NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

April 1, 2021

Group Chairman's Factual Report

METEOROLOGY

DCA20FM009

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A. ACCIDENT

Location: Near Sutwik Island, Alaska
Date: December 31, 2019
Time: 2200 Alaska standard time
0700 Coordinated Universal Time (UTC), January 1, 2020
Vehicles: *F/V Scandies Rose*

B. METEOROLOGY GROUP

Paul Suffern
Senior Meteorologist
Operational Factors Division (AS-30)
National Transportation Safety Board

Noelle Runyan
Meteorologist in Charge
NOAA/National Weather Service – Anchorage Weather Forecast Office

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 February 22, and March 5, 2021. 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 and from the National Centers for Environmental Information (NCEI). This specialist factual contains the meteorological factors pertinent to the weather surrounding the accident time. All times are Alaska standard time (AKST) on December 31, 2019, 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 location was latitude 56.503657° N, longitude 157.03347° 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 (NCEP), 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 (FAA) Advisory Circular "Aviation Weather Services", AC 00-45H[1] and in the NWS Directive System.[2]

1.1 Surface Analysis Chart

The OPC Surface Analysis Charts for 2100 AKST on December 31, 2019, and 0300 AKST on January 1, 2020, are provided as figures 1 and 2 with the approximate location of the accident site marked within the red circle. The charts depicted a low pressure center over the Anchorage area with a surface pressure of 970- to 971-hectopascals (hPa). The low pressure center remained in the same area between 2100 AKST on December 31, and 0300 AKST January 1. A surface trough[3] located over the accident region at 2100 AKST on December 31 (figure 1), became a cold front moving eastward across the accident region by 0300 AKST on January 1 (figure 2). The station models around the accident site (figure 3) depicted air temperatures of 16° to 8° Fahrenheit (F), a northwest wind of 20 to 30 knots, cloudy skies, and heavy snow reported at Port Heiden, Alaska (west of the accident site).

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

2 https://www.nws.noaa.gov/directives/

3 Trough – An elongated area of relatively low atmospheric pressure or heights.

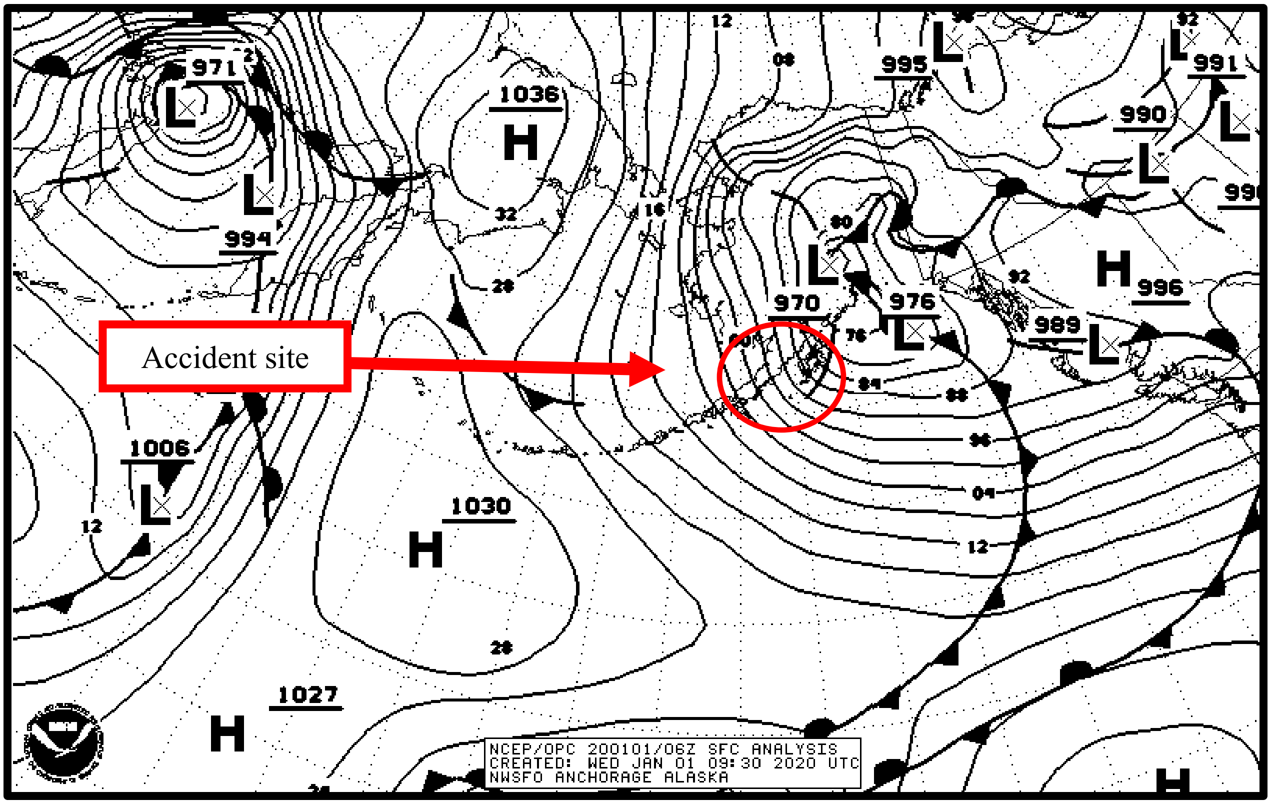

Figure 1 – OPC Surface Analysis Chart for 2100 AKST.

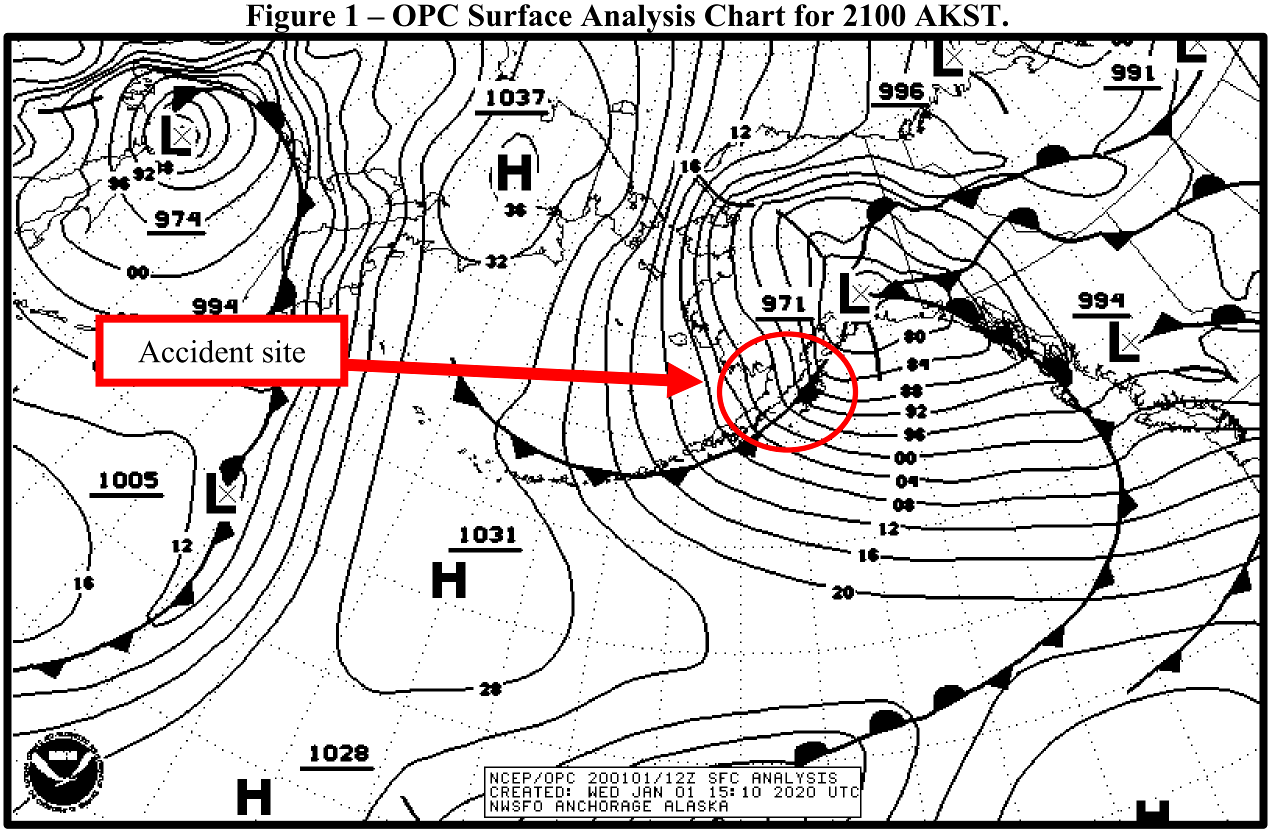

Figure 2 – OPC Surface Analysis Chart for 0300 AKST on January 1.

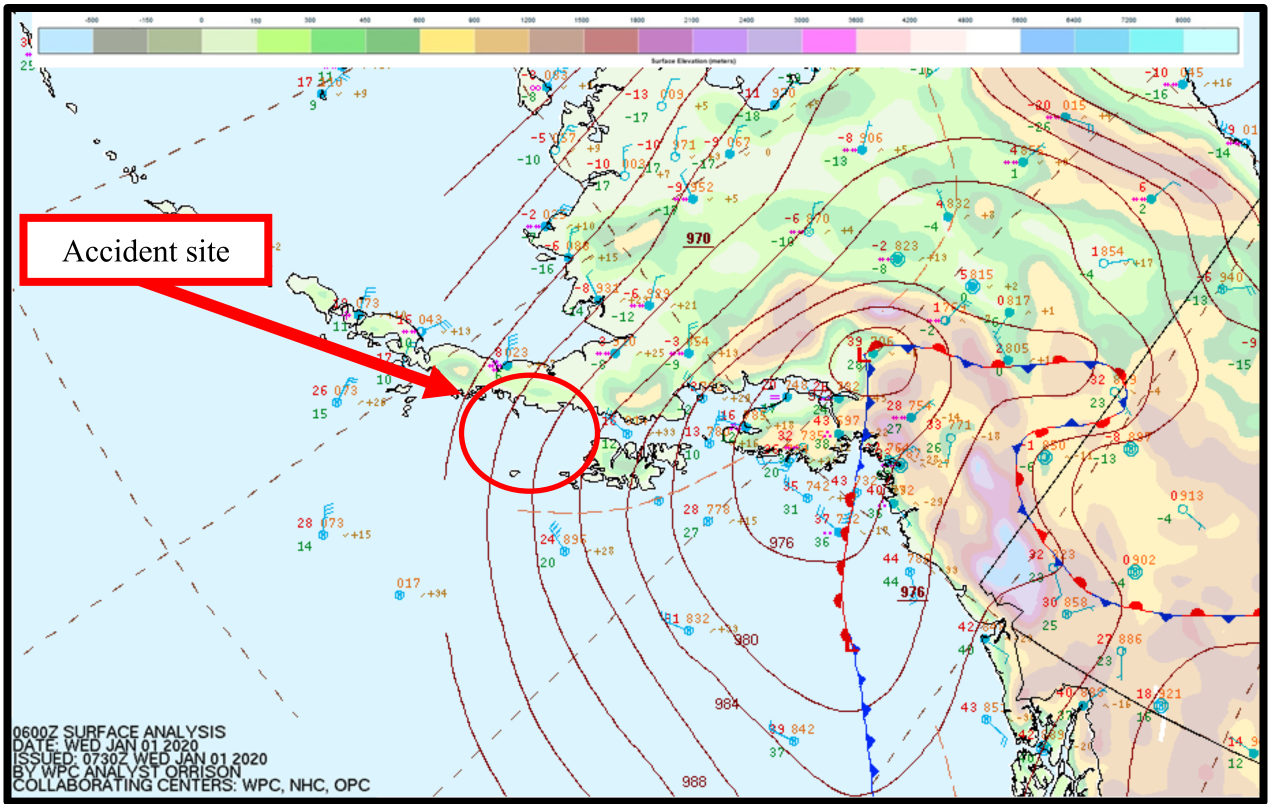

Figure 3 – NWS Surface Analysis Chart for 2100 AKST.

2.0 Surface Observations

The area surrounding the accident site was documented using official Aviation Routine Weather 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 4 is a local observation map with the accident site and the closest weather reporting locations marked.

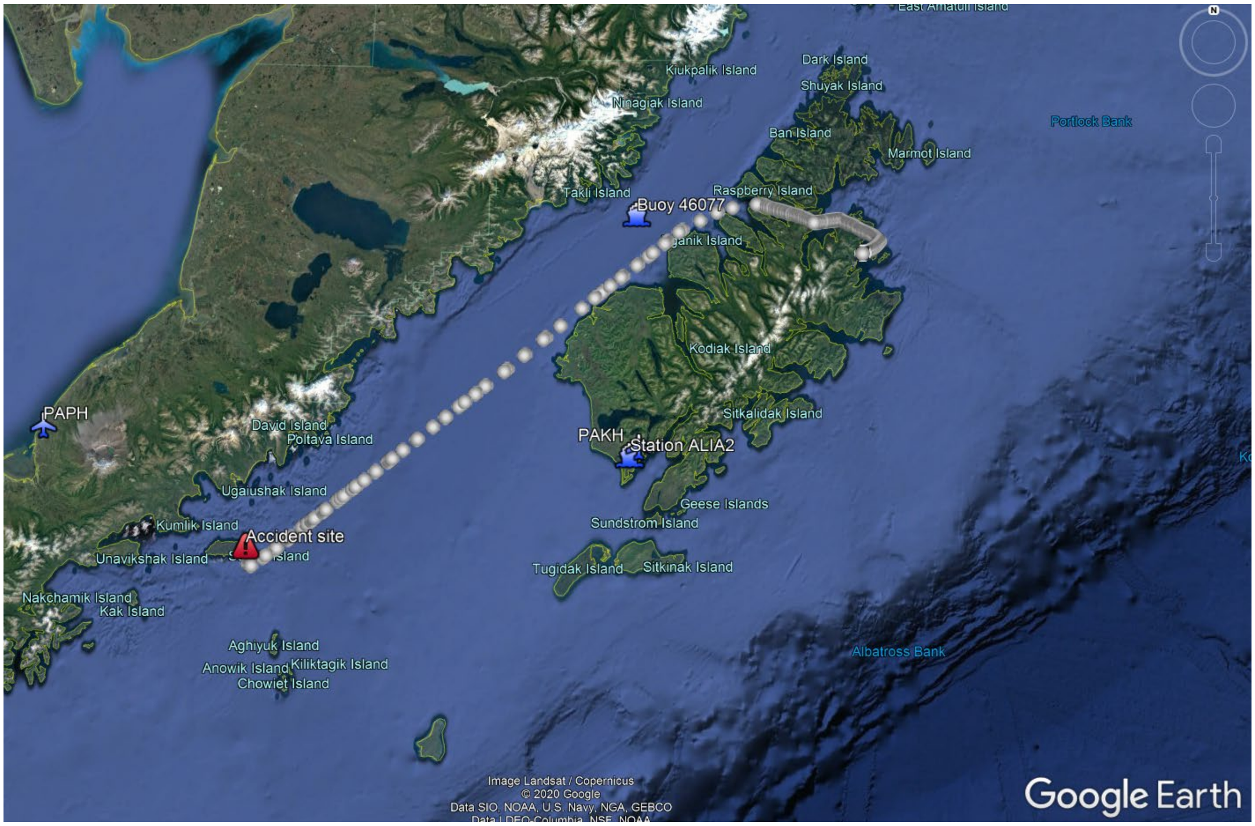

Figure 4 – Google Earth map of accident area with the location of the accident site, surface observation sites, and accident track (white dots).

Port Heiden Airport (PAPH) was the closest official surface weather station to the accident site, located 6 miles northeast of Port Heiden, Alaska. PAPH had an Automated Weather Observing System (AWOS[4]) whose reports were not supplemented. PAPB was located 59 miles northwest of the accident site, at an elevation of 95 feet (ft), and had a 13° easterly magnetic variation[5] (figure 4). The following observations were taken and disseminated during the times surrounding the accident:[6]

[1749 AKST] SPECI PAPH 010249Z AUTO 31034G40KT 1/4SM +SN FZFG SCT003 BKN006 OVC029 M13/M14 A2938 RMK AO2 PK WND 30044/0212 CIG 004V009 P0000 FZRANO=

[4] AWOS – Automated Weather Observing System is equipped with meteorological instruments to observe and report temperature, dewpoint, wind speed and direction, visibility, cloud coverage and ceiling up to 12,000 ft, and altimeter setting.

[5] Magnetic variation – The angle (at a particular location) between magnetic north and true north. Latest measurement taken from https://skyvector.com/

[6] 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.

[1756 AKST] METAR PAPH 010256Z AUTO 32035G41KT M1/4SM +SN FZFG SCT001 BKN007 OVC033 M12/M14 A2939 RMK AO2 PK WND 30044/0212 CIG 005V010 SLP956 P0000 60000 T11221139 56010 FZRANO=

[1842 AKST] SPECI PAPH 010342Z AUTO 30032G41KT M1/4SM +SN FZFG BKN002 BKN009 OVC018 M12/M14 A2939 RMK AO2 PK WND 31044/0311 CIG 001V005 P0000 FZRANO=

[1856 AKST] METAR PAPH 010356Z AUTO 30036G44KT 1/4SM +SN FZFG BKN002 BKN009 OVC017 M13/M14 A2940 RMK AO2 PK WND 30044/0355 CIG 001V006 SLP957 P0000 T11281139 FZRANO=

[1956 AKST] METAR PAPH 010456Z AUTO 30032G41KT 1/4SM +SN FZFG OVC002 M13/M14 A2927 RMK AO2 PK WND 31042/0420 PRESFR SLP914 P0000 T11281144 FZRANO=

[2056 AKST] METAR PAPH 010556Z AUTO 31034G43KT M1/4SM +SN FZFG OVC002 M13/M14 A2959 RMK AO2 PK WND 30045/0513 SLP023 P0000 60000 T11331144 11122 21133 53067 FZRANO=

[2156 AKST] METAR PAPH 010656Z AUTO 31031G39KT 1/4SM +SN FZFG BKN002 BKN008 OVC021 M13/M14 A2954 RMK AO2 PK WND 30044/0636 SLP005 P0000 T11331144 FZRANO=

ACCIDENT TIME 2200 AKST

[2205 AKST] SPECI PAPH 010705Z AUTO 31035G43KT 1/4SM +SN FZFG SCT002 BKN006 OVC014 M13/M14 A2951 RMK AO2 PK WND 31043/0705 CIG 005V011 P0000 FZRANO=

[2223 AKST] SPECI PAPH 010723Z AUTO 31034G41KT 1/4SM +SN FZFG BKN002 BKN008 OVC018 M13/M15 A2963 RMK AO2 PK WND 31043/0705 P0000 FZRANO=

[2256 AKST] METAR PAPH 010756Z AUTO 31033G44KT 1/4SM +SN FZFG BKN002 BKN011 OVC024 M13/M14 A2940 RMK AO2 PK WND 32044/0754 CIG 001V005 SLP958 P0000 T11331144 410611133 FZRANO=

[2318 AKST] SPECI PAPH 010818Z AUTO 31031G40KT 1/4SM +SN FZFG FEW002 BKN014 OVC029 M13/M15 A2940 RMK AO2 PK WND 32042/0757 P0000 FZRANO=

PAPH weather at 2156 AKST, automated, wind from 310° at 31 knots with gusts to 39 knots, a quarter mile visibility, heavy snow and freezing fog, a broken ceiling at 200 ft above ground level (agl), broken skies at 800 ft agl, overcast skies at 2,100 ft agl, temperature of -13° Celsius (C), dew point temperature of -14°C, and an altimeter setting of 29.54 inches of mercury (inHg). Remarks, station with a precipitation discriminator, peak wind of 44 knots from 300° at 2136 AKST, sea level pressure 1000.5 hPa, a trace of precipitation since 2056 AKST, temperature -13.3°C, dew point temperature -14.4°C, freezing rain sensor is not available.

PAPH weather at 2205 AKST, automated, wind from 310° at 35 knots with gusts to 43 knots, a quarter mile visibility, heavy snow and freezing fog, scattered clouds at 200 ft agl, broken ceiling at 600 ft agl, overcast skies at 1,400 ft agl, temperature of -13°C, dew point temperature of -14°C, and an altimeter setting of 29.51 inHg. Remarks, station with a precipitation discriminator, peak wind of 43 knots from 310° at 2205 AKST, ceiling varying between 500 and 1,100 ft agl, a trace of precipitation since 2156 AKST, freezing rain sensor is not available.

Akhiok Airport (PAKH) was the closest official surface weather station to the accident site east of the Aleutian Range. PAKH had an AWOS whose reports were not supplemented. PAKH was located 97 miles east-northeast of the accident site, at an elevation of 44 ft, and had a 15° easterly magnetic variation (figure 4). The following observations were taken and disseminated during the times surrounding the accident:

[1656 AKST] METAR PAKH 010156Z AUTO 32027G38KT OVC032 M09/M14 A2905 RMK AO2 PK WND 31041/0143 SLP839 T10941139 PWINO FZRANO $=

[1756 AKST] METAR PAKH 010256Z AUTO 31018G36KT OVC032 M09/M15 A2909 RMK AO2 PK WND 30040/0220 SLP852 T10941150 53027 PWINO FZRANO $=

[1856 AKST] METAR PAKH 010356Z AUTO 30026G34KT BKN033 M10/M16 A2912 RMK AO2 PK WND 28048/0319 SLP863 T11001161 PWINO FZRANO $=

[2056 AKST] METAR PAKH 010556Z AUTO 29026G43KT 260V330 FEW019 BKN035 OVC045 M11/M17 A2915 RMK AO2 PK WND 32043/0556 SLP873 T11111167 11083 21111 51021 PWINO FZRANO $=

[2105 AKST] SPECI PAKH 010605Z AUTO 30025G43KT FEW008 BKN026 OVC041 M11/M16 A2916 RMK AO2 PK WND 31037/0604 PWINO FZRANO $=

[2142 AKST] SPECI PAKH 010642Z AUTO 31025G35KT BKN008 BKN024 OVC041 M12/M15 A2919 RMK AO2 PK WND 31037/0604 CIG 003V013 PWINO FZRANO $=

[2156 AKST] METAR PAKH 010656Z AUTO 31019G37KT BKN006 OVC012 M12/M14 A2919 RMK AO2 PK WND 32037/0652 CIG 003V011 SLP887 T11171144 PWINO FZRANO $=

ACCIDENT TIME 2200 AKST

[2224 AKST] SPECI PAKH 010724Z AUTO 28027G38KT SCT006 BKN013 OVC028 M12/M15 A2922 RMK AO2 PK WND 29038/0722 PWINO FZRANO $=

[2237 AKST] SPECI PAKH 010737Z AUTO 30028G40KT FEW008 BKN022 OVC028 M12/M15 A2922 RMK AO2 PK WND 27040/0733 PWINO FZRANO $=

[2256 AKST] METAR PAKH 010756Z AUTO 30026G45KT 260V330 FEW008 BKN024 OVC043 M13/M16 A2922 RMK AO2 PK WND 27045/0753 SLP895 T11281156 PWINO FZRANO $=

[2336 AKST] SPECI PAKH 010836Z AUTO 30028G50KT FEW021 BKN031 OVC038 M13/M17 A2925 RMK AO2 PK WND 30050/0832 PWINO FZRANO $=

PAKH weather at 2156 AKST, automated, wind from 310° at 19 knots with gusts to 37 knots, broken ceiling at 600 ft agl, overcast skies at 1,200 ft agl, temperature of -12°C, dew point temperature of -14°C, and an altimeter setting of 29.19 inHg. Remarks, station with a precipitation discriminator, peak wind of 37 knots from 320° at 2152 AKST, ceiling varying between 300 and 1,100 ft agl, sea level pressure 988.7 hPa, temperature -11.7°C, dew point temperature -14.4°C, precipitation identifier sensor is not available, freezing rain sensor is not available, maintenance is needed on the system.

PAKH weather at 2224 AKST, automated, wind from 280° at 27 knots with gusts to 38 knots, scattered clouds at 600 ft agl, broken ceiling at 1,300 ft agl, overcast skies at 2,800 ft agl, temperature of -12°C, dew point temperature of -15°C, and an altimeter setting of 29.22 inHg. Remarks, station with a precipitation discriminator, peak wind of 38 knots from 290° at 2222 AKST, precipitation identifier sensor is not available, freezing rain sensor is not available, maintenance is needed on the system.

For more METAR observations from PAPH and PAKH including observations from before the accident vessel departed on the accident trip please see attachment 1.

2.1 Local Marine Observations

Additional surface and marine observations were examined around the accident site and Kodiak Island. A marine station 95 miles east-northeast of the accident site (figure 4, ALIA2) owned and maintained by NOAA's National Ocean Service (NOS) provided wind and temperature information around the accident time (figure 5, time in UTC).[7] ALIA2 is part of the National Water Level Observation Network (NWLON) and reported a wind from 296° to 299° between 30.5 and 31.9 knots with gusts to 44.3 knots, air temperatures of -10.5°C, and water temperatures between 3.9° and 4°C around the accident time (figure 5). For additional ALIA2 observations surrounding the accident time please see attachment 2.

