APPENDIX 13-A: FATE AND BEHAVIOR ANALYSIS IN THE MARINE ENVIRONMENT: REFORMATE AND MIXED XYLENES

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TESORO

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April 19, 2016

Skagit County Planning & Development Services
1800 Continental Place
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Attn: John Cooper

Subject: File # PL15-0302; Tesoro Anacortes Refinery Clean Products Upgrade Project (CPUP)
Fate and Behavior Analysis in the Marine Environment: Reformate and Mixed Xylenes Technical Report (April 2016)

Per your request, please find enclosed the Tesoro Anacortes Refinery Clean Products Upgrade Project (CPUP) *Fate and Behavior Analysis in the Marine Environment: Reformate and Mixed Xylenes Technical Report (April 2016).*

Please contact me at (360) 293-1664 if you have any questions or concerns.

Respectfully,

Rebecca Spurling

Rebecca Spurling
Lead Environmental Engineer

Enclosure

TECHNICAL REPORT

Tesoro Anacortes Refinery
Clean Products Upgrade Project (CPUP)

Fate and Behavior Analysis in the Marine Environment: Reformate and Mixed Xylenes

Prepared for

Tesoro Refining & Marketing Company LLC

April 2016

Polaris Applied Sciences, Inc.

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Executive Summary

> In the event of a spill, reformate and mixed xylenes would evaporate and dissipate rapidly.
>
> The materials are non-persistent in the shoreline environment, and thereby beach impacts would be temporary and unlikely to require shoreline clean-up.

Tesoro Refining & Marketing Company LLC's (Tesoro's) Anacortes Refinery is located in Fidalgo Bay in Skagit County, Washington state, about 70 miles north of Seattle. The Refinery receives crude oil and other materials for refining via pipeline, rail and marine vessel. It produces a range of products, including gasoline, jet fuel, diesel fuel, propane, and industrial fuel oil. The Refinery also exports refined products via marine vessels (ships and barges), pipeline, railcar, and tanker trucks.

The proposed Clean Products Upgrade Project (CPUP) would include construction of an Aromatics Recovery Unit (ARU) capable of extracting 15,000 barrels per day of mixed xylenes from gasoline blendstocks that are already produced in the refining process. Xylenes are a common petrochemical used to make a wide variety of products including clothing, film for medical x-rays, plastics, cleaners, and many other products.

Mixed xylenes will be extracted from the Refinery's existing high-octane gasoline blendstock called *reformate.* Reformate is produced at the Refinery's existing Catalytic Reformer (CR) unit and is normally used as a primary blendstock in gasoline. Additional reformate will be received at the terminal by marine vessel from other refineries. Reformate delivery is planned to require about 40 vessels annually.

These vessels are expected to be similar in size to vessels that currently call at the Refinery – with a capacity of about 180,000 barrels (bbl). Mixed xylenes are planned to be shipped from the terminal by ships similar in size to product tankers that currently call at the Refinery – with a capacity of about 330,000 bbl. On average, about 20 shipments of mixed xylenes are expected on an annual-basis. The CPUP is planned to begin operations in 2018.

The fate and effects report focuses on spill scenarios of reformate and mixed xylenes, and illustrates the comparison that can be made to gasoline. Spill scenario locations examined are representative of the Salish Sea transit pathway, including transfer operations (Refinery Dock), open waters (West of Neah Bay), ports (Northwest of Port Angeles), and island community areas (Rosario Strait).

a) Spill scenario volumes at the Refinery Dock are consistent with the Northwest Area Contingency (NWACP) Geographic Response Plans (GRPs) and the Tesoro Oil Spill Contingency Plan (OSCP), which is approved by the Washington State Department of Ecology (Ecology) and the United States Coast Guard (USCG).

b) Spill scenario volumes in the Salish Sea were selected to be consistent with the Federal Spill Planning Volumes of 33 CFR 155.1020 and include the worst-case discharge (WCD) which means a discharge of a vessel's entire cargo.

c) Average summer and winter meteorological data (wind speed and direction) were used for each spill scenario location.

ADIOS 2.0 (Automated Data Inquiry for Oil Spills), a weathering model, and GNOME™ (General NOAA Operational Modeling Environment), a trajectory model, both provided by National Oceanic and Atmospheric Administration (NOAA), were used to assess of fate and behavior under a variety of spill scenarios.

