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Alaska AIS Transmit Prototype Test, Evaluation, and Transition Summary Report

For The Near Shore Arctic Navigational Safety Information System (ANSIS)

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October 2018

Homeland Security

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16. Abstract (MAXIMUM 200 WORDS)

The United States Coast Guard (USCG) District 17 (D17) and USCG Office of Navigation Systems (CG-NAV) sponsored this effort to utilize the Automatic Identification System (AIS) to improve Arctic Navigation and Safety. AIS is an autonomous and continuous broadcast system that exchanges maritime safety/security information between participating vessels and shore stations. This report briefly discusses the function of AIS as a means to transmit information to ships from shore that contributes to safety-of-navigation and protection of the environment. An AIS transmit architecture aligned with International standards has been developed to implement the efficient and robust transmission of Application Specific Messages (ASMs). A partnership between RDC and Marine Exchange of Alaska (MXAK), which operates a network of 26 AIS transmitters, was established to develop an operational Alaska AIS transmit capability.

This report discusses the collaboration between RDC, MXAK, D17 and CG-NAV to implement an Alaska AIS transmit prototype system. It discusses in detail the various contributions of each organization. It summarizes the components of the transitioned system and makes recommendations for continued operations.

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EXECUTIVE SUMMARY

The Automatic Identification System (AIS) is an autonomous and continuous broadcast system that exchanges maritime safety/security information between participating vessels and shore stations. It is a system primarily designed for ship to ship communications to support collision avoidance. In addition to supporting collision avoidance and providing a means for maritime administrations to effectively track the movement of vessels (i.e. United States Coast Guard Vessel Traffic Services) in coastal and inland waters, AIS is used by shore facilities to transmit information that contributes to safety-of-navigation and protection of the environment to ships in port or underway.

In 2007, the United States Coast Guard Research and Development Center (RDC) was asked to begin developing AIS transmit capabilities, determine what additional information is required by AIS users, recommend how information should be transmitted, and demonstrate the viability of transmission at test bed sites. Information would be transmitted using AIS Application Specific Messages (ASMs). RDC defined several standard ASMs and developed prototype methods for message creation, routing, queuing, transmission, and monitoring.

Since 2013, RDC partnered with the Marine Exchange of Alaska (MXAK), via a Cooperative Research and Development Agreement (CRADA), as well as with USCG District Seventeen (D17) and USCG Office of Navigation Systems (CG-NAV) to prototype an AIS transmit service in Alaska. This effort has been focused on prototyping the Alaska transmit services to fill a coverage gap in Alaska and prototype the concept of using third-party systems to provide AIS transmit services. As a result of the cooperative research an Alaska AIS transmit prototype system is operational.

This report describes the technical details of the Alaska AIS Transmit System architecture as implemented, the location and coverage of the transmitters, and the software used to enable operations. Although the prototype has been transitioned to MXAK and D17 for operations, there are still some details (e.g. access, sustainability, licensing, service, etc.) to be resolved for a full operational system which are addressed in the report. The result of this work highlights the potential value for implementing this same AIS ASM capability in the contiguous US using the Nationwide AIS (NAIS) for transmission.

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LIST OF ACRONYMS

AIS	Automatic Identification System
ANSIS	The Arctic Navigational Safety Information System
APP	Application
ASM	Application Specific Message
AtoN	Aids to Navigation
BBM	Broadcast Binary Message
CG-NAV	USCG Office of Navigation Systems
CPU	Central Processing Unit
CRADA	Cooperative Research and Development Agreement
D17	USCG District Seventeen (covering Alaska and the Arctic)
DAC	Designated Area Code
DTED	Digital Terrain Elevation Data
ECS	Electronic Charting System
EM	Environmental Message (ASM)
eMSI	electronic Marine Safety Information
FATDMA	Fixed Access Time Division Multiple Access
FCC	Federal Communications Commission
FF	Fetcher Formatter (APP)
GAD	GateHouse AIS Display
GN	Geographic Notice (ASM)
GNC	Geographic Notice Creator (APP)
GUI	Graphical User Interface
HF	High Frequency
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
IMO	International Maritime Organization
I/O	Input/Output
IP	Internet Protocol
LSS	Logical Shore Station
met/hydro	meteorological and hydrographic
MXAK	Marine Exchange of Alaska
MMSI	Maritime Mobile Service Identity
MOU	Memorandum of Understanding
MPI	MultiProtocol Interface (APP)
MSI	Marine Safety Information
NAIS	Nationwide AIS
NASA	National Aeronautics and Space Administration
NDBC	National Data Buoy Center
NMEA	National Maritime Electronic Association
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NSI	Navigation Safety Information
NTSC	National Transportation Systems Center
NWS	National Weather Service

LIST OF ACRONYMS (Continued)

RATDMA	Random Access Time Division Multiple Access
RDC	Research and Development Center
RTCM	Radio Technical Commission for Maritime Services
SCI	Seaman's Church Institute
TCP/IP	Transmission Control Protocol/Internet Protocol
TIREM	Alion's Terrain Integrated Rough Earth Model
TV32	VOLPE National Transportation Systems Center Transview (32 bit edition)
US	United States
USAIMS	US Aids to Navigation Information Management System
USACE	United States Army Corp of Engineers
USCG	United States Coast Guard
USN	United States Navy
UTC	Universal Time Coordinated
VACT	Virtual Aid Creation Tool (APP)
VDL	VHF Data Link
VDM	AIS VHF Data-Link Message
VDO	AIS VHF Data Link Message for Own Ship
VHF	Very High Frequency
VNTSC	Volpe National Transportation Systems Center
VTS	Vessel Traffic Services

1 INTRODUCTION

The United States Coast Guard (USCG) Arctic Strategy [1] stresses the important role that public-private partnerships will play in developing the critical infrastructure needed for effective, efficient, and safe operations in this emerging remote and hazardous environment. This report, in part, focuses on the partnership established to support improving maritime safety information available in the Arctic.

This report provides introductory information about important aspects of implementing an Alaska Automatic Identification System (AIS) transmit capability. It includes: a discussion of the challenges facing mariners as they navigate their vessels in the Arctic; a description of AIS and how it can be used to transmit critical navigation safety information to the mariner; and finally, a discussion of the public-private partnership established to make a prototype Alaska AIS transmit service a reality.

1.1 Arctic and Alaska

There is concern with increasing maritime activity in the Arctic, along with potential for maritime accidents and serious environmental harm to the fragile Arctic environment, warranting the need to implement enhanced maritime safety measures. One challenge is the dynamic, constantly changing environment of the Arctic; another challenge is the minimal Arctic infrastructure, as compared to other, less harsh maritime regions. The goal is to provide important safety information, to allow the mariner to better identify, assess, and mitigate the risks of operating in the Arctic. The maritime community and other stakeholders look to the USCG to provide important oversight of expanding maritime activity, as well as critical tools required to ensure safe, efficient, and environmentally sound maritime operations. Various governmental agencies (National Oceanic and Atmospheric Administration (NOAA), United States Navy (USN), National Aeronautics and Space Administration (NASA), etc.) are striving to improve the quality of Arctic weather and ice forecasting. As these governmental agencies improve the quality of Arctic weather and ice forecasts, timely delivery and relevant presentation of this information to mariners, particularly commercial mariners becomes important.

1.2 AIS for Transmit

The Automatic Identification System (AIS) is an internationally agreed upon and globally deployed technology used by mariners to automatically exchange important navigation information between ships, and between shore facilities and ships [2]. The International Maritime Organization (IMO) established AIS to improve collision avoidance and support an authority's ability to monitor marine traffic. Besides being used by mariners to make navigation decisions, AIS provides real-time maritime situational awareness useful for vessel traffic services and search and rescue operations. Real-time AIS information is useful for live management of marine traffic, security, navigation, and emergency operations [3]. Use of shore-to-ship exchange of maritime safety/security information has been developed [4]. The shore facility is able to transmit a wide variety of information such as: meteorological and hydrographic data; carriage of dangerous cargos; safety and security zones; status of locks and Aids to Navigation (AtoN); and other port/waterway safety information (including those related to the protection of environment). In the AIS community, these transmitted messages are called Application Specific Messages (ASMs). This report describes the processes and functions of creating, routing, managing and monitoring these ASMs transmissions from shore to ship in an Alaska AIS transmit prototype service.

1.3 Public Private Partnership

In 2013, The USCG Research and Development Center (RDC) began partnering with the Marine Exchange of Alaska (MXAK), via a Cooperative Research and Development Agreement (CRADA), as well as with USCG District Seventeen (D17) and USCG Office of Navigation Systems (CG-NAV). The stated objective was to promote a public-private analysis and eventual solution to the Arctic concerns presented in Paragraph 1.1.

The specific objectives for this CRADA were to define, develop, demonstrate, and evaluate, in an operational setting, at least one promising technology approach to the "Next Generation Arctic Maritime Navigational Safety Information System (ANSIS)." This system provides important, time-critical information to mariners so they may better assess and manage their voyage risks as they transit the remote and hazardous waters of the US Arctic Exclusive Economic Zone (EEZ).

2 FOUNDATIONAL WORK LEADING TO RDC/MXAK CRADA

The roots of this project were based on significant previous RDC work on AIS Transmit dating back to 2007. Three projects between 2007 and 2013 defined the full potential of an AIS transmit capability. The first two of the projects, Expanded Use of AIS within Vessel Traffic Services (VTS) and AIS Transmit Capability had three goals: determine functional requirements; establish a Radio Technical Commission for Maritime Services (RTCM) Special Committee (SC) 121 working group; and establish test beds to determine methods and procedures to develop AIS transmit. The third project, a Western Rivers Joint Capabilities Technology Demonstration (JCTD) -- a joint effort with the United States Army Corp of Engineers (USACE) -- was focused on further development of the AIS transmit capability. A summary of this foundational work is discussed in the sections below.

2.1 Functional Requirements

Information from various AIS and VTS Stakeholders about the type of data available that the mariner could use was gathered. Then, preferences of VTS Centers and Users were compared to overall importance of information that Binary Messages (ASMs) could provide via AIS.

This effort showed a desire for more information to flow from VTS to the mariners as data rather than voice. There was also a call for flexibility in information delivery and the ability to send the data that is needed to the mariner who needs it, based on the area of operation [5]. A summary of informational needs are listed below.

Environmental Data Functional Requirements:

- Tides (now and predicted)
- Water levels
- Water current velocity (speed and direction)
- Visibility/fog
- Air and water temperature
- Wind speed and direction
- Precipitation

Area Notice or Geographic Information Functional Requirements:

- Aids to Navigation (AtoN) outages/changes
- Ice advisories
- Dredge locations/information
- Security zone locations/information
- Restricted operation areas due to low visibility or security
- Location and information on marine events/regattas
- Anchorage management

Waterways Management Information Functional Requirements:

- Lock order
- Bridge openings/closings
- Procession order for narrow channels

2.2 RTCM SC121 Working Group

VTS AIS capabilities in US waters were reviewed; "consolidated" AIS binary messages (for regional and international implementation) were recommended; and changes in AIS equipment to support new capabilities were identified.

Results: Several AIS binary messages or ASMs were developed. These included:

1) Environmental Message (EM) to transmit environmental data (tides, currents, etc.),
2) Geographic Notice (GN) to transmit geographic areas (restricted areas, whales in area, dredging, obstruction, security zone, etc.),
3) Waterways Management (WM) (lock queue, gate, narrows, single passage area, air gap, etc.), and
4) Associated Text to be included with any of the above messages as well as on its own to describe or add text information.

In addition, the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) took on the role of developing an ASM registry for all regional and international ASMs[1]. As with other member states, the USCG posted the above ASMs as U.S. regional ASMs, making them available to the global maritime community.

2.3 Test Beds

Test beds were developed to explore concepts and ideas, draft standards, and validate requirements prior to USCG implementation. These test beds were located in existing VTS area; used AIS base stations; and encouraged active participation by marine pilots.

A total of four test beds were established. During field testing, processes to manage the ASMs at shore facilities were developed. Several methods were developed for message creation, routing, queuing, transmission, and monitoring. An AIS transmit architecture aligned with international standards was developed to implement an efficient and robust transmission of ASMs. It was during these tests that processes and software were fine tuned for transmitting ASMs via AIS base stations.

[1] http://www.iala-aism.org/asm/

2.3.1 Test Bed 1

Tampa Bay (September 2008): Tampa Bay Pilots were the test user group. NOAA Physical Oceanographic Real Time System (PORTS) data was transmitted using the Environmental ASM. Figure 1 displays transmitted information on an Electronic Chart System (ECS).

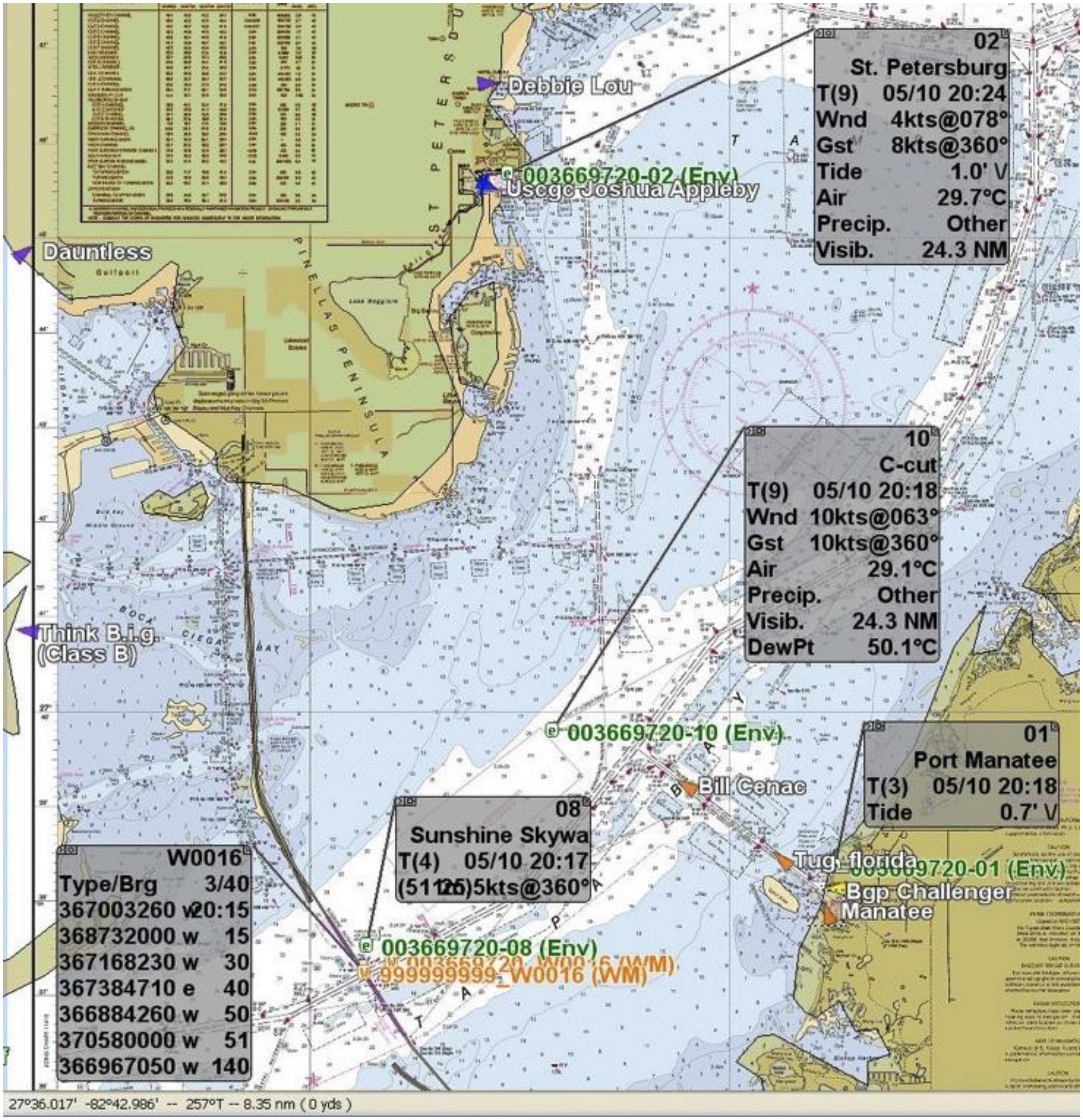


Figure 1. Tampa Bay demonstration area (PORTS sensor data displayed on Transview 32 - TV32).

2.3.2 Test Bed 2

Stellwagen Bank, MA (October 2008): Transmitted right whale locations identified by NOAA National Marine Sanctuary's (NMS) acoustic system located in the traffic separation scheme at the entrance to Boston Harbor. This test bed included support from University of New Hampshire (UNH) and Cornell University. Figure 2 shows detection of areas with and without whales present.

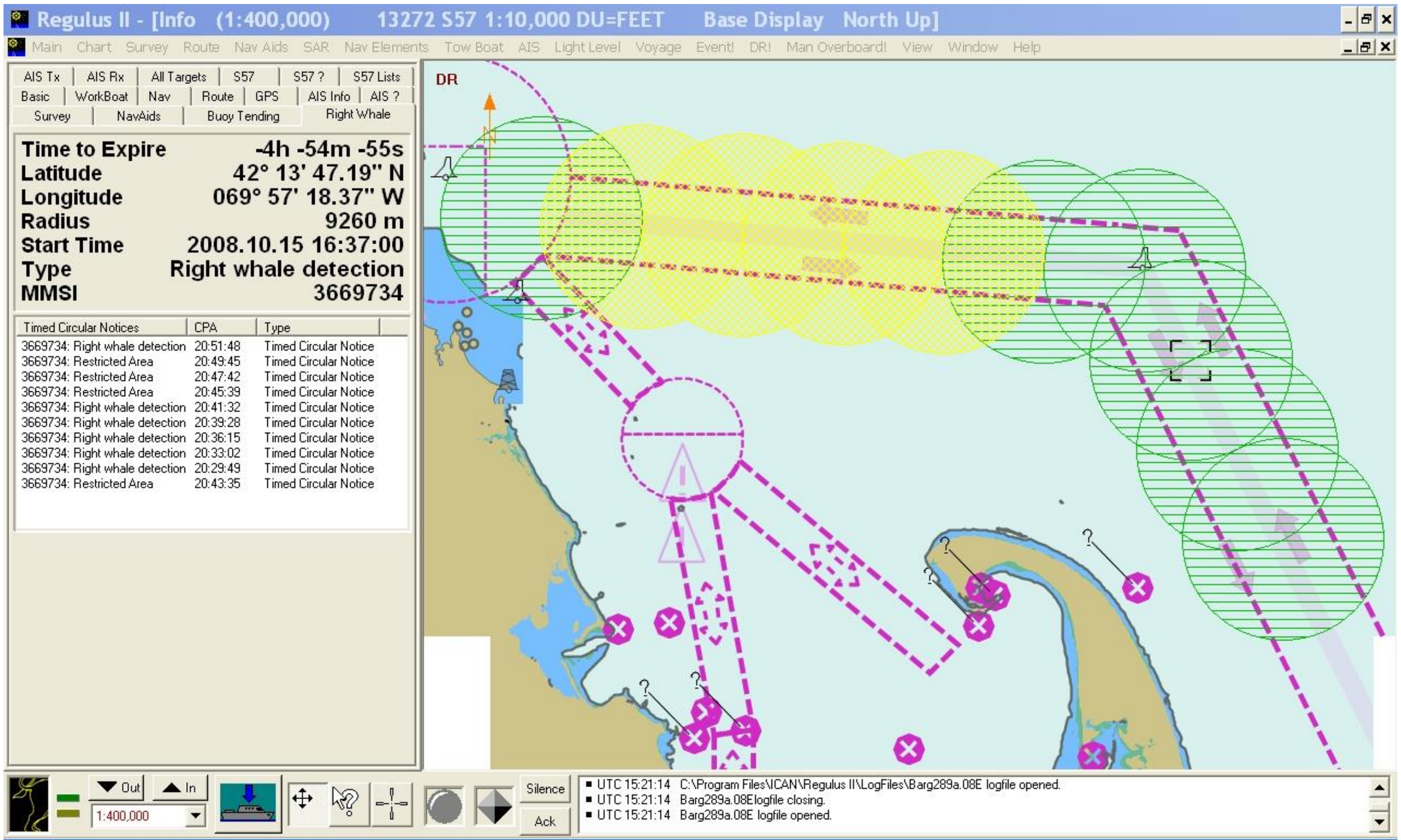


Figure 2. Stellwagen Bank demonstration area (yellow circles indicate whales present; green circles indicate no whales detected).

2.3.3 Test Bed 3

Columbia River (April 2010): Test user group was the Columbia River Pilots (COLRIP). The US Department of Transportation, Volpe Center had responsibility for AIS transmit operations in the Columbia River as part of their contracted support to the COLRIP. There were two AIS base stations (Green Mountain and Meglar Mountain), which operated in repeater mode so all traffic received by each base station was retransmitted. COLRIP and Volpe were responsible for monitoring system performance and VHF Data Link (VDL) loading using data feeds from the two transmitter sites. RDC conducted monitoring on an ad hoc basis using the USCG Nationwide AIS (NAIS) receiver at Cape Disappointment. A chart showing relative positions of the transmitters/receiver is shown in Figure 3. The Columbia River Pilots actively use the environmental data as part of their operations. They use Volpe-supplied TV32 as their Personal Pilot Units and liked the geographically tied text display.

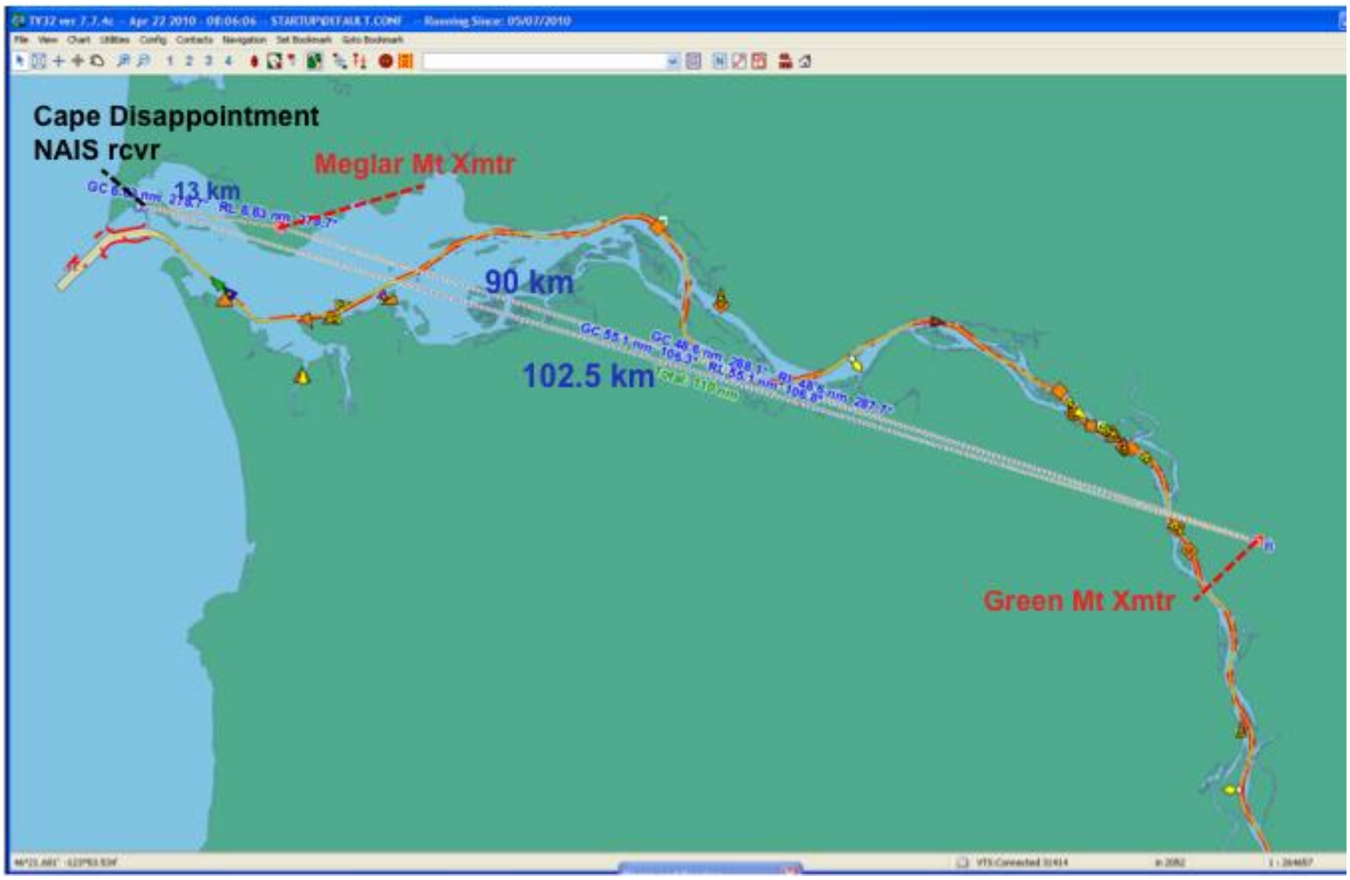


Figure 3. Columbia River demonstration diagram showing transmitter locations.

2.3.4 Test Bed 4

VTS Louisville, KY (May 2011): Tested new sources of environmental data for transmission such as river current sensors and river gauge sensors; tested the usage of the Waterways Management (WM) ASMs to assess their usefulness for lock queuing; and develop the ability to transmit virtual or synthetic (electronic) AtoN.

- It is important to note that until establishment of this test bed, all others were with a closed group of users who were willing to modify their electronic chart systems or portable pilot units to decode and portray the information from the ASMs on their displays or use TV32, the government-owned test system. In Louisville, there was a wide range of users and ECS units aboard vessels. In 2013, RDC worked with two software manufacturers, CEACT and RosePoint, through a CRADA, to update software to support the decoding and display of the ASMs. Figure 4 shows information displayed for Louisville.

