ROC Final Report
BSEE – NOAA Project: IAG #E14PG00064
March 31, 2017

Transition existing Response Options Calculator (ROC) Into an Open Source Web Tool

Project Overview

The Response Options Calculator (ROC) is a publicly available spill response planning model that simulates: (1) oil weathering and spreading and (2) recovery by deploying skimming systems, treatment by dispersant application, and removal by in situ burning. For user-designed scenarios, ROC assesses the system performance of response tactics and their result on the overall mass balance of the slick. ROC is not intended for calculating system performance during an actual oil spill — the complexity of actual response operations and rapidly changing on-scene conditions could result in far different results than those predicted by ROC.

ROC was initially developed and implemented as a stand-alone desktop application and online tool employing Adobe Flash technology. As part of the Interagency Agreement EI4PG00064 between the Department of the Interior (DOI) Bureau of Safety and Environmental Enforcement (BSEE), and the U.S. Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), Office of Response and Restoration, Emergency Response Division (NOAA/NOS/ORR/ERD, hereafter, ERD), the ROC functionality has been updated and incorporated into a larger open source modeling system that includes oil fate and transport.

Over the last few years, ERD has developed an updated modeling system, bringing together oil spill fate and transport into a single Web-based application. The new system is more accessible and powerful and expands on the capabilities of its predecessors. Specifically, it combines NOAA's operational oil spill trajectory model, the General NOAA Operational Modeling Environment (GNOME) with an oil weathering model. This updated modeling system consists of a computational core written in Python and C++ (pyGNOME) and a web-based graphical user interface (WebGNOME). The combined system is referred to as the GNOME modeling suite and is described further in Section 2.

As part of the development of the GNOME modeling suite, many of the weathering algorithms used in the previous stand-alone weathering model (ADIOS2) were updated using recent research results. By incorporating ROC into this modern, open source framework, these improved weathering algorithms and any future improvements are automatically leveraged in the response options analysis. An overview of the current weathering algorithms used in the GNOME modeling suite are also included in Section 2.

The existing algorithms for calculating efficiency of response options in ROC were re-written in the Python programming language. The incorporation of these algorithms into the GNOME modeling suite required some modifications due to different programmatic approaches. For example, the ROC application considered the oil spill as a single discrete object representing the entire "slick" to which mass is removed by weathering and clean-up operations. For a continuous release, where there would be a mixture of fresh and weathered oil, it could not model the weathering process. However, GNOME uses a Lagrangian element approach (often called "particle tracking") in which the spill is divided up into a number of individual elements which together represent the entire spill. These elements are independently moved, weathered, and acted upon by response options. Section 4 details how the response operations algorithms were adapted to work within the Lagrangian element framework.

Finally, a new ROC user interface was integrated into the WebGNOME application. Similar to the old ROC application, the interface includes numerous panels for selecting response options, including skimming, burning, and dispersing oil. It also includes improved output displays for oil fate/weathering including the oil budget and changing oil properties. In addition to the ROC user interface, elements of the more recent EDRC calculators were included — specifically the response options efficiency graphs. Section 5 steps through a scenario illustrating the functionality and look of the new ROC interface.

Incorporating ROC into this modern open source framework will allow for continuing implementation of updated response technologies and oil weathering algorithms. In addition, by coupling with an oil transport model, it will also ultimately allow for spatial dependence in response applications, for example, targeting specific areas of the spill for response operations or dynamically calculating asset transit times. Although that geographic coupling was beyond the scope of this current agreement, the foundation now exists for future implementation. Some potential future improvements are outlined in Section 6.

The GNOME modeling suite

The GNOME modeling suite combines NOAA's operational oil spill trajectory model, the General NOAA Operational Modeling Environment (GNOME) with an oil weathering model. This updated modeling system consists of a computational core written in Python and C++ (pyGNOME) and a web-based graphical user interface (WebGNOME). GNOME is not specific for any particular region. The interface allows users to run simulations using available "Location Files" (which are already set up with the required regional data) or to design custom setups at a location of their choosing. These custom setups require a map and inputs for ocean currents and winds. Various data sources for use in GNOME can be downloaded through a publicly available website at http://gnome.orr.noaa.gov/goods. Complete documentation for the GNOME modeling suite will be published as a NOAA technical report in 2017. Here we briefly describe the model components and highlight their integration with the ROC.

Transport

GNOME is fundamentally a Eulerian/Lagrangian spill trajectory model in which the environmental conditions are simulated as Eulerian (continuous) fields within which the slick's Lagrangian elements move. Elements can be released into the model en masse to simulate a near instantaneous release, or over time to simulate a continuous release. Elements are then moved under the influence of surface ocean currents, wind drift, and horizontal mixing. GNOME can be used to simulate very simple scenarios using constant value ocean currents and winds, or much more complex scenarios utilizing output from external hydrodynamic models. This very flexible approach is one of the strengths of the GNOME modeling suite and makes it a valuable tool for use during response, as well as for response planning.

GNOME models the various physics influencing the movement of the oil using simple linear superposition. Advective transport movers in GNOME include net movements due to currents and “wind drift.” In spill trajectory models, it is common to combine a number of physical processes related to wind forcing (e.g., wind stress, Stokes drift, and surface drift) into a wind drift factor which has been determined experimentally to be ~3-4% of the wind speed for fresh oil in light winds [6]. GNOME allows the user to specify a range of values for the wind drift, along with a persistence time scale — simulating the time-varying windage as the wind and wave conditions are not generally spatially uniform, nor is the oil all the same age since its release (due to varying degrees of weathering). Turbulent diffusive processes that spread spills horizontally are simulated in GNOME by a random walk. A user-specified diffusion coefficient is used to calculate random step lengths in the x- and y-directions from a uniform distribution. This diffusive transport is added to the total transport vector and spreads the elements over time.

Elements may become “beached” if the combined movement brings them in contact with the shoreline. The shoreline data contained in the map is rasterized into a land/water bitmap for tracking this beaching. GNOME also has an all-water boundary by default so users can specify a spill without importing a map file. For the initial integration of ROC into the GNOME modeling suite, this default all-water map was utilized for consistency with the previous ROC implementation, which did not include beaching.

Weathering

Individual elements have inherent properties based on the release conditions (e.g., type of oil spilled, spill volume) These properties— for example, mass, oil thickness, density, and viscosity— change over time as weathering algorithms are applied. These changes in physical properties can affect the transport, or in the case of ROC, the efficiency of response operations. Algorithms used in GNOME are documented thoroughly in the GNOME technical documentation but will be described briefly with reference to integration with ROC.

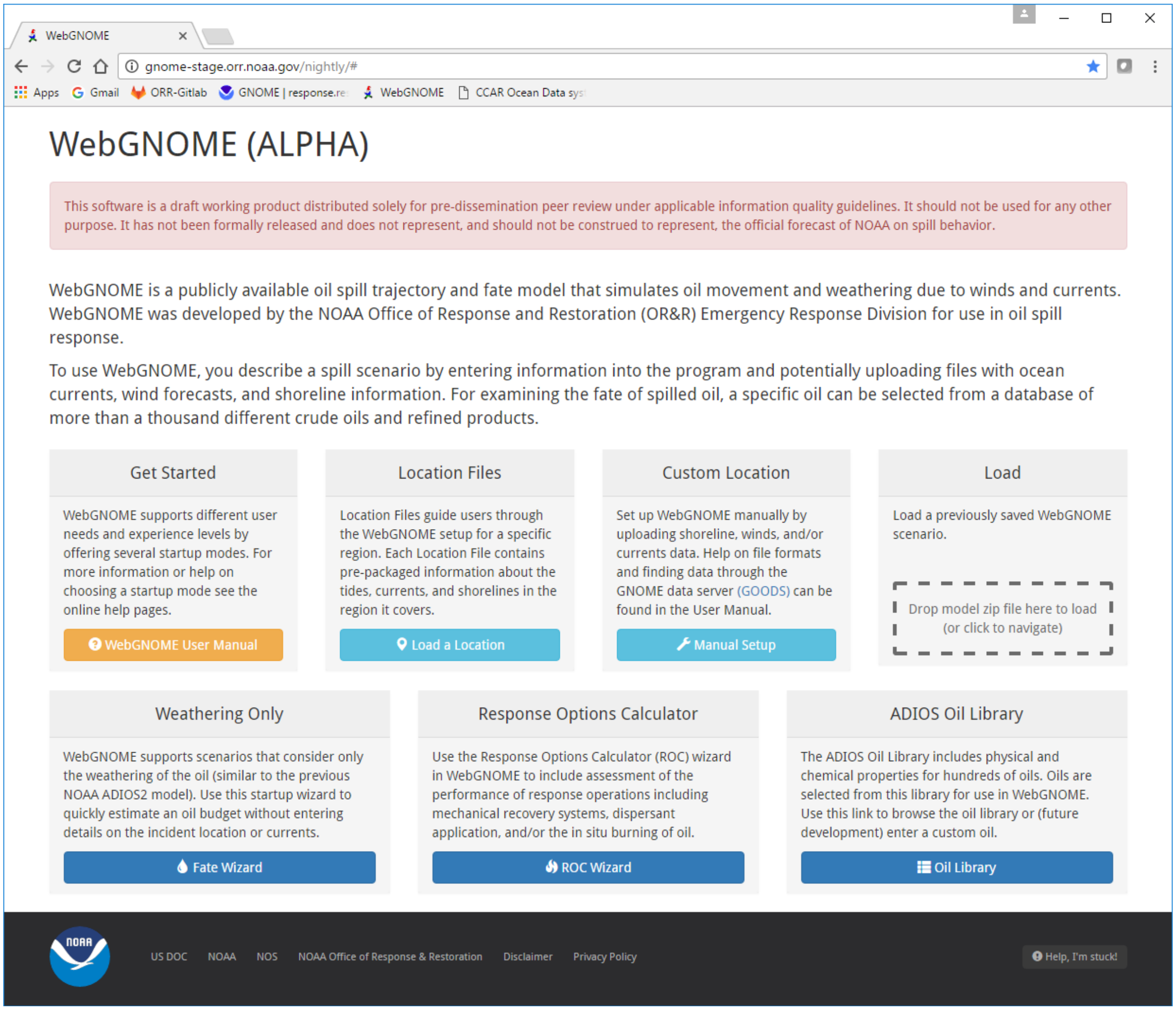
The GNOME modeling suite includes algorithms for all the weathering processes that were included in ROC (spreading, evaporation, and natural dispersion). In addition, it includes dissolution and sedimentation. The algorithms used in GNOME were derived from NOAA’s ADIOS2 stand-alone weathering model [1] as a starting point with some significant modifications and improvements, notably the inclusion of biodegradation and dissolution and an updated emulsification algorithm.