In the event of a release to the marine environment, the fate of reformate and mixed xylenes involves rapid evaporation with no residual material, and thereby beach impacts would be temporary and unlikely to require shoreline clean up. This behavior is dictated by the physical properties of low density, low viscosity, high volatility and low solubility. Once evaporated, reformate and mixed xylenes will quickly disperse and be consumed by photochemical oxidation in the atmosphere.

When evaluating the worst-case release to the marine environment, there is a possibility that natural resources in the proximity of the spill could be at risk of exposure. However, since reformate, mixed xylenes, and gasoline will only remain on the water surface for a short period of time, the potential adverse effects would be geographically limited to the spreading of the spill during the initial 6 to 72 hours (depending on the volume spilled), weather conditions and the amount of exposure with those resources.

Reformate and mixed xylenes do not pose a significant risk to seafood consumption due to limited exposure resulting from the rapid evaporation rate and very limited quantities that disperse into the water. This is supported by observations and data collected from prior mixed xylenes spills elsewhere in the world.

A multi-layered, integrated and well developed program is in place for the Salish Sea to respond to a potential spill of petroleum. The Northwest Area Contingency Plan (NWACP) has guidance and procedures in place that encompass responding to a spill of reformate and mixed xylenes.

The Refinery currently has in place an Oil Spill Contingency Plan (OSCP) approved by the USCG and Ecology. The plan currently includes responding to a potential spill of reformate and gasoline. The properties of mixed xylenes are similar to reformate and gasoline, whereby the response strategies currently in place are directly applicable to mixed xylenes. Regardless, the OSCP will be updated prior to start-up to specifically address mixed xylenes, and will include any special safety and material handling/compatibility requirements that might be unique to mixed xylenes.

The Refinery participates in the National Preparedness Response Exercise Program (NPREP) as well as Ecology's drill program that is designed to demonstrate the capability to respond and manage a coordinated response to petroleum spills.

As part of the OSCP, in the event of a spill, the incident command system is utilized, and includes establishing a Site Safety Plan to ensure the safety of workers and the public.

The marine industry has implemented sophisticated measures and programs to prevent spills, including, but not limited to a comprehensive vessel traffic management systems for the study area as well as a Traffic Separation Scheme (TSS) that directs vessels into controlled one-way traffic lanes. Double-hulled vessels will be used to transport reformate and mixed xylenes; these vessels are required to have a vessel response plan (VRP) to respond to a potential spill, in accordance with USCG rules.

Acronyms and Abbreviations

ADIOS	Automated Data Inquiry for Oil Spills (a weathering model)
AMPD	Average most probable discharge
ARU	Aromatics Recovery Unit
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
BBL	Barrel of Petroleum (equivalent to approximately 42 US Gallons)
°C	centigrade (a measure of temperature)
CCG	Canadian Coast Guard
CPUP	Clean Products Upgrade Project
cP	centipoise (a measure of viscosity)
CR	Catalytic Reformer
CVTS	Cooperative Vessel Traffic Service
DOT	U. S. Department of Transportation
Ecology	Washington State Department of Ecology
EPA	Environmental Protection Agency
ERM	Tesoro Emergency Response Manual
ERMA	Environmental Response Management Application
ESA	Endangered Species Act
ESI	Environmental Sensitivity Index
°F	degrees Fahrenheit (a measure of temperature)
g/cc	grams per cubic centimeter (a measure of density)
GNOME™	General NOAA Operational Modeling Environment (a spill trajectory model)
GRP	Geographical Response Plans
HNS	Hazardous and Noxious Substances
HRS	hours
ICS	Incident Command System
ITOPF	International Tanker Owner Pollution Federation
LC50	Lethal concentration for 50% of the population
LEs	Lagrangian Elements (a modelling unit used in the trajectory analysis by GNOME™)
mg/L	milligrams per liter (a measure of solubility)
MMPD	Maximum most probable discharge
MPH	miles per hour

NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OSCP	Oil Spill Contingency Plan
OSHA	Occupational Safety and Health Administration
NIOSH	National Institute for Occupational Safety and Health
NPREP	National Preparedness Response Exercise Program
NWACP	Northwest Area Contingency Plan
PEL	Permissible Exposure Limit
Refinery	Tesoro Anacortes Refinery
REL	Recommended Exposure Limit
SPCC	Spill Prevention Control and Countermeasures
TAP	Trajectory Analysis Planner
TSS	Traffic Separation Scheme
TWA	Time Weighted Average
UK	United Kingdom
USCG	United States Coast Guard
VRP	Vessel Response Plan
WCD	Worst-case discharge
WDFW	Washington Department of Fish &Wildlife
WHO	World Health Organization

Introduction and Overview

1.1 Purpose

This report addresses the question of what might happen if reformate or mixed xylenes were accidently released or spilled into the marine environment.