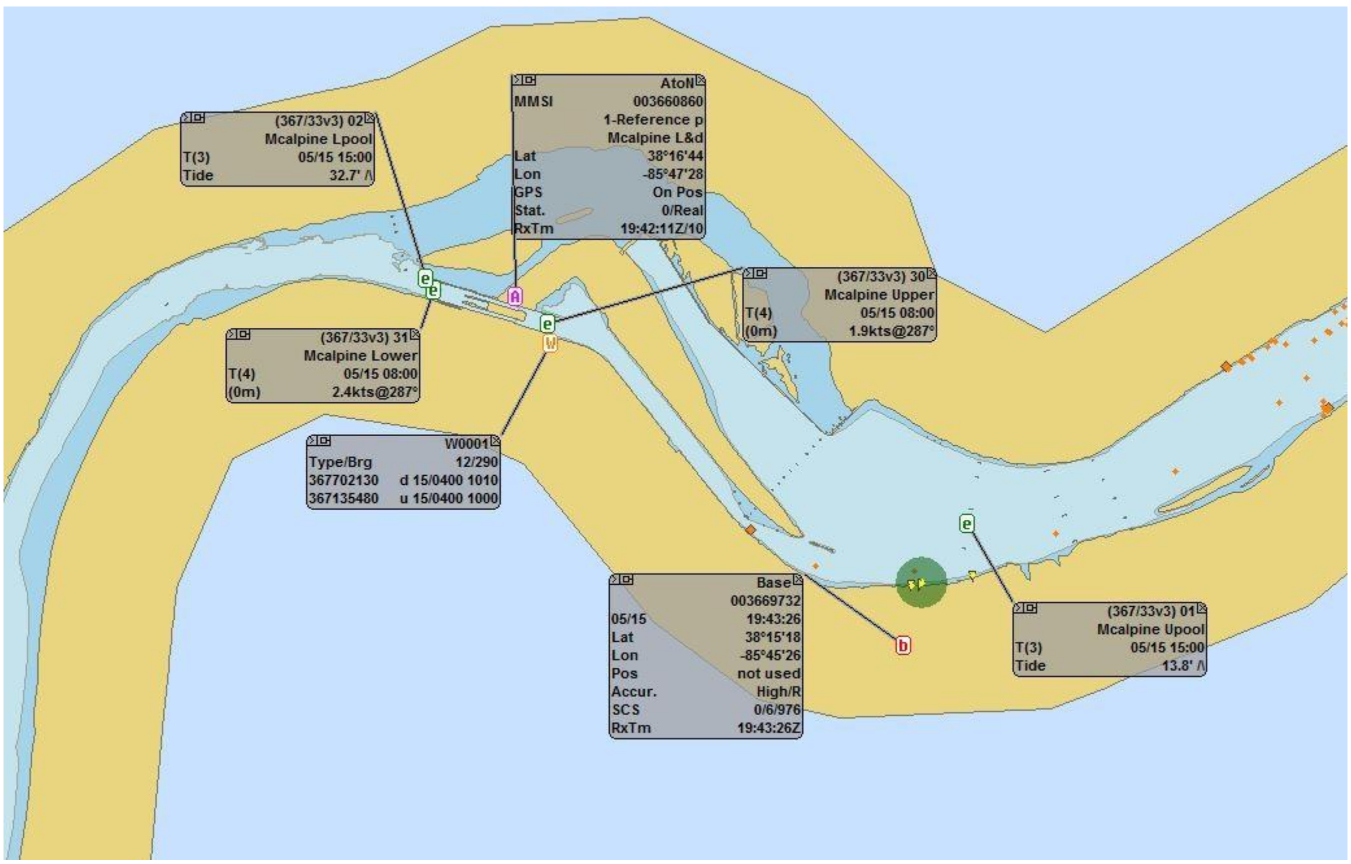


Figure 4. VOLPE Transview 32 (TV32) chart display showing ASMs transmitted at Louisville.

2.4 RDC Western Rivers Joint Capabilities Technology Demonstration (JCTD) Project

At the conclusion of work on the fourth test bed, RDC entered into a Memorandum of Understanding (MOU) with USACE to further develop the test bed in Louisville and apply it to other areas in the Western Rivers [6]. The goals of this Joint Capabilities Technology Demonstration (JCTD) project were to fully understand the components required for a complete AIS Transmit System using USACE AIS AtoN as transmitters and to determine the policies and procedures needed for USCG to support and integrate NAIS with another agency's AIS Transmit System. NAIS is the USCGs operational system utilizing AIS to support maritime domain awareness [7].

During the 15-month demonstration, RDC discovered that gaps needed to be filled to have a complete transmit system. The research team developed, implemented, and tested solutions during the demonstration. The demonstration successfully simulated full AIS Transmit System broadcasting eMSI continuously throughout the test bed (see Figure 5 – a sample of the approximately 93,000 ASM messages transmitted per day). As a result of this work, USACE continues to operate an AIS Western Rivers transmit system.

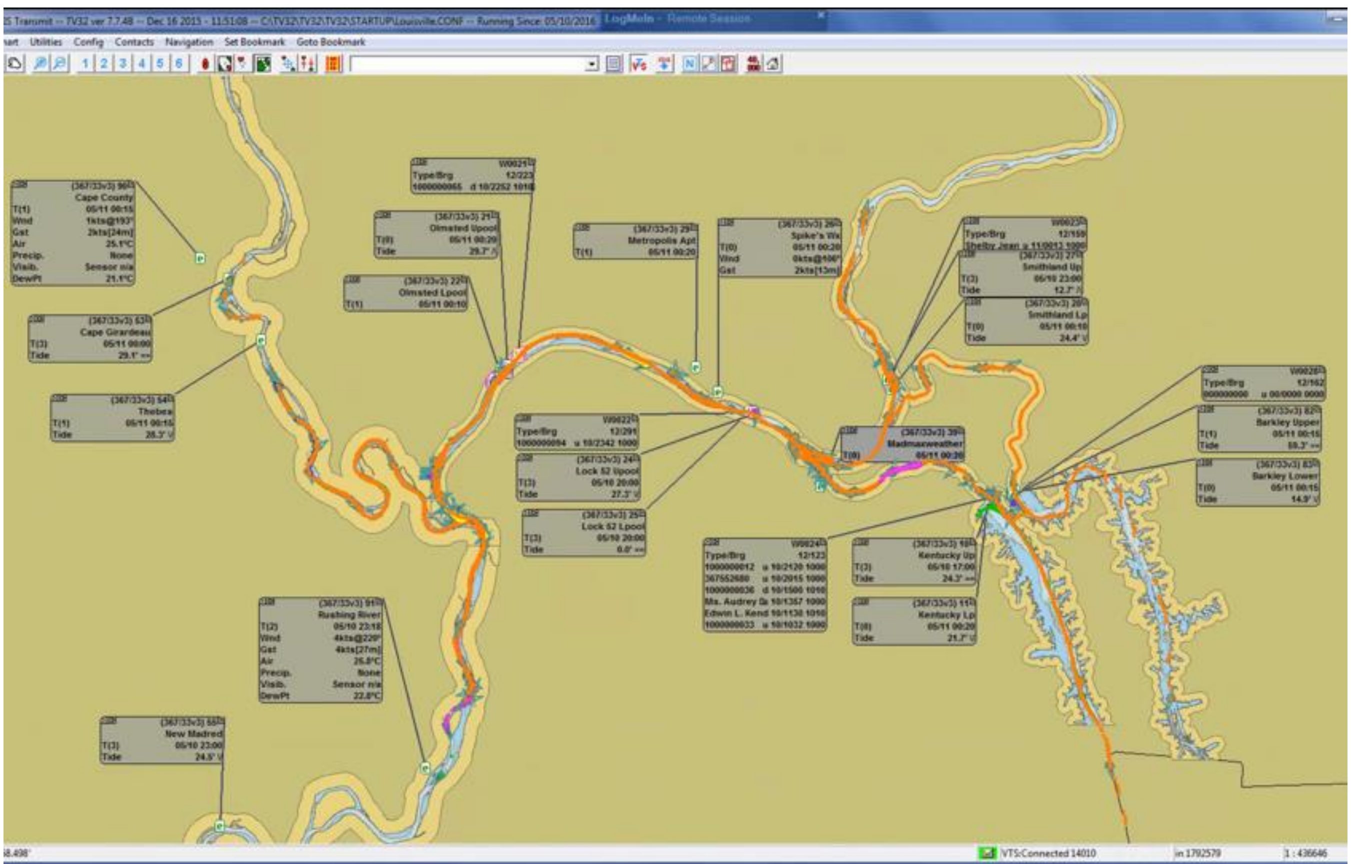


Figure 5. TV32 chart display showing ASMs transmitted for JCTD over lower Ohio River.

The JCTD demonstrated the shortfalls of NAIS to support a complete AIS transmit capability. As the USCG did not currently have a system to create, route, manage, transmit, and monitor messages.

3 ANSIS PROJECT

The JCTD effort helped develop USCG procedures and policy requirements to support other government agencies requesting use of AIS AtoN to transmit eMSI. This led to USCG interest in developing procedures and policy for non-government organizations interested in transmitting information to mariners via AIS. Both the USCG and MXAK had interest in providing Arctic mariners with navigation and maritime safety information. A CRADA was established in 2013 to develop and demonstrate at least one promising technology approach that would provide important, time-critical information to mariners in the remote and hazardous waters of the US Arctic Exclusive Economic Zone (EEZ).

This effort focused on prototyping the Alaska AIS transmit service through the CRADA partnership to both provide an AIS transmit service in Alaska, as well as prototype the concept for use of third-party system to provide AIS transmit services in areas for which the USCG does not have coverage.

RDC worked with MXAK and D17 Waterways Branch to preliminarily transition operation of the transmit capability from RDC to D17 and MXAK. The purpose of this preliminary transition is to ensure the tasks and activities that need to take place to fully transition the Alaska AIS transmit prototype service to the operations and maintenance environment are addressed. The completion of a full transition is anticipated with the ending of the CRADA (October 2018).

3.1 RDC/MXAK CRADA

RDC and MXAK cooperatively developed the prototype Alaska AIS transmit service under RDC Project 6211, "the Arctic Navigational Safety Information System (ANSIS)." The CRADA agreement was signed in 2013 for a duration of 5 years. The aim of the ANSIS project was to explore electronic Marine Safety Information (eMSI) delivery solutions for nearshore (Alaska AIS transmit service), extended-range (AIS receive), and long-range (High Frequency [HF] digital radio broadcast). This report focuses on the nearshore solution. Reports on the extended range [8] and long-range [9] were published previously.

The Alaska AIS transmit service prototype was designed to broadcast meteorological, hydrographic, and safety information via AIS. This partnership included D17 and CG-NAV. Each partner contributed vital information, software, hardware, and expertise to develop the Alaska AIS transmit service prototype through the CRADA. Figure 6 illustrates core contributions of each partner.

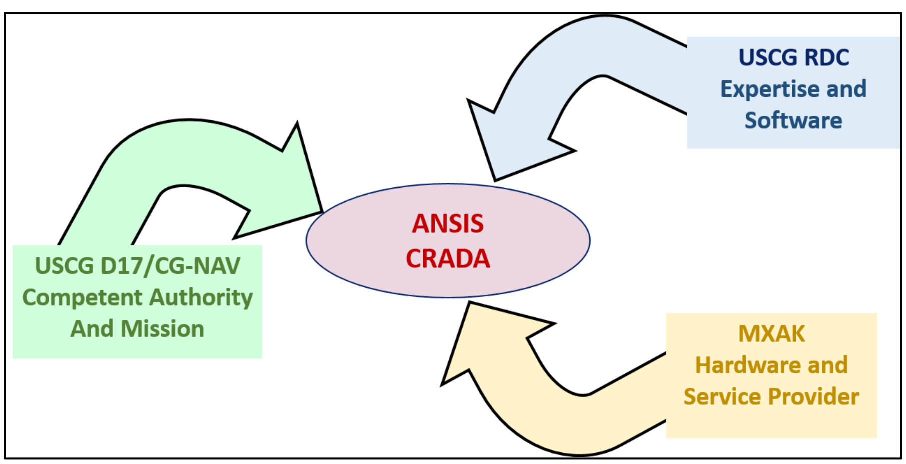


Figure 6. Contributions from RDC, MXAK, and D17/CG-NAV to ANSIS CRADA.

RDC contributed AIS transmit expertise and software. The software included:

- Application Specific Message (ASM) Manager
- Fetcher Formatters (FF)
- Geo Notice Creator (GNC)
- Multi-Protocol Interface (MPI)
- Transview 32 (TV32) Volpe National Transportation Systems Center (VNTSC) Government Electronic Chart Testing System

MXAK contributed the AIS hardware and service to support and manage a network of AIS transceivers. This included:

- 26 AIS AtoN transceivers
- GateHouse AIS System
- Weather sensors
- 24/7 watch-monitoring

D17 and CG-NAV provided necessary direction and feedback on policy and mission performance as the competent authority. This included:

- Authority for messages to be transmitted
- System Requirements – security, redundancy, licensing
- Approval Process
- Support Agreement
- Monitoring

Details about each of these contributions are discussed in more detail throughout this report.

3.2 Reporting Subsistence Hunting/Fishing through Whale Alert

One aspect of the CRADA was to develop a means to inform mariners when and where subsistence hunting/fishing is occurring. RDC partnered with NOAA's Stellwagen Bank National Marine Sanctuary (NMS) to develop a way to support D17's needs to communicate indigenous hunting/fishing activities in Alaska. Due to the remote locations of these indigenous (subsistence) hunting/fishing activities, it is difficult to inform mariners of these activities.

NOAA has an application (APP) to report locations of all whales identified by individuals on the water, flyovers, or AIS. NOAA's free mobile APP is called *Whale Alert* and supported by a cloud-based data infrastructure. It is designed to provide comprehensive and immediate information to mariners relative to whale management. For this effort, the APP allowed authorized users to log on to the *Whale Alert* APP and turn "on" areas where subsistence hunting/fishing was taking place. It then activated these areas graphically on the APP. The Alaska AIS transmit service then fetched the information from the APP and transmitted it via AIS. The North Pacific Right Whale Critical Habitat Area is also available when active. Figure 7 and Figure 8 show the areas presently available on the *Whale Alert* APP and via the Alaska AIS transmit service. More details about how this capability was implemented is provided in Section 5.2.2 – Automated message creation for Indigenous Whaling Activity.

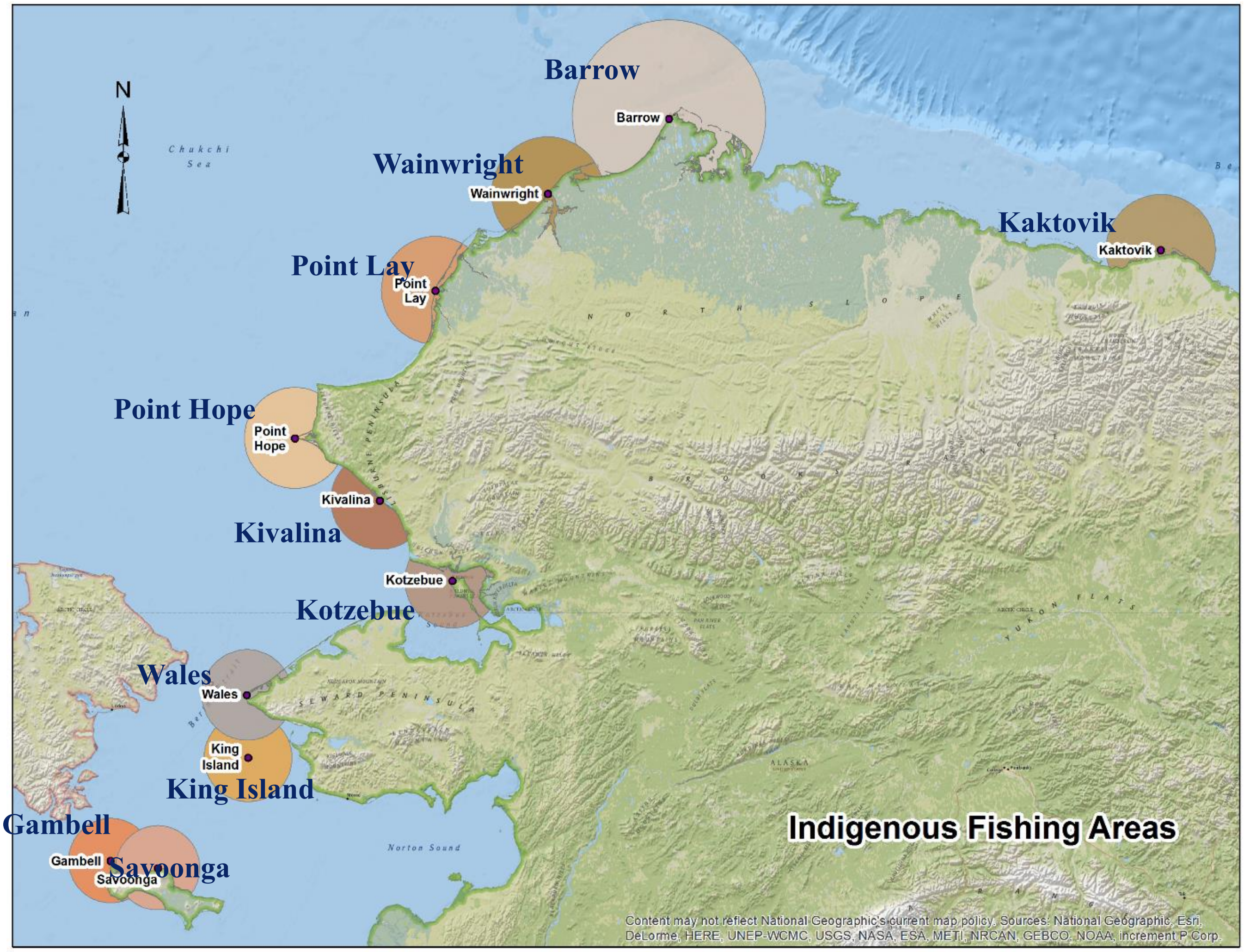


Figure 7. Indigenous subsistence hunting/fishing areas when active, are displayed, in the *Whale Alert* APP and through Alaska AIS Transmit Service.

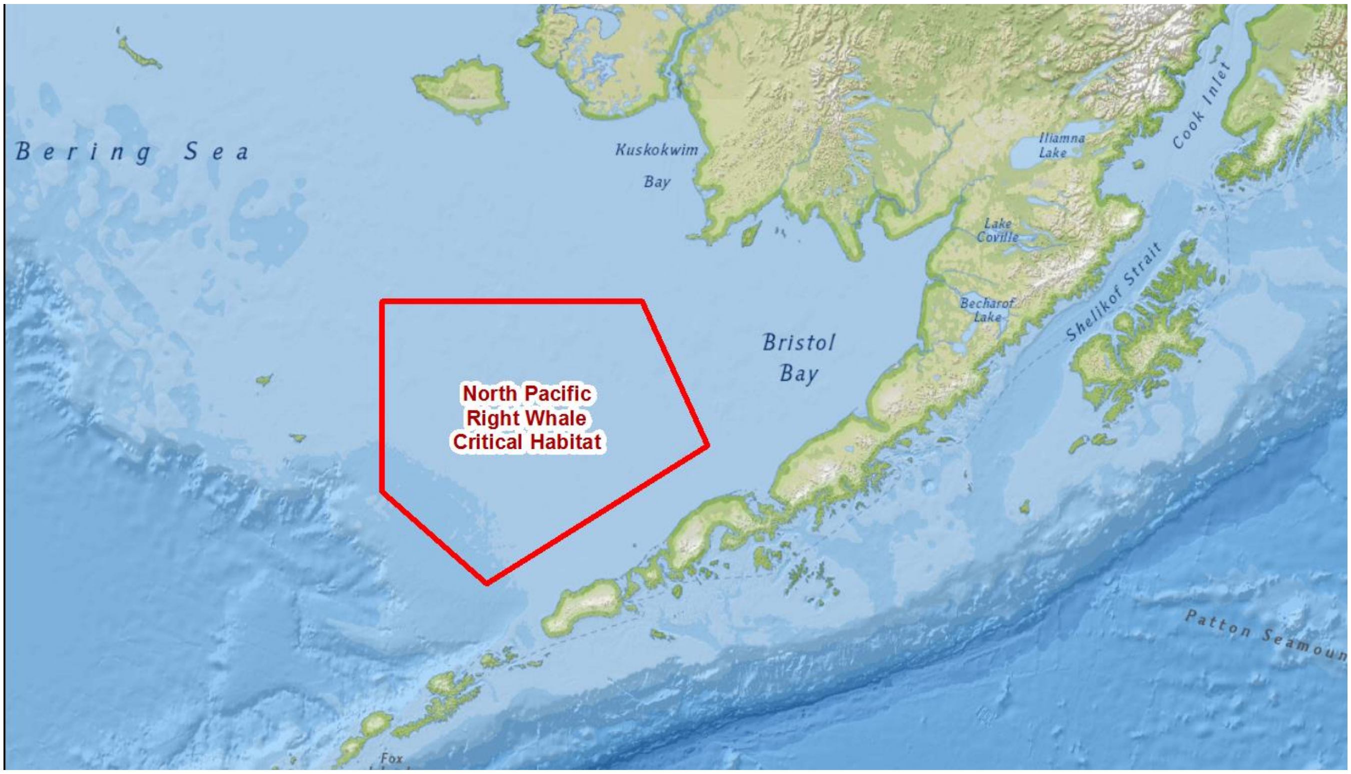


Figure 8. North Pacific Right Whale Critical Habitat Area, when active, is displayed in the *Whale Alert* APP and through Alaska AIS Transmit Service.

3.3 Current State

The prototype system was transitioned (hardware and software) to operation by MXAK and D17. However, additional work is required to complete the AIS Transmit System. As developed by RDC, a complete AIS Transmit System Architecture includes all of the following components (see also Figure 9). At a minimum, an AIS Transmit System requires components 1-5.

1. Message Creation
2. Message Routing
3. Message Management
4. Message Transmissions
5. Data Assurance
6. Transmit Permission
7. Shoreside Operator Display
8. System Monitoring
9. Connectivity
10. Cybersecurity
11. Mariner Display

Although not all of these components were developed under the prototype, the most essential components were developed and the others have a placeholder within the architecture. Each component is described below.

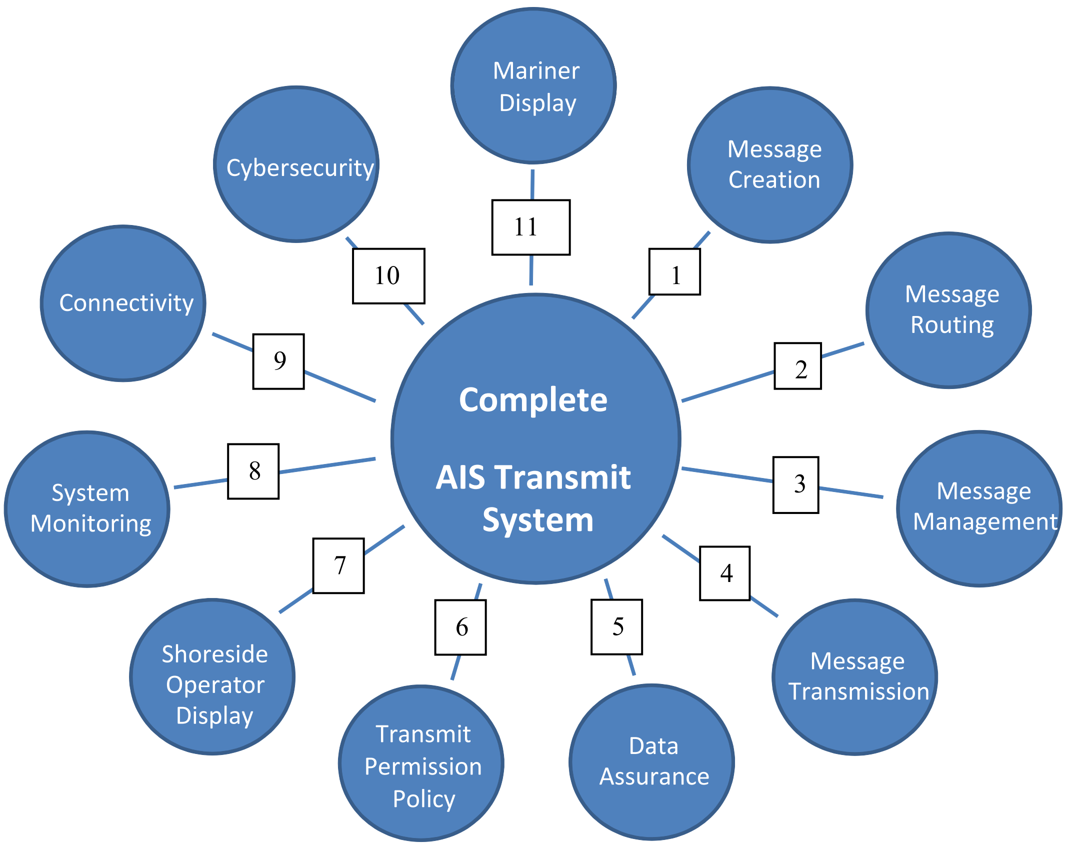


Figure 9. Components of ANSIS (AIS Transmit System) prototype.

3.3.1 Message Creation

Message creation is the ability to draft messages for transmission either manually or automatically. Messages are manually generated using a Graphical User Interface (GUI) display. Messages are created automatically for transmission (typically using information from databases) using a software application. An example of an automated message is when a particular area of subsistence hunting/fishing is active. From a shore side computer or mobile device, an authorized individual can turn the specific area "active" on the APP. This information contained in the APP database can then be automatically "fetched and formatted" for transmission by AIS.

The prototype included the message creation component as described in Section 4.2. Integrating these software tools into present USCG workflow is difficult; it may be easier to contract for the message creation function in the short term.

3.3.2 Message Routing

The message routing of ASMs to and from end-point transmitters and receivers can be simple or complex, depending on how related areas -- such as transmit permission policy, interagency connectivity, cybersecurity, geographic area of message applicability, transmission and reception effectiveness, etc. -- are implemented in an operational AIS Transmit System.

The ANSIS Prototype handles routing using the GateHouse system as described in Section 4.2.

3.3.3 Message Management

The Message Management component answers the questions of when and how often a message is transmitted and re-transmitted. This is needed to provide a reliable delivery service (ensure all messages are transmitted) and to ensure more efficient use of network bandwidth by controlling when messages are transmitted. If a message management service is not used, then there is no capability to re-transmit messages at a set interval or to ensure messages are transmitted.

The ANSIS Prototype uses ASM Manager to provide this capability as described in Sections 4.2 and 5.1.

3.3.4 Message Transmission

The Message Transmission component deals with how the messages are transmitted. There are two parts to this: the transmitter itself and the transmission method. The transmitter can be either an AIS AtoN or base station (the ANSIS Prototype uses MXAK AIS AtoN – See Figure 10 and Figure 11, respectively). AIS AtoN use Random Access Time Division Multiple Access (RATDMA) for their channel access; base stations may use RATDMA or Fixed Access (FATDMA) and reserve slots for their transmissions. If a base station is used, then reserved slots with FATDMA is recommended. There are three ways to command the transmitters to send messages:

1) configure the transmitter for autonomous transmissions (using National Maritime Electronic Association (NMEA) configuration sentence),
2) send the transmitter AIS messages (embedded in AIS VHF Data-Link Message (VDM) sentences – used to transfer the entire contents of a received AIS message packet), or
3) send the transmitter data for the AIS message in a Broadcast Binary Message (BBM) sentence.

Each of these methods has pros and cons. For the ANSIS Prototype, methods 1 and 3 are used. Method 1 was used to configure the Anchorage AIS AtoN to transmit two virtual aids in Cook Inlet. All other messages are sent using Method 3.

Figure 10. Photo of AIS AtoN.

Figure 11. Photo of AIS Base Station.

3.3.5 Data Assurance

The data assurance component addresses the integrity of data delivered to the mariner or Coast Guard asset over the AIS VHF Data Link Channels. It ensures that the data received have only been transmitted by the competent authority and were not modified or spoofed. This can be ensured through monitoring of the VDL. In the ANSIS Prototype, MXAK has an Operations Center that monitors all AIS traffic 24 hours a day. Although there are not sufficient sites to monitor 100% of the coastline, where there is coverage, there is live monitoring. Monitoring is achieved using various software as described in Section 4.2. Developing tools that could monitor the VDL and automatically detect and flag anomalous transmissions for operator review would improve the efficiency of operations in the future.

3.3.6 Transmit Permission

The transmit permission component addresses policy and authority permissions concerning access and use of the system. This is currently not instituted formally in the ANSIS Prototype. Access to the MXAK transmitter network is restricted by IP-filter, but it is not tied to usernames and passwords that would allow tracking of message origination by individual.

3.3.7 Shoreside Operator Display

The MXAKs shoreside operator display component supports the viewing of ASMs during manual message creation and following ASM transmission. The ANSIS Prototype handles this as described in Section 4.2 using a variety of software. D17 has this capability on a stand-alone computer provided under the CRADA. Support for this computer terminates with the end of the CRADA. Without this computer and software, D17 does not have the capability to display any of the information because other USCG systems do not support ASMs. This support need must be addressed to achieve full transition.

3.3.8 System Monitoring

The system monitoring component is necessary to ensure proper management of the VDL, proper message transmission, data assurance, operation of transmitters and receivers, and all shoreside components. In the ANSIS Prototype, MXAK can monitor all aspects of the system, (e.g. transponder interface connections) through the Gatehouse system and delivered software; D17 has only the delivered software, ASM Watch program (see Sections 4.2 and 5.4), for monitoring.