Slick Spreading and Encounter Rate

The weathering of the oil affects the amount of oil available for response operations. Of particular importance to ROC is the encounter rate -- simply put, it is not possible to recover, disperse, or burn more oil than is encountered. At each model time step, average thickness of the spilled oil is used in encounter rate calculations to estimate the potential response performance. In the Lagrangian element framework, each element has an average thickness associated with it that is utilized for this calculation. Thickness is a subtle concept in real spills, as oil on the surface of the water tends to be patchy, with highly variable thickness. For ROC, an average thickness at the scale of response operations is used to compute encounter rate.

WebGNOME Interface

Although it is possible (and often desirable) to run pyGNOME by itself through a scripting environment, most users will run the model through the WebGNOME interface, publicly available at www.gnome.orr.noaa.gov (beta version as of March 2017). The interface has user-friendly input screens for setting up spill scenarios, and multiple output views for examining the fate and transport of the oil. Results can be output in a variety of formats, including netCDF and standard GIS formats. A custom ROC interface can be selected as a starting point from the main WebGNOME entry page (Figure 1).



WebGNOME (ALPHA)

This software is a draft working product distributed solely for pre-dissemination peer review under applicable information quality guidelines. It should not be used for any other purpose. It has not been formally released and does not represent, and should not be construed to represent, the official forecast of NOAA on spill behavior.

WebGNOME is a publicly available oil spill trajectory and fate model that simulates oil movement and weathering due to winds and currents. WebGNOME was developed by the NOAA Office of Response and Restoration (OR&R) Emergency Response Division for use in oil spill response.

To use WebGNOME, you describe a spill scenario by entering information into the program and potentially uploading files with ocean currents, wind forecasts, and shoreline information. For examining the fate of spilled oil, a specific oil can be selected from a database of more than a thousand different crude oils and refined products.

Get Started

WebGNOME supports different user needs and experience levels by offering several startup modes. For more information or help on choosing a startup mode see the online help pages.

Location Files

Location Files guide users through the WebGNOME setup for a specific region. Each Location File contains pre-packaged information about the tides, currents, and shorelines in the region it covers.

Custom Location

Set up WebGNOME manually by uploading shoreline, winds, and/or currents data. Help on file formats and finding data through the GNOME data server (GOODS) can be found in the User Manual.

Load

Load a previously saved WebGNOME scenario.

Drop model zip file here to load (or click to navigate)

Weathering Only

WebGNOME supports scenarios that consider only the weathering of the oil (similar to the previous NOAA ADIOS2 model). Use this startup wizard to quickly estimate an oil budget without entering details on the incident location or currents.

Response Options Calculator

Use the Response Options Calculator (ROC) wizard in WebGNOME to include assessment of the performance of response operations including mechanical recovery systems, dispersant application, and/or the in situ burning of oil.

ADIOS Oil Library

The ADIOS Oil Library includes physical and chemical properties for hundreds of oils. Oils are selected from this library for use in WebGNOME. Use this link to browse the oil library or (future development) enter a custom oil.

Figure 1: Entry point for ROC from the WebGNOME application as it appears in the beta version (March 2017). The start-up page design is still under development but will have multiple entry points tailored to the wide range of possible use cases.

Response Operations Algorithms

The incorporation of the ROC response operations algorithms into the GNOME modeling suite required some modifications due to different programmatic approaches -- i.e., moving from a single oil object to an individual element based approach. However, a similar approach to the previous version of ROC was used, in which response options remove mass from the entire slick. The code framework was flexibly designed so future development could allow response options to be geographically focused.

Algorithms for operational constraints, for example, determining transit times, offloading, sortie parameters, were unchanged. Detailed descriptions of the ROC algorithms are documented elsewhere; here, we briefly summarize the mass removal algorithms for the three response options and highlight any significant modifications from the previous implementation.

Skimming Systems

The algorithms used in ROC for removing oil due to mechanical recovery systems are well documented [2, 3] and essentially unchanged in the current implementation within the GNOME modeling suite. Users enter information about each skimming system, such as its swath width, on-board storage capacity, pump-rates, and speed, and the circumstances of its operation, such as transit time to secondary storage. The model then estimates the amount of oil that the system could collect during the operating period each day of the spill scenario that the asset is deployed.

The equations used in the calculations are outlined in the ROC Technical Documentation [2]. Briefly, the rate at which oil/emulsion is encountered by a skimmer is a function of the swath width, the speed of the system relative to the water, and the average thickness of the oil/emulsion. The encounter rate is used, along with the specified Throughput Efficiency for the system to calculate the Oil/Emulsion Recovery Rate, OERR (typically reported in gallons/min). The oil recovery rate is then determined by taking into account the percent water content in the emulsified oil. (If the oil is not emulsified, then these rates will be identical.)

The total volume recovered by the skimmer (oil/emulsion and free water) is determined by multiplying the OERR by a Recovery Efficiency. Recovery efficiency is the percent oil or emulsion in the total fluid volume recovered onboard the skimmer. Estimates based on field trials and tank tests are available for many recovery systems, but they may be difficult to categorize, i.e., there may be a combination of recovery modes within a single skimming system. In addition, this number is dependent on numerous factors which may not be assessed, e.g., oil type, thickness encountered by system, speed of advancement, wind/wave conditions, etc. Therefore, the values available in ROC are rough approximations and user-entered values for Recovery Efficiency will override ROC estimates.

There are further restrictions on the total volume recovery rate, for example, the rated pump rate on the system, and the maximum effective swath width for a skimmer operating on a slick thickness. These are unchanged from the original ROC implementation, as are the calculations for determining the time to fill the onboard storage and transit considerations.

For implementation within GNOME’s Lagrangian element framework, individual elements have mass removed based on the oil recovery rate. For the case of an instantaneous release, all the elements will have identical properties (density, viscosity, mean thickness) and equal portions of mass will be removed from each element.

Under some conditions, skimmer performance becomes impaired or impossible. For example, a wind speed >19 knots will result in a cessation of skimming activities. Similarly, if the viscosity exceeds a threshold of 50,000 cSt, skimming is no longer possible. In GNOME, the properties are evaluated for each element, so fresher elements may still be operated on even if older elements exceed the threshold.

In Situ Burn Systems

The algorithms used in ROC for removing oil due to *in situ* burning (ISB) are also well documented [2, 4] and essentially unchanged in the current implementation within the GNOME modeling suite. The ROC library does not contain defined systems for ISB as it does for skimming systems. Users enter the length of fire boom and its draft to define a system.

Encounter rate is calculated as for mechanical recovery as a function of swath width, speed, and average oil thickness. In this case, swath width is defined as 3/10 the boom length. The algorithms include calculations for the amount of time to fill the boom to capacity, which is dependent on the holding capacity of the boom as determined by its length and draft, the encounter rate, and a throughput efficiency (amount collected divided by amount encountered; default is 75%). Also taken into account is the time needed to move the oil away from the source prior to ignition to maintain control. Finally, the burn duration will depend on the size of the burn area within the boom and the burn rate.

The burn rate in ROC is based on nominal burn rates for light to medium un-emulsified crude oils. For emulsified oils, this rate is reduced in proportion to the water content. The nominal burn rate for an un-emulsified oil is 0.14 inches/minute. For emulsified oil, the burn rate is equal to 0.14 inches/minute * fraction of oil in the emulsion.

Once the holding capacity of the boom is reached, the burn rate is used to remove mass from the model elements. In addition to modification due to water content, if the viscosity becomes too high (>100,000 cSt), the burn system will become inactive. The burn system will also not operate if winds exceed 24 kts.

Dispersant Application Systems

The algorithms previously used in ROC for dispersant application are well documented elsewhere [2, 5]. ROC provides performance estimates for both vessel and aerial dispersant applications with a library of dispersant application systems. Unlike skimming and ISB systems, dispersant systems begin their cycle of operations at a staging area where they can load dispersant or refuel. These include airports within a reasonable range for aircraft systems, or a barge near the slick for a vessel system.

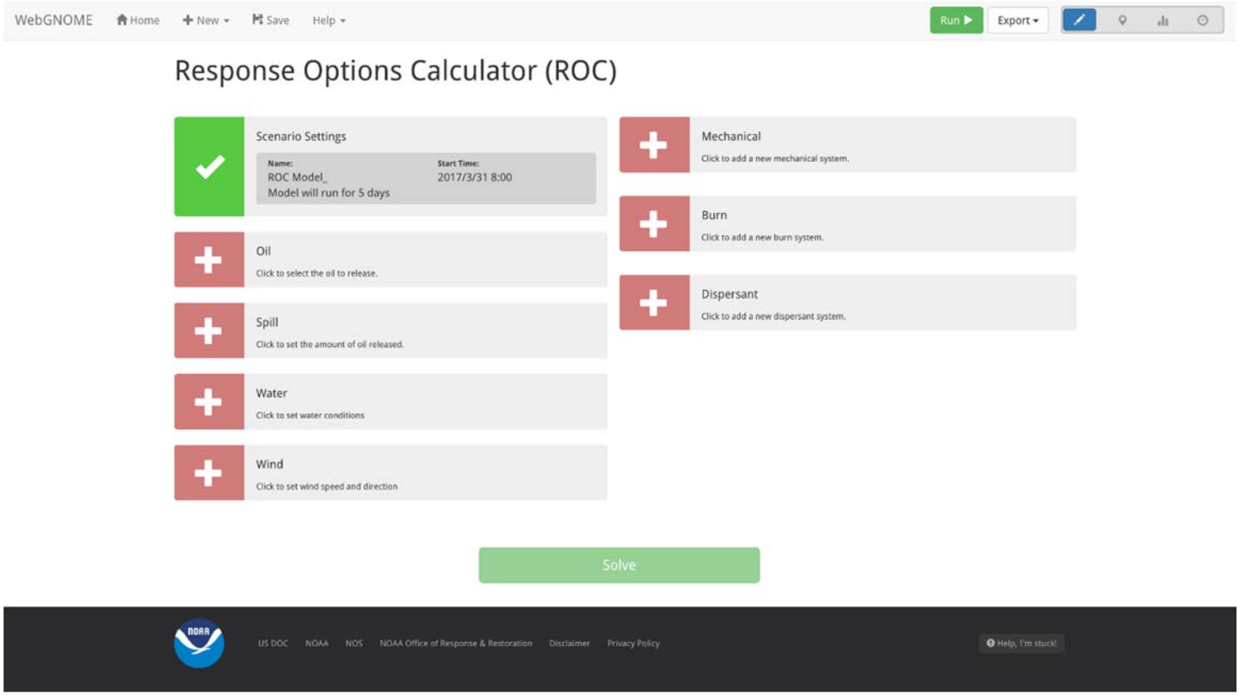
The time for a dispersant application sortie includes all the necessary operations to start from the staging area fully loaded with dispersant and fuel, deliver one payload of dispersant, and return to the staging area. More information on the details of aircraft and vessel sorties is available in the ROC technical documentation [2].

A desired dosage for treatment of the slick is based on the Dispersant-to-Oil Ratio (DOC) recommended by the dispersant manufacturer and the average thickness of the slick. The actual achievable dosage applied to the slick may be different as it depends on the swath width, speed of the platform, and the rate at which dispersant can be pumped and hence may be higher or lower than the desired dosage.

