Aleutian Disabled Ship Drift Study

Prepared for
Arctic Beringia Program
Wildlife Conservation Society
Dec, 2015

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Genwest Technical Publication 16-001 - revised 20160424

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Summary

The primary objectives of this study were two-fold. The first was to configure an established public domain particle trajectory model (**General NOAA Oceanographic Modeling Environment – GNOME**) (NOAA Hazardous Materials Response and Assessment Division – web site) location file representing the oceanographic settings surrounding the Aleutian Chain and use it to numerically explore the threat of disabled ships grounding on or near sensitive environmental habitats. The products of this phase of the study will be a working model of the region, loaded with approximately three years of realistic potential scenarios, and a large data base archive of greater then 3 million "pseudo ship" trajectories each of 7 days duration. This archive will contain data that can be analyzed in any number of ways for future regional studies.

The second objective of this study is based on the realization that in any on-going numerical research an a priori formulation of the problem is not likely to cover all of the potential questions that will come up during the inquiry. Along with the model and the archive, this study will develop a set of configuration files and numerical analysis algorithms that can be used by the sponsors to completely recreate or extend the archive with any variations in model parameters that they think might be interesting, as will as perform simple kinds of analysis on the "pseudo ship" trajectories yielding graphic representations of grounding sites and Eulerian density measures of beaching.

Introduction

Definition of the problem

The growth of international trade, particularly between the Far-East or Russian Arctic and the Pacific North West coast of the United States and Canadian British Columbia has led to an increased use of Northern (great circle) shipping lanes which transit near or even through the Aleutian Islands. At the same time, the Aleutians represent a huge natural resource haven for many wildlife species. (Johnson,2003)

Within the near future the marketing associated with rapidly developing energy markets point to an increasing trend of shipment;

including hazardous materials, tanker, and bulk carriers that have significant amounts of fuel. Even the most modest estimates suggest the present levels of transits may double and then double again over the next few years This increases concerns associated with operational risks. Weather conditions in the Aleutians are notoriously difficult for shipping and locations with rescue and repair facilities are limited. In addition, stockpiles and spill cleanup and response equipment are minimal. (Nuka Research, 2015)

The aggregate of these conditions suggests a requirement for developing a realistic understanding of the environmental risk to the Aleutians' natural resource communities that are associated with increased shipping traffic through the region. This study is designed to look at one facet of this problem. In particular this study considers the drift of a statistical ensemble of “pseudo-ships” whose trajectories are modeled on the assumption that: 1) they have an engine room causality that disables their propulsion; and 2) they are subject to a drift due to a realistic “situation space” of regional winds and currents. To carry out this study we incorporated a particle trajectory model which was sufficiently flexibility to simulate the drift characteristics of a ships and which was a climatological representation of the correlated winds and surface currents for the oceanic conditions in and around the Aleutian chain. There are a number of particle tracking algorithms available, many of which have the ability to characterize (at least to some degree) the particles interactions with the geophysical transport fields such as currents and winds. These transport fields are invariably supplied by auxiliary oceanographic and meteorological analysis. These are the starting points for assembling the computational components for this study.

Historical Approach

The immediate choice for a modeling framework was GNOME. The selection was based on the fact that this model is in the public domain and is maintained by NOAA and freely down-loadable from their website. (NOAA web site) It also turns out that the GNOME model is a direct descendant of NOAA's previous generation of trajectory analysis models, OSSM. The OSSM model was successfully used in a previous ship drift study which addressed many of the issues associated with this study. (US Dept. of Comm (a), 1997). In the nearly twenty years since that study the modeling framework still retains the essential features needed for the investigation, but vast improvements in computational capabilities make it possible to carry a out much stronger statistical analysis of the climatological “situation space”. In particular NOAA work on a Trajectory Analysis Planner (TAP) (Barker,C.H.,2011) and powerful ensemble methods developed and used during the DeepWater Horizon response (MacFadyen,et.al.,2011) have all contributed to the field as well as decades of work by Department of Interior resource modelers.

Oceanographic and Meteorological Setting

Given a modeling framework, it is then necessary to formulate the hydrodynamic and atmospheric transport fields that “localize” the particle trajectory model to a region in the time and space domain. This defines the “situation space” that can be statistically investigated by the study. This is usually a major effort. The spatial domain is typically oceanic (in this case the entire Aleutian Chain) and must be of sufficiently fine scale to resolve inter-island channels as well as realistic geophysical shorelines. The time domain must be long enough to span the actual population of likely events that would be expected to occur. In addition, the oceanographic and meteorological fields are coupled and interact with each other and both interact with the hypothesized “pseudo-ship” particles. Given these cross correlations, the ocean and atmospheric driving fields must themselves be self-consistent. This has all been studied in work sponsored over many years by the Navy and Deptartment of Interior and typical data sets are developed for multi-year periods using complex 3-d ocean models and careful reanalysis of actual observed weather data.

Fortunately for the present study, a great deal of the required oceanographic and meteorological background work was carried out using the GNOME modeling framework for a related, but totally different study. The NOAA Marine Debris Program, while studying the debris fields released during the Japanese tsunami of March 2011, gathered together an approximately three year data set of correlated current and wind fields for the North Pacific Ocean and Bering Sea based on the Navy's HYCOM model and a reanalysis of the appropriate wind observations. (US Dept. of Comm (b), 2015). This data set was made available and provided a three year “situation space” that could be statistically sampled.   The approach taken for this study use this GNOME configured formulation as the environmental setting to estimate the likelihood of a disabled and drifting ship being grounded somewhere in the Aleutian Chain.

Ship Drift

One of the important assumptions of this study was that we could configure the GNOME particle trajectory model so that a class of particles, “pseudo-ships”, would represent the hypothetical drift of an actual disabled ship. This problem was addressed in the already referenced (US Dept. of Comm (a), 1997 as: Holder et al,1981; Lewison et al 1981; Smeation,1981). More recent work by Sorgard and Vada (1998)present a detailed model.