3.3.9 Connectivity

The connectivity component addresses the ability to share transmit resources between parties. For the Prototype, MXAK provides an access point between their network and the USCG. This access point is a client connection to the GateHouse server called the Logical Shore Station.

3.3.10 Cybersecurity

The cybersecurity component addresses the issue of protection against criminal or unauthorized use of electronic data. The MXAK network is protected by a firewall and access is restricted by IP filtering. If more stringent controls are needed in the future, they would need to be added. D17's standalone computer is also protected by firewall and account restrictions.

3.3.11 Mariner Display

The mariner display component supports the viewing of ASMs following message transmission. Currently, there are two commercial ECS systems identified during this effort that support the expanded AIS capability: RosePoint and SEAiq Pilot.

4 ARCHITECTURE

4.1 Generic AIS Transmit Architecture

Figure 12 shows a block diagram of the AIS Transmit architecture. There are five primary components: Message Creation, Routing, Queuing, Transmission, and VDL Monitoring. *Message creation* may be accomplished automatically by drawing information from an existing database, i.e., met/hydro, weather, or ice edge or user-created. If the message content is derived from a database, then software is needed to fetch the data and put it into the correct format (AIS ASM) embedded into a National Maritime Electronic Association (NMEA) standard sentence for Interfacing Marine Electronic Devices (NMEA 0183). If the message is user-created, then software tools (preferably based on a GUI) are needed to put the desired information into the ASM. *Message routing* is getting the message from the source to the desired transmitter or transmitters (AIS base station, AtoN, or perhaps, limited base station) according to the area to which the content of the message applies (i.e., "broadcast") or to reach a specific addressee (auto or user-specified; i.e., "addressed"). *Message queuing* (for each transmitter) involves both the queue process and rules-based prioritization along with message repetition and guaranteed delivery. *Message transmission* is the AIS transmitter sending the message via the AIS VDL. *Monitoring* is VDL load monitoring to ensure that the number of messages desired to be transmitted do not overload the VDL.

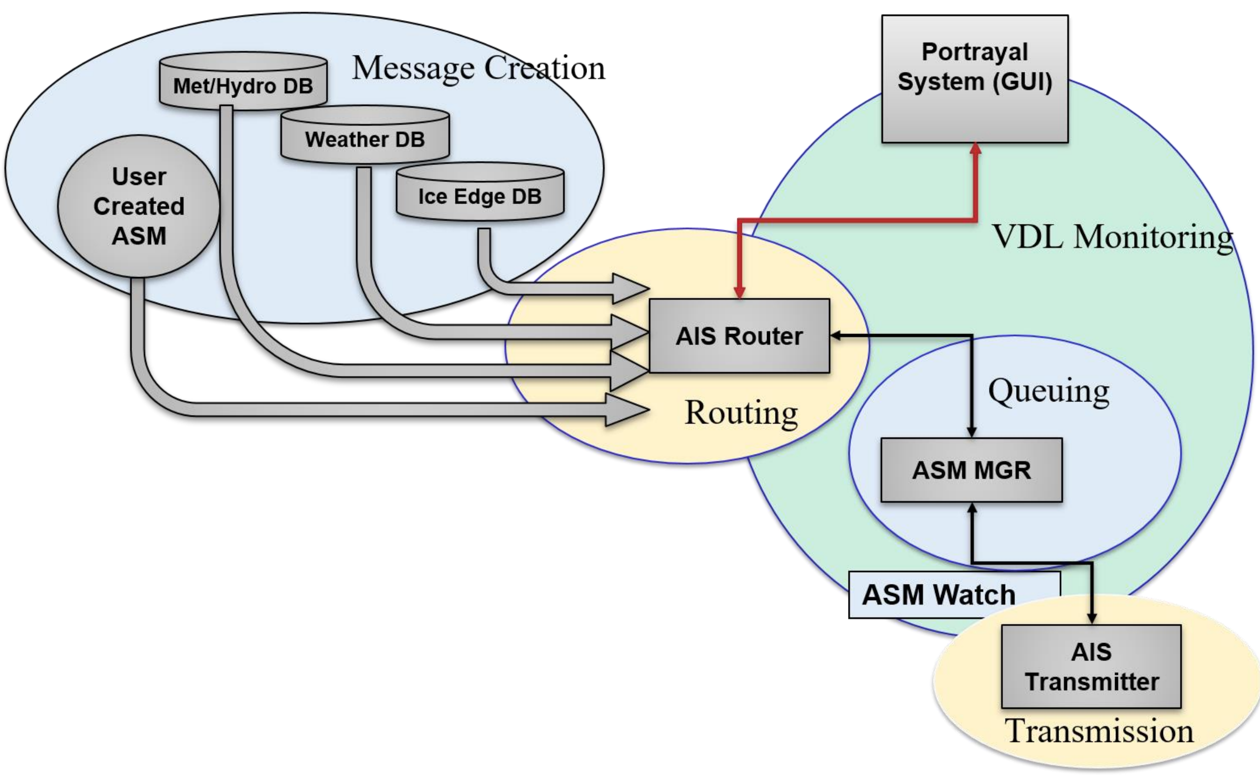


Figure 12. AIS transmit architecture.

4.2 Alaska AIS Transmit Architecture

Figure 13 shows the conceptual Alaska AIS Transmit architecture based upon the generic architecture. Message creation is accomplished at either of two locations: MXAK or D17 (green). Both locations have the software necessary to create ASMs automatically (from database information) and manually (Geographic Notices and Virtual AtoN). The GateHouse system installed at MXAK (yellow) accomplishes routing. The set of ASM Managers running at MXAK (tan) handle queuing. The 26 MXAK AIS AtoN transmitters (red) transmit. Both MXAK and D17 use a variety of software (blue) for VDL monitoring.

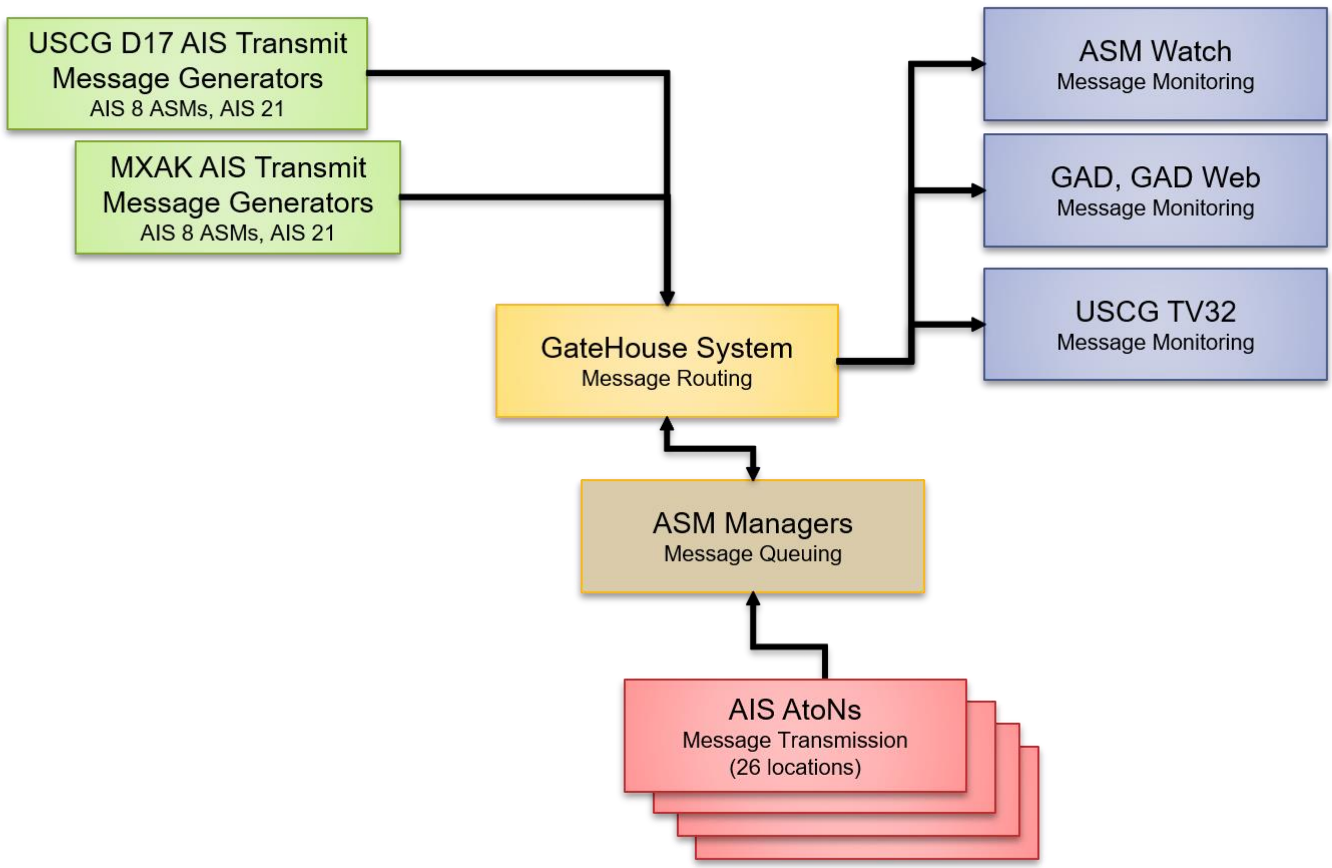


Figure 13. AK AIS transmit services conceptual diagram.

ASM Manager and MultiProtocol Interface (MPI) Configuration is designed to pass data seamlessly, but also provide trouble shooting capability by logging all data received and sent from both the GateHouse System and each individual AIS AtoN transceiver site. As illustrated below in Figure 14, for each AIS AtoN transceiver site, GateHouse connects to the ports configured on top of the MPI APP. One MPI port listens for data from the GateHouse and the other connects to the top of the ASM Manger server port. Within the configuration of the ASM Manager, there are two additional ports: one connects to the ASM console port and the other connects to MPI. The MPI then connects to the Transmission Control Protocol/Internet Protocol (TCP/IP) port for each AIS AtoN.

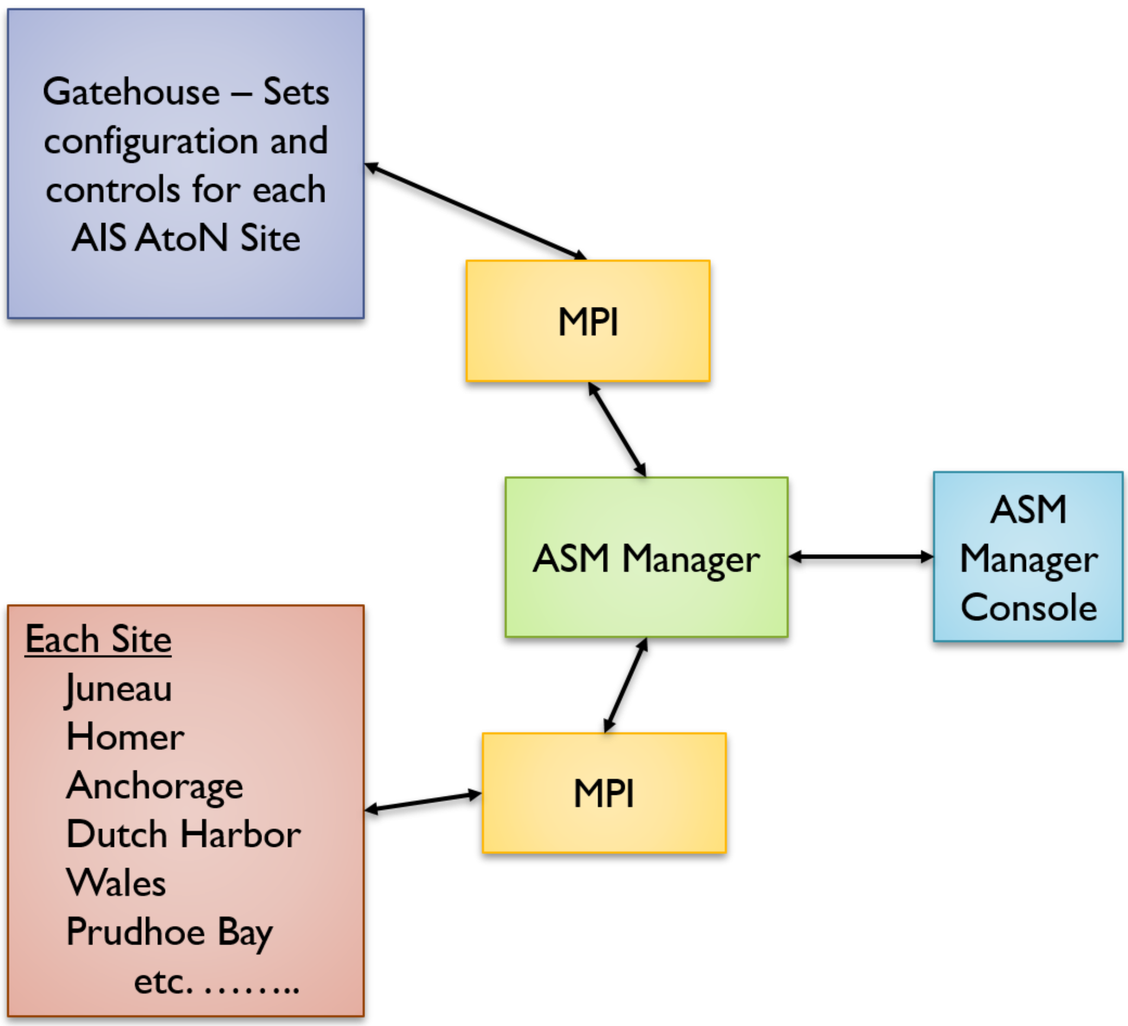


Figure 14. ASM Manager and MPI TCP/IP configuration.

Figure 15 is a more detailed block diagram of the MXAK configuration. Message creation is managed using a variety of software listed in Table 1. In addition to the GateHouse system for routing and ASM Managers for queuing, MPI software is used for data logging and connection sharing. One instance of ASM Manager is used for each transmitter. To provide comprehensive logging and troubleshooting, two instances of MPI are used for each transmitter; one before ASM Manager and one after (Figure 15). Software for monitoring the system includes: ASM Watch, Transview 32 (TV32), RosePoint ECS, GateHouse AIS Display (GAD), and GAD web.

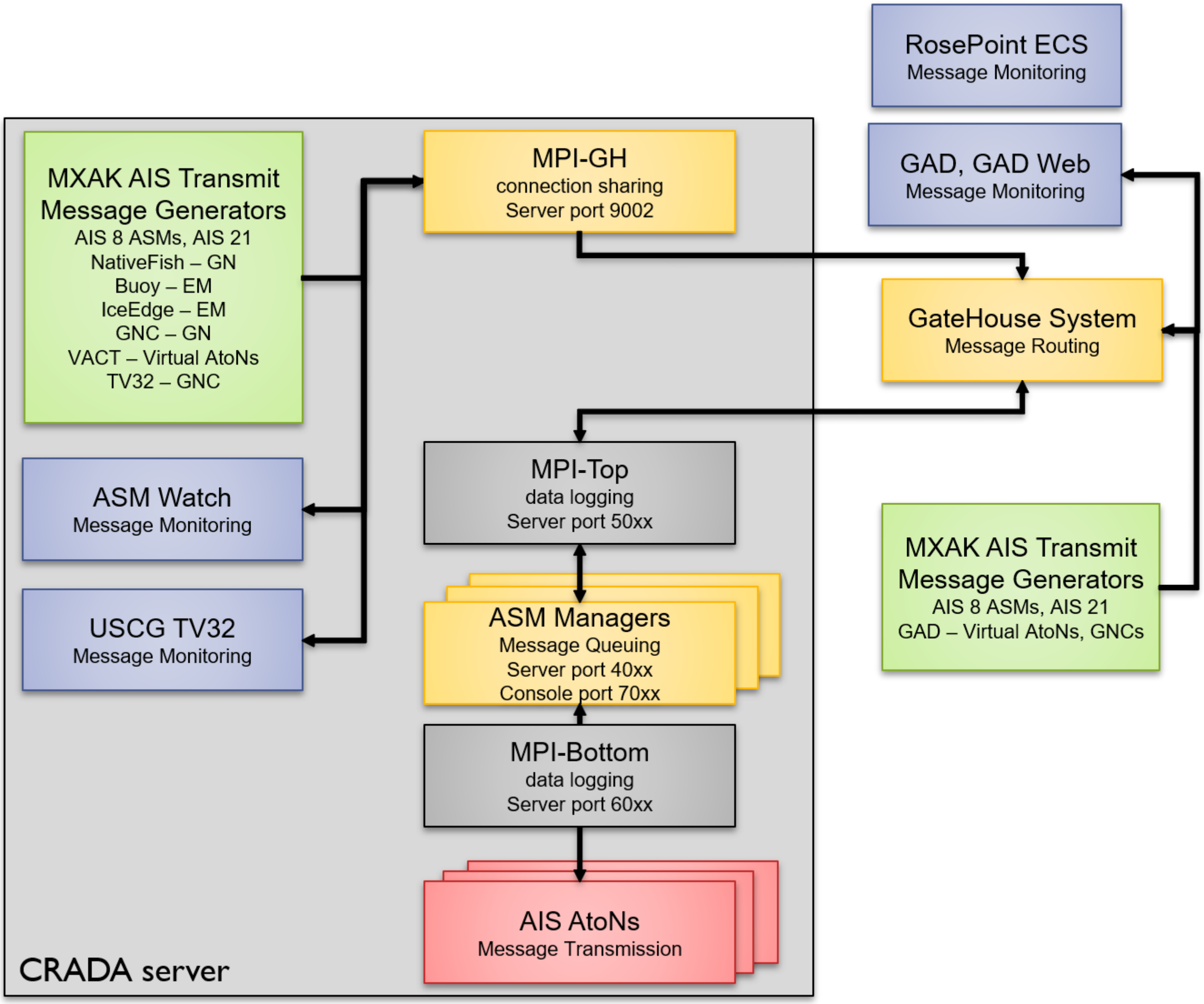


Figure 15. MXAK transmit configuration.

Figure 16 shows the configuration at D17. This consists of software for message creation (the same software listed in Table 1, except for GAD and monitoring software [e.g. ASM Watch, TV32, and RosePoint CE], along with MPI software for connection sharing.)

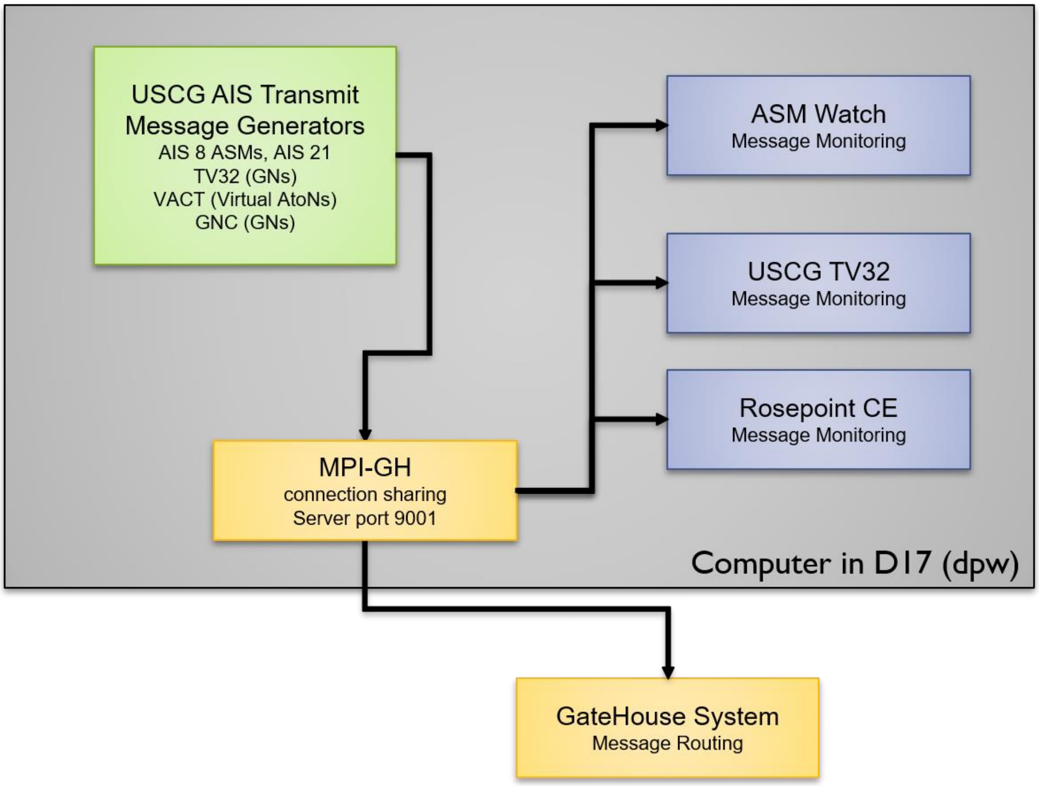


Figure 16. D17 AIS transmit configuration.

The various software applications listed in Table 1 can create messages to be transmitted (ASM). Note that in some cases more than one application is able to create the same type of message. Section 5 of this report provides more details about each software application.

Table 1. Message creation software.

Software	ASM	AIS Message
Automated Message Creation		
Ice Edge FF	Geographic Notice (GN)	8
Indigenous Whaling Fetcher Formatter (FF)	GN	8
Buoy Weather FF	Environmental Message (EM)	8
Manual Message Creation		
Geographic Notice Creator (GNC)	GN	8
Virtual Aid Creation Tool (VACT)	Virtual Aid	21
TV32	GN	8
GateHouse GAD	GN	8
GAD	Virtual AtoN	21

4.2.1 Transmit Sites

When the CRADA began, seven transmitters were available for testing. As of this report, MXAK is operating 26 transmitters. These sites are listed in Table 2. All of the transmitters are L-3 AIS AtoN units operating at 12.5 W. The sites use a variety of antennas and tower configurations as listed in the table. All of the sites connect back to the MXAK office in Juneau via Internet connections. Many of the sites also have co-located weather stations.

Table 2. MXAK transmit sites.

AIS AtoN Transceiver Site	Antenna Structure	Antenna Height	Antenna Model/Type
Juneau	Trylon Tower	50ft	Celwave BA1010-2
Homer	2nd Story building mast mount	35ft	Celwave BA1010-2
Anchorage	2nd Story building mast mount	35ft	Celwave BA1010-2
Dutch Hbr	Commercial Comm Tower	30ft	Celwave BA1010-2
Wales	2nd Story building mast mount	35ft	Comrod AV7
Prudhoe Bay	Commercial Comm Tower	100ft	Super Stationmaster PD620-5
Barrow	Quonset hut roof structure	35ft	Celwave BA1010-2
Ketchikan	2nd Story Building Mast mount	25ft	Comrod AV7
Haines	Single Story Building Mast mount	20ft	Comrod AV7
Gustavos	25GS Rohn Tower	30ft	Celwave BA1010-2
Middleton Island	Building Mast mount	120ft	Comrod AV7
Valdez	2nd Story Building Mast mount	30ft	Comrod AV7
Kenai	Light Pole	30ft	Comrod AV7
Bethel	Wood Light Pole	30ft	Comrod AV7
Cordova	45GS Rohn Tower	30ft	Morad VHF 162 10db AIS
Kodiak	Trylon Tower	1,230ft	Celwave BA1010-2
Seward	45GS Rohn Tower	30ft	Morad VHF 162 10db AIS
Sitka	Wood Light Pole	100ft	Morad VHF 162 10db AIS
Nome	Wind Turbine Mast	600ft	Telewave 150F22
Fivefinger	Aluminum Frame	20ft	Celwave BA1010-2
Whittier	Aluminum Lightpole	30ft	Telewave 150F22
Coffmancove	25GS Rohn Tower	285ft	Celwave BA1010-2
Petersburg	2nd Story building mast mount	40ft	Telewave 150F22
Wrangell	45GS Rohn Tower	30ft	Comprod 295-70
Akun	2nd Story building mast mount	30ft	Celwave BA1010-2
Guard Island	45GS Rohn Tower	30ft	Celwave BA1010-2

Figure 17 shows predicted coverage of all 26 sites. Appendix A provides additional predicted coverage plots for each site. These coverage plots were prepared using STK™ and Matlab™ software. Each site was configured with its location, tower height, and antenna gain characteristics. Propagation predictions were computed using the Terrain Integrated Rough Earth Model (TIREM) module in STK, using Digital Terrain Elevation Data (DTED) level 1 terrain data. Plots were created in Matlab using -115 dB as the minimum received signal level. Transmitted AIS data received on *USCGC Healy* during Arctic Shields 2014 [10] and 2015 [11] validated this methodology for the first seven sites.

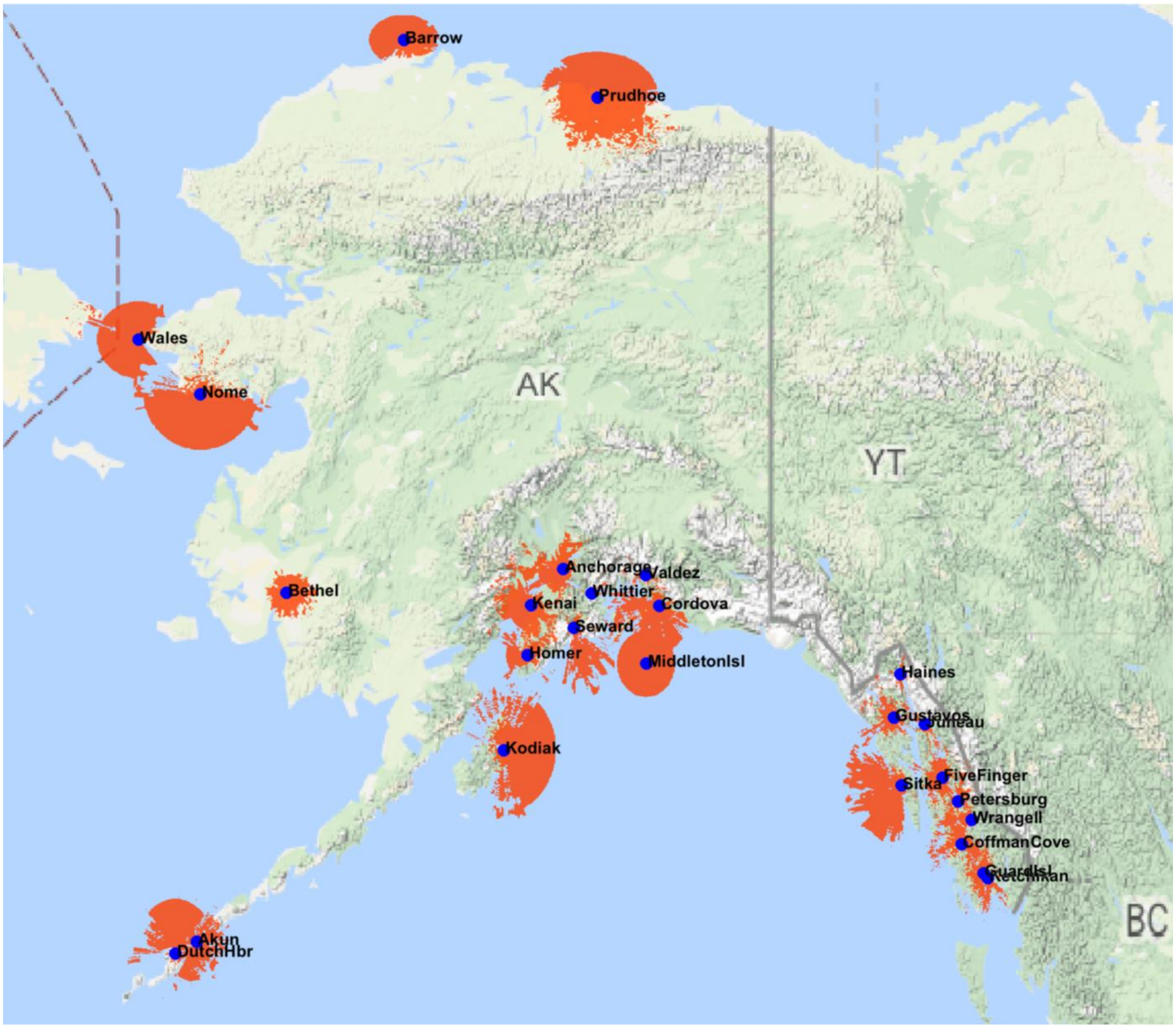


Figure 17. All MXAK Transmitters – Predicted coverage.