The dispersion rate is modified based on the Dispersion Efficiency parameter. Efficiency of dispersant operations is very difficult to assess quantitatively and in spill response is often only a rough qualitative estimate like “no dispersion observed” or “rapid dispersion observed”. Efficiencies that are more precise may be obtained at testing facilities in controlled conditions, but do not cover the range of environmental conditions and oil types possible. In general, dispersion is likely to be more successful on light to moderate weight crude oils that are relatively fresh and un-emulsified under a moderate wind. ROC includes look-up tables for Dispersant Efficiencies based on viscosity and wind speed/wave height.

The dispersion system will not act if the water content is >70% or the viscosity is greater than 100,000 cSt. High wind speeds, defined as >36 kts, will also cause dispersant operations to cease. As before, in GNOME, the properties are evaluated for each element, so fresher elements may still be operated on even if older elements exceed the thresholds.

ROC User Interface



Response Options Calculator (ROC)

Scenario Settings

Name: ROC Model_
Model will run for 5 days
Start Time: 2017/3/31 8:00

Oil
Click to select the oil to release.

Spill
Click to set the amount of oil released.

Water
Click to set water conditions

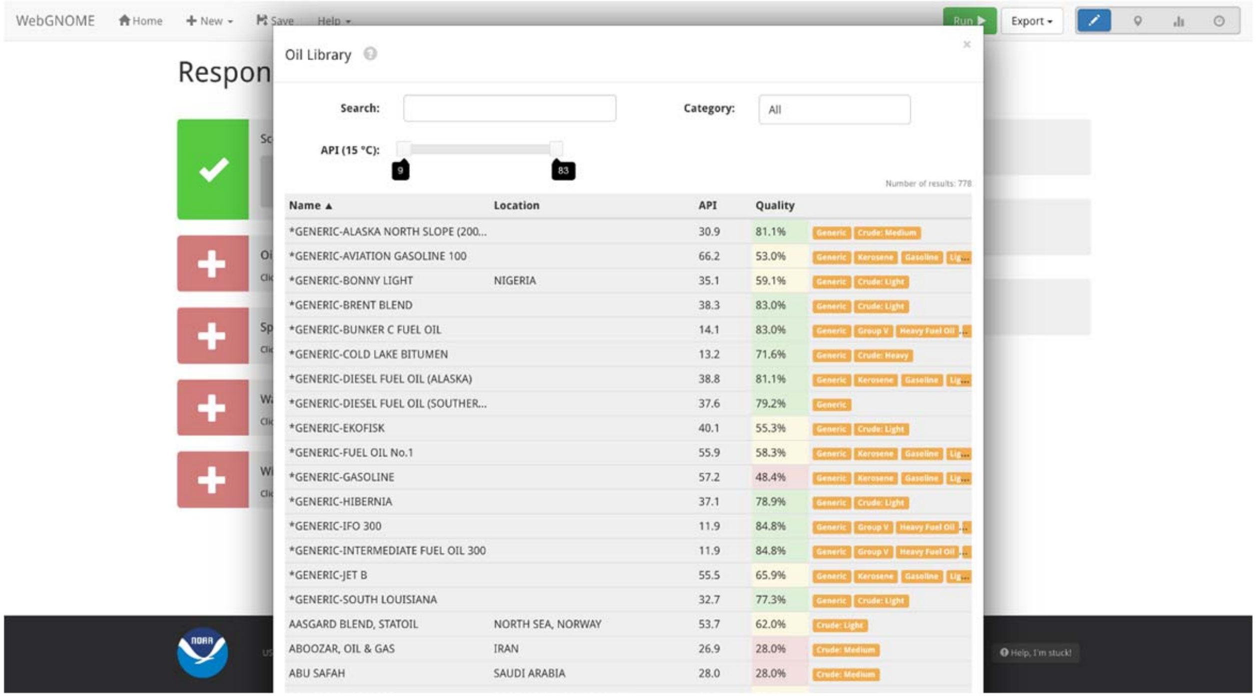
Wind
Click to set wind speed and direction

Mechanical
Click to add a new mechanical system.

Burn
Click to add a new burn system.

Dispersant
Click to add a new dispersant system.

Figure 2: ROC setup screen



Oil Library

Search:

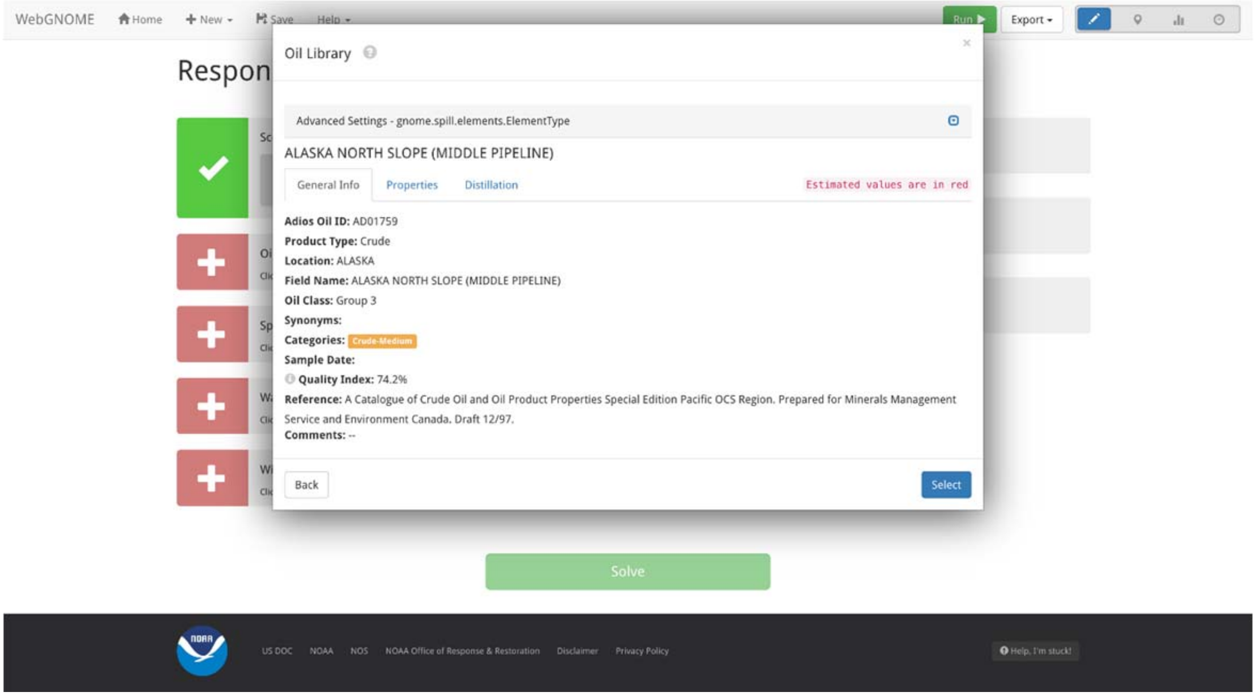
Category: All

API (15 °C): 9 – 83

Number of results: 778

Name ▲	Location	API	Quality	
*GENERIC-ALASKA NORTH SLOPE (200...		30.9	81.1%	Generic Crude: Medium
*GENERIC-AVIATION GASOLINE 100		66.2	53.0%	Generic Kerosene Gasoline Lig...
*GENERIC-BONNY LIGHT	NIGERIA	35.1	59.1%	Generic Crude: Light
*GENERIC-BRENT BLEND		38.3	83.0%	Generic Crude: Light
*GENERIC-BUNKER C FUEL OIL		14.1	83.0%	Generic Group V Heavy Fuel Oil ...
*GENERIC-COLD LAKE BITUMEN		13.2	71.6%	Generic Crude: Heavy
*GENERIC-DIESEL FUEL OIL (ALASKA)		38.8	81.1%	Generic Kerosene Gasoline Lig...
*GENERIC-DIESEL FUEL OIL (SOUTHER...		37.6	79.2%	Generic
*GENERIC-EKOFISK		40.1	55.3%	Generic Crude: Light
*GENERIC-FUEL OIL No.1		55.9	58.3%	Generic Kerosene Gasoline Lig...
*GENERIC-GASOLINE		57.2	48.4%	Generic Kerosene Gasoline Lig...
*GENERIC-HIBERNIA		37.1	78.9%	Generic Crude: Light
*GENERIC-IFO 300		11.9	84.8%	Generic Group V Heavy Fuel Oil ...
*GENERIC-INTERMEDIATE FUEL OIL 300		11.9	84.8%	Generic Group V Heavy Fuel Oil ...
*GENERIC-JET B		55.5	65.9%	Generic Kerosene Gasoline Lig...
*GENERIC-SOUTH LOUISIANA		32.7	77.3%	Generic Crude: Light
AASGARD BLEND, STATOIL	NORTH SEA, NORWAY	53.7	62.0%	Crude: Light
ABOOZAR, OIL & GAS	IRAN	26.9	28.0%	Crude: Medium
ABU SAFAH	SAUDI ARABIA	28.0	28.0%	Crude: Medium

Figure 3: Oil selection



Oil Library

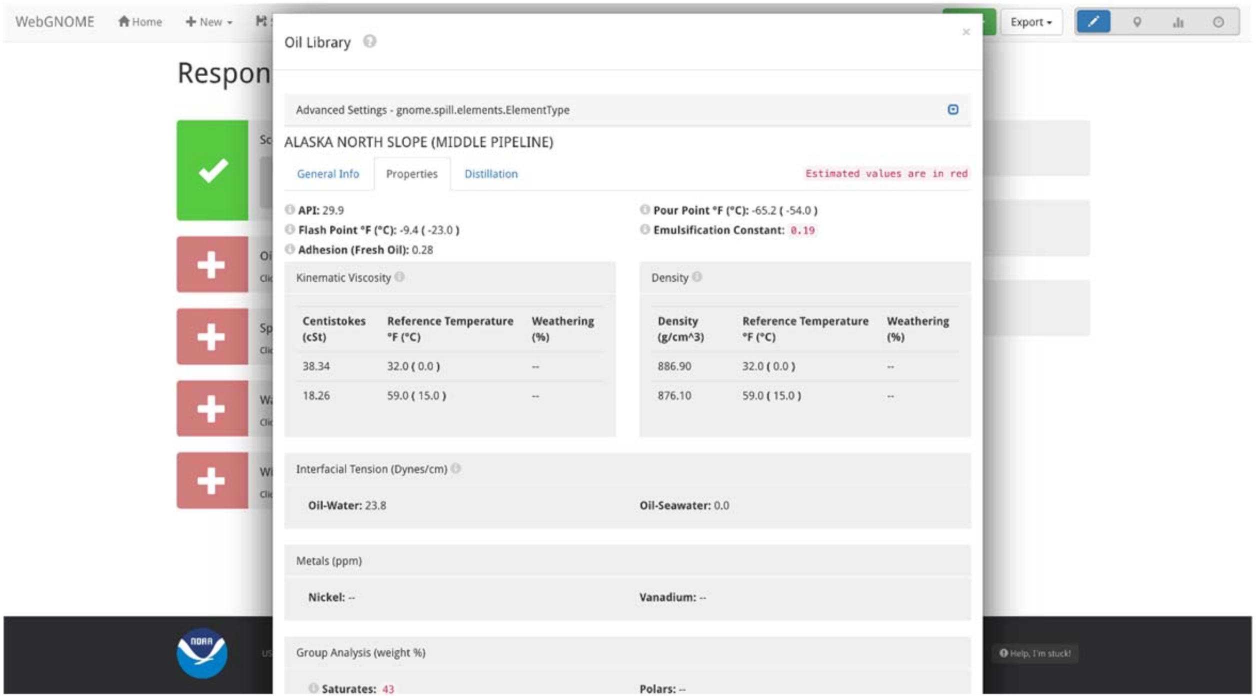
Advanced Settings - gnome.spill.elements.ElementType