In general, interactions between a drifting ship and background winds and currents can be very complex depending on a number of details related to keel depth, free-board, wave height, wave periods, ship harmonics and actual loading configurations. Gnerally the above water drag profile is not the same as the below water drag profile and ships are likely to settle into a “quartering” orientation drift at some angle off the wind and thus slightly tacking to the right or left. Although modeling of ship drift does show some skill, the details are so situation and ship specific that the models fine tuning is lost when trying to generalize. For general classes of ships the representation of scatter does not seem to be improved by the more detailed formulations. Based on this, the present study will take a relatively simple approach where the ship is assumed to drift with the current and this motion is added (as a vector) to a randomly selected wind drift factor which is bounded between high and low values and right and left drift angles. This approach has the advantage of being simple and spanning most real observations. In addition, the values can be easily changed in the configuration files so that it is possible to rapidly check alternate bounding assumptions and represent different drift models for different types of ships. Figure 1 indicates the vector motions applied to the hypothetical pseudo-ships.

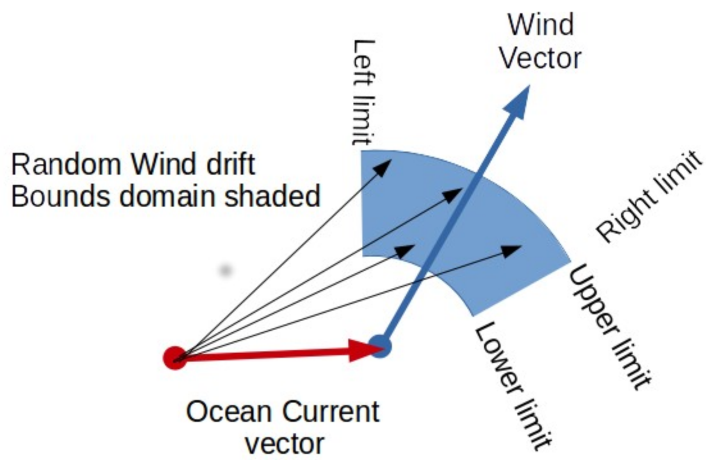

Figure 1 – Representation of pseudo-ship drift where each element is assigned a net drift displacement represented by a random (one of the small light black arrows) selected from a uniform distribution over the shaded area.

As representative of a typical VLCC we will set the wind drift bounds at (lower 0% , upper 10%, right -.25 rad, left +.25 rad). These values are easily modified using the tools and configuration files presented as part of the development of this project (see the following section on TOOLS).

Statistical Approach

The minimum kernel of the statistical study will be a single pseudo ship trajectory of seven days duration that will be qualified by: 1) the initial site where it starts to drift; 2) the initiation time within the models three year "scenario space" when the trajectory starts; and 3) a random statistical realization of the pseudo ships drift characterization as indicated in Figure 1.

The next level of statistical aggregation will be to consider a cluster of 40 pseudo-ships that are all released at the same location and initial starting time. Thus this cluster will experience the same situation space in terms of geophysical surroundings, but each pseudo ship will have a different drift factor characteristic bounded by the statistical variations expected for that class of vessel.

The third level of statistical aggregation will be 250 clusters of 40 pseudo ships all starting at the same release site, but initialized at randomly selected start times chosen from within a 3 month seasonal window spanned by the model. At this point we have 10,000 pseudo ship trajectories giving an ensemble representation of a single site and a single (3 month) season with all the variations that might be expected from the environmental situation space of the model and the hypothesized ship drift statistics.

The next level of statistical aggregation will be to repeat the previous analysis for the remaining three (3 month) seasons. This ensemble will present us with 40,000 pseudo ship trajectories aggregated by season for a single site. Putting these ensembles together gives a robust statistical look at regional grounding probabilities. Figure 2 summarizes seasonal beaching statistics for a release site. The horizontal axis is duration of drift in days and the vertical axis is number of groundings per 10000 pseudo-ships released.

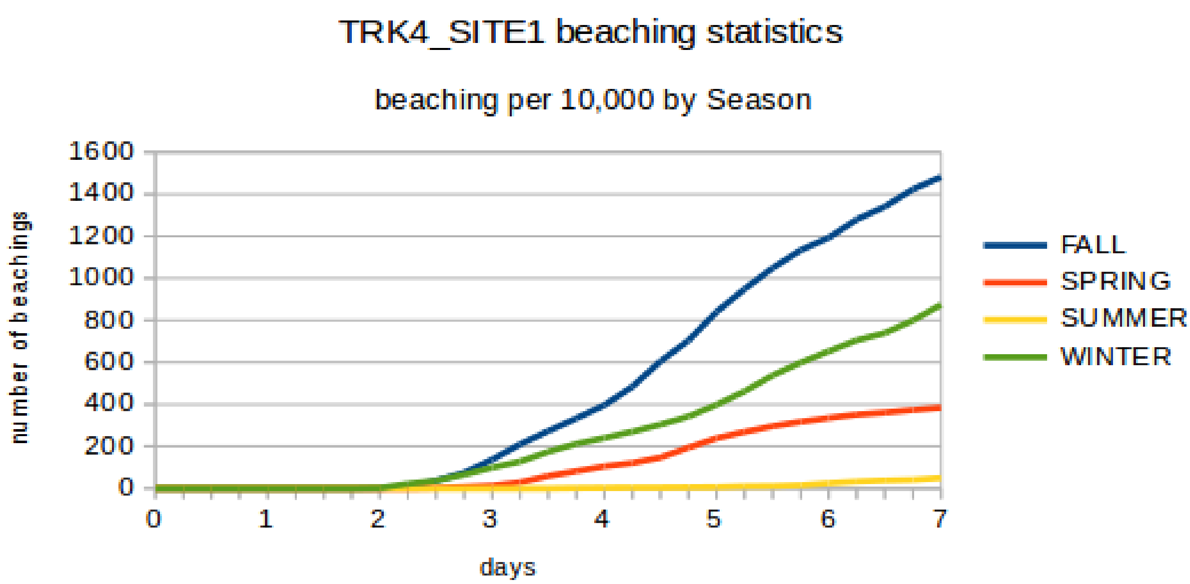

Figure 2 – Representative Statistical Summary of beaching expectations for an example site Unimak Pass TRK4_SITE1.

Looking at the site the figure clearly shows that for this location the threat of grounding remains low for about 2 days (for any time during the year), but after that the probability steadily rises through out the remainder of the trajectory. In addition the Fall season (Oct-Nov-Dec) is clearly more threatening than the remaining seasonal periods. Finally, during the Fall the maximum probability of grounding after a week is nearly 15%. Spot checking various release sites indicates significant variability.