The remainder of this report and the Appendix provides the technical details of the prototype Alaska AIS Transmit System.

5 SOFTWARE

Since 2008, several individual software applications were developed to support the process required for an AIS transmit capability. This was an iterative process with more capability and refinement added to the software as understanding increased. Software was developed through a contract. All software is either written in Java or C++. All the applications are: relatively small (less than ½ megabyte); open source; and able to run on any platform. Effort was made during development to properly annotate/document code to make for smooth transition to independent programmers if necessary. All software created for this effort has Government Use Rights. Version control may become an issue for the Government if changes are made. All software, manuals, and documentation are available upon request.

The following section discusses the software developed and is broken down into the following broad areas:

- Transmit Message Management
- Automated Message Creation
- Manual Message Creation
- Monitoring

5.1 Transmit Message Management

5.1.1 ASM Manager

The ASM Manager software is an RDC-developed series of services used to manage the AIS message transmit queue for each AIS transmitter. The ASM Manager Service resides logically between the AIS router and the AIS base station or AtoN AIS transmitters. The ASM Manager Service creates separate transmit queues for each transmitter and manages the message flow for each transmitter individually. Each queue has its own Transmission Control Protocol/Internet Protocol (TCP/IP) port to receive data. Each transmit queue is configured based upon the desired queue management parameters and the type of AIS transmitter (fixed access time division multiple access - FATDMA) for an AIS base station, and random access time division multiple access (RATDMA) for an AIS AtoN) to ensure proper queuing with respect to slot configurations. The ASM Manager transmit buffer is synchronized to Universal Time Coordinated for better control of the timing.

The ASM Manager is software that adds necessary functionality to the “AIS router” (the GateHouse system, in this case). The program was designed to shield the message creator from the details of the transmitter locations and manage ASM transmissions by performing the following functions:

1. Ensure messages are valid before transmission;
2. Buffer the incoming messages to ensure that no more than the user-specified number of slots are used for transmission in each minute in order to minimize the transmit loading on the VDL;
3. Allow for user-specified priorities along with prioritization based upon message type and content;
4. Determine if a message should be transmitted from a given transmitter based upon location;
5. Manage the queue of messages to ensure that priority messages are transmitted first and that older data in the queue is replaced with more recent data of the same type;
6. Ensure all messages are transmitted;
7. Keep messages in queue until acknowledgement is received from the transmitter;
8. Allow for acknowledgement to be routed back to user; and
9. Manage the repetition of messages that need to be retransmitted on a periodic basis as well as those that fail transmission for any reason.

The ASM Manager software process can run anyplace, as all connections are TCP/IP network connections. Logically, the ASM Manager process sits between the AIS Router and the Transmitter. There must be one ASM Manager process for each and every transmitter so that each transmitter has its own transmit queue. A configuration file and NMEA sentences control ASM Manager operation.

ASM Manager is running as a service on the MXAK server. The status of the ASM Manager Services can be checked under the task manager (Figure 18). Details about an individual ASM Manager can be seen by connecting up to the ASM Manager console port (Figure 18 and Figure 19).

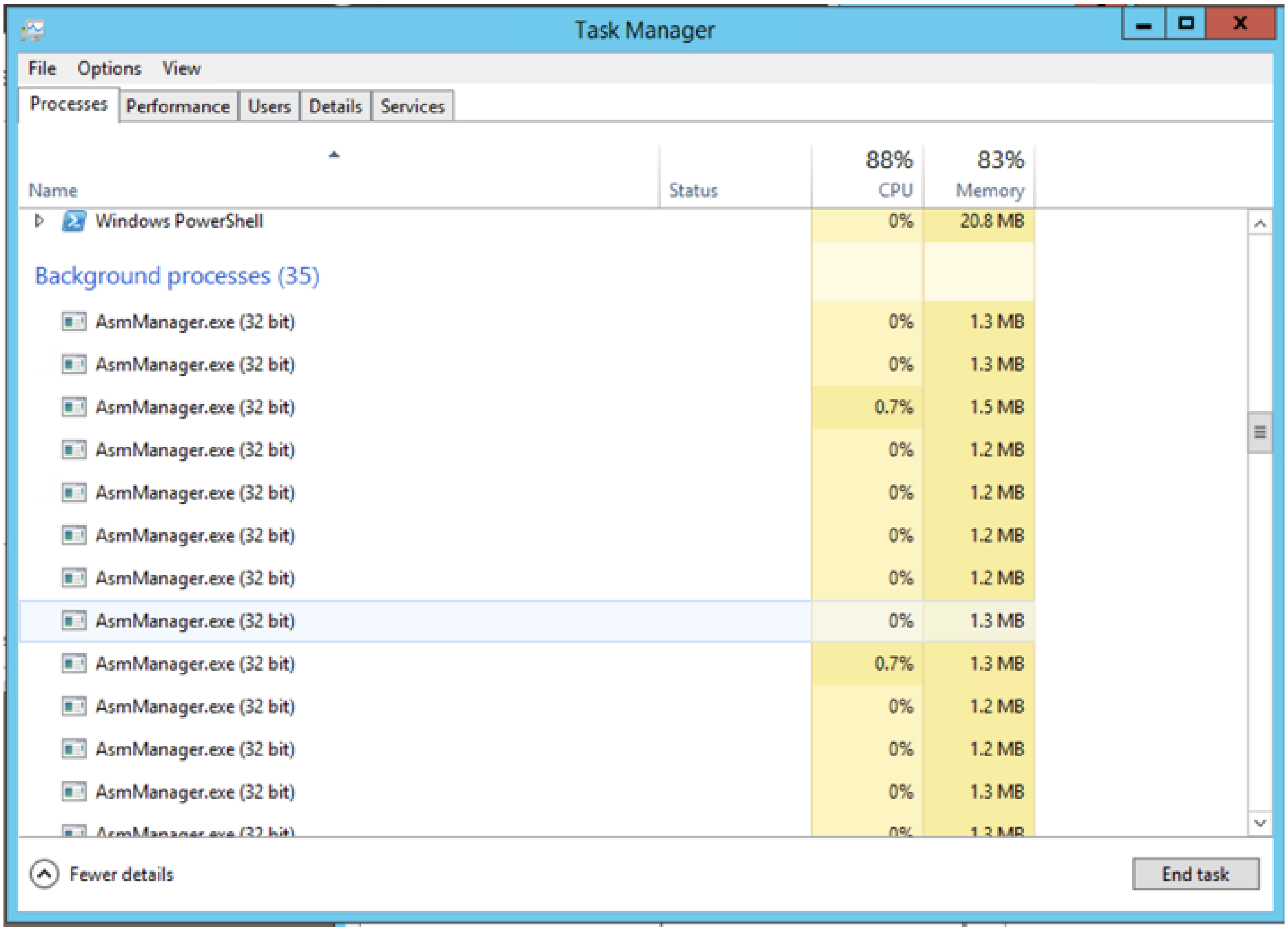


Figure 18. Task Manager window showing ASM Manager running in the background.

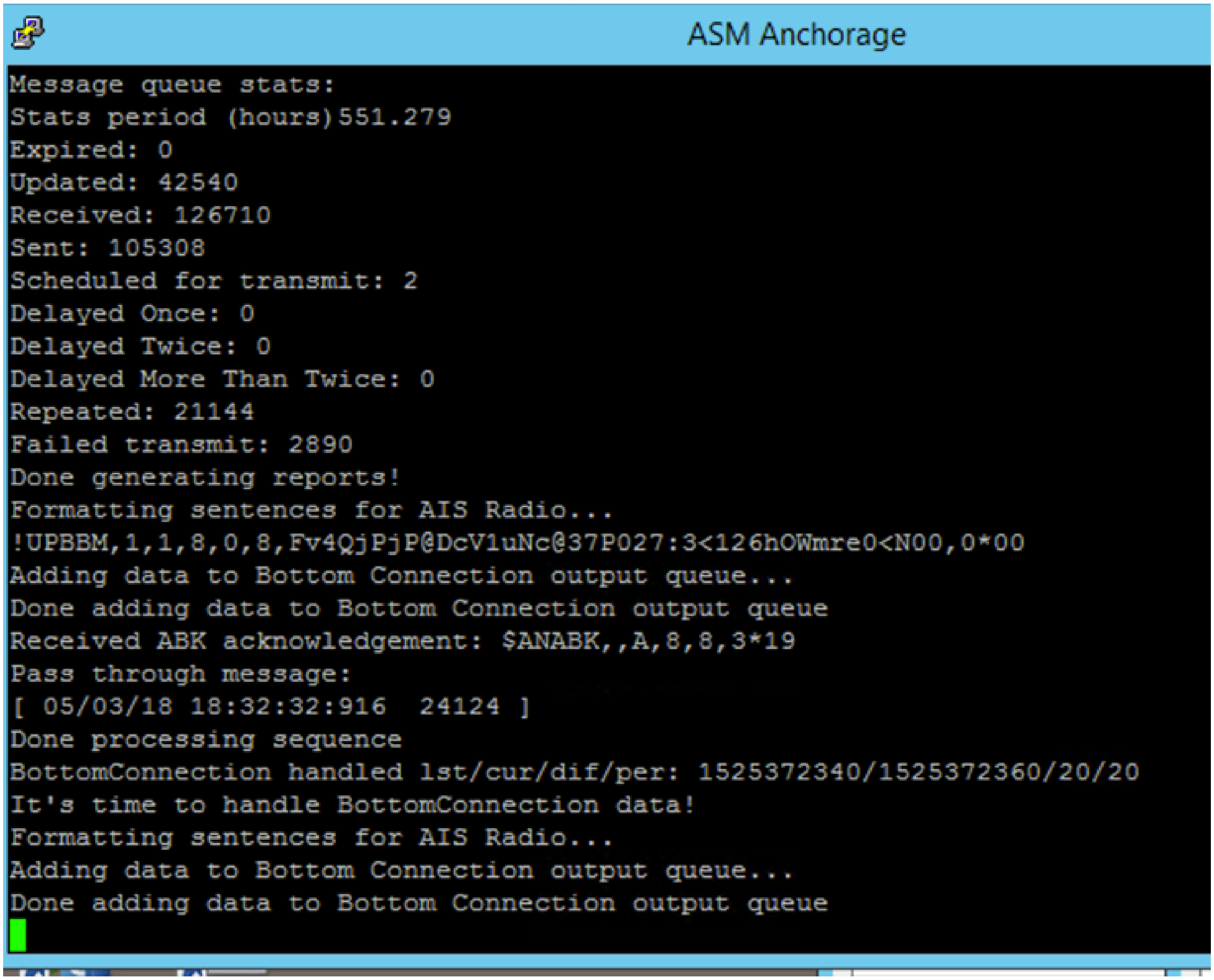


Figure 19. Console Window for ASM Manager for Anchorage.

5.1.2 MPI

RDC developed the MPI software application to manage connections between different interfaces. It can manage both serial and TCP/IP connections; TCP/IP connection can be either client or server. Data can be passed between open connections and displayed on the standard output, as well as logged to a file. MPI is configured at runtime using command line switches. The easiest way to do this is to create a batch file that contains the desired command line switches. While the program is running, in addition to logging all of the data, it is also displayed in a console window (Figure 20).

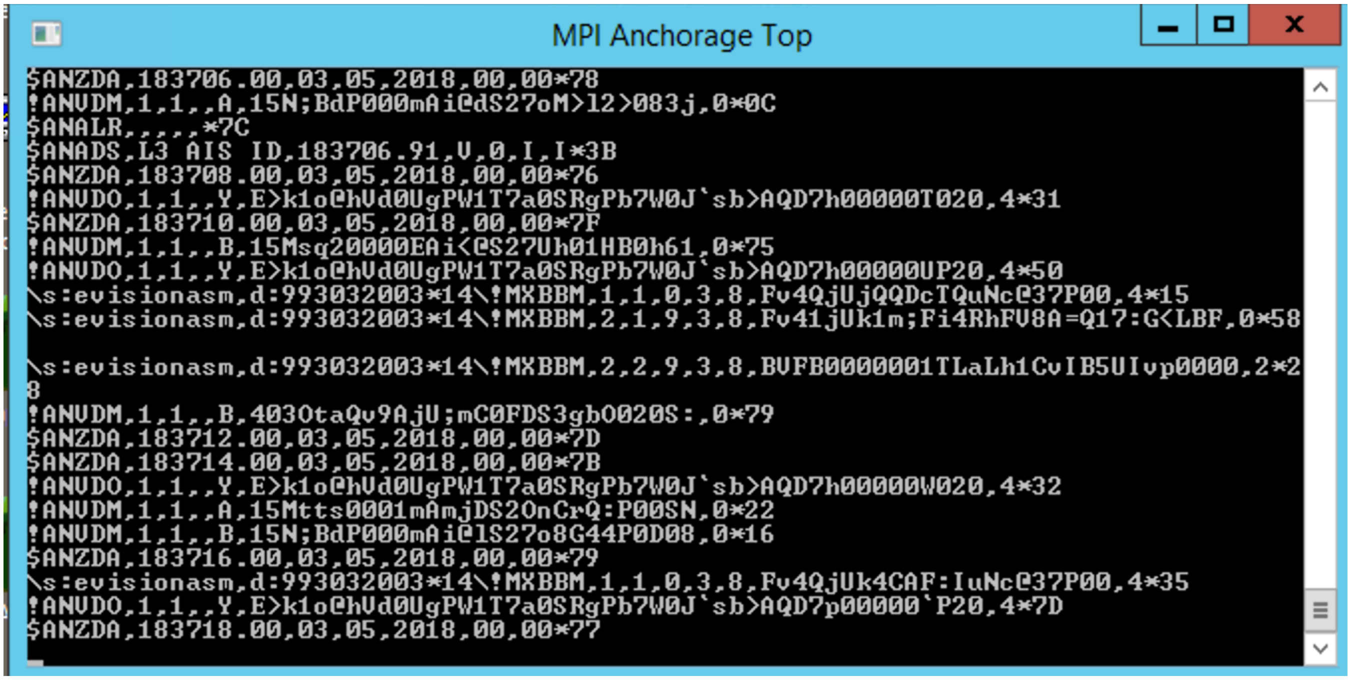


Figure 20. MPI Window for Anchorage.

5.1.3 Process Manager

The Transmit Process Manager is an application used to manage all Fetcher/Formatter and ASM Manager Services. The application makes better use of central processing unit resources by running several instances of the Fetcher/Formatter and ASM Manager code as services rather than as separate executable applications. Process Manager responsibilities include launching child-processes with configurable executable paths, working directories and command line parameters, maintaining Input/Output buffers, and subsequently shutting down those processes. Using a single process management service makes it easier to install, configure, manage, and monitor AIS data feeds and transmit queues.

5.2 Automated Message Creation through Fetcher Formatters

Fetcher/Formatters (FFs), a series of software applications were developed to fetch data from some source, format it into the applicable ASM, and forward it on to the transmit system as a NMEA Broadcast Binary Message (BBM) sentence.

5.2.1 Ice Edge

The Ice Edge message generator software is a Windows console application that reads ice edge data from a web site and generates ASM Geographic Notice (GN) messages for transmission through the AIS Transmit system. This environmental information is transmitted using the type 8 binary message with a function identifier of 22.

This program is designed to generate polyline GN messages. The data is read from the NOAA National Ice Center web site that contains ice edge lines defined by a series of latitude and longitude points. The program reads all these points, calculates which ones are in the area of interest (center and radius of circle defined in the configuration file), and generates polylines that correspond to these ice edge positions. The program generates a GN message for each ice edge polyline segment that it identifies. These ASMs are put into

NMEA BBM sentences and forwarded to the TCP/IP address and port specified in the configuration file. See Figure 21 for the Ice Edge FF in operation and Figure 27 for a display of the ice edge on an ECS.

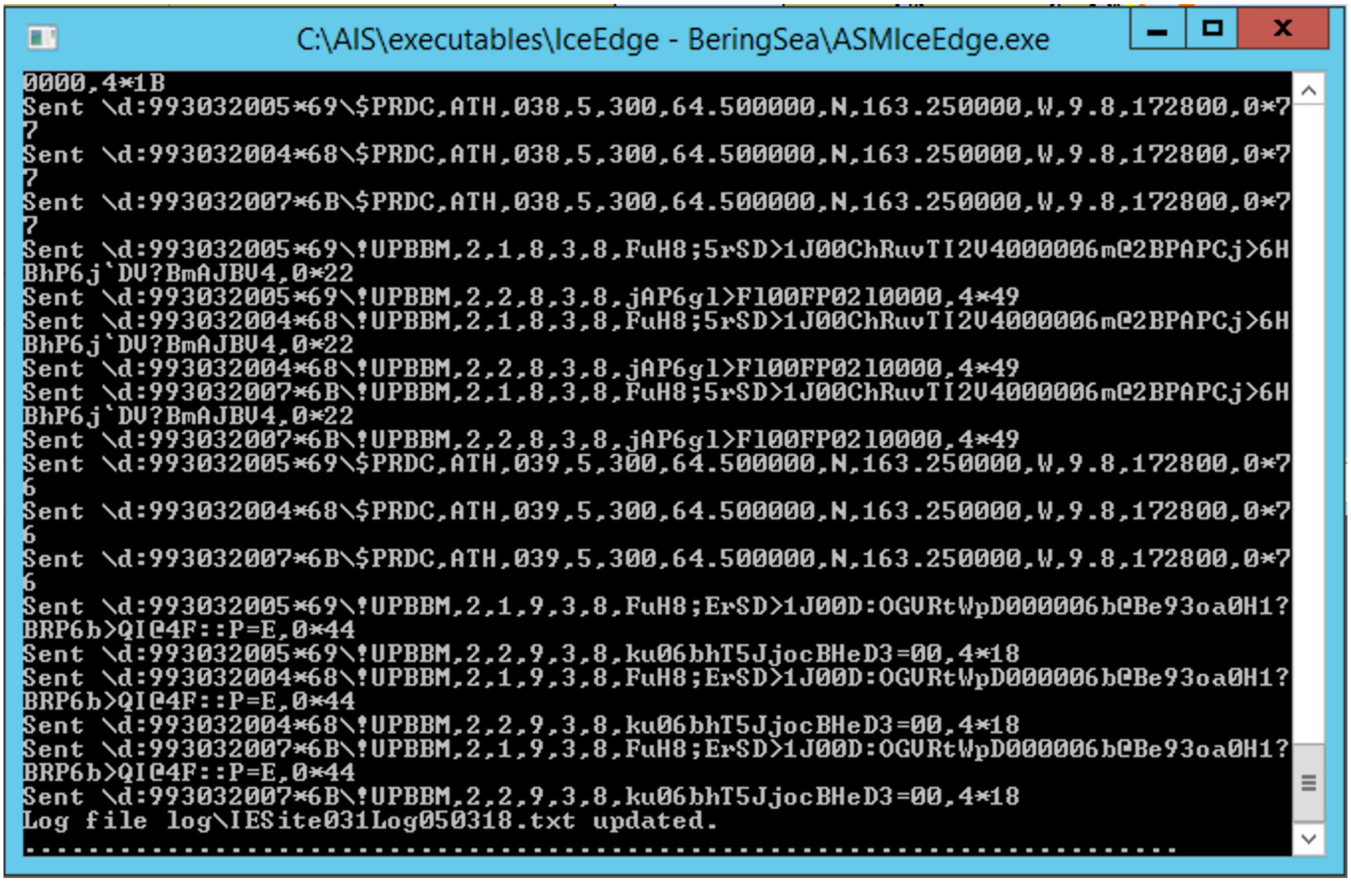
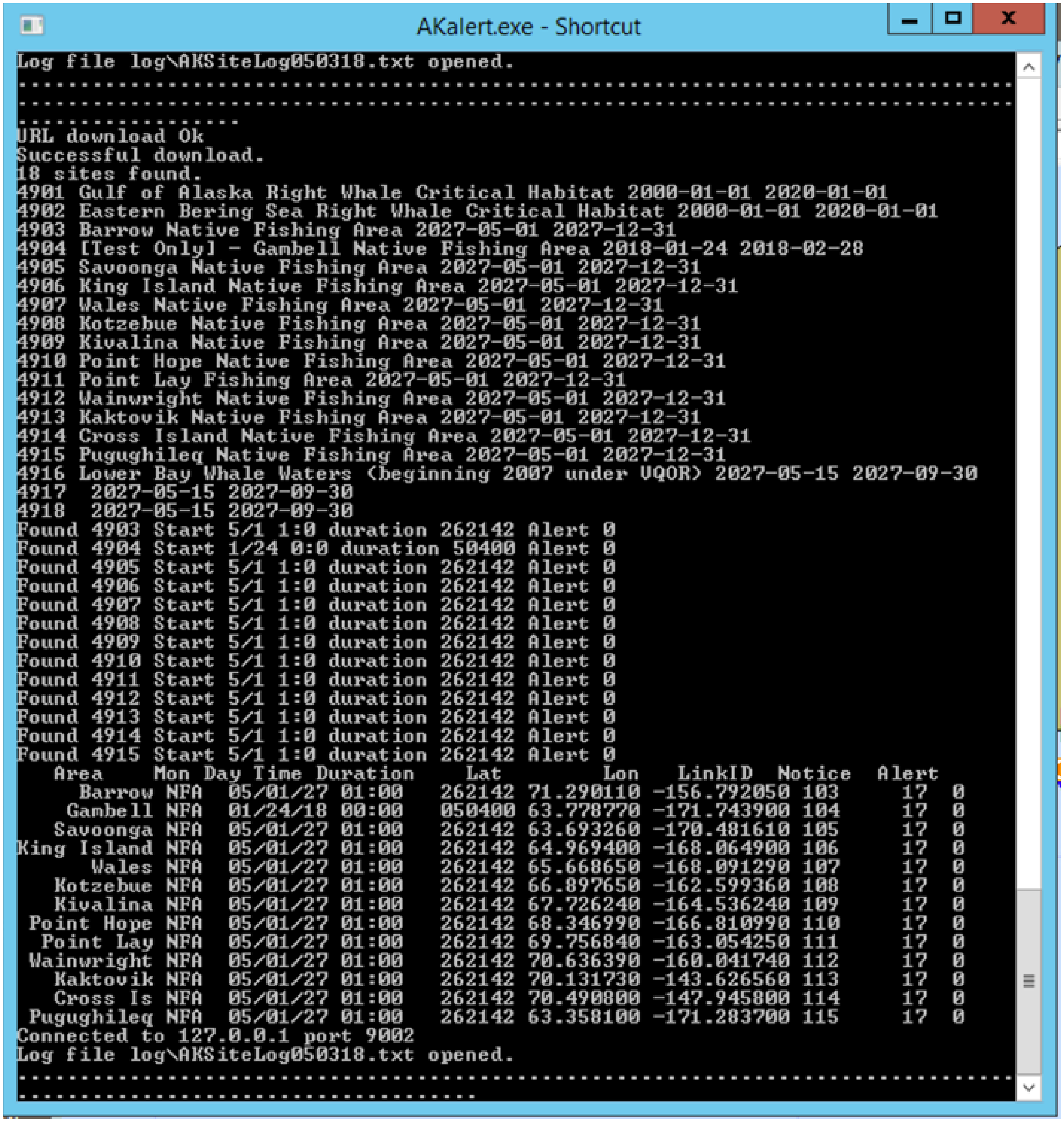


Figure 21. Bering Sea Ice Edge FF.

5.2.2 Indigenous Whaling Area

The ASM Alaska Native Subsistence Hunting/fishing Message Generator Software is a Windows console application that reads subsistence hunting/fishing data from a web site and generates ASM GN messages for transmission through the AIS. This environmental information is transmitted using the type 8 binary message with a function identification of 22.

This program is designed to generate circle GN messages of areas where Alaskan Natives are engaged in subsistence hunting/fishing. The data are read from a web site that contains information about each native hunting/fishing area and the start and end dates of when the natives are engaged in hunting/fishing. The web site is an "https" URL. Users must ensure that the Internet Options on the Windows computer has the "Do not save encrypted pages to disk" option unselected. If this option is selected, then the web site data will not download. The program generates a GN message for each native hunting/fishing area currently active. See Figure 22 for a view of the FF running and Figure 23 for a screen shot of an area displayed on the GateHouse GAD.



```
AKalert.exe - Shortcut
Log file log\AKSiteLog050318.txt opened.
..........................................................................................
..........................................................................................
..................
URL download Ok
Successful download.
18 sites found.
4901 Gulf of Alaska Right Whale Critical Habitat 2000-01-01 2020-01-01
4902 Eastern Bering Sea Right Whale Critical Habitat 2000-01-01 2020-01-01
4903 Barrow Native Fishing Area 2027-05-01 2027-12-31
4904 [Test Only] - Gambell Native Fishing Area 2018-01-24 2018-02-28
4905 Savoonga Native Fishing Area 2027-05-01 2027-12-31
4906 King Island Native Fishing Area 2027-05-01 2027-12-31
4907 Wales Native Fishing Area 2027-05-01 2027-12-31
4908 Kotzebue Native Fishing Area 2027-05-01 2027-12-31
4909 Kivalina Native Fishing Area 2027-05-01 2027-12-31
4910 Point Hope Native Fishing Area 2027-05-01 2027-12-31
4911 Point Lay Fishing Area 2027-05-01 2027-12-31
4912 Wainwright Native Fishing Area 2027-05-01 2027-12-31
4913 Kaktovik Native Fishing Area 2027-05-01 2027-12-31
4914 Cross Island Native Fishing Area 2027-05-01 2027-12-31
4915 Pugughileq Native Fishing Area 2027-05-01 2027-12-31
4916 Lower Bay Whale Waters (beginning 2007 under VQOR) 2027-05-15 2027-09-30
4917  2027-05-15 2027-09-30
4918  2027-05-15 2027-09-30
Found 4903 Start 5/1 1:0 duration 262142 Alert 0
Found 4904 Start 1/24 0:0 duration 50400 Alert 0
Found 4905 Start 5/1 1:0 duration 262142 Alert 0
Found 4906 Start 5/1 1:0 duration 262142 Alert 0
Found 4907 Start 5/1 1:0 duration 262142 Alert 0
Found 4908 Start 5/1 1:0 duration 262142 Alert 0
Found 4909 Start 5/1 1:0 duration 262142 Alert 0
Found 4910 Start 5/1 1:0 duration 262142 Alert 0
Found 4911 Start 5/1 1:0 duration 262142 Alert 0
Found 4912 Start 5/1 1:0 duration 262142 Alert 0
Found 4913 Start 5/1 1:0 duration 262142 Alert 0
Found 4914 Start 5/1 1:0 duration 262142 Alert 0
Found 4915 Start 5/1 1:0 duration 262142 Alert 0
   Area     Mon Day Time Duration     Lat        Lon    LinkID  Notice   Alert
     Barrow NFA   05/01/27 01:00   262142 71.290110 -156.792050 103      17   0
    Gambell NFA   01/24/18 00:00   050400 63.778770 -171.743900 104      17   0
   Savoonga NFA   05/01/27 01:00   262142 63.693260 -170.481610 105      17   0
King Island NFA   05/01/27 01:00   262142 64.969400 -168.064900 106      17   0
      Wales NFA   05/01/27 01:00   262142 65.668650 -168.091290 107      17   0
   Kotzebue NFA   05/01/27 01:00   262142 66.897650 -162.599360 108      17   0
   Kivalina NFA   05/01/27 01:00   262142 67.726240 -164.536240 109      17   0
 Point Hope NFA   05/01/27 01:00   262142 68.346990 -166.810990 110      17   0
  Point Lay NFA   05/01/27 01:00   262142 69.756840 -163.054250 111      17   0
 Wainwright NFA   05/01/27 01:00   262142 70.636390 -160.041740 112      17   0
   Kaktovik NFA   05/01/27 01:00   262142 70.131730 -143.626560 113      17   0
   Cross Is NFA   05/01/27 01:00   262142 70.490800 -147.945800 114      17   0
 Pugughileq NFA   05/01/27 01:00   262142 63.358100 -171.283700 115      17   0
Connected to 127.0.0.1 port 9002
Log file log\AKSiteLog050318.txt opened.
..........................................................................................
....................................
```

Figure 22. Indigenous Whaling FF console window.