ALASKA NORTH SLOPE (MIDDLE PIPELINE)

General Info | Properties | Distillation — Estimated values are in red

Adios Oil ID: AD01759
Product Type: Crude
Location: ALASKA
Field Name: ALASKA NORTH SLOPE (MIDDLE PIPELINE)
Oil Class: Group 3
Synonyms:
Categories: Crude-Medium
Sample Date:
Quality Index: 74.2%
Reference: A Catalogue of Crude Oil and Oil Product Properties Special Edition Pacific OCS Region. Prepared for Minerals Management Service and Environment Canada. Draft 12/97.
Comments: --

Figure 4: Oil data General Info tab



Advanced Settings - gnome.spill.elements.ElementType

ALASKA NORTH SLOPE (MIDDLE PIPELINE)

Estimated values are in red

API: 29.9
Flash Point °F (°C): -9.4 (-23.0)
Adhesion (Fresh Oil): 0.28
Pour Point °F (°C): -65.2 (-54.0)
Emulsification Constant: 0.19

Kinematic Viscosity

Centistokes (cSt)	Reference Temperature °F (°C)	Weathering (%)
38.34	32.0 (0.0)	--
18.26	59.0 (15.0)	--

Density

Density (g/cm^3)	Reference Temperature °F (°C)	Weathering (%)
886.90	32.0 (0.0)	--
876.10	59.0 (15.0)	--

Interfacial Tension (Dynes/cm)

Oil-Water: 23.8
Oil-Seawater: 0.0

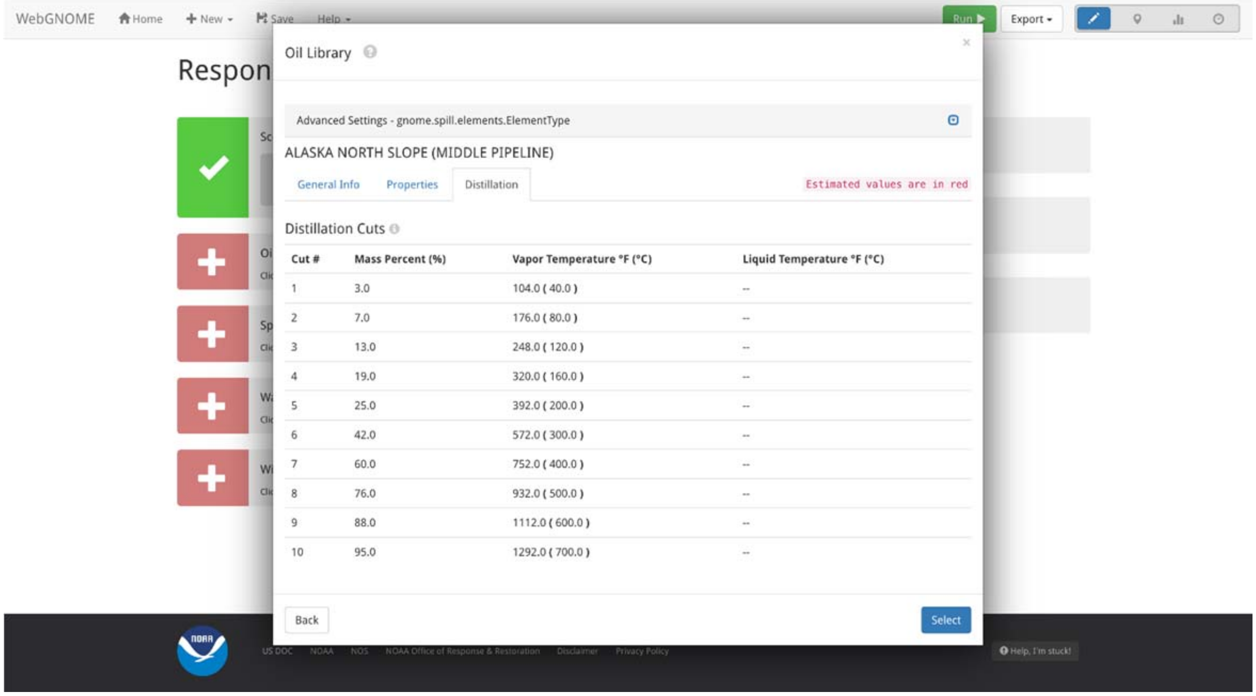
Metals (ppm)

Nickel: --
Vanadium: --

Group Analysis (weight %)

Saturates: 43
Polars: --

Figure 5: Oil data Properties tab



Advanced Settings - gnome.spill.elements.ElementType

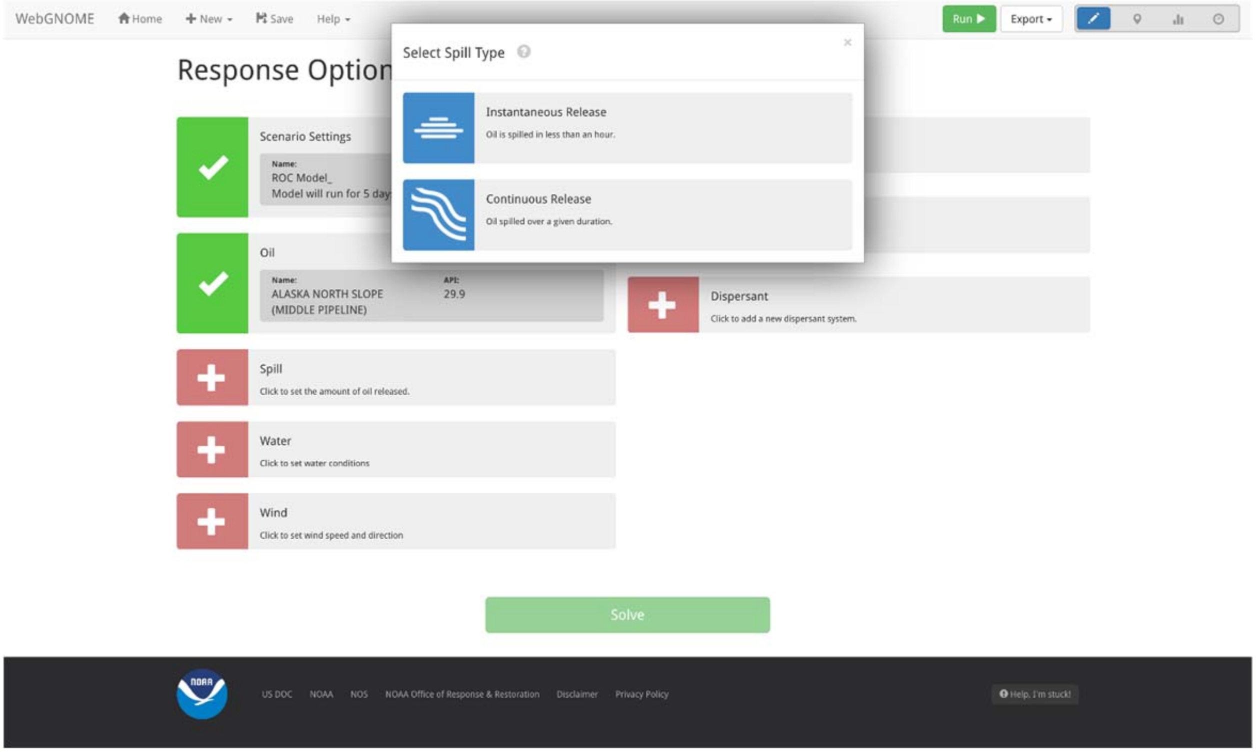
ALASKA NORTH SLOPE (MIDDLE PIPELINE)

Estimated values are in red

Distillation Cuts

Cut #	Mass Percent (%)	Vapor Temperature °F (°C)	Liquid Temperature °F (°C)
1	3.0	104.0 (40.0)	--
2	7.0	176.0 (80.0)	--
3	13.0	248.0 (120.0)	--
4	19.0	320.0 (160.0)	--
5	25.0	392.0 (200.0)	--
6	42.0	572.0 (300.0)	--
7	60.0	752.0 (400.0)	--
8	76.0	932.0 (500.0)	--
9	88.0	1112.0 (600.0)	--
10	95.0	1292.0 (700.0)	--

Figure 6: Oil data Distillation Cuts tab



Select Spill Type

Instantaneous Release
Oil is spilled in less than an hour.

Continuous Release
Oil spilled over a given duration.

