“North Slope Coastal Imagery Site”

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This final report has been reviewed by the BSEE and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the BSEE, nor does mention of the trade names or commercial products constitute endorsement or recommendation for use.

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Cover photos by Mandy Lindeberg of Auk Bay Lab, NOAA as part of the 2012 ShoreZone survey. Top left is near Drew Point, Beaufort Sea coast. Right center is northern Kasegaluk Lagoon with Wainwright Inlet in the background, Chukchi Sea coast. Lower left is in Harrison Bay, Beaufort Sea coast. All can be accessed and downloaded using the North Slope Coastal Imagery Site.
EXECUTIVE SUMMARY

The North Slope Coastal Imagery Site (www.NorthSlopeCoast.net) was developed to assist the Federal On-Scene Coordinator (FOSC) and Incident Command with a decision-support system for spill response. The Imagery Site is based on the premise that (a) more detailed information will lead to better decision-making and (b) high resolution coastal imagery will build consensus about appropriate shoreline response (seeing is believing).

The North Slope Coastal Imagery Site provides a map-based, online access to over 30 hr of georeferenced high-definition videography and to over 16,000 high-resolution, georeferenced photographs. The map interface requires no specialized training. By clicking on a flight track location near a shoreline of interest, open-water videography and photos of the coastline are immediately displayed. Full resolution photos (>3 MB) can be downloaded and video screen grabs can be used to capture the videography. Videography and photos are stored in the “cloud” on Vimeo and Flickr hosting services; they are not copyrighted and are free for public use.

The North Slope Coastal Imagery Site is compatible with NOAA’s Emergency Resource Management Application (ERMA), which has become the standard Common Operating System for spill response. ERMA accesses the North Slope Coastal Imagery Site Geographic Information (GIS) files through the Web Feature Service (WFS) protocol (Arctic ERMA).
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Appendix A  Listing of Electronic Files
1.1 Statement of the Problem
During a spill response, coastal habitats are often the key concern of the Incident Command. These concerns include the issue of protecting sensitive coastal habitats and removing oil from these habitats once it has stranded. While there are a number of response tools that focus on environmental concerns (e.g., the Environmental Sensitivity Index or ESI maps), there is considerably less information available on logistical problems that may be encountered during a response. For example, shoreline access to cleanup equipment and response personnel, trafficability of beaches and coastal hazards all contribute to the assessment of the most appropriate of response actions. In addition, there may be conflicting information about these resources.

It is our experience that when two or more people are viewing the same image, they will almost always agree on what they see and agree on the proposed response action. As such, the North Slope Coastal Imagery Site is built on the premise that **high resolution imagery that is georeferenced and easily accessible is an important decision-support tool for spill planning and response**. Imagery often captures environmental context that may be difficult to capture in maps or graphs (e.g., a rugged, high wave exposure shoreline). Where there is conflicting information, imagery usually resolves the conflict (Fig. 1). High resolution coastal imagery provides a consensus-building tool and as well as environmental context for spill response personnel.

Imagery of the coastline is especially important for the North Slope of Alaska (Fig. 1), where logistical support is very limited and few people are likely to have first-hand familiarity with the coast. Google Earth imagery, which is easily accessed, of the North Slope coast is often very poor resolution (Fig. 2, 3). All of the North Slope shores have permafrost, are undergoing rapid change and include a complex of offshore barrier islands and shallow lagoons, which will complicate response options. While the coast may appear largely unoccupied, subsistence hunting occurs along all stretches of shoreline and entire “the coast” is considered a critical resource to the six permanent communities of the North Slope.

1.2 Objectives
In addition to standardized on-line satellite imagery, there are number of existing georeferenced, oblique coastal imagery datasets for the North Slope. None of the
datasets are online or easily accessible. The overall goal of this project is to make these
data publicly and easily accessible to they can be used in preparedness and planning, in
response and cleanup operations and in post spill monitoring. Specific objectives include:

1. Inventory and collect all georeferenced coastal imagery for the North Slope,
2. Geotag all photos and images,
3. Web-post all videography and photography on open-source or publicly accessible
website,
4. Provide an access portal that provides a simple video and photo imagery access
interface so that images can be viewed, downloaded or accessed through other
portals (e.g., ERMA).
5. Develop a peer-reviewed journal that summarizes key elements of imagery
response tool.