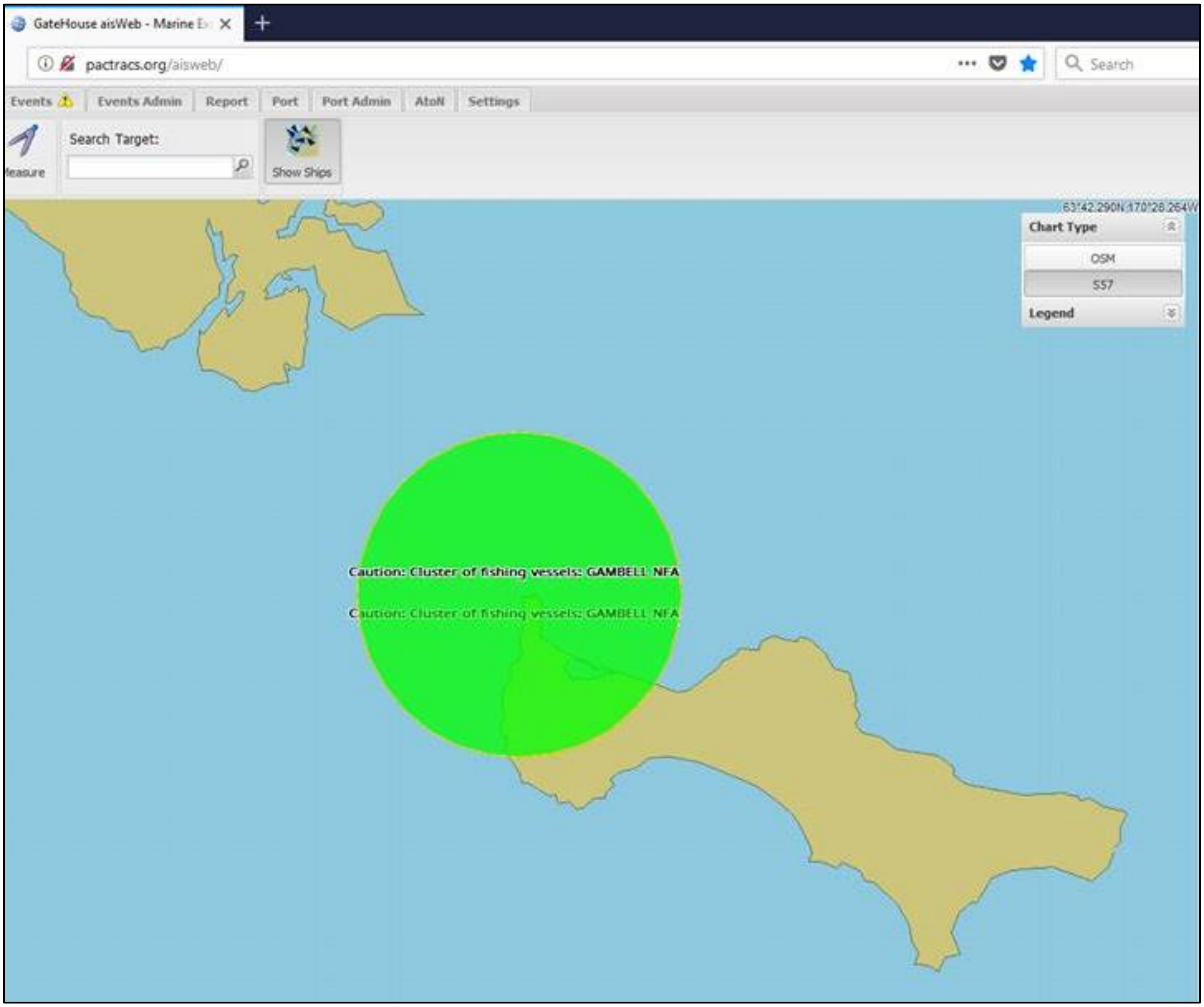


Figure 23. GateHouse GAD View of an Indigenous Whaling Area that is Active. User moves cursor over area to see additional text details describing area (in this case Indigenous Whaling Activity)

5.2.3 Weather Buoy Report

This Fetcher Formatter (FF) retrieves data from a NOAA National Data Buoy Center (NDBC) server for a specified weather buoy. The weather data (wind, sea state, temperature) are formatted into an Environmental Message (EM) ASM and passed along to the transmit system embedded in a BBM sentence. See Figure 24 for a screen capture of the FF in operation.

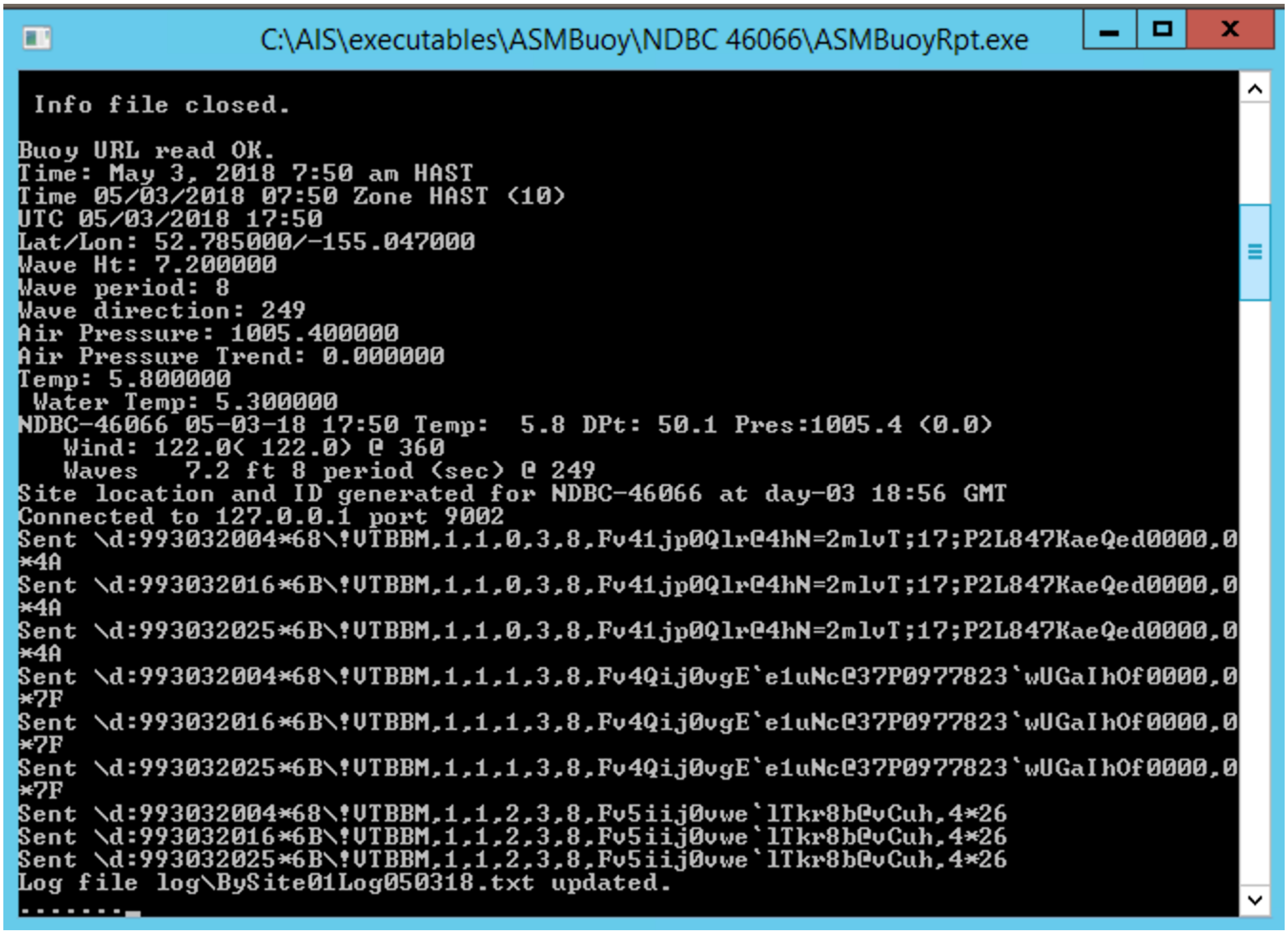


Figure 24. Buoy Report FF console window.

5.3 Manual Message Creation

5.3.1 GNC

Geographic Notice Creator (GNC) software is used to configure AIS transmitters to transmit AIS Geographic Notice messages. These ASMs communicate information related to a specific area for a defined time interval, such as channel obstructions, closures, safety zones, etc. These ASMs are intended to be displayed as an overlay on an ECS; see Figure 25 for an example.

The GNC software generates a message based on a data file of polygon points (nodes) and other parameters set by the user. The parameters determine the type of message, where it is sent, when the message starts, and when it should end.

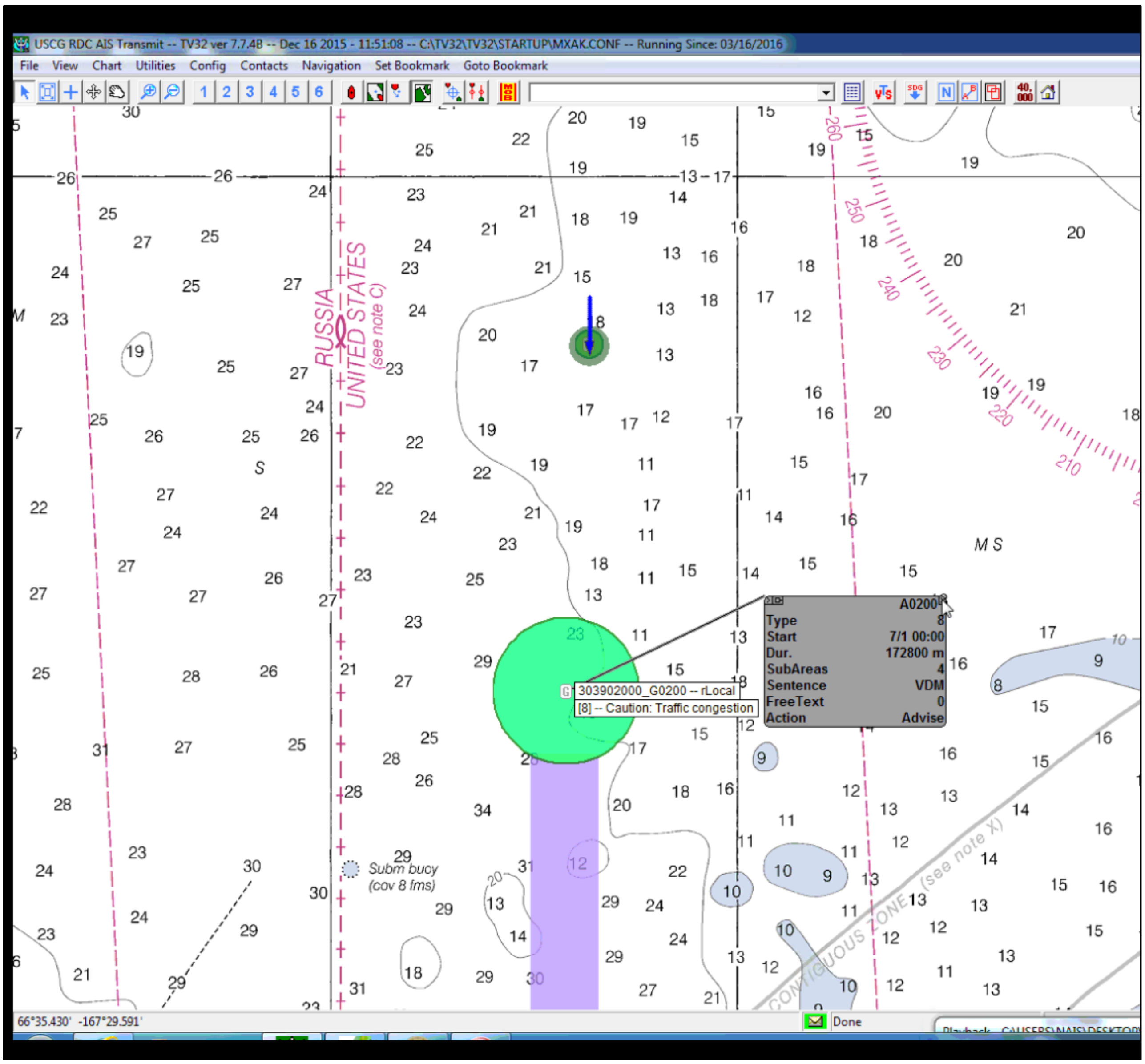


Figure 25. TV32 chart display of geographic notice – Traffic Congestion Area.

5.3.2 VACT

The Virtual Aid Creation Tool (VACT) is used to configure AIS AtoN transmitters to autonomously transmit AIS AtoN messages (message 21) for virtual/synthetic aids. It was designed and tested for use with AIS AtoN transmitters using both the old and new NMEA sentence standards, for base stations, and for use with ASM Manager.

To program an AIS AtoN transmitter to generate virtual/synthetic AtoN reports, four NMEA sentences are needed:

- The NMEA AID (AtoN Identification Configuration Command) sentence which sets the Maritime Mobile Service Identify (MMSI) of the virtual AtoN.
- The NMEA ACF (General AtoN Station Configuration Command) and ACE (Extended General AtoN Station Configuration Command) (or ACG) sentences which configures the virtual AtoN parameters (the L3 AtoN uses the deprecated ACE rather than the current ACG sentence).
- The AAR (Configure Broadcast Rates) (or CBR) sentence which sets the transmission schedule (the L3 AtoN uses the deprecated AAR rather than the current CBR).

See Figure 26 for a GateHouse Web GAD display of two virtual AtoN in Cook Inlet (along with environmental ASM data).

Figure 26. GateHouse Web GAD display of Virtual AtoN and Environmental ASMs.

5.3.3 TV32

TV32 is a Volpe National Transportation Systems Center (VNTSC)-developed software application that has been in use by USCG for over 20 years. TV32 provides an ECS display and is used primarily for viewing and tracking AIS-equipped vessels. Since 2010, the application was upgraded several times - to support manual creation (field values and NMEA-compliant formatting) and display of ASMs. In addition to serving as a message creation tool, TV32 is also used for shoreside display. Transmitted messages are shown on the TV32 chart display below (Figure 27).

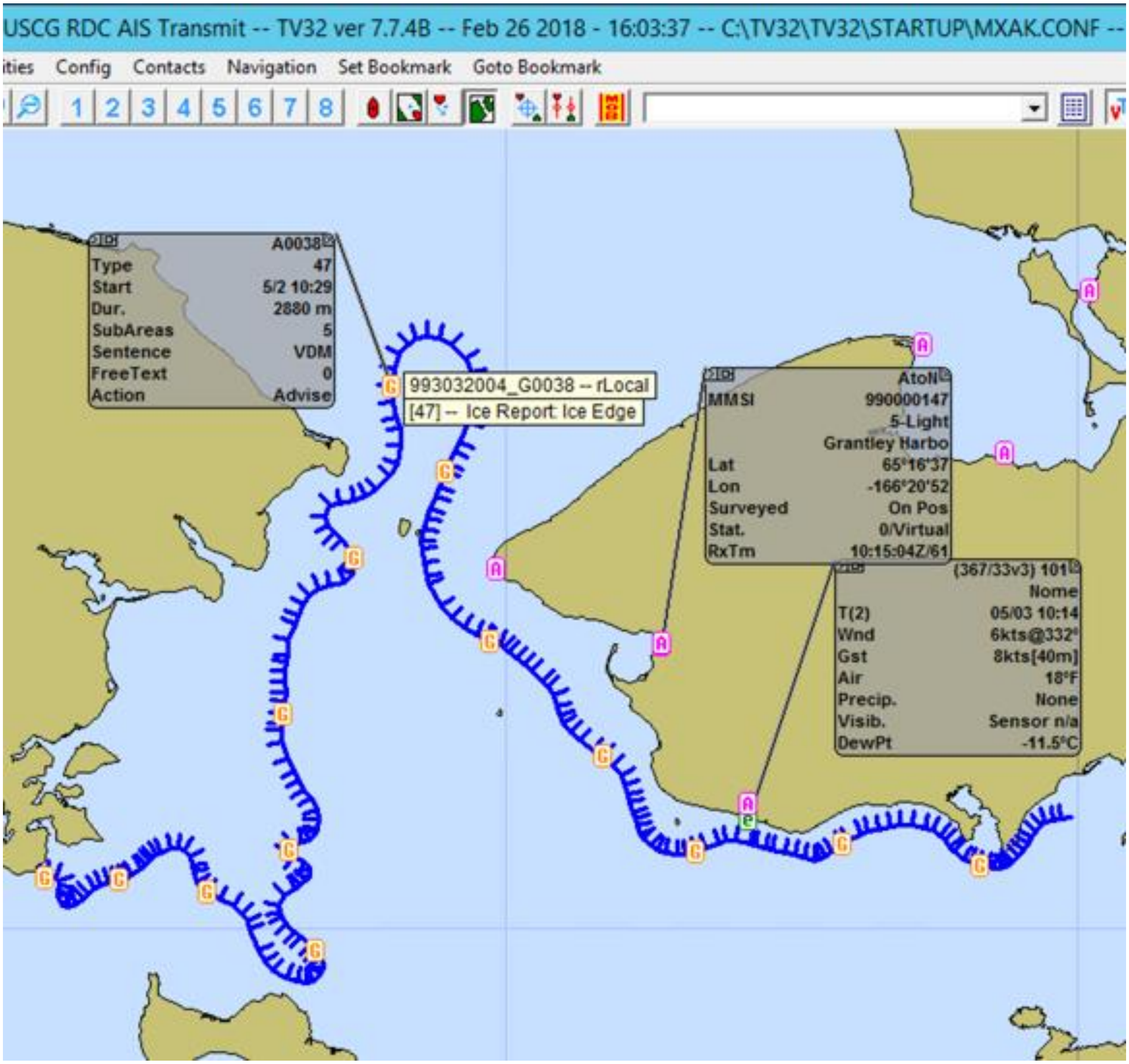


Figure 27. TV32 chart display showing synthetic AtoN, environmental data, and ice edges in Bering Sea.

5.4 Monitoring Software

5.4.1 ASM Watch

ASM Watch provides a dashboard view of the status of transmit operations. The software is configured with a list of MMSI to monitor and an IP address and port from which to read data. The software tracks when message 4s or 21s are received (indicates station is working) and when message 8s are received (indicates station is transmitting ASMs). Figure 28 shows an example of the ASM Watch display.

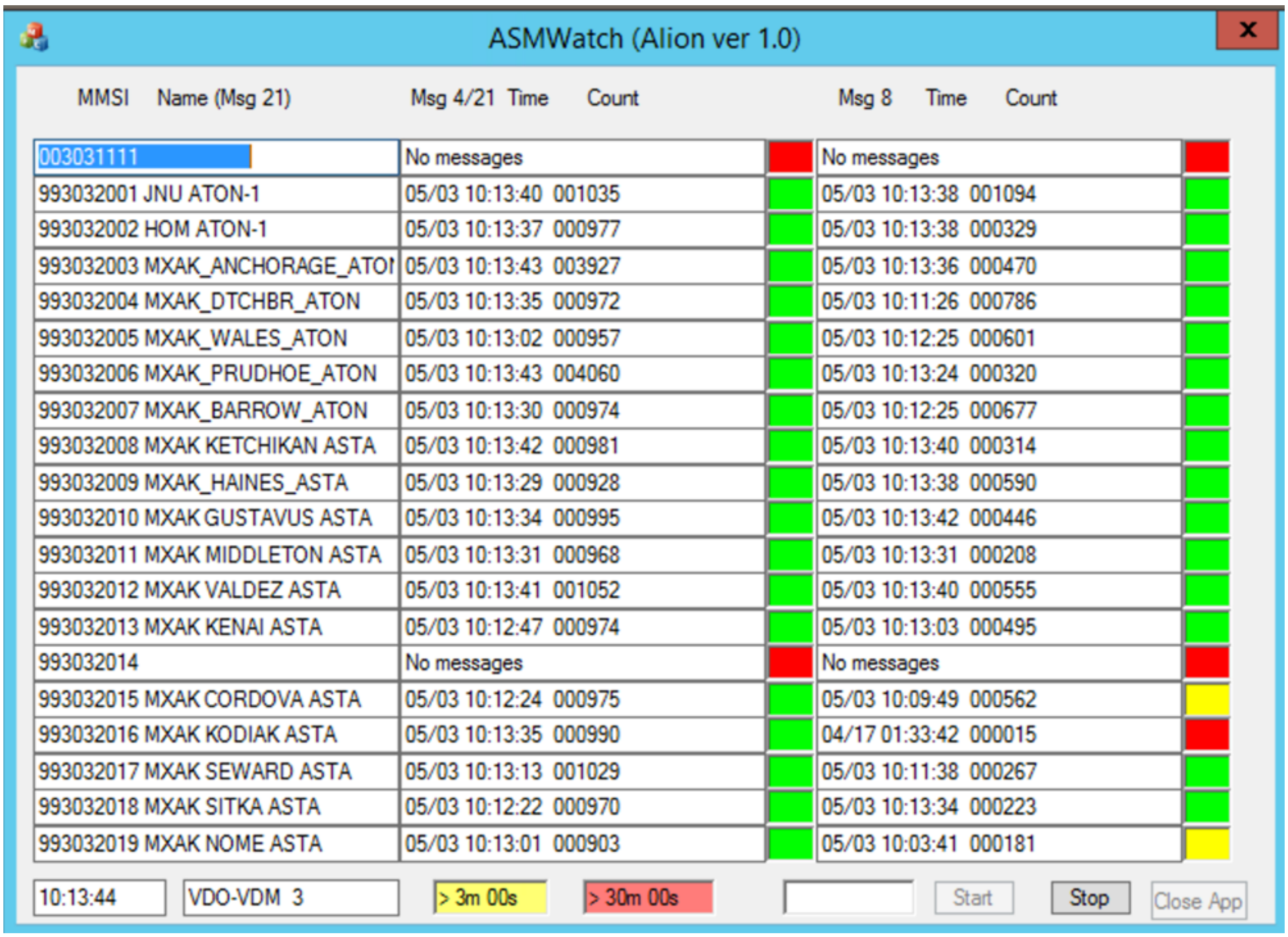


Figure 28. ASM watch display.

6 SUMMARY

The prototype Alaska AIS transmit service provides Navigation Safety Information (NSI) and Marine Safety Information (MSI) to mariners in specific areas of Alaska where the existing 26 transmitters are located (out to approximately 20 nautical miles). MXAK indicates they have plans to expand coverage locations over time. Even in prototype form, this service provides D17 with a means to send NSI/MSI, a capability they did not have until now. In the future, this system could be integrated into the USCG's Nationwide AIS (NAIS) transmit system, expanding its reach. This could be an evolutionary process between USCG (D17, CG-NAV, and CG-7611) and a third party provider as more is learned regarding:

- Capabilities and limitations of the prototype Alaska AIS transmit service,
- Procedures and policy needed to optimize use of the system,
- Types of information to be disseminated, and
- User feedback on how to improve the service.

Maritime activity, whether from commercial interest in natural resources or tourism, will most likely continue to increase in Alaska [12]. An Alaska AIS transmit system supports growing vessel activity by providing critical navigation safety information in real time. The work of preliminarily transitioning the prototype system from RDC to MXAK and D17 is complete. Work still remains to fully integrate and support the prototype operations.

There is still a decision to be made by D17 and CG-NAV on how/who/where messages are created during continued use of the prototype. D17 could create and send messages to the transmitters, or D17 could send information to the AIS transmit service provider who would create and send the messages to the transmitter. As of April 2018, the transitioned prototype is set up so that either option is possible. In the long-term, CG-NAV is exploring the use of the US Aids to Navigation Information Management System (USAIMS) program to create messages to send into a transmit system. In the medium-term, D17 can send the information content and authorization to the AIS transmit service provider and the provider can create and transmit the messages.

MXAK's GateHouse System has two access methods: GAD and web access. The GAD is a full-featured piece of desktop software similar to a shipboard ECS. The Web access has less capability, but is in the process of improvement by GateHouse. MXAK plans to continue to work with GateHouse to develop the GUI to create messages within GateHouse System. MXAK may provide GateHouse System Web interface access to D17 and, as the GUI is developed, more responsibility for the creation of ASMs can fall on D17 if desired.

D17 will require a static Internet Protocol (IP) address from its network provider for continued interim viewing of MXAK data and transmissions until USAIMS and/or Web based interface to a GateHouse system is available.

Weather information is of paramount importance to the Arctic mariner. MXAK has plans to transmit all available weather and sensor data via the Alaska AIS transmit service. MXAK also plans to continue to work with National Ocean Service (NOS) to formalize their own, and other private, weather stations.

One issue being resolved with the current prototype is continuing FCC authorization for the transmitters. The current authorization, which is an experimental license, ends with the CRADA. MXAK has begun negotiations with FCC to continue to provide transmit services.

6.1 Electronic Chart Display Systems

Under the RDC Joint Capabilities Technology Demonstration Project mentioned in Section 2.4, a CRADA was established with several ECS manufacturers. RosePoint implemented many of the changes needed to support the portrayal of ASMs on both versions of their systems – Coastal Explorer (CE) and ECS. Many vessels on the Western Rivers use one of these systems. In Alaska, there is more variety in ECS manufacturer use. During the CRADA, researchers encountered several types of display issues. Some ECS decode some of the ASM types like virtual AtoN, but some do not. Many do not decode geographical notice ASMs or environmental ASMs. Below is a list of some of the display issues encountered during the

CRADA:

- Selection and display of multiple data sensor messages that come from the same location – sometimes only the last sensor is displayed, sometimes the first, and rarely does an ECS have a means to portray all sensor data from the same location.
- Some systems show ASM data in text sidebar and/or on display in text boxes. The number of sensors displayed is often limited to a particular number, for example “only shows closest 3 sensors.” A chart system may provide flexibility to the user to be able to choose how many are displayed.
- Currents are of particular interest to mariners. Information on currents in text on the sidebar is helpful, but portraying information graphically on the chart (e.g. current arrows) may be more intuitive for the mariner.
- Also for currents, bearing line (direction from sensor that the currents are being picked up) is often not given – this is important information for the mariner and may better be presented on the chart and in text on the sidebar.

These types of details for portrayal are best for continued evaluation and improved understanding by chart display manufacturers, users, and standards organizations.

6.2 Considerations for Future State

To provide AIS transmit services in Alaska, the Government has two apparent courses of action: either install a network of transmitters, or work with an AIS transmit service provider. The latter may be more cost effective.

Assuming service provider transmitters are used, system monitoring is probably most easily done by the provider, as they would have a watch on their AIS network. A service provider could provide the Government notification of any anomalies for investigation.

7 RECOMMENDATIONS

7.1 Extended User Evaluation

Recommend an extended user evaluation to determine the full capabilities and limitations of an Alaska AIS transmit service. This would demonstrate and document value to the mariner, AIS transmit service provider, and the Government.