[7] MM = month, DD = day, hh = hour (UTC), mm = minute, WDI = wind direction, R WSP = wind speed in meters per second (m/s) 1 m/s = 1.94384 knots, D GST = wind gust in m/s, PRES = pressure in hPa, ATMP = air temperature in °C, WTMP = water temperature in °C.

#YY	MM	DD	hh	mm	WDIR	WSPD	GST	PRES	ATMP	WTMP
#yr	mo	dy	hr	mn	deg	m/s	m/s	hPa	degC	degC
2020	1	1	5	36	304	11.8	17.7	986.4	999	999
2020	1	1	5	42	303	12.2	19	986.4	999	999
2020	1	1	5	48	301	11.9	18	986.6	999	999
2020	1	1	5	54	311	10.7	17.3	986.7	-10.7	4.1
2020	1	1	6	0	304	13.4	17.9	986.7	-10.7	4
2020	1	1	6	6	308	12.6	18.8	986.9	-10.6	4
2020	1	1	6	12	303	14.6	19.3	986.9	-10.5	4
2020	1	1	6	18	306	13.1	19.8	987	-10.8	4
2020	1	1	6	24	298	15.9	20.2	987	-10.3	4
2020	1	1	6	30	305	15.7	21	987.1	-10.5	4
2020	1	1	6	36	299	15.5	21.6	987.3	-10.3	3.9
2020	1	1	6	48	300	15.8	20.8	987.6	-10.3	4
2020	1	1	6	54	299	15.7	19.9	987.7	-10.4	4
2020	1	1	7	0	296	16.4	21.4	987.7	-10.3	4
2020	1	1	7	6	297	16.1	22.8	987.8	-10.5	3.9
2020	1	1	7	12	300	16	23.2	987.9	-10.7	3.9
2020	1	1	7	18	297	15.7	20.6	988.1	-10.7	3.9
2020	1	1	7	24	299	15.1	21.7	988.2	-11	3.8
2020	1	1	7	30	305	14.2	20.6	988.3	-11.1	3.8
2020	1	1	7	36	304	15.4	22.9	988.3	-11.1	3.8
2020	1	1	7	42	295	15.8	21.5	988.5	-11.1	3.8
2020	1	1	7	48	302	14.7	20.4	988.5	-11	3.7
2020	1	1	7	54	304	14.6	21.5	988.7	-11.2	3.6
2020	1	1	8	0	296	13.8	23.5	988.8	-11.1	3.6
2020	1	1	8	6	302	16.4	22.6	989	-11.3	3.6
2020	1	1	8	12	295	15.9	21.8	988.9	-11.3	3.6
2020	1	1	8	18	302	13.6	22.1	989.2	-11.7	3.6
2020	1	1	8	24	283	11.2	21.7	989.4	-11.2	3.6
2020	1	1	8	30	292	12.9	18.7	989.6	-11	3.5
2020	1	1	8	36	294	16	20.7	989.7	-11.5	3.5
2020	1	1	8	42	299	15.7	21.4	989.7	-11.6	3.5
2020	1	1	8	48	283	12	20.1	989.9	-11.4	3.5
2020	1	1	8	54	277	11.9	21.6	989.9	-11.2	3.5

Figure 5 – ALIA2 surface and marine data from around the accident time (time in UTC).[8]

[8] The term "999" is missing data.

A marine weather buoy station was located 125 miles northeast of the accident site (figure 4) and was owned and maintained by the National Data Buoy Center as station 46077. Buoy 46077 provided wind and temperature information around the accident time (figure 6 time in UTC).[9] Buoy 46077 reported a wind from 255° to 260° at 29.7 knots with gusts to 36.5 knots, significant wave heights[10] between 8.4 and 9.2 ft, a mean wave direction between 233° and 240°, and a dominant wave period of 8 to 9 seconds around the accident time (figure 6). For additional Buoy 46077 observations surrounding the accident time please see attachment 3.

#YY	MM	DD	hh	mm	WDI	R WSP	D GST	WVHT	DPD	APD	MWD	PRES	ATMP	WTMP	DEWP
#yr	mo	dy	hr	mn	deg	T m/s	m/s	m	sec	sec	deg	hPa	degC	degC	degC
2019	12	31	8	50	182	8.1	10.1	1.27	12.12	5.86	214	975.6	6.2	6.3	4.7
2019	12	31	9	50	175	5.9	7.5	1.56	12.12	6.75	222	975.1	6	6.3	4.9
2019	12	31	10	50	238	4.7	6.1	1.4	12.12	6.09	243	974.8	4.2	6.3	3.8
2019	12	31	11	50	243	6.7	8	1.25	12.9	6.7	257	974.4	1.8	6.3	1.2
2019	12	31	12	50	245	7.6	8.9	1.36	13.79	6.42	253	974.2	0.2	6.3	-0.6
2019	12	31	13	50	241	7.6	9.5	1.32	12.9	5.85	235	973.7	0.1	6.3	-1.2
2019	12	31	14	50	246	7.7	9.1	1.48	13.79	5.75	245	973.4	-0.3	6.2	-0.3
2019	12	31	15	50	237	8.8	10.5	1.43	12.12	5.58	258	973.3	-0.7	6.1	-0.8
2019	12	31	16	50	240	9.8	11.6	1.71	6.67	5.85	241	973.6	-1.5	5.9	-1.5
2019	12	31	17	50	236	11.1	13	1.74	7.14	5.66	241	974.4	-1.4	6	-3.3
2019	12	31	18	50	246	10.9	13.1	2.04	7.69	6.13	239	975.3	-2	5.9	-5.5
2019	12	31	19	50	246	11.8	14.6	2.43	7.69	6.36	242	975.8	-2.7	6.1	-6.2
2019	12	31	20	50	249	12.2	14.2	2.65	7.14	6.21	244	976.1	-3.3	6	-7.5
2019	12	31	21	50	255	11.5	14	2.75	7.69	6.38	242	976.1	-2.9	6	-6.6
2019	12	31	22	50	244	11.6	13.7	2.52	8.33	6.06	240	976.6	-4.4	6.2	-9.2
2019	12	31	23	50	244	13.7	17.3	2.77	7.69	6.05	243	976	-5.3	6.1	-9.3
2020	1	1	0	50	244	14.8	18.1	2.72	8.33	6.17	241	975.8	-5.3	6.1	-8.3
2020	1	1	1	50	259	15.8	19.5	3.19	8.33	6.17	240	976.9	-6.1	6.1	-9.2
2020	1	1	2	50	259	15.4	19.1	3.03	8.33	6.16	244	978.1	-7	6	-11.1
2020	1	1	3	50	252	14.3	18.4	3	8.33	6.02	239	979.4	-7.8	6	-11.1
2020	1	1	4	50	253	16.3	20.4	2.86	9.09	6.02	233	980.6	-8.6	6.1	-12.2
2020	1	1	5	50	256	15.3	18.8	2.79	9.09	6.4	237	981.4	-8.8	6.1	-11.2
2020	1	1	6	50	258	13.6	16.8	2.57	9.09	5.95	233	982.3	-9.4	6.1	-12.9
2020	1	1	7	50	259	14.1	17.8	2.68	7.69	6.01	240	983.4	-9.8	6.2	-12.4
2020	1	1	8	50	257	15.5	19.7	2.84	7.14	6.06	240	984.5	-10.6	6.2	-13.2
2020	1	1	9	50	266	14.1	17.9	2.53	7.69	5.89	232	985.4	-11.2	6.2	-13.7
2020	1	1	10	50	257	13.7	18.5	2.46	7.69	5.63	225	986.4	-11.6	6.2	-13.6
2020	1	1	11	50	252	15.1	19	2.76	8.33	5.9	232	987.3	-12.1	6.1	-13.7
2020	1	1	12	50	254	15.6	19.6	2.67	9.09	5.72	223	988	-12.6	6	-13.9
2020	1	1	13	50	258	16.5	20.2	2.96	8.33	6.19	224	988.8	-13.6	5.9	-15.2
2020	1	1	14	50	263	15.9	20.1	3.01	8.33	6.02	215	989.2	-13.2	5.9	-14.7
2020	1	1	15	50	260	15.6	19.4	3.25	7.69	6.2	232	989.7	-13.5	5.9	-14.9
2020	1	1	16	50	257	14.9	19.1	3.12	8.33	6.27	206	990.6	-13.8	5.9	-15.4
2020	1	1	17	50	261	13.2	16.6	3.04	7.69	6.2	212	991.4	-13.8	5.9	-15.7

Figure 6 – Buoy 46077 surface and marine data from around the accident time (time in UTC).

[9] MM = month, DD = day, hh = hour (UTC), mm = minute, WDI = wind direction, R WSP = wind speed in m/s, D GST = wind gust in m/s, WVHT = significant wave height in meters, DPD = dominant wave period in seconds, APD = average wave period in seconds, MWD = mean wave direction, PRES = pressure in hPa, ATMP = air temperature in °C, WTMP = water temperature in °C, DEWP = dew point temperature in °C.

[10] See section 9.0 for definition and information.

3.0 Satellite Data

Infrared data from the Geostationary Operational Environmental Satellite number 17 (GOES-17) data were 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-17 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 7 and 8 present the GOES-17 infrared imagery from 2200 and 2230 AKST at 4X magnification with the accident site highlighted with a red square. Inspection of the infrared imagery indicated abundant cloud cover, in the form of cloud streets[11], over and around the accident site at the accident time with the cloud cover moving from northwest to southeast. It should be noted these figures have not been corrected for any parallax error.

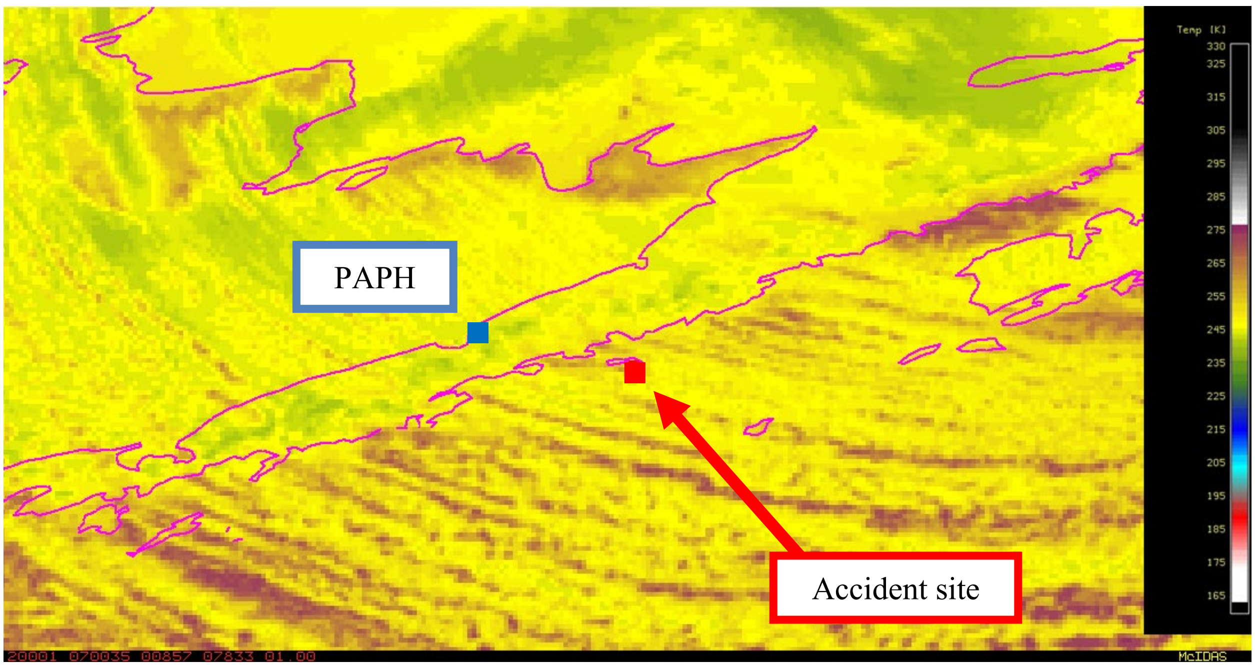

Figure 7 – GOES-17 infrared image at 2200 AKST.

[11] Cloud Street – A cloud street is a type of organized convection. It has the form of an extended line of cumulus cloud almost parallel to the wind direction, often in an otherwise lightly cloudy sky. http://rammb.cira.colostate.edu/wmovl/VRL/Tutorials/SatManu-eumetsat/SatManu/CMs/ClStr/index.htm

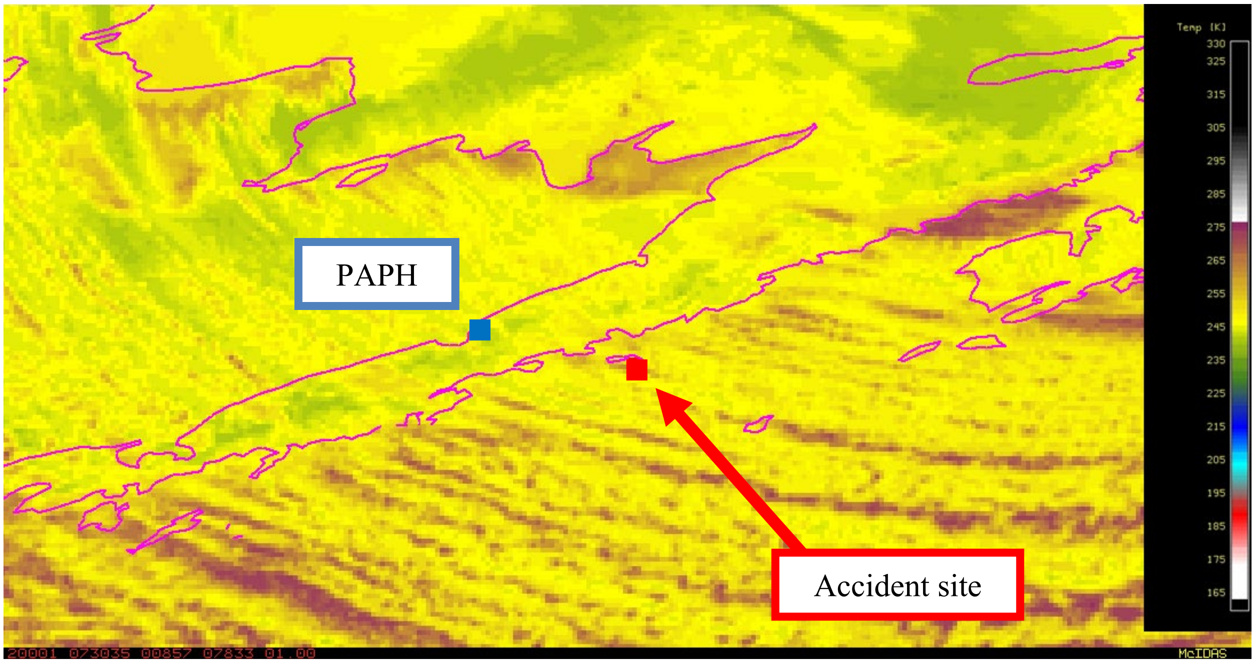

Figure 8 – GOES-17 infrared image at 2230 AKST.

4.0 Radar Imagery Information

The closest NWS Weather Surveillance Radar-1988, Doppler (WSR-88D)[12] to the accident site was the King Salmon, Alaska, radar (PAKC), which was located 131 miles north of the accident site. The lowest PAKC WSR-88D elevation beam provided data between approximately 13,000 and 26,000 ft msl above the accident site and there were no precipitation targets above the accident site around the accident time.

5.0 NWS Area Forecast Discussion

The NWS Office in Anchorage, Alaska, (PAFC) issued the following Area Forecast Discussion (AFD) at 1623 AKST (closest AFD to the accident time). The AFD discussed that the northwesterly winds would bring colder air and heavy freezing spray to the marine areas and snow squalls:

FXAK68 PAFC 010123
AFDAFC

Southcentral and Southwest Alaska Forecast Discussion
National Weather Service Anchorage AK
423 PM AKST Tue Dec 31 2019

.ANALYSIS AND UPPER LEVELS...
A major upper level Arctic trough remains over southwest Alaska
and the eastern Bering Sea bringing very cold temperatures to

[12] 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.

areas under it. South central Alaska is in the warm southerly flow aloft ahead of this trough, but that will change over the next day as a cut off low develops from this trough over Southwest and Southcentral Alaska. At the surface, the main low is tracking up Cook Inlet this evening and will move into the western Copper River Basin overnight. **Satellite imagery shows cold air cumulus clouds streaming off the ice edge over the northern Bering Sea and tracking over the central and eastern Bering Sea. These clouds are bringing snow squalls to the eastern Bering to the eastern Aleutians and Alaska Peninsula. Very cold air is also moving north up Cook Inlet today and will move into the rest of south central Alaska by Wednesday morning.**

&&

.MODEL DISCUSSION...

Models are all in good alignment with the synoptic pattern as well as the system moving through southwest and south central Alaska through tomorrow. The differences mainly are due to model resolution and ability to resolve small details. The NAM has been doing a very good job with this storm and both it and the GFS seem to have good timing on the cold front as it moves up Cook Inlet this afternoon. After this system passes, models look to be locked in good agreement through the weekend before some more notable discrepancies creep in for early next week.

&&

.AVIATION...
PANC...The strong southeasterly winds will abruptly shift to the southwest this evening as much colder air moves up Cook Inlet and rapidly switches rain to snow sometime between 4Z to 6Z this evening. Snow will likely be moderate-to-heavy in intensity for a while with gusty winds producing IFR conditions. The biggest challenge is forecasting the duration of this heavy snow, though it should become light or end no later than 15Z.

&&

.SHORT TERM FORECAST SOUTHCENTRAL ALASKA (Days 1 through 3: Tuesday night through Friday)...

Low pressure currently located over Kodiak Island is continuing to produce strong southerly flow and warm temperatures for much of south central AK. **However, cold air can be seen on satellite streaming into the western Gulf of Alaska and surface observations are indicating snow and cold air are now moving up Cook Inlet.** Blizzard conditions arrived as expected for the Homer area as well. This means the forecast is on track for a sharp drop in temperatures and 4-8 inches of snow for the Anchorage area tonight. The Mat-Su Valley will also see snow tonight with highest totals just under 6 inches in areas near Skwentna.

Both the Blizzard Warning and Winter Weather Advisory remain in effect due to these conditions into tomorrow morning. After the initial push of cold weather, light snow will linger through the morning as temperatures continue to fall. The low pressure system will then exit, but cloud cover is expected to linger keeping temperatures steady in the single digits for much of south central Alaska and Kodiak for the next couple of days. The exception is the Copper River Basin where temperatures will continue to drop to around 10 below zero by Friday.

&&

.SHORT TERM FORECAST SOUTHWEST ALASKA (Days 1 through 3)...

A deep upper level trough combined with an elongated low centered near Kodiak Island is continuing to enhance snowfall over the Middle Kuskokwim Valley. An additional 4 inches is likely over this area through New Year's morning. Gusty northwesterly winds will lead to periods of blowing snow as well. Farther west, a Wind Chill Advisory remains in effect for the Kuskokwim Delta. Lows near -15 combined with the aforementioned winds will lead to wind chills near -40. Snow will taper off and winds will gradually diminish through the day Wednesday as a broad upper level low stalls over Bristol Bay. Precipitation chances will be minimal on Thursday, however temperatures will remain below zero across much of the region.

&&

.**SHORT TERM FORECAST BERING SEA/ALEUTIANS (Days 1 through 3)...**

Northwesterly flow will persist across the central and eastern Bering/Aleutians bringing widespread snow showers. Heavy freezing spray is likely given the gusty winds combined with the very cold airmass. A weak ridge will bring more settled weather across the western Aleutians through Thursday.

&&

.MARINE (Days 3 through 5: Friday through Sunday)...

A relatively quiet weather pattern sets up for this time of year all across Southern Alaska and the Bering. A low over the southern Gulf of Alaska may get winds to gale force along the North Gulf coast, southern Cook Inlet, the Barren Islands, and Shelikof Strait on Friday. The low moves into the eastern Gulf of Alaska Saturday, with a chance of some northwesterly gales through the Barren Islands. A new North Pacific low may move into the southern Gulf of Alaska on Sunday, but there is substantial model disagreement, and confidence in that is low.

For the Bering, high pressure will keep all winds below gale force all across the Bering Sea, with a possible exception of a dying front over the western Aleutians early on Friday. Winds may approach gale force in the western Aleutians Sunday night as a strong low approaches.

&&

.LONG TERM FORECAST (Days 3 through 7: Friday through Tuesday)...

A much quieter weather pattern is setting up for much of Southern
Alaska in the long-term period as a cold air mass becomes firmly
entrenched across the area. This will divert the storm track from
being over us to instead staying south over the North Pacific with
any lows impacting the Panhandle. This is generally well-agreed
upon in the models.

With that said, there will still be a few storm systems that will
be worth watching. On Friday, a weak low will be centered off the
coast of Kodiak, over the southwestern Gulf. It will slowly move
eastward across the southern Gulf and into the eastern Gulf on
Saturday. Snow may impact Kodiak into Friday morning, though a
repeat of the near blizzard conditions of a few days ago does not
appear likely. On Sunday, a new North Pacific low may approach the
AK Pen and Kodiak, but there is poor model agreement on this.
There is much better agreement on the leading front of a strong
North Pacific low moving into the western Aleutians on Monday. The
front should slowly track across the southern Bering into
Tuesday.

Elsewhere, cold and dry will be the name of the game over mainland
Alaska, which means the main weather hazards will be strong gap
winds, particularly through Thompson Pass, but also possibly
through the Matanuska Valley. These winds coupled with the cold
air may lead to wind chill concerns, which unlike previous days,
will focus more on Southcentral, rather than Southwest Alaska.
Continued polar air pouring southward across the Bering on Friday
looks to diminish this weekend, to more light and variable winds.

&&

.AFC WATCHES/WARNINGS/ADVISORIES...
PUBLIC...Blizzard Warning 181 and 121. Snow Advisory 101. Flood Advisory 145.
Heavy Snow Warning 152. Wind Chill Advisory 155.
MARINE...Storm Warning 130 Gale Warning 131 132 138 139 150 155 160 165 172 179 180
181 185.
Heavy Freezing Spray Warning 130 131 132 136 137 138 139 140 141 150 160 165
179 180 181 185.
FIRE WEATHER...DONE.

&&

$$

6.0 NWS Marine Forecast Products

PAFC issued the official marine forecasts along the route the accident vessel took after departure from Kodiak, Alaska, including the accident site. The accident vessel passed through 2 different marine forecast zones (figure 9, PKZ138, and PKZ150). The PKZ138 marine forecast for

Shelikof Strait valid before departure and issued at 1529 AKST on December 30 forecast a gale warning for the accident night with freezing spray conditions and seas[13] at 9 ft. The next forecast for PKZ138 issued at 0308 AKST on December 31 indicated a gale warning through that night with a heavy freezing spray warning for the following day. Freezing spray conditions were forecast for the afternoon and evening of the accident day with a west wind of 45 knots diminishing to 30 knots after midnight and seas at 10 ft. The PKZ138 marine forecast valid at the accident time was issued at 1455 AKST on December 31 and forecast a gale warning with heavy freezing spray conditions through the following night, a west wind of 45 knots diminishing to 30 knots after midnight with seas of 10 ft.

FZAK51 PAFC 310029
CWFAER

Coastal Waters Forecast
National Weather Service Anchorage Alaska
329 PM AKST Mon Dec 30 2019

Coastal Waters Forecast for the Northern Gulf of Alaska Coast
up to 100 nm out including Kodiak Island and Cook Inlet.

Wind forecasts reflect the predominant speed and direction
expected. Sea forecasts represent an average of the highest
one-third of the combined wind wave and swell height.

PKZ197-311345-
329 PM AKST Mon Dec 30 2019
.SYNOPSIS FOR THE NORTH GULF COAST+KODIAK ISLAND WATERS+
COOK INLET...

A front pushes over the North Gulf Coast for Tue afternoon. A 974
mb low 70 nm South of Chignik moves along the front to 25 nm North
of Anchorage and inland Tue night. Its front sweeps across the
North Gulf Coast and the Gulf through Wed afternoon.

$$

PKZ138-311345-
Shelikof Strait-
329 PM AKST Mon Dec 30 2019

...GALE WARNING TUESDAY NIGHT...

.TONIGHT...S wind 25 kt. Seas 5 ft. Rain.
.TUE...S wind 15 kt becoming SW 25 kt in the afternoon.
Seas 3 ft building to 6 ft in the afternoon.
.TUE NIGHT...W wind 35 kt. Seas 9 ft. Freezing spray.
.WED...W wind 30 kt. Seas 8 ft.
.WED NIGHT...W wind 25 kt. Seas 4 ft.
.THU...NW wind 20 kt. Seas 5 ft.
.FRI THROUGH SAT...NW wind 25 kt. Seas 6 ft.

$$

[13] Seas = significant wave height

FZAK51 PAFC 311208
CWFAER

Coastal Waters Forecast
National Weather Service Anchorage Alaska
308 AM AKST Tue Dec 31 2019

Coastal Waters Forecast for the Northern Gulf of Alaska Coast
up to 100 nm out including Kodiak Island and Cook Inlet.

