with a 30-knot magnitude at 1500 AKST on February 11 (figure 5).

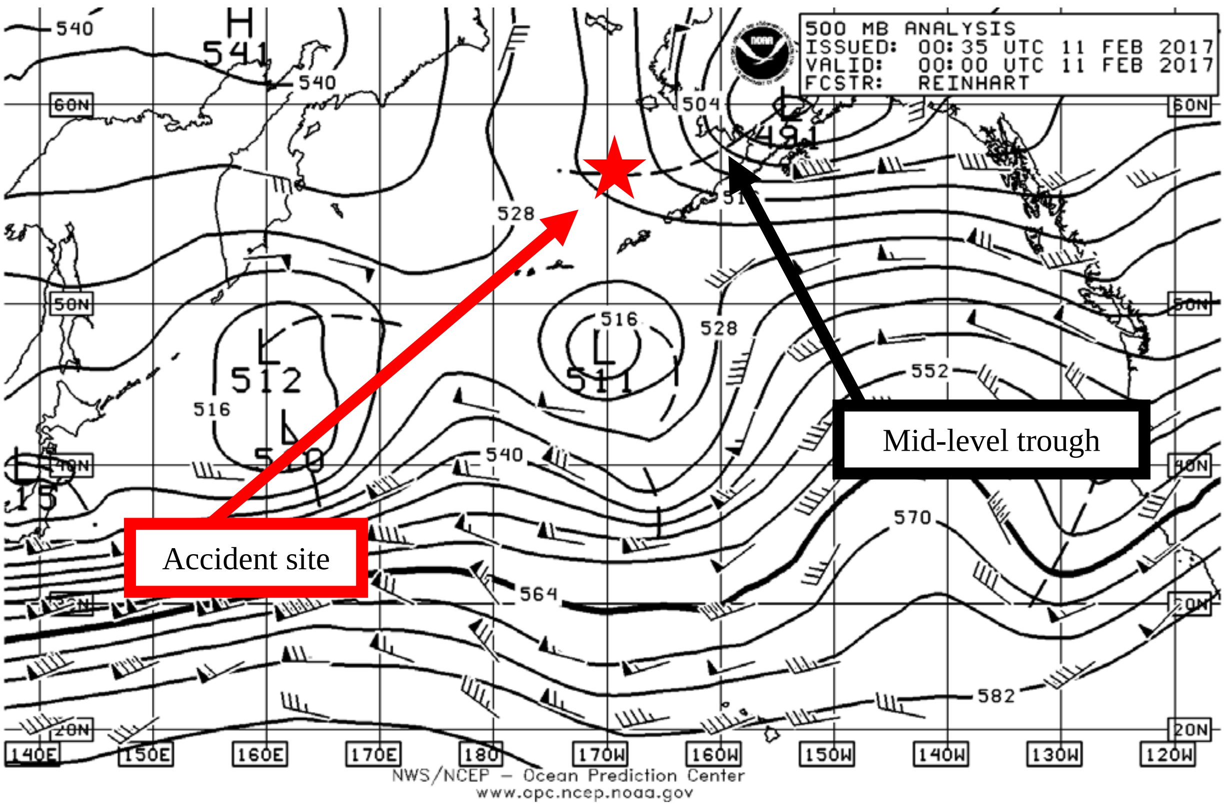

Figure 3 – OPC 500-hPa Constant Pressure Chart for 1500 AKST on February 10

[2] Trough – An elongated area of relatively low atmospheric pressure or heights.

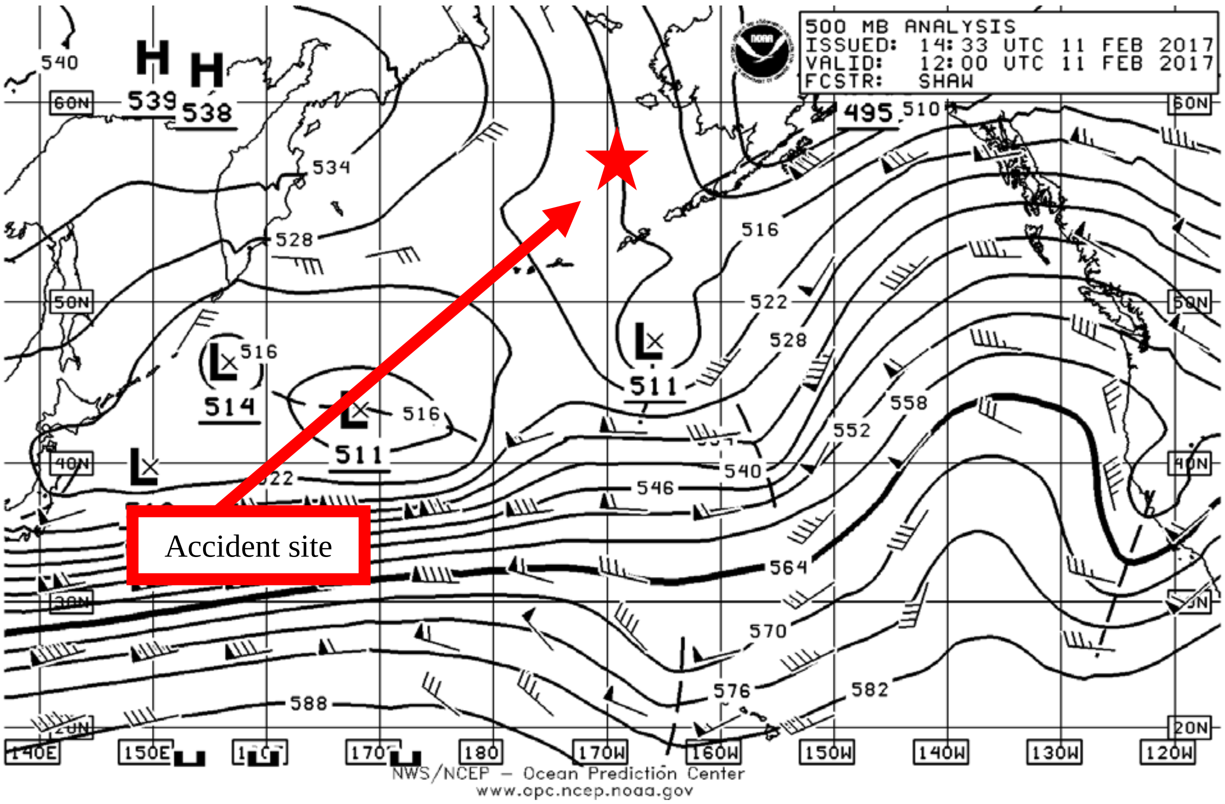

Figure 4 – OPC 500-hPa Constant Pressure Chart for 0300 AKST

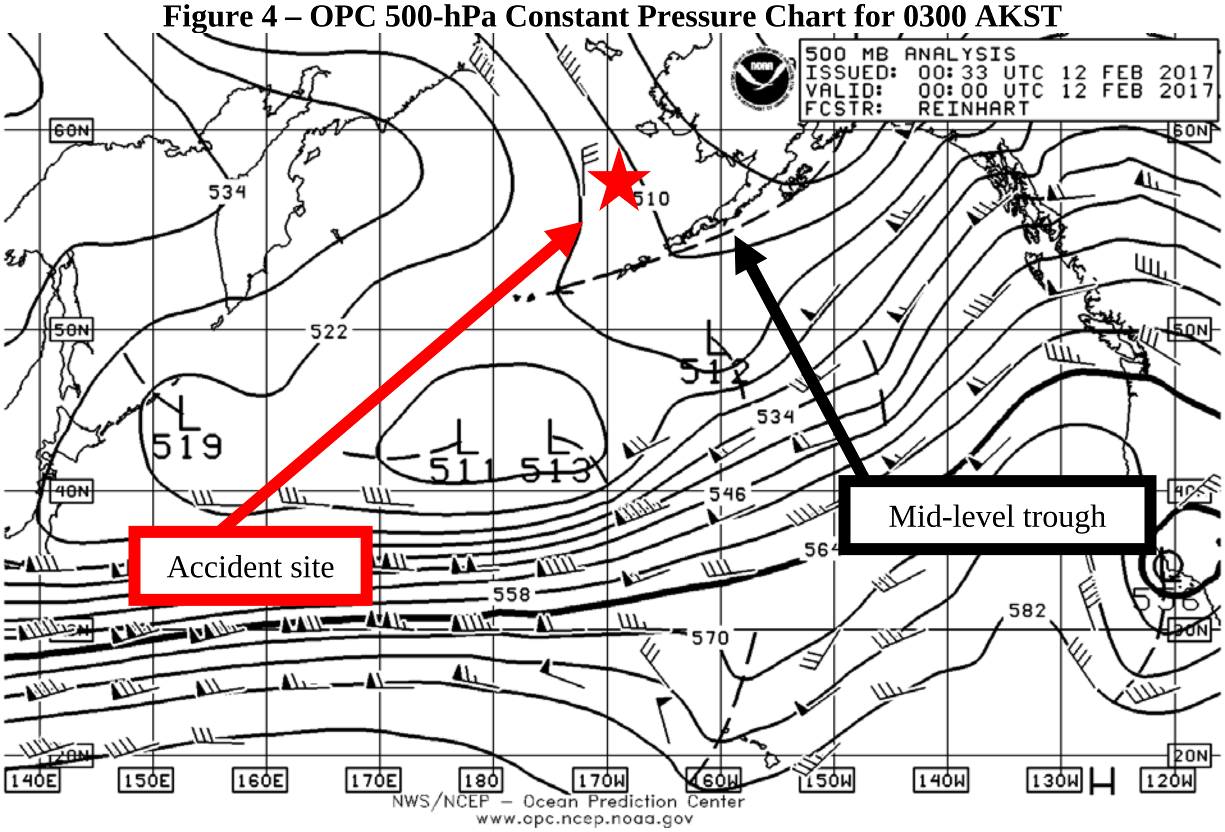

Figure 5 – OPC 500-hPa Constant Pressure Chart for 1500 AKST

2.0 Surface Observations

The area surrounding the accident site was documented using official NWS Meteorological Aerodrome Reports (METARs) and Specials (SPECIs). The following observations were taken from standard code and are provided in plain language with visibility reported in statute miles for this section. Figure 6 is a local observation map with the accident site and the closest weather reporting locations marked.

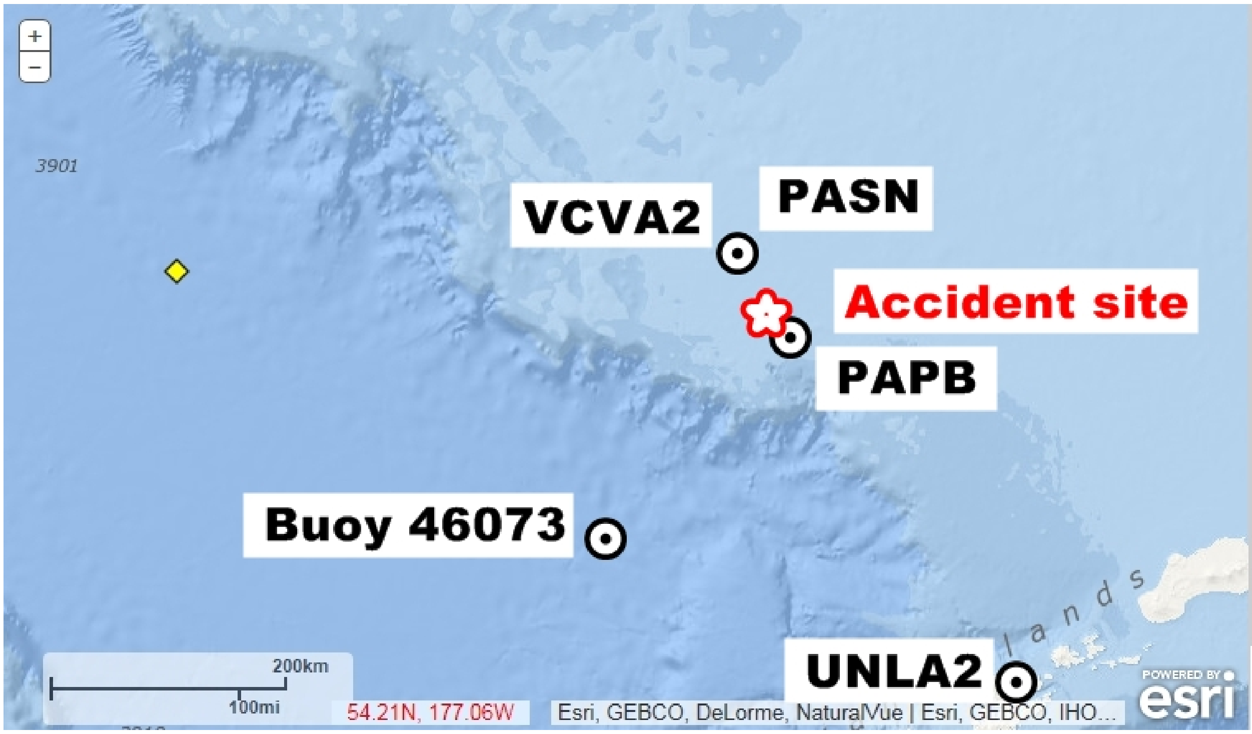

Figure 6 – Local map of accident area with the location of the accident site and surface observation sites

St. George Airport (PAPB) was the closest official surface weather station to the accident site, located 4 miles southwest of St. George, Alaska. PAPB had an Automated Surface Observing System (ASOS[3]) whose reports were not supplemented. PAPB was located 7 miles southeast of the accident site, at an elevation of 128 feet, and had a 11° easterly magnetic variation[4] (figure 6). The following observations were taken and disseminated during the times surrounding the accident: [5]

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[3] ASOS – Automated Surface Observing System is equipped with meteorological instruments to observe and report wind, visibility, ceiling, temperature, dewpoint, altimeter, and barometric pressure.

[4] Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2000, latest measurement taken from http://www.airnav.com/airport/PAPB

[5] The bold sections in this NWS product and the rest of products in this report are intended to highlight the sections that directly reference the weather conditions that affected the accident location around the accident time. The local times in section 2.0 next to the METARs are provided for quick reference between UTC and local times around the accident time.

[0053 AKST] METAR PAPB 110953Z AUTO 04027G34KT 5SM -SN OVC017 M08/M12 A2964 RMK AO2 PK WND 04037/0936 SLP027 P0000 T10831117 TSNO $=

[0153 AKST] METAR PAPB 111053Z AUTO 05030G33KT 2 1/2SM -SN OVC017 M08/M12 A2964 RMK AO2 PK WND 05038/1011 VIS 1 1/2V4 SLP025 P0000 T10831117 TSNO $=

[0202 AKST] SPECI PAPB 111102Z AUTO 04024G32KT 6SM -SN OVC017 M08/M12 A2964 RMK AO2 PK WND 05032/1054 P0000 T10831117 TSNO $=

[0253 AKST] METAR PAPB 111153Z AUTO 04022G34KT 9SM -SN OVC018 M08/M12 A2964 RMK AO2 PK WND 04037/1110 SLP025 P0000 60000 T10831117 11083 21089 56003 TSNO $=

[0353 AKST] METAR PAPB 111253Z AUTO 04023G31KT 3SM -SN OVC018 M08/M11 A2963 RMK AO2 PK WND 03033/1201 SLP022 P0000 T10781111 TSNO $=

[0453 AKST] METAR PAPB 111353Z AUTO 04024G30KT 6SM -SN OVC020 M08/M12 A2961 RMK AO2 PK WND 03033/1308 SLP016 P0000 T10781117 TSNO $=

[0553 AKST] METAR PAPB 111453Z AUTO 04023G31KT 9SM -SN BKN020 OVC025 M08/M12 A2959 RMK AO2 PK WND 03034/1408 SLP009 P0000 60000 T10781117 58016 TSNO $=

ACCIDENT TIME 0610 AKST

[0653 AKST] METAR PAPB 111553Z AUTO 04022G31KT 9SM -SN BKN020 M08/M12 A2958 RMK AO2 PK WND 04032/1455 SLP006 P0000 T10781122 TSNO $=

[0753 AKST] METAR PAPB 111653Z AUTO 03020G28KT 3SM -SN OVC020 M08/M12 A2957 RMK AO2 PK WND 03030/1600 SLP002 P0000 T10781117 TSNO $=

[0805 AKST] SPECI PAPB 111705Z AUTO 02019G30KT 2 1/2SM -SN OVC018 M08/M12 A2956 RMK AO2 PK WND 04030/1701 VIS 1 1/2V5 P0000 T10781117 TSNO $=

[0814 AKST] SPECI PAPB 111714Z AUTO 04024G28KT 3SM -SN OVC018 M08/M11 A2956 RMK AO2 PK WND 04030/1701 P0000 T10781111 TSNO $=

PAPB weather at 0453 AKST, automated, wind from 040° at 24 knots with gusts to 30 knots, 6 miles visibility, light snow, overcast ceiling at 2,000 feet above ground level (agl), temperature of -8° C, dew point temperature of -12° C, and an altimeter setting of 29.61 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 33 knots from 030° at 0408 AKST, sea level pressure 1001.6 hPa, one-hourly precipitation of a trace, temperature -7.8° C, dew point temperature -11.7° C, lightning detection system is not operating, maintenance is needed on the system.

PAPB weather at 0553 AKST, automated, wind from 040° at 23 knots with gusts to 31 knots, 9 miles visibility, light snow, a broken ceiling at 2,000 feet agl, overcast skies at 2,500 feet agl, temperature of -8° C, dew point temperature of -12° C, and an altimeter setting of 29.59 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 34 knots from 030° at 0508 AKST, sea level pressure 1000.9 hPa, one-hourly precipitation of a trace, 6-hourly precipitation of a trace, temperature -7.8° C, dew point temperature -11.7° C, 3-hourly pressure decrease of 1.6 hPa, lightning detection system is not operating, maintenance is needed on the system.

PAPB weather at 0653 AKST, automated, wind from 040° at 22 knots with gusts to 31 knots, 9 miles visibility, light snow, a broken ceiling at 2,000 feet agl, temperature of -8° C, dew point temperature of -12° C, and an altimeter setting of 29.58 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 32 knots from 040° at 0555 AKST, sea level pressure 1000.6 hPa, one-hourly precipitation of a trace, temperature -7.8° C, dew point temperature -12.2° C, lightning detection system is not operating, maintenance is needed on the system.

PAPB weather at 0753 AKST, automated, wind from 030° at 20 knots with gusts to 28 knots, 3 miles visibility, light snow, overcast ceiling at 2,000 feet agl, temperature of -8° C, dew point temperature of -12° C, and an altimeter setting of 29.57 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 30 knots from 030° at 0700 AKST, sea level pressure 1000.2 hPa, one-hourly precipitation of a trace, temperature -7.8° C, dew point temperature -11.7° C, lightning detection system is not operating, maintenance is needed on the system.