7.2 Audit Capability

Recommend an audit capability be added to allow the monitoring of information coming into the system. This could include who is sending the information, what is the information, and does that individual have appropriate access. This could provide a mechanism to track, verify, and account for users and for proper information dissemination.

7.3 Access and Sustainment

Based on feedback from project participants, recommend CG-NAV/CG-7611 work across the Government to determine the way forward for an Alaska AIS transmit service prototype. With some effort and planning, the USAIMS tool could be used to interface with an Alaska AIS transmit service to create and manage NOAA PORTS data and AtoN. Additional capabilities to create geographic notice messages could also be developed with this tool. CG-NAV is currently responsible for ownership and development of USAIMS and is positioned to develop this tool as a permanent operationally-supported interface to transmit ASMs. The output of USAIMS could go directly to a GateHouse system to properly route and transmit AtoN details.

7.4 Subsistence Hunting/Fishing

Recommend CG-NAV/D17 work across the Government to test and implement the *Whale Alert* account access feature and develop policy for its use. NOAA is responsible for the front end of this APP. NOAA has been working with RDC, MXAK, and D17 to develop functionality that meets user needs.

7.5 Regional ASMs

The USCG has several regional ASMs posted on the IALA registry[2]. These are the messages discussed in Section 2.2 of this report, plus several others. These messages broadcast from Columbia River, Western Rivers, and/or Alaska and have been in use for many years. Messages posted on the IALA Registry can be assigned one of the following states by that country's competent authority: in force, testing, draft, proposal or deprecated. Manufacturers look for "in force" messages to be confident before investing resources. All USCG regional ASMs states are "testing, draft, or deprecated;" none are "in force." Recommend CG-NAV work across Government to move these states to "in force."

7.6 NAIS

Steps to implement a similar capability within NAIS, whether regionally or nationally, have potential to benefit mariners operating in the continental US. The functional requirements are developed, tested, and implemented in the Columbia River, Western Rivers, and Alaska. RDC recommends that CG-7611 consider selecting a region or area (e.g. Sector Long Island Sound or Sector New York) to implement a prototype AIS transmit capability within NAIS. This implementation could advance the development and refinement of ASMs and provide mariners with important maritime and safety information to support safer and more efficient navigation.

[2] http://www.iala-aism.org/asm/

8 REFERENCES

[1] United States Coast Guard - Arctic Strategy, May 2013, Washington, DC

[2] International Telecommunications Union, "Technical characteristics for an automatic identification system using time division multiple access in the VHF maritime mobile frequency band," International Telecommunications Union Mobile, radio determination, amateur and related satellite services Series (M Series), Recommendation, **ITU-R M.1371-5**, February 2014.

[3] USCG Navigation Center (NAVCEN) Web site on Vessel Traffic Service (VTS) history and main page, July 2014, https://www.navcen.uscg.gov/?pageName=vtsHistory, https://www.navcen.uscg.gov/?pageName=vtsMain.

[4] G. W. Johnson and I. M. Gonin, "AIS ASM Operational Integration Plan," U.S. Coast Guard R&D Center, New London, CT. Final, R&DC UDI #1260, August 2013.

[5] G. W. Johnson, L. Alexander, I. M. Gonin, and B. J. Tetreault, "Automatic Identification System Transmit: Functional Requirements Study," U.S. Coast Guard R&D Center, Groton, CT. Final, R&DC UDI # 978, 25 July 2008.

[6] S. L. Fields, J. E. Fletcher, S. F. Lester, I. M. Gonin, G. W. Johnson, and T. C. Berube, "Western Rivers Joint Capability Technical Demonstration," U.S. Coast Guard R&D Center, New London, CT. Final, R&DC UDI #1553, June 2017.

[7] United States Coast Guard Nationwide Automatic Identification System (NAIS) Concept of Operations (CONOPS), Version 1.0, January 2012.

[8] L. Luft, I. M. Gonin, D. Pietraszewski, "Researching Technology Improvements for AIS," U.S. Coast Guard R&D Center, New London, CT. Final, R&DC UDI #1677, July 2018.

[9] I. M. Gonin, G. W. Johnson, A. P. Dahlen, C. Grayson, and H. Shafeian, "HF Digital Radio Mondiale (DRM) Broadcast Summary Report for Long Range Dissemination of Maritime Information," U.S. Coast Guard R&D Center, New London, CT. Final, R&DC UDI #1732, April 2018.

[10] S. Tripp, R. Hansen, K. Hansen, A. Aquino, "After Action Report – After Action Report (AAR) from Arctic Shield 2014 Technology Evaluation," U.S. Coast Guard R&D Center, New London, CT. Final, R&DC UDI #1493, Dec 2014.

[11] J. Story, S. Tripp, S. Jenkins, D. Decker, D. J. Hasting, and S. Dunn, "After Action Report – Arctic Technology Evaluation 2015," U.S. Coast Guard R&D Center, New London, CT. Final, R&DC UDI #1542, Aug 2015.

[12] National Security Presidential Directive (NSPD) 66/Homeland Security Presidential Directive (HSPD) 25, January 2009.

APPENDIX A COVERAGE PLOTS

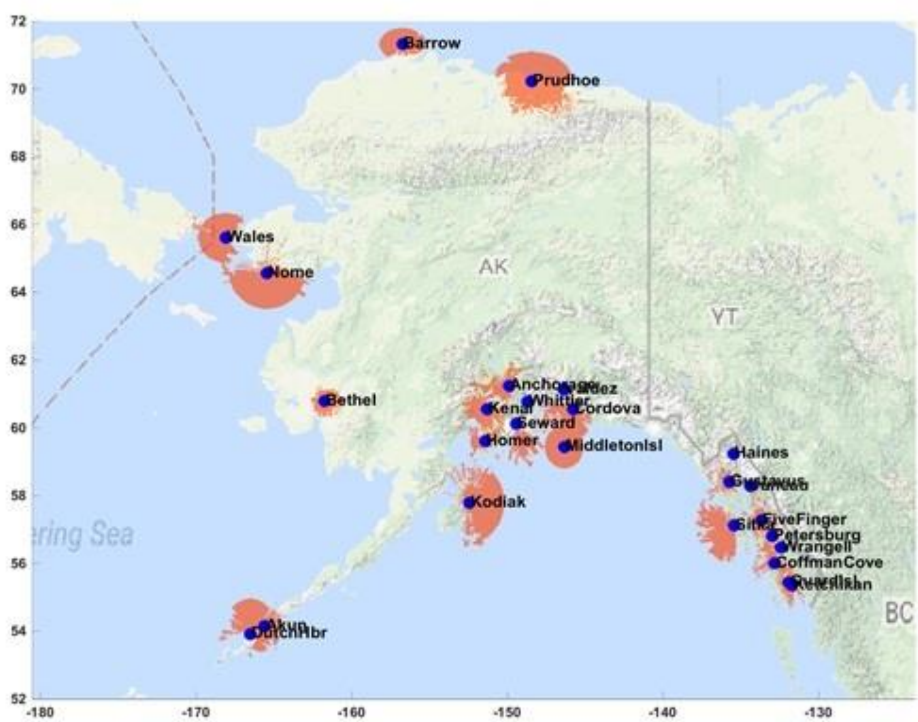


Figure A-1. All Transmitters - Zoomed out view (same as Figure 2 in Section 3).

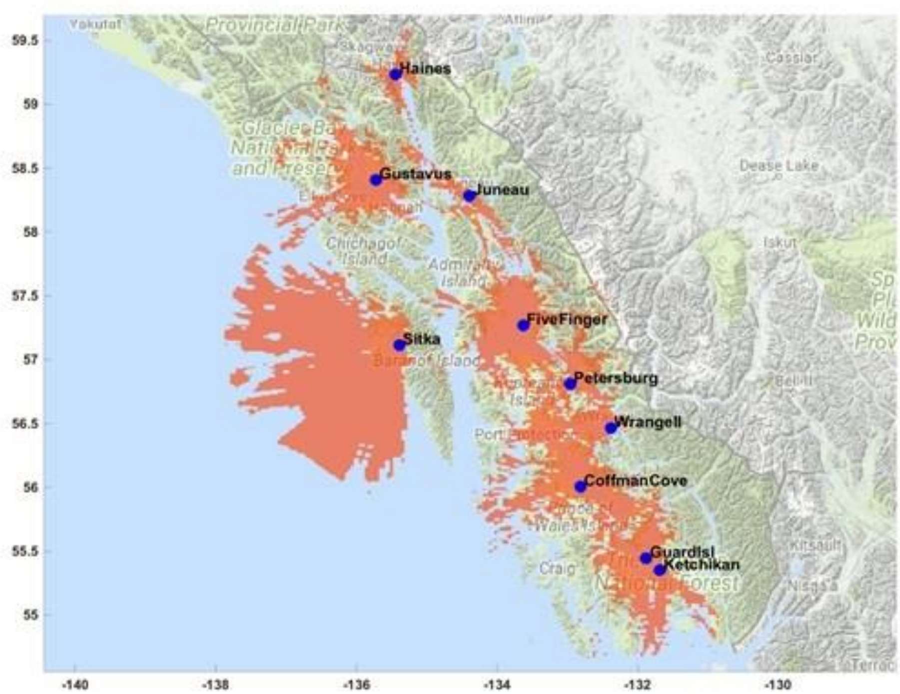


Figure A-2. All Transmitters - Zoomed in around Sitka.

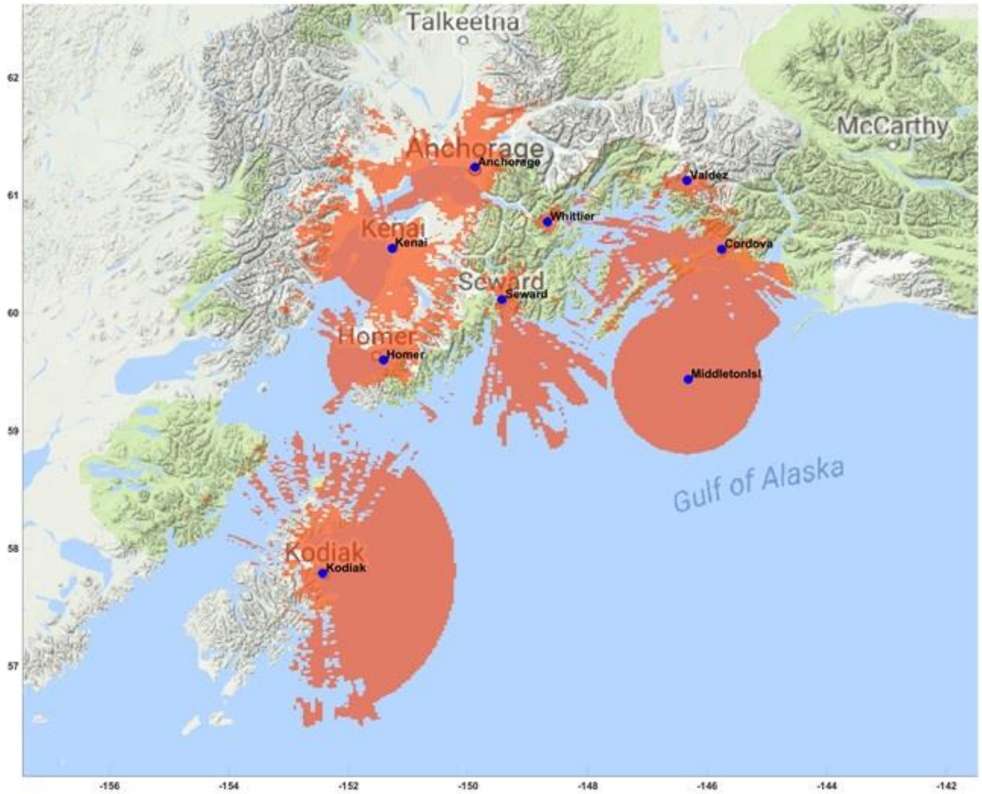


Figure A-3. All Transmitters – Around Seward.

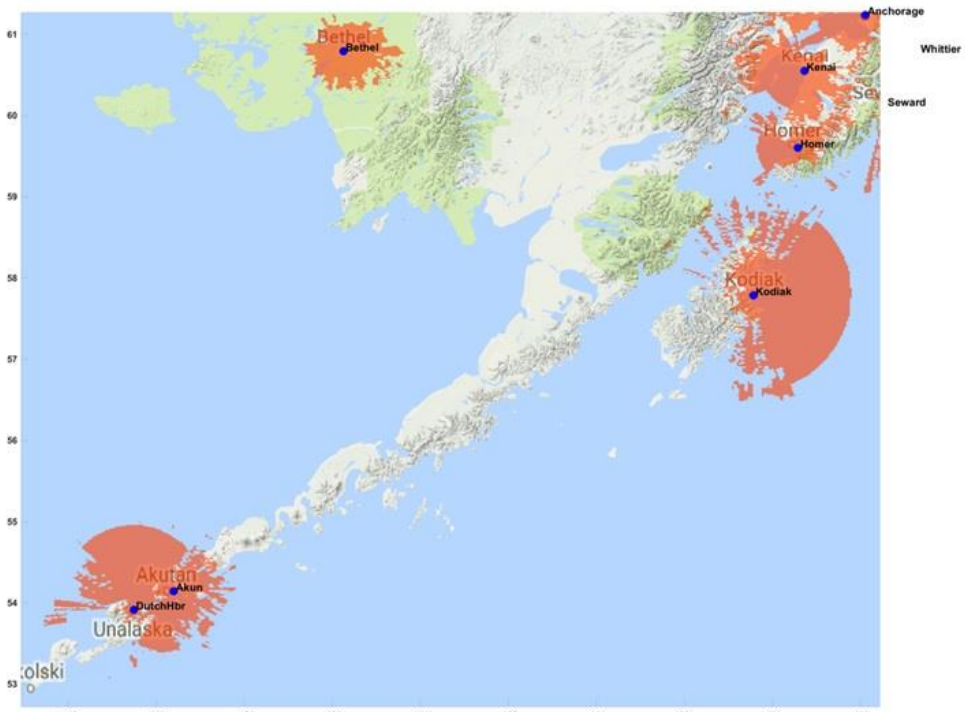


Figure A-4. All Transmitters – Between Akutan and Kodiak.

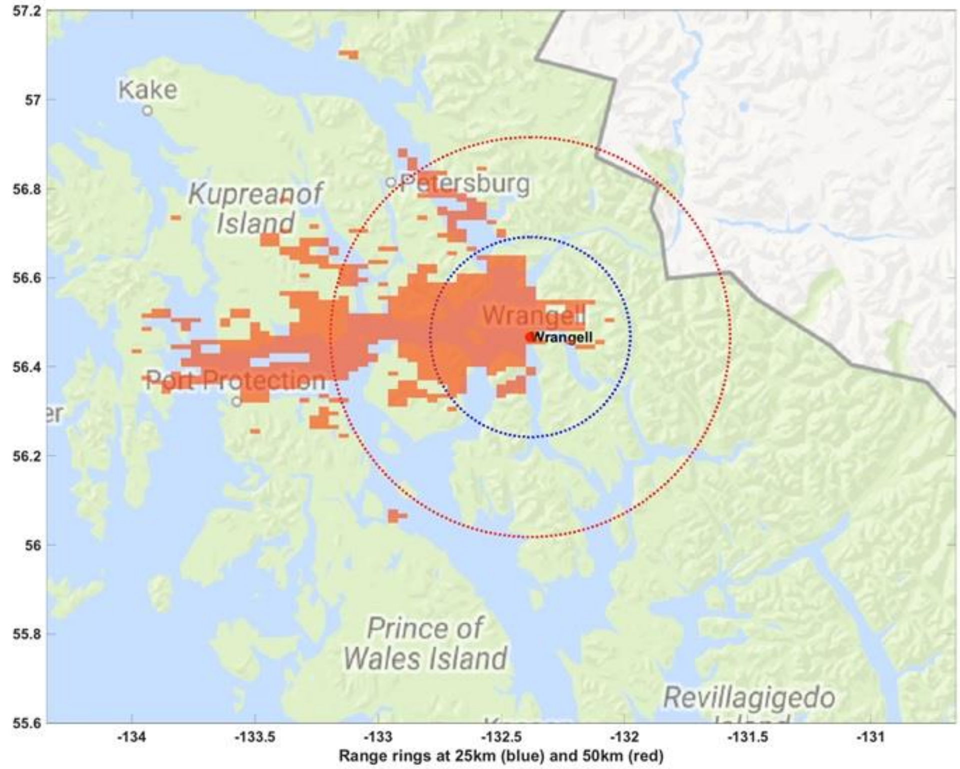


Figure A-5. Wrangell.

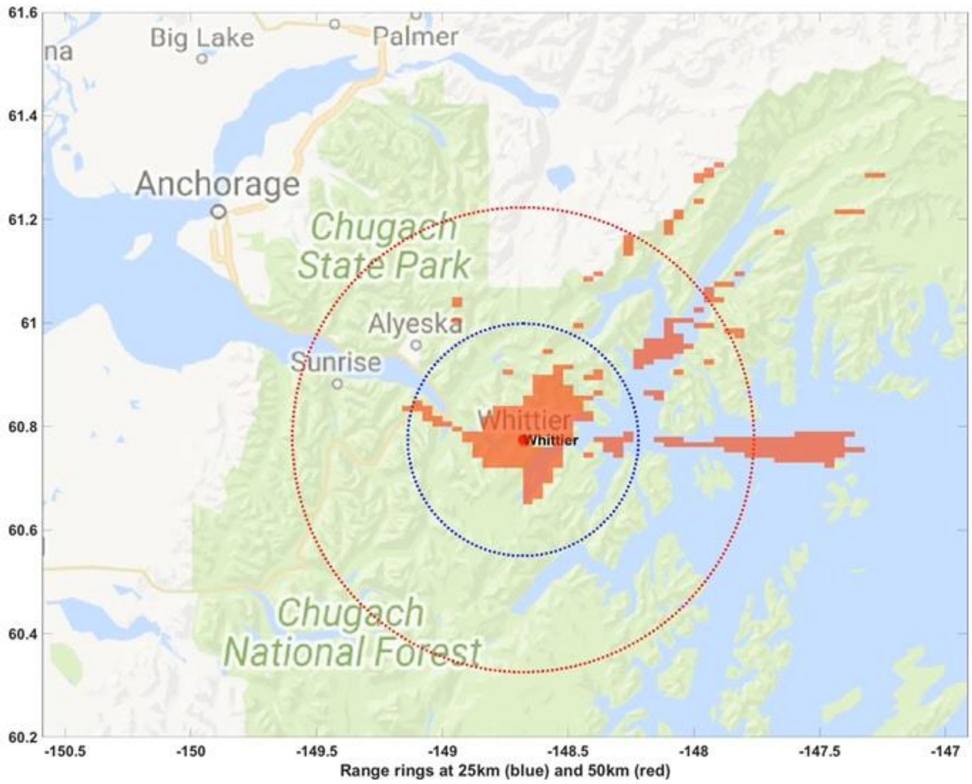


Figure A-6. Whittier.

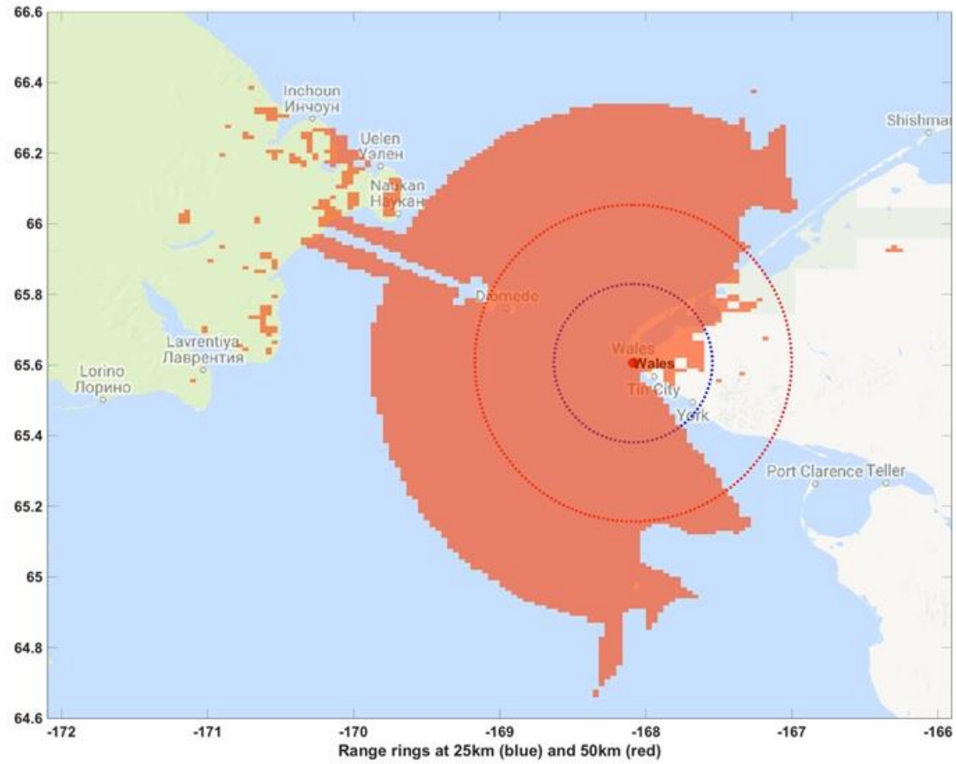


Figure A-7. Wales.

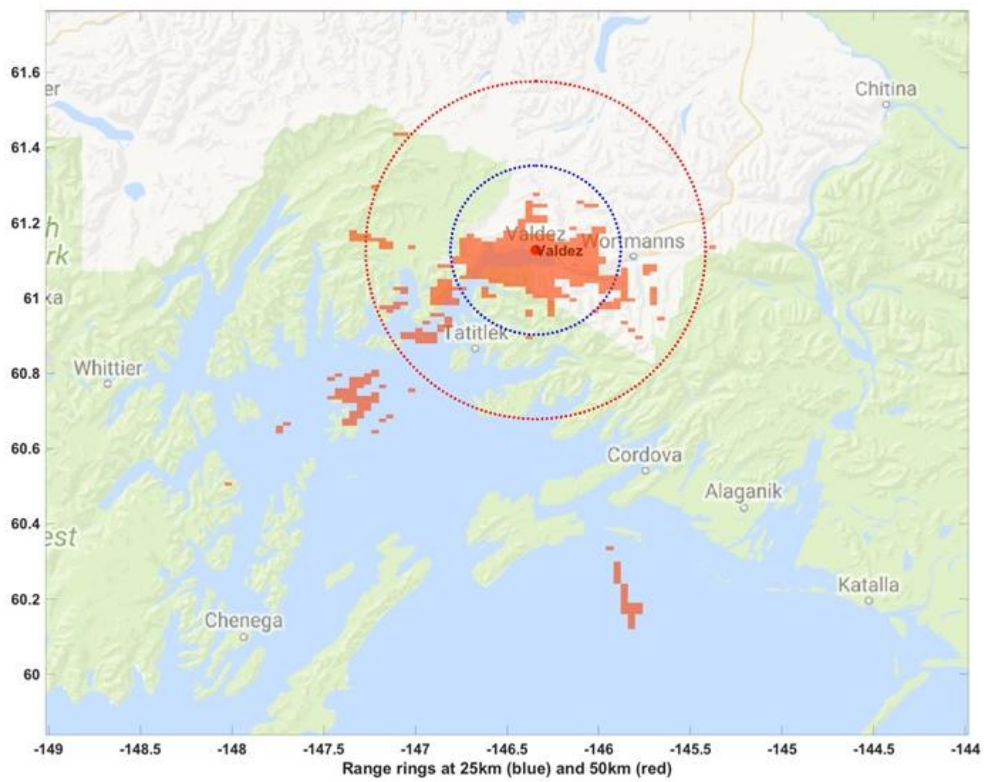


Figure A-8. Valdez.

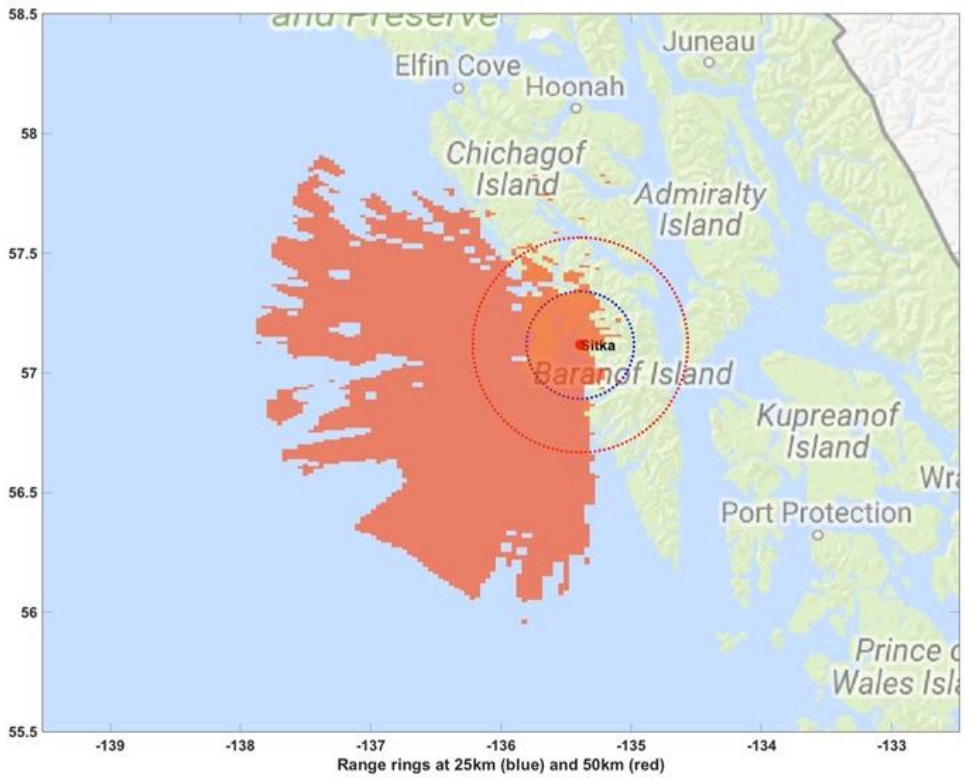


Figure A-9. Sitka.

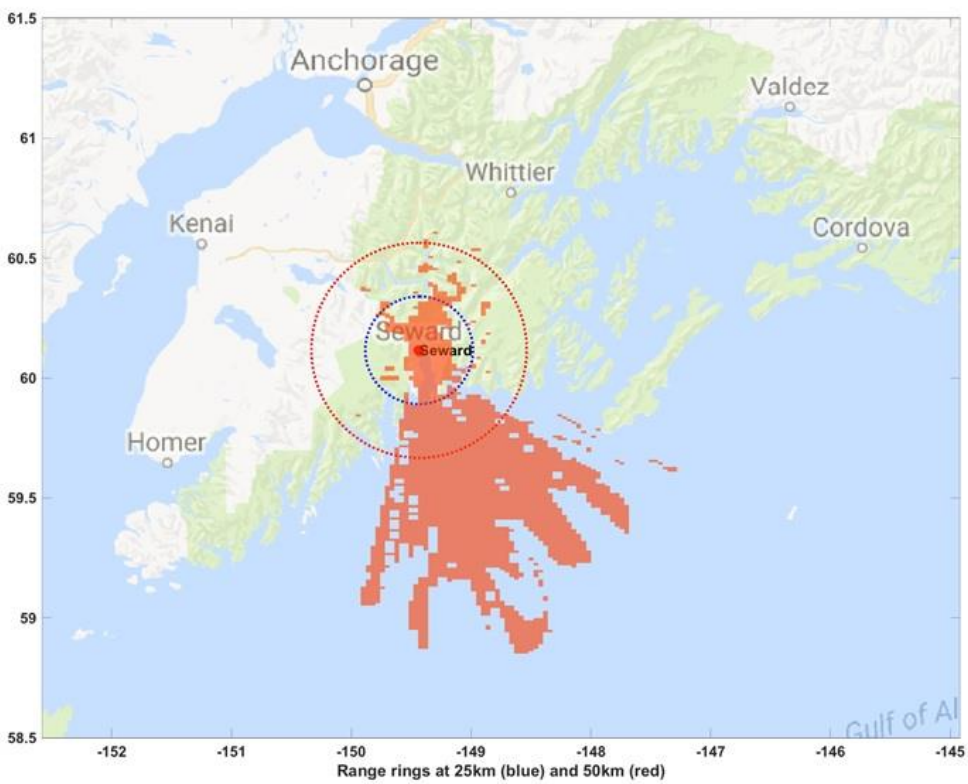


Figure A-10. Seward.