The next level of statistical aggregation will be to extend the above to each of the release sites along the tracks, approximately 20 per track, of the proposed shipping lane. And finally extend this for each of the 4 proposed tracks which were outlined in the scope of this study. Figure 3 presents a map of the 4 ship tracks proposed in this study and the location of each of the release sites.

This then defines the pseudo ship trajectories that are covered within the original scope of this study, but it should be pointed out that with the included tool set it should be relatively easy to extend the archive to other release sites, or tracks that may become of interest.

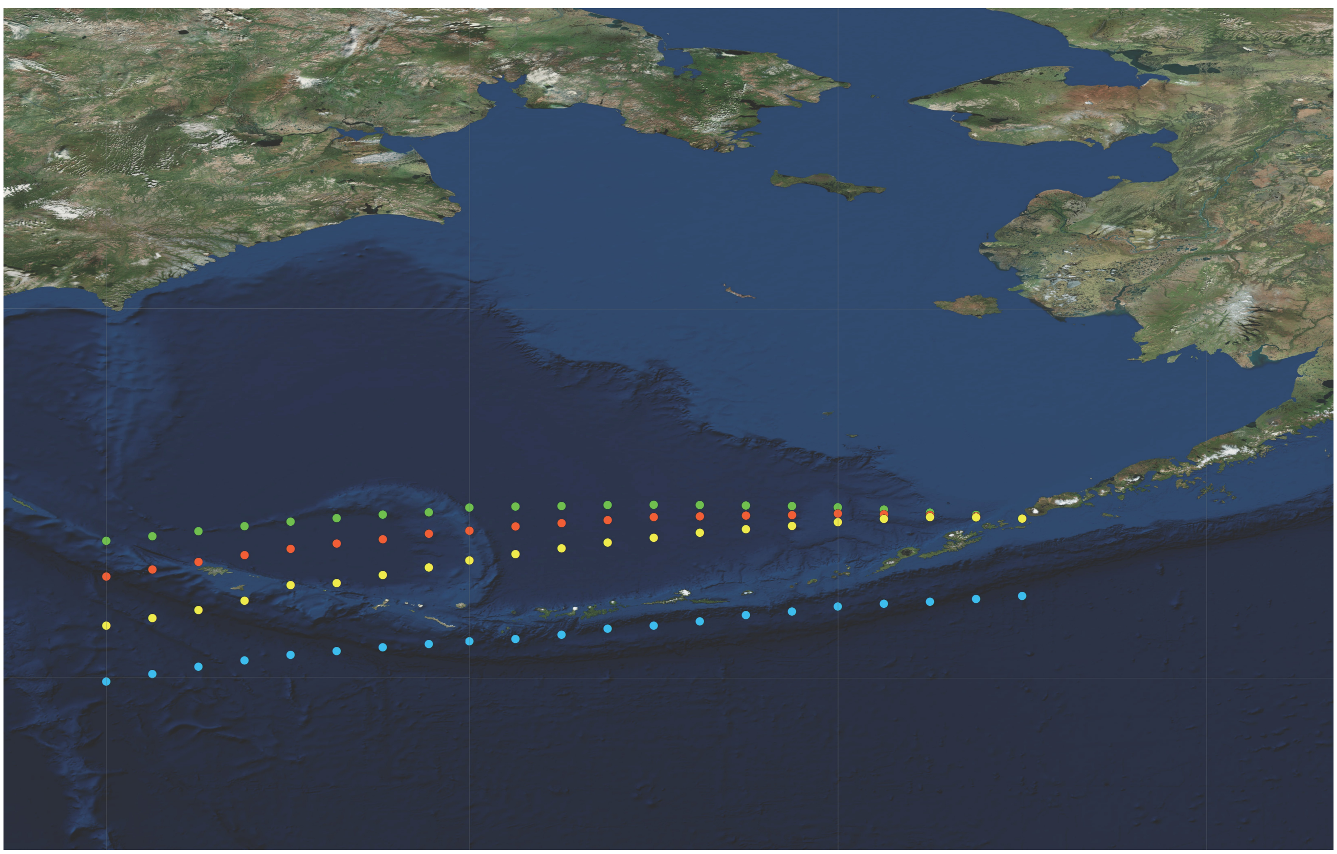

Figure 3 – Tracks and release Sites considered in the (ART) Aleutian Report Trajectory Archive

Data Base

The Aleutian Report Trajectory Archive (ART) contains over 3 million seven day trajectories. The trajectories output position data every 6 hours (this interval can be changed in the configuration file). The raw trajectories were combined into ensembles of trajectory sets sorted by three month seasons (intervals also adjustable in scripts) for each release site. Summaries of of pseudo-ships statistics have been combined in an additional .csv format files for input into spreadsheet programs. All told, the archive will contain a bit under 30,000 files. In order to make this collection useful and easy to navigate a hierarchical file system has been be used. Reserved names for the directories and files are used to facilitate the writing of scripting tools for automatic file creation and processing.

The base directory containing the complete pseudo-ship ART is:

ART_ARCHIVE[_optionalVersion#]

Within this directory is one file and four subdirectories:

ART_ARCHIVE

BaseMap.bna	file
Sites	directory
Times	directory
Locations	directory
CopyOfTools	directory

BaseMap.bna is a .bna formated line file (text) that contains the clockwise polygon data describing all of the shorelines used to define the Aleutian Islands and thus potential grounding sites.

Sites will be a directory with an single ASCII .csv file with a listing of the track and release site locations as comma delimited fields **"TRK#_SITE#", "Latitude in dec.deg", "Longitude in dec.deg".**

Times will be a directory containing four files:

Times

Winter	file
Spring	file

Summer file

Fall file

Winter is a text file containing 250 lines each of which is a random start time chosen from the Jan-Feb-Mar segments of the models span of situation space. The format for each line is basic csv , (example "**16 , 10 , 2011 , 7 , 1** ") where the data is (day, month, year, hour, minute).

Spring same as above except that three month season covers Apr-May-Jun.

Summer same as above except that three month season covers Jul-Aug-Sep.

Fall same as above except that three month season covers Oct-Nov-Dec.