For more METAR observations from PAPB including observations from before the accident vessel departed Dutch Harbor, Alaska, please see attachment 1.

St. Paul Island Airport (PASN) was the next closest official surface weather station to the accident site, located 3 miles northeast of St. Paul Island, Alaska. PASN had an ASOS whose reports were supplemented by an official human observer until 0800 AKST on the day of the accident. PASN was located 34 miles north-northwest of the accident site, at an elevation of 66 feet, and had a 10° easterly magnetic variation[6] (figure 6). The following observations were taken and disseminated during the times surrounding the accident:

[2353 AKST][7] METAR PASN 110853Z AUTO 03023G28KT 9SM -SN OVC018 M10/M13 A2971 RMK AO2 PK WND 04031/0835 SLP060 P0000 60000 T11001128 410781106 56009 TSNO=

[0053 AKST] METAR PASN 110953Z 04020KT 8SM -SN OVC016 M10/M12 A2971 RMK AO2 PK WND 03031/0910 SLP060 P0000 T11001122=

[0153 AKST] METAR PASN 111053Z 05016G24KT 9SM -SN OVC019 M09/M12 A2970 RMK AO2 PK WND 04028/1002 SLP058 P0000 T10941122=

[6] Magnetic variation – The angle (at a particular location) between magnetic north and true north. 2005, latest measurement taken from http://www.airnav.com/airport/PASN

[7] February 10

[0253 AKST] METAR PASN 111153Z 04020G25KT 6SM -SN OVC017 M09/M12 A2969 RMK AO2 SLP057 P0000 60000 T10941122 11094 21106 58004=

[0353 AKST] METAR PASN 111253Z 04018KT 8SM -SN OVC020 M09/M12 A2968 RMK AO2 PK WND 04026/1219 SLP053 P0000 T10941122=

[0453 AKST] METAR PASN 111353Z 03017G23KT 7SM -SN OVC019 M09/M12 A2967 RMK AO2 PK WND 03026/1325 SLP047 P0000 T10941122=

[0553 AKST] METAR PASN 111453Z 04014KT 9SM -SN OVC021 M10/M13 A2965 RMK AO2 SLP042 P0000 60000 T11001128 58015=

ACCIDENT TIME 0610 AKST

[0653 AKST] METAR PASN 111553Z 03013G20KT 9SM -SN BKN020 OVC026 M10/M13 A2964 RMK AO2 SLP037 P0000 I1001 T11001128=

[0753 AKST] METAR PASN 111653Z 04015KT 9SM -SN OVC020 M10/M13 A2962 RMK AO2 SLP033 P0000 T11001128=

[0853 AKST] METAR PASN 111753Z 03019G24KT 10SM -SN OVC022 M09/M13 A2961 RMK AO2 SNE1655B52 SLP029 P0000 60000 I1001 I6002 T10941128 11094 21100 56013=

[0953 AKST] METAR PASN 111853Z 04016KT 10SM BKN021 M09/M13 A2961 RMK AO2 SNE00 SLP027 P0000 I1001 T10941128=

PASN weather at 0453 AKST, wind from 030° at 17 knots with gusts to 23 knots, 7 miles visibility, light snow, overcast ceiling at 1,900 feet agl, temperature of -9° C, dew point temperature of -12° C, and an altimeter setting of 29.67 inches of mercury. Remarks, station with a precipitation discriminator, peak wind of 26 knots from 030° at 0425 AKST, sea level pressure 1004.7 hPa, one-hourly precipitation of a trace, temperature -9.4° C, dew point temperature -12.2° C.

PASN weather at 0553 AKST, wind from 040° at 14 knots, 9 miles visibility, light snow, an overcast ceiling at 2,100 feet agl, temperature of -10° C, dew point temperature of -13° C, and an altimeter setting of 29.65 inches of mercury. Remarks, station with a precipitation discriminator, sea level pressure 1004.2 hPa, one-hourly precipitation of a trace, 6-hourly precipitation of a trace, temperature -10.0° C, dew point temperature -12.8° C, 3-hourly pressure decrease of 1.5 hPa.

PASN weather at 0653 AKST, wind from 030° at 13 knots with gusts to 20 knots, 9 miles visibility, light snow, a broken ceiling at 2,000 feet agl, overcast skies at 2,600 feet agl, temperature of -10° C, dew point temperature of -13° C, and an altimeter setting of 29.64 inches of mercury. Remarks, station with a precipitation discriminator, sea level pressure 1003.7 hPa, one-hourly precipitation of a trace, one-hourly ice accumulation of 0.01 inches, temperature -10.0° C, dew point temperature -12.8° C. The ice accumulation was reported by the freezing rain sensor, which is completely automated at PASN.

PASN weather at 0753 AKST, wind from 040° at 15 knots, 9 miles visibility, light snow, overcast ceiling at 2,000 feet agl, temperature of -10° C, dew point temperature of -13° C, and an altimeter setting of 29.62 inches of mercury. Remarks, station with a precipitation discriminator, sea level pressure 1003.3 hPa, one-hourly precipitation of a trace, temperature -10.0° C, dew point temperature -12.8° C.

For more METAR observations from PASN including observations from before the accident vessel departed Dutch Harbor, Alaska, please see attachment 2.

2.1 Local Marine Observations

Additional surface and marine observations were examined around the accident site and within the Bering Sea. A marine station 32 miles north-northwest of the accident site (figure 6, VCVA2) owned and maintained by NOAA's National Ocean Service (NOS) provided wind and temperature information around the accident time (figure 7, time in UTC).[8] VCVA2 is part of the National Water Level Observation Network (NWLON) and reported a wind from 030° to 040° between 15.9 and 18.1 knots with gusts to 22.9 knots, air temperatures of -8.6° C, and water temperatures between -0.6° and -0.7° C around the accident time (figure 7). For additional VCVA2 observations surrounding the accident time please see attachment 3. Section 10.0 will discuss the marine vessel icing potential given the wind and temperature information.

[8] 1 m/s = 1.94384 knots

#YY	MM	DD	hh	mm	wind direction	wind speed	wind gusts	pressure	air temp	water temp
#yr	mo	dy	hr	mn	deg	T m/s	m/s	T hPa	degC	degC
2017	2	11	16	54	40	6.7	8.8	1003.7	-8.7	-0.9
2017	2	11	16	48	40	6.7	8.8	1003.7	-8.8	-0.9
2017	2	11	16	42	40	7.7	9.8	1003.7	-8.7	-0.9
2017	2	11	16	36	50	7.7	9.3	1003.8	-8.7	-0.8
2017	2	11	16	30	30	7.2	9.8	1003.8	-8.7	-0.8
2017	2	11	16	24	30	8.2	9.8	1003.9	-8.6	-0.8
2017	2	11	16	18	30	7.7	9.3	1004	-8.7	-0.8
2017	2	11	16	12	40	8.8	10.3	1004.1	-8.9	-0.7
2017	2	11	16	6	40	8.2	11.3	1004.1	-8.8	-0.7
2017	2	11	16	0	40	8.2	10.8	1004.2	-8.7	-0.6
2017	2	11	15	54	40	8.8	10.8	1004.2	-8.8	-0.6
2017	2	11	15	48	40	7.2	9.8	1004.3	-8.9	-0.6
2017	2	11	15	42	40	7.7	9.8	1004.2	-8.6	-0.6
2017	2	11	15	36	40	8.2	10.8	1004.3	-8.7	-0.6
2017	2	11	15	30	40	7.7	9.8	1004.4	-8.6	-0.6
2017	2	11	15	24	40	8.2	10.3	1004.4	-8.6	-0.6
2017	2	11	15	18	30	9.3	11.8	1004.5	-8.6	-0.7
2017	2	11	15	12	30	8.2	10.8	1004.5	-8.6	-0.7
2017	2	11	15	6	40	8.2	9.3	1004.6	-8.6	-0.7
2017	2	11	15	0	50	7.7	9.8	1004.5	-8.6	-0.7
2017	2	11	14	54	40	8.2	10.3	1004.6	-8.6	-0.7
2017	2	11	14	48	40	8.2	10.3	1004.7	-8.5	-0.7
2017	2	11	14	42	40	8.2	11.3	1004.8	-8.4	-0.7
2017	2	11	14	36	40	6.7	9.8	1004.8	-8.4	-0.7
2017	2	11	14	30	40	7.7	10.3	1004.8	-8.4	-0.7
2017	2	11	14	24	30	8.2	10.3	1004.9	-8.5	-0.7
2017	2	11	14	18	40	7.7	9.3	1004.9	-8.4	-0.7
2017	2	11	14	12	40	8.2	9.8	1005	-8.6	-0.7
2017	2	11	14	6	40	6.7	9.8	1005.1	-8.7	-0.7
2017	2	11	14	0	30	9.3	11.3	1005.2	-8.6	-0.7
2017	2	11	13	54	30	8.8	10.8	1005.2	-8.5	-0.7
2017	2	11	13	48	40	8.2	9.8	1005.3	-8.6	-0.7
2017	2	11	13	42	50	8.2	9.8	1005.4	-8.6	-0.7
2017	2	11	13	36	40	8.2	10.8	1005.5	-8.6	-0.7
2017	2	11	13	30	40	10.3	12.4	1005.6	-8.8	-0.8
2017	2	11	13	24	40	8.8	10.3	1005.6	-8.7	-0.8

Figure 7 – VCVA2 surface and marine data from around the accident time (time in UTC)

A marine weather buoy station was located 121 miles southwest of the accident site (figure 6) and was owned and maintained by the National Data Buoy Center as station 46073. Buoy 46073 provided wind and temperature information around the accident time (figure 8, time in UTC). Buoy 46073 reported a wind from 050° at 9.7 knots with gusts to 25.3 knots, significant wave heights[9] between 12.1 and 14.1 feet, a mean wave direction between 036° and 041°, and a dominant wave period of 9 to 10 seconds around the accident time (figure 8). For additional Buoy 46073 observations surrounding the accident time please see attachment 4. Section 10.0 will discuss the marine vessel icing potential.

#YY	MM	DD	hh	mm	wind speed	wind gusts	wave height	dominant wave period	average wave period	mean wave direction	pressure
#yr	mo	dy	hr	mn	m/s	m/s	m	sec	sec	deg	hPa
2017	2	12	0	50	4	10	3.3	8	6.7	33	998.2
2017	2	11	23	50	5	11	3.5	9	6.8	47	998.7
2017	2	11	22	50	5	8	3.5	9	6.8	65	999.3
2017	2	11	21	50	5	10	3.4	10	6.7	69	999.7
2017	2	11	20	50	5	9	3.7	9	7.1	40	999.9
2017	2	11	19	50	5	12	3.7	9	6.9	31	1000
2017	2	11	18	50	5	11	3.8	9	6.9	43	1000
2017	2	11	17	50	5	10	4.1	9	7.1	25	999.8
2017	2	11	16	50	5	10	3.7	9	6.9	36	999.8
2017	2	11	15	50	5	13	3.9	10	7	41	1000.3
2017	2	11	14	50	5	10	4.3	10	7.3	40	1000.6
2017	2	11	13	50	6	12	4.9	10	7.7	40	1001.1
2017	2	11	12	50	6	13	4.3	10	7.4	30	1001.5
2017	2	11	11	50	6	12	4.4	10	7.4	37	1001.9
2017	2	11	10	50	6	13	4.6	11	7.5	49	1002.2
2017	2	11	9	50	6	15	5.1	10	7.8	33	1002.1
2017	2	11	8	50	6	15	4.9	10	7.7	30	1002.4
2017	2	11	7	50	6	13	4.7	10	7.5	25	1002.3
2017	2	11	6	50	6	14	4.6	9	7.2	42	1002.3
2017	2	11	5	50	6	14	4.9	9	7.4	26	1002.3
2017	2	11	4	50	5	14	4.5	9	7.1	46	1002.3
2017	2	11	3	50	5	14	4.2	9	7	19	1002.1
2017	2	11	2	50	5	13	5.2	9	7.7	19	1002
2017	2	11	1	50	6	14	4.9	9	7.5	16	1002.2
2017	2	11	0	50	5	12	5	9	7.5	22	1002.5
2017	2	10	23	50	6	15	4.2	8	7.1	35	1002.9
2017	2	10	22	50	5	11	4.3	8	7.1	26	1003.1
2017	2	10	21	50	6	14	4.4	9	7.2	26	1003.3
2017	2	10	20	50	6	13	5.1	9	7.5	27	1003.3
2017	2	10	19	50	6	14	3.7	9	6.7	28	1003.4
2017	2	10	18	50	6	12	4.1	8	6.8	31	1003.2
2017	2	10	17	50	6	15	3.9	8	6.7	31	1003.1
2017	2	10	16	50	6	13	3.8	8	6.4	32	1003.4
2017	2	10	15	50	6	14	3.4	7	6.1	32	1003.7
2017	2	10	14	50	6	12	3.4	7	6.2	32	1004
2017	2	10	13	50	6	12	2.9	7	5.8	33	1004.4

Figure 8 – Buoy 46073 surface and marine data from around the accident time (time in UTC)

[9] See section 11.0 for definition and information.

A marine station 201 miles south-southeast of the accident site (figure 6, UNLA2) owned and maintained by NOS provided additional wind and temperature information around the accident time (figure 9, time in UTC). UNLA2 was located in Dutch Harbor, Alaska, which was the accident vessel's departure location (the accident vessel departed around 1800 AKST on February 9). UNLA2 is part of the NWLON and reported a wind from 030° at 7 knots with gusts to 8.9 knots, an air temperature of -1.3° C, and water temperatures between +3.9° and +4.0° C at the time of departure (figure 9). Around the accident time, UNLA2 reported a wind from 030° at 14.0 knots with gusts to 24.1 knots, an air temperature of -3.9° C, and a water temperature around +3.2° C (attachment 5). For additional UNLA2 observations surrounding the accident time please see attachment 5. Section 10.0 will discuss the marine vessel icing potential given the wind and temperature information.

#YY	MM	DD	hh	mm	wind direction	wind speed	wind gusts	pressure	air temp	water temp
#yr	mo	dy	hr	mn	degT	m/s	m/s	hPa	degC	degC
2017	2	10	4	0	20	4.1	5.1	1007	-1.7	4
2017	2	10	3	54	30	4.1	5.7	1007	-1.6	4
2017	2	10	3	48	30	3.6	6.2	1007	-1.6	4
2017	2	10	3	42	30	3.6	5.1	1007.1	-1.6	4
2017	2	10	3	36	20	2.1	5.1	1007.2	-1.4	3.9
2017	2	10	3	30	40	3.6	6.2	1007.2	MM	3.9
2017	2	10	3	24	40	3.1	6.2	1007.3	MM	3.9
2017	2	10	3	18	50	4.1	6.7	1007.3	-1.4	3.9
2017	2	10	3	12	20	4.1	6.2	1007.4	-1.5	3.9
2017	2	10	3	6	30	3.6	4.6	1007.4	-1.3	4
2017	2	10	3	0	MM	MM	MM	MM	MM	3.9
2017	2	10	2	54	MM	MM	MM	MM	MM	3.9
2017	2	10	2	48	MM	MM	MM	1007.6	-1.4	3.9
2017	2	10	2	42	MM	MM	MM	1007.6	-1.4	3.9
2017	2	10	2	36	MM	MM	MM	1007.7	-1.4	3.9
2017	2	10	2	30	20	4.6	5.7	1007.8	MM	4
2017	2	10	2	24	30	5.1	8.2	1007.8	MM	4
2017	2	10	2	18	MM	MM	MM	1007.7	-1.2	3.9
2017	2	10	2	12	MM	MM	MM	1007.7	-1.1	3.9
2017	2	10	2	6	MM	MM	MM	1007.8	-1.1	4
2017	2	10	2	0	40	4.1	6.2	MM	MM	4
2017	2	10	1	54	50	2.6	4.1	MM	MM	4
2017	2	10	1	48	20	3.6	5.1	1008.1	-1	4
2017	2	10	1	42	20	5.1	6.2	1008.1	-1.1	3.9
2017	2	10	1	36	40	2.1	4.6	1008.2	-0.8	3.9
2017	2	10	1	30	40	2.6	5.1	1008.2	-0.8	4
2017	2	10	1	24	30	3.6	5.1	1008.3	-0.9	4
2017	2	10	1	18	MM	MM	MM	1008.4	-0.9	4
2017	2	10	1	12	MM	MM	MM	1008.5	-0.7	4
2017	2	10	1	6	MM	MM	MM	1008.5	-0.7	3.9
2017	2	10	1	0	MM	MM	MM	MM	MM	4
2017	2	10	0	54	MM	MM	MM	MM	MM	3.9
2017	2	10	0	48	MM	MM	MM	1008.8	-0.7	4
2017	2	10	0	42	MM	MM	MM	1008.9	-0.8	4
2017	2	10	0	36	MM	MM	MM	1008.9	-0.8	4
2017	2	10	0	30	40	3.6	5.7	MM	MM	MM

Figure 9 – UNLA2 surface and marine data from around the accident time (time in UTC)[10]

[10] The term "MM" is missing data from UNLA2 station.

3.0 Satellite Data

Infrared data from the Geostationary Operational Environmental Satellite number 15 (GOES-15) data was obtained from an archive at the Space Science Engineering Center (SSEC) at the University of Wisconsin-Madison in Madison, Wisconsin, and processed using the Man-computer Interactive Data Access System (McIDAS) software. Infrared imagery (GOES-15 band 4) at wavelengths of 10.7 microns was retrieved for the period. Satellite imagery surrounding the time of the accident, from 0400 AKST through 0800 AKST at approximately 15-minute intervals were reviewed, and the closest images to the time of the accident are documented here.

Figures 10 and 11 present the GOES-15 infrared imagery from 0600 and 0630 AKST at 4X magnification with the accident site highlighted with a red square. Inspection of the infrared imagery indicated abundant cloud cover over and around the accident site at the accident time with the cloud cover moving from northeast to southwest. It should be noted these figures have not been corrected for any parallax error.