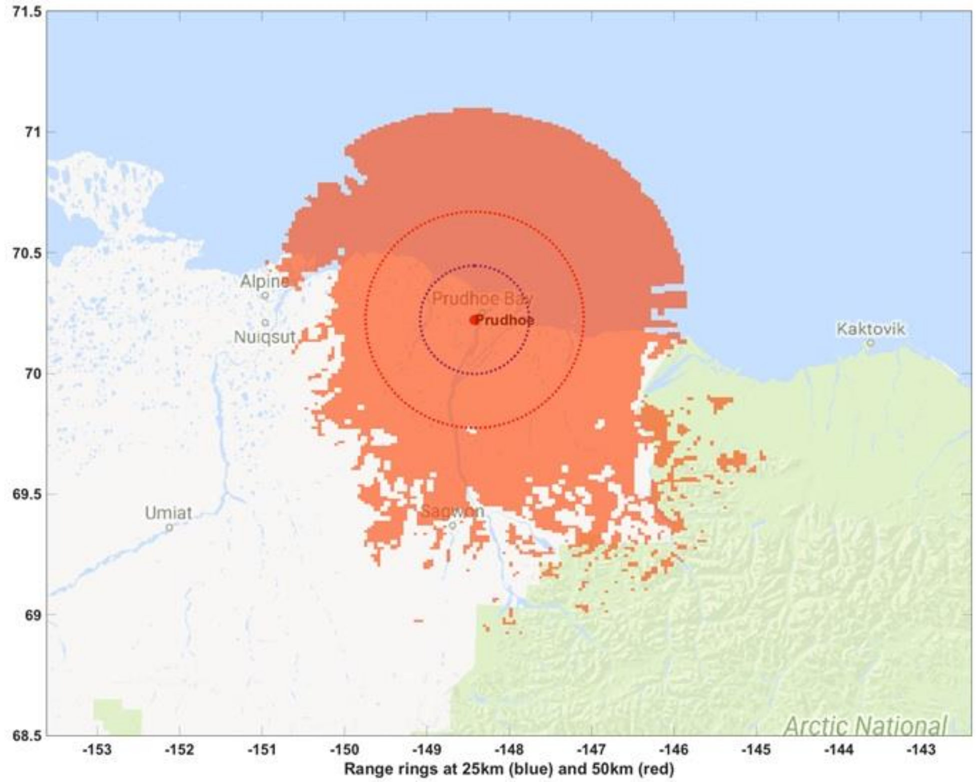


Figure A-11. Prudhoe.

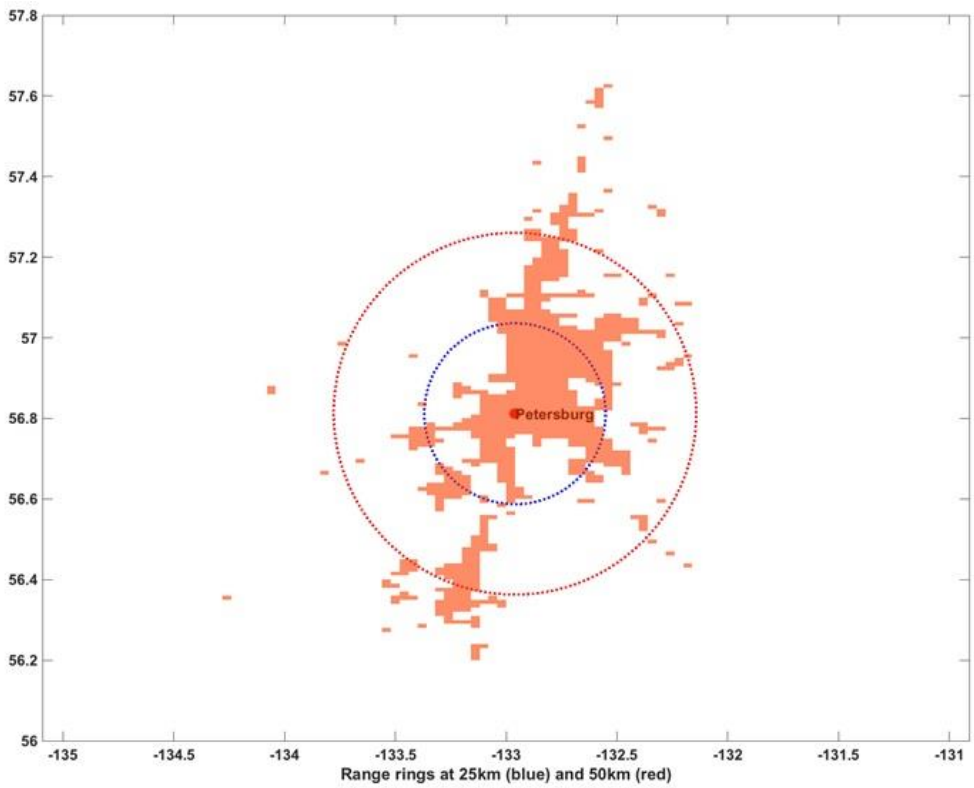


Figure A-12. Petersburg

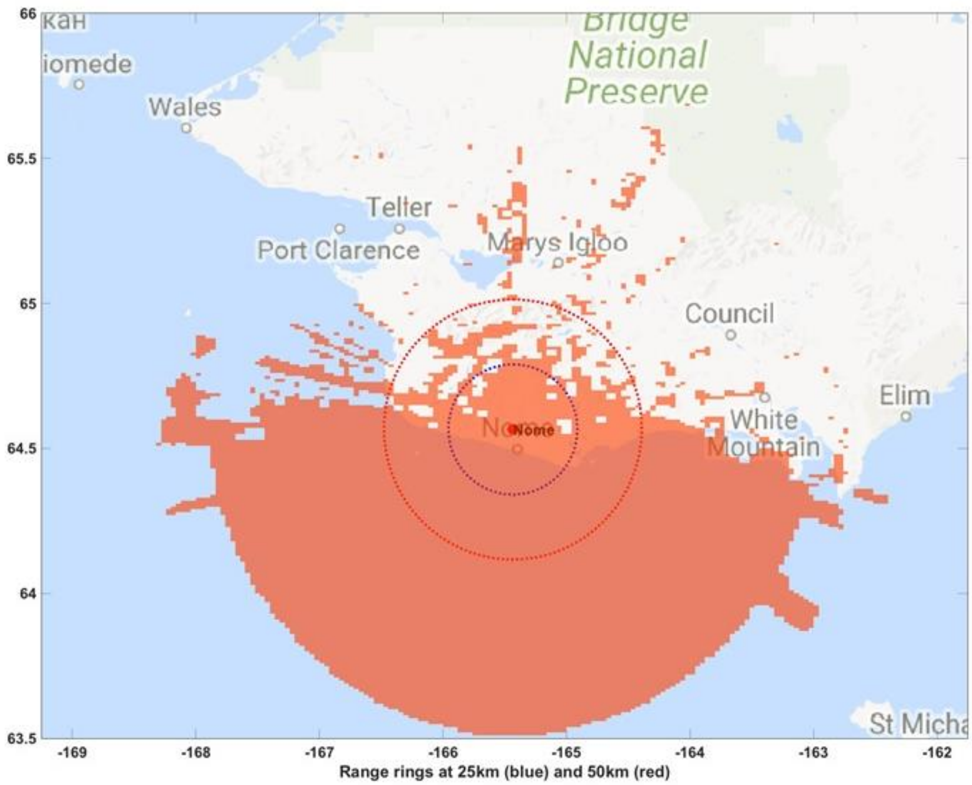


Figure A-13. Nome.

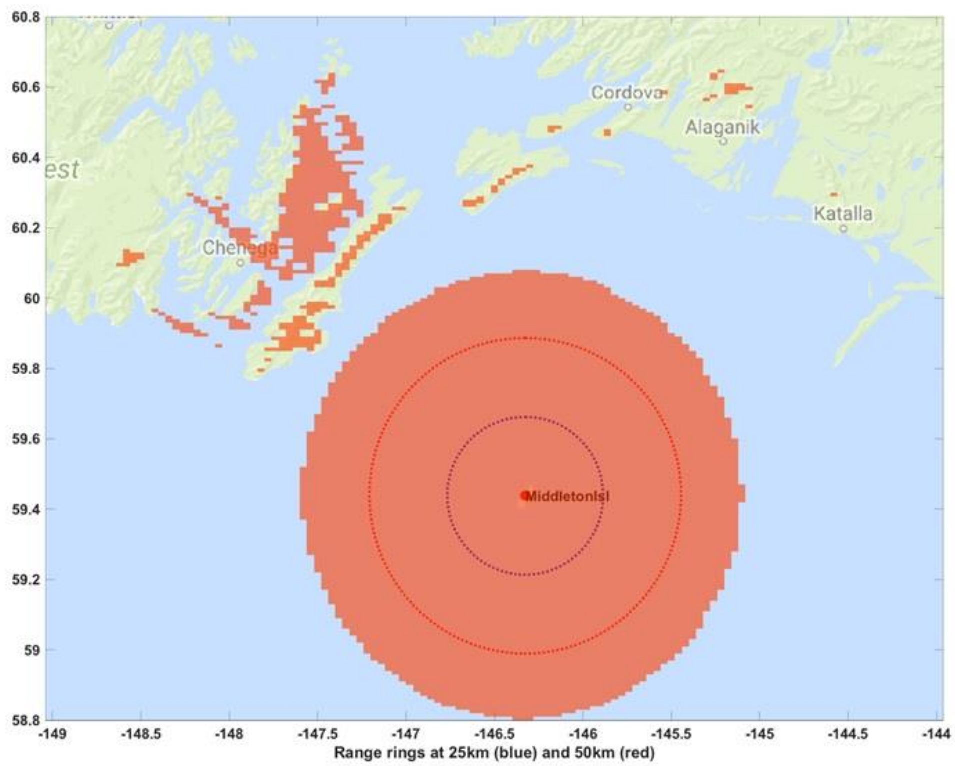


Figure A-14. Middleton Island.

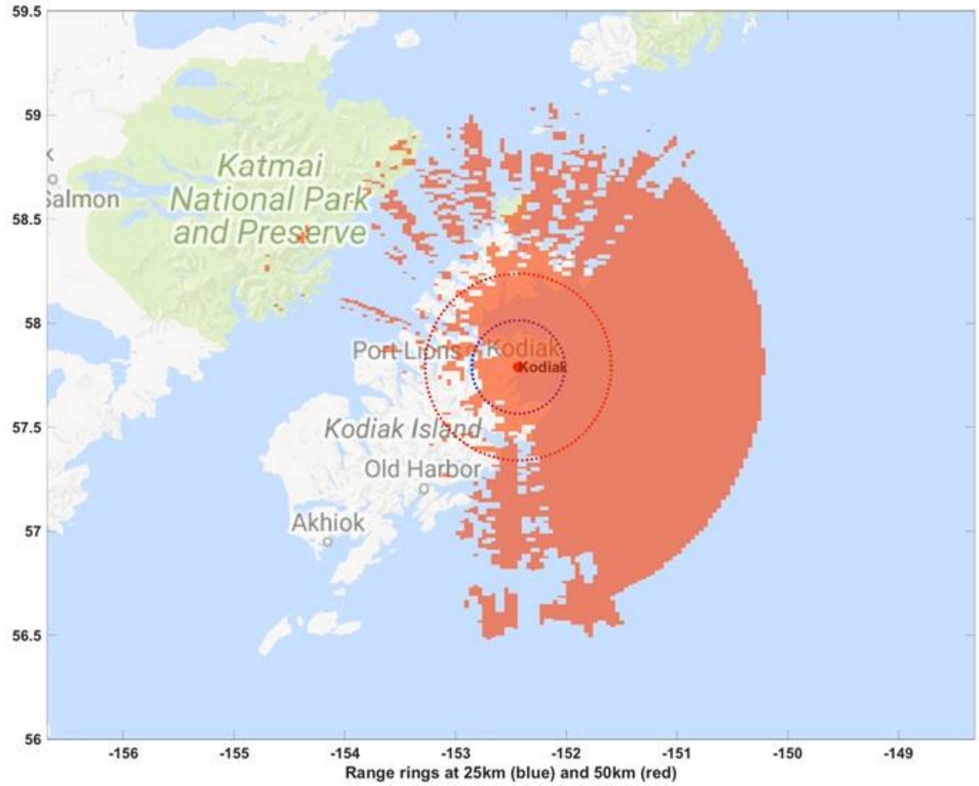


Figure A-15. Kodiak.

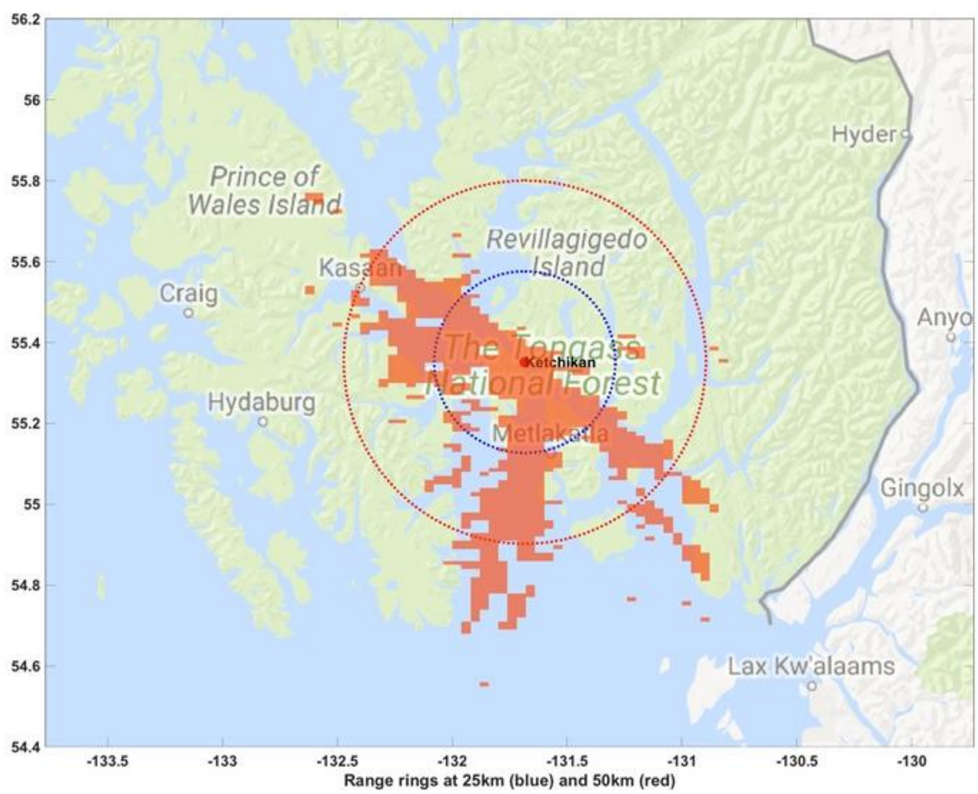


Figure A-16. Ketchikan.

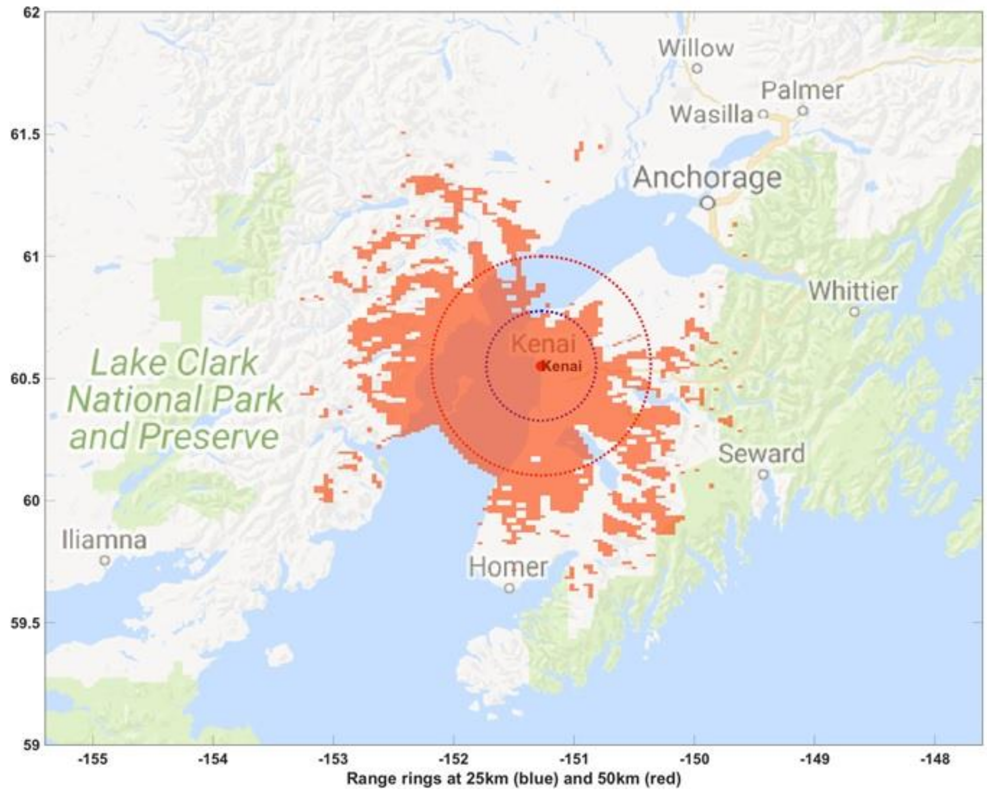


Figure A-17. Kenai.

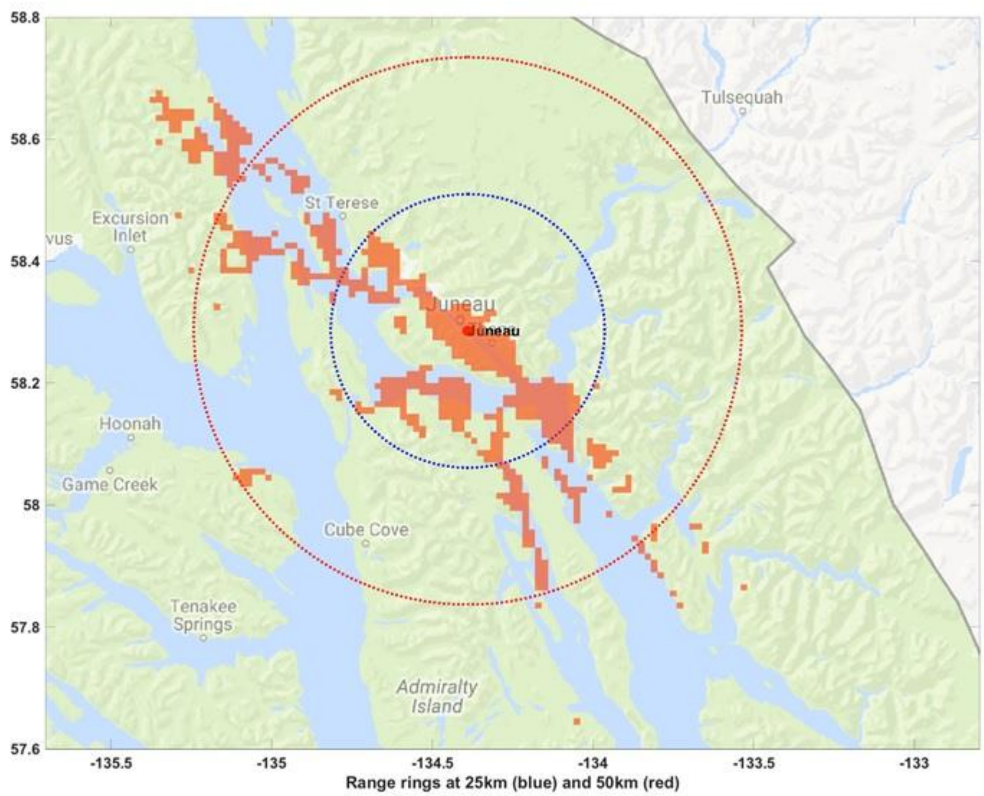


Figure A-18. Juneau – Zoomed out.

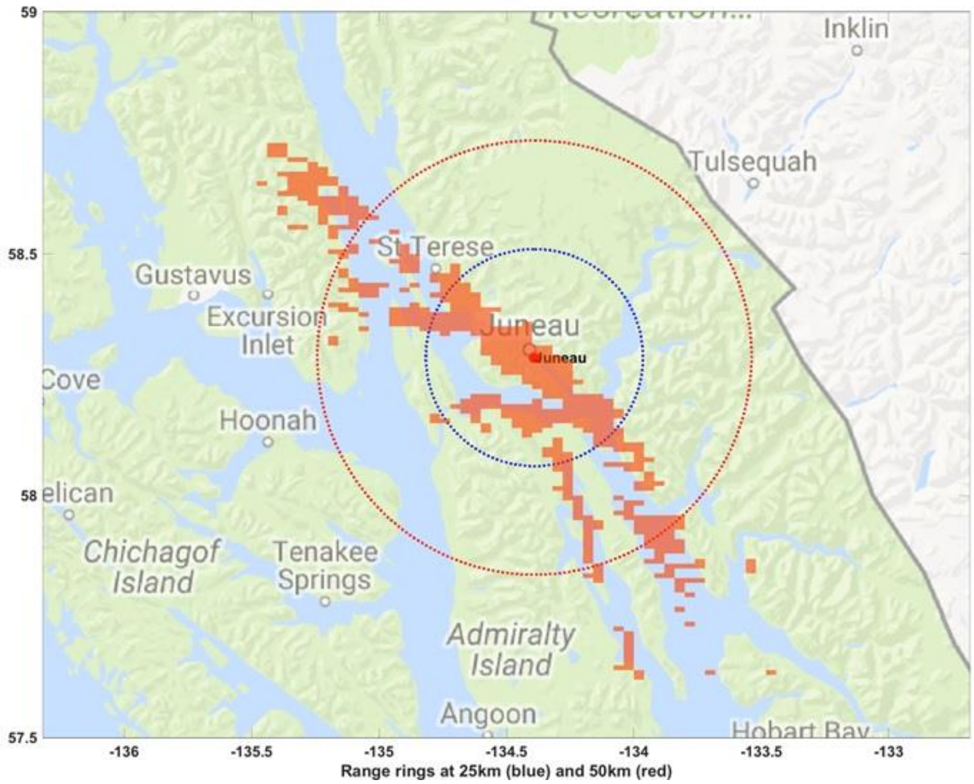


Figure A-19. Juneau zoomed in.

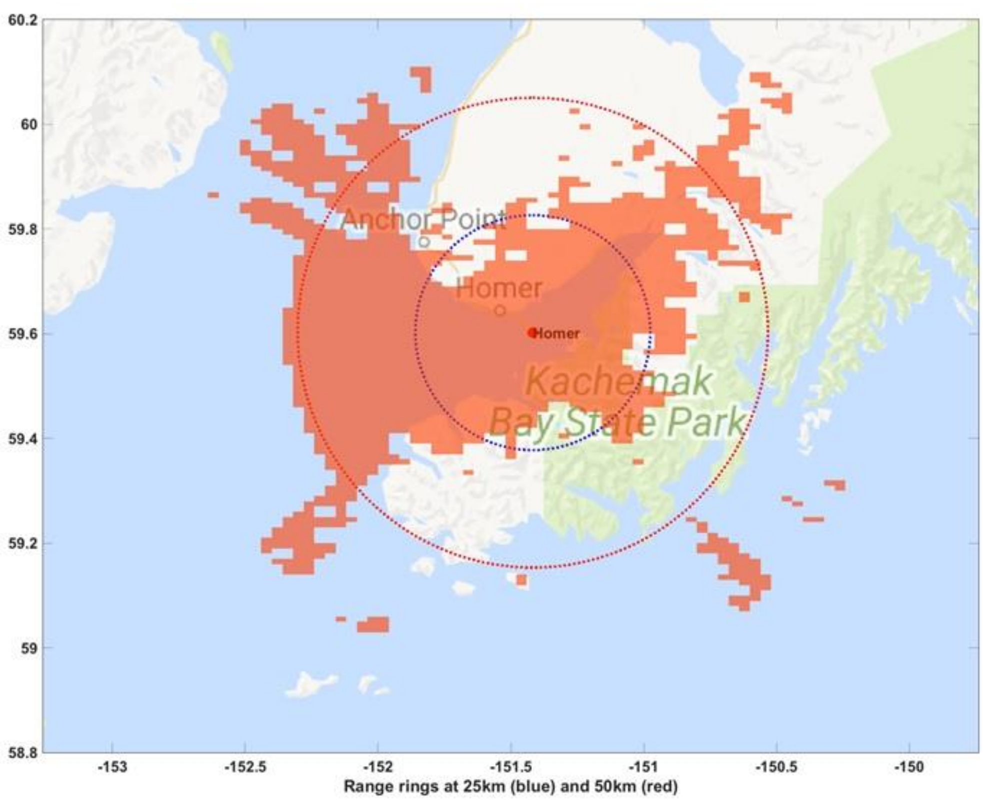


Figure A-20. Homer.

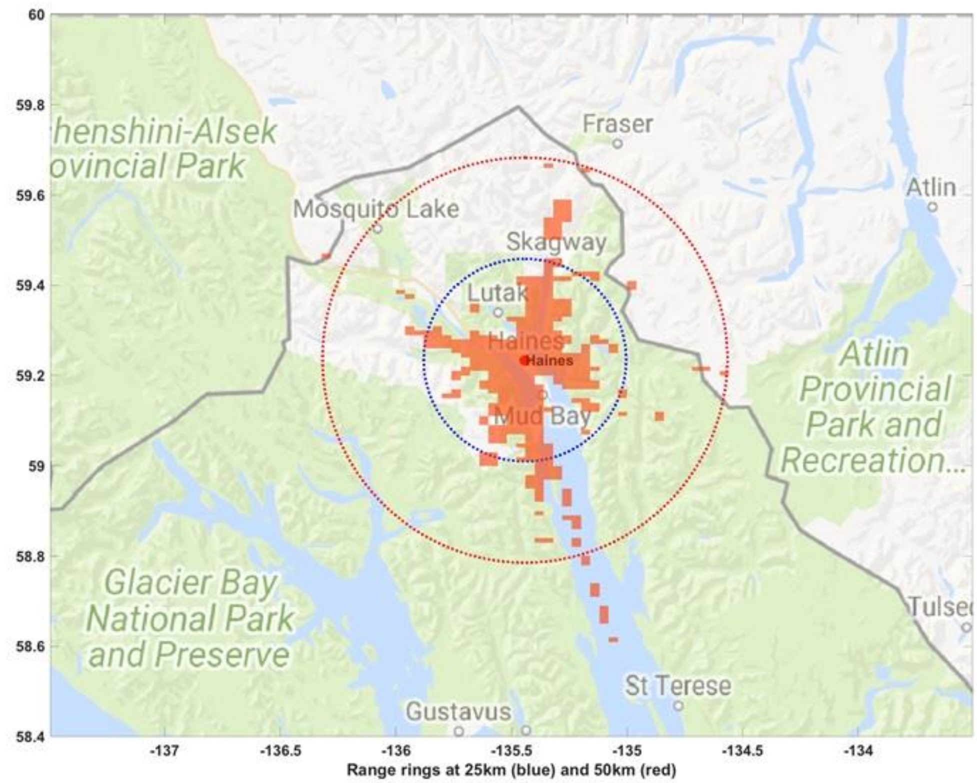


Figure A-21. Haines.