The analysis is focused on spill scenarios of reformate and mixed xylenes, and illustrates the comparison that can be made to gasoline. Spill scenario locations were selected along the Salish Sea transit pathway that includes open-water areas, areas near ports, island communities, and transfer operations at the Refinery dock. It evaluates the spill scenarios for two tide conditions (spring and neap), and five (5) wind conditions (average spring, average winter, 0 mph, 5 mph and 10 mph).

This introductory section provides an overview of the CPUP and an introduction to the technical discussions presented in the body of the report.

1.2 Project Description

Tesoro Refining & Marketing Company LLC (Tesoro) proposes to upgrade its Anacortes Refinery (Refinery) to extract and export mixed xylenes that are presently contained in gasoline blendstocks. The Refinery is located in Fidalgo Bay, about 70 miles north of Seattle. The Refinery, as with all refineries in western Washington, receives crude and other feedstocks via pipeline, by rail, and by tanker. It produces a range of products that includes gasoline, jet fuel, diesel fuel, propane, and industrial fuel oil. The Refinery has a capacity of processing about 120,000 barrels per day (bpd) of crude oil. The quantities, types and methods of delivery of crude will not change as a result of this project.

The proposed Clean Products Upgrade Project (CPUP) would include construction of an Aromatics Recovery Unit (ARU) capable of extracting about 15,000 bpd of mixed xylenes from existing reformate gasoline blendstocks. Mixed xylenes are a gasoline blendstock and a common petrochemical feedstock used to make a wide variety of products including clothing, film for medical x-rays, plastics, cleaners and many other products. There are three forms of xylenes: meta-xylene, ortho-xylene, and para-xylene (m-, o-, and p-xylene). These different forms are referred to as isomers. Mixed xylenes are a mixture of the three isomers and usually also contains about 18 percent ethylbenzene. All of these xylene isomers, as well as ethylbenzene, are in gasoline sold by the various petroleum refineries across the nation.

The CPUP will require delivery of reformate by double-hulled ships, barges, or articulated-tug-barge-units (ATBs) with about 40 vessel arrivals annually. Vessels delivering reformate are expected to be similar in size to vessels currently calling at the Refinery – with a capacity of about 180,000 barrels (bbl). Reformate has been received by marine vessel at the Refinery in the past. The offsite reformate feed, in addition to contributing to the mixed xylenes production, will also yield gasoline blendstocks, referred to in this report as *reformate (backhaul)*. It is specifically included in the analysis of this report to illustrate the fate and behavior of reformate after the xylenes and ethylbenzene are removed.

Mixed xylenes are planned to be shipped from the terminal by tanker similar in size to vessels that currently call at the Refinery (vessels of a capacity of about 330,000 bbl) with an estimated 20 shipments annually. The combined estimated vessel traffic volume, about 60 vessel calls annually, will fluctuate with xylene production and vessel size.

1.3 Technical Approach

This report provides an evaluation of the potential fate and behavior of reformate and mixed xylenes for a variety of spill scenarios to the marine environment. The report also examines the Northwest Area Contingency Plan (NWACP) and Tesoro's Oil Spill Contingency Plan (OSCP) to illustrate existing spill prevention and response measures already in place to protect the Salish Sea.

The technical approach developed for this report proceeded along a methodical path that included:

- Understanding the physical and chemical characteristics of reformate and mixed xylenes.
- Determining the appropriate models and evaluation tools to:
    - Show what could happen to the materials in the environment if spilled or released (fate and behavior), and
    - Show where the materials could end up (trajectory)
- Choosing representative locations to evaluate potential spill scenarios.
- Establishing the appropriate quantities of spilled liquids to be modeled at each location.
- Establishing a representative range of meteorological conditions to model.
- Reviewing literature and case studies to understand the potential adverse effects of a spill into the marine environment.
- Examining available mitigation and response measures.

1.4 Report Structure

This Fate and Behavior Analysis report includes the following:

- A description of the chemical and physical properties of reformate[1], mixed xylenes, and gasoline.
- A description of the weathering processes of spilled materials and how they affect fate and behavior.
- A description of the spill scenarios modeled including the locations selected, the quantities of spilled materials, oceanographic and weather data and comparisons to other recorded spill incidents in the United States.
- A summary of how models of fate and behavior used in this report were selected, how they work and what they conclude.
- A presentation of the ADIOS 2.0 fate and behavior modeling results for the scenarios developed for this report.
- A presentation of the GNOME™ spill trajectory modeling results for the scenarios developed for this report.