Scenario Settings
Name:
ROC Model_
Model will run for 5 day

Oil
Name:
ALASKA NORTH SLOPE (MIDDLE PIPELINE)
API:
29.9

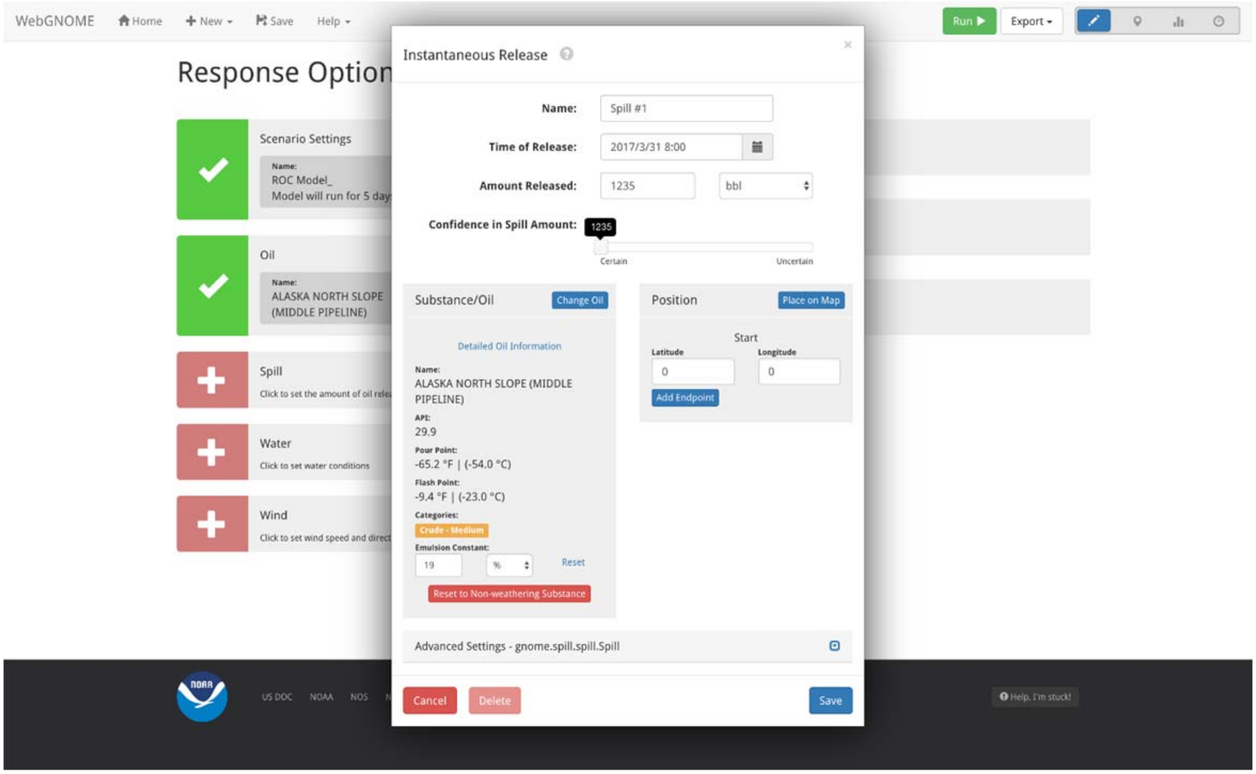
Dispersant
Click to add a new dispersant system.

Spill
Click to set the amount of oil released.

Water
Click to set water conditions

Wind
Click to set wind speed and direction

Figure 7: Spill type selection



Instantaneous Release

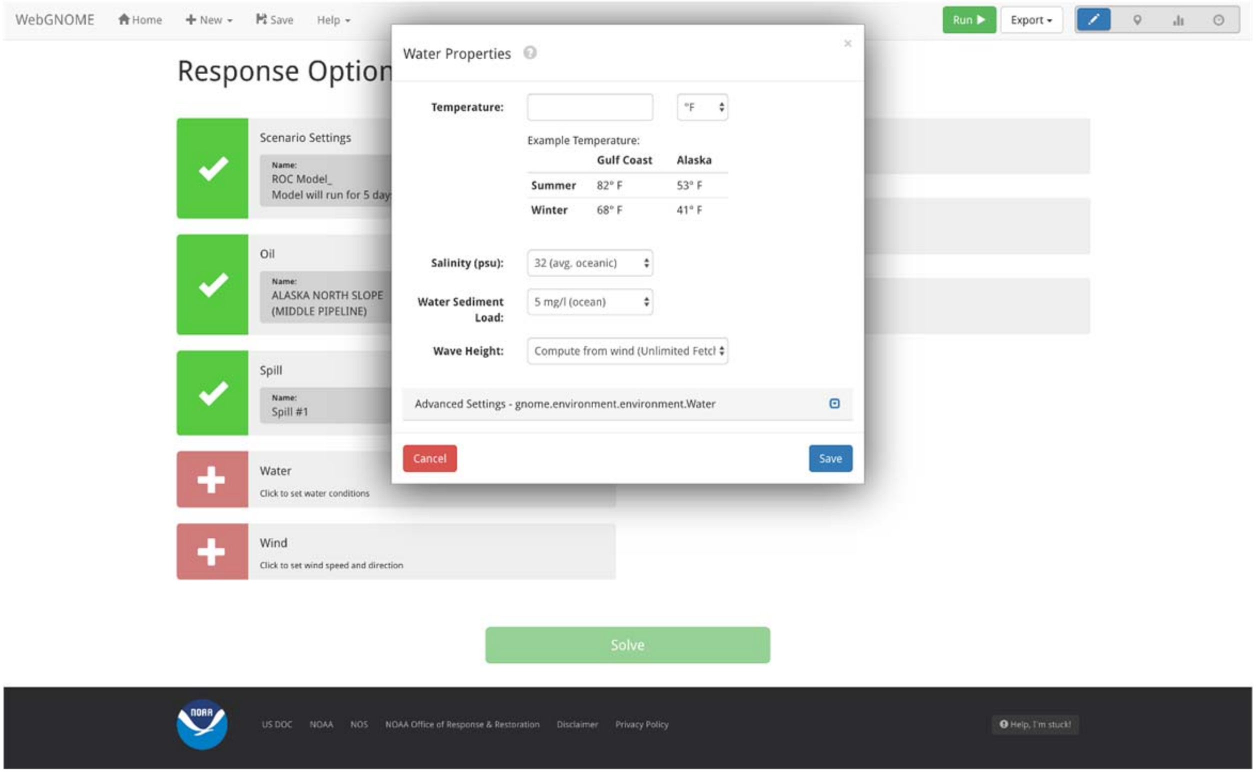
Name: Spill #1
Time of Release: 2017/3/31 8:00
Amount Released: 1235 bbl
Confidence in Spill Amount: 1235
Certain — Uncertain

Substance/Oil
Detailed Oil Information
Name:
ALASKA NORTH SLOPE (MIDDLE PIPELINE)
API:
29.9
Pour Point:
-65.2 °F | (-54.0 °C)
Flash Point:
-9.4 °F | (-23.0 °C)
Categories:
Crude - Medium
Emulsion Constant:
19 %

Position
Start
Latitude: 0
Longitude: 0

Advanced Settings - gnome.spill.spill.Spill

Figure 8: Spill setup screen



Response Options

Scenario Settings
Name: ROC Model_
Model will run for 5 day

Oil
Name: ALASKA NORTH SLOPE (MIDDLE PIPELINE)

Spill
Name: Spill #1

Water
Click to set water conditions

Wind
Click to set wind speed and direction

Water Properties

Temperature: °F

Example Temperature:

	Gulf Coast	Alaska
Summer	82° F	53° F
Winter	68° F	41° F

Salinity (psu): 32 (avg. oceanic)

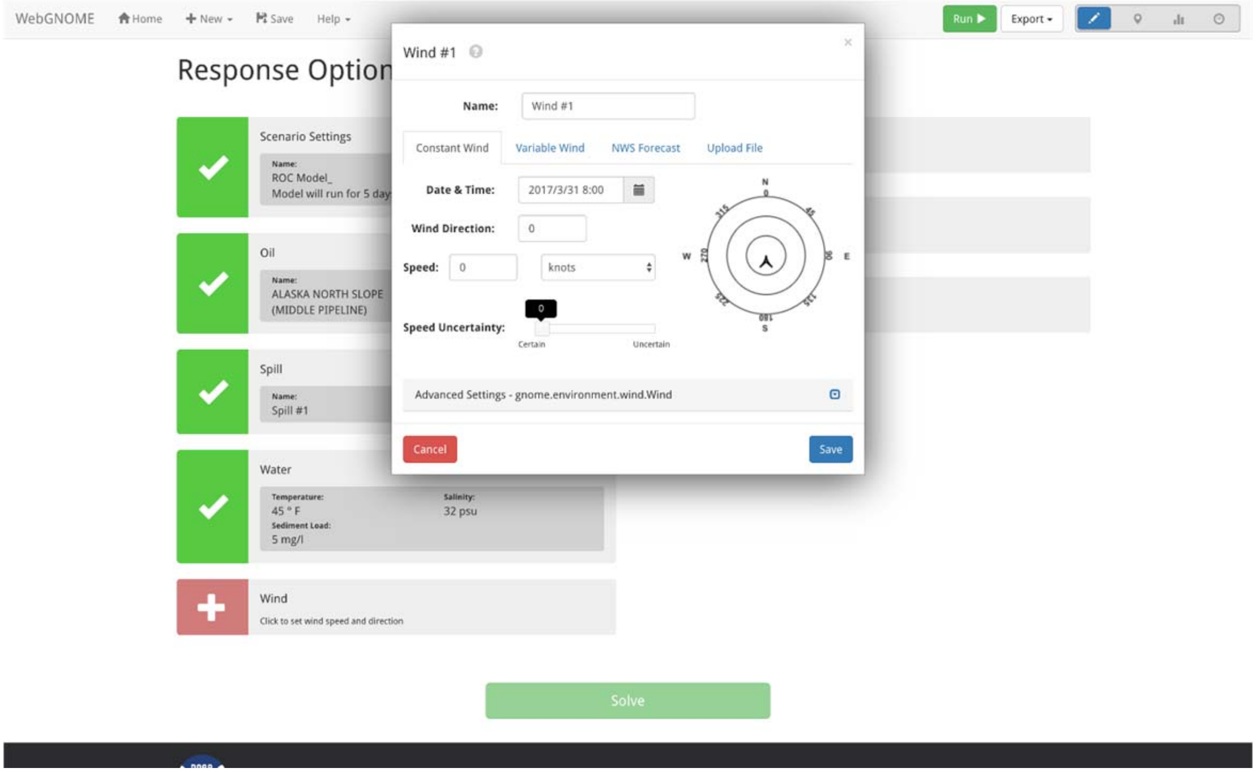
Water Sediment Load: 5 mg/l (ocean)

Wave Height: Compute from wind (Unlimited Fetcl

Advanced Settings - gnome.environment.environment.Water

Cancel Save

Figure 9: Water properties



Response Options

Scenario Settings
Name: ROC Model_
Model will run for 5 day

Oil
Name: ALASKA NORTH SLOPE (MIDDLE PIPELINE)