The **Locations** directory contains the majority of the archive files and contain subdirectories. Each subdirectory contains information about one of the study release sites. Each site is referenced by a Track Number (TRK#_) and a Site Number (SITE#). This then gives the following directory and 81 subdirectories:

Locations

TRK1_SITE1

TRK1_SITE2

…

TRK2_SITE1

…

TRK3_SITE1

…

TRK4_SITE1

…

At the next level each of the **TRK#_SITE#** directories contains five subdirectories such that ;

TRK#_SITE#

rawTRK#_SITE#_FALL

rawTRK#_SITE#_SPRING

rawTRK#_SITE#_SUMMER

rawTRK#_SITE#_WINTER

Ensemble

Each of the **TRK#_SITE#_(season)** subdirectories contains 250 (designated as “index#”) subdirectories each of which will contain the seven day trajectory model output of a 40 pseudo-ship clusters release originating at the designated site and beginning at a random start time within the model situation space (restricted to the designated season). The actual model output files have a suffix made up of a three digit integer ranging from 000 to 028 which represent sequential six hour intervals from the random start time.

The **Ensemble** subdirectory contains four additional subdirectories and one standalone file:

Ensemble

enTRK#_SITE#_FALL

enTRK#_SITE#_SPRING

enTRK#_SITE#_SUMMER

enTRK#_SITE#_WINTER

beachStatsTRK#_SITE#.csv

Each of the **enTRK#_SITE#_(season)** directories contains an ensemble of the 250 individual 40 pseudo-ship data that is represented in the “raw” data directories of the previous section. Each directory therefore has (000 – 028) model output files representing 10,000 pseudo-ship trajectories for the indicated season.

The final **beachStatsTRK#_SITE#.csv** file that is in the **Ensemble** directory is an analysis of all of the data contained in the archive pertaining to a particular site. In the .csv format it can be directly read into a standard spreadsheet application for additional analysis. Figure 2 (a,b) is a simple example of using the spreadsheet “chart” function to present the data.

Archives In This Report

This report contains two separate archives. Each of them contains a complete hierarchical file system as is described in the previous section of this report. Each archive is based on the same four tack lines and hypothesizes the same release sequences and number of pseudo ships. The difference between the archives is in the determination of the wind drift factors as illustrated in **figure 1.**

The first archive **ART_ARCHIVE(v000)** has higher values of coupling and scatter between the pseudo ships and the local time dependent wind fields. Referring to **figure 1** the **upper value** is 10% and the **lower value** is 0%. For the angular uncertainty the **Right limit** and **Left limit** is 0.25 radians. These values are thought to span the observations expected of ships with relatively large amounts of "free board" compared to their sub surface drag area. This type of ship may represent large VLCC container carriers with high stacks of container vans on deck, or automobile carriers.

The second archive **ART_ARCHIVE(v001)** has slightly reduced values of wind coupling. And again referring to **figure 1** the **upper value** is 7% and the **lower value** is 1%. For the angular uncertainty the **Right limit** and **Left limit** is 0.20 radians. These values are more characteristic of a ship which sets low in the water and has a relatively reduced amount of "free board". For example a loaded tanker.

The intension of presenting these two separate archives is to give a statistical representation that would span the expected behavior large classes of marine traffic. As is mentioned in the ship drift section of this report the detailed drift behavior of any particular ship can be quite complex and vary considerably depending specific trip loading and harmonic coupling between waves and ship stability. Given particular ship and situation data more complex algorithmic approaches might be appropriate.

Trajectory File Output Format

All of the GNOME trajectory runs that are presented in the archive of pseudo-ships has be written out in the GNOME Moss save-file output format. These are simple ASCII text formatted files where the relevant data is in files with suffixes (.ms.4 and .ms5 – for regular particles) or (.ms6 and .ms7 – for uncertainty particles). Both sets are used and exchanged by the tool set that is presented with this study. The detailed field descriptions are described in (NOAA web site - Digital Distribution Standard for NOAA Trajectory Analysis Information – HAZMAT Report 96-4, January 1996)

Tools

The GNOME model is designed for scientific support during actual responses. It therefore has a rich graphical user interface (GUI) that allows the user/investigator to add components and develop scenarios. Dozens of model components can be manipulated to address virtually any commonly encountered trajectory problems in a very general environmental setting. This flexibility is very desirable in a tactical response, but requires an unimaginably large amount of attention when applied to statistical problems or the creation of ensemble data archives. The ART_ARCHIVE as described in the preceding sections requires thousands of GNOME runs and requires an alternate approach to the standard tactical GNOME user interface.

The model and all of the analysis routines used in this study have "silent" modes of running where no direct user input is required. The salient feature of this mode is that all of the necessary input data to set-up and control of the model is provided by either a configuration file, or machine command line scripts that can contain structured programming components. This makes it possible to set-up single control programs that cycle through hundreds or even thousands of scenarios with a single process launch. The control programs can be templates with variables (for example site latitude and longitude) that can recreate the thousands of output files needed to study a new location. This opens up all kinds of chaining and parallel processing options for extending the study bounds.

The results of this study are the actual ART_ARCHIVE and all of the "configuration file templates" and "command line scripts" used to create and/or extend it. The following tool sections describe these control programs.

Gnome Configuration Script

Scenarios can be instantiated with all the relevant information necessary for the model and run from a text format file with the name, **Command.txt** that is co-located with the GNOME application as GNOME is launched or a text format file with any name can be run from within GNOME. The Command file can also just have the information necessary to instantiate a particular release scenario within a GNOME.SAV or location file pre-configured with a BNA format map and whatever movers the user desires to drive the released particles, such as variable or constant wind, tides or other movers and random diffusion. In this instance, a pre-configured .SAV file (Base.SAV) was created and each release of pseodo-ships was instantiated from the Command file. Each Command file, e.g. **TRK1_SITE1_allseasons.txt**, released 40 pseudp-ships from one starting location on 1000 different dates and times (250 dates and times from each season) and tracked the pseudo-ships over one week. The start dates and times were randomly selected from the date range within which we had wind and current data files for the Aleutian area. In the Command file, we included information to account for anticipated variability in the wind and current movers on the ships, and the data type and locations for outputting the results of the model every 6 hours. Following is an excerpt of the file, **TRK1_SITE1_allseasons.txt** which includes the required header information and the information to instantiate Site 1 on Track 1. (Anon, 2015)