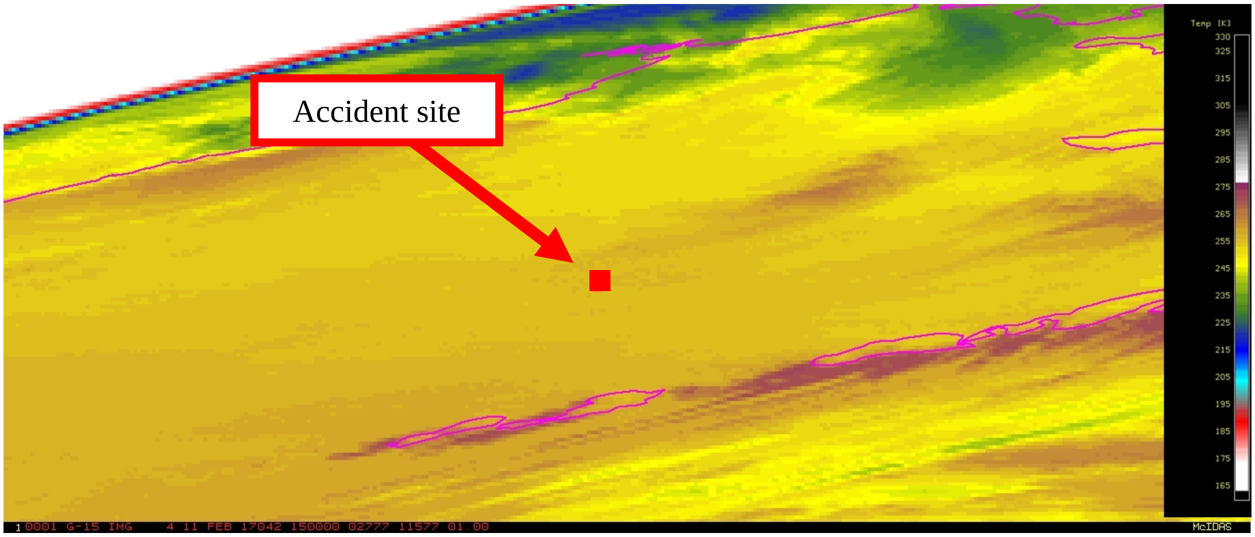

Figure 10 – GOES-15 infrared image at 0600 AKST

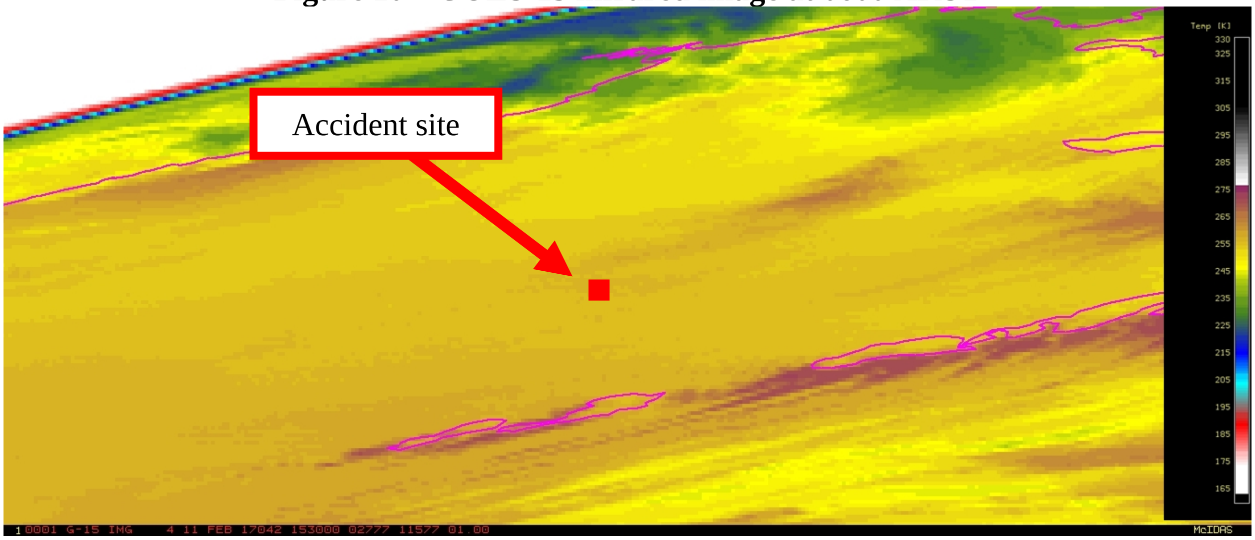

Figure 11 – GOES-15 infrared image at 0630 AKST

4.0 Radar Imagery Information

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)[11] to the accident site was the Bethel, Alaska, radar (PABC), which was located 355 miles northeast of the accident site at an elevation of 161 feet. The PABC WSR-88D was too far away to provide any weather radar information above the accident site or along the accident route.

5.0 NWS Area Forecast Discussion

The NWS Office in Anchorage, Alaska, issued the following Area Forecast Discussion (AFD) at 0457 AKST (closest AFD to the accident time). The AFD discussed that the northerly surface wind flow would continue with small craft advisory level wind conditions and freezing spray continuing through the weekend:

765
FXAK68 PAFC 111357
AFDAFC

Southcentral and Southwest Alaska Forecast Discussion
National Weather Service Anchorage AK
457 AM AKST Sat Feb 11 2017

.ANALYSIS AND UPPER LEVELS...

On the morning weather map there is an upper low on top of Southcentral Alaska with a very cold arctic airmass in place across nearly all of southern Alaska. A weakening surface low near Prince William Sound continues to kick off scattered snow showers across most of the area, though the majority are confined to the North Gulf Coast. These showers will be on the rapid decline this morning as the upper Low weakens and moves off to the northeast. This will prove to be the opening act of a fairly dramatic amplification of the upper level pattern that is going to bring markedly different weather to southern Alaska over much of the upcoming week. We can already start to see on satellite imagery the beginning of a dramatic amplification of ridging (high pressure) over the west coast of North America and a high-amplitude trough digging southward in the Bering Sea. If this sounds familiar, it's because we spent much of the last 2 winters in this pattern. And, much like those winters, we're going to see above-normal temperatures and the return of steady rainfall to the coastal areas as this pattern unfolds.

But in the meantime, we remain firmly in the grip of an Arctic airmass, with bitterly cold temperatures and gusty north winds producing continued wind chill advisory conditions over parts of

[11] The WSR-88D is an S-band 10-centimeter wavelength radar with a power output of 750,000 watts, and with a 28-foot parabolic antenna that concentrates the energy between a 0.87° and 0.96° beam width. The radar produces three basic types of products: base reflectivity, base radial velocity, and base spectral width.

the Kuskokwim Delta. In addition, gusty west winds combined with ongoing snowfall in Whittier continue to produce blowing snow and significantly reduced visibilities in that area.

&&

.MODEL DISCUSSION...

The models are in pretty good agreement in the first 36 hours or so of the forecast, as the first low ushering in the broad southerly flow makes its way into the northern Panhandle today and tonight. However, by Monday morning, as the ridge to our east continues to amplify, the models are still really struggling with the timing, placement, and intensity of the numerous low pressure centers that will be working their way toward our area for at least the first half of the upcoming week. The main impacts from this uncertainty will be just how warm the temperatures get early in the week and, accordingly, pinpointing when the precipitation type will change to rain at any given location. The GFS remains the warmest and most aggressive solution bringing energy northward past 60N, although some of the other models have begun to hint this direction as well. this would make it easier for well-above-freezing temperatures to surge into Anchorage. For now, we're still considering the GFS a bit of an outlier, and utilized a NAM/ECMWF blend for the morning forecast. Regardless of which solution you choose, precipitation starts as snow along the Gulf Coast but does change to rain for most of the storm cycle (which will span most of the week).

&&

.AVIATION...
PANC...Light north winds will persist throughout the forecast period. Persistent MVFR ceilings should fairly rapidly give way to VFR conditions by mid morning as the weakening storm moves away. By tonight, there is high confidence in clear and cold VFR conditions through Sunday morning. You can never completely rule out some patchy fog forming this evening off Knik Arm and floating around the area, but the inversion strength will be much weaker than many previous fog events, so the most likely scenario at this point is no fog.

&&

.SHORT TERM FORECAST SOUTHCENTRAL ALASKA (Days 1 and 2...Sat and Sun night)...

A cold upper low over the northern Gulf lifts north this morning to over the Copper River Basin then moves into the upper Canadian Yukon tonight. With the exception of the eastern Copper River Basin, snow/snow showers should taper off west of the Chugach. Snow showers will likely hold on across some locales on the North Gulf Coast as a rapidly north-moving low heads toward the panhandle. Marine winds over the western Gulf will slowly diminish through this afternoon. Brisk outflow winds across the eastern Kenai/Western Prince Sound will be slow to diminish and will likely hold on until the evening hours. Gap flows in Valdez/Thompson

pass will increase this afternoon with a brief up tick in the
pressure gradients and supporting 850 mb low, but should diminish
by late evening. With cold air in place and some cloud breaks
tonight, expect quite a few areas inland to see overnight temps
below zero.

Sunday through Sunday night will usher in a change in the pattern
toward windy, warmer, and wet. The culprit: a strong weather
front which moves into the southern Gulf Sunday afternoon and to
the northern Gulf Sunday night. This feature will bring abundant
warm air with a mix of rain and snow to Kodiak Sunday afternoon
which should transition to rain in the evening. The warming may
evening bring mixed precipitation types to some coastal locations
as early as Monday morning. Strong winds will also accompany this
front and bring gales to the western Gulf waters and brisk Gap
flows to favored locales across Southcentral.

&&

.SHORT TERM FORECAST SOUTHWEST ALASKA (Days 1 and 2)...
Cold and dry conditions will persist over the bulk of the
southwest mainland through the weekend as an arctic trough remains
entrenched over the western half of Alaska. A weakening pressure
gradient will allow winds to diminish enough to bring an end to
wind chill concerns over the Kuskokwim Delta by later this
morning. An elongating North-South oriented front associated with
a deep North Pacific low south of the Alaska Peninsula will bring
a chance of snow to the Aleutian Range and perhaps other portions
of Bristol Bay beginning Sunday night. This will initiate a slow
warming trend area-wide, although most locations will still remain
below zero into the start of the work week.

&&

.SHORT TERM FORECAST BERING SEA/ALEUTIANS (Days 1 and 2)...
**Cold northerly flow on the western periphery of the longwave
trough will maintain a regime of scattered snow showers
accompanied by widespread Small Craft Advisory conditions and
freezing spray through the weekend.** A weak disturbance dropping
through the Central Bering will possibly serve to enhance shower
activity over the Pribilof Islands late tonight into Sunday. The
deep North Pacific low then begins to approach the Alaska
Peninsula on Sunday bringing an increase in northeasterly winds,
however at this point in time it appears that the bulk of the
impacts will be confined to the coastal waters south of the Akpen
and Kodiak Island in the form of gale force winds and heavier
precipitation. Will continue to monitor this system for changes in
track that would shift these conditions closer to the Akpen.

&&

.LONG TERM FORECAST (Days 3 through 7)...
Confidence continues to increase in the significant pattern change
early next week as warm, moist southerly flow and an active storm
track pushes into the Gulf of Alaska. The initial surface low
pushing into the southwestern Gulf Sunday afternoon will continue

north-northeast Monday night to track along the outer coast of Kodiak Island Tuesday morning. This surface low track, combined with an inverted trough extending north across the Kenai Peninsula and into the Susitna Valley will act to reduce downsloping as the front lifts north Sunday night and Monday. While downsloping should still generally dominate, it's likely the typically downsloped areas of Cook Inlet will see some light precipitation at some point.

With cold northerly winds increasing out of Broad Pass and into the Susitna Valley as the low approaches during the day Monday confidence is higher in precipitation remaining snow with amounts in the range of a foot or more possible. The second low coming up Tuesday looks warmer with strong downsloping southeasterly winds also increasing temperatures, so rain rather than snow looks more likely for most low elevation locations. A third deep low follows a similar track for a round of strong winds and rain. Areas along the Gulf coast will get hit hardest in terms of precipitation totals with between 5 and 7 inches of rain possible between Sunday night and Wednesday.

Along the coast snow will quickly turn over to rain at the lower elevations but do have concerns in the Coastal Mountains for snow becoming increasingly wet and heavy on top of significant new accumulations. Snow levels will increase to around 1500 ft along the immediate Gulf Coast on Monday and then to 1500 to 2000 ft over a broader area Monday night. Tuesday looks to be the warmest portion of the storm with snow levels around 2500 ft. By the third frontal system Wednesday snow levels will fall back to around 2000 ft and then return to sea level as cooler air pushes back in on Thursday.

Southwest Alaska and the Bering will remain on the cold side of the baroclinic zone through much of the time period with temperatures solidly in the snow range. As the various frontal systems from Southcentral Alaska rotate west across the Alaska/Aleutian Range and into Southwest Alaska, periods of snow will be likely through the week with moderate to heavy snow possible at times where deformations bands set up. Over the Bering, persistent northerly flow will continue instability driven snow showers from the contrast between the cold air temperatures and warmer sea surface.

&&

.AFC WATCHES/WARNINGS/ADVISORIES...
PUBLIC...blowing snow advisory 125
wind chill advisory 155
MARINE...heavy freezing spray 121 129 130 131 132 136 138 139 150
160 165 170 180 185 414
gale warning 155

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SYNOPSIS AND MODEL DISCUSSION...AMD
SOUTHCENTRAL ALASKA...BC
SOUTHWEST ALASKA/BERING SEA/ALEUTIANS...CB
LONG TERM...JR

6.0 NWS Marine Forecast Products

The NWS Office in Anchorage, Alaska, issued the official marine forecasts along the route the accident vessel took after departure from Dutch Harbor, Alaska. The accident vessel passed through 3 different marine forecast zones between 1800 AKST on February 9 and the accident time (figure 12, PKZ170, PKZ414, and PKZ179). The PKZ170 marine forecast valid at 1800 AKST on February 9 was issued at 1515 AKST on February 9. This forecast mentioned a northerly to northeasterly 25 to 35 knot wind starting on the evening of February 9 and continuing through February 13, with seas[12] between 7 and 13 feet, gale warnings for February 10, and a heavy freezing spray warning for the evening and overnight hours of February 10. The PKZ414 marine forecast valid at 1800 AKST on February 9 (issued at 1515 AKST on February 9) had a heavy freezing spray warning valid through the overnight hours of February 10 with a northeast wind increasing to 30 knots by the morning of February 10 and seas between 7 and 12 feet through the accident time. The PKZ179 marine forecast valid at 1800 AKST on February 9 (issued at 1515 AKST on February 9) had a heavy freezing spray warning and a small craft advisory valid through the overnight hours[13] of February 10 with heavy freezing spray expected through February 10, a northeast wind of 15 knots increasing to 30 knots by February 10, and seas of 7 feet increasing to 9 feet by February 10. See text below figure 12 for full forecast.

The PKZ179 marine forecast valid at the accident time (issued at 0353 AKST on February 11) had a small craft advisory valid for a northeast wind of 25 knots. The PKZ179 0353 AKST forecast also warned of freezing spray conditions through February 12 with a northeast wind between 20 and 25 knots and seas of 4 to 8 feet. The PKZ414 marine forecast valid at the accident time (issued at 0345 AKST on February 11) had a heavy freezing spray warning through February 12 with the heavy freezing spray for waters north of 55° latitude. The PKZ414 0345 AKST forecast also mentioned a northeast wind between 10 to 25 knots through February 12 with seas of 3 to 10 feet. The PKZ170 marine forecast valid at the accident time (issued at 0353 AKST on February 11) had a heavy freezing spray warning valid for February 11 with a small craft advisory valid through February 12. The PKZ170 0353 AKST forecast warned of heavy freezing spray conditions through February 11 with a northeast wind between 25 and 30 knots and seas of 9 to 13 feet through February 12. See text below figure 12 for full forecast.

[12] Seas = significant wave height
[13] Overnight hours included through 0400 local time.

The first PKZ179 marine forecast with the mention of heavy freezing spray was the 1524 AKST PKZ179 forecast from February 8, which forecast heavy freezing spray for the overnight hours of February 9 into February 10 with a northeast wind of 25 knots and seas to 8 feet. The first PKZ414 marine forecast with the mention of heavy freezing spray was the 0345 AKST PKZ414 forecast from February 9, which forecast heavy freezing spray for the overnight hours of February 9 through February 10 with a northeast wind of 15 to 30 knots and seas to 11 feet. For more text information regarding the PKZ170, PKZ414, and PKZ179 marine forecast valid from before 1800 AKST on February 9 through the accident time please see attachments 6 and 7.

Current NWS Instruction (NWSI) 10-310[14] states that, "WFOs should include watch headlines[15] when criteria are met for the second, third, or occasionally fourth and fifth periods[16], when there is significant chance of a hazardous marine weather event meeting or exceeding warning criteria." Additionally NWSI 10-310 states, "WFOs will include the following warning headlines when criteria are met for the first period, and may issue warning headlines for events that begin in the second, third or fourth periods when forecaster confidence is high." The weather computer text formatters[17] used by the NWS forecasters will automatically put the "heavy freezing spray" headline in the first 5 periods of the marine forecasts when "heavy freezing spray" criteria is met. A forecast of just "freezing spray" does not receive a headline in the marine forecasts. See attachments 8 and 9 for current NWSI 10-310 and NWS 10-303[18] policy.