Spill
Name: Spill #1

Water
Temperature: 45 ° F
Salinity: 32 psu
Sediment Load: 5 mg/l

Wind
Click to set wind speed and direction

Wind #1

Name: Wind #1

Constant Wind | Variable Wind | NWS Forecast | Upload File

Date & Time: 2017/3/31 8:00

Wind Direction: 0

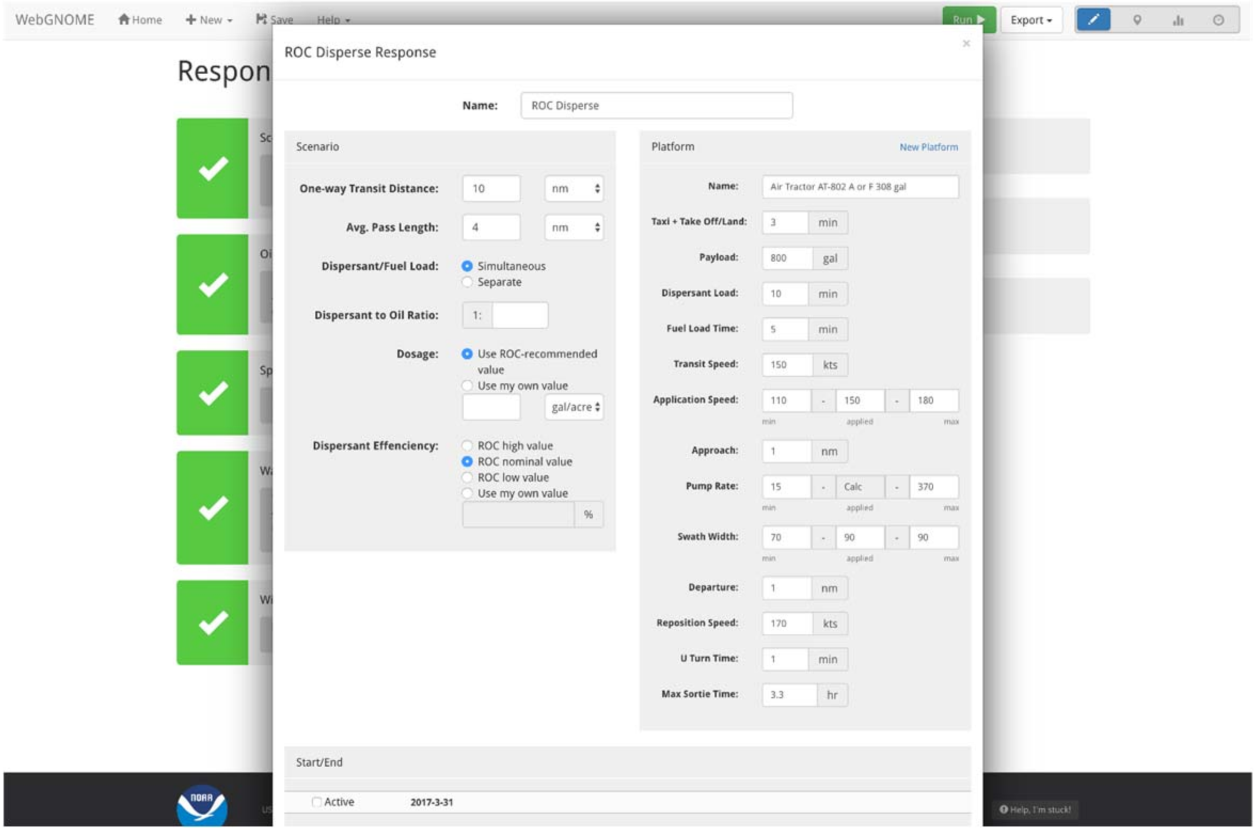
Speed: 0 knots

Speed Uncertainty: 0

Advanced Settings - gnome.environment.wind.Wind

Cancel Save

Figure 10: Wind properties



ROC Disperse Response

Name: ROC Disperse

Scenario

One-way Transit Distance: 10 nm
Avg. Pass Length: 4 nm
Dispersant/Fuel Load: ● Simultaneous ○ Separate
Dispersant to Oil Ratio: 1:
Dosage: ● Use ROC-recommended value ○ Use my own value gal/acre
Dispersant Effenciency: ○ ROC high value ● ROC nominal value ○ ROC low value ○ Use my own value %

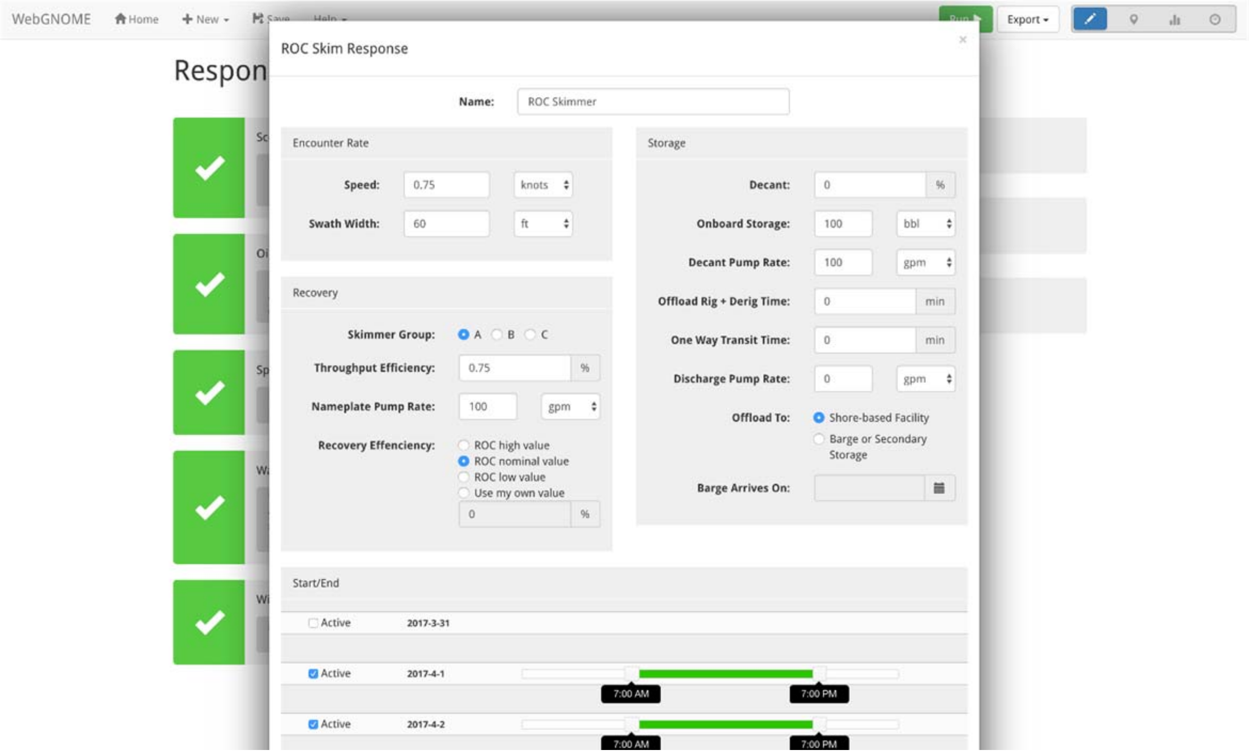
Platform — New Platform

Name: Air Tractor AT-802 A or F 308 gal
Taxi + Take Off/Land: 3 min
Payload: 800 gal
Dispersant Load: 10 min
Fuel Load Time: 5 min
Transit Speed: 150 kts
Application Speed: 110 (min) - 150 (applied) - 180 (max)
Approach: 1 nm
Pump Rate: 15 (min) - Calc (applied) - 370 (max)
Swath Width: 70 (min) - 90 (applied) - 90 (max)
Departure: 1 nm
Reposition Speed: 170 kts
U Turn Time: 1 min
Max Sortie Time: 3.3 hr

Start/End

☐ Active 2017-3-31

Figure 11: Dispersant operation setup screen



ROC Skim Response

Name: ROC Skimmer

Encounter Rate

Speed: 0.75 knots
Swath Width: 60 ft

Recovery

Skimmer Group: ● A ○ B ○ C
Throughput Efficiency: 0.75 %
Nameplate Pump Rate: 100 gpm
Recovery Effenciency: ○ ROC high value ● ROC nominal value ○ ROC low value ○ Use my own value 0 %

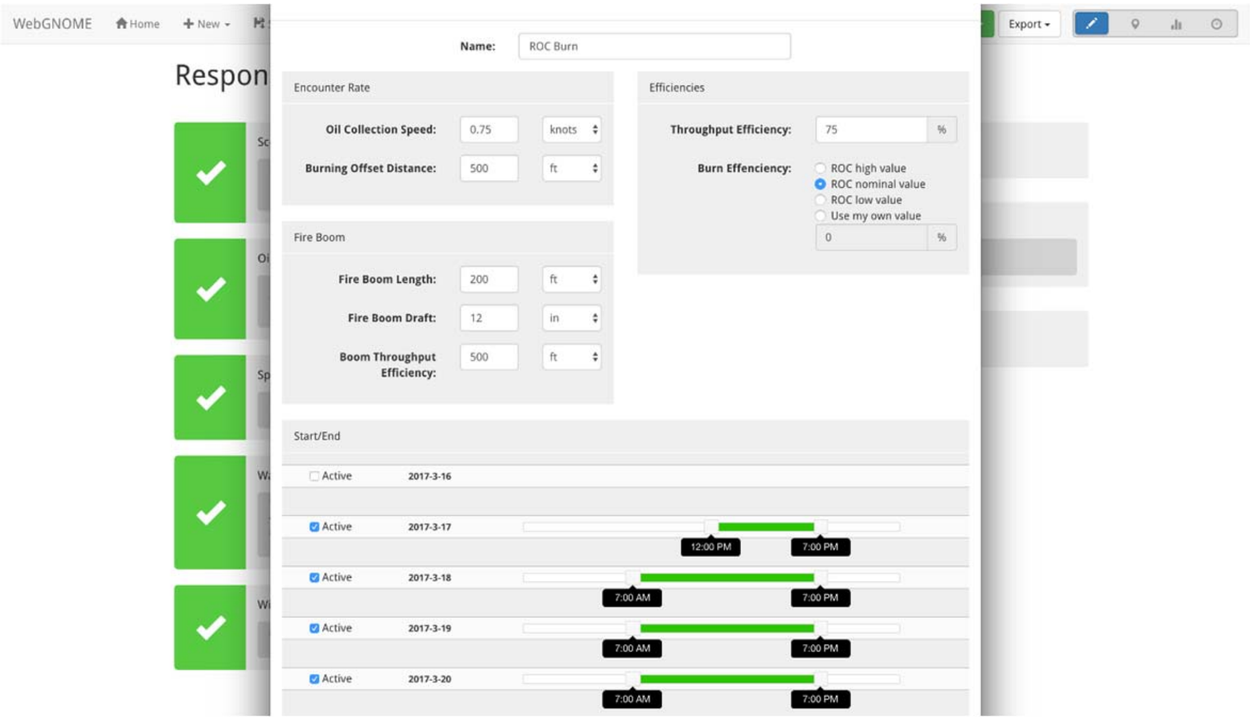
Storage

Decant: 0 %
Onboard Storage: 100 bbl
Decant Pump Rate: 100 gpm
Offload Rig + Derig Time: 0 min
One Way Transit Time: 0 min
Discharge Pump Rate: 0 gpm
Offload To: ● Shore-based Facility ○ Barge or Secondary Storage
Barge Arrives On:

Start/End

☐ Active 2017-3-31
☑ Active 2017-4-1 7:00 AM 7:00 PM
☑ Active 2017-4-2 7:00 AM 7:00 PM