[1] The term *reformate* is used in this report to collectively reference both the inbound reformate feeding the ARU and the outbound gasoline blendstocks, referred to in this report as *reformate (backhaul)*. *Reformate (backhaul)* is the remaining reformate after the xylenes and ethylbenzene are extracted. This outbound stream can vary slightly in composition based on gasoline blending requirements at the Refinery; however the composition represented in this report is conservatively inclusive of the range of components that could be expected, and how it compares to the reformate feed and mixed xylenes.

- Potential adverse effects of a possible spill to the marine environment.
- Mitigation measures and spill response procedures for reformate, mixed xylenes, and gasoline.
- Appendices of model inputs and results as well as other select relevant data and references.

Chemical and Physical Properties of Reformate, Mixed Xylenes and Gasoline

This section includes a description of the chemical and physical properties of reformate, mixed xylenes and gasoline. It is important to understand these properties in order to properly evaluate how these liquids might behave in the marine environment. These properties determine how specific materials behave in the event of a spill. For example, reformate and mixed xylenes evaporate quickly and do not persist in the environment. This fact is documented and discussed in more detail in subsequent sections. Appendix B includes a compilation of chemical and physical properties of reformate, mixed xylenes and gasoline referenced in this section.

2.1 Chemical and Physical Properties of Reformate

Reformate is a gasoline blendstock that primarily contains a mixture of the following chemical compounds: xylenes, trimethylbenzene, ethylbenzene, toluene, octane (and isomers) and isopropylbenzene. Chemical compounds in petroleum mixtures, like reformate, are often referred to as *components.*

Reformate is classified as a flammable material. While reformate is flammable, it is less flammable than gasoline, as measured by flash point. Reformate has a flash point in the range of 72.1°F (22.3°C) to 76.5 °F (24.7°C). Flash point refers to the minimum temperature at which reformate (in this case) would give off sufficient vapor to ignite in air if an ignition source were present.

Reformate has a density in the range of 0.85 to 0.87 g/cc. At this low density, reformate is lighter than both saltwater and freshwater and would float on the surface in all marine and estuarine environments. Reformate will not sink in water and will evaporate readily. [2]

The viscosity of reformate ranges from 0.79 to 1.03 cP at 10.0°C, which is about the ambient temperature of the waters of the Salish Sea.

2.2 Chemical and Physical Properties of Mixed Xylenes

Mixed xylenes will behave very similarly to reformate in the marine environment. Xylenes and ethylbenzene are extracted from reformate to form the mixed xylenes product. There are three forms of xylenes: meta-xylene, ortho-xylene, and para-xylene (m-, o-, and p-xylene). These different forms are referred to as isomers. Mixed xylenes are a mixture of these three isomers and ethylbenzene .

Mixed xylenes are classified as a flammable material. While mixed xylenes are flammable, it is less flammable than gasoline, as measured by flash point. Mixed xylenes have a flash point of approximately 82.2 °F (27.9°C). Flash point refers to the minimum temperature at which xylenes (in this case) would give off sufficient vapor to ignite in air if an ignition source were present.

Mixed xylenes have a density in the range of 0.87 to 0.88 g/cc. At this low density, mixed xylenes will float on the surface of the water. Mixed xylenes will not sink in water and will evaporate readily.

[2] Density of freshwater and seawater is 1.0 g/cc and 1.03 g/cc, respectively.

The viscosity of mixed xylenes is approximately 0.74 cP at 10.0°C, which is about the ambient temperature of the waters of the Salish Sea.

2.3 Chemical and Physical Properties of Gasoline

Gasoline is a material that is currently shipped via the marine waters and is a well-studied material. There is a valid comparison between the behaviors of reformate, mixed xylenes and gasoline given that reformate is a material used in producing gasoline, and mixed xylenes are already contained in reformate and thereby are also already contained in gasoline.

Gasoline contains more *components*, or chemical compounds, than reformate or mixed xylenes, but is similar in many physical properties affecting distribution and trajectory in the marine environment. Reformate and mixed xylenes have densities in the range of 0.85 to 0.88 g/cc. Gasoline has an approximate density of 0.75 g/cc[3]. At this low density, all of these materials will behave similarly by floating on the surface of the water and spreading into a thin floating layer that will evaporate quickly. Some of the components in gasoline evaporate more quickly and some take longer to degrade, when compared to reformate or mixed xylenes. Refer to Section 3.4.3.2 for a more detailed explanation.