Figure 1. This image of a 200 m-section of Beaufort Sea coastline illustrates the complexity that a spill
responder might face. Within this short section of shoreline, there is a sand and gravel berm
(lower left), a small lagoon behind the berm, peat overwash deposits (dark brown),
tundra/marsh (center) and several tundra thaw lakes subject to inundation during storm surges.
Such variability is very difficult to capture in a map yet will dictate quite different responses.
Figure 2. The highest resolution Google Earth image of Cooper Island, to the east of Barrow.

Figure 3. One of the georeferenced images of Cooper Island from the North Slope Coastal Imagery Site showing a high level of detail for the same location as shown in Figure 2.
Coastal & Oceans had used North Slope imagery as part of its ShoreZone mapping program 2012 (a project for Nuka Planning and Research and the Bureau of Ocean and Energy Management [BOEM]). As such, we had some familiarity with the imagery and the flight trackline data; we also had a copy of all imagery in our office. However, a number of additional steps were required to prepare the imagery for web accessibility.

2.1 Data Assembly
There were two key elements associated with the data assembly activities: (1) location of the coastal imagery and (2) location of georeferencing data associated with the imagery. Coastal & Ocean had previously handled some of these datasets as part of our ShoreZone mapping contract with BOEM (Table 1).

A composite GIS project was developed for all acquired imagery and screened for “best available” photography and videography for each section of coast (Fig. 4a and 4b). The screening criteria used to determine best available imagery is summarized in Table 2.

2.2 Data Digitizing
This task involves organizing all imagery, ensuring that each image file is linked to a geographic position and each image is Geotagged so that its location is included in the image metadata. It is estimated that 30 hours of digital video files and 16,629 photos were compiled (Table 1).

A QAQC review of data points (out of range or out of sequence checks), and randomized spot checks where the oblique image is compared to satellite imagery were conducted within our in-house GIS environment. Following resolution of issues identified in the QAQC process, the “clean” imagery and data files were archived on hard-drives. An archive imagery hard-
Figure 4a. General distribution of imagery for the Chukchi Sea coast (~2,000 km of shoreline).
Figure 4b. General distribution of imagery for the Beaufort Sea coast (~4,000 km of shoreline).
### Table 2 Criteria Used to Select Best Available Imagery

<table>
<thead>
<tr>
<th>Image Quality</th>
<th>Source</th>
<th>Rationale for Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest</td>
<td>2012 BOEM Imagery</td>
<td>This imagery is most recent and was obtained with the use of a helicopter. High Definition video and still images were captured and commentary on coastal geomorphology and biology is provided on the video.</td>
</tr>
<tr>
<td>Moderate</td>
<td>2006 &amp; 2009 USGS Imagery</td>
<td>High Definition video and still imagery obtained using a fixed wing aircraft. This aircraft is not as maneuverable as a helicopter and generally flies further offshore. Most imagery was taken through the aircraft window and commentary on the geomorphology and biology is not provided.</td>
</tr>
<tr>
<td>Lowest</td>
<td>2001 NOAA Imagery</td>
<td>This video imagery was flown using a standard definition camera with the mixed use of a helicopter and a fixed wing aircraft. There are no associated still images but commentary on geomorphology is included. The imagery in the Beaufort Sea is generally better than the Chukchi Sea however this imagery was only used where no other imagery existed due to its age and quality.</td>
</tr>
</tbody>
</table>

drive with all videographic and photographic imagery and GIS shape files was provided to BSEE as an interim deliverable. Appendix A contains of listing of electronic files on the hard drive.

### 2.3 Web-Posting

Following the internal QAQC of imagery and georeferencing links, imagery was uploaded to open-source image-handling sites. Flight tracks were posted to ArcGIS On-line, an open source GIS platform (as part of our contract with BSEE, we will maintain the subscription to this site until 2015). Imagery was then linked to the flight-track data posted on ArcGIS Online.