Figure 12: Skimming operation setup screen



Name: ROC Burn

Encounter Rate

Oil Collection Speed: 0.75 knots

Burning Offset Distance: 500 ft

Fire Boom

Fire Boom Length: 200 ft

Fire Boom Draft: 12 in

Boom Throughput Efficiency: 500 ft

Efficiencies

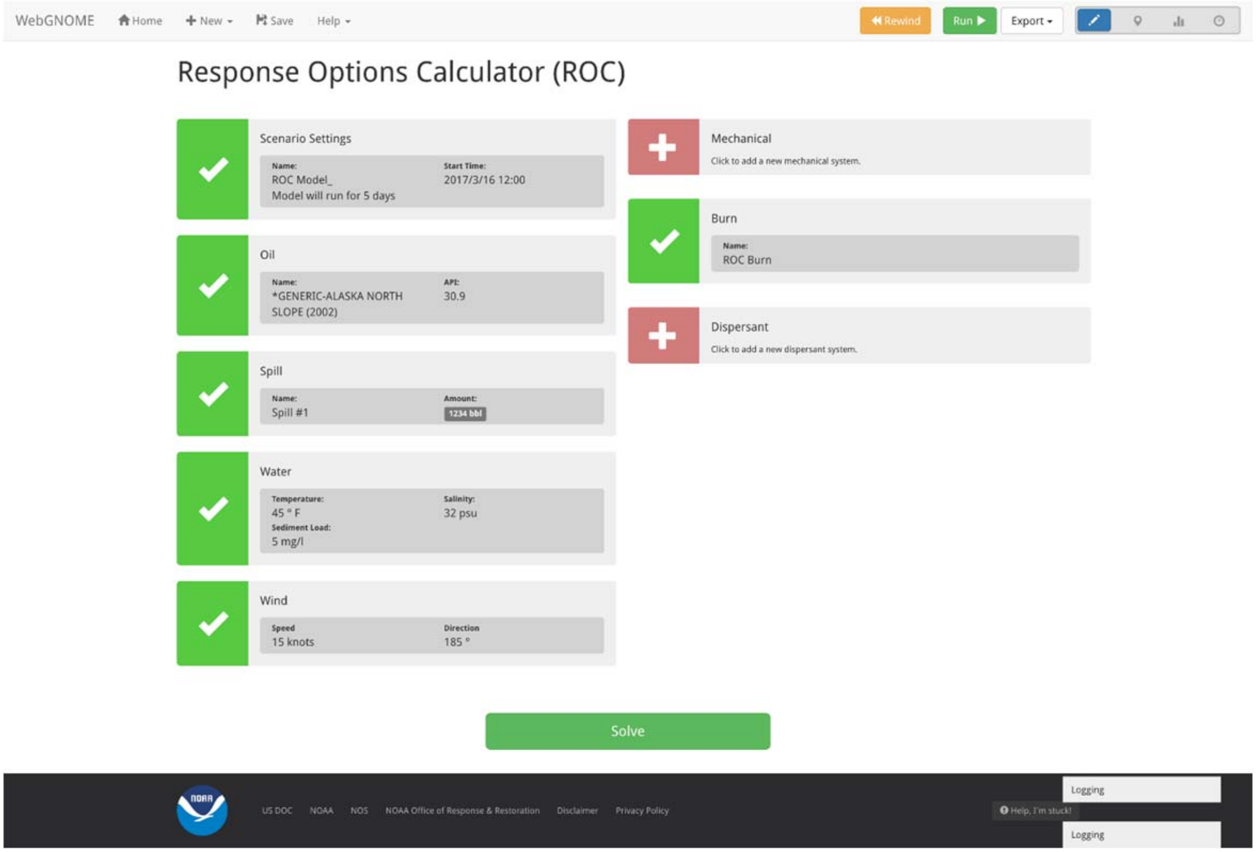
Throughput Efficiency: 75 %

Burn Effenciency:
○ ROC high value
● ROC nominal value
○ ROC low value
○ Use my own value
0 %

Start/End

☐ Active	2017-3-16		
☑ Active	2017-3-17	12:00 PM	7:00 PM
☑ Active	2017-3-18	7:00 AM	7:00 PM
☑ Active	2017-3-19	7:00 AM	7:00 PM
☑ Active	2017-3-20	7:00 AM	7:00 PM

Figure 13: In situ Burn operation setup screen



Response Options Calculator (ROC)

Scenario Settings
Name: ROC Model_
Model will run for 5 days
Start Time: 2017/3/16 12:00

Oil
Name: *GENERIC-ALASKA NORTH SLOPE (2002)
API: 30.9

Spill
Name: Spill #1
Amount: 1234 bbl

Water
Temperature: 45 ° F
Salinity: 32 psu
Sediment Load: 5 mg/l

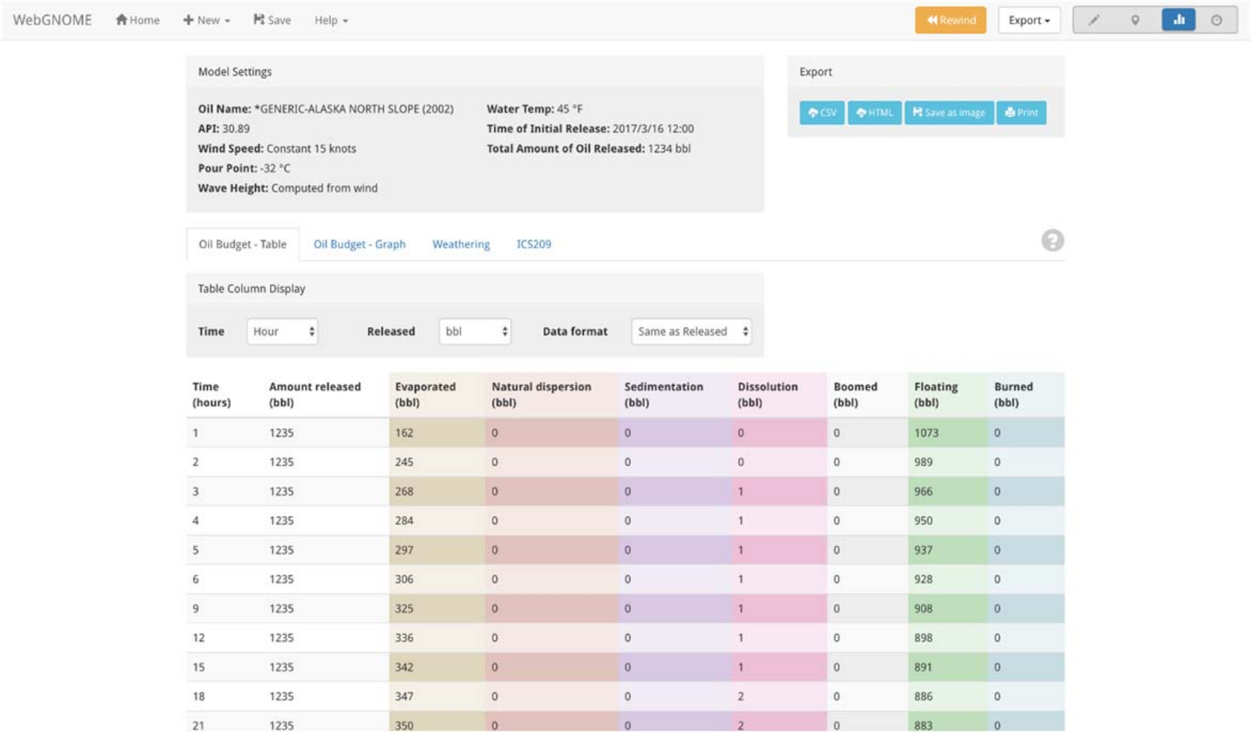
Wind
Speed 15 knots
Direction 185 °

Mechanical
Click to add a new mechanical system.

Burn
Name: ROC Burn

Dispersant
Click to add a new dispersant system.

Figure 14: Model configured for a burn operation



Model Settings

Oil Name: *GENERIC-ALASKA NORTH SLOPE (2002)
API: 30.89
Wind Speed: Constant 15 knots
Pour Point: -32 °C
Wave Height: Computed from wind

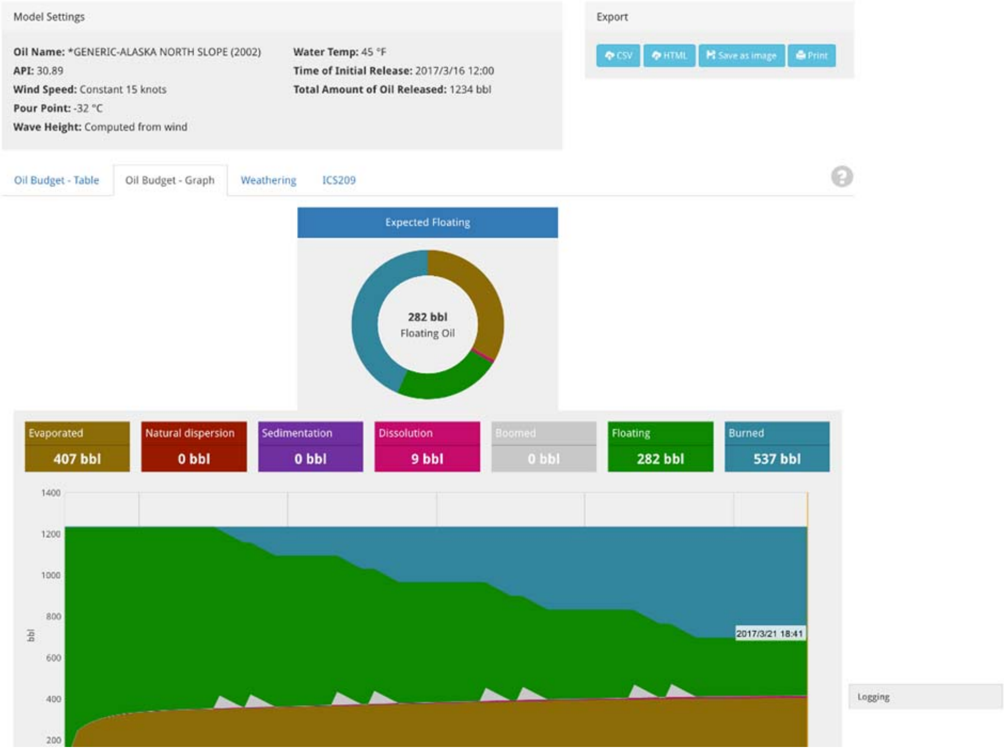
Water Temp: 45 °F
Time of Initial Release: 2017/3/16 12:00
Total Amount of Oil Released: 1234 bbl

Table Column Display

Time: Hour
Released: bbl
Data format: Same as Released

Time (hours)	Amount released (bbl)	Evaporated (bbl)	Natural dispersion (bbl)	Sedimentation (bbl)	Dissolution (bbl)	Boomed (bbl)	Floating (bbl)	Burned (bbl)
1	1235	162	0	0	0	0	1073	0
2	1235	245	0	0	0	0	989	0
3	1235	268	0	0	1	0	966	0
4	1235	284	0	0	1	0	950	0
5	1235	297	0	0	1	0	937	0
6	1235	306	0	0	1	0	928	0
9	1235	325	0	0	1	0	908	0
12	1235	336	0	0	1	0	898	0
15	1235	342	0	0	1	0	891	0
18	1235	347	0	0	2	0	886	0
21	1235	350	0	0	2	0	883	0