[3] Gasoline (Unleaded) Shell, from ADIOS 2.0 Oil Library – V2 1/27/2015

Understanding the Weathering Process and Modeling

This section includes a description of the weathering processes and how reformate, mixed xylenes, and gasoline, given their specific physical and chemical properties, are expected to behave with respect to those processes. It also introduces the two models selected for this analysis (ADIOS 2.0 and GNOME™) by providing an overview of how these models work and what the models conclude regarding the potential consequences of a reformate or mixed xylenes spill in the marine environment.

3.1 The Weathering Process

When petroleum materials spill into the water, the physical and chemical characteristics of the spilled material interacts with the physical and biochemical features of the environment in ways that determine how the material will behave as well as its fate.

There are eight main weathering processes as illustrated in Figure 3-1.

1. Spreading
2. Evaporation
3. Dispersion
4. Emulsification
5. Dissolution
6. Oxidation
7. Sedimentation and sinking
8. Biodegradation

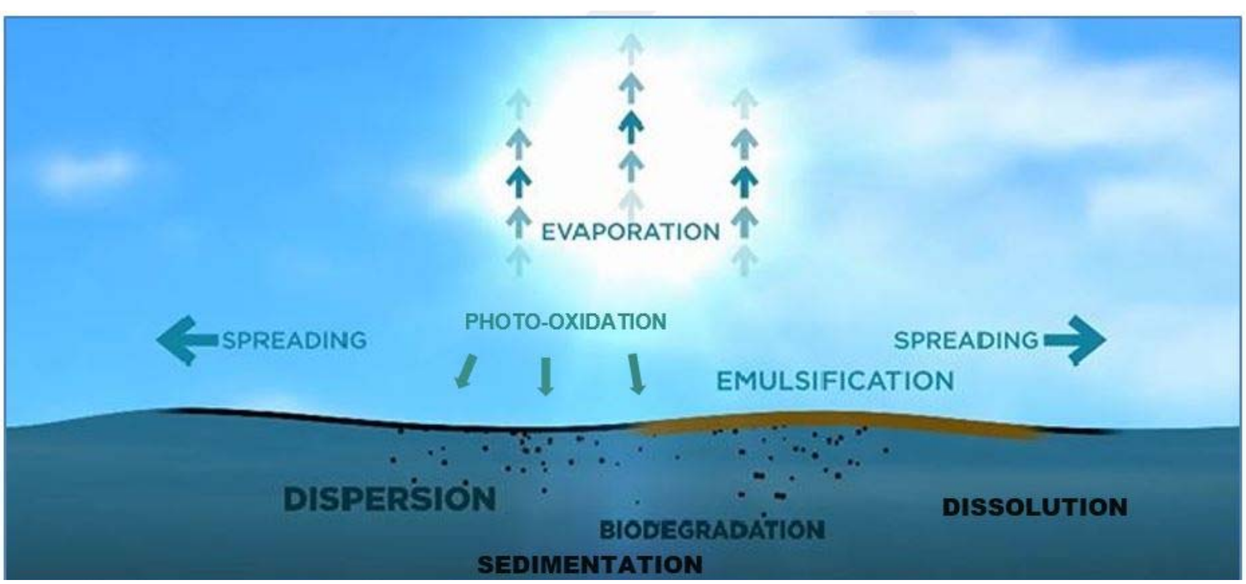

Figure 3-1. Weathering processes of petroleum materials in the environment (adapted from ITOPF)[4].

[4] International Tanker Owner Pollution Federation (ITOPF):

Some petroleum components are more volatile than others, and evaporate more rapidly when spilled. Some petroleum components are more easily broken down by microbes in the ocean or on the beaches. Sunlight can also degrade petroleum components, in both the liquid form or as a gas after vaporization.[5] The sum of these physical and biological processes is termed *weathering*, reflecting changes in chemical composition, physical characteristics over time, and the persistence in the environment of any risk to human health and ecology.

As a general rule, each process can be put into one of two chronological categories in terms of when the effect is most significant:

1. Early stage of a spill: spreading, evaporation (and subsequent photo-oxidation of vapor), dispersion, emulsification and dissolution.