[14] http://www.nws.noaa.gov/directives/sym/pd01003010curr.pdf
[15] A "headline" is a statement (usually a few words to a sentence in length) inserted at the top of the NWS weather forecaster product to alert a user of a certain hazard.
[16] Each NWS period is a 12-hour timeframe from when the weather forecast is issued. For example, period 2 would be the 12 to 24-hour timeframe from the current forecast hour. Period 3 would be the 24 to 36-hour timeframe from the current forecast hour, etc…
[17] Part of the process in which NWS forecasters make the official weather products.
[18] http://www.nws.noaa.gov/directives/sym/pd01003003curr.pdf

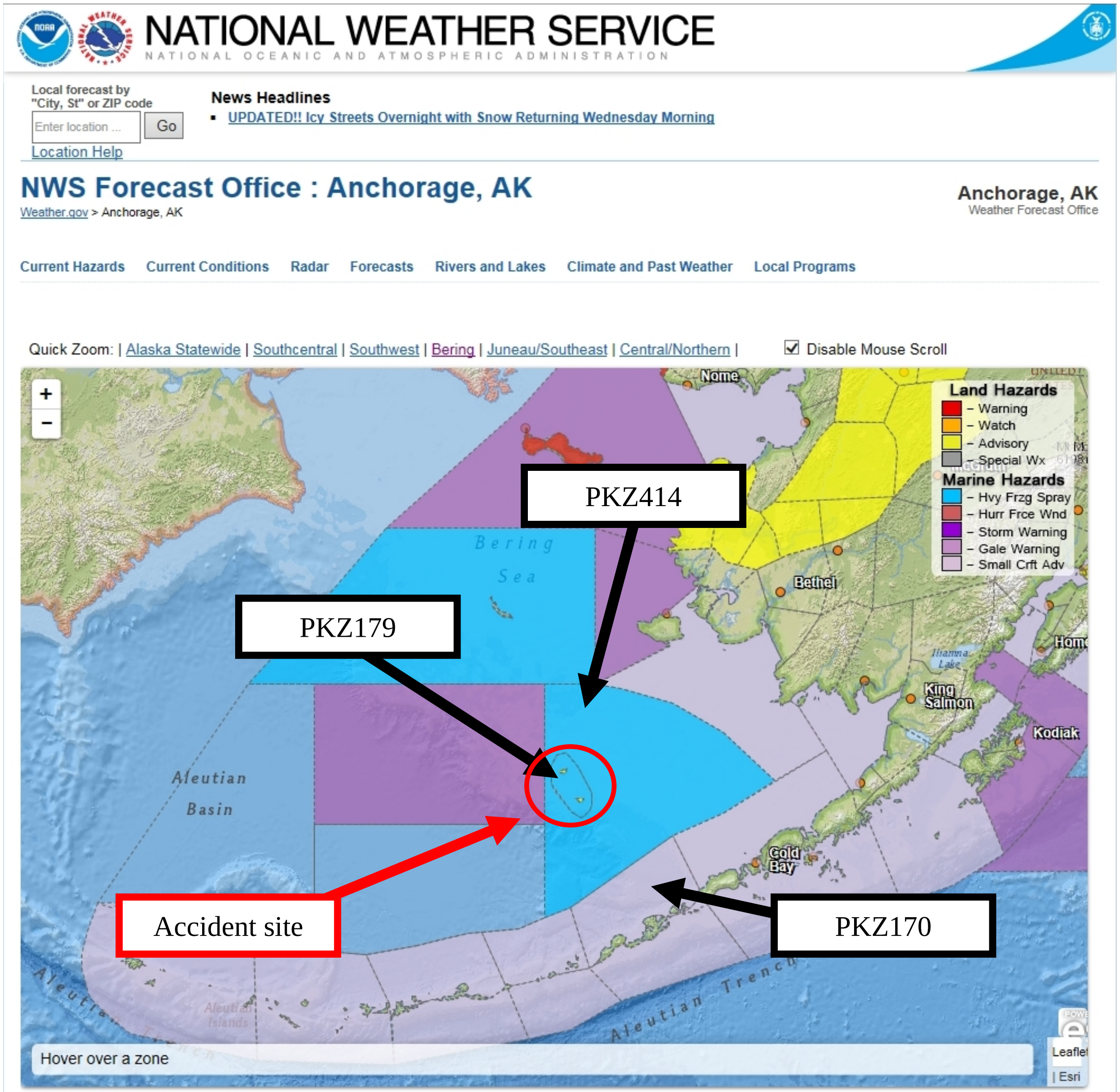

Figure 12 – Exemplar map NWS Anchorage forecast areas

PKZ170-101300-
CAPE SARICHEF TO NIKOLSKI BERING SIDE-
315 PM AKST THU FEB 9 2017

...GALE WARNING FRIDAY AND FRIDAY NIGHT...
...HEAVY FREEZING SPRAY WARNING FRIDAY NIGHT...

.TONIGHT...NE WIND 20 KT INCREASING TO 30 KT AFTER MIDNIGHT.
SEAS 7 FT. FREEZING SPRAY.
.FRI...NE WIND 35 KT. SEAS 12 FT. FREEZING SPRAY.
.FRI NIGHT...NE WIND 35 KT. SEAS 13 FT. HEAVY FREEZING SPRAY E OF
UNALASKA.
.SAT...NE WIND 30 KT. SEAS 12 FT.

.SAT NIGHT...NE WIND 25 KT. SEAS 9 FT.
.SUN THROUGH MON...N WIND 30 KT. SEAS 12 FT.
.TUE...N WIND 25 KT. SEAS 10 FT.

$$

PKZ414-101400-
BERING SEA OFFSHORE EAST OF 171W-
315 PM AKST THU FEB 9 2017

...HEAVY FREEZING SPRAY WARNING THROUGH FRIDAY NIGHT...

.TONIGHT...NE WIND 15 TO 25 KT. SEAS 7 FT. HEAVY FREEZING SPRAY.
.FRI...NE WIND 30 KT. SEAS 7 TO 10 FT. HEAVY FREEZING SPRAY.
.FRI NIGHT...NE WIND 20 TO 30 KT. SEAS 7 TO 12 FT. HEAVY FREEZING SPRAY.
.SAT...NE WIND 15 TO 25 KT. SEAS 5 TO 10 FT.
.SAT NIGHT...NE WIND 15 TO 25 KT. SEAS 3 TO 8 FT.
.SUN THROUGH TUE...N WIND 15 TO 30 KT. SEAS 6 TO 11 FT.

$$

PKZ179-101300-
PRIBILOF ISLANDS NEAR SHORE WATERS-
315 PM AKST THU FEB 9 2017

...HEAVY FREEZING SPRAY WARNING THROUGH FRIDAY NIGHT...
...SMALL CRAFT ADVISORY THROUGH FRIDAY NIGHT...

.TONIGHT...NE WIND 15 KT INCREASING TO 25 KT AFTER MIDNIGHT. SEAS 7 FT. HEAVY FREEZING SPRAY.
.FRI...NE WIND 30 KT. SEAS 9 FT. HEAVY FREEZING SPRAY.
.FRI NIGHT...NE WIND 30 KT. SEAS 9 FT. HEAVY FREEZING SPRAY.
.SAT...NE WIND 25 KT. SEAS 9 FT.
.SAT NIGHT...NE WIND 20 KT. SEAS 6 FT.
.SUN THROUGH TUE...N WIND 25 KT. SEAS 10 FT.

$$

PKZ179-120145-
PRIBILOF ISLANDS NEAR SHORE WATERS-
353 AM AKST SAT FEB 11 2017

...SMALL CRAFT ADVISORY TODAY...

.TODAY...NE WIND 25 KT. SEAS 8 FT. FREEZING SPRAY.
.TONIGHT...NE WIND 20 KT. SEAS 6 FT. FREEZING SPRAY.
.SUN...NE WIND 20 KT. SEAS 4 FT. FREEZING SPRAY.
.SUN NIGHT...NE WIND 25 KT. SEAS 8 FT.
.MON...N WIND 35 KT. SEAS 11 FT.
.TUE...N WIND 40 KT. SEAS 13 FT.
.WED...N WIND 35 KT. SEAS 14 FT.

$$

PKZ414-120145-

BERING SEA OFFSHORE EAST OF 171W-
345 AM AKST SAT FEB 11 2017

...HEAVY FREEZING SPRAY WARNING THROUGH SUNDAY...

.TODAY...NE WIND 15 TO 25 KT. SEAS 5 TO 10 FT. HEAVY FREEZING SPRAY N OF 55N.
.TONIGHT...NE WIND 10 TO 20 KT. SEAS 3 TO 8 FT. HEAVY FREEZING SPRAY N OF 55N.
.SUN...NE WIND 10 TO 25 KT. SEAS 3 TO 7 FT. HEAVY FREEZING SPRAY N OF 55N.
.SUN NIGHT...N WIND 15 TO 30 KT. SEAS 5 TO 10 FT.
.MON THROUGH WED...N WIND 30 TO 45 KT. SEAS 9 TO 14 FT.

$$

PKZ170-120145-
CAPE SARICHEF TO NIKOLSKI BERING SIDE-
353 AM AKST SAT FEB 11 2017

...HEAVY FREEZING SPRAY WARNING TODAY...
...SMALL CRAFT ADVISORY THROUGH SUNDAY...

.TODAY...NE WIND 30 KT. SEAS 13 FT. HEAVY FREEZING SPRAY IN THE MORNING FROM UNALASKA E.
.TONIGHT...NE WIND 25 KT. SEAS 9 FT. FREEZING SPRAY.
.SUN...NE WIND 30 KT. SEAS 9 FT. FREEZING SPRAY.
.SUN NIGHT...N WIND 30 KT. SEAS 11 FT.
.MON...N WIND 30 KT. SEAS 11 FT.
.TUE...N WIND 40 KT. SEAS 13 FT.
.WED...N WIND 30 KT. SEAS 14 FT.

$$

7.0 NWS Zone Forecast Product

The NWS Office in Anchorage, Alaska, issued the following official zone forecast products (ZFP), which included St. Paul and St. George Islands. The latest ZFP valid at the accident time was issued at 0356 AKST and it warned of heavy freezing spray with mostly cloudy skies and scattered snow showers. High air temperatures were forecast to be in the lower 20°s Fahrenheit (F) with a northeast wind of 20 to 30 miles-per-hour (mph). The ZFP issued before the accident vessel departed Dutch Harbor, Alaska, was issued at 1539 AKST on February 9 and it forecast mostly cloudy to partly cloudy skies through February 12 with a chance of snow showers, temperatures in the mid-20°s F to mid-10°s F, and a northeast wind between 15 to 35 mph. The 1013 AKST ZFP from February 9 did have a warning for heavy freezing spray conditions through February 10 for the St. Paul and St. George Islands, but that headline was not in the 1539 AKST February 9 ZFP. In the ZFPs issued between February 9 and the accident time there were 6 ZFPs with the heavy freezing spray warning headline and 4 ZFPs with no headline warning of heavy freezing spray (attachment 10). According the NWS, "The reason the headline appeared then was gone then reappeared is due to the text formatters performing incorrectly. The heavy freezing spray warning is not supposed to be in a public zone forecast, it's only in the marine forecast. When the forecaster on duty caught the mistake, it was corrected by removing it. Subsequent running of the formatter repeated the mistake and that forecaster on duty at that time sent it out without realizing this mistake. We have since fixed our formatter to not put the marine headlines in the public products." (attachment 11):

AKZ195-120145-
PRIBILOF ISLANDS-
INCLUDING THE CITY OF...SAINT PAUL
356 AM AKST SAT FEB 11 2017

...HEAVY FREEZING SPRAY WARNING IN EFFECT UNTIL NOON AKST TODAY...
...HEAVY FREEZING SPRAY WARNING IN EFFECT FROM 6 PM TO 9 PM AKST THIS EVENING...

.TODAY...MOSTLY CLOUDY WITH SCATTERED SNOW SHOWERS. HIGHS IN THE LOWER 20S. NORTHEAST WIND 20 TO 30 MPH.
.TONIGHT...MOSTLY CLOUDY WITH SCATTERED SNOW SHOWERS. LOWS AROUND 15. NORTHEAST WIND 10 TO 20 MPH.
.SUNDAY...MOSTLY CLOUDY WITH SCATTERED SNOW SHOWERS. HIGHS IN THE LOWER 20S. NORTHEAST WIND 10 TO 20 MPH.
.SUNDAY NIGHT...MOSTLY CLOUDY WITH SCATTERED SNOW SHOWERS. LOWS AROUND 20. NORTHEAST WIND 15 TO 30 MPH.
.MONDAY...PARTLY SUNNY WITH SCATTERED SNOW SHOWERS. HIGHS AROUND 20. NORTH WIND 20 TO 30 MPH.
.MONDAY NIGHT...MOSTLY CLOUDY WITH SCATTERED SNOW SHOWERS. LOWS AROUND 20.
.TUESDAY AND TUESDAY NIGHT...CLOUDY WITH A CHANCE OF SNOW SHOWERS. VERY WINDY. HIGHS IN THE MID 20S. LOWS AROUND 20.
.WEDNESDAY THROUGH FRIDAY...CLOUDY WITH A CHANCE OF SNOW SHOWERS. VERY WINDY. HIGHS IN THE MID 20S. LOWS 20 TO 25.

&&
TEMPERATURE / PRECIPITATION

SAINT PAUL 19 15 22 / 30 30 30

$$

AKZ195-101330-
PRIBILOF ISLANDS-
INCLUDING THE CITY OF...SAINT PAUL
339 PM AKST THU FEB 9 2017

.TONIGHT...MOSTLY CLOUDY WITH A CHANCE OF SNOW SHOWERS. LOWS AROUND 20. NORTHEAST WIND 20 TO 30 MPH.
.FRIDAY...PARTLY SUNNY WITH A CHANCE OF SNOW SHOWERS. HIGHS AROUND 20. NORTHEAST WIND 20 TO 35 MPH.
.FRIDAY NIGHT...PARTLY CLOUDY WITH A CHANCE OF SNOW SHOWERS. LOWS AROUND 15. NORTHEAST WIND 25 TO 35 MPH.
.SATURDAY...PARTLY CLOUDY WITH A CHANCE OF SNOW SHOWERS. HIGHS AROUND 20. NORTHEAST WIND 20 TO 30 MPH.
.SATURDAY NIGHT...MOSTLY CLOUDY WITH ISOLATED SNOW SHOWERS. LOWS 15 TO 20. NORTHEAST WIND 15 TO 25 MPH.
.SUNDAY...MOSTLY CLOUDY WITH SCATTERED SNOW SHOWERS. HIGHS 20 TO 25.
.SUNDAY NIGHT THROUGH WEDNESDAY NIGHT...MOSTLY CLOUDY WITH A CHANCE OF SNOW SHOWERS. LOWS AROUND 20. HIGHS 20 TO 25.
.THURSDAY...MOSTLY CLOUDY WITH A CHANCE OF SNOW. HIGHS IN THE MID 20S.

&&

	TEMPERATURE				/	PRECIPITATION			
SAINT PAUL	17	18	14	20	/	50	40	40	30

$$

AKZ195-100115-
PRIBILOF ISLANDS-
INCLUDING THE CITY OF...SAINT PAUL
1013 AM AKST THU FEB 9 2017

...HEAVY FREEZING SPRAY WARNING IN EFFECT FROM 6 PM THIS EVENING TO 6 PM AKST FRIDAY...

.TODAY...PARTLY SUNNY. FLURRIES IN THE MORNING...THEN A CHANCE OF SNOW SHOWERS IN THE AFTERNOON. HIGHS IN THE MID 20S. NORTHEAST WIND 15 TO 20 MPH.
.TONIGHT...PARTLY CLOUDY WITH A SLIGHT CHANCE OF SNOW SHOWERS. LOWS AROUND 20. NORTHEAST WIND 20 TO 30 MPH.
.FRIDAY...PARTLY CLOUDY WITH A SLIGHT CHANCE OF SNOW SHOWERS. HIGHS AROUND 20. NORTHEAST WIND 20 TO 35 MPH.
.FRIDAY NIGHT...PARTLY CLOUDY WITH A SLIGHT CHANCE OF SNOW SHOWERS. LOWS AROUND 15. NORTHEAST WIND 25 TO 35 MPH.
.SATURDAY...PARTLY CLOUDY WITH A SLIGHT CHANCE OF SNOW SHOWERS. HIGHS IN THE LOWER 20S. NORTHEAST WIND 20 TO 30 MPH.
.SATURDAY NIGHT...MOSTLY CLOUDY WITH A SLIGHT CHANCE OF SNOW SHOWERS. LOWS 15 TO 20.
.SUNDAY THROUGH WEDNESDAY...MOSTLY CLOUDY WITH A CHANCE OF SNOW

SHOWERS. HIGHS 20 TO 25. LOWS 15 TO 20.

&&

	TEMPERATURE			/	PRECIPITATION		
SAINT PAUL	23	17	18	/	40	20	20

$$

8.0 Weather Briefing Information[19]

It is unknown what, if any, weather information was received or reviewed by the captain or crew before they departed Dutch Harbor, Alaska, on February 9.

9.0 Marine Information

UNLA2 reported the mean lower water (MLLW)[20] at 2.9 feet at 1800 AKST on February 9, when the accident vessel departed Dutch Harbor, Alaska (figure 13). VCVA2 reported the MLLW at 3.038 feet at 0610 AKST on February 11 (figure 14). Surface sea current data was retrieved from the Hybrid Coordinate Ocean Model (HYCOM) Global Navy weather model for 0600 AKST on February 11 for around the accident area (figure 15). The HYCOM surface sea current data indicated that at 0600 AKST the surface sea current was from 183° at 0.67 knots at the accident vessel location. At 0610 AKST the surface sea current was from 168° at 0.78 knots at the accident site.

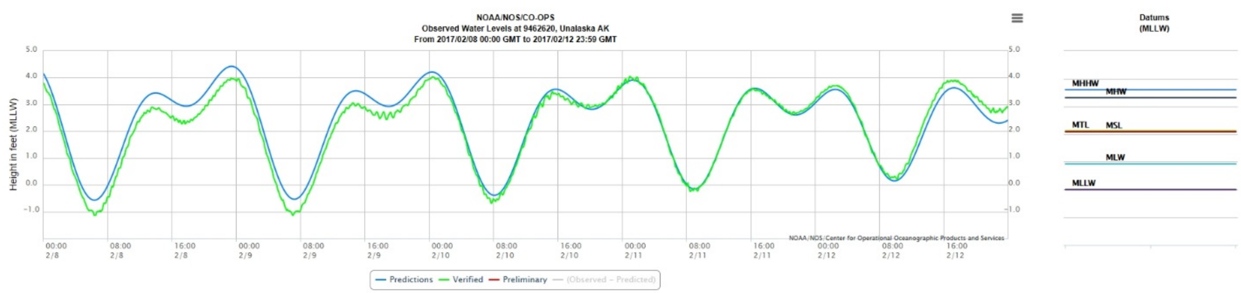

Figure 13 –Observed Water Levels from UNLA2 from departure from Dutch Harbor, Alaska, to around accident time

[19] For more information please see the USCG MBI transcripts.

[20] Mean lower low water (MLLW) - Tidal datum that is the arithmetic mean of the lower low water heights of each tidal day observed over a specific 19-year Metonic cycle (the National Tidal Datum Epoch). For stations with shorter series, simultaneous observational comparisons are made with a control tide station to derive the equivalent of the National Tidal Datum Epoch. MLLW has been designated for use in lieu of MLW as the adopted reference NOS chart and sounding datum in most coastal tidal waters per the National Tidal Datum Convention of 1980.