The is an excerpt for the referenced text configuration file:

```
-- this would clear all maps etc in case we are not launching GNOME

MESSAGE close; TO model;

---------------------------------

-- Set the error log file

---------------------------------

MESSAGE setField; TO model; errorLog C:\WCS\errorlog.txt;

---------------------------------

-- Either open a save file

---------------------------------

MESSAGE open; TO model; PATH C:\WCS\Base.sav;

---------------------------------

-- Or use normal messages from wizard commands in location file

---------------------------------

MESSAGE setfield; TO model; startTime 1, 10, 2011, 21, 40;
```

```
MESSAGE setfield;TO model; INCLUDEMINREGRET true;
--
MESSAGE runSpill;TO model; startRelTime 1, 10, 2011, 21, 40;
runDurationInHrs 168;timeStepInMinutes 60; numLEs 40; startRelPos 195
E 54.3255 N;outputStepInMinutes 360; totalMass 1000;pollutantType
CONSERVATIVE; massUnits GALLONS; windageA 0.05; windageB 0.05;
persistence 0.25; mossFolder C:\WCS\TRK1_SITE1_FALL\Index0\;
```

NOTE: The full listings of the Command files are located on the hard drive provided as a deliverable for this project.

Ensemble JAVA.jar Tool

For each site the basic GNOME seven day pseudo-ship trajectories were generated using the configuration script described in the previous section. This populates each **rawTRC#_SITE#_(season)** directory with 250 random start time directories. The next task was to create the ensemble trajectory output by merging these 250 output directories (each consisting of 7 days of 40 "pseudo ship" clusters) into a **enTRC#_SITE#_(season)** directory of 10,000 pseudo-ship for a 7 day duration. This was a massive scan-cut-copy type of operation and was carried out using a java application bundled into a stand alone Java executable **.jar.** file. The stand alone Java program is written in standard Java commands and will be run in the local machines runtime environment. The procedure will be to first copy the **BuildEnsemble.jar** file into the **TRK#_SITE#** directory that the user wishes to process. Then open the command line interface, navigate to the **TRC#_SITE#** directory and enter the command **java -jar BuildEnsemble.jar .** The program will run, showing its progress though the 0-28 time steps of the 4000 files. On completion the script will have created a **Ensemble** directory in the parent **TRC#_SITE#** directory (if one does not already exist) and populated it with an "**enTRC#_SITE#_(season)**" directories of 10,000 pseudo-ship trajectories for that season. The program will then continue to calculate a beaching summary set of statistics and place the results in a **beachStatsTRK#_SITE#.csv** file which is created in the **Ensemble** directory. This file is also listed in the command line standard output for user inspection and a typical example is shown as follows:

Example file listing of **.csv

 , FALL , SPRING , SUMMER , WINTER (note: lines may starts with a bland space)
0 , 0 , 0 , 0 , 0
 , 0 , 0 , 0 , 0

, 0 , 0 , 0 , 0
, 0 , 0 , 0 , 0
1 , 0 , 0 , 0 , 0
, 0 , 0 , 0 , 0
, 0 , 0 , 0 , 0
, 0 , 0 , 0 , 0
2 , 0 , 0 , 0 , 0
, 0 , 0 , 0 , 0
, 0 , 0 , 0 , 0
, 0 , 0 , 0 , 0
3 , 0 , 0 , 2 , 1
, 0 , 0 , 4 , 9
, 3 , 0 , 8 , 15
, 4 , 0 , 12 , 22
4 , 9 , 0 , 12 , 41
, 17 , 0 , 20 , 59
, 29 , 5 , 24 , 82
, 40 , 13 , 28 , 116
5 , 57 , 29 , 38 , 161
, 68 , 59 , 51 , 215
, 86 , 82 , 60 , 258
, 98 , 103 , 66 , 331
6 , 112 , 134 , 81 , 391
, 126 , 166 , 101 , 463
, 154 , 196 , 107 , 531
, 177 , 215 , 125 , 615
7 , 210 , 242 , 143 , 709

This is a standard ASCII, comma delimited file that can be cut and pasted (or drag and dropped) in any modern spreadsheet program for additional analysis or charting output. The graphics shown in figure 2 are created in this manner using "OpenLibre" and the same results are available using Microsoft EXCEL. The Java source code used in **BuildEnsemble.jar** are included in the .jar file and can be accessed using standard Java Jar methods. The code is open source under a standard **GNU_General Public License, Version 3, 29 June 2007 Copyright © 2007 Free Software Foundation, Inc.**

Visualize Beaching/Probability Density JAVA.jar Tool

The **ART_ARCHIVE** is both a rich and extensible database providing a massive collection of pseudo-ship drift trajectory estimates. There are many ways to examine the data and we do not pretend to exhaust, or even scratch the surface of how to analyze this information. We do however, provide a simple tool to graphically and directly display the Eulerian probability densities associated with the Ensemble distribution collections. This tool is based on a Lagrangian to Eulerian transformation procedure that is described by **Galt, 2015.** The Lagrangian distribution that results from the trajectory analysis is partitioned into floating and beached particles. The beached subset is then subjected to cluster analysis **(Xu and WunchII, 2009)** so that Eulerian densities of particles/ kilometer are derived.

This tool is presented as a stand alone Java application bundled into a **.jar.** file. In order to run the application the user: 1) opens the command line console. 2) navigates to the directory where the **BeachingProbability.jar** file is stored (it could be anywhere on your computer that is convenient), and 3) type in **Java -jar BeachingProbability.jar .** The program will run: 1) first presenting the user with a choice dialog on whether a map will be included – answer "yes", 2) the Application will present the user with a file chooser dialog – navigate to and select **ART_ARCHIVE/aleutions.bna,** 3) the application will present user with a data file suffix option dialog – answer ".ms4", 4) the application will present the user with a file chooser dialog – navigate to and select (file and time to analyze):

ART_ARCHIVE/TRK#_SITE#/Ensemble/enTRK#_SITE#_(season)/en###.ms4

The application will run and present three graphic windows. The first, seen here as Figure 4 is a sorted list of the neighbor metrics (clustering) associated with each of the beached particles or pseudo-ships. This measure is the linear density (kilometer/pseudo-ship) of groundings. This graph is constructed by calculating the length scale for each particle and then sorting them in descending order. Plotting these values with element number along the horizontal axis and a vertical axis measure of the weighted mean distance to another grounded pseudo-ship up the vertical axis results in the plot with the blue region representing the sorted scale metrics. Each horizontal line (from top to bottom) in Figure 4 represents a doubling in the concentration. Sharp decreases in the slope of the curve indicate the onset of clustering. The highest values of clustering (lower right side of figure) indicate the maximum probabilities of beaching in the data set that is analyzed.