The Vimeo hosting site is an open-source site for loading the videography to the web and the Flickr hosting site was used for loading the photographs to the web. As a back-up to the hard-drive and the open-source sites, we will also provide NOAA with a ShoreZone compatible set of photos and video that NOAA will process and install on the Geographic Information Network of Alaska (GINA) at the University of Alaska, Fairbanks.
3.0 RESULTS

The primary goal of the project is to:

*Develop a tool to support the decision-making process of the Federal On Scene Coordinator (FOSC) when determining the optimum response methods given a unique marine oil spill scenario.*

We chose to develop a decision-support tool that is built around shoreline imagery, recognizing that imagery helps build consensus during spill events when many different personnel from different disciplines are brought together into a crisis situation. For the decision support tool be effective, the tool must be transparent (easily understood by users) and very simple to operate (no training required). Meeting these two criteria is clearly a challenge when handling very large dataset. Other interpretative data, such as habitat classifications or the Environmental Sensitivity Index (ESI), are not nearly so transparent whereas imagery provides a first-order, obvious representation of the coast and response constraints.

The challenges of developing such a decision-support tool include: finding a simple online GIS interface to provide georeferencing of the imagery and trackline data, linking tens of thousands of photo points to an online photo host (*Flickr*), identifying a stable video hosting site (*Vimeo*) and linking hours and hours of videography in such a way that the video imagery plays from the selected track point, and most importantly, ensuring that the dataset and site are ERMA compatible.

A web access page has been created at [www.NorthSlopeCoast.net](http://www.NorthSlopeCoast.net) to provide an easy-to-recall link to the site. This page presently provides an overview of the project, acknowledgment of contributors and a disclaimer (Fig. 5).

3.1 Selection of the Online Geographic information System

There are a number of online mapping services for displaying and managing spatial data. The largest provider of professional-grade geographic information systems (GIS) is ESRI, who market ArcGIS GIS products. In 2013, ESRI launched an online GIS service *ArcGIS OnLine*[^1] which includes a number of base maps (Fig. 6) and the ability to easily add shape files, the most common GIS file data exchange format. Other GIS mapping services, including ERMA, can access *ArcGIS Online* data via data exchange protocols (i.e., the Web Feature Service or WFS) so, for example, maps and imagery can be displayed within ERMA without having to store the data in-house (that is, ERMA does not actually have to host any of the data but rather just access other online data).

Figure 5. Screen captures of the “splash” page or entry page to the *North Slope Coastal Imagery Site* at [www.northslopecoast.net](http://www.northslopecoast.net).
Figure 6  Screen capture of the North Slope Coastal Imagery Site\textsuperscript{2} showing Barrow, Alaska (and Pt Barrow, the northernmost tip of the USA) using a satellite imagery base map. Other base map choices are shown in the small panel at upper left. The map also shows the various imagery tracklines around Barrow; zooming into allows selection specific high resolution video or photos. White/grey coloration is sea ice present at the time the satellite image was collected.

\textsuperscript{2}http://northslopecoast.net/
The ArcGIS Online site also permits pointing to external URLs, an important feature allowing imagery to be stored at external locations. This functionality means that data can be stored on a secure server within “the cloud” or on other servers remote from ArcGIS Online.

For these reasons, we felt that the value-added features (e.g., base maps including very high resolution satellite imagery), the data interchange flexibility, the ability to point to URLs outside the site and the strong reputation of ESRI in GIS support all provided excellent value for a small annual subscription fee.

3.2 Photographic Imagery

Our review of coastal imagery identified over 16,000 georeferenced photos the North Slope coastline. All of these are considered high-resolution (>3 MB file size). We examined a number “cloud” hosting sites but identified Flickr as having the most functionality. A sequential photo series could be loaded into Flickr so that users could page through a section of shoreline once they link to the Flickr site. Flickr also stores the full resolution file size, although the display is a much reduced size. This storage technique allows rapid loading and display of photos while allowing the user to download the full resolution photos of interest.

Flickr photo handling presents some challenges in that each Flickr URL is completely independent; that is, URLs loaded in a series are not sequential. This creates some “book-keeping” challenges but these proved surmountable.

Use of the Flickr site for several months has not identified any significant stability or other problems. We have noted that Flickr introduces occasional advertisements into the photo stream but such ads appear to be infrequent (<1 in 50 photos).

The geotagged and georeferenced photos will also be provided to the Alaska ShoreZone program and it their intention to store those photos on both the NOAA and GINA servers for use through the NOAA ShoreZone website. This procedure will result in an independent and redundant on-line backup of photos.