Wind forecasts reflect the predominant speed and direction
expected. Sea forecasts represent an average of the highest
one-third of the combined wind wave and swell height.

PKZ197-010100-
308 AM AKST Tue Dec 31 2019
.SYNOPSIS FOR THE NORTH GULF COAST+KODIAK ISLAND WATERS+
COOK INLET...

A 974 mb low over Kodiak Island this morning will move up Cook
Inlet through Tue night at 973 mb then weaken through Wed night.

$$

PKZ138-010100-
Shelikof Strait-
308 AM AKST Tue Dec 31 2019

...GALE WARNING THROUGH TONIGHT...
...HEAVY FREEZING SPRAY WARNING WEDNESDAY...

.TODAY...SW wind 15 kt becoming W 35 kt in the afternoon. Seas 5 ft building to 10 ft in the afternoon.
.TONIGHT...W wind 45 kt diminishing to 30 kt after midnight. Seas 10 ft. Freezing spray.
.WED...W wind 30 kt. Seas 8 ft. Heavy freezing spray.
.WED NIGHT...W wind 25 kt. Seas 4 ft.
.THU...N wind 20 kt. Seas 5 ft.
.FRI...N wind 25 kt. Seas 5 ft.
.SAT...NW wind 25 kt. Seas 5 ft.

$$

FZAK51 PAFC 312355
CWFAER

Coastal Waters Forecast
National Weather Service Anchorage Alaska
255 PM AKST Tue Dec 31 2019

Coastal Waters Forecast for the Northern Gulf of Alaska Coast
up to 100 nm out including Kodiak Island and Cook Inlet.

Wind forecasts reflect the predominant speed and direction
expected. Sea forecasts represent an average of the highest

one-third of the combined wind wave and swell height.

PKZ197-011245-
255 PM AKST Tue Dec 31 2019
.SYNOPSIS FOR THE NORTH GULF COAST+KODIAK ISLAND WATERS+
COOK INLET...

A 972 mb low over the Kenai Peninsula Tuesday afternoon moves
inland Tue night. A 999 mb 210 nm southwest of Kodiak City Thu
morning moves 150 nm southwest of Kodiak City at 997 mb Thu
afternoon.

$$

PKZ138-011245-
Shelikof Strait-
255 PM AKST Tue Dec 31 2019

...GALE WARNING TONIGHT...
...HEAVY FREEZING SPRAY WARNING THROUGH WEDNESDAY NIGHT...

.TONIGHT...W wind 45 kt diminishing to 30 kt after midnight.
Seas 10 ft. Heavy freezing spray.
.WED...W wind 30 kt. Seas 8 ft. Heavy freezing spray.
.WED NIGHT...W wind 30 kt. Seas 8 ft. Heavy freezing spray.
.THU...N wind 25 kt. Seas 5 ft.
.THU NIGHT...NE wind 35 kt. Seas 10 ft.
.FRI...N wind 35 kt. Seas 10 ft.
.SAT...NW wind 25 kt. Seas 5 ft.
.SUN...NW wind 20 kt. Seas 4 ft.

$$

The PKZ150 marine forecast for Sitkinak to Castle Cape (which included the accident site) valid before departure was issued at 1525 AKST on December 30 and forecast a gale warning for the accident day with heavy freezing spray conditions at the accident time. Winds were forecast from the west at 30 knots on the accident day becoming 40 knots by the accident day afternoon with gusts to 50 knots out of bays and passes and seas at 17 ft. By the accident time the forecast called for 45 knot winds from the northwest and gusts to 55 knots out of bays and passes with heavy freezing spray, snow showers, and seas at 21 ft. The next forecast for PKZ150 issued at 0313 AKST on the morning of the accident indicated a gale warning through the following day with a heavy freezing spray warning for the accident time through the following day. A west wind of 30 knots was forecast to become 40 knots and then increase to 45 knots by the accident time with heavy freezing spray, snow showers, and seas at 21 ft. The PKZ150 marine forecast valid at the accident time was issued at 1452 AKST on the accident day and forecast a gale warning with heavy freezing spray conditions through the following day, a northwest wind of 45 knots, snow showers, and seas of 21 ft.

FZAK52 PAFC 310025
CWFALU

Coastal Waters Forecast
National Weather Service Anchorage Alaska

325 PM AKST Mon Dec 30 2019

Coastal Waters Forecast for Southwest Alaska+Bristol Bay+The
Alaska Peninsula Waters and the Aleutian Islands up to 100 nm out.

Wind forecasts reflect the predominant speed and direction
expected. Sea forecasts represent an average of the highest
one-third of the combined wind wave and swell height.

PKZ199-311330-
325 PM AKST Mon Dec 30 2019
.SYNOPSIS FOR SOUTHWEST ALASKA+BRISTOL BAY+THE ALASKA
PENINSULA WATERS AND THE ALEUTIAN ISLANDS...

An Eastern Aleutian front moves into the Gulf of Alaska by Tue
morning. A front approaches the Western Aleutians and Bering for
Wed afternoon associated with a 994 mb low in the Sea of Okhotsk.

$$

PKZ150-311330-
South of the AK Peninsula Sitkinak to Castle Cape-
325 PM AKST Mon Dec 30 2019

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

.TONIGHT...S wind 30 kt. Seas 22 ft. Rain and snow showers.
.TUE...W wind 30 kt becoming NW 40 kt in the afternoon. Gusts to
40 kt increasing to 50 kt out of bays and passes in the afternoon.
Seas 17 ft. Freezing spray.
.TUE NIGHT...NW wind 45 kt. Gusts to 55 kt out of bays and passes.
Seas 21 ft. Heavy freezing spray. Snow showers.
.WED...W wind 45 kt. Seas 21 ft.
.WED NIGHT...W wind 40 kt. Seas 16 ft.
.THU THROUGH FRI...NW wind 30 kt. Seas 11 ft.
.SAT...NW wind 25 kt. Seas 10 ft.

$$

PKZ155-311330-
South of the AK Peninsula Castle Cape to Cape Sarichef-
325 PM AKST Mon Dec 30 2019

...GALE WARNING THROUGH TUESDAY NIGHT...

.TONIGHT...NW wind 35 kt. Seas 19 ft. Freezing spray. Snow
showers.
.TUE...NW wind 40 kt. Gusts to 50 kt out of bays and passes.
Seas 16 ft. Freezing spray. Snow showers.
.TUE NIGHT...NW wind 40 kt. Gusts to 50 kt out of bays and passes.
Seas 16 ft. Freezing spray. Snow showers.
.WED...NW wind 40 kt. Seas 14 ft.
.WED NIGHT...NW wind 35 kt. Seas 12 ft.
.THU...NW wind 30 kt. Seas 12 ft.
.FRI...NW wind 25 kt. Seas 9 ft.

.SAT...NW wind 15 kt. Seas 11 ft.

$$

FZAK52 PAFC 311213
CWFALU

Coastal Waters Forecast
National Weather Service Anchorage Alaska
313 AM AKST Tue Dec 31 2019

Coastal Waters Forecast for Southwest Alaska+Bristol Bay+The
Alaska Peninsula Waters and the Aleutian Islands up to 100 nm out.

Wind forecasts reflect the predominant speed and direction
expected. Sea forecasts represent an average of the highest
one-third of the combined wind wave and swell height.

PKZ199-010045-
313 AM AKST Tue Dec 31 2019
.SYNOPSIS FOR SOUTHWEST ALASKA+BRISTOL BAY+THE ALASKA
PENINSULA WATERS AND THE ALEUTIAN ISLANDS...

A 974 mb low over Kodiak Island this morning will move inland
along the North Gulf Coast through Tue night then weaken through
Wed night. High pressure over the western Bering Sea will weaken
as a front moves into the Western Aleutians and Bering Sea Wed and
Wed night.

$$

PKZ150-010045-
South of the AK Peninsula Sitkinak to Castle Cape-
313 AM AKST Tue Dec 31 2019

...GALE WARNING THROUGH WEDNESDAY...
...HEAVY FREEZING SPRAY WARNING TONIGHT AND WEDNESDAY...

**.TODAY...W wind 30 kt becoming NW 40 kt in the afternoon. Seas
17 ft. Freezing spray.**
**.TONIGHT...NW wind 45 kt. Seas 21 ft. Heavy freezing spray. Snow
showers.**
**.WED...W wind 45 kt. Seas 21 ft. Heavy freezing spray. Snow
showers.**
.WED NIGHT...W wind 40 kt. Seas 16 ft.
.THU...NW wind 30 kt. Seas 12 ft.
.FRI THROUGH SAT...NW wind 30 kt. Seas 8 ft.

$$

PKZ155-010045-
South of the AK Peninsula Castle Cape to Cape Sarichef-
313 AM AKST Tue Dec 31 2019

...GALE WARNING THROUGH WEDNESDAY...

.TODAY...NW wind 40 kt. Seas 16 ft. Freezing spray. Snow showers.
.TONIGHT...NW wind 40 kt. Seas 16 ft. Freezing spray. Snow
showers.
.WED...NW wind 40 kt. Seas 14 ft. Freezing spray. Snow showers.
.WED NIGHT...NW wind 35 kt. Seas 12 ft.
.THU...NW wind 30 kt. Seas 12 ft.
.FRI...NW wind 30 kt. Seas 8 ft.
.SAT...NW wind 25 kt. Seas 7 ft.

$$

FZAK52 PAFC 312352
CWFALU

Coastal Waters Forecast
National Weather Service Anchorage Alaska
252 PM AKST Tue Dec 31 2019

Coastal Waters Forecast for Southwest Alaska+Bristol Bay+The
Alaska Peninsula Waters and the Aleutian Islands up to 100 nm out.

Wind forecasts reflect the predominant speed and direction
expected. Sea forecasts represent an average of the highest
one-third of the combined wind wave and swell height.

PKZ199-011300-
252 PM AKST Tue Dec 31 2019
.SYNOPSIS FOR SOUTHWEST ALASKA+BRISTOL BAY+THE ALASKA
PENINSULA WATERS AND THE ALEUTIAN ISLANDS...

Northerly flow across the Bering will continue through Thu
afternoon. A front moves into the western Aleutians Wed afternoon
and remains stationary through Thu afternoon.

$$

PKZ150-011300-
South of the AK Peninsula Sitkinak to Castle Cape-
252 PM AKST Tue Dec 31 2019

...GALE WARNING THROUGH WEDNESDAY NIGHT...
...HEAVY FREEZING SPRAY WARNING THROUGH WEDNESDAY NIGHT...

.TONIGHT...NW wind 45 kt. Seas 21 ft. Heavy freezing spray.
Widespread snow showers.
.WED...NW wind 45 kt. Seas 20 ft. Heavy freezing spray. Widespread
snow showers.
.WED NIGHT...W wind 40 kt diminishing to 30 kt after midnight. Seas
15 ft subsiding to 9 ft after midnight. Heavy freezing spray.
.THU...W wind 25 kt. Seas 9 ft.
.THU NIGHT...NW wind 30 kt. Seas 9 ft.
.FRI...NW wind 35 kt. Seas 8 ft.
.SAT...NW wind 30 kt. Seas 8 ft.
.SUN...N wind 25 kt. Seas 8 ft.

$$

PKZ155-011300-
South of the AK Peninsula Castle Cape to Cape Sarichef-
252 PM AKST Tue Dec 31 2019

...GALE WARNING THROUGH WEDNESDAY...

.TONIGHT...NW wind 40 kt. Seas 16 ft. Freezing spray.
.WED...NW wind 35 kt. Seas 13 ft. Freezing spray.
.WED NIGHT...NW wind 30 kt. Seas 10 ft. Freezing spray.
.THU...NW wind 35 kt. Seas 10 ft.
.THU NIGHT...NW wind 30 kt. Seas 8 ft.
.FRI...NW wind 35 kt. Seas 9 ft.
.SAT THROUGH SUN...N wind 25 kt. Seas 7 ft.

$$

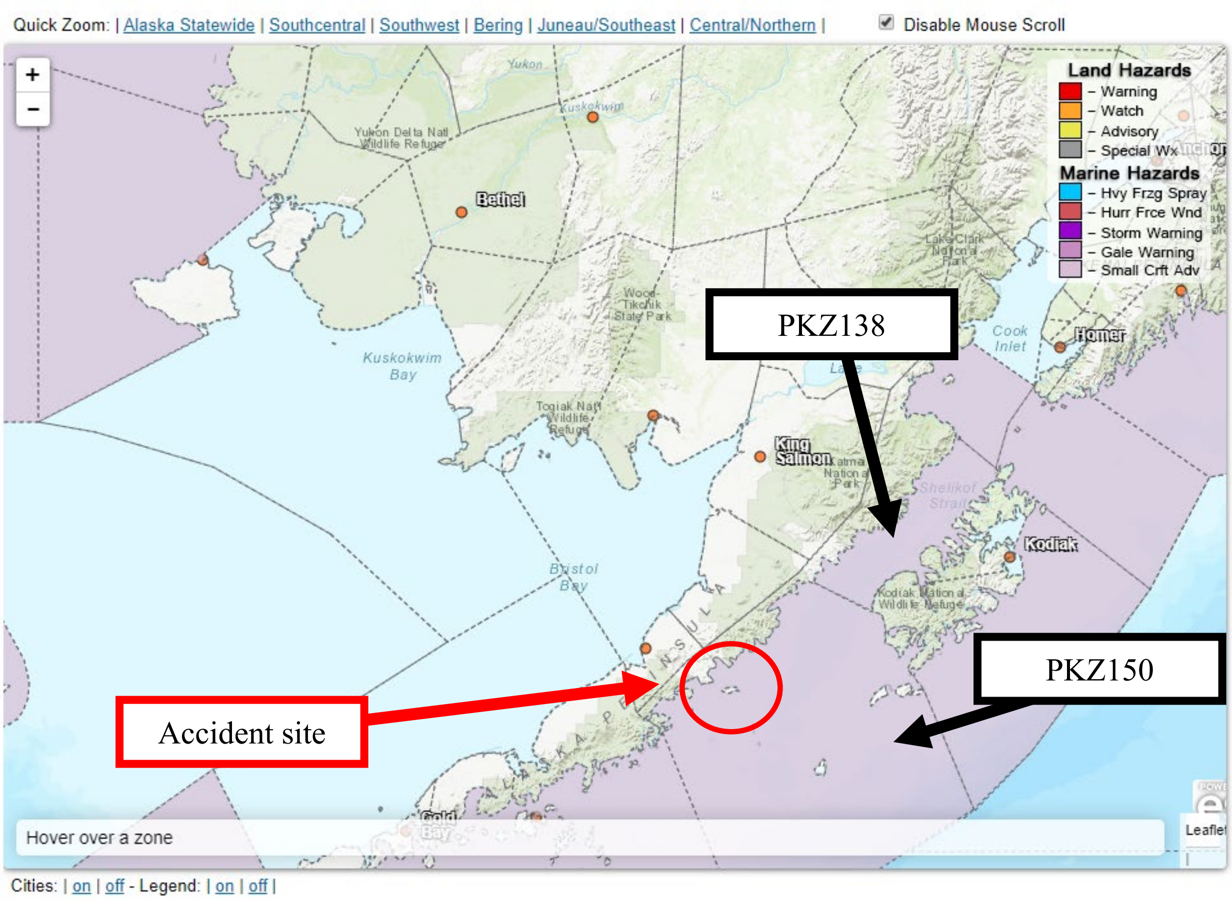

Figure 9 – Exemplar map PAFC forecast areas.

24-hour graphical marine forecasts were issued for the accident region and can be found below in figures 10 through 13. The 24-hour PAFC graphical marine forecast indicated a developing storm force low in the Gulf of Alaska with 35 to 45 knot winds near the accident site and heavy freezing spray and seas 9 to 18 ft.

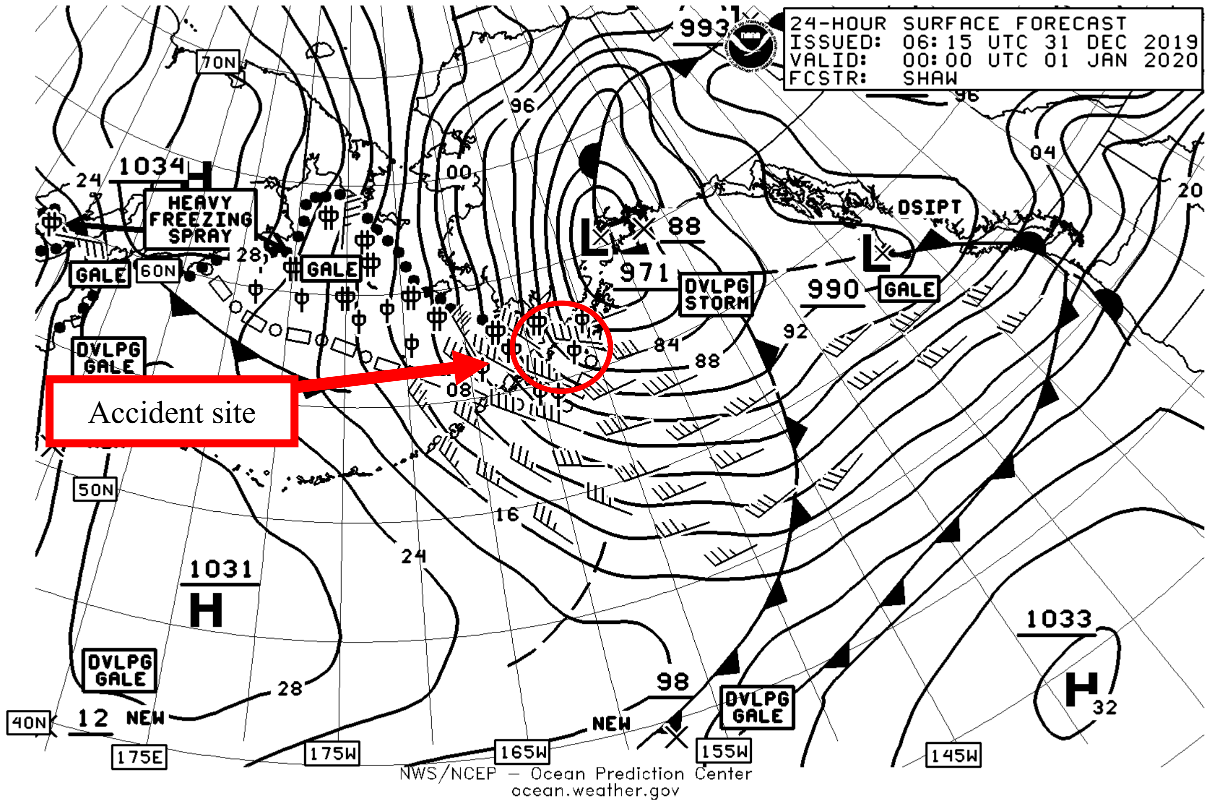

Figure 10 – PAFC 24-hour marine forecast issued at 2115 AKST on December 30 and valid at 1500 AKST on December 31.

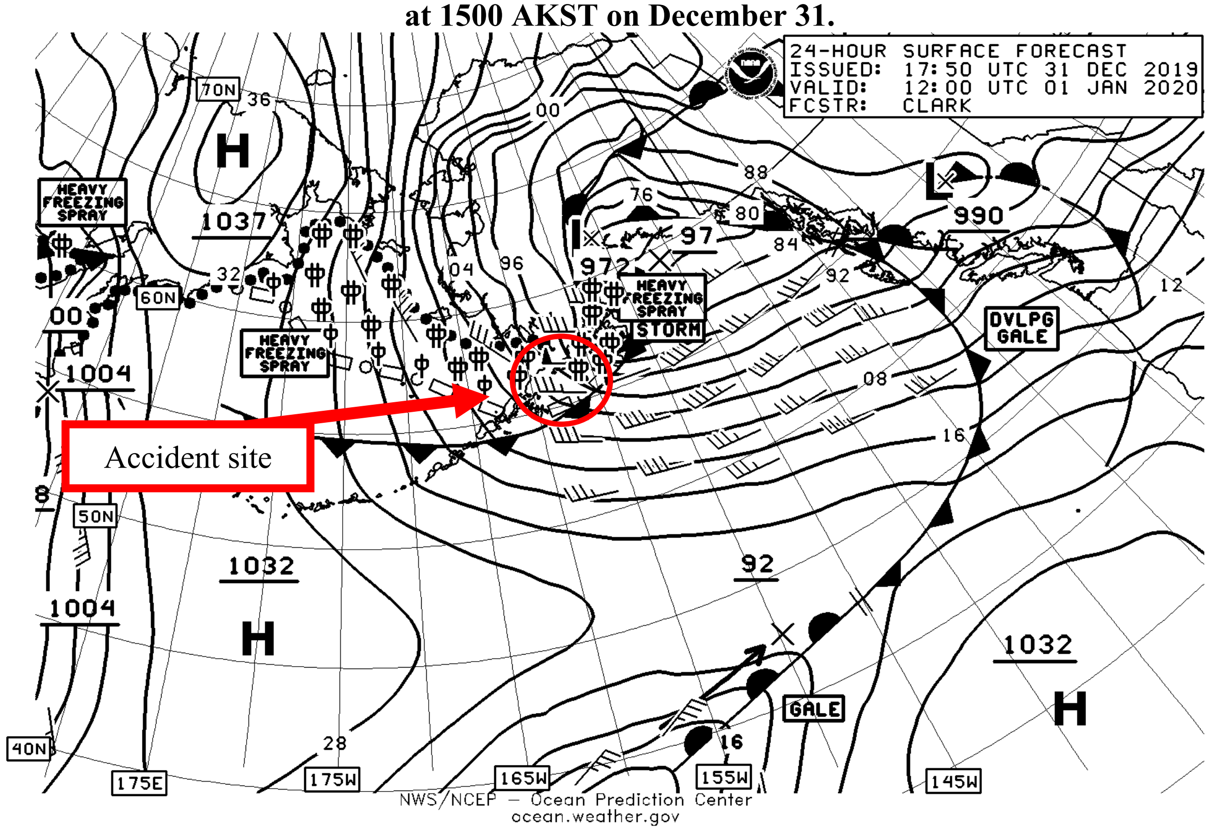

Figure 11 – PAFC 24-hour marine forecast issued at 0850 AKST on December 31 and valid at 0300 AKST on January 1.

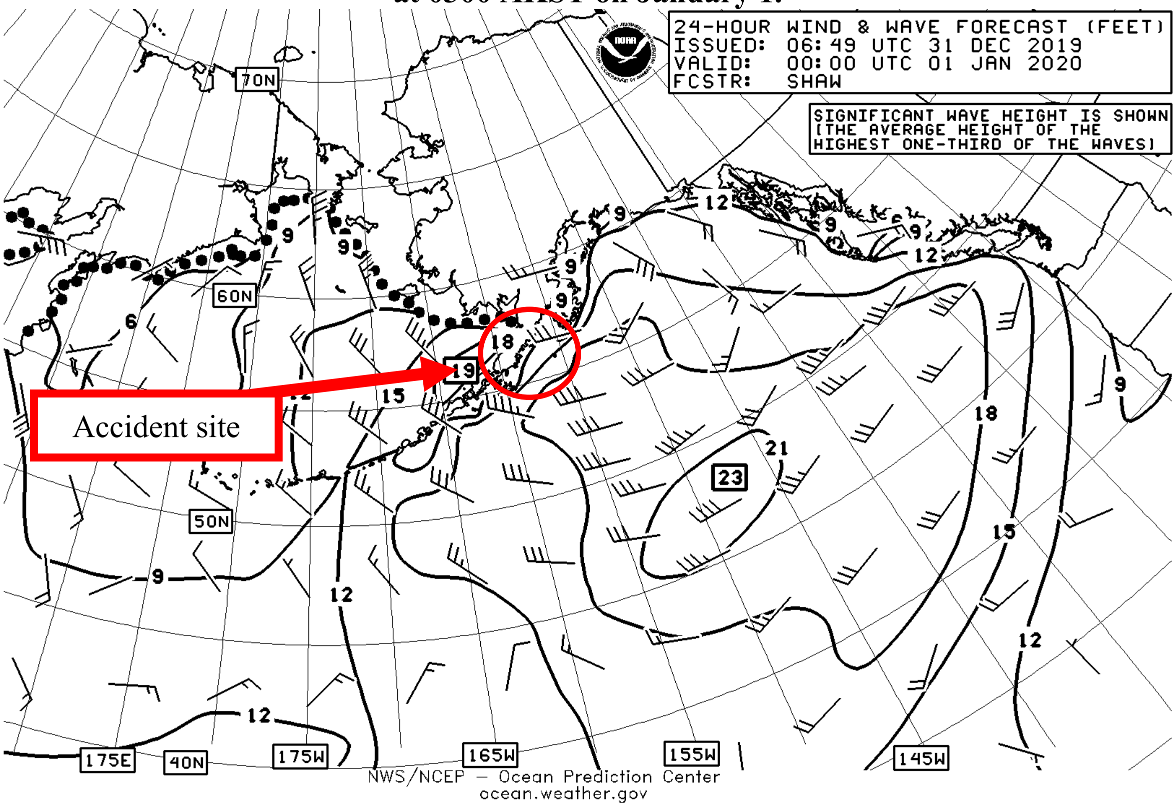

Figure 12 – PAFC 24-hour wind and wave forecast issued at 2149 AKST on December 30 and valid at 1500 AKST on December 31.