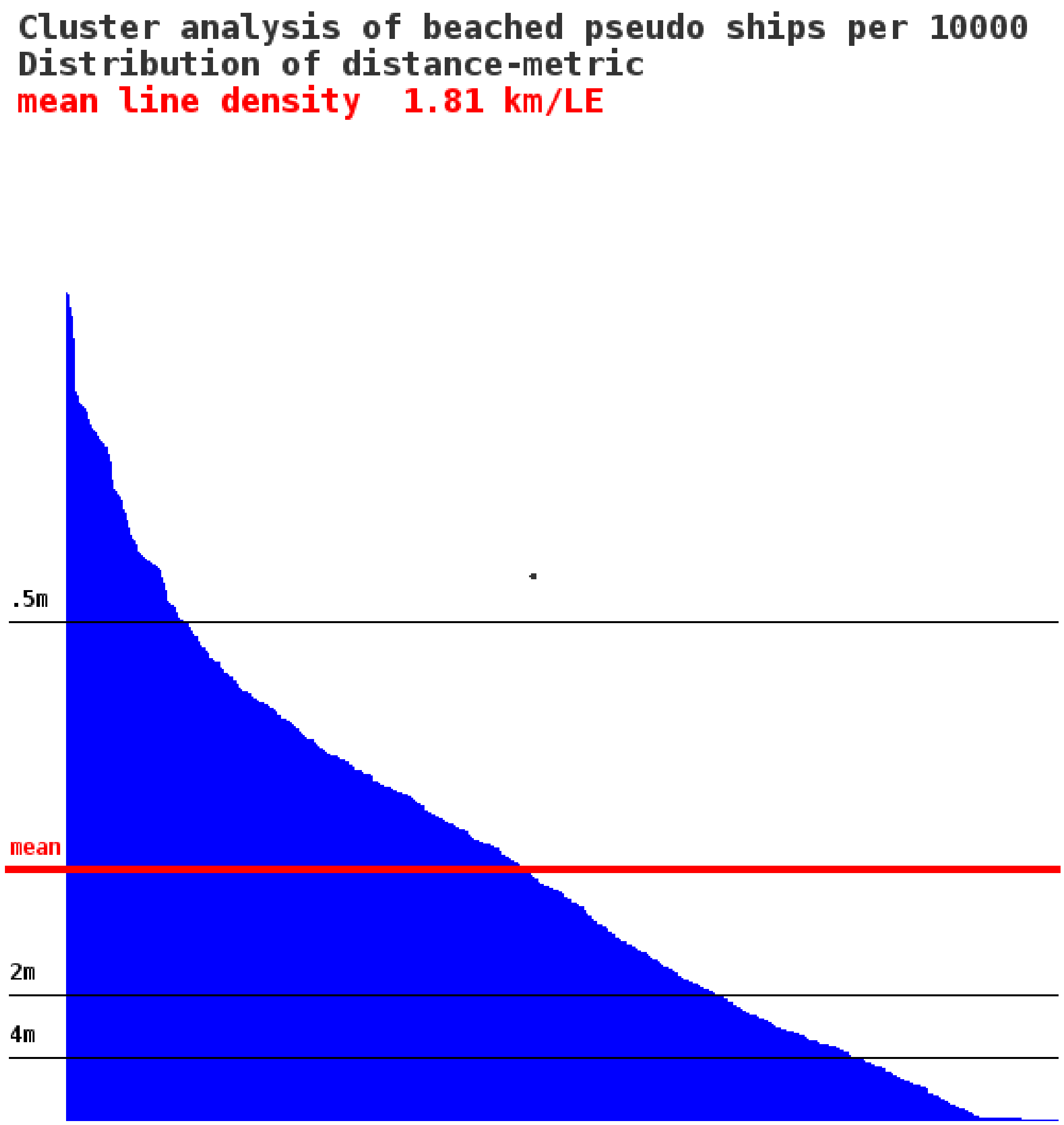

Figure 4 – Plot of the sorted length-metric where the vertical axis represents $1/\ln_2(l_i)$ and the horizontal axis is particle index.

The second graphic window will contain the essentially the same data that is presented in the previous figure in the reciprocal form of density (pseudo-ships/km).