2. Later stage of a spill: oxidation, sedimentation and biodegradation.

3.1.1 Early Stage Weathering Process

For petroleum materials with sufficient volatility like reformate, mixed xylenes, and gasoline, early stage processes dominate due to rapid evaporation. These types of petroleum materials are often described as being *light* due to their rapid rate of evaporation.

3.1.1.1 Spreading

Spreading occurs immediately after a material is spilled on water as a result of interacting forces including gravity, wind and surface tension. This process is also directly influenced by the viscosity or fluidity of the material. The less viscous, the more it will spread and increase the area of water covered. Reformate and mixed xylenes have low viscosities. Additionally, underwater tides and currents, the weather and many other factors influence the rate of spreading.

3.1.1.2 Evaporation

As the spilled material spreads, the evaporation rate, or the rate at which molecules of spilled material volatilize, increases. Wind speed is a predominant factor influencing evaporation for volatile materials such as reformate, mixed xylenes and gasoline; that is higher winds lead to higher rates of evaporation. The role of wind speed and direction in modeling spill scenarios is discussed in more detail in Section 4.

3.1.1.3 Dispersion

Dispersion is the integration of droplets of spilled material into the water column by wind and wave action. Dispersion is a process that if it occurs, (if the droplets are small enough and there is enough turbulence in the water from wind and waves) it keeps the petroleum material from resurfacing temporarily. As such, dispersion is influenced by wind and wind-generated waves.

3.1.1.4 Emulsification

An emulsion is a suspension of two liquids within each other that would not naturally mix. Mayonnaise is an example of an emulsion of vinegar and oil, using eggs as the emulsifying agent. Specific to a petroleum spill, emulsification is the incorporation of water droplets into the spilled oil. Oil/water emulsions, referred to as *mousse*, typically only form when there is an emulsifying agent present. Such emulsifying agents occur in heavier petroleum products and are not present in reformate, mixed xylenes or gasoline. Reformate, mixed xylenes and gasoline do not form emulsions.

[5] http://www.atsdr.cdc.gov/toxprofiles/tp71-c6.pdf

3.1.1.5 Dissolution

Dissolution is the process by which the original state of the material (reformate or mixed xylenes) becomes a solute (dissolved component), forming a solution of the material in the solvent; in this case the ocean. Many materials, including reformate and mixed xylenes, tend not to dissolve in salt water. Conversely, salt and sugar are examples of materials that *do* dissolve in water.

3.1.2 Later Stage Weathering Process

The later stage weathering processes, while applicable to types of petroleum that may contain heavier components, are not applicable to light petroleum materials like reformate, mixed xylenes and gasoline. Due to rapid vaporization, these liquids will not exist long enough in a marine environment for such late stage weathering processes to occur. Regardless, the later stage weathering processes are described below to provide a complete description for general awareness.

3.1.2.1 Oxidation

Spilled materials may react chemically with oxygen either breaking down into soluble products or forming persistent compounds or residues. This process is promoted by sunlight, but is a late stage process and is slow with even thin films of spilled petroleum material breaking down slowly whereby they are likely already removed by other short term processes. However, these typically do not occur until several days after a spill, and often involve photochemical reactions[6].

3.1.2.2 Sedimentation

Sedimentation involves spilled materials being adsorbed onto particulate suspended material that could be deposited to the bottom.

3.1.2.3 Biodegradation

Biodegradation is the process whereby marine microorganisms metabolize compounds. As with all of the weathering processes, biodegradation is influenced by chemical and physical properties, temperature and availability of oxygen and nutrients.

3.2 Physical/Chemical Properties Important to the Weathering Process

Section 2 described several aspects of the chemical and physical properties of reformate, mixed xylenes and gasoline for comparison. These specific properties are important to understanding how reformate and mixed xylenes would behave if spilled into the marine environment. The properties of reformate and mixed xylenes are used by the models in this study to predict behavior. These properties are also important to understand the similarities between the behaviors of reformate and mixed xylenes when compared to gasoline, which is a well-studied petroleum product. Refer to Appendix B for a list of chemical and physical properties applicable to this analysis.

3.2.1 Density, Solubility and Viscosity

The combined effects of the properties of density, solubility and viscosity dictate the form a material will take when spilled. Reformate and mixed xylenes have a low density, in the range of 0.85 to 0.88 g/cc, which is significantly lower than the density of seawater (1.03 g/cc). Reformate and mixed xylenes are

[6] http://www.offshore-environment.com/oil.html

relatively insoluble and have low viscosities in the range of 0.74 to 1.03 cP at cool seawater temperatures of 50°F (10°C) like those found in the Salish Sea. These properties will not change appreciably during the weathering process due to the similar physical properties of the individual components comprising reformate and mixed xylenes.