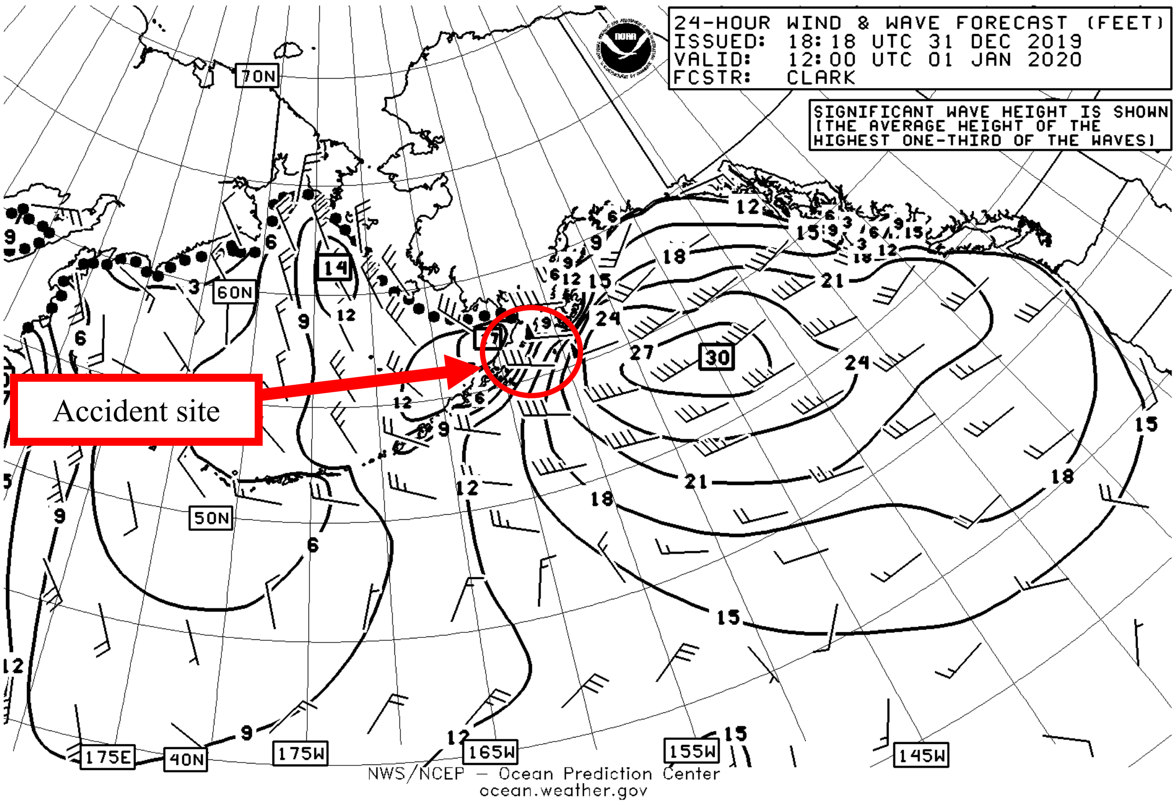

Figure 13 – PAFC 24-hour wind and wave forecast issued at 0918 AKST on December 31 and valid at 0300 AKST on January 1.

NWS Instruction (NWSI) 10-310[14] states that, "WFOs/WSO should include watch headlines when criteria are met for the second, third, or occasionally fourth and fifth periods, 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[15] for events that begin in the second, third or fourth periods when forecaster confidence is high." The weather computer text formatters[16] 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. For more information please see current NWSI 10-310 and NWS 10-303[17] policy.

[14] http://www.nws.noaa.gov/directives/sym/pd01003010curr.pdf , accessed January 2021.
[15] Headlines to include:
Hurricane Force Wind Warning,
Storm Warning,
Gale Warning,
Heavy Freezing Spray Warning,
Ashfall Warning,
Hazardous Seas Warning (Optional)
[16] Part of the process in which NWS forecasters make the official weather products.
[17] http://www.nws.noaa.gov/directives/sym/pd01003003curr.pdf

The NWS uses NOAA Weather Radio (NWR) as another avenue for mariners to receive weather forecast and weather observation information. The weather information is broadcast using very high frequency (VHF) transmitters on certain frequencies[18]. The NWS forecast information would have been available to the accident captain from the time of departure through the Middle Cape (WZ2556, figure 14) area, or about 1200 AKST on the accident day. The NWS forecast information (pages 18 to 24) valid for the accident time would have been made available on the NWR within the NWR coverage areas (figure 14) within 10 minutes (or less) of forecast issuance time. The majority owner of the accident vessel and a family member to the accident captain stated that the accident captain had access to and used a VHF radio to receive NWR information. For more information please see the docket for this accident.[19]

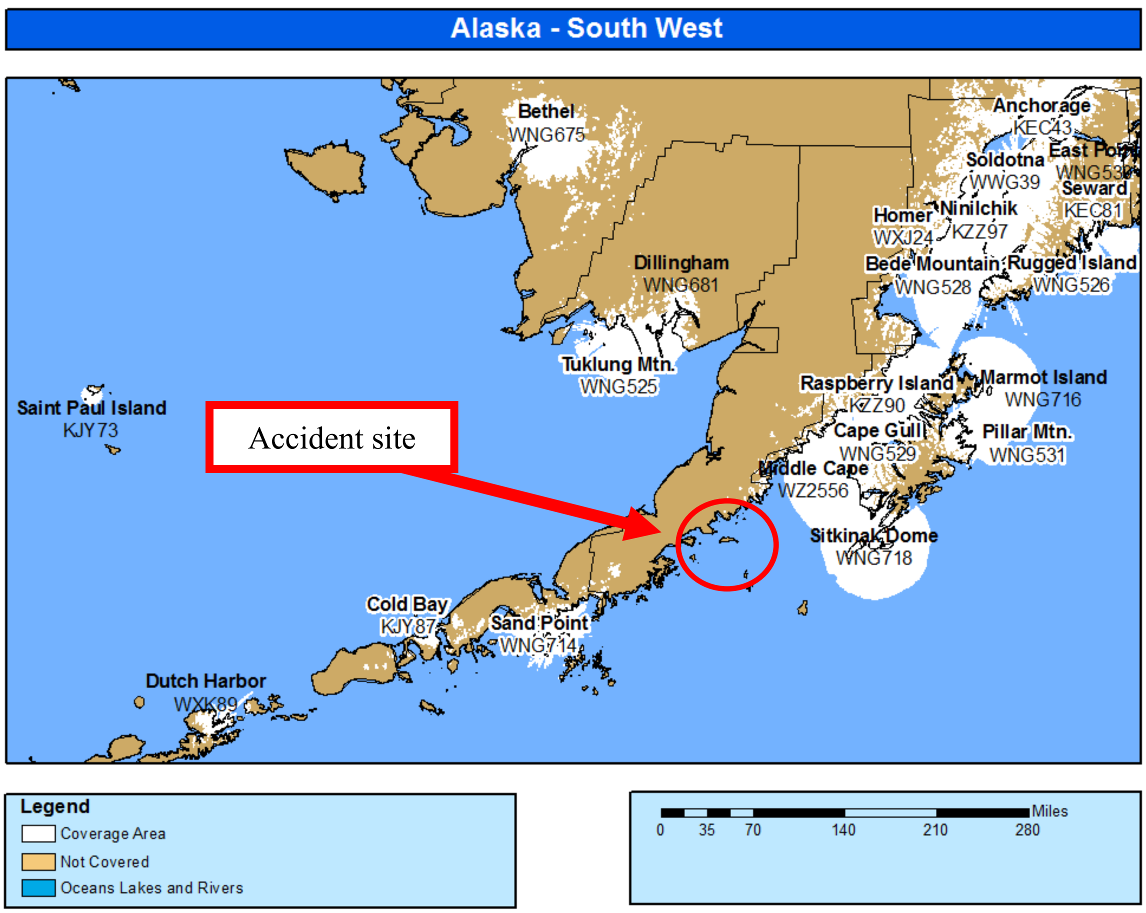

Figure 14 – NWR coverage area across southern Alaska valid at the accident time.

[18] https://www.weather.gov/nwr/nwr_receivers
https://www.weather.gov/nwr/stations?State=AK

[19] Please see the interview and USCG MBI transcripts located in the docket of this investigation.

7.0 Marine Information

Surface sea current data was retrieved from the Hybrid Coordinate Ocean Model (HYCOM) Global NCEP weather model for 1800 and 2100 AKST on December 31 and 0000 AKST on January 1 around the accident area (figures 15, 16, and 17). The HYCOM surface sea current data indicated that at 1800 AKST the surface sea current was from the north-northwest between 0.67 and 1.11 knots at the accident site (figure 15). At 2100 AKST the surface sea current was from the north-northwest between 0.89 and 1.33 knots at the accident site (figure 16). At 0000 AKST on January 1 the surface sea current was from the north between 0.89 and 1.33 knots at the accident site (figure 17).

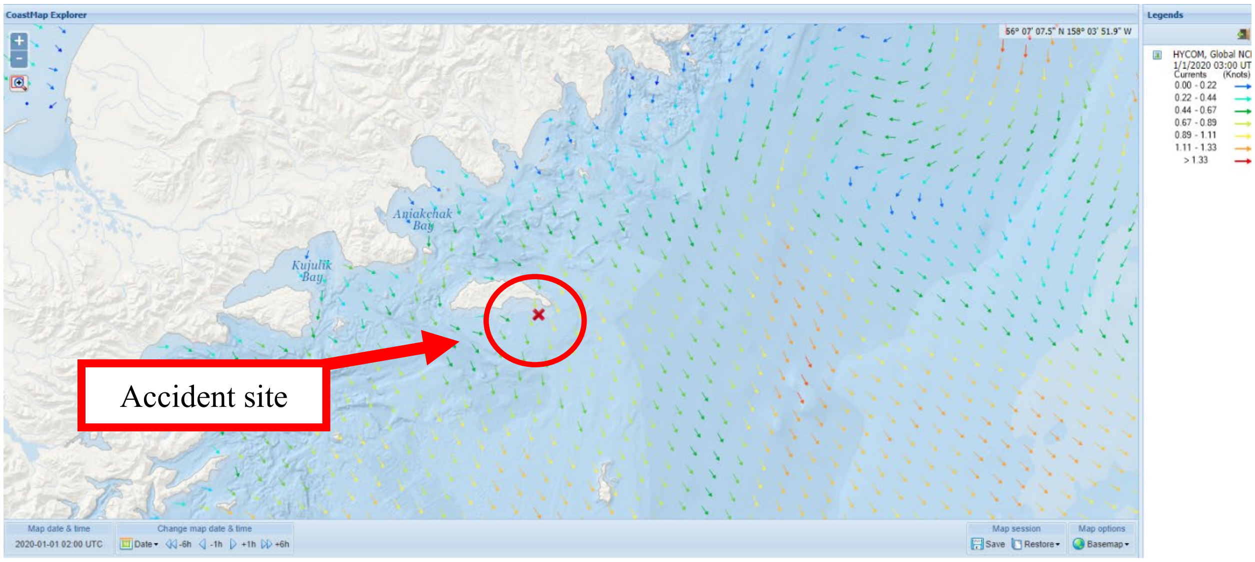

Figure 15 –HYCOM Global NCEP weather model surface sea current data valid at 1800 AKST.

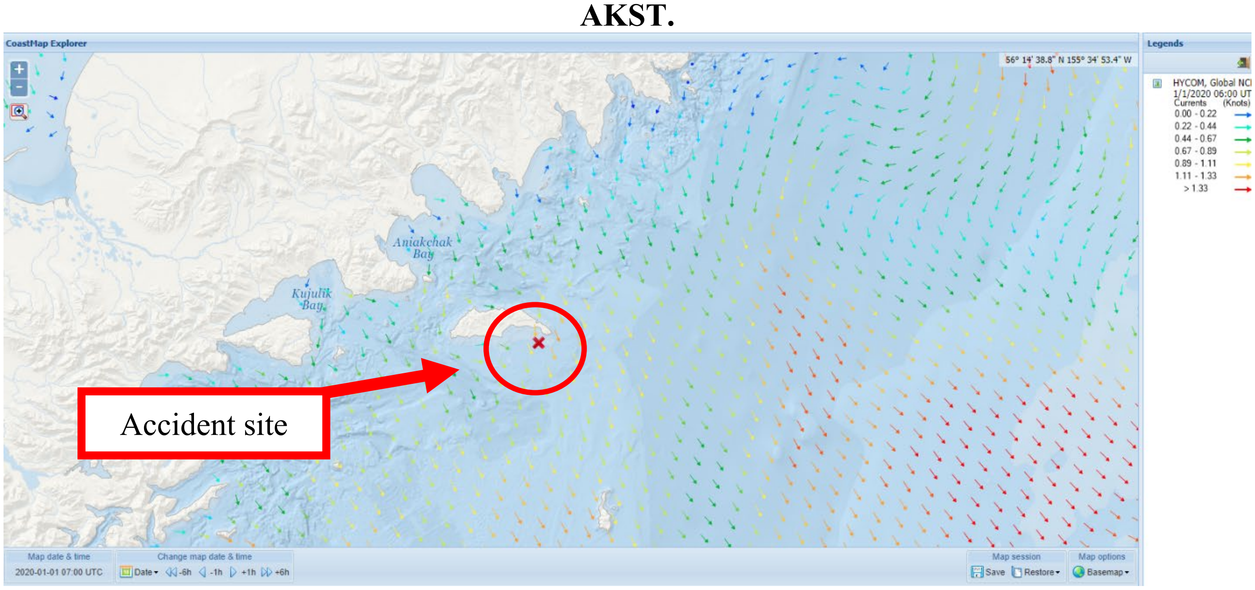

Figure 16 –HYCOM Global NCEP weather model surface sea current data valid at 2100 AKST.

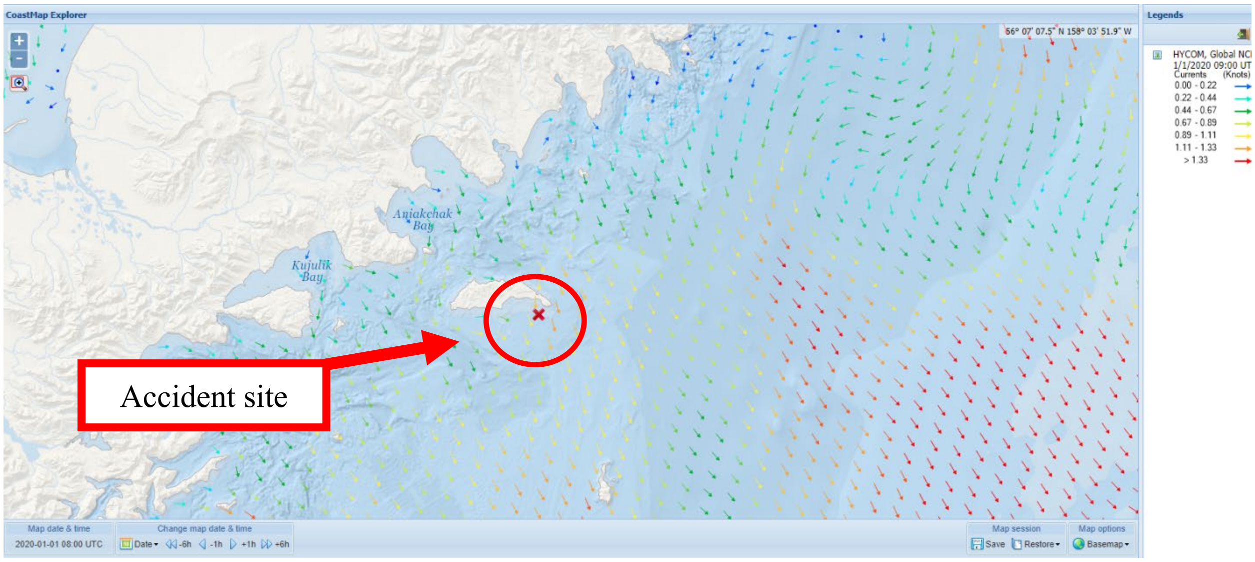

Figure 17 –HYCOM Global NCEP weather model surface sea current data valid at 0000 AKST January 1.

Additional weather model surface wind data were retrieved from the North American Mesoscale (NAM) Alaska 6-km weather model for the accident region (figures 18, 19, and 20). The NAM Alaska 6-km wind data indicated at 1800 AKST that the wind was from the northwest at 30 to 35 knots (figure 18) and the wind increased to 30 to 40 knots by 0000 AKST on January 1 (figure 20) for the accident site.

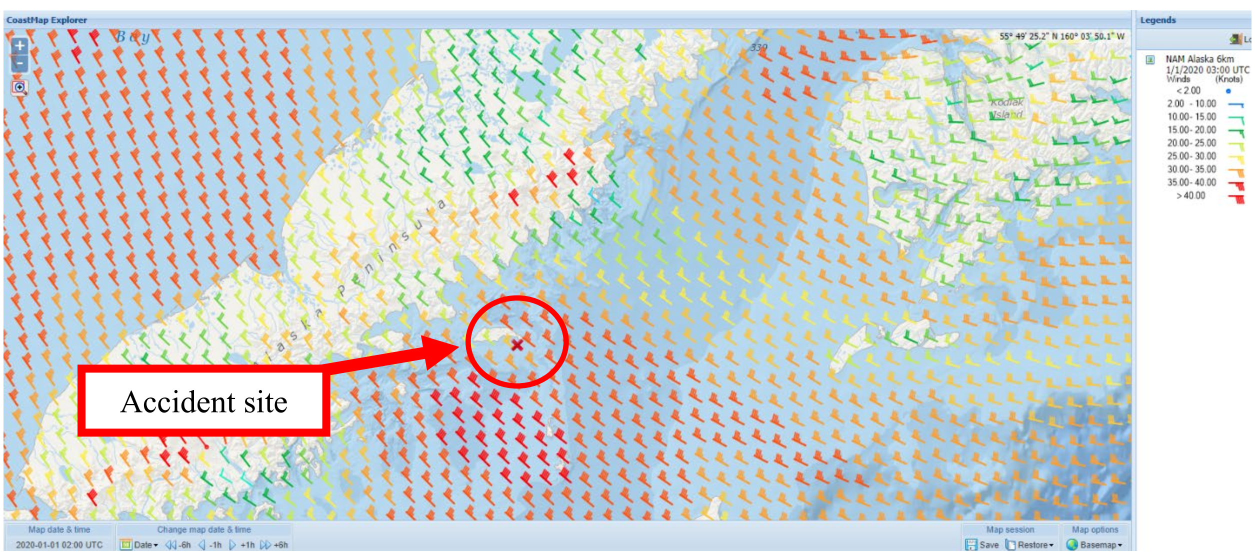

Figure 18 – NAM Alaska 6-km weather model wind data valid at 1800 AKST.

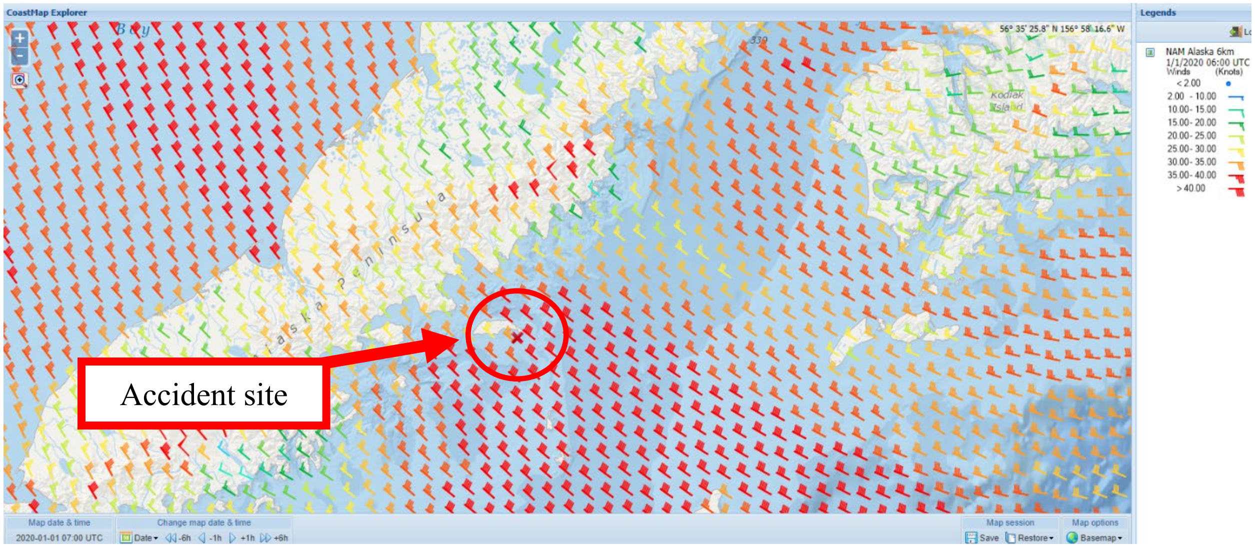

Figure 19 – NAM Alaska 6-km weather model wind data valid at 2100 AKST.

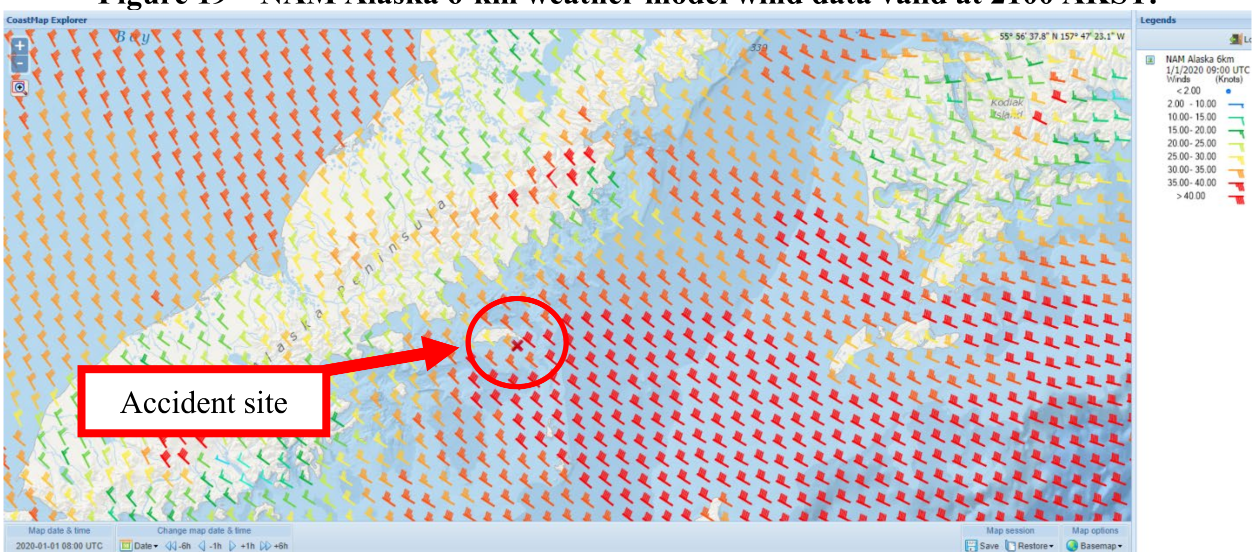

Figure 20 – NAM Alaska 6-km weather model wind data valid at 0000 AKST January 1.

8.0 Sea Spray Icing information

Sea spray icing has long been a serious hazard to marine vessels[20]. To estimate the amount of sea spray ice accretion Overland (1990)[21] (attachment 4) developed an algorithm that is currently being used by NWS Alaska to forecast situations of freezing spray and heavy freezing spray.[22] 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 21 and 22 for sea surface water temperatures of 4.0°C and 6.0°C, respectively. Additional charts can be found at: http://www.vos.noaa.gov/MWL/dec_05/ves.shtml, https://www.met.nps.edu/~psguest/polarmet/vessel/predict.html, and in attachments 4 and 9. Additional algorithms to determine sea spray ice accretion on marine vessels have been developed in the scientific community and summaries of these algorithms can be found in attachments 5, 6, 7 and 8.

NWS Alaska provided the daily sea surface analysis graphics for December 31 and January 1 (figures 23 and 24). The daily sea surface analysis graphics indicated that colder sea surface temperatures were located at the accident site on January 1, 2020.