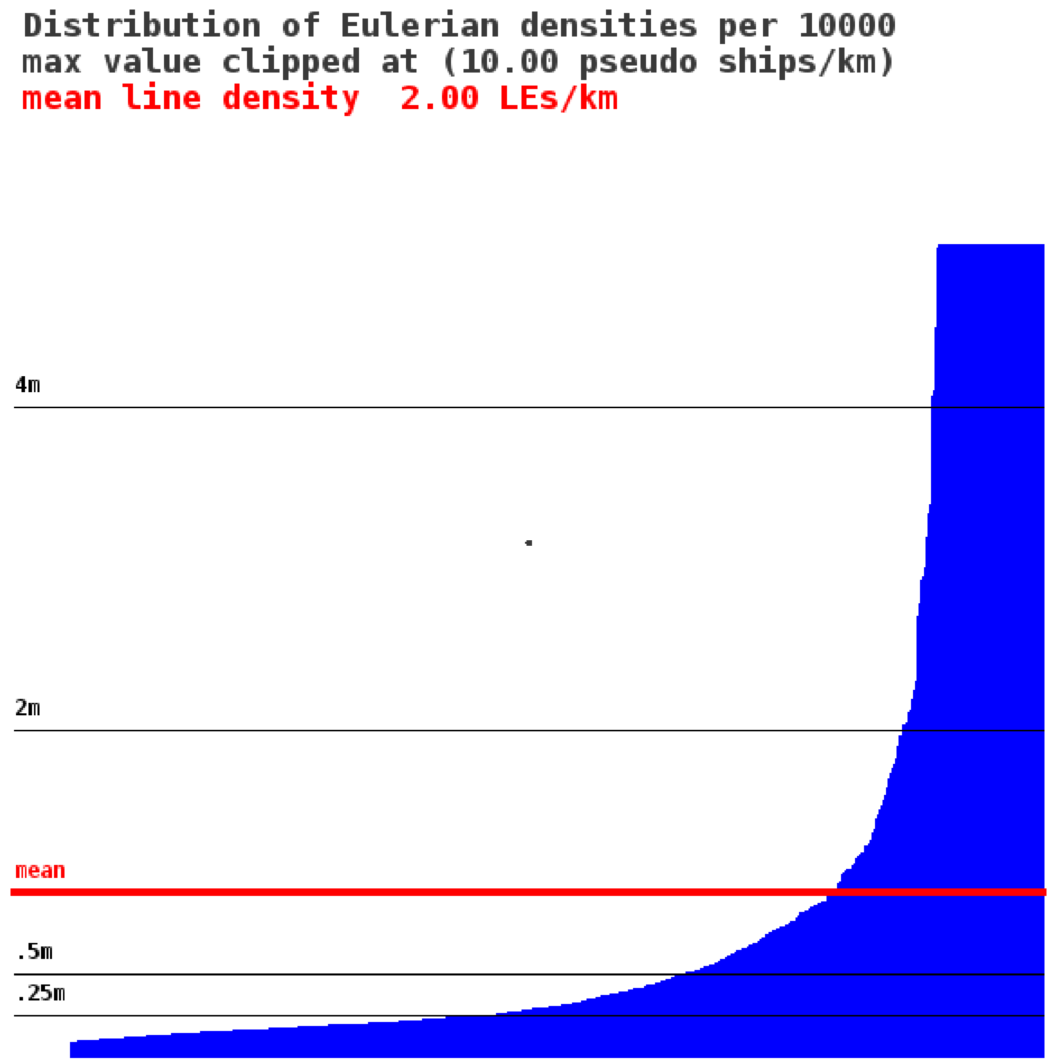

Figure 5 – Plot of the sorted pseudo ship density where the vertical axis represents number of grounding per km and the horizontal axis is particle index.

The third graphic window, seen as Figure 6, will display a regional map with each of the grounding sites indicated by a circular dot. The color and area covered by the dot will be scaled into four classes directly proportional to the clustering density metric. Locations with cluster metrics < half the mean will be black. Locations with clustering density metrics between half the mean and the mean will be very dark red and cover twice the area. Locations with cluster metric densities between the mean and twice the mean will appear dark red and be twice the area of the previous class. Finally locations with cluster metric densities greater then twice the mean will be red and cover twice the area of the previous class.

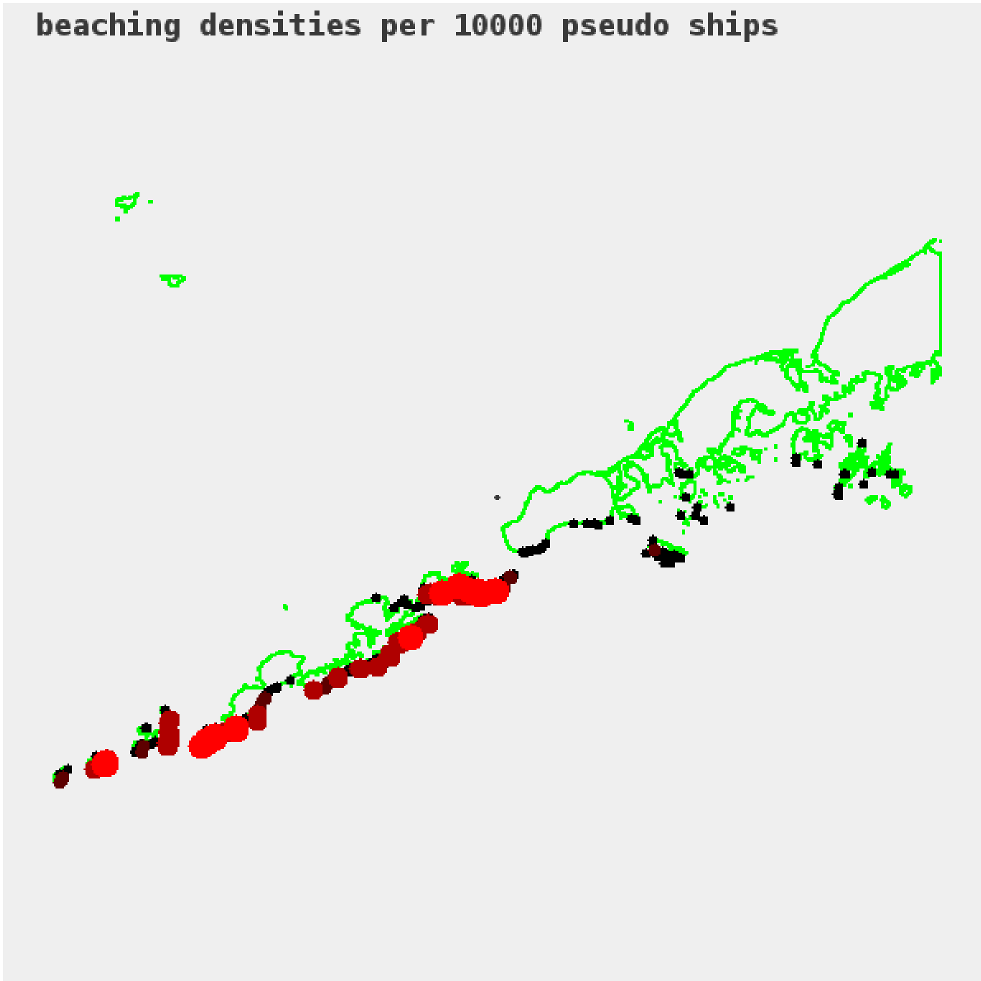

Figure – 6 Plot of all beached particles scaled to Eulerian density

This plot will be interactive and a mouse click anyplace in the window will recenter the view frame so that it is centered on the click-location. In addition, the up-arrow key will zoom in the view by approximately 10% and the down-arrow key will zoom out the view by the same amount. If a "s" key is pressed the user is presented with a dialog input box where they can enter the lower limit percent of beaching probabilities that are displayed. For example: "s" – 50 will display the half of the groundings with the highest Eulerian densities, and "s" – 95 will discard the 5% of groundings which have the lowest hit densities, which is to say the outlying data points that are not particularly common in the sampled scenario space. (Default is 100% meaning show the length metrics for all beached particles.) Figure 7 shows a zoomed in view containing some of the beached pseudo-ship released from T**RK1_SITE1_WINTER028** which is in Unimak Pass and corresponds to the beaching statistics presented in the lower panel of Figure 2