3.3 Videography

In addition to the coastal photographs, there is videography of the entire North Slope coast. The 2001 videography is a digital video (DV) quality (resolution of 520 scan lines) whereas the 2006, 2009 and 2012 videography is high definition (HD) quality (resolution of >720 scan lines). We pilot tested YouTube and Vimeo video-hosting services. While the functionality of both services is similar, promotions on the YouTube site were much more invasive (e.g., the word “coastal” appeared to trigger many...
promotions for videos related to beach parties). The Vimeo hosting service required a small annual service but allowed us to control the information panel to the right of the display screen (Fig. 7).

![Vimeo](image)

**Figure 7.** Vimeo display screen showing the video at Barrow, Alaska. By subscribing to the Vimeo service, the content of the information panel to the right was designed to support the North Slope Coastal Imagery Site.

Our use of the Vimeo hosting service during two months of testing has shown this site to be stable and functioning properly. One issue that we identified is that the Vimeo site linking does not work correctly on either an iPhone or iPad. It appears that a dedicated app may be required to address this issue (note- this is not an issue with the display of the photos).

### 3.4 ERMA Compatibility

The ArcGIS Online service is completely compatible with ERMA. ERMA can access flightline data through the Web Feature Service data exchange protocol. When the flight track points are clicked, additional pages open to access both Flickr and Vimeo so that technically these services are running outside of the ERMA platform and do not present copyright issues. We have received email verification from ERMA staff indicating the North Slope Coastal Imagery Site is fully-compatible and now linked to with Arctic ERMA (Fig. 8).
4.0 CONCLUSIONS

1. The *North Slope Coastal Imagery Site* provides easy, on-line access to tens of hours of georeferenced videography and to tens of thousands of georeferenced photos with a simple to use geographic information system interface.

2. To date, the use of “cloud-based” storage for videography and for photos has proven highly stable.

3. For both spill response planning and for an actual spill response, the *North Slope Coastal Imagery Site* will permit easy access to tens of thousands of georeferenced, high resolution images of the shoreline. These images will provide the Federal On-Scene Coordinator and Incident Command with an unprecedented level of detail of the coastline and will contribute to improved decision-making during a response event.

4. The *North Slope Coastal Imagery Site* is ERMA compatible and now incorporated into Arctic ERMA (*Arctic ERMA*)
APPENDIX A

Organization of Electronic Imagery Files Provided to BSEE
An Archive Imagery Hard Drive was provided to BSEE in December 2013 and that hard drive contains the “Best Available Imagery” for the North Slope. There are over 16,000 files on the hard drive.

Imagery Organization:

1. a) NS12 Beaufort Videos (2012): This is the best imagery for the Beaufort Sea so all 12 videos were used. Notably video #11 is missing; this video was not of coastal imagery but was rather a ground station verification video.  
   b) NS12 Beaufort Photos: Geotagged still images arranged by videotape number to match the above noted Beaufort Sea videos; photos are in subfolders by tape number.

2. a) NS12 Chukchi Videos: This is the best imagery for the Chukchi Sea so all 12 videos were used. Notably videos #1 and 13 are missing; these videos were not of coastal imagery but were rather ground station verification videos.  
   b) NS12 Chukchi Photos: Geotagged still images arranged by videotape number to match the above noted Chukchi Sea videos; photos are in sub-folders by tape number.

3. a) 2006 USGS Videos: There are 9 videos and all are in the Beaufort Sea. Notably video #8 was not needed since the area was covered by 2012 imagery.  
   b) 2006 USGS Photos: Geotagged still images arranged by videotape number to match the above noted 2006 USGS videos; photos are in sub-folders, labelled by tape.

4. a) 2009 USGS Videos: There are 9 videos and all are in the Chukchi Sea except video #1 which is in the Beaufort Sea. Notably video #2 was not needed since the area was covered by 2012 imagery.  
   b) 2009 USGS Photos: Geotagged still images arranged by videotape number to match the above noted 2009 USGS videos; photos are sorted into subfolders by tape number.

5. Beaufort 2001 Videos: 10 videos were used, mostly just smaller segments of video to fill in missing gaps in imagery. Notably there are no still images associated with this video.

6. Chukchi 2001 Videos: 4 videos were used, mostly just smaller segments of video to fill in missing gaps in imagery. Notably there are no still images associated with this video.