[20] https://www.met.nps.edu/~psguest/polarmet/vessel/description.html

[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

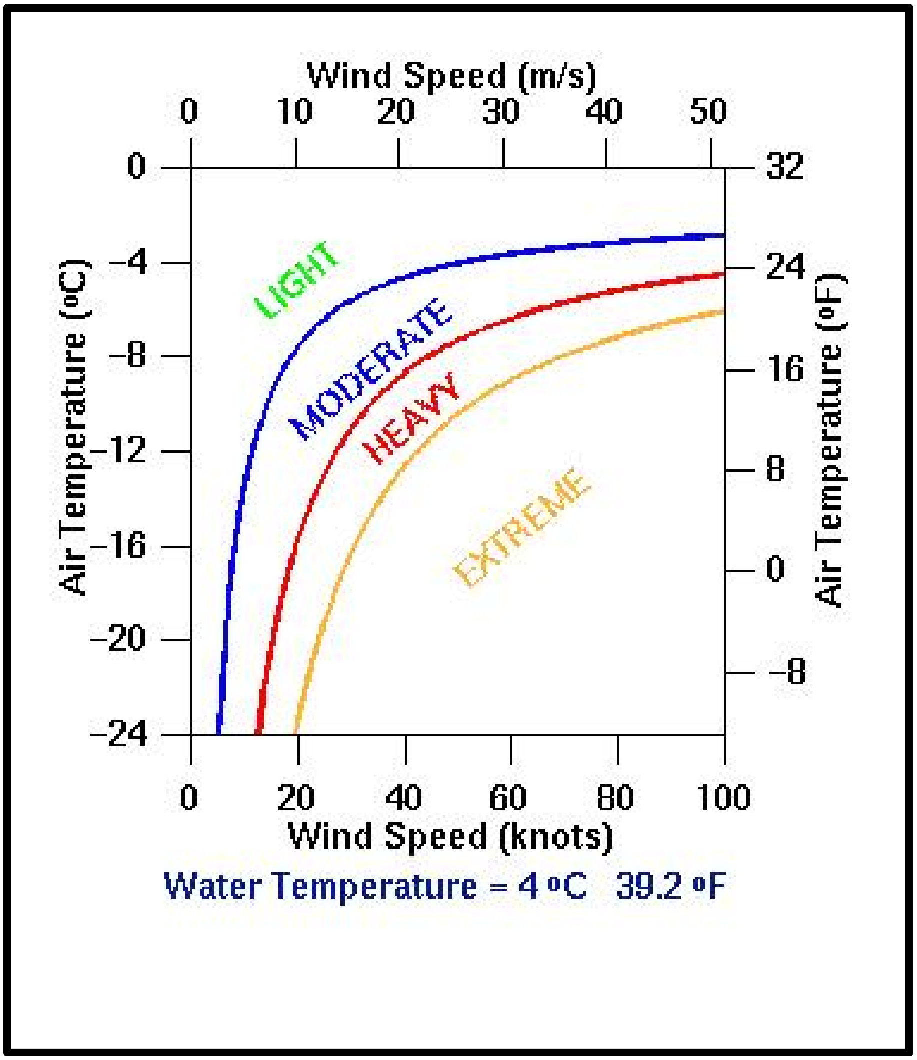

Figure 21 – Overland (1990) sea spray ice accretion potential for water temperature of 4.0°C.

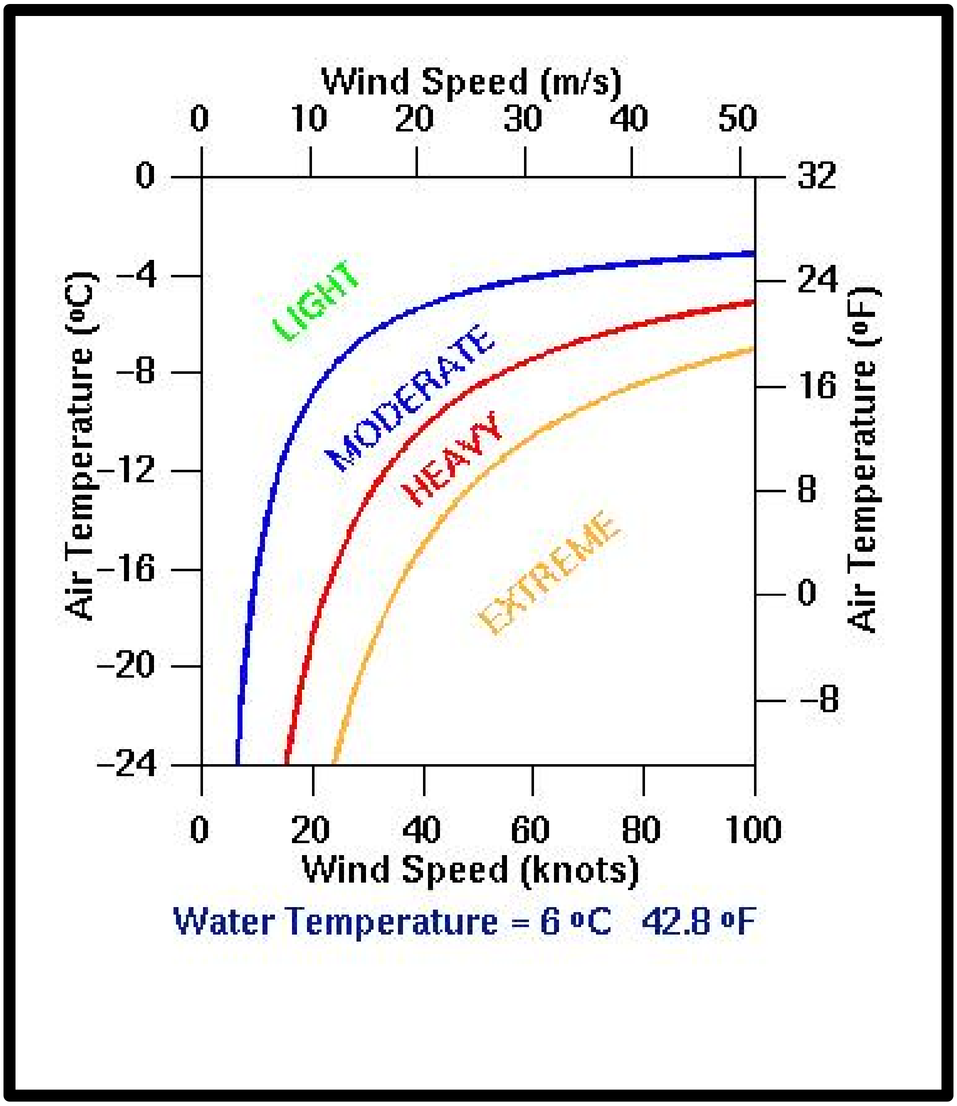

Figure 22 – Overland (1990) sea spray ice accretion potential for water temperature of 6.0°C.

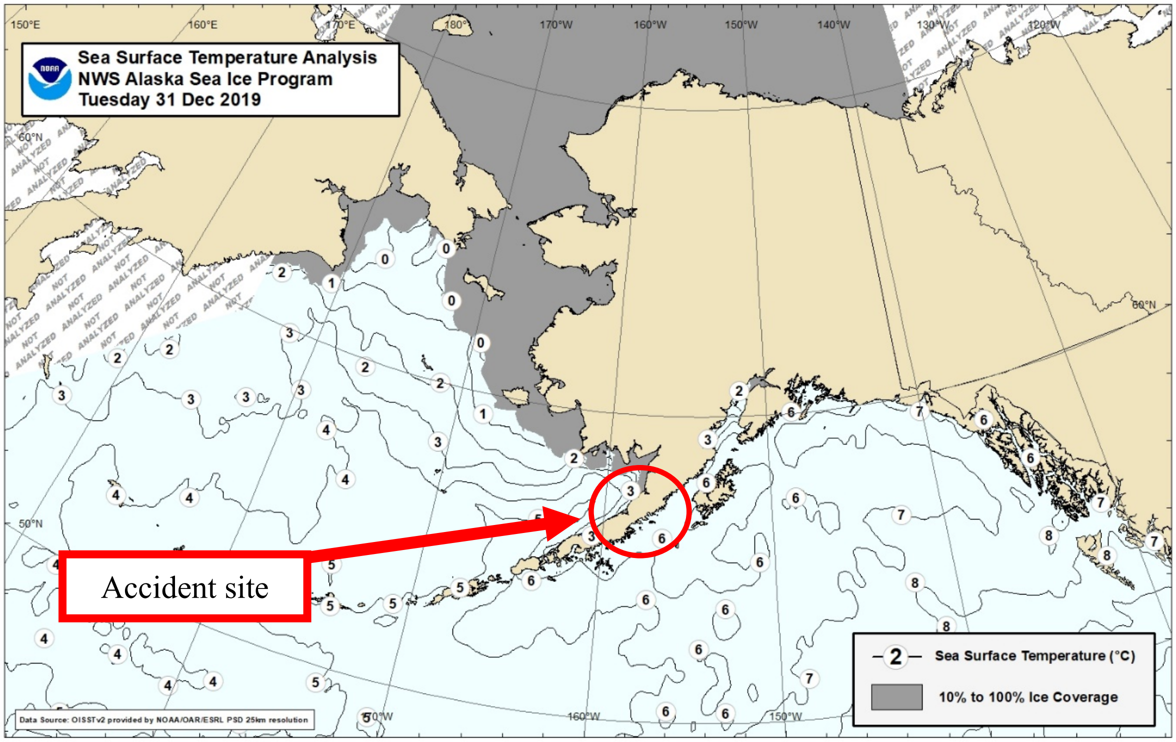

Figure 23 – NWS Alaska sea surface temperature analysis for December 31.

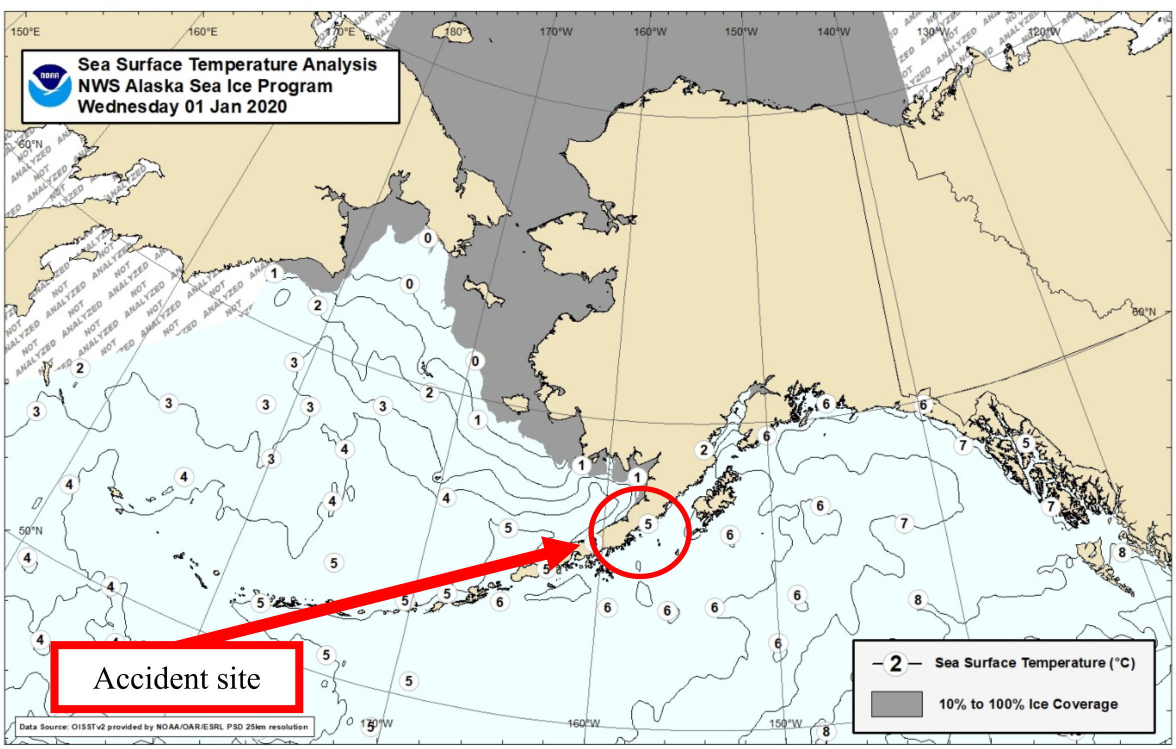

Figure 24 – NWS Alaska sea surface temperature analysis for January 1.

OPC has developed an Experimental Freezing Spray Guidance website (https://ocean.weather.gov/icing_rates/index.php?area=ak&fhour=012) which provided 12, 24 and 36 hour icing rate (in cm/hr) forecasts using both a modified Overland algorithm and the Stallabrass[23] sea spray icing rate algorithm. This website was available at the time of the accident, but the investigation was unable to retrieve the imagery and forecast information valid around the accident time. This website and experimental sea spray guidance imagery was made available around 2014 with the NWS' target audience for the website consisted of both internal and external users.[24]

9.0 Significant Wave Height[25]

The standard ocean wave forecast set forth by the World Meteorological Organization (WMO) states that the countries responsible for the weather forecasts 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 northern Pacific Oceans. NWS Weather Forecast Offices (WFO)s are responsible for NOAA forecasts for coastal regions (which include the Bering Sea). 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 25 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 ft, the mean wave height encountered by a vessel for that wave spectrum would be 12.8 ft with the most probable wave height encountered of 12 ft. However, the highest 10 percent of waves within that wave spectrum would be 25.4 ft and the highest one percent of waves would be around 33.4 ft high. The highest wave a vessel could encounter with a significant wave height of 20 ft would be 40 ft. From the PAFC marine forecast for the accident site with seas[26] of 21 ft forecast, the highest wave heights the accident vessel could have expected would have been 42 ft with most of the waves encountered around 12.6 ft high (section 6.0). Buoy 46077 located in Shelikof Strait (figure 4) indicated that seas of 8.4 to 9.2 ft were present around the accident time. The highest wave height possibly encountered near buoy 46077 would have been around 18.4 ft with most of the wave heights around 5.5 ft at the accident time.

[23] https://rmets.onlinelibrary.wiley.com/doi/10.1002/qj.3174
[24] Please see the interview and USCG MBI transcripts located in the docket of this investigation.
[25] http://www.vos.noaa.gov/MWL/apr_06/waves.shtml
[26] Seas = significant wave height

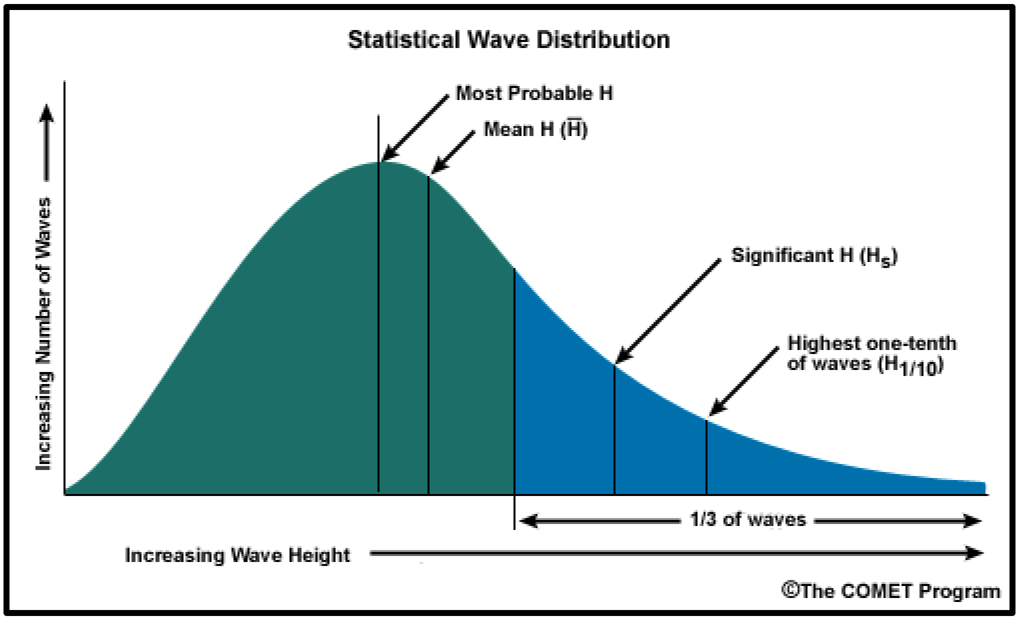

Figure 25 – Typical statistical wave distribution.

10.0 Captain's Weather Information

Before departure from Kodiak the accident captain mentioned to Deckhand 2 that the accident vessel would be going into icing conditions. Deckhand 2 mentioned that all the crew members including the accident captain knew the weather was going to be bad and the crew members and accident captain discussed the weather conditions prior to departure from Kodiak. Deckhand 2 mentioned that the accident captain viewed weather information prior to departure on the Windy app[27]. At the USCG MBI the vessel manager mentioned that the accident captain had direct links on his computer desktop (located on the bridge of the accident vessel) to both NWS Alaska information and the Windy.com application and checked weather information frequently. For more information please see the docket for this accident.[28]

11.0 Witness Information and Images[29]

Interviews were conducted with the survivors of the accident vessel and their comments related to the weather and sea conditions around the accident time and voyage are summarized below. Deckhand 2 stated, "…everybody has a Windy app. We knew it was going to like purple, so yeah…". Deckhand 2 stated that during his first watch on the accident day between 0800 and 0900 AKST, the weather had picked up from the previous night with ice building on the pots, seas 10 to 15 ft and building, and the accident vessel did not have a list. Around 1915 AKST on the accident day after being on watch, Deckhand 2 woke up the accident captain (for the captain's 2000 AKST watch) and Deckhand 2 shared with the captain that there was a 2 degree list and ice was continuing to build on the pots and boat. The accident captain stated to Deckhand 2 that the weather was too bad for the crew to go out and break ice, but that the accident captain said they would wait until

27 https://www.windy.com/
28 Please see the interview and USCG MBI transcripts located in the docket of this investigation.
29 For more information please see the USCG MBI transcripts.

they found protection after which point they could break ice. Deckhand 2 mentioned that he had the Windy app and he viewed the information using the default layer application. He stated he was not familiar with the NWS forecast marine zone similar to figure 9. He stated that he would stay updated on the weather during his wheel watch by viewing the weather conditions outside the boat and referencing the accident vessel's barometer. At the time of the accident, Deckhand 2 estimated the wind as gusting to 50 to 60 miles per hour (mph) and 30 ft seas with icing conditions.

Deckhand 1 stated that icing was present on both wheel watches he took on December 31 with worse icing on the second wheel watch in 15 to 20 ft seas.[30] Deckhand 1 was monitoring the NWS weather forecast and information via VHF during his wheel watches.

Interviews were conducted pertaining to this investigation and additional information was received at the USCG MBI in February and March 2021 and the interviews are summarized below for weather and sea information surrounding the accident time and accident voyage.

F/V PACIFIC SOUNDER

The captain of the *F/V PACIFIC SOUNDER* stated that the accident captain called him around 2100 to 2130 AKST December 31. The captain of the *F/V PACIFIC SOUNDER* stated the accident captain said the accident vessel was heading for Sutwik Island to break ice, it was blowing 60 to 70 knots, was 12°F, the accident vessel had a 20-degree list to the starboard side, and that the accident vessel was icing really bad. During the accident timeframe, the captain of the *F/V PACIFIC SOUNDER* stated that his crew was breaking ice off the *F/V PACIFIC SOUNDER* at their location north of the Alaskan Peninsula (attachment 19) with up to a half of a foot of ice on various parts of the vessel. It took 2 hours to clear all the ice off the vessel at that time with a 45 knot northwest wind and 15 to 20 ft seas. The captain of the *F/V PACIFIC SOUNDER* heard the weather report around 0600 AKST on December 31 for worsening weather conditions and started setting pots around 0900 AKST to avoid the accumulation of ice at their location north of the Alaskan Peninsula. By the time the captain of the *F/V PACIFIC SOUNDER* had set all their pots on December 31 (around 2100 AKST) they were in heavy freezing spray conditions. The captain of the *F/V PACIFIC SOUNDER* stated that the area around Sutwik Island and west of Kodiak Island is known to get bad weather in northwest through north winds with cold air moving off across the Alaskan Peninsula. The captain of the *F/V PACIFIC SOUNDER* also mentioned that "Pretty much we all use Windy app".

F/V RUFF N REDDY

The captain of the *F/V RUFF N REDDY* stated that during the early morning of December 31 they were getting weather in between Sutwik Island and Nakchamik Island and as they were travelling southwesterly, they continued towards and sheltered behind Nakchamik Island and dropped anchor around 0500 AKST on December 31. In between Sutwik and Nakchamik Islands is when the *F/V RUFF N REDDY* started to accumulate ice in 25 to 30 knot northwest winds in between 0100 and 0500 AKST on December 31. The *F/V RUFF N REDDY* dropped anchor about 0.1 miles in the lee of Nakchamik Island with a maximum of a half inch of ice on the rails in snow conditions with heavy northwest winds and gusts. Around the time of the accident while the boat

[30] Please see the interview and USCG MBI transcripts located in the docket of this investigation.

was in the lee of Nakchamik Island, the captain of the *F/V RUFF N REDDY* stated they were experiencing northwest wind of 40 knots with heavier gusts with seas 1 foot or less and no building seas. The captain of the *F/V RUFF N REDDY* stated he uses the Windy app to review wind and sea height conditions and finds it more accurate than the NWS due to the finer scale details in the graphics and has been using the Windy app for 7 years. The captain of the *F/V RUFF N REDDY* has had no formal training on weather forecast or use of Windy app, just experience as a vessel captain, and use of the Windy app over time. The captain of the *F/V RUFF N REDDY* stated that he checks the Windy app via phone while in port (with internet service) and checks NWS weather information via VHF if within range. In addition, the captain of the *F/V RUFF N REDDY* while underway will call other captains that have the Windy app to request and discuss Windy app graphical weather information. The captain of the *F/V RUFF N REDDY* stated that on the Windy app he uses the wind, wind gusts, and waves layers and he does not use the "weather warnings" layer. The captain of the *F/V RUFF N REDDY* stated that the OPC Experimental Freezing Spray Site (section 8.0) would be a helpful tool to use as he reviews weather information.

F/V WESTERN MARINER

The captain (at the time of the accident) of the *F/V WESTERN MARINER* stated that he reviews the weather via the Windy app on his phone, the NWS forecast both via website and VHF, and looks at additional weather charts. On the Windy app, he used the wind and wave height overlays, and he had not used the "weather warnings" overlay. He will request and discuss weather conditions with other captains throughout his voyages. They used to pass weather information and reports to the NWS via satellite phone or sideband radio, but rarely pass weather information along now. The captain of the *F/V WESTERN MARINER* stated that the OPC Experimental Freezing Spray Site (section 8.0) would be a helpful tool to use as he reviews weather information as he stated they use any weather information they can get their hands on. He finds that when the NWS Alaska redid their webpages a few years ago that the NWS Alaska webpages are more difficult to navigate now. The area around Sutwik Island has some of the "worst icing he has ever seen in his life." He would like to see more weather observation sites or buoys near Sutwik Island and southwest of Kodiak Island as Buoy 46077 and Buoy 46078[31] are not representative of the weather conditions near Sutwik Island or southwest of Kodiak Island especially with a northwest or northeast wind.

F/V HANDLER

The captain of the *F/V HANDLER* stated he uses the NWS weather information and the Windy app for his weather with the Windy app "being entirely more accurate." He views the Windy app information via his phone and is able to check that Windy app information while enroute due to broadband internet connection. While viewing Windy app information he uses the wind, wave height, and temperature overlays and has set his Windy app user preferences to be alerted if a weather warning is issued for his user preference set locations and believes he receives those weather warnings in a timely manner. When the *F/V HANDLER* departed Kodiak Island on December 29 they experienced light winds and the next day while in Shelikof Strait enroute to Dutch Harbor they experienced south winds 25 knots with "the weather coming up quickly" by

[31] https://www.ndbc.noaa.gov/

1330 AKST on December 30. The wind became more northerly during the rest of the voyage to Dutch Harbor.

F/V NEW VENTURE

The captain of the *F/V NEW VENTURE* stated he uses the Windy app on his phone for review of wind information and uses NWS weather information via VHF and reviews the NWS zone forecast information for the seas information. He also used to receive the NWS zone text forecast via Garmin. He uses the Windy App to view more detailed graphical wind information than the more general wind information found in the NWS zone forecast. He will also call and asks other vessels for weather information. Around the time of the accident, the captain of the *F/V NEW VENTURE* recalled winds 25 knots with no icing conditions at their location (attachment 19). The *F/V NEW VENTURE* just received Fleet One[32] and is able to view PredictWind[33] on the computer in the wheelhouse. On the Windy app the captain of the *F/V NEW VENTURE* uses the wind and wind gusts overlays along with the cloud height. The captain of the *F/V NEW VENTURE* stated that the OPC Experimental Freezing Spray Site (section 8.0) would be a helpful tool to use as he reviews weather information. He does pass icing information along to other vessels, but does not pass along icing information to the NWS as he does not directly communicate with them.