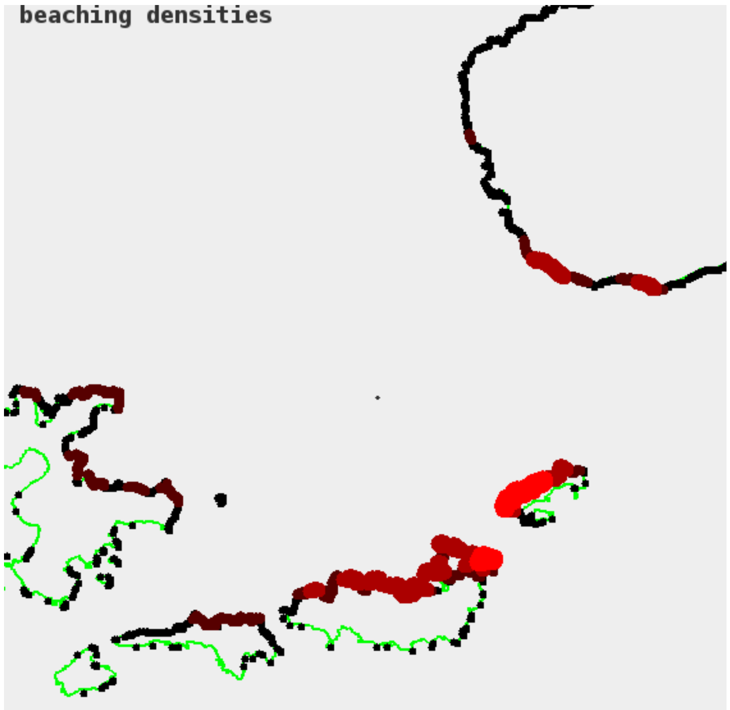

Figure – 7 Zoomed in detailed view of beached pseudo-ships for Unimak Pass,Winter,7days

Finally the **BeachingProbability.jar** will write out a file **beachGIS_Data.csv** as:

"index","Long(md)","Lat(md)","length(km)","density(1/km)"

as one line for each beached pseudo ship.

The Java source code used in **BeachingProbability.jar** are included in the .jar file and can be accessed using standard Java Jar methods. The code is open source under a standard **GNU_General Public License, Version 3, 29 June 2007 Copyright © 2007 Free Software Foundation, Inc.**

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Physical Media

Full data base archive HFS+ (mac,windows,Unix/Linux) comparable hard drive.

Appendix Sofware Listings

Sample section of GNOME command file (for TRK1_SITE1)

```
[GNOME COMMAND FILE]

-- this would clear all maps etc in case we are not launching GNOME

MESSAGE close; TO model;
```

```
---------------------------------
-- Set the error log file
---------------------------------
MESSAGE setField; TO model; errorLog C:\WCS\errorlog.txt;
---------------------------------
-- Either open a save file
---------------------------------
MESSAGE open; TO model; PATH C:\WCS\Base.sav;
---------------------------------
-- Or use normal messages from wizard commands in location file
---------------------------------
--
--
--
--
MESSAGE setfield; TO model; startTime 1, 10, 2011, 21, 40;
MESSAGE setfield;TO model; INCLUDEMINREGRET true;
--
--
MESSAGE runSpill;TO model; startRelTime 1, 10, 2011, 21, 40;
runDurationInHrs 168;timeStepInMinutes 60; numLEs 40; startRelPos 195
E 54.3255 N;outputStepInMinutes 360; totalMass 1000;pollutantType
CONSERVATIVE; massUnits GALLONS; windageA 0.05; windageB 0.05;
persistence 0.25; mossFolder C:\WCS\TRK1_SITE1_FALL\Index0\;
```

(full copies for all command files files given in ACT_ARCHIVE)

THE THREE MESSAGES ABOVE ARE REPEATED FOR EACH START TIME USED IN THE COMMAND FILE – IN THIS CASE 999 MORE TIMES TO MAKE A TOTAL OF 1000 START TIMES FOR THIS COMMAND SET

Appendix Data Base Template

Aleutian Report Trajectory [versionNo]
Data Base
~28,500 files

```
BaseMap.bna “1” file line map
CopyOfTools – “4”files, “2” directories
     BuildEnsemble.jar
     BeachingProbility.jar
     BeachedStats.ods (template)
     BeachedStats.xlt (template)
     CommandFiles_Mac_Unix_Linux
     CommandFile_Windows
Times (directory) “4” files
     Winter – (file) of 250 start times
     Spring – (file) of 250 start times
     Summer – (file) of 250 start times
     Fall – (file) of 250 start times
Sites – (file) of 84 startpoints
Locations (directory)  “84” directories
     Sites#index – (directory) “5” directorys
          RawWinter – (directory) “250” directories
               Runs(0-249) – (directory) “28” files
                    hr6 – (file) 40LE trajectory
                    hr12 – (file) 40LE trajectory
                    -------
          RawSpring – (directory) “250” directories
               Runs(250-449) – (directory) “28” files
                    hr6 – (file) 40LE trajectory
                    hr12 – (file) 40LE trajectory
```

```
        -------
RawSummer – (directory) “250” directories
    Runs(500-749) – (directory) “28” files
        hr6 – (file) 40LE trajectory
        hr12 – (file) 40LE trajectory
        -------
RawFall – (directory)  “250” directories
    Runs(750-999) – (directory) “28” files
        hr6 – (file) 40LE trajectory
        hr12 – (file) 40LE trajectory
        -------
Ensemble - (directory) “4” directories
    enWinter – (directory) “29” files
        hr6 – (file) 10000LE trajectory
        hr12 – (file) 1000LE trajectory
        -------
    enSpring – (directory)  “29” files
        hr6 – (file) 10000LE trajectory
        hr12 – (file) 1000LE trajectory
        -------
    enSummer – (directory)  “29” files
        hr6 – (file) 10000LE trajectory
        hr12 – (file) 1000LE trajectory
        -------
    enFall – (directory)  “29” files
        hr6 – (file) 10000LE trajectory
        hr12 – (file) 1000LE trajectory
        -------
    BeachingTable.csv – (file)
```