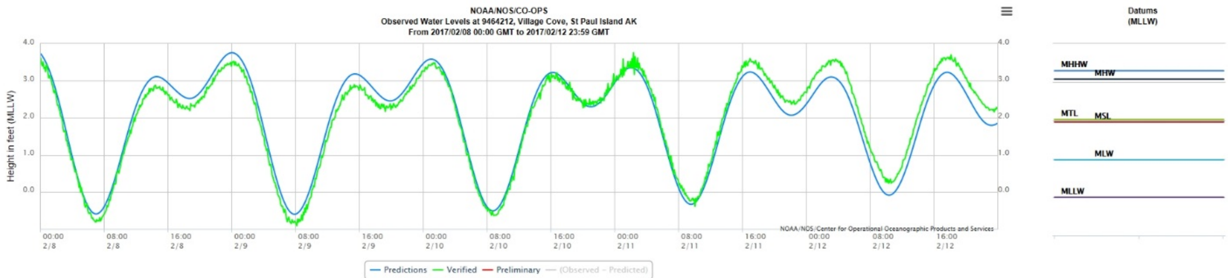

Figure 14 –Observed Water Levels from VCVA2 from departure from Dutch Harbor, Alaska, to around accident time

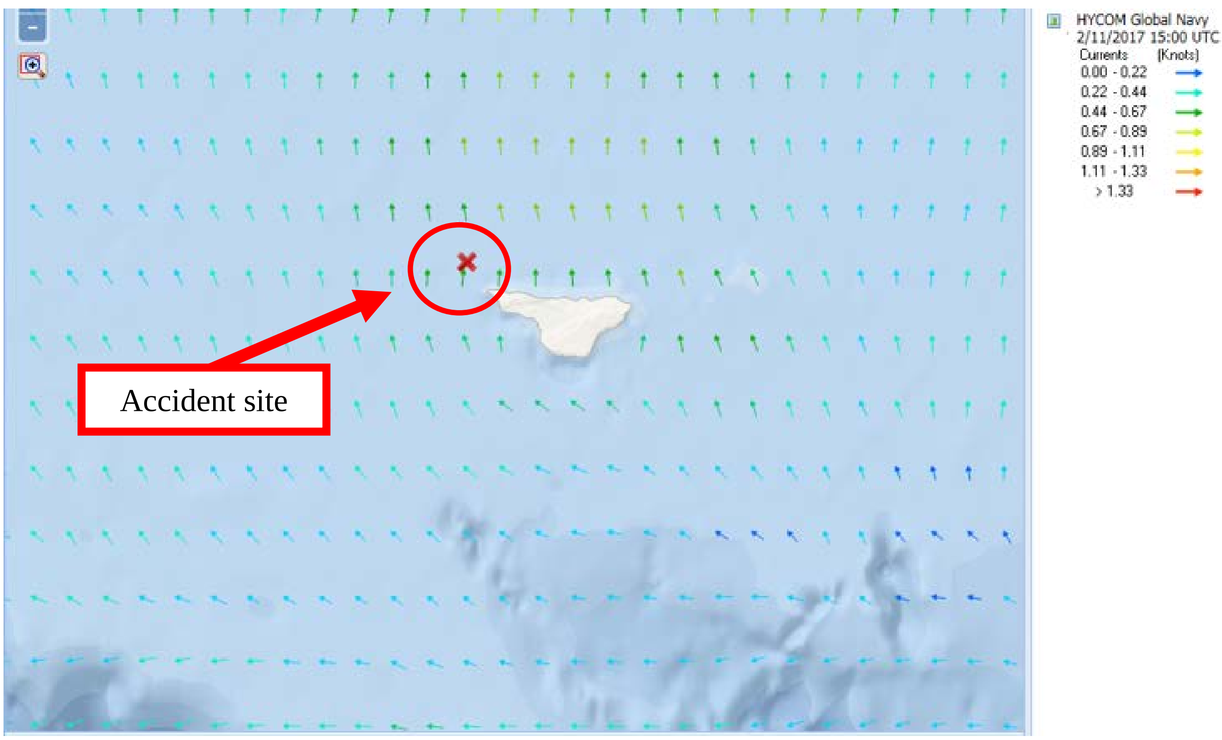

Figure 15 –HYCOM Global Navy weather model surface sea current data valid at 0600 AKST

10.0 Sea Spray Icing information

Sea spray icing has long been a serious hazard to marine vessels. To estimate the amount of sea spray ice accretion Overland (1990)[21] (attachment 12) developed an algorithm that is currently being used by NWS Alaska to forecast situations of freezing spray and heavy freezing spray.[22] Additional algorithms to determine sea spray ice accretion on marine vessels developed in the scientific community and summaries of these algorithms can be found in attachments 13 and 14. The sea spray ice accretion charts on vessels that are between 20 and 70 meters in length (which included the accident vessel) are included in figures 16 through 20 for sea surface water temperatures of -1° C, -0.5° C, 0.0° C, 0.5° C, and 3.5° C. Additional charts can be found at: http://www.vos.noaa.gov/MWL/dec_05/ves.shtml.

Using the Overland (1990) method with the information from VCVA2 (attachment 3) and UNLA2 (attachment 5), sea spray ice accretion rates were able to be predicted from before the accident vessel left Dutch Harbor, Alaska, through the accident time. With a water temperature above 3.5° C from UNLA2, no ice accretion potential was indicated using the Overland (1990) method for when the accident vessel departed Dutch Harbor, Alaska (figure 21, attachment 16). Light ice accretion potential was first indicated from the UNLA2 data by 0400 AKST on February 10 (figure 22, attachment 16), with light ice accretion potential through the accident time from the UNLA2 data. Heavy ice accretion potential was indicated from the VCVA2 data by 1500 AKST on February 10 (figure 23, attachment 15), when the accident vessel was half way between Dutch Harbor, Alaska, and the accident location. Moderate to heavy ice accretion potential was indicated from the VCVA2 data between 0300 and 0600 AKST on February 11 (figure 24, attachment 15), and that moderate to heavy ice accretion continued through the accident time. Attachments 15 and 16 contain all the VCVA2 and UNLA2 Overland (1990) algorithm calculations. At times atmospheric data is missing from VCVA2 and UNLA2. When this occurs the Overland (1990) algorithm cannot be solved and the Excel data indicates: “#VALUE!” (attachments 15 and 16). When this Excel data error occurred, those data and times were treated as missing.

NWS Alaska provided the daily sea surface analysis graphics from February 9, 10, and 11 in figures 25 through 27. The daily sea surface analysis graphics indicated that colder sea surface temperatures moved from northeast to southwest in the Bering Sea across the accident site between February 9 and February 11, with the Bering Sea sea-ice coverage increasing to the south. The daily sea ice concentration analysis graphics from February 9 through February 11 also indicated that the sea ice concentration in the Bering Sea increased towards the south between February 9 and February 11 (figures 28 through 30). The Bering Sea sea-ice was not over the accident site at the accident time.

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[21] Overland, J.E., Prediction of Vessel Icing for Near-Freezing Sea Temperatures (Weather and Forecasting, 1990), pp. 62-77.

[22] For more information on NWS Alaska sea spray icing forecast please see: http://www.vos.noaa.gov/MWL/dec_05/ves.shtml

In addition, to the information above, Memorial University (MU) ran simulations on the icing conditions that the accident vessel encountered. The MU icing simulations consider many more variables than the Overland algorithm calculations do. The MU icing simulations used data from the HYCOM Global Navy weather model, the accident vessel's automatic identification system (AIS) track, and from a NTSB Weather Research and Forecasting (WRF) model run. Information provided to MU from the HYCOM model, the accident vessel's AIS and the NTSB WRF model are provided in attachment 19. The initial results from MU are provided in attachment 20. The MU icing simulations indicated that if the accident vessel was at full load then between 92.4 and 154.0 tons of ice would have accumulated and been distributed across the entire vessel's surface by the accident time. Similarly, if the accident vessel was at low load then between 46.2 and 77.0 tons of ice would have accumulated and been distributed across the entire vessel's surface by the accident time. For reference each crab pot on board the accident vessel weighed approximately 0.42 tons (840 pounds, crab pot and gear inside the crab pot). For more information please see attachments 19 and 20.

On March 29, 2018, Memorial University provided their final document entitled: "Numerical Prediction of Accumulated Ice Loads on the Fishing Vessel *F.V. Destination* Lost in the Bering Sea", which documented the icing loads and stability on the *F.V. Destination* from February 9, 2017, through the accident time (attachment 21).

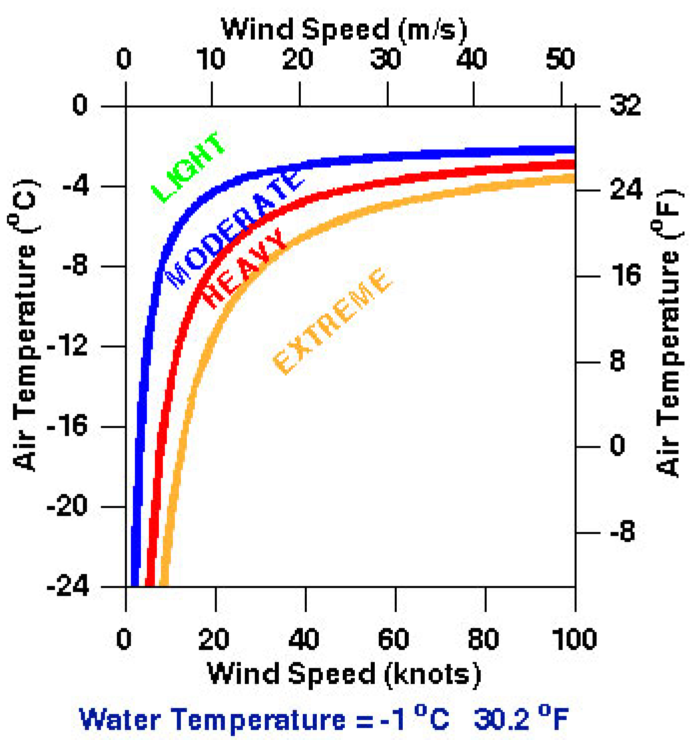

Figure 16 – Overland (1990) sea spray ice accretion potential for water temperature of -1° C

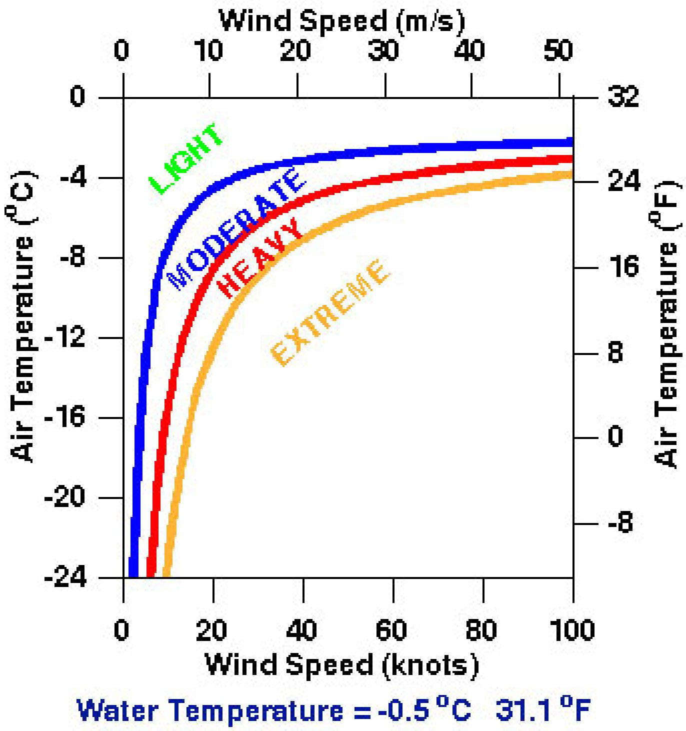

Figure 17 – Overland (1990) sea spray ice accretion potential for water temperature of -0.5° C

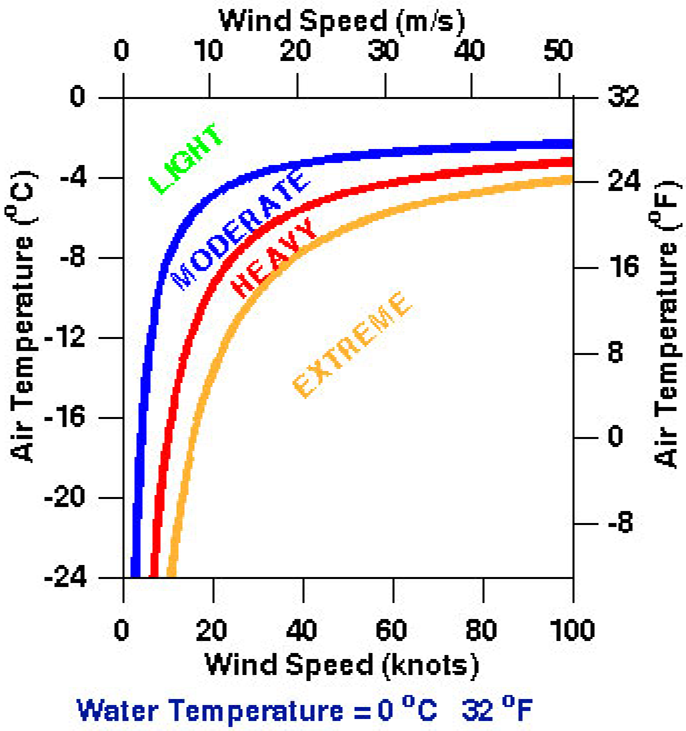

Figure 18 – Overland (1990) sea spray ice accretion potential for water temperature of 0.0° C

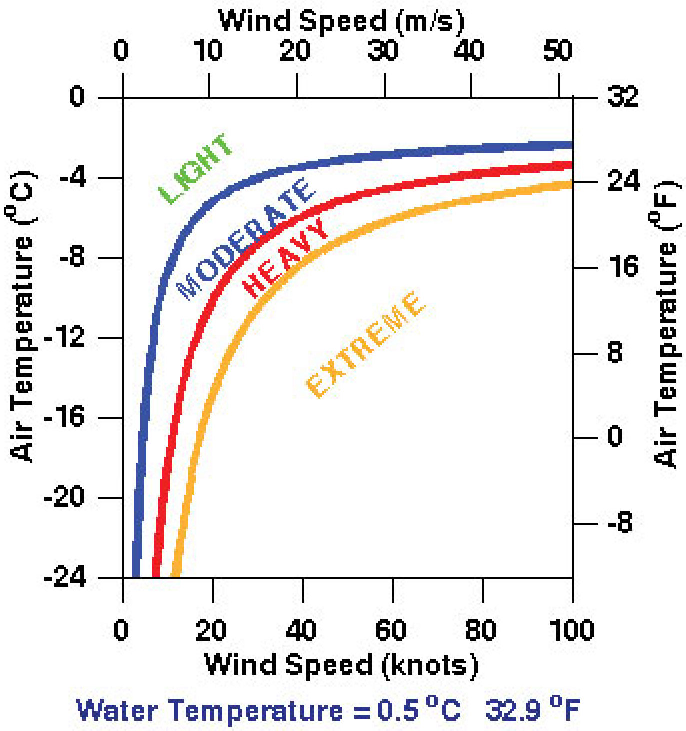

Figure 19 – Overland (1990) sea spray ice accretion potential for water temperature of 0.5° C

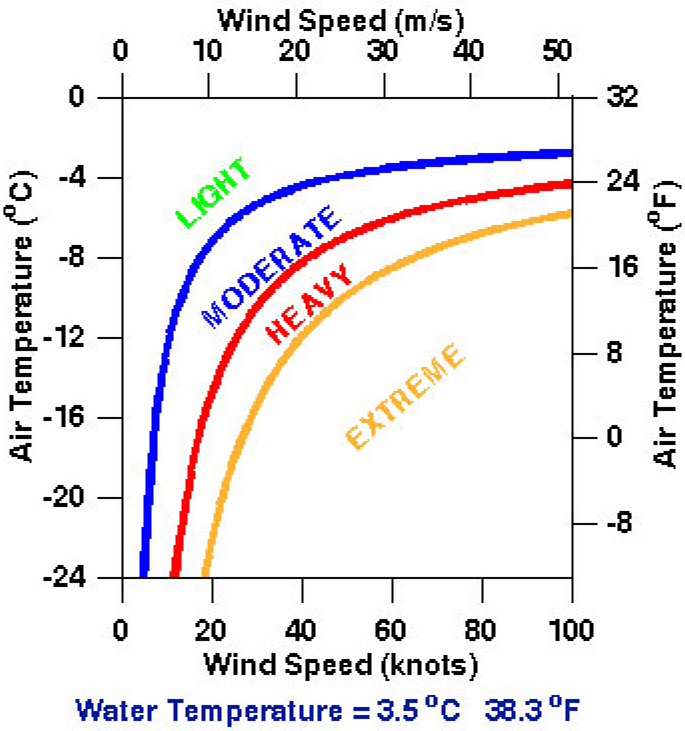

Figure 20 – Overland (1990) sea spray ice accretion potential for water temperature of 3.5° C

year	month	day	hour	minute	wind direction	wind speed m/s	wind gusts m/s	pressure hPa	air temp C	water temp C	PPR speed	PPR gusts	Icing Y or N speed	Icing Y or N gusts	Category of icing based on Table 2 speed	Category of icing based on Table 2 gusts
2017	2	10	5	6	20	3.6	6.7	1006.3	-1.6	4	-0.19817	-0.36881	N	N	None	None
2017	2	10	5	0	30	4.6	6.7	1006.3	-1.6	4	-0.25321	-0.36881	N	N	None	None
2017	2	10	4	54	30	3.6	5.7	1006.4	-1.6	4	-0.19817	-0.31376	N	N	None	None
2017	2	10	4	48	30	4.1	7.2	1006.5	-1.6	4	-0.22569	-0.39633	N	N	None	None
2017	2	10	4	42	40	3.6	5.7	1006.5	-1.6	4	-0.19817	-0.31376	N	N	None	None
2017	2	10	4	36	20	4.6	5.7	1006.7	-1.6	4	-0.25321	-0.31376	N	N	None	None
2017	2	10	4	30	20	2.1	5.1	1006.7	-1.5	3.9	-0.19481	-0.4731	N	N	None	None
2017	2	10	4	24	30	2.6	6.7	1006.7	-1.6	3.9	-0.14471	-0.37291	N	N	None	None
2017	2	10	4	18	20	3.1	5.7	1006.8	-1.6	3.9	-0.17254	-0.31725	N	N	None	None
2017	2	10	4	12	30	3.6	5.7	1006.8	-1.7	3.9	-0.06679	-0.10575	N	N	None	None
2017	2	10	4	6	30	3.1	6.2	1006.8	-1.6	4	-0.17064	-0.34128	N	N	None	None
2017	2	10	4	0	20	4.1	5.1	1007	-1.7	4	-0.07523	-0.09358	N	N	None	None
2017	2	10	3	54	30	4.1	5.7	1007	-1.6	4	-0.22569	-0.31376	N	N	None	None
2017	2	10	3	48	30	3.6	6.2	1007	-1.6	4	-0.19817	-0.34128	N	N	None	None
2017	2	10	3	42	30	3.6	5.1	1007.1	-1.6	4	-0.19817	-0.28073	N	N	None	None
2017	2	10	3	36	20	2.1	5.1	1007.2	-1.4	3.9	-0.27273	-0.66234	N	N	None	None
2017	2	10	3	30	40	3.6	6.2	1007.2	MM	3.9	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2017	2	10	3	24	40	3.1	6.2	1007.3	MM	3.9	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2017	2	10	3	18	50	4.1	6.7	1007.3	-1.4	3.9	-0.53247	-0.87013	N	N	None	None
2017	2	10	3	12	20	4.1	6.2	1007.4	-1.5	3.9	-0.38033	-0.57514	N	N	None	None
2017	2	10	3	6	30	3.6	4.6	1007.4	-1.3	4	-0.5945	-0.75963	N	N	None	None
2017	2	10	3	0	MM	MM	MM	MM	MM	3.9	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2017	2	10	2	54	MM	MM	MM	MM	MM	3.9	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2017	2	10	2	48	MM	MM	MM	1007.6	-1.4	3.9	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2017	2	10	2	42	MM	MM	MM	1007.6	-1.4	3.9	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2017	2	10	2	36	MM	MM	MM	1007.7	-1.4	3.9	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2017	2	10	2	30	20	4.6	5.7	1007.8	MM	4	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!