F/V ALEUTIAN MARINER

The chief engineer of the *F/V ALEUTIAN MARINER* stated he uses the VHF for weather information along with the Windy app and the Windy app has become his "go-to" source for weather information. He views the Windy app information via his phone and finds the option to select exact location for weather information with graphics of wind, wave, and swell height useful. He will occasionally look at the NWS site if he has his tablet out and will discuss and request weather information from other vessels. On the Windy app the chief engineer of the *F/V ALEUTIAN MARINER* also uses the snow prediction information overlays for land based recreation activities. He has viewed the "weather warnings" overlay on the Windy App, but already knows there is a weather warning because he has heard that on the VHF. He finds the Windy app interface easier to use than the NWS webpages.

F/V AMATULI

The captain of the *F/V AMATULI* provided the vessel logs including weather information from December 26 through December 31 (attachment 20) which included the voyage time between Kodiak Island and Dutch Harbor (attachment 19). In the vessel logs (attachment 20) on the morning of December 30 a north wind of 40 to 45 knots is noted as the *F/V AMATULI* was located near Ukolnoi Island as indicated by the latitude and longitude in the vessel logs. The captain of the *F/V AMATULI* stated he would receive weather information via Fleet One and also have the vessel manager send him the latest weather information via email or text message. He would monitor the weather trends via his vessel's barometer and receive weather warning information via VHF when within range. He has the Windy app on his phone but uses the application more down in the Seattle area, rather than when fishing along the Aleutians. The captain of the *F/V AMATULI* stated that

[32] https://www.inmarsat.com/en/solutions-services/maritime/services/fleet-one.html
[33] http://www.globalmarinenet.com/product/predictwind/

the *F/V SCANDIES ROSE* had internet and the accident captain could pull up weather information while enroute.

USCG Search and Rescue Mission Coordinator (SMC)

The USCG SMC stated they have a ForeFlight available for weather information, but that the weather information is not updated in flight. Alaska Flight Service is another source of weather information used. The USCG SMC stated he wished there was more weather observation information in the area of the accidents site.

USCG Air Station Kodiak helicopter pilot

The USCG Air Station Kodiak helicopter pilot stated that during the search and rescue mission (SAR) for the survivors, their helicopter flight went to the north side of Kodiak island and the weather conditions were worse than what they thought they would be. The weather had cloud ceilings at 300 ft above ground level (agl), a half mile visibility to no visibility and strong headwinds. The headwinds caused severe turbulence with multiple downdrafts that took both pilots to keep helicopter flying as level as possible. The turbulence was so severe the USCG SAR helicopter pilots had to slow the flight down. The USCG Air Station Kodiak helicopter pilot stated this flight was the most challenging flight of his career. It was blowing snow and turbulent the whole way and they flew at 200 ft agl most of the way so they could see the ocean. As they approached the accident scene the visibility improved to 2 miles. They stayed at a 60 ft hoover and noted that seas were 30 ft. The freezing spray was so bad they had to de-ice the rescue swimmer in between hoists. The USCG helicopter pilot heard the C-130 aircraft on scene when the helicopter was hoisting up the first survivor and the C-130 was able to confirm the good visibility conditions back in Kodiak. They flew in cold conditions and while doing the rescue there was ice on the deck of the helicopter. The pilot used the Windy app and ForeFlight in preflight weather review and reviewed the Windy app weather information on his phone. He prefers the Windy app information because it gives a visual representation of the winds and the winds close to the surface. They USCG Air Station Kodiak helicopter pilot stated ForeFlight does not have surface winds, but winds from 1,000 ft and above. The Foreflight information was available on the helicopter pilot's iPad. The winds were stronger on scene than what the Windy app showed before departure. The pilot noticed icing on the fuel tank after landing back in Kodiak. The night vision googles made it difficult to have forward visibility in the snow and created an effect termed the "star wars effect". Due to this effect the pilots remained on instruments for the duration of the flight. The pilot finds the most helpful weather information during the daytime is the FAA weather cameras located around Alaska.

USCGC MELLON

Figure 26 was taken from the *USCG CUTTER (USCGC) MELLON* during the search of the accident site on the afternoon of January 1 with icing present on the vessel. The captain (at the time of the accident) of the *USCGC MELLON* stated they arrived on scene around 1615 AKST on January 1, and stopped the search pattern to break ice because the captain wanted to make sure and break ice before dark. They had 2 to 3 inches of solid ice on the deck from voyage from Beaver Inlet (started at 2326 AKST on December 31) all the way to 1615 AKST on January 1 (attachment

21). The icing built up on the ship asymmetrically and they had to steer 40 degrees off track line to maintain search lines (attachment 21). During the search there was a 30 knot wind with 6 ft seas as they were traveling at 6 knots. As captain of the *USCGC MELLON* he viewed weather information via the Windy app through the internet (but at dial-up speeds). In addition, the captain viewed NWS information but the NWS marine forecast and areas are too large to provide helpful information. The Windy app provides more detailed information. They had weather equipment onboard the *USCGC MELLON* and took weather logs regularly and transmitted that weather information to the NWS. He stated the worst icing conditions experienced during his career were in the Shelikof Strait while on the *USCGC HICKORY*. For more information please see the docket for this accident.[34]

Figure 26 – USCG Mellon with icing on the vessel during the afternoon of January 1, 2020.

[34] Please see the interview and USCG MBI transcripts located in the docket of this investigation.

12.0 Additional Weather Technological Information

Further information was retrieved about the Windy app, as well as similar sources of information such as Buoy Weather[35], Windfinder[36], and Ventusky[37]. Applications such as Windy.com provide users weather information in graphical format from weather model data sources using different interfaces and layers. A Windy.com representative stated the default layer of the Windy app is weather computer model wind information. On Windy.com a user can select different weather models, locations, and times (attachment 11). Windy.com information is available via iOS[38] app and Android as well as standard computer interface. For the weather model specific data the user has to select a specific point on the map and then when that dataset is loaded it will provide the user with information on when that weather model was last updated. There is no human in the loop for the weather information except for a layer on Windy.com indicated as "Weather warnings". This weather warning layer on Windy.com takes individual country's (including the United States') Common Alerting Protocol (CAP)[39] human-initiated warnings and advisories and displays the warning or alert areas usually within 30 minutes of the weather warning issuance.[40] The CAP information is freely accessible and the coloring or display layer information of the CAP alerts is determined by individual applications or users. The CAP information has different versions. Currently most of the NWS is using CAP version 1.2 and version 1.2 of CAP has 3 main subcategories worded: urgency, severity, and certainty. The ranking of the subcategories is determined by the NWS. The CAP version 1.2 rankings are found in attachment 10. Based on version 1.2 of NWS CAP categories (attachments 10, 11, and 18) and the configuration of the Windy.com app weather warnings layer, a heavy freezing spray advisory as issued by the NWS would have been displayed in yellow when a user selected the weather warning layer and a heavy freezing spray warning as issued by the NWS would have been displayed in orange when a user selected the weather warning layer. However, for NWS Anchorage marine areas, it was discovered that version 1.1 of CAP was used (attachment 17) in which a heavy freezing spray warning is classified as "moderate" (in the severity category) which would displayed as yellow in the Windy.com "weather warnings" layer. Heavy freezing spray advisory in CAP V1.1 does not have an urgency, severity or certainty category and therefore heavy freezing spray advisories would not have been highlighted with a color on Windy.com. Due to the size of the marine zones in the Anchorage area of responsibility, it is possible to have 2 storms in the same zone at the same time, and with this issue, the NWS CAP Handler for version 1.2 cannot correctly parse the marine warnings or advisories. Therefore, NWS Anchorage marine areas remain using CAP version 1.1. By summer 2021, after some changes in the NWS CAP Handler coding, NWS Anchorage plans to be only using CAP version 1.2. The NWS determines the categories for CAP from user feedback via the NWS service program teams[41]. For more information please see the docket for this accident.[42]

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[35] http://www.buoyweather.com/
[36] https://www.windfinder.com/
[37] https://www.ventusky.com/
[38] https://www.apple.com/ios/ios-14/ accessed March 2021.
[39] https://www.weather.gov/documentation/services-web-alerts
https://www.weather.gov/media/alert/CAP_v12_guide_05-16-2017.pdf
[40] https://blog.windy.com/cap-alerts-weather-warnings/
[41] https://nws.weather.gov/products/CARDS/protected/documents/Reference/SPT_Charter.pdf
[42] Please see the interview and USCG MBI transcripts located in the docket of this investigation.

13.0 Additional NWS Information

Additional information was received from the NWS regarding the observations and data around the accident time. In addition, the NWS provided a flyer that they had developed to request more freezing spray and icing observations from the mariner community. The NWS indicated that they had not received any feedback from the mariner community related to the 2018 flyer request for icing reports (attachment 13).[43] Please see attachments 12 and 13.

14.0 Weather Research and Forecasting Model Simulation

A Weather Research and Forecasting Model (WRF) simulation was run to simulate the weather conditions surrounding the time of the accident using initialization data from the GFS4.[44] WRF ARW (Advanced Research WRF core) version 4.1.2 was run with 2 domains with horizontal grid spacing of 8 km and 1.6 km over the accident site. Other WRF simulation parameters included: 50 vertical levels, the multi-scale Kain-Fritsch cumulus parameterization scheme used on the outer domain, a Lin et al. microphysics scheme, a Yonsei University boundary layer scheme, Noah land surface physics, the Dudhia scheme used for short wave radiation, and the RRTM scheme for the long wave radiation. The terrain (in ft) used in domain 2 is shown in figure 27 with the location of the accident site marked.

Figures 28, 29, 30, 31 and 32 depict the winds[45] at 980 hPa (surface to ~200 ft msl) in knots at 1500, 1800, 2100, 2200, and 2300 AKST, respectively. The WRF simulation indicated increasing wind magnitudes with time with sustained winds between 40 and 55 knots near the accident site at the accident time (figures 30 through 32). The location of the accident vessel (attachment 14) is marked on the figures using a red star.

[43] Please see the interview and USCG MBI transcripts located in the docket of this investigation.
[44] https://nomads.ncdc.noaa.gov/data/gfs4/
[45] All wind magnitudes are in knots and are sustained wind speeds.

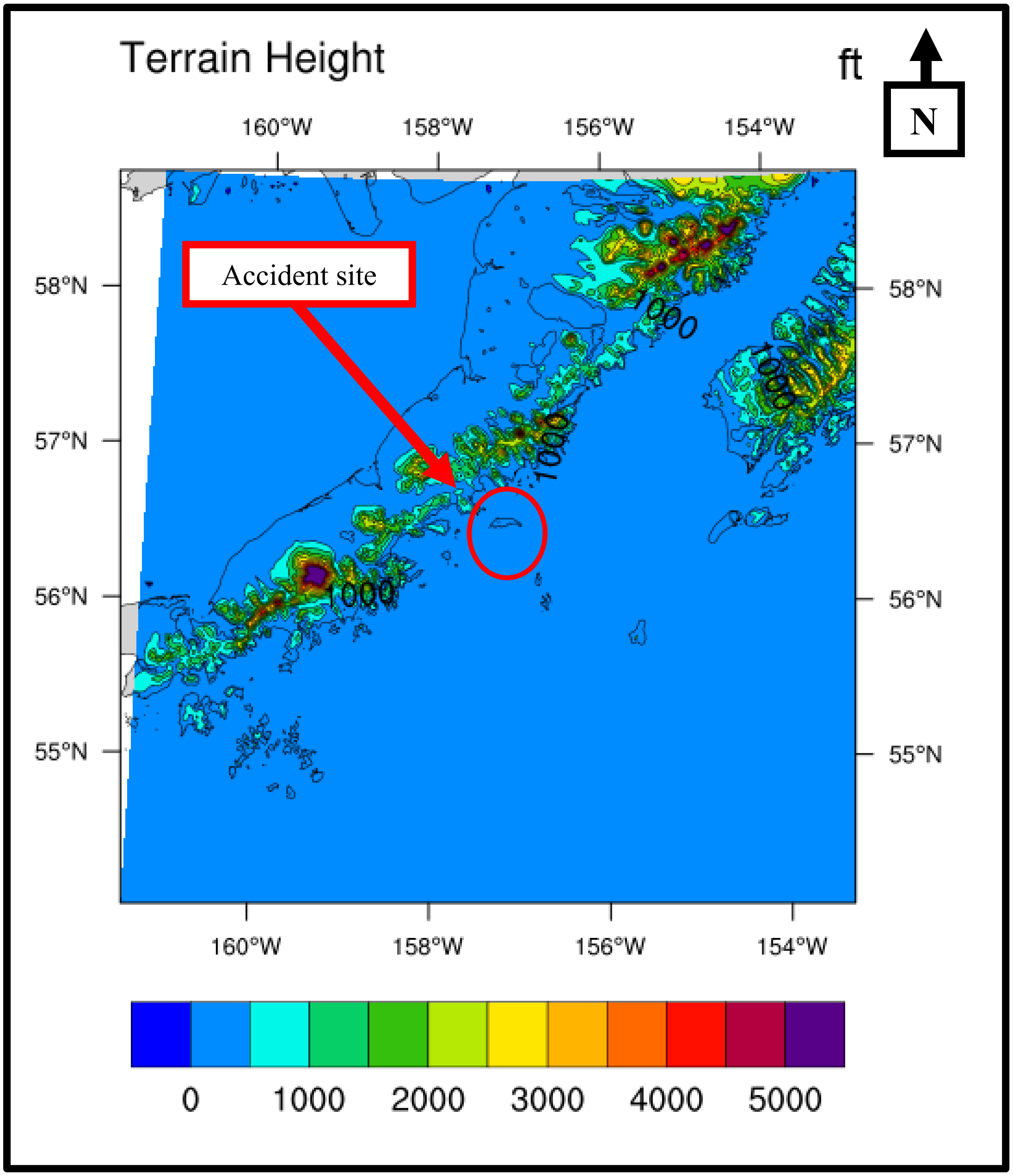

Figure 27 – WRF simulation terrain for domain 2 in ft with the accident site marked.

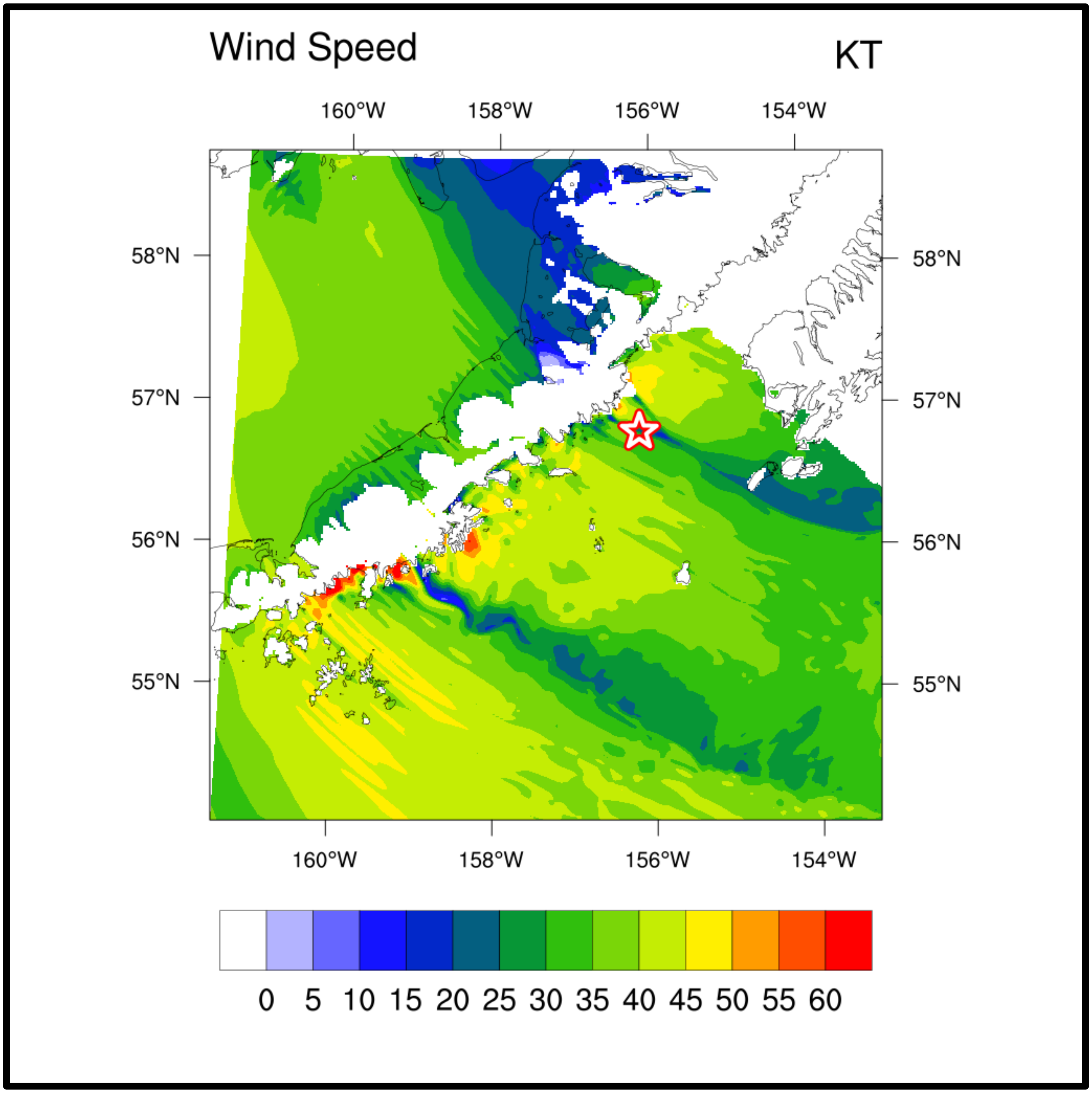

Figure 28 – WRF domain 2 wind in knots at 980 hPa (surface to ~200 ft msl) from 1500 AKST with the approximate accident vessel location marked by the star.

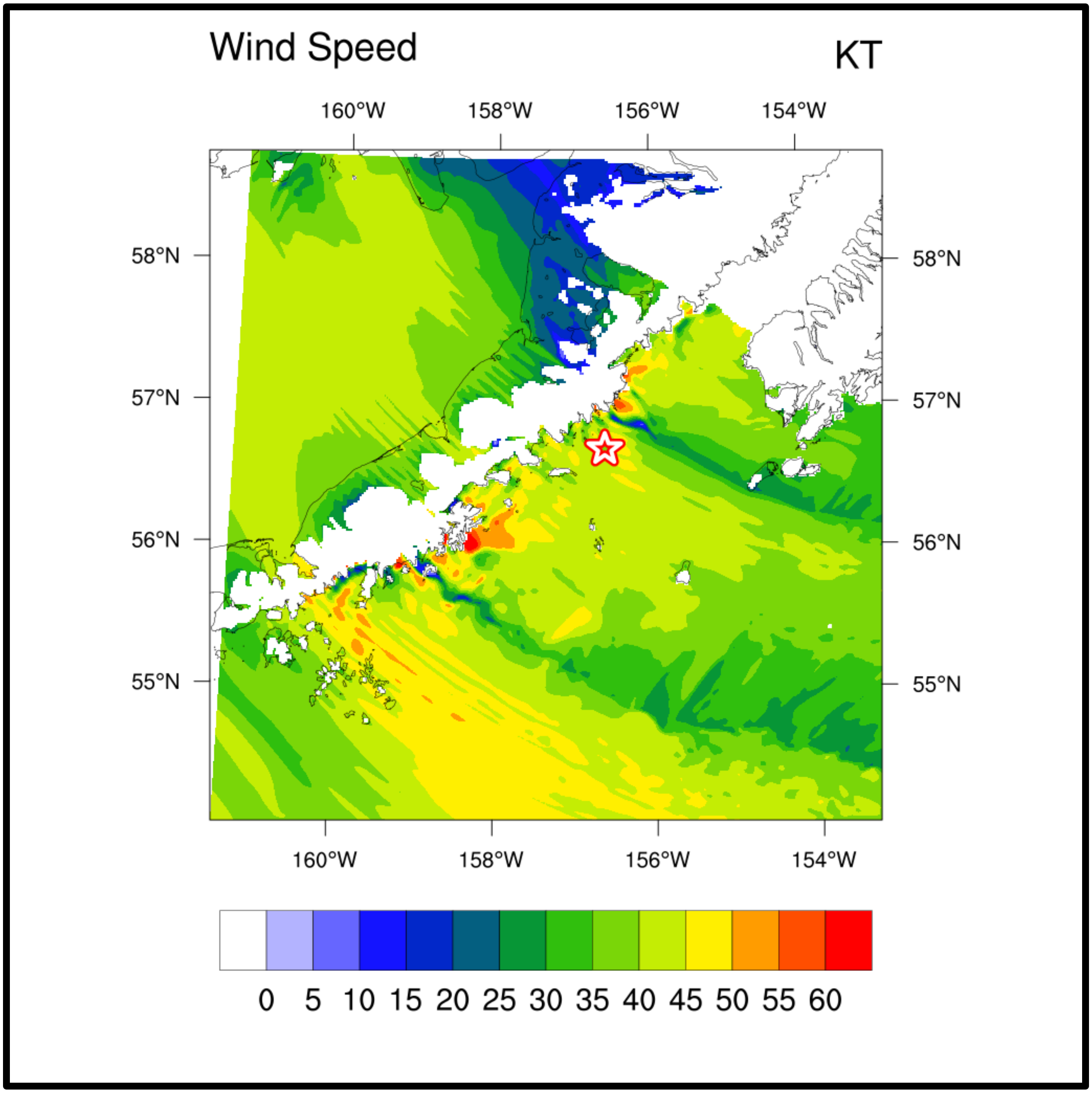

Figure 29 – WRF domain 2 wind in knots at 980 hPa (surface to ~200 ft msl) from 1800 AKST with the approximate accident vessel location marked by the star.

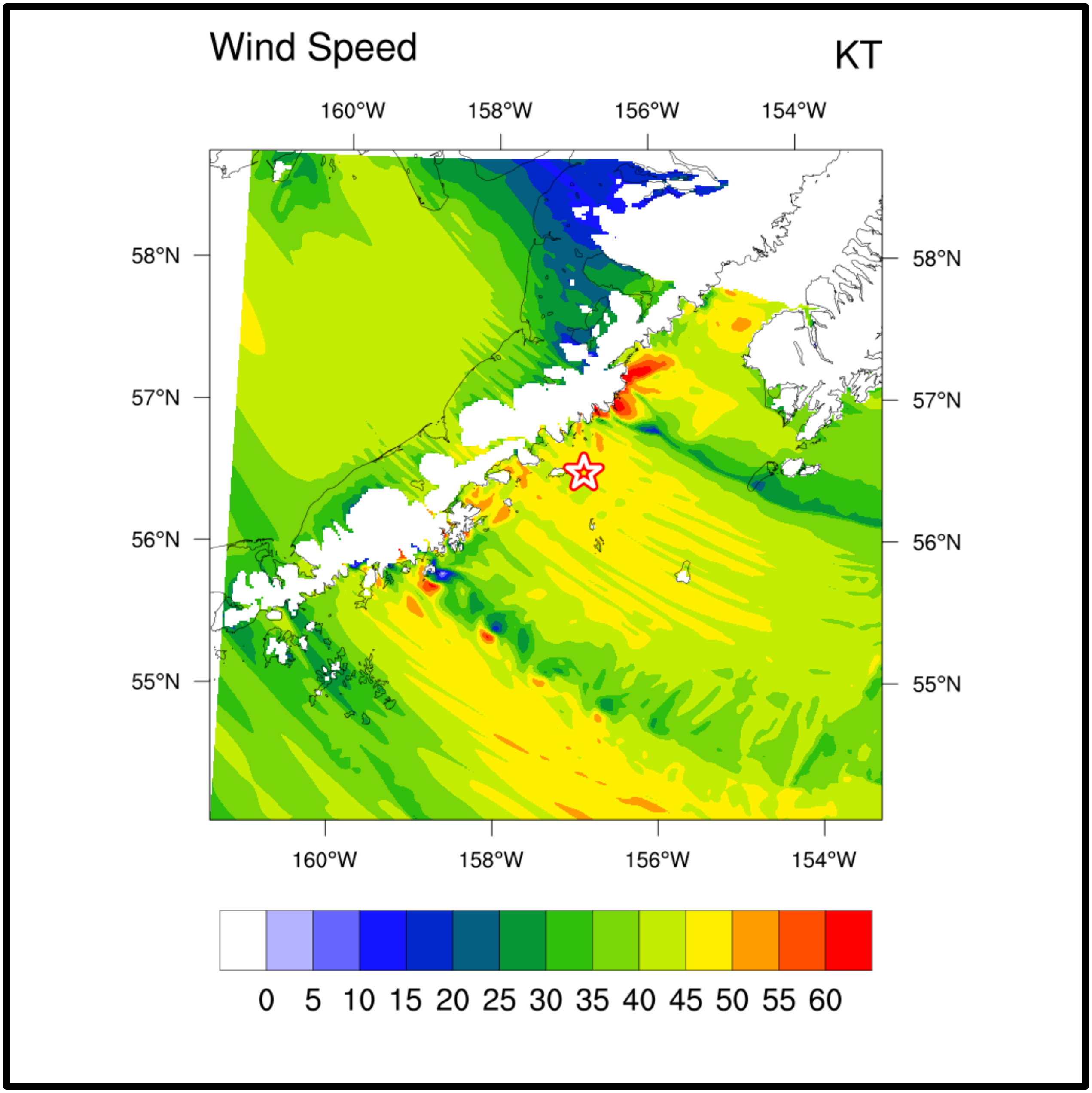

Figure 30 – WRF domain 2 wind in knots at 980 hPa (surface to ~200 ft msl) from 2100 AKST with the approximate accident vessel location marked by the star.