3.2.2 Volatility and Vapor Concentration

Materials which have low density, solubility and viscosity, as described above, and that also have high vapor pressures, vaporize rapidly in a marine environment. For materials such as reformate and mixed xylenes only light petroleum-based materials (that volatize readily) are present in the mixture. As such, the evaporation process for reformate and mixed xylenes, as with the process for gasoline, will continue to completion leaving no appreciable residue. The actual rate of evaporation for reformate and mixed xylenes during this process will be relatively consistent because the properties of the individual components are very similar.

There are more individual compounds in gasoline, some of which evaporate more readily than those in reformate and mixed xylenes and some of which evaporate more slowly. The overall time for reformate, mixed xylenes and gasoline to evaporate to completion is very similar, as discussed in Section 5.0.

Relative to the actual vapor concentration that may be observed at an ocean spill location, the vapor concentration is proportional to the evaporation rate. Increasing wind speeds will increase the rate of evaporation, and will dilute the airborne concentrations. Mixed xylenes and ethylbenzene vapors have a short atmospheric life ranging from is 14 to 26 hours and 8 to 46 hours respectively.[7]. Given this, vapor concentrations will rapidly decline below levels of risk for flammability and human health.

Reformate and mixed xylenes are less flammable than gasoline because their mixture excludes some of the more volatile components found in gasoline. When compared to gasoline, both reformate and mixed xylenes will have a lower initial peak vapor concentration after a spill.

3.3 Modeling Early Stage Weathering Evaporation and Dispersion – ADIOS 2.0

A model provided by the National Oceanic and Atmospheric Administration – ADIOS 2.0 – was selected to evaluate the fate and behavior of spilled reformate or mixed xylenes. ADIOS 2.0 (Automated Data Inquiry for Oil Spills) is the standard recommended tool for spill response modeling. Its predictions are designed to help decision-makers develop cleanup strategies based on estimates of how long spilled petroleum will remain in the environment. The details of the model can be found online at http://response.restoration.noaa.gov/adios. ADIOS is an appropriate tool to assess fact and behavior and is able to generate complex outputs for planning purposes.

3.3.1 What ADIOS 2.0 Can Tell Us

ADIOS 2.0 can estimate how different types of spilled materials undergo physical and chemical changes in the marine environment based on a suite of their physical and chemical properties as well as local environmental parameters. This allows the model to estimate how the various weathering processes

[7] Alan S. Kao (1994) Formation and Removal Reactions of Hazardous Air Pollutants, Air & Waste, 44:5, 683-696, DOI: 10.1080/1073161X.1994.10467272, http://dx.doi.org/10.1080/1073161X.1994.10467272

described above will interact with a spill in the marine environment; providing an assessment of how quickly the material would spread, evaporate, and disperse.

3.3.2 How ADIOS 2.0 Works

ADIOS 2.0 models a wide range of parameters that affect the spread and degradation of petroleum materials in the marine environment. One of the features of ADIOS 2.0 is that it allows the user to input the specific detailed physical and chemical properties of the materials being evaluated. This means that, for reformate and mixed xylenes, the model considers the detailed chemical and physical properties (i.e. distillation data, density, viscosity, and other properties) in its algorithms. ADIOS algorithms also factor in specific information related to spill scenarios such as the type and amount of petroleum material spilled; and the rate and duration of the release.

In addition, ADIOS considers specific relevant environmental conditions. These include wind speed, wave height, water temperature, and water salinity. For example, ADIOS is able to describe and compare the rates by which reformate and mixed xylenes evaporate over time as the weathering process proceeds and make comparison to the behavior of a well-known material such as gasoline.

As presented in Section 5, ADIOS predicts that the gasoline evaporation rate will be faster at the beginning of a spill event, but then be slower as evaporation reaches completion when compared to reformate and mixed xylenes.

3.4 Modeling Spreading and Movement on Water – GNOME™

The results from ADIOS modeling provide insights into the length of time that reformate or xylenes would remain in the marine environment. However, ADIOS was not intended to nor can it indicate how a spilled petroleum product might spread or move on the water in specific oceanographic conditions. Therefore, ADIOS information was combined with another model to better understand how a possible spill of reformate or xylenes might travel on the water. The analysis of movement on water allows responders to assess potential actions and planners to evaluate the types of natural resources that could be at risk.