Table 2
Icing Class and Rate

PPR	<0	0-22.4	22.4-53.3	53.3-83.0	>83.0
Icing Class	None	Light	Moderate	Heavy	Extreme
Icing Rates (cm/hour)	0	<0.7	0.7-2.0	2.0-4.0	>4.0
(inches/hour)		<0.3	0.3-0.8	0.8-1.6	>1.6

Figure 21 – Overland (1990) sea spray ice accretion potential using data from UNLA2 for departure time from Dutch Harbor, Alaska

year	month	day	hour	minute	wind direction	wind speed m/s	wind gusts m/s	pressure hPa	air temp C	water temp C	PPR speed	PPR gusts	Icing Y or N speed	Icing Y or N gusts	Category of icing based on Table 2 speed	Category of icing based on Table 2 gusts
2017	2	10	16	0	50	6.2	9.3	999.5	-2.7	4.2	2.114901	3.172352	Y	Y	Light	Light
2017	2	10	15	54	30	6.7	8.8	999.5	-2.6	4.2	2.044883	2.685817	Y	Y	Light	Light
2017	2	10	15	48	40	5.7	8.8	999.5	-2.6	4.3	1.721137	2.657194	Y	Y	Light	Light
2017	2	10	15	42	50	5.1	7.2	999.6	MM	4.2	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2017	2	10	15	36	40	6.2	9.3	999.7	MM	4.2	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2017	2	10	15	24	40	6.7	8.8	999.8	MM	4.2	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2017	2	10	15	18	40	3.6	8.8	999.8	-2.4	4.2	0.840215	2.05386	Y	Y	Light	Light
2017	2	10	15	12	40	5.7	9.3	1000	-2.5	4.3	1.51865	2.477798	Y	Y	Light	Light
2017	2	10	15	6	30	5.1	9.3	1000.1	-2.6	4.3	1.539964	2.808171	Y	Y	Light	Light
2017	2	10	15	0	30	6.7	9.3	1000.2	-2.7	4.2	2.285458	3.172352	Y	Y	Light	Light
2017	2	10	14	54	30	5.7	9.8	1000.2	-2.6	4.3	1.721137	2.959147	Y	Y	Light	Light
2017	2	10	14	48	50	6.7	8.8	1000.3	-2.5	4.3	1.78508	2.344583	Y	Y	Light	Light
2017	2	10	14	42	30	5.1	8.2	1000.3	-2.4	4.2	1.190305	1.913824	Y	Y	Light	Light
2017	2	10	14	36	50	5.7	9.8	1000.4	-2.4	4.2	1.330341	2.287253	Y	Y	Light	Light
2017	2	10	14	30	40	5.1	9.8	1000.5	-2.3	4.2	1.007181	1.935368	Y	Y	Light	Light
2017	2	10	14	24	50	4.6	9.8	1000.4	-2.2	4.3	0.735346	1.566607	Y	Y	Light	Light
2017	2	10	14	18	40	6.2	8.2	1000.5	-2.2	4.3	0.991119	1.310835	Y	Y	Light	Light
2017	2	10	14	12	40	5.7	7.7	1000.5	-2.1	4.3	0.708703	0.957371	Y	Y	Light	Light
2017	2	10	14	6	40	5.7	9.3	1000.6	-2	4.3	0.506217	0.825933	Y	Y	Light	Light
2017	2	10	14	0	50	6.7	8.8	1000.6	-1.8	4.3	0.119005	0.156306	Y	Y	Light	Light
2017	2	10	13	54	40	5.1	7.2	1000.7	-1.7	4.2	-0.09156	-0.12926	N	N	None	None
2017	2	10	13	48	60	5.7	8.2	1000.8	-1.7	4.2	-0.10233	-0.14722	N	N	None	None
2017	2	10	13	42	50	4.6	6.2	1000.9	-1.7	4.3	-0.08171	-0.11012	N	N	None	None
2017	2	10	13	36	50	4.1	6.2	1001	-1.6	4.3	-0.21847	-0.33037	N	N	None	None
2017	2	10	13	30	60	4.1	7.2	1001	-1.6	4.3	-0.21847	-0.38366	N	N	None	None
2017	2	10	13	24	30	4.1	5.7	1001.1	-1.6	4.3	-0.21847	-0.30373	N	N	None	None
2017	2	10	13	18	10	3.6	6.7	1001.2	-1.6	4.3	-0.19183	-0.35702	N	N	None	None
2017	2	10	13	12	30	4.6	6.7	1001.3	-1.8	4.3	0.081705	0.119005	Y	Y	Light	Light
2017	2	10	13	6	30	5.1	9.3	1001.4	-1.7	4.2	-0.09156	-0.16697	N	N	None	None
2017	2	10	13	0	30	5.1	7.7	1001.5	-1.8	4.3	0.090586	0.136767	Y	Y	Light	Light

Table 2
Icing Class and Rate

PPR	<0	0-22.4	22.4-53.3	53.3-83.0	>83.0
Icing Class	None	Light	Moderate	Heavy	Extreme
Icing Rates (cm/hour)	0	<0.7	0.7-2.0	2.0-4.0	>4.0
(inches/hour)		<0.3	0.3-0.8	0.8-1.6	>1.6

Figure 22 – Overland (1990) sea spray ice accretion potential using data from UNLA2 for between 0400 and 0700 AKST on February 10

year	month	day	hour	minute	wind direction	wind speed m/s	wind gusts m/s	pressure hPa	air temp C	water temp C	PPR speed	PPR gusts	Icing Y or N speed	Icing Y or N gusts	Category of icing based on Table 2 speed	Category of icing based on Table 2 gusts
2017	2	11	3	6	50	11.3	13.9	1007.8	-9.2	-0.3	58.66551	72.16376	Y	Y	Heavy	Heavy
2017	2	11	3	0	40	11.8	13.9	1007.8	-9.4	-0.3	62.90592	74.10105	Y	Y	Heavy	Heavy
2017	2	11	2	54	50	11.3	12.9	1007.8	-9.3	-0.3	59.45296	67.87108	Y	Y	Heavy	Heavy
2017	2	11	2	48	50	10.8	13.4	1007.8	-9.3	-0.3	56.8223	70.50174	Y	Y	Heavy	Heavy
2017	2	11	2	42	40	10.8	14.4	1007.8	-9.3	-0.4	58.03559	77.38078	Y	Y	Heavy	Heavy
2017	2	11	2	36	40	11.3	13.9	1007.8	-9	-0.4	58.30961	71.72598	Y	Y	Heavy	Heavy
2017	2	11	2	30	40	11.3	14.4	1007.7	-9.1	-0.4	59.11388	75.33096	Y	Y	Heavy	Heavy
2017	2	11	2	24	40	10.3	13.9	1007.7	-9	-0.4	53.14947	71.72598	Y	Y	Moderate	Heavy
2017	2	11	2	18	40	10.8	13.9	1007.6	-9	-0.3	54.56446	70.22648	Y	Y	Heavy	Heavy
2017	2	11	2	12	50	11.3	13.4	1007.6	-9	-0.4	58.30961	69.14591	Y	Y	Heavy	Heavy
2017	2	11	2	6	50	10.8	13.9	1007.6	-8.9	-0.4	54.96085	70.73665	Y	Y	Heavy	Heavy
2017	2	11	2	0	50	9.8	12.9	1007.7	-8.9	-0.4	49.87189	65.64769	Y	Y	Moderate	Heavy
2017	2	11	1	54	40	11.8	13.4	1007.8	-8.9	-0.4	60.04982	68.19217	Y	Y	Heavy	Heavy
2017	2	11	1	48	50	9.8	12.4	1007.8	-8.9	-0.3	48.82927	61.78397	Y	Y	Moderate	Heavy
2017	2	11	1	42	50	10.3	13.4	1007.8	-9	-0.3	52.03833	67.70035	Y	Y	Moderate	Heavy
2017	2	11	1	36	50	11.8	13.9	1007.9	-9.2	-0.3	61.26132	72.16376	Y	Y	Heavy	Heavy
2017	2	11	1	30	40	9.8	13.4	1008	-9.1	-0.3	50.19512	68.63415	Y	Y	Moderate	Heavy
2017	2	11	1	24	40	10.8	12.9	1008.1	-9.3	-0.3	56.8223	67.87108	Y	Y	Heavy	Heavy
2017	2	11	1	18	50	9.8	13.4	1008.2	-9	-0.3	49.5122	67.70035	Y	Y	Moderate	Heavy
2017	2	11	1	12	40	10.8	12.9	1008.2	-9	-0.3	54.56446	65.17422	Y	Y	Heavy	Heavy
2017	2	11	1	6	40	11.3	13.9	1008.3	-9	-0.3	57.09059	70.22648	Y	Y	Heavy	Heavy
2017	2	11	1	0	40	10.3	12.4	1008.3	-9.2	-0.3	53.47387	64.37631	Y	Y	Heavy	Heavy
2017	2	11	0	54	50	9.3	12.9	1008.3	-8.8	-0.3	45.6899	63.37631	Y	Y	Moderate	Heavy
2017	2	11	0	48	50	10.8	13.9	MM	MM	MM	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2017	2	11	0	42	40	10.8	15.4	1008.4	-9.2	-0.3	56.06969	79.95122	Y	Y	Heavy	Heavy
2017	2	11	0	36	40	12.4	14.4	1008.5	-9.5	-0.3	66.96864	77.77003	Y	Y	Heavy	Heavy
2017	2	11	0	30	50	10.8	13.4	1008.5	-9.2	-0.3	56.06969	69.56794	Y	Y	Heavy	Heavy
2017	2	11	0	24	40	10.8	14.4	1008.5	-9.5	-0.3	58.32753	77.77003	Y	Y	Heavy	Heavy
2017	2	11	0	18	50	10.3	14.9	MM	MM	MM	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
2017	2	11	0	12	40	9.8	13.9	1008.7	-9.2	-0.3	50.87805	72.16376	Y	Y	Moderate	Heavy

Table 2
Icing Class and Rate

PPR	<0	0-22.4	22.4-53.3	53.3-83.0	>83.0
Icing Class	None	Light	Moderate	Heavy	Extreme
Icing Rates (cm/hour)	0	<0.7	0.7-2.0	2.0-4.0	>4.0
(inches/hour)		<0.3	0.3-0.8	0.8-1.6	>1.6

Figure 23 – Overland (1990) sea spray ice accretion potential using data from VCVA2 for between 1500 and 1800 AKST on February 10

year	month	day	hour	minute	wind direction	wind speed m/s	wind gusts m/s	pressure hPa	air temp C	water temp C	PPR speed	PPR gusts	Icing Y or N speed	Icing Y or N gusts	Category of icing based on Table 2 speed	Category of icing based on Table 2 gusts
2017	2	11	14	48	40	8.2	10.3	1004.7	-8.5	-0.7	42.09125	52.87072	Y	Y	Moderate	Moderate
2017	2	11	14	42	40	8.2	11.3	1004.8	-8.4	-0.7	41.46768	57.14449	Y	Y	Moderate	Heavy
2017	2	11	14	36	40	6.7	9.8	1004.8	-8.4	-0.7	33.88213	49.55894	Y	Y	Moderate	Moderate
2017	2	11	14	30	40	7.7	10.3	1004.8	-8.4	-0.7	38.93916	52.08745	Y	Y	Moderate	Moderate
2017	2	11	14	24	30	8.2	10.3	1004.9	-8.5	-0.7	42.09125	52.87072	Y	Y	Moderate	Moderate
2017	2	11	14	18	40	7.7	9.3	1004.9	-8.4	-0.7	38.93916	47.03042	Y	Y	Moderate	Moderate
2017	2	11	14	12	40	8.2	9.8	1005	-8.6	-0.7	42.71483	51.04943	Y	Y	Moderate	Moderate
2017	2	11	14	6	40	6.7	9.8	1005.1	-8.7	-0.7	35.41065	51.79468	Y	Y	Moderate	Moderate
2017	2	11	14	0	30	9.3	11.3	1005.2	-8.6	-0.7	48.44487	58.86312	Y	Y	Moderate	Heavy
2017	2	11	13	54	30	8.8	10.8	1005.2	-8.5	-0.7	45.1711	55.43726	Y	Y	Moderate	Heavy
2017	2	11	13	48	40	8.2	9.8	1005.3	-8.6	-0.7	42.71483	51.04943	Y	Y	Moderate	Moderate
2017	2	11	13	42	50	8.2	9.8	1005.4	-8.6	-0.7	42.71483	51.04943	Y	Y	Moderate	Moderate
2017	2	11	13	36	40	8.2	10.8	1005.5	-8.6	-0.7	42.71483	56.25856	Y	Y	Moderate	Heavy
2017	2	11	13	30	40	10.3	12.4	1005.6	-8.8	-0.8	56.50973	68.03113	Y	Y	Heavy	Heavy
2017	2	11	13	24	40	8.8	10.3	1005.6	-8.7	-0.8	47.59533	55.70817	Y	Y	Moderate	Heavy
2017	2	11	13	18	40	9.8	11.8	1005.7	-8.6	-0.8	52.24125	62.90272	Y	Y	Moderate	Heavy
2017	2	11	13	12	40	7.2	9.3	1005.7	-8.7	-0.7	38.05323	49.15209	Y	Y	Moderate	Moderate
2017	2	11	13	6	40	9.3	12.9	1005.7	-8.6	-0.7	48.44487	67.19772	Y	Y	Moderate	Heavy
2017	2	11	13	0	40	8.8	11.3	1005.8	-8.6	-0.7	45.8403	58.86312	Y	Y	Moderate	Heavy
2017	2	11	12	54	40	9.8	12.4	1005.9	-8.5	-0.7	50.30418	63.65019	Y	Y	Moderate	Heavy
2017	2	11	12	48	40	8.8	11.3	1005.9	-8.6	-0.7	45.8403	58.86312	Y	Y	Moderate	Heavy
2017	2	11	12	42	40	7.7	11.8	1005.8	-8.6	-0.7	40.11027	61.46768	Y	Y	Moderate	Heavy
2017	2	11	12	36	50	9.3	11.8	1005.9	-8.6	-0.7	48.44487	61.46768	Y	Y	Moderate	Heavy
2017	2	11	12	30	40	8.8	10.8	1005.9	-8.6	-0.7	45.8403	56.25856	Y	Y	Moderate	Heavy
2017	2	11	12	24	50	8.2	10.3	1005.9	-8.6	-0.7	42.71483	53.65399	Y	Y	Moderate	Heavy
2017	2	11	12	18	40	8.8	12.4	1006	-8.7	-0.7	46.50951	65.53612	Y	Y	Moderate	Heavy
2017	2	11	12	12	40	7.7	11.3	1006	-8.7	-0.7	40.69582	59.72243	Y	Y	Moderate	Heavy
2017	2	11	12	6	50	8.8	12.4	1006.1	-8.7	-0.7	46.50951	65.53612	Y	Y	Moderate	Heavy
2017	2	11	12	0	40	10.3	12.9	1006.1	-8.9	-0.7	56.0038	70.14068	Y	Y	Heavy	Heavy
2017	2	11	11	54	40	9.3	11.8	1006.2	-8.8	-0.6	48.74721	61.8513	Y	Y	Moderate	Heavy

Table 2
Icing Class and Rate

PPR	<0	0-22.4	22.4-53.3	53.3-83.0	>83.0
Icing Class	None	Light	Moderate	Heavy	Extreme
Icing Rates (cm/hour)	0	<0.7	0.7-2.0	2.0-4.0	>4.0
(inches/hour)		<0.3	0.3-0.8	0.8-1.6	>1.6

Figure 24 – Overland (1990) sea spray ice accretion potential using data from VCVA2 for between 0300 and 0600 AKST on February 11