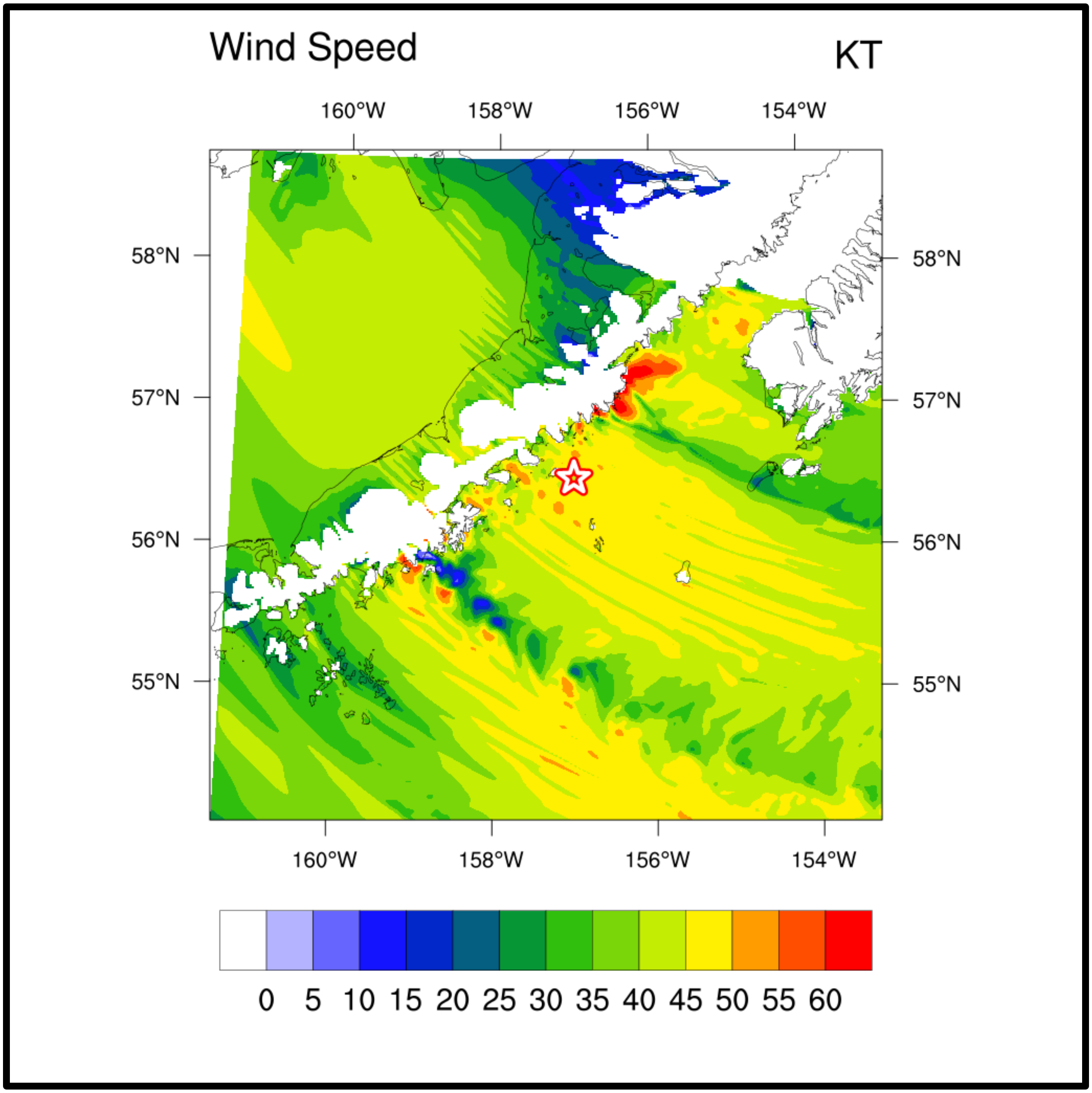

Figure 31 – WRF domain 2 wind in knots at 980 hPa (surface to ~200 ft msl) from 2200 AKST with the approximate accident vessel location marked by the star.

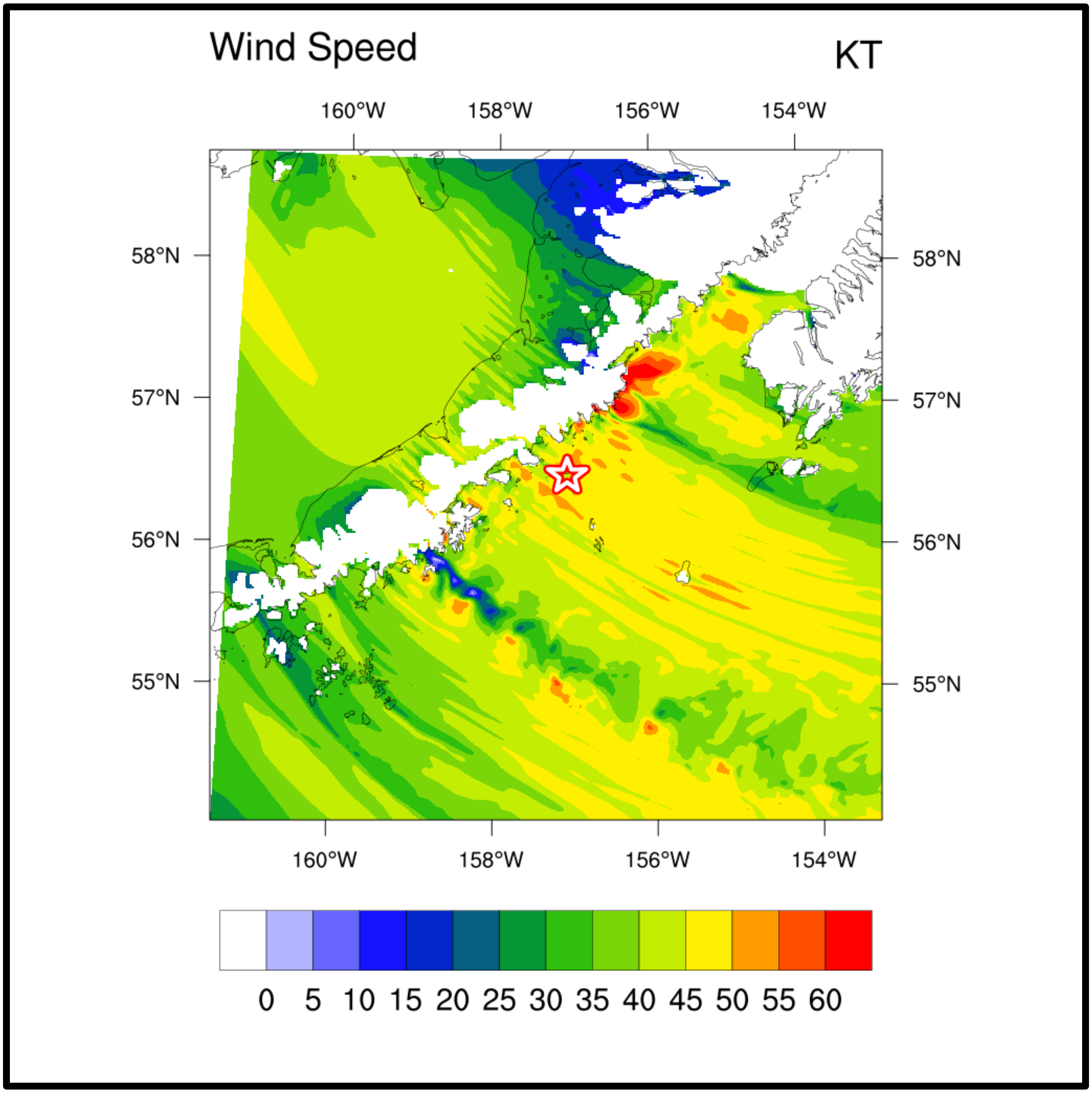

Figure 32 – WRF domain 2 wind in knots at 980 hPa (surface to ~200 ft msl) from 2300 AKST with the approximate accident vessel location marked by the star.

15.0 Additional Icing Calculations

Using data from the NTSB WRF simulation, calculations were made to estimate the amount of sea spray ice accretion (PPR) (Overland, 1990) with the color scale done to match table 2 and PPR values from https://www.met.nps.edu/~psguest/polarmet/vessel/predict.html (attachment 9). The location of the accident vessel (attachment 14) is marked on the sea spray ice accretion figures using a star. Figures 33, 34, 35, 36, 37, 38 and 39 depicted the PPR values at 0600, 0900, 1200, 1500, 1800, 2100 and 2200 AKST, respectively. A 3-Dimensional (3-D) overlay of the PPR values between 1900 and 2300 AKST was created and are displayed in figures 40 to 42 and attachment 16 with the data overlaid on a map of Alaska. The accident vessel continued southwestward into an area of increasing values of PPR from 0500 AKST on December 31 through the accident time (attachments 15 and 16).

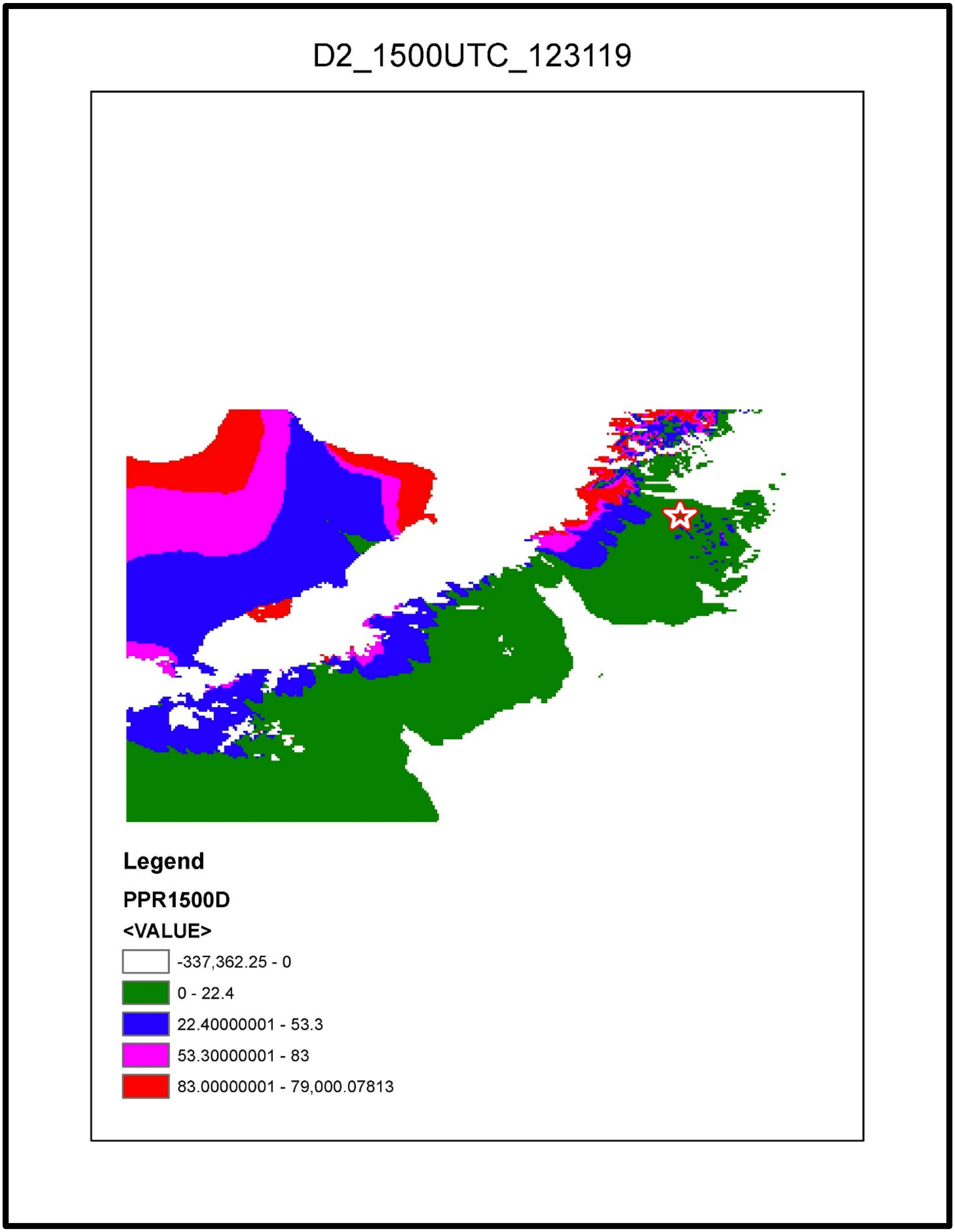

Figure 33 – PPR values for around the accident site from 0600 AKST with the approximate accident vessel location marked by the star.

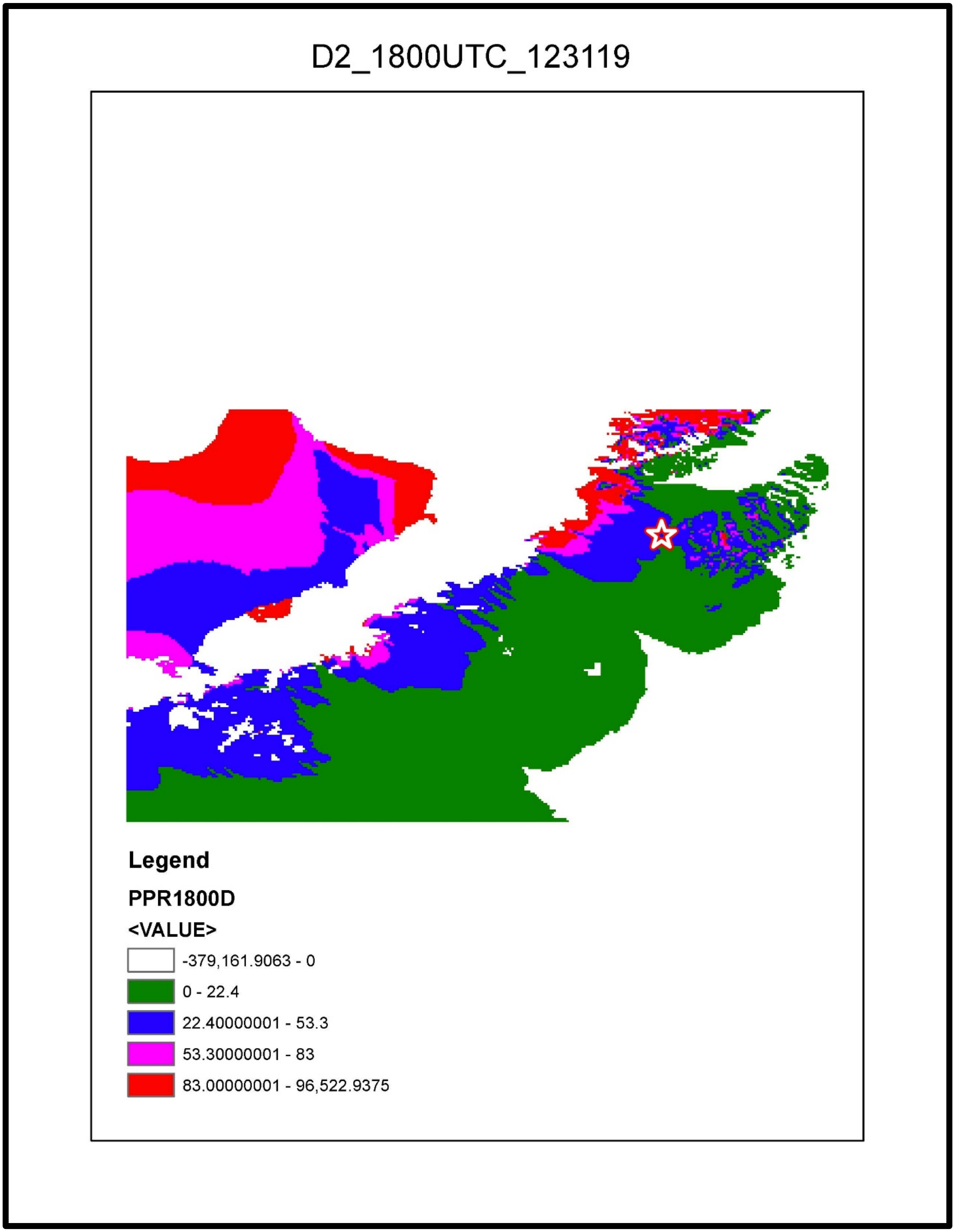

Figure 34 – PPR values for around the accident site from 0900 AKST with the approximate accident vessel location marked by the star.

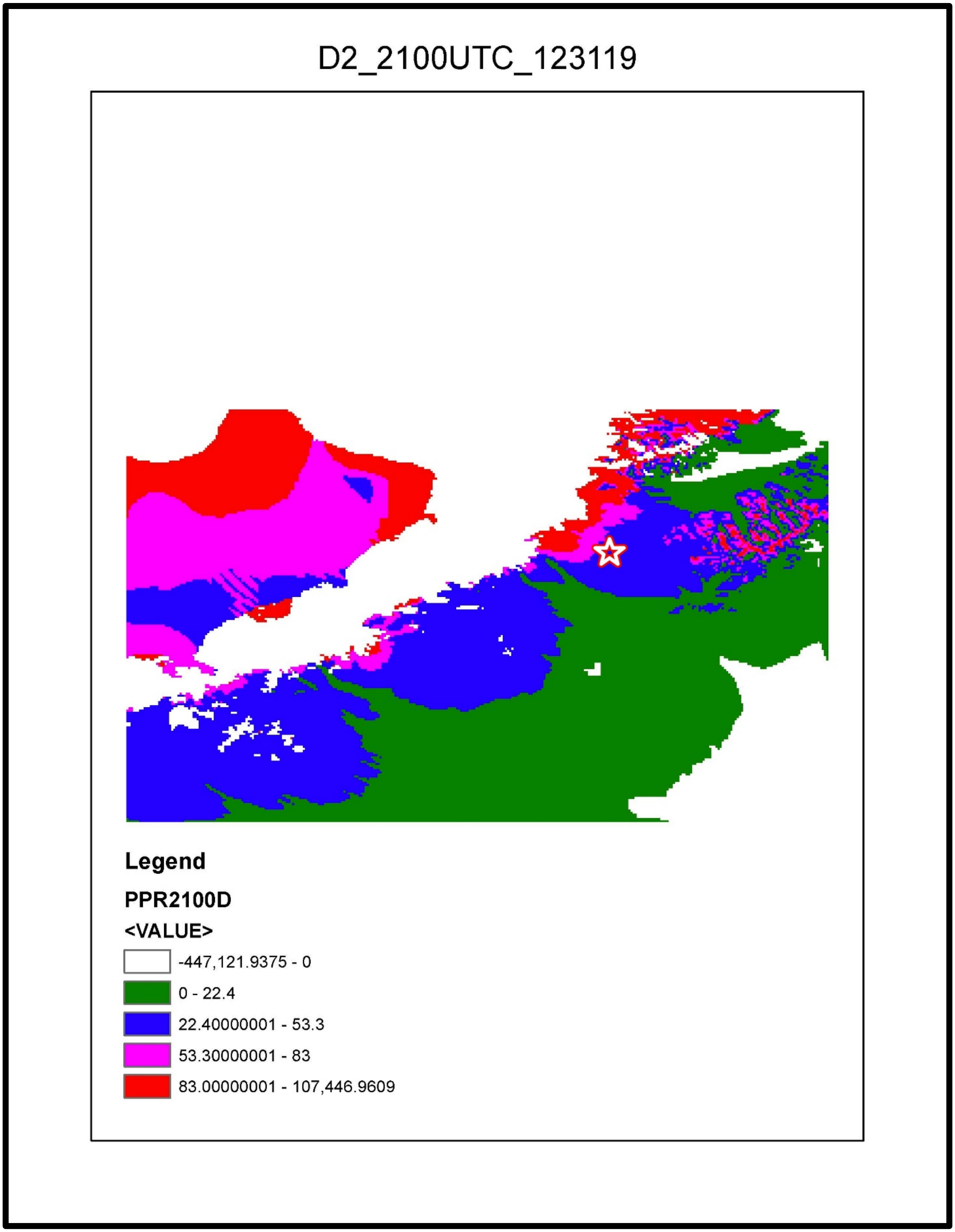

Figure 35 – PPR values for around the accident site from 1200 AKST with the approximate accident vessel location marked by the star.

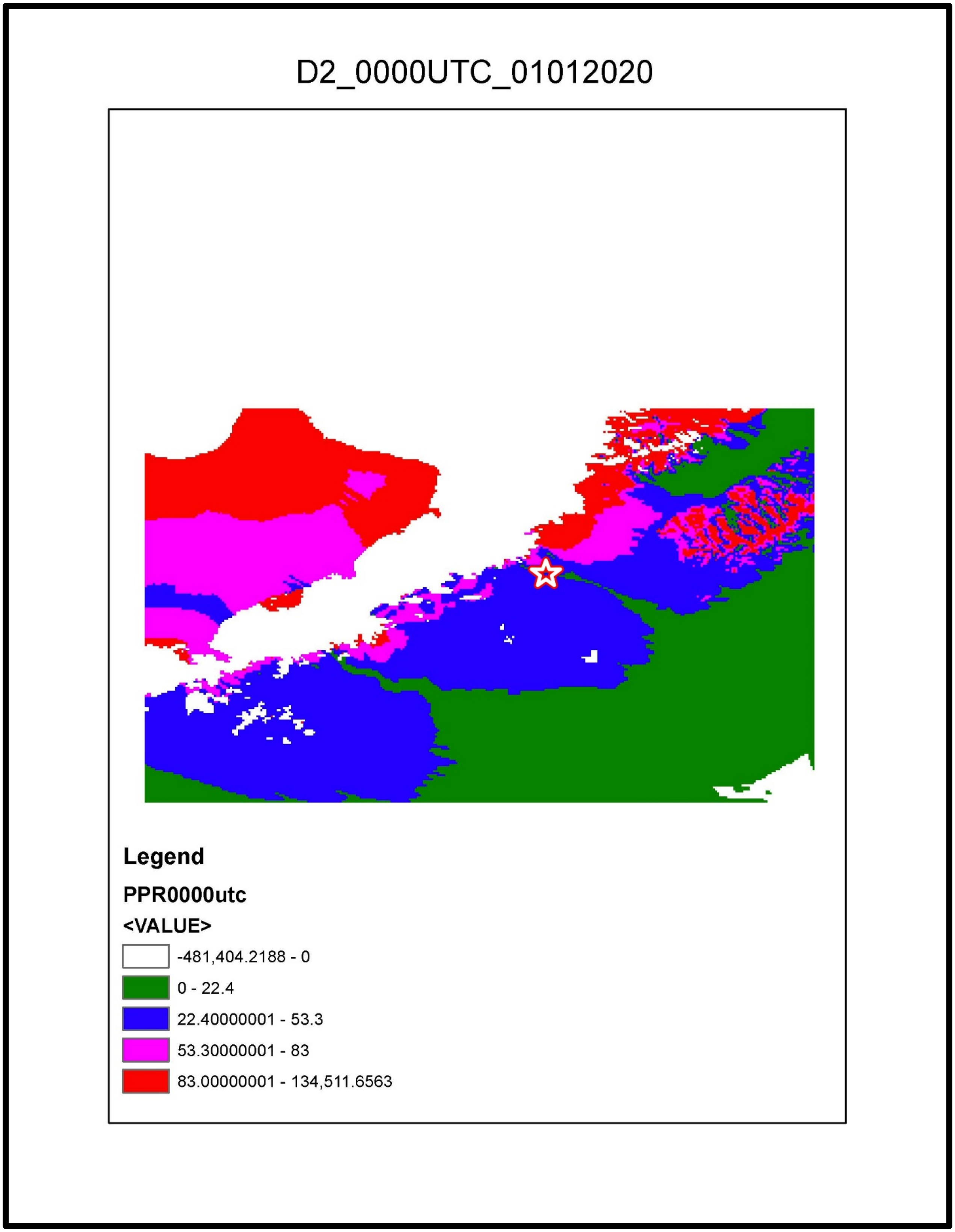

Figure 36 – PPR values for around the accident site from 1500 AKST with the approximate accident vessel location marked by the star.