Figure 15: Mass balance table

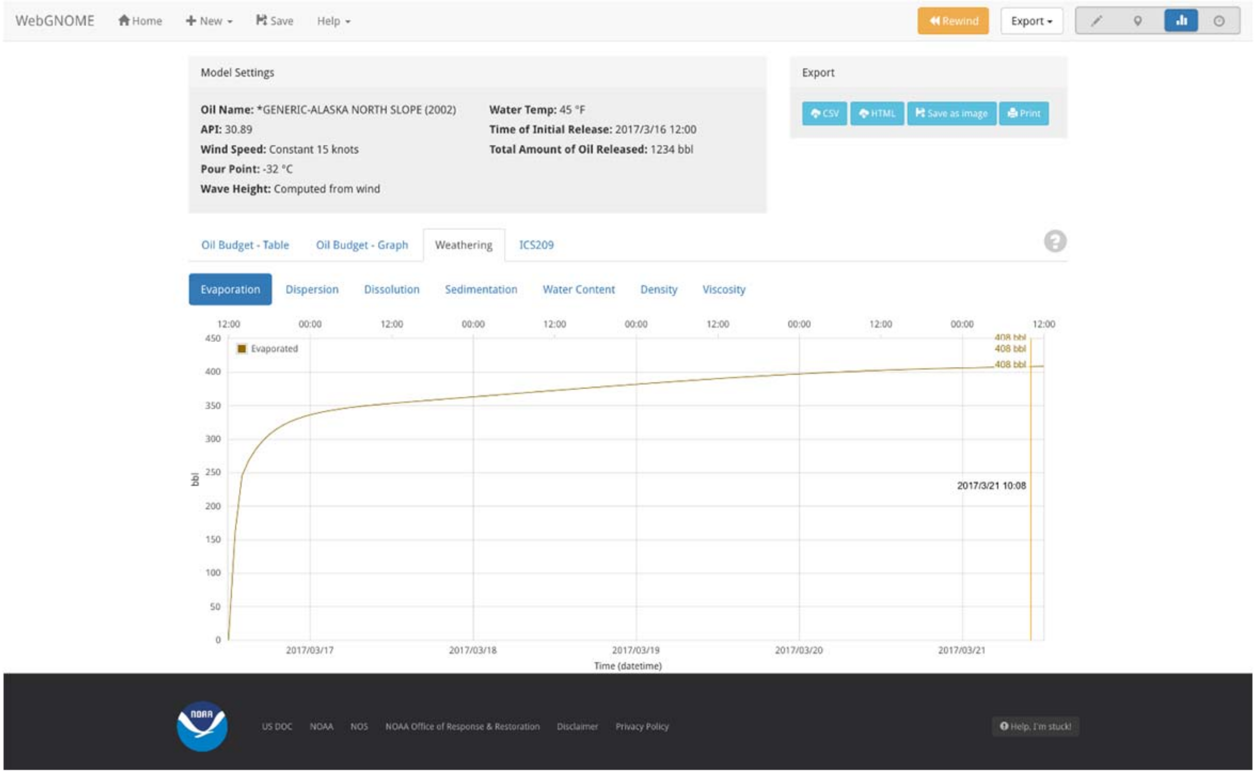


Model Settings

Oil Name: *GENERIC-ALASKA NORTH SLOPE (2002)
API: 30.89
Wind Speed: Constant 15 knots
Pour Point: -32 °C
Wave Height: Computed from wind

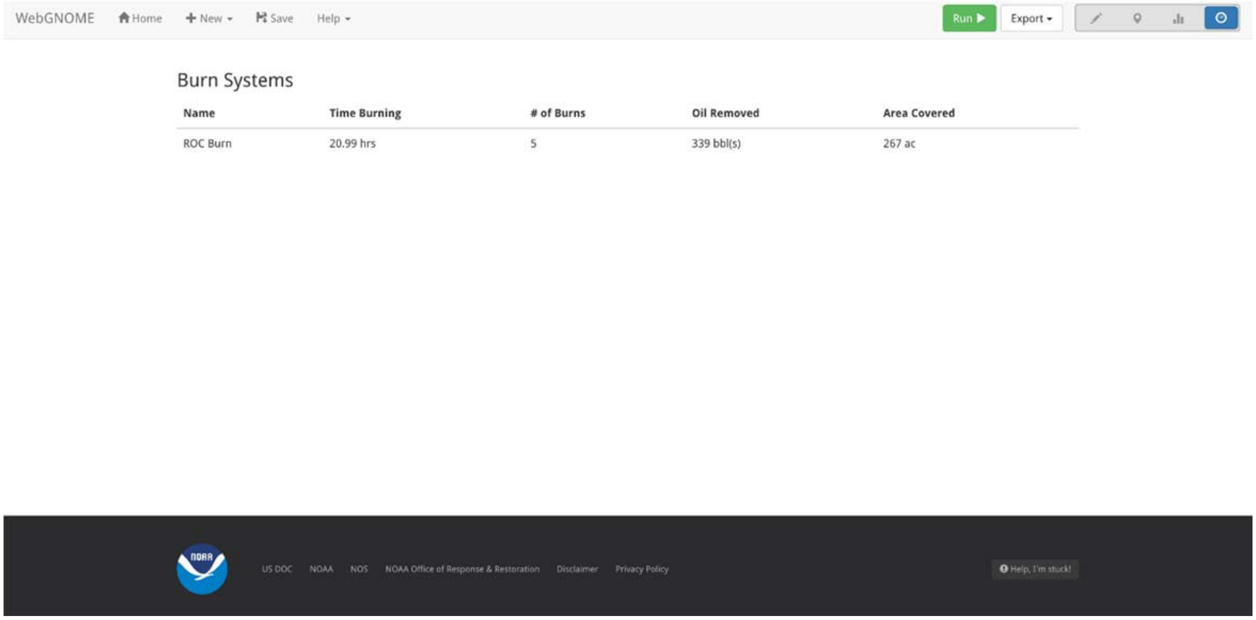
Water Temp: 45 °F
Time of Initial Release: 2017/3/16 12:00
Total Amount of Oil Released: 1234 bbl

Figure 16: Mass balance graph



Oil Name: *GENERIC-ALASKA NORTH SLOPE (2002)
API: 30.89
Wind Speed: Constant 15 knots
Pour Point: -32 °C
Wave Height: Computed from wind
Water Temp: 45 °F
Time of Initial Release: 2017/3/16 12:00
Total Amount of Oil Released: 1234 bbl

Figure 17: Weathering graphs showing evaporation



Burn Systems

Name	Time Burning	# of Burns	Oil Removed	Area Covered
ROC Burn	20.99 hrs	5	339 bbl(s)	267 ac

Figure 18: Response statistics for a single burn operation

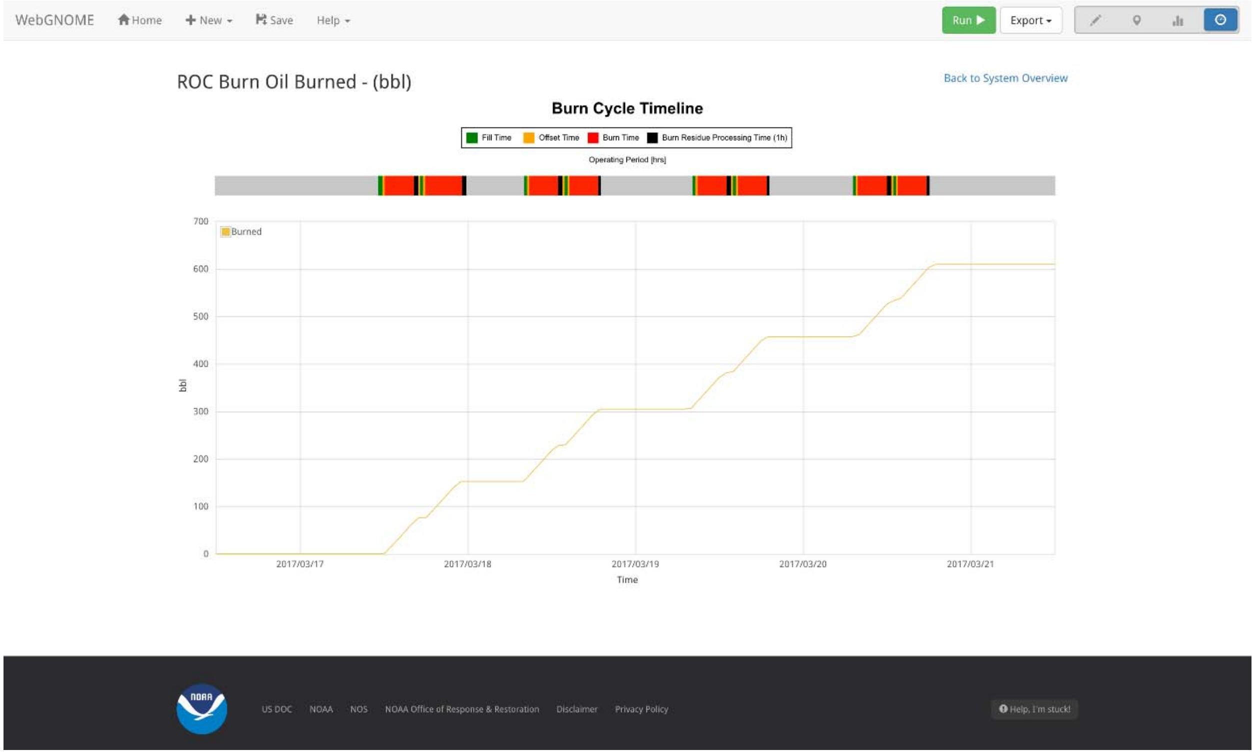


Figure 19: Response timeline and graph for a single burn operation

Summary and Future Enhancements

The current project focused on incorporation of existing ROC algorithms into the GNOME modeling suite framework. The work resulted in a ROC-specific interface through which users can run simulations in a very intuitive manner, similar to the previous stand-alone version with added improvements pulled from the more recent EDRC calculators. The interface also includes some improved output visualization and options for saving the results in various formats for further analysis.

Incorporating ROC into the modern, open source GNOME framework has many benefits. As part of the supported and future operational NOAA oil spill model, it will continue to be updated and improved. The underlying code was designed to be as modular and flexible as possible so that algorithms for individual components (e.g., transport, weathering, and/or response options) can be easily updated.

The coupling of oil fate and transport in GNOME could allow some valuable future enhancements to the response options. For example, discrete portions of the slick, represented by individual elements, could be targeted for various response options based on oil properties or geographic location. Transit times to the slick, which are manually entered, could be dynamically calculated based on element positions and updated as the slick moves.

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