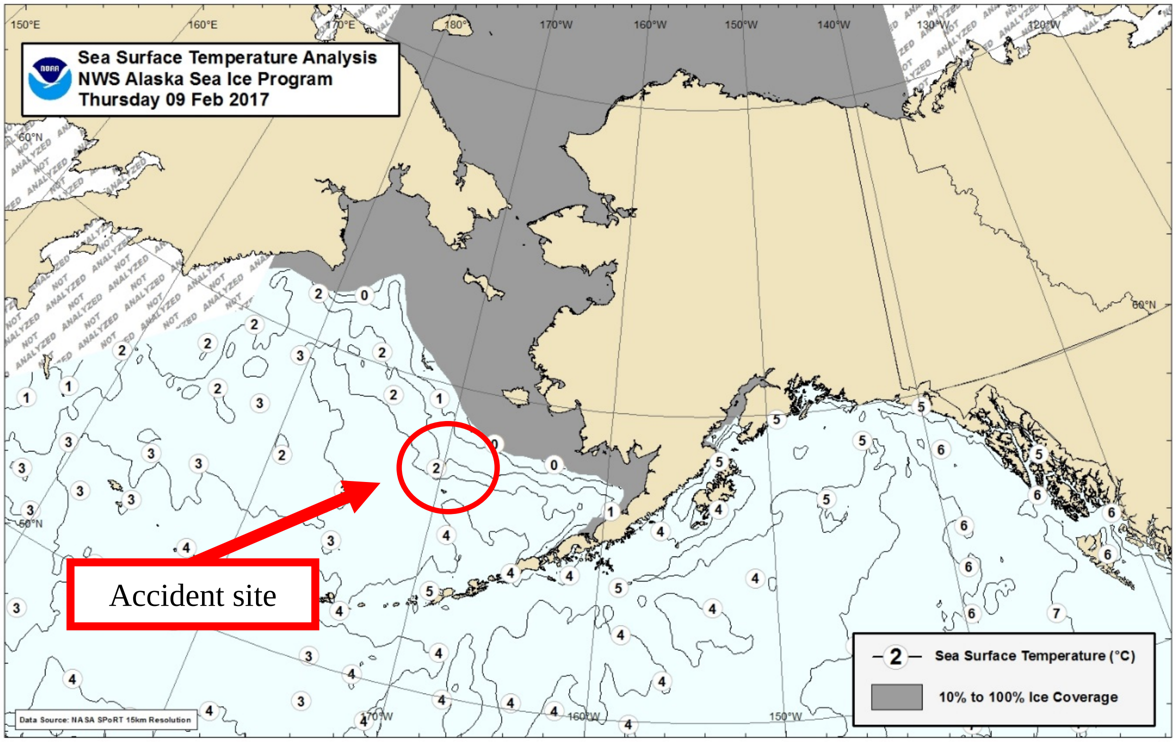

Figure 25 – NWS Alaska sea surface temperature analysis for February 9

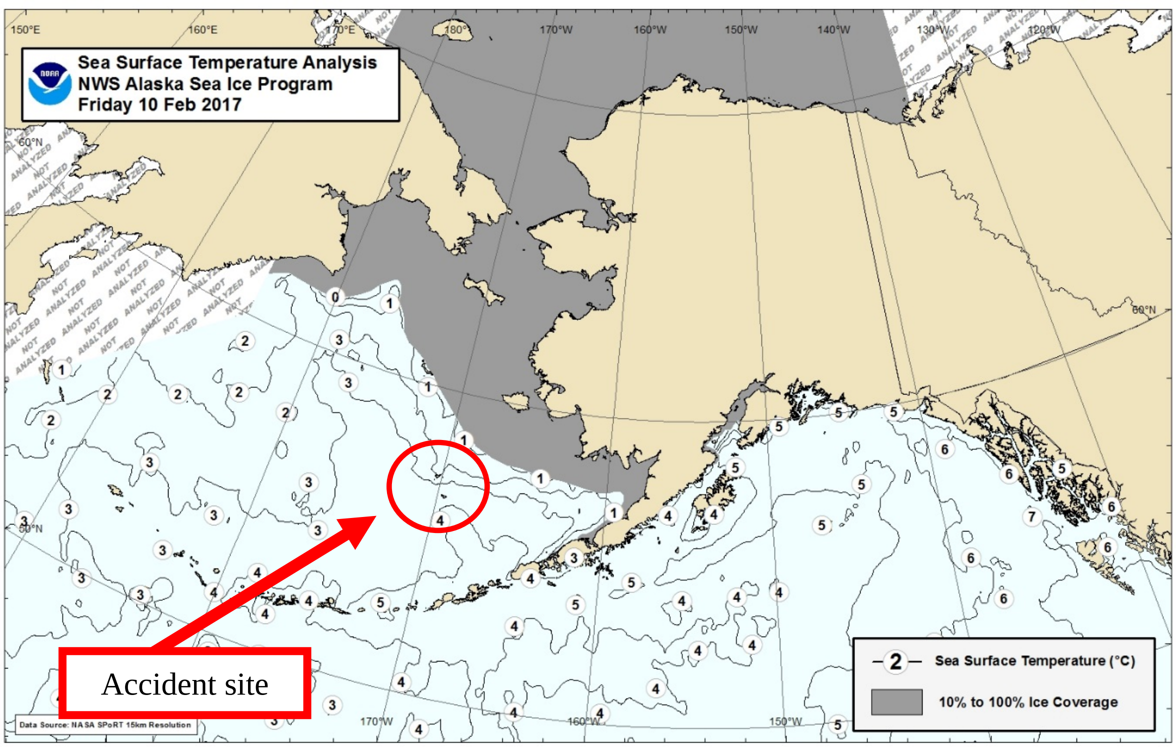

Figure 26 – NWS Alaska sea surface temperature analysis for February 10

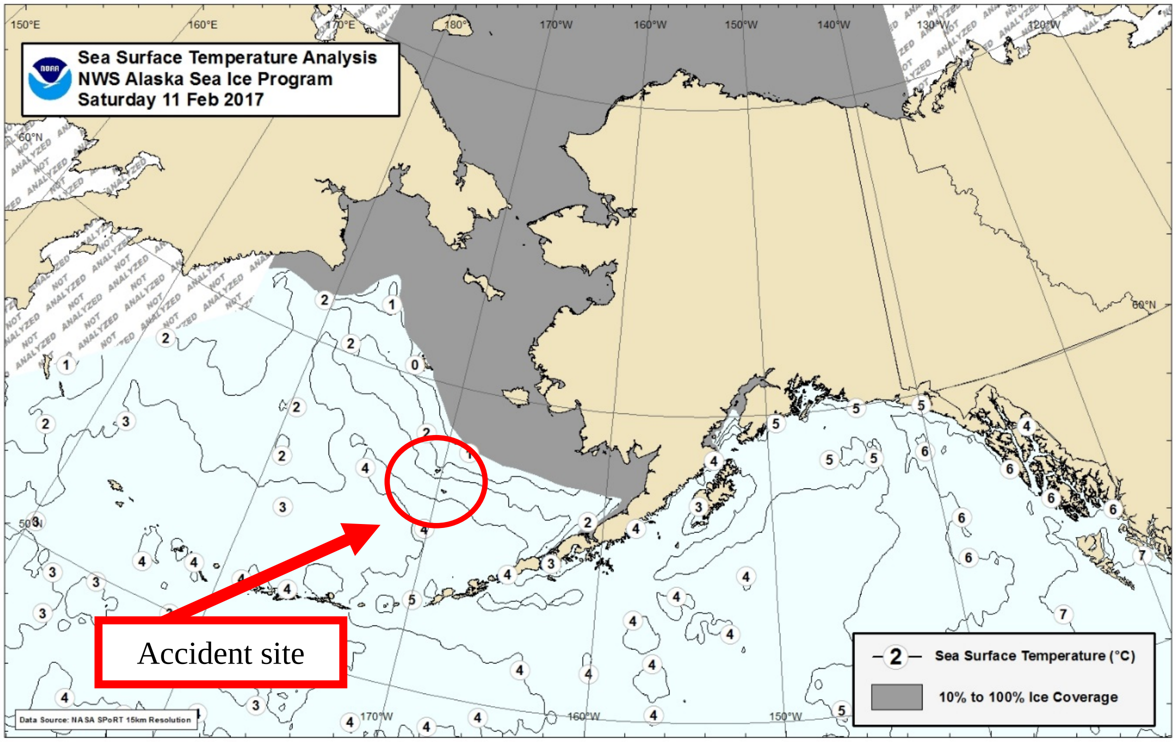

Figure 27 – NWS Alaska sea surface temperature analysis for February 11

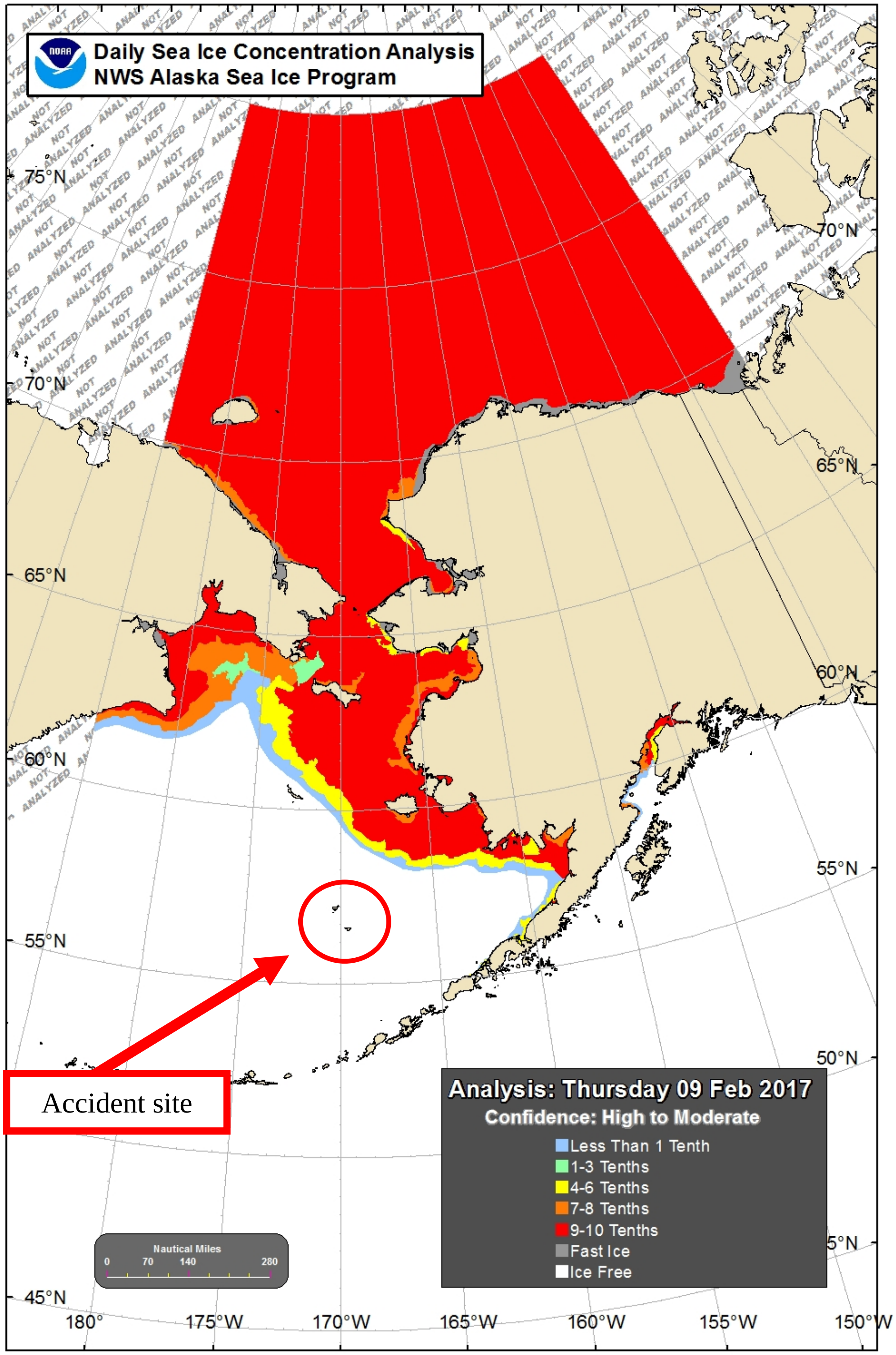

Figure 28 – NWS Alaska daily sea ice concentration analysis for February 9

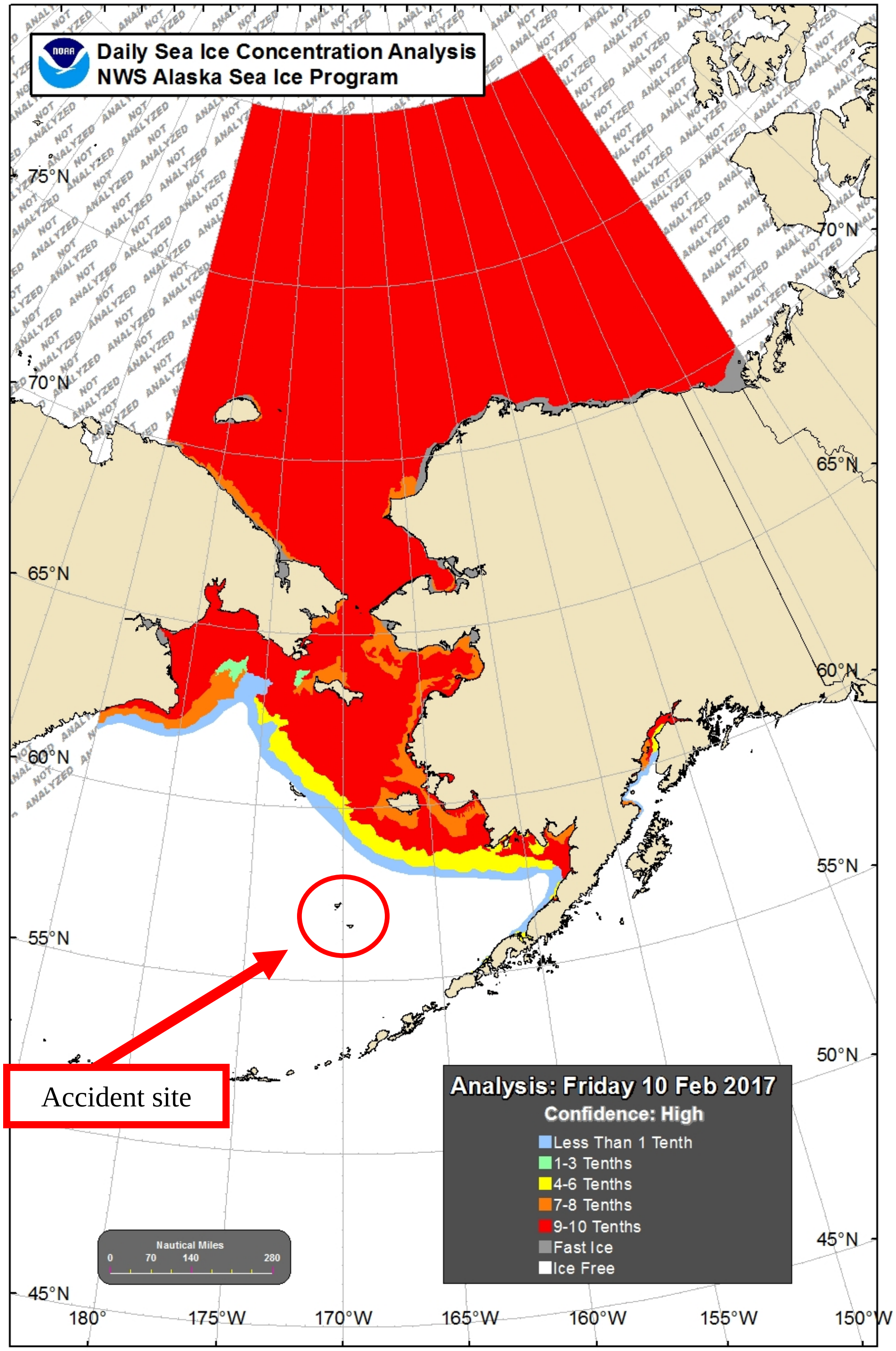

Figure 29 – NWS Alaska daily sea ice concentration analysis for February 10

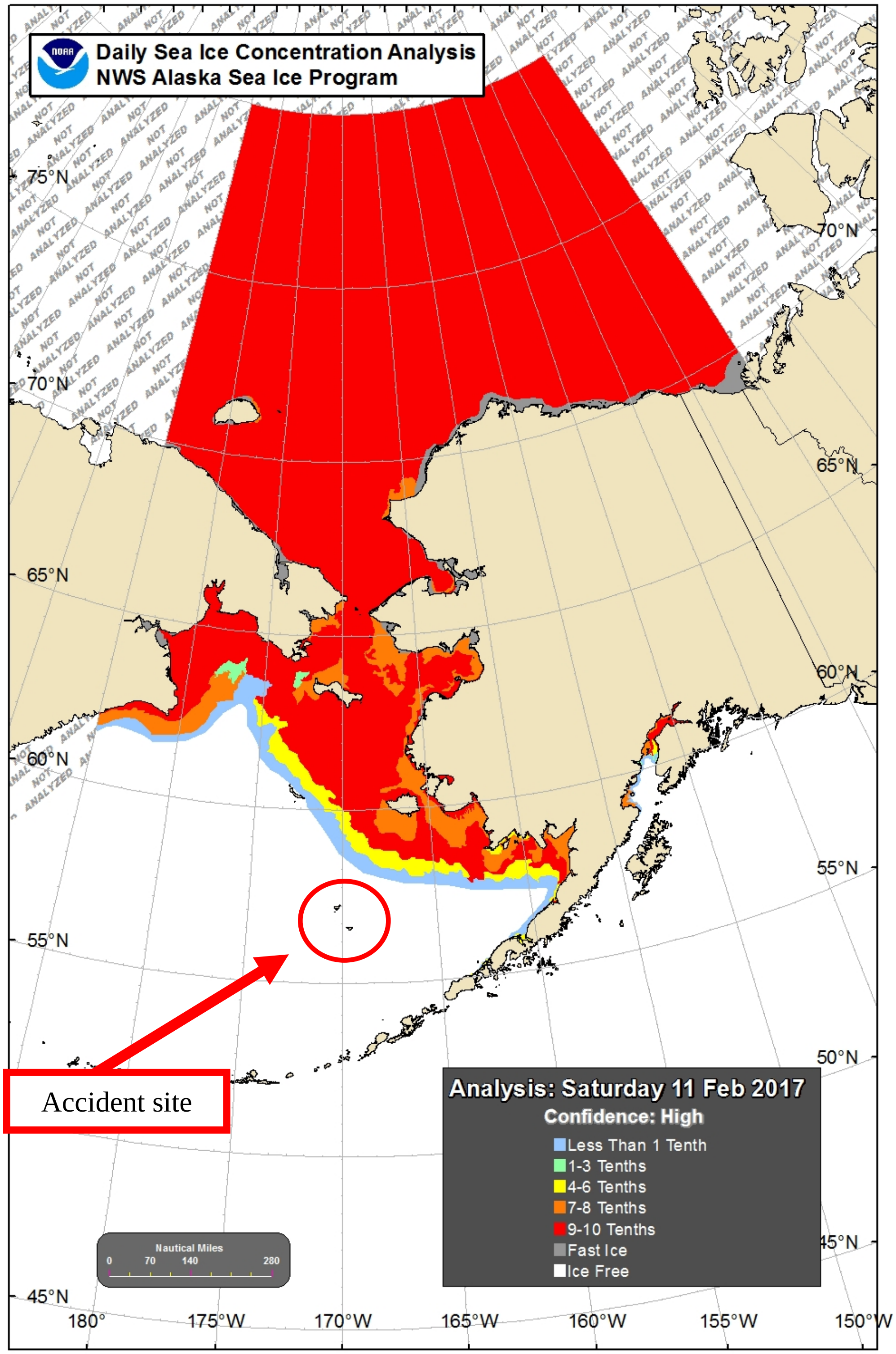

Figure 30 – NWS Alaska daily sea ice concentration analysis for February 11

11.0 Significant Wave Height[23]

The standard ocean wave forecast set forth by the World Meteorological Organization (WMO) instructs that the countries responsible for the weather forecast for the world's oceans use significant wave height for their ocean wave height forecasts. The OPC and the National Hurricane Center's Tropical Analysis and Forecast Branch are responsible for the NOAA forecasts for the northern Atlantic and Pacific Oceans. NWS Weather Forecast Offices (WFO)s are responsible for NOAA forecasts closer to the coastal regions, including the Bering Sea and the NWS Anchorage WFO was the responsible office for the weather forecast for the accident area.

The wavy water surface in the ocean is made up of an entire spectrum of waves and the waves can vary quite a bit for a given wind speed and fetch. Significant wave height is defined as the average height of the highest one-third of the waves in a wave spectrum. Figure 31 shows a typical wave spectrum distribution. This distribution shows that for a given wavy ocean surface the most probable wave height and mean wave height a person would encounter would be lower than the significant wave height, with statistically a much smaller chance of encountering a wave whose height is larger than the significant wave height. For example, given a significant wave height observed of 20 feet, the mean wave height encountered by a vessel for that wave spectrum would be 12.8 feet with the most probable wave height encountered of 12 feet. However, the highest 10 percent of waves within that wave spectrum would be 25.4 feet and the highest 1 percent of waves would be around 33.4 feet high. The highest wave a vessel could encounter with a significant wave height of 20 feet would be 40 feet. From the NWS Alaska marine forecast for the accident site with seas[24] of 8 feet forecast, the highest wave heights the accident vessel could have expected would have been 16 feet with most of the waves encountered around 4.8 feet high (section 6.0). Buoy 46073 indicated that seas of 6.6 to 17.1 feet were present between the time the accident vessel departed Dutch Harbor, Alaska, through the accident time. From the Buoy 46073 data (attachment 4), the highest wave height possibly encountered by the accident vessel after leaving Dutch Harbor, Alaska, would have been 34.2 feet (occurring at 1750 AKST on February 10). Most of the wave heights would have been at 7.1 feet between the time the accident vessel departed Dutch Harbor, Alaska, through the accident time. At the accident time, seas were 14.1 feet, with the highest wave height possible of 28.2 feet and most of the wave heights at 8.5 feet (attachment 4).