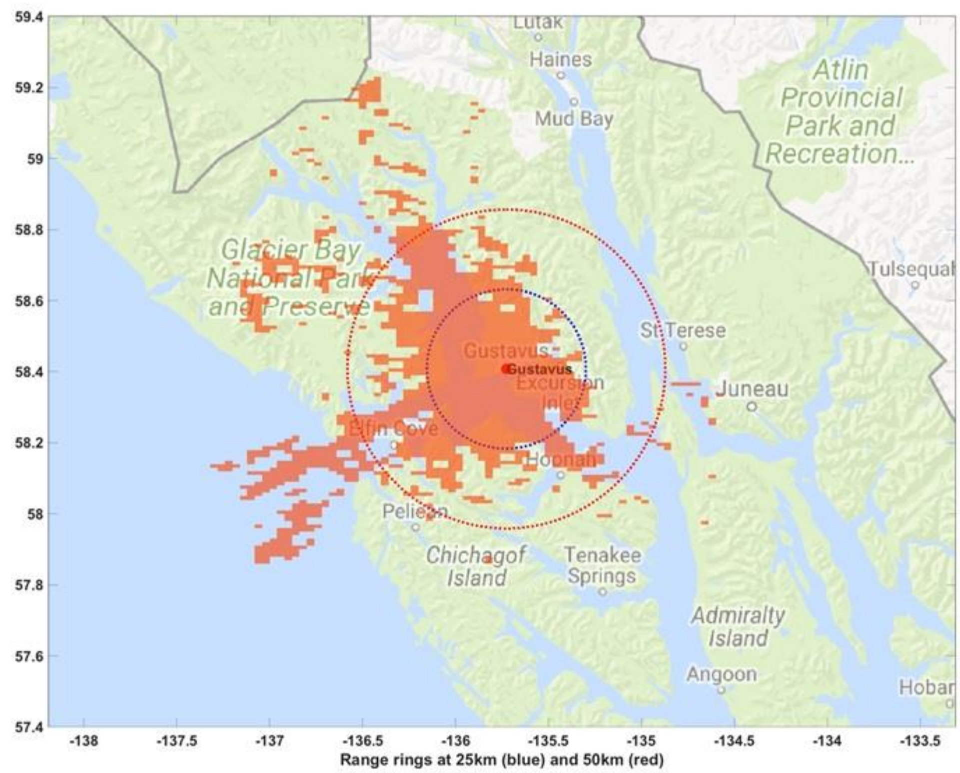


Figure A-22. Gustavus.

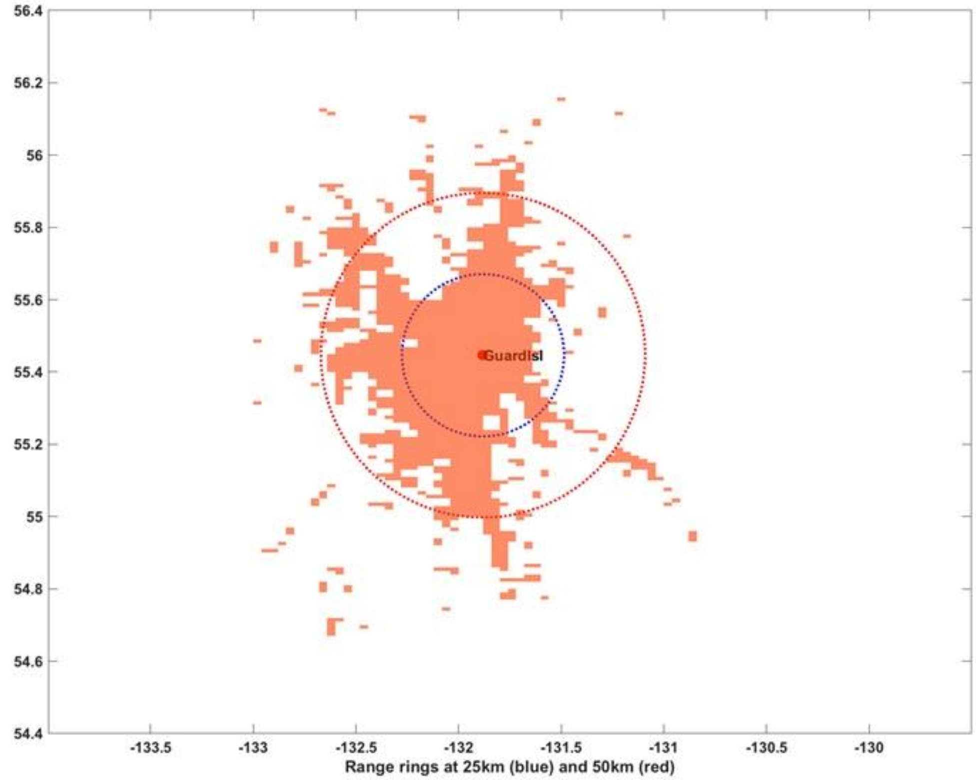


Figure A-23. Guard Island.

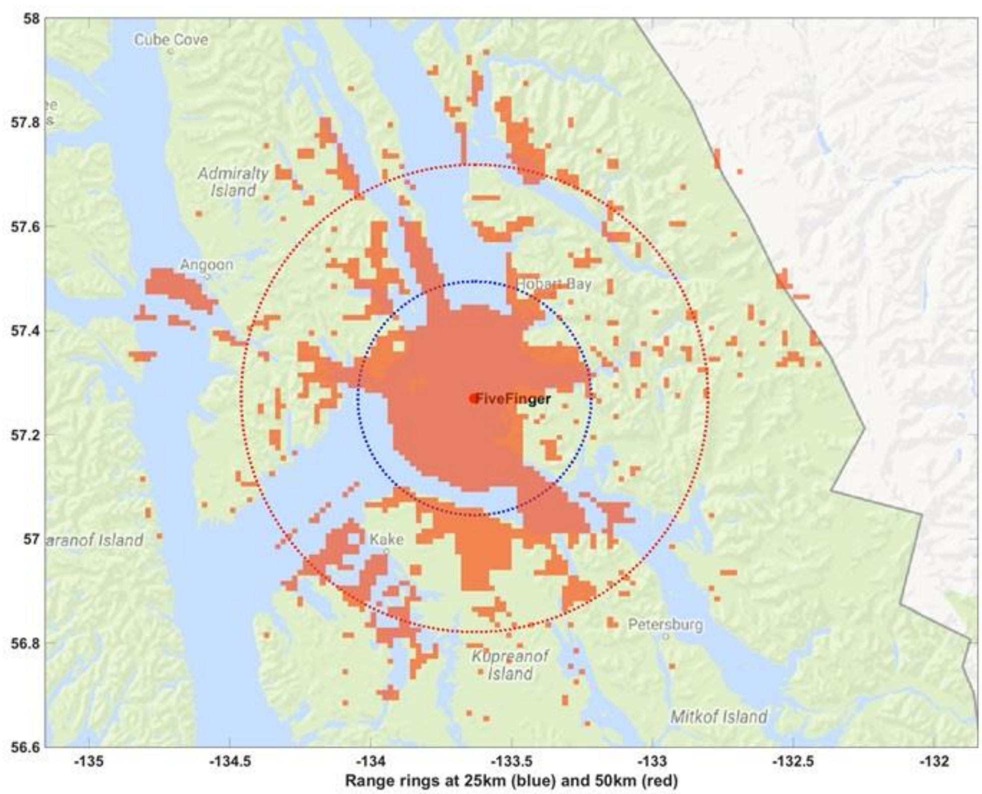


Figure A-24. Five Finger.

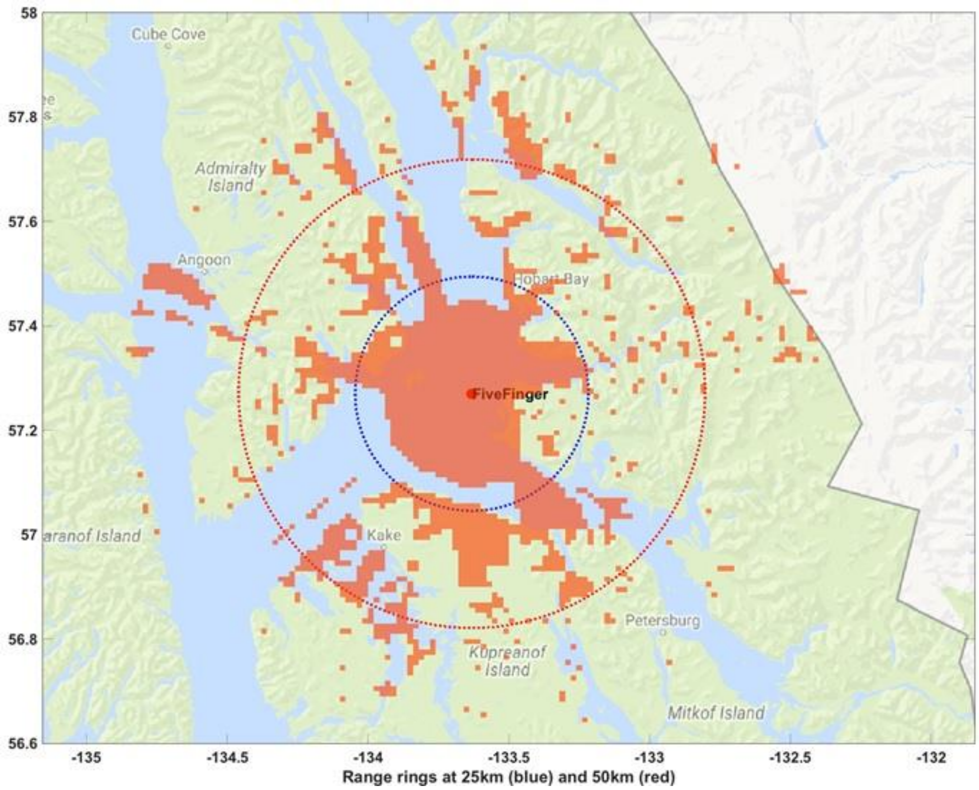


Figure A-25. Five Finger – Zoomed in.

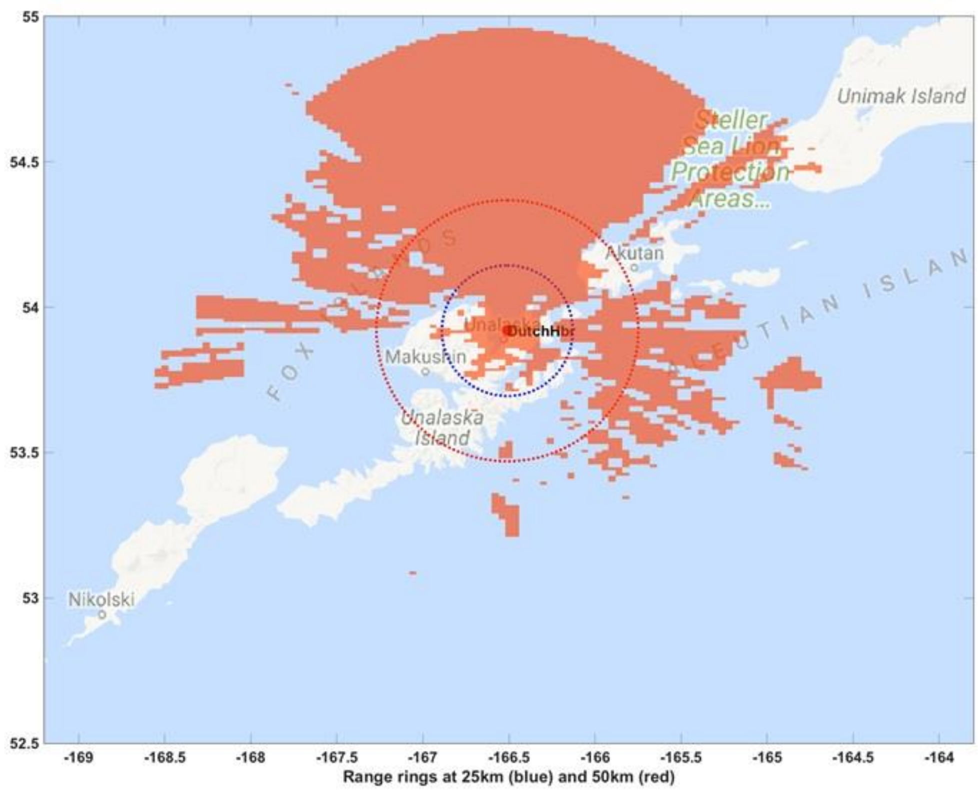


Figure A-26. Dutch Harbor

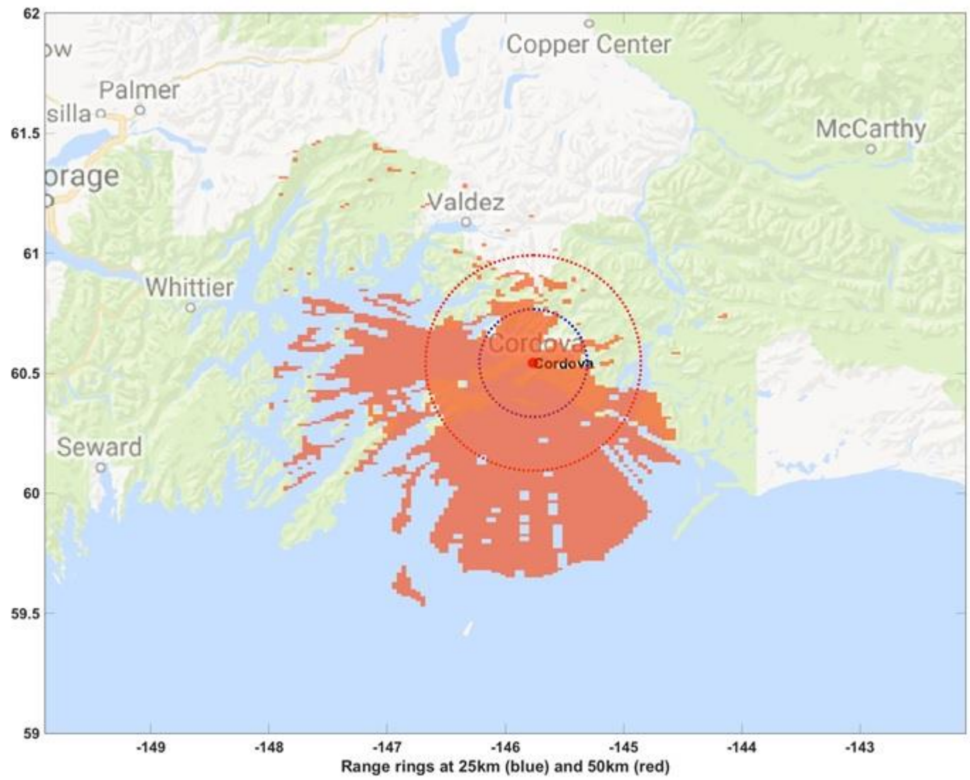


Figure A-27. Cordova.

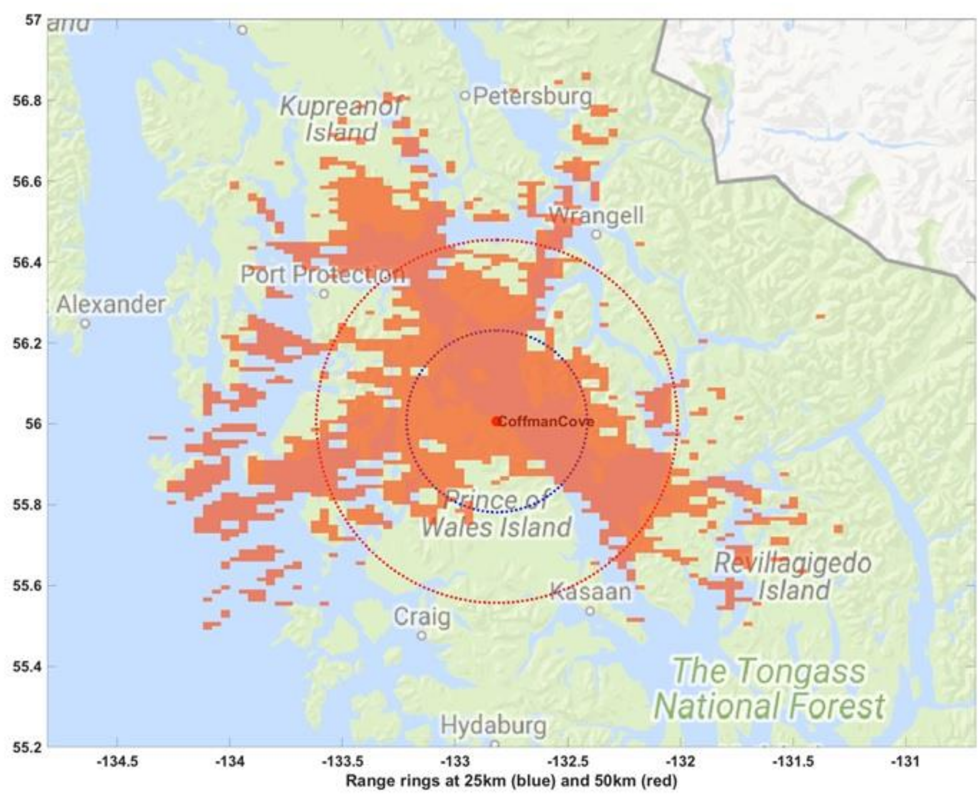


Figure A-28. Coffman Cove.

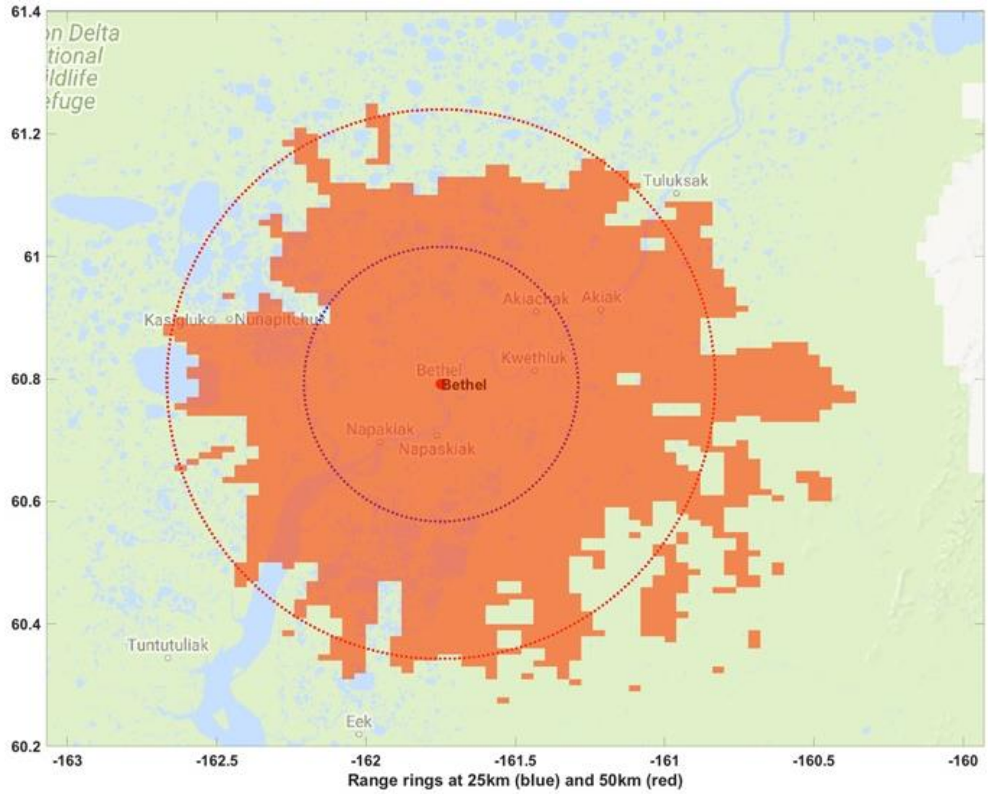


Figure A-29. Bethel.

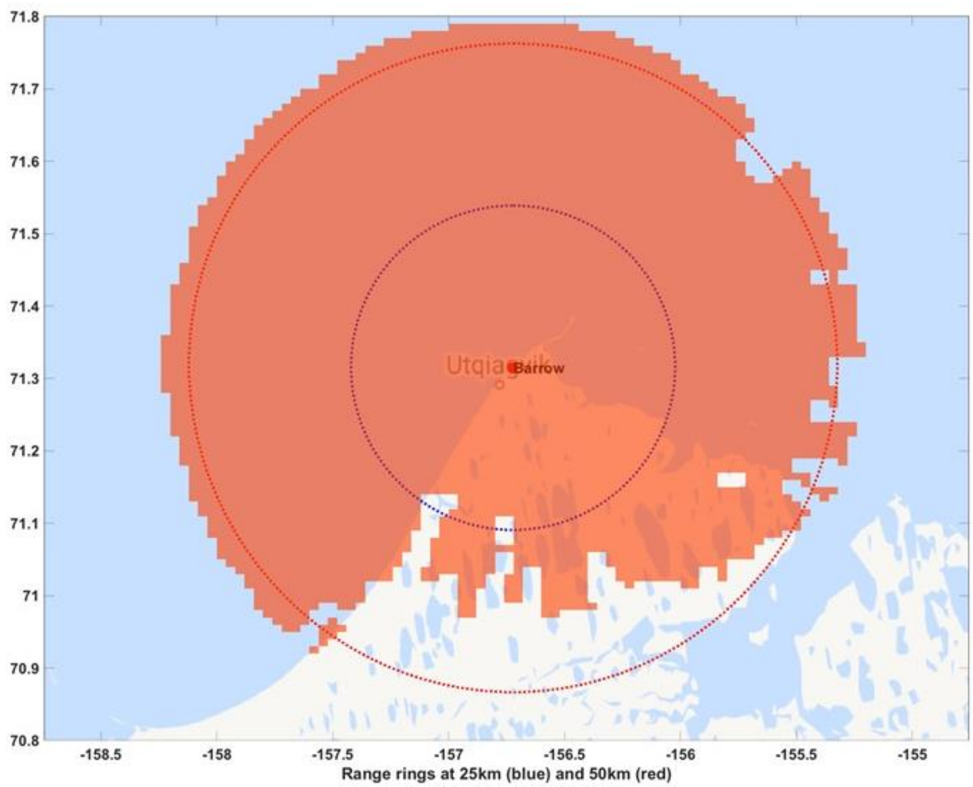
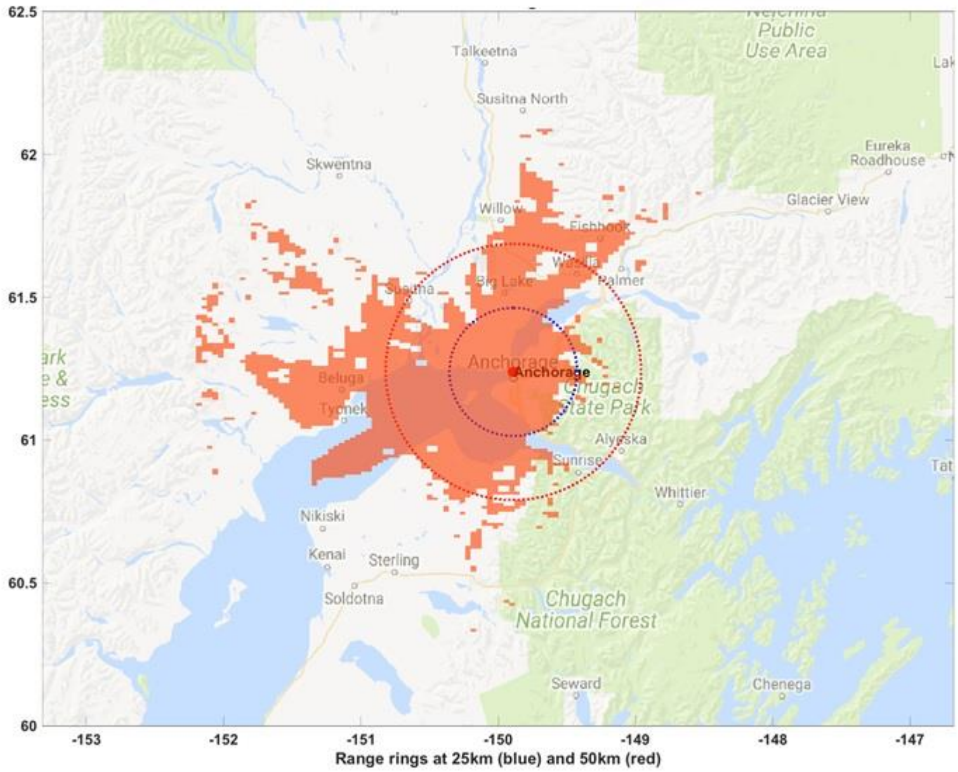


Figure A-30. Barrow.



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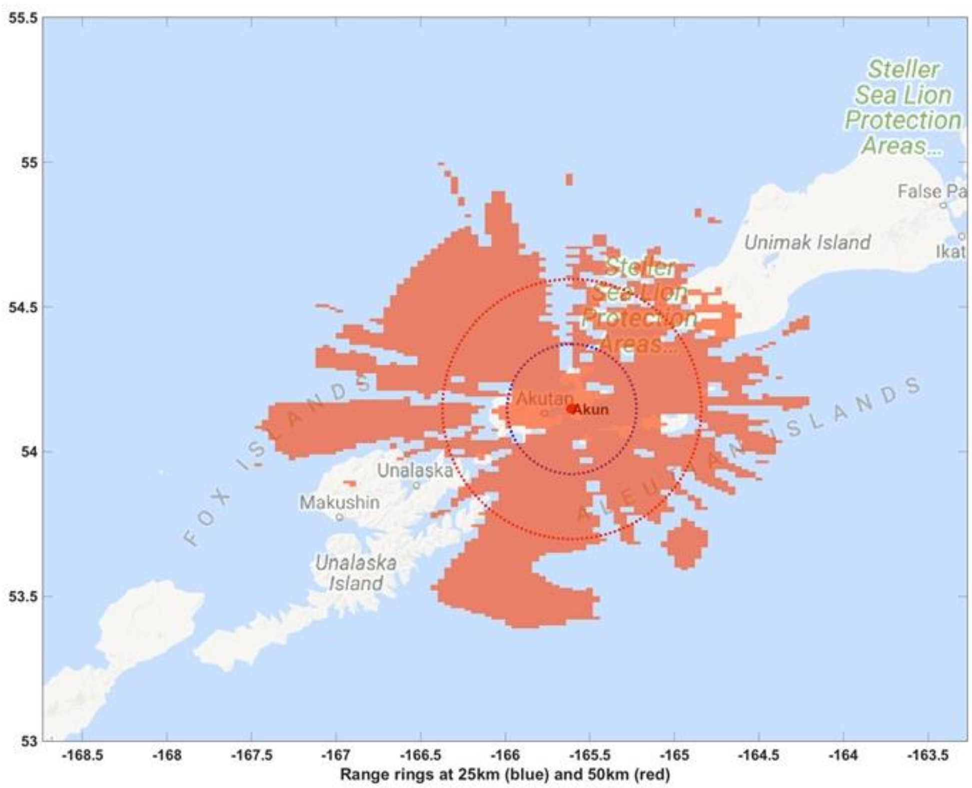

Figure A-32. Akun.