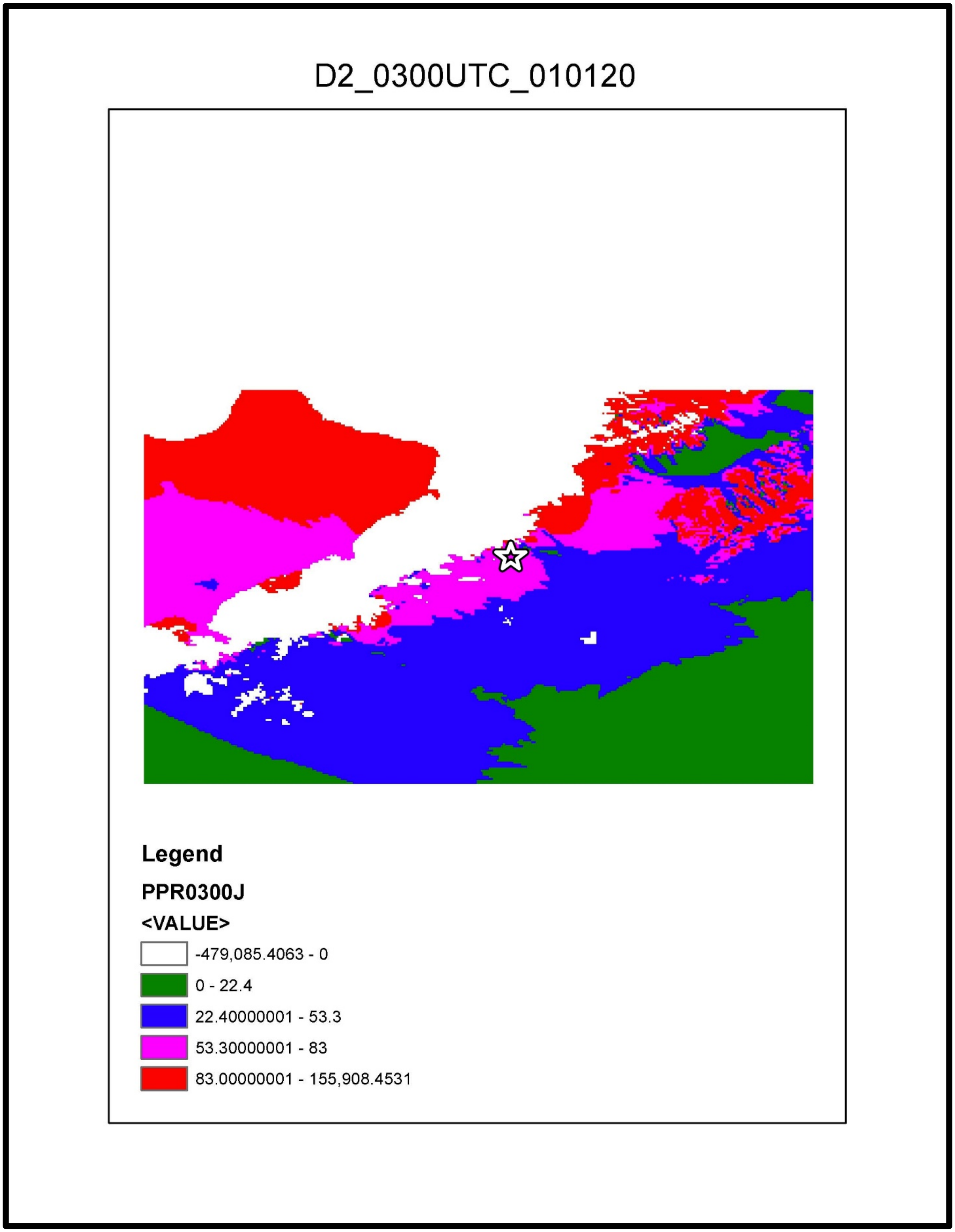

Figure 37 – PPR values for around the accident site from 1800 AKST with the approximate accident vessel location marked by the star.

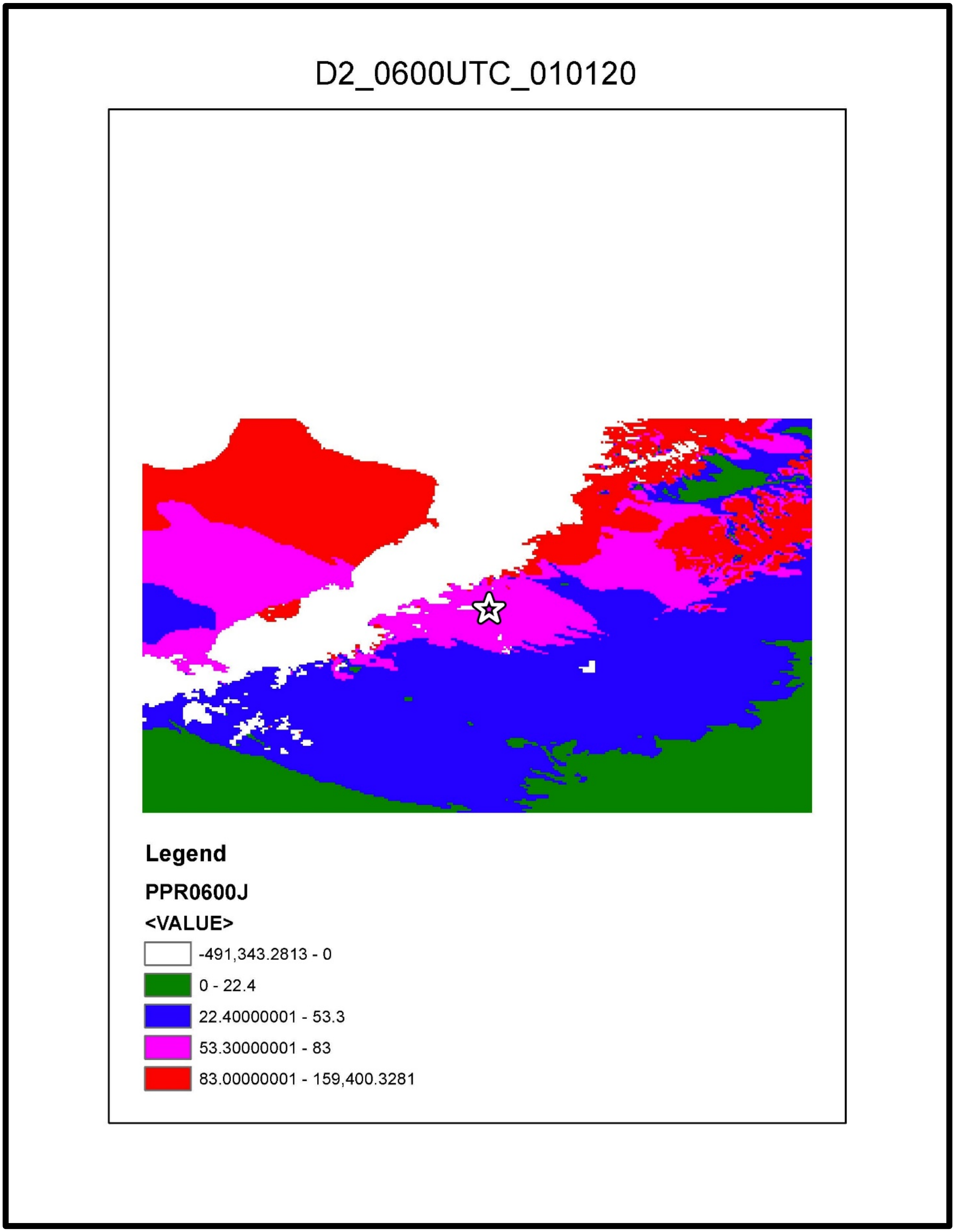

Figure 38 – PPR values for around the accident site from 2100 AKST with the approximate accident vessel location marked by the star.

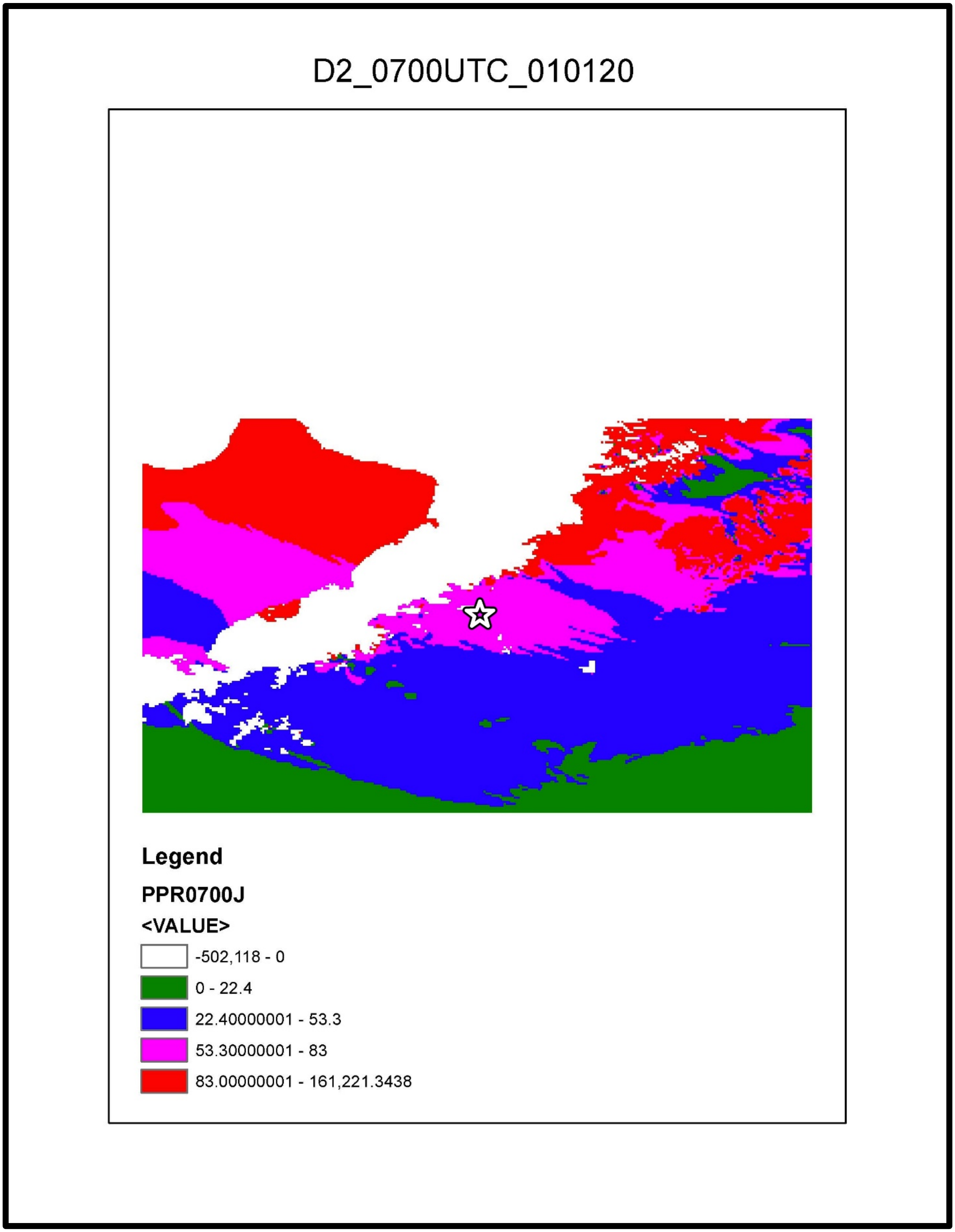

Figure 39 – PPR values for around the accident site from 2200 AKST with the approximate accident vessel location marked by the star.

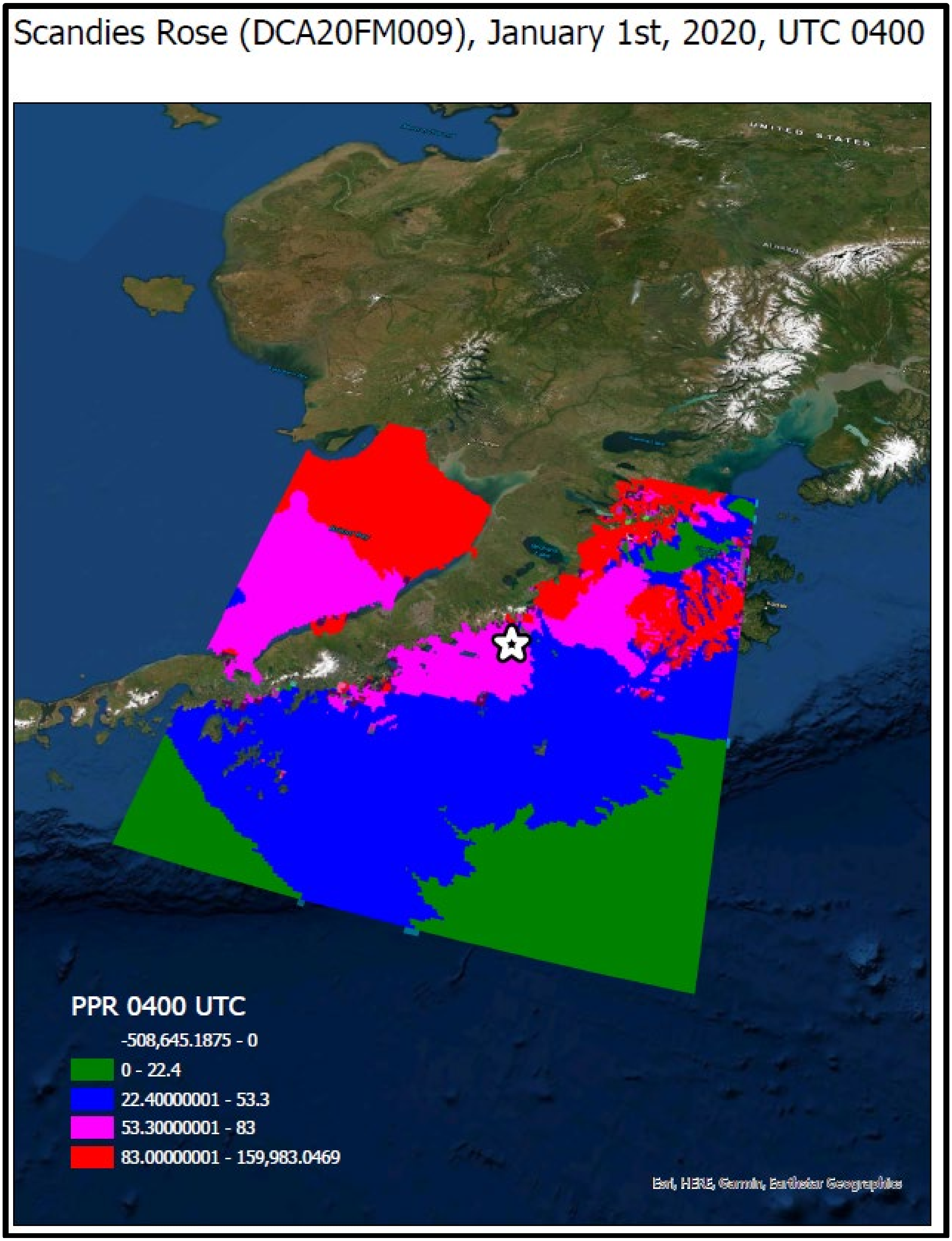

Figure 40 – 3-D map of PPR values for around the accident site from 1900 AKST with the approximate accident vessel location marked by the star.

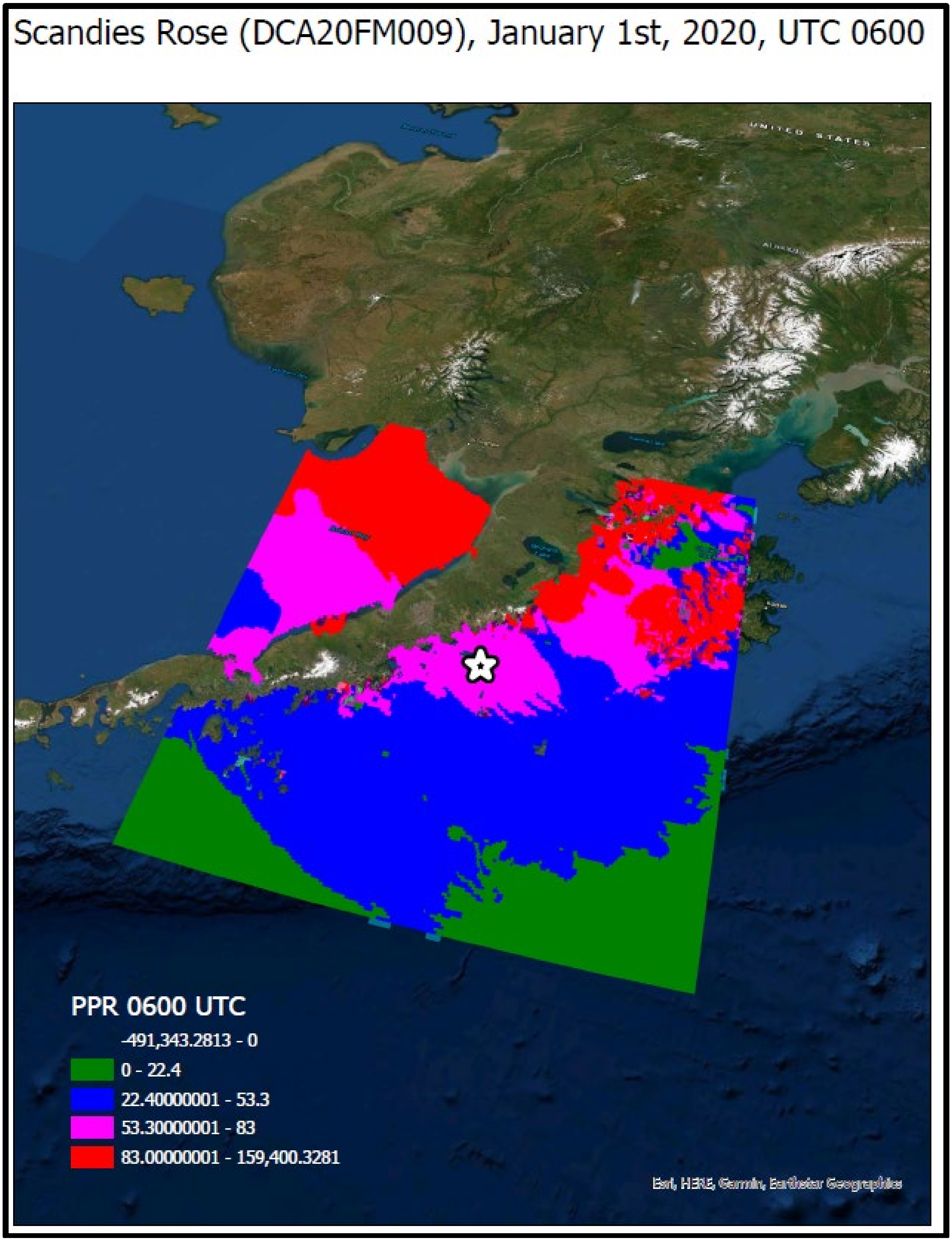

Figure 41 – 3-D map of PPR values for around the accident site from 2100 AKST with the approximate accident vessel location marked by the star.

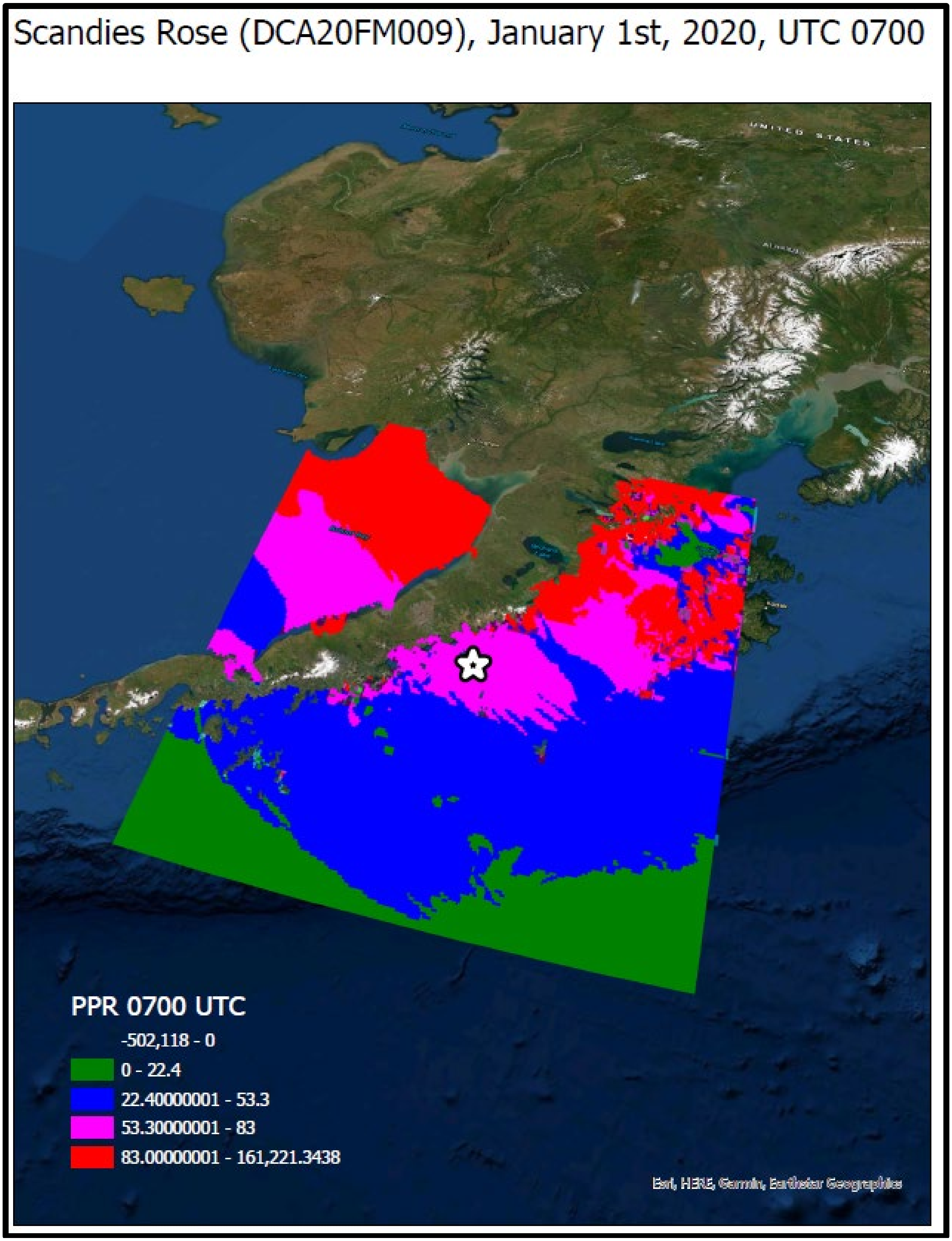

Figure 42 – 3-D map of PPR values for around the accident site from 2200 AKST with the approximate accident vessel location marked by the star.

16.0 Astronomical Data

The astronomical data obtained from the United States Naval Observatory for the accident site on December 31, 2019, indicated the following:

SUN	
Begin civil twilight	0915 AKST
Sunrise	1002 AKST
Sun transit	1331 AKST
Sunset	1700 AKST
End civil twilight	1748 AKST
Accident time	**2200 AKST**[46]

MOON	
Moonrise	1305 AKST
Moon transit	1810 AKST
Accident time	**2200 AKST**[47]
Moonset	2327 AKST

The phase of the Moon was Waxing Crescent with 32.5% of the Moon's visible disk illuminated.

E. LIST OF ATTACHMENTS

Attachment 1 – Additional METAR observations

Attachment 2 – ALIA2 additional observations

Attachment 3 – Buoy 46077 additional observations

Attachment 4 – Prediction of Vessel Icing for Near-Freezing Sea Temperatures paper by Overland (1990)

Attachment 5 – Additional paper of algorithms used to determine sea spray ice accretion on marine vessels

Attachment 6 – Additional paper of algorithms used to determine sea spray ice accretion on marine vessels in the northern Atlantic Canadian waters

Attachment 7 – Additional paper of algorithms used to determine sea spray ice accretion on marine vessels in the Arctic waters

[46] Inserted accident time for reference and context.
[47] Inserted accident time for reference and context.

Attachment 8 – Additional paper of algorithms used to determine sea spray ice accretion on marine vessels in the Barents Sea

Attachment 9 – Additional information on Overland calculation methods

Attachment 10 – CAP V1.2 spreadsheet and information

Attachment 11 – Additional Windy.com information

Attachment 12 – Additional NWS accident observation information

Attachment 13 – NWS freezing spray and icing observation request flyer

Attachment 14 – AIS tracking data for accident vessel

Attachment 15 – Animation of PPR values and accident vessel location from 0300 AKST on December 31 through 2300 AKST on December 31

Attachment 16 – 3-D view of PPR values between 1900 AKST on December 31 through 2300 AKST on December 31 plotted on a map of Alaska

Attachment 17 – CAP V1.1 spreadsheet and information

Attachment 18 – Additional Windy.com information regarding the "weather warnings" layer

Attachment 19 – Location of the accident vessel and other vessels around the accident time

Attachment 20 – Vessel logs from the *F/V AMATULI* around the accident time

Attachment 21 – SAR Overview Documentation

Submitted by:

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Paul Suffern
Senior Meteorologist

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