[23] http://www.vos.noaa.gov/MWL/apr_06/waves.shtml

[24] Seas = significant wave height

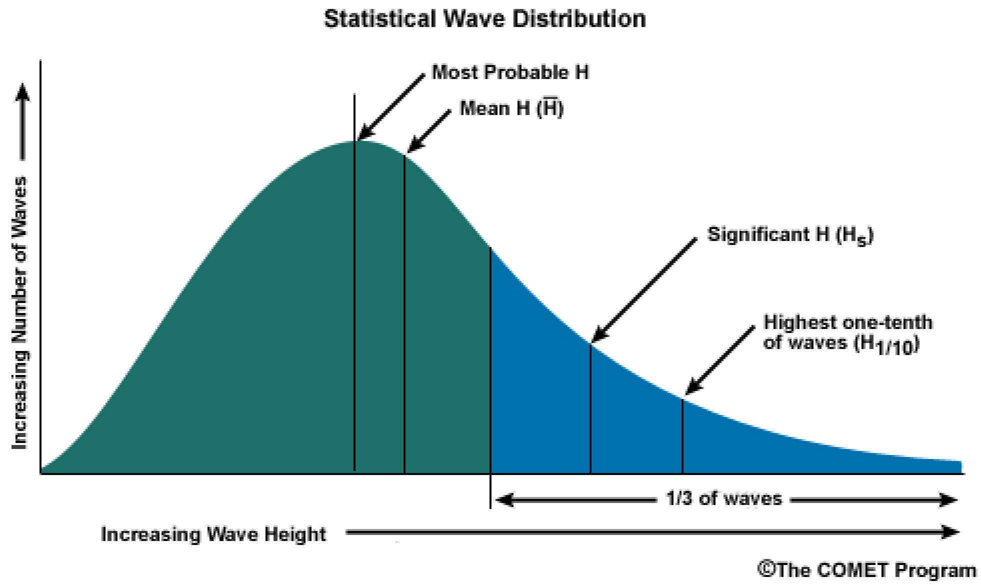

Figure 31 – Typical statistical wave distribution

12.0 Witness Information and Images[25]

Testimony from the captains of several vessels was received at the USCG MBI in August 2017 and the witness information pertaining to the weather and icing conditions at those vessel locations is summarized below. The estimated location of those vessels is plotted in figure 32 with the location of the accident site and last 3 hours of the accident vessel's AIS track:

F/V ALEUTIAN LADY

In the days leading up to the February 11, 2017, the *F/V ALEUTIAN LADY*, a house forward crabbing vessel, was operating approximately 50 miles due west of St. Paul Island (figure 32), just below the 57th parallel. During February 8 and 9, 2017, the vessel experienced "a stretch of good weather", winds of 25 knots to 30 knots, but cold temperatures in the mid-20's °F. On February 10, winds were blowing a steady northeast at 35 knots, with temps dropping to the lower 20's °F. The winds did not build large seas, despite the steady northeast winds.

The *ALEUTIAN LADY* did not build "very much" ice from freezing spray, as they were primarily in the same location - not moving fast or transiting into the seas for long periods of time. However, by February 10, the crew stopped to break ice. During MBI testimony, when asked if he ever considered in advance forecasted weather calling for heavy (freezing) spray to load less pots on deck prior to leaving port, the Captain of the *Aleutian Lady*[26] stated "Absolutely."

[25] For more information please see the USCG MBI transcripts.
[26] Captain of the *ALEUTIAN LADY*

When transiting in the vicinity of St. Paul and St. George Islands, the captain of *F/V Aleutian Lady* explained that the waters are generally shallow around the islands which creates fast currents, and thus requires caution in foul weather. The islands offer protection from the prevailing winds and seas, especially winds coming from the east to northeast.

F/V CLIPPER SURPRISE

In the days leading up to the February 11, 2017, the *F/V CLIPPER SURPRISE*, a 130-foot longliner fishing vessel, was operating approximately 10 miles west of St. George Island (figure 32). At times, they were operating as close as six miles and as far as 15 miles from the island. During MBI testimony, the captain of *F/V Clipper Surprise* stated that he knew of the freezing spray warnings “days in advance.” He primarily uses the ships onboard satellite internet to view the NWS weather forecasts. On February 10, 2017, he noted the weather forecast called for heavy freezing spray warnings and small craft advisories, with northeast winds between 20 and 25 knots. The captain of *F/V Clipper Surprise* decided to conduct fishing operations in the shelter of the leeward side of St. George Island. Wave heights were about 10-12 feet, as it was fairly well protected from the brunt of the winds. Sea and swell heights significantly reduced as the vessel operated within five miles of St. George.

Despite this and operating (*F/V CLIPPER SURPRISE)* at slower speeds (1-1.5 knots), the vessel was still accumulating ice at a rate of approximately less than half an inch an hour, eventually accumulating approximately four inches of ice from freezing spray. The captain of *F/V Clipper Surprise* explained that if the vessel was transiting at greater speeds, 6-7 knots, into the seas, he believes the *CLIPPER SURPRISE* would have accumulated significant amounts of ice, required them to have to stop and knock the ice off the vessel.

The captain of *F/V Clipper Surprise* stated that he observed several vessels in Zapadni Bay “hiding out from the weather” closer to the shore. He did observe the *DESTINATION* on AIS transiting northwest about a mile off the west coast of St. George Island. He assumed the *DESTINATION* was staying out of the weather to prevent any further ice buildup. He did not know whether they had stopped to knock the ice off, but he would have.

When asked to discuss on the challenges when transiting near St. George and St. Paul Islands, and how those islands can be used for protection, the captain of F/V *Clipper Surprise* explained during Nor’easter or steady northerly winds during the winter, vessels can run up into Zapadni Bay on the west side of St. George for protection and “jog around” and wait for the weather to clear.

The captain of *F/V Clipper Surprise* further explained that he accesses weather information provided by the NWS on Ultra High Frequency (UHF) radio and other numerous weather sites using the satellite internet connection. While operating west of St. George Island on February 11, 2017, the captain of *F/V Clipper Surprise* was aware of forecasted conditions calling for heavy freezing spray warnings, small craft advisories, with northeast and north winds at 30 knots. The *CLIPPER SURPRISE* was experiencing 30 knots winds from the North/Northeast, with gusts of 35 knots. The *CLIPPER SURPRISE* accumulated approximately 4 inches of freezing spray ice.

F/V POLAR SEA

In the days leading up to the February 11, 2017, the *F/V POLAR SEA*, a 105-foot house forward crab fishing vessel, was transiting with no crab pots onboard starting from an approximate position of 85 miles east of St. George Island (figure 32). On February 10, the vessel left its fishing grounds to transit to St. Paul Island to pick up parts for the boat, remove the ice that accumulated on the boat from the freezing spray, and take some time off and relax.

During the transit, the vessel experienced cold temperatures, 35 to 40 knot winds, and 15-foot waves. The vessel accumulated ice from freezing spray, requiring the crew to knock off the ice. the captain of *F/V Polar Sea* explained that he had to stop the transit four times on February 10 to knock off the ice, with each evolution lasting about five hours each (figures 33 through 36). When asked to describe the rate of ice accumulation, the captain of *F/V Polar Sea* explained that it is difficult to ascertain the accumulation rate, as it depended on various factors involving vessel speed, course, and operations during the course of fishing operations and the transit.

When asked if the life rafts onboard his vessel are ever covered in ice during freezing spray events, the captain of *F/V Polar Sea* explained that indeed ice accumulates on the life rafts. During the *POLAR SEA*'s transit towards St. Paul Island, he recalled having to chip a thin layer of ice off the life raft located aft of the wheel house. He chips the ice himself because the life raft is very fragile.

The captain of *F/V Polar Sea* explained that he always evaluates weather conditions, obtaining weather forecasts and reports numerous time a day from web pages and e-mails using the onboard computer. He also receives weather information by communicating with other vessels, the nearby processing facilities.

On the morning of February 11, the captain of *F/V Polar Sea* heard the Coast Guard's marine broadcasts request hailing assistance to contact the *DESTINATION*. He attempted several times to hail the *DESTINATION* with no response. He then explained that he could not assist with the search because of safety reasons considering the heavy ice that had accumulated onboard and prevailing weather conditions.

F/V BERING ROSE

On February 9, 2017, the *F/V BERING ROSE*, a 125-foot trawler, departed Dutch Harbor to trawl for fish in the vicinity of St. George Island. By the early morning hours of February 10, the vessel started fishing on the east side of St. George Island. At this location, the vessel experienced 35-40 knots winds from the northeast, 15-foot seas, with heavy freezing spray and ice accumulation of approximately over a quarter of an inch per hour, but no more than an inch per hour (ice accumulation).

During MBI testimony, captain of *F/V Bering Rose* explained that the waters around St. George Island, especially the northwestern side (Dalnoi Point), are notorious for its "nasty" sea state and winds. When asked if there is any particular wind direction that is worse when transiting that area, captain of *F/V Bering Rose* stated "Out of the northeast, just like it was that day (February 11, 2017). That would be the worst. Or if it (the wind or seas) came out of the southwest, you don't usually see that too much in the wintertime. Whenever the winds are against the tide is the worst."

Regarding precautions to prevent ice accumulations from freezing spray, captain of *F/V Bering Rose* explained when winds exceeded 40 knots under heavy freezing spray forecasts, it's best not to leave port. Also, since it takes many hours for the crew to clear the deck of ice, he believes it's best to just slow down, to proceed really slow, to avoid ice buildup in the first place.

F/V SILVER SPRAY

The captain of *F/V Silver Spray* was also part owner and master of the *F/V SILVER SPRAY*, a 116-foot crabber vessel. On February 9, 2017, after departing fishing grounds about 40 miles east of St. George Island, the SILVER SPRAY arrived into St. Paul to offload its crab scheduled for the following day. In the days preceding their arrival, the vessel experienced a good stretch of weather with temperatures in the upper 20s °F and no freezing spray ice accumulation.

After observing the weather forecasts issued on February 10 called for heavy freezing spray conditions, the captain of *F/V Silver Spray* decided to anchor in St. Paul and delay his departure for the fishing grounds until the morning of February 11, stating that ice buildup tends to increase during the evening and decrease in daylight hours.

When asked to describe the challenges when transiting in the vicinity of the Pribilof Islands, the captain of *F/V Silver Spray* indicated the islands offer relief from the weather and areas to anchor to wait out the weather, icing conditions, or stopping in anticipation for rough weather forecasts. However, a lot of times there is a lot of current around the islands that when going up against the wind can cause greater seas to chop and form closer together which reduces the speed of the vessel at the same time.

During USCG MBI testimony, when asked to speak about measures to reduce the effects of icing caused from sea spray, the captain of *F/V Silver Spray* explained it's important to constantly pay attention to the elements - to air and water temperature and the winds. His crew takes extra precautions by plastic wrapping apparatus to shed water off to keep them from freezing. And generally, slowing the vessel down and seeking shelter if it persists to a manner that you can't control anymore.

Further information from the USCG MBI testimony can be found attachments 17 and 18.

Figure 32 – Estimate of witness locations and accident site

Figure 33 – Photo taken by the Captain of the *F/V POLAR SEA* of ice accumulation during the transit towards St. Paul Island on February 10

Figure 34 – Photo taken by the Captain of the *F/V POLAR SEA* of ice accumulation during the transit towards St. Paul Island on February 10

Figure 35 – Photo taken by the Captain of the *F/V POLAR SEA* of ice accumulation during the transit towards St. Paul Island on February 10

Figure 36 – Photo taken by the Captain of the *F/V POLAR SEA* of ice accumulation during the transit towards St. Paul Island on February 10

In addition to the captains' witness testimony above, the Meteorologist in Charge (MIC) of the Alaska AAWU and Anchorage Volcanic Ash Advisory Center, also provided testimony. During testimony at the USCG MBI[27], he stated that the weather forecasts are issued twice daily at 0400 and 1600 local and the weather forecasts can be updated as necessary throughout the day. The determination for inputting "freezing spray" into a weather forecast at the NWS is done mainly through an algorithm. The NWS uses the Overland method (section 10.0) and this method is incorporated into the NWS computer systems for display to the NWS forecasters use. NWS forecasters use very little professional judgement and rarely change the Overland method freezing spray output, because the NWS Alaska Region receives very little information back to help verify or validate the freezing spray forecast. In fact, for marine forecast in general, the NWS Alaska Region receives very little information back to verify or validate the marine forecast. Using the Overland method, if the term "light" for freezing spray comes up then the NWS Alaska will input the wording "freezing spray" into their forecast. Using the Overland method, if the term "moderate, heavy, or extreme" for freezing spray comes up then the NWS Alaska will input the wording "heavy freezing spray" into their forecast along with a warning headline. The NWS will issue the heavy freezing spray warnings as much as 72-hours in advance of the event. As the weather models

[27] For more information please see the USCG MBI transcripts.

improve over time there has been some discussion about providing more than 72-hours of warning time (for heavy freezing spray conditions), but if the weather forecaster's confidence is low and the NWS cannot get more validation of what weather conditions are occurring they would be hesitant to extent the warning beyond 72-hours.

The MIC of the Alaska AAWU and Anchorage Volcanic Ash Advisory Center stated that one ship weather observation could change a weather forecast for an entire marine area and the NWS Alaska treats the ship observations with a lot of credibility. NWS Alaska Region is aware of other methods for determining freezing spray conditions (other than the Overland method), and are looking at some of those techniques, but at the current time they do not have the computer power to be able to use other methods due to the intensive calculations needed over a broad area.

The MIC of the Alaska AAWU and Anchorage Volcanic Ash Advisory Center stated the NWS Alaska marine forecast are available through NOAA Weather Radio (NWR) Very High Frequency (VHF) broadcasts, marine radio fax system, and the internet websites for text and graphical forecasts. The NWS forecasters receive weather information directly from mariners through the Voluntary Observing Ship (VOS) program. When asked how many weather observations from mariners in the Bering Sea and along the Aleutian Chain the NWS Alaska receives, he stated, "Probably a handful, at most, if we are lucky." Some of the feedback the NWS Alaska has received from mariners (over the past few years) include that the NWS weather forecast likely under forecast the wind or wave conditions, and the NWS forecasters are aware of that low bias. The NWS Alaska has received "very, very little" feedback from mariners on the freezing spray forecasts. The NWS Alaska would be open to participating on a marine customer board or committee to receive feedback on products and weather services. The NWS Alaska works with the USCG quite a bit, especially during search and rescue or for oil spills, etc… but would be open to work together more in the area of outreach to the mariner community.

When asked about how mariners are supposed to interpret a NWS mariner forecast with the header, "freezing spray" or "heavy freezing spray", he stated that the NWS would hope that the mariners would consider their plans into the future and that the forecast would keep mariners situational awareness of the potential for hazardous conditions. The marine forecast could be used as part of the mariner's decision-making process for "go" "no-go" decisions. The NWS does not currently have a guide specifically for boat captains on how to apply heavy freezing spray or freezing spray forecast. The NWS does have internally written standard operating procedures for NWS forecasters on how to apply freezing spray criteria in weather forecast. If NWS Alaska could have any feedback from the mariner community they wanted, the number one choice would be for more weather information reports from mariners. Both text information and graphical information from mariners would be beneficial. Mariners can provide the weather information reports to NWS Alaska via Twitter and the other social media platforms, by calling the local NWS Alaska office, and via email. NWS Alaska acknowledges that mariners may be very busy during their shift, but if there was a company coordinator person that could provide the reports to the NWS or even if the reports are provided later on, NWS Alaska would be happy to have them. NWS Alaska will take mariner weather information "any way that we can get it." For more information please see attachment 18.

13.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on February 11, 2017, indicated the following:

SUN	
Begin civil twilight	0915 AKST
Sunrise	0955 AKST
Sun transit	1434 AKST
Sunset	1914 AKST
End civil twilight	1954 AKST

MOON	
Moonrise	1923 AKST on preceding day
Moon transit	0257 AKST
Moonset	1015 AKST
Moonrise	2040 AKST

The phase of the Moon was Waning Gibbous with 99% of the Moon's visible disk illuminated.

E. LIST OF ATTACHMENTS

Attachment 1 – PAPB ASOS observations from before the accident vessel departed Dutch Harbor, Alaska, through the accident time

Attachment 2 – PASN ASOS observations from before the accident vessel departed Dutch Harbor, Alaska, through the accident time

Attachment 3 – VCVA2 observations from before the accident vessel departed Dutch Harbor, Alaska, through the accident time

Attachment 4 – Buoy 46073 observations from before the accident vessel departed Dutch Harbor, Alaska, through the accident time

Attachment 5 – UNLA2 observations from before the accident vessel departed Dutch Harbor, Alaska, through the accident time

Attachment 6 – NWS Alaska offshore waters forecast valid from 1533 AKST on February 7 through the accident time

Attachment 7 – NWS Alaska coastal waters forecast valid from 0344 AKST on February 8 through the accident time

Attachment 8 – NWS Instruction document 10-310

Attachment 9 – NWS Instruction document 10-303

Attachment 10 – NWS Alaska zone weather forecast valid from February 9 through the accident time

Attachment 11 – Correspondence with NWS Alaska Region

Attachment 12 – Prediction of Vessel Icing for Near-Freezing Sea Temperatures paper by Overland (1990)

Attachment 13 – Additional paper of algorithms used to determine sea spray ice accretion on marine vessels

Attachment 14 – Additional paper of algorithms used to determine sea spray ice accretion on marine vessels in the northern Atlantic Canadian waters

Attachment 15 – Sea spray ice accretion potential given VCVA2 data

Attachment 16 – Sea spray ice accretion potential given UNLA2 data

Attachment 17 – USCG MBI testimony from August 14, 2017

Attachment 18 – USCG MBI testimony from August 15, 2017

Attachment 19 – NTSB provided data to MU from the HYCOM model, accident vessel's AIS and WRF models for MU icing calculations

Attachment 20 – MU initial report on the numerical estimation of ice load accumulation on the accident vessel

Attachment 21 – Memorial University final document: "Numerical Prediction of Accumulated Ice Loads on the Fishing Vessel *F.V. Destination* Lost in the Bering Sea"

Submitted by:

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