A model provided by the National Oceanic and Atmospheric Administration – GNOME™ – was selected to evaluate the trajectory of a possible spill of reformate or xylenes. NOAA GNOME™ (General NOAA Operational Modeling Environment) is a component of the NOAA Trajectory Analysis Planner (TAP) used to predict the spread of spilled petroleum product in certain areas given local bathymetry, shoreline configuration, tide based currents, winds and volume and type of spilled product.

3.4.1 What GNOME™ Can Tell US

The GNOME™ model is used to provide potential geographic extent of the size and duration of a spill under a specified set of wind, tide and current conditions. Using various inputs, the GNOME™ algorithms forecast how far and how fast a spill would spread from the initial release point. The GNOME™ modeling tool provides trajectories of both *Forecast* and *Uncertainty*. The *Forecast* represents the best guess of where spilled materials will be located while *Uncertainty* represents where spilled material has a 90% likelihood of being observed.

Unlike ADIOS 2.0, GNOME™ does not evaluate the weathering processes that may dissipate materials moving across the surface of the water. Therefore, the weathering results from ADIOS 2.0 were referenced to dictate when all the material has dissipated and no longer moving along the surface of the water. At this point, the spill scenario timeline stops, and the GNOME™ trajectory analysis is concluded.

3.4.2 How GNOME™ Works

Like ADIOS, GNOME™ considers the physical and chemical properties of the petroleum material that might be spilled. GNOME™ uses an evaporation algorithm appropriate for planning and educational comparisons. The ADIOS weathering model has more complex evaporation and petroleum fate calculation algorithms compared to GNOME™. ADIOS also has an extensive chemical component library that can be used for a large range of petroleum materials. GNOME™ has a smaller library of specific petroleum materials such as gasoline, jet, diesel, fuel oil and crude oil, but does not have the capability to input detailed custom data for specific chemical and physical characteristics. However, the chemical and physical properties of gasoline, which is similar to reformate and mixed xylenes, is available in GNOME™ and suitable for this analysis. The properties of gasoline were presented in Section 2.3 and compared to reformate and mixed xylenes. Additional information is provided in Section 3.4.3 to support using gasoline to model spill scenarios of reformate and mixed xylenes.

GNOME™ accounts for a range of tidal, current and meteorological data to produce its output. These data are contained in *location files* for specific geographic areas. These files were developed in collaboration with NOAA as foundational input to the model. For this report, the North Puget Sound Location File was used as input into GNOME™.

In GNOME™, spilled substances are modeled as point masses of Lagrangian elements (LEs) called *splots*, derived from *spill dots*. Lagrangian elements (or *splots*), are discrete vectors originating from the spill with parameters assigned to each point including location (latitude/longitude), release time, age, pollution type, density, amount of pollutant (variable) and status – floating, beached, evaporated.

One splot does not equate to a specific quantity of spilled liquid. Instead, a splot indicates where some unquantified amount of spilled liquid may have traveled over time, based on the GNOME™ algorithms. This lack of linkage between quantity and location in GNOME™ required an artistic rendering of potential shoreline impacts generated by GNOME™. Section 6.1 describes the assumptions in more detail.

3.4.3 Reformate and Mixed Xylenes modeled using *Gasoline* in GNOME™

As explained above, GNOME™ does not allow custom input data for materials like reformate or mixed xylenes. Therefore, it was necessary to select *gasoline* from the standard petroleum materials accepted by the model to be used in place of reformate and mixed xylenes.

GNOME™ allows modeling of only certain common petroleum materials like gasoline, jet fuels, diesel, fuel oil and crude oil. From this list, gasoline was selected as the best and most appropriate material to model reformate and mixed xylenes in GNOME™. The reason is that gasoline has similar chemical and physical properties in comparison to reformate and mixed xylenes and thereby behaves similarly under spill scenario situations.

Gasoline is a material that is currently shipped via the marine waters, and a well-studied spill scenario that includes a subset of components present in reformate and mixed xylenes. This is the basis whereby a comparison can be made between the behavior of reformate and mixed xylenes with gasoline in the marine environment for planning and evaluation purposes. The behavior of gasoline releases are well understood and are known to evaporate without leaving an appreciable residue[8] and serve as a reasonable comparative material for modeling the trajectory of reformate and mixed xylenes.

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[8] http://response.restoration.noaa.gov/sites/default/files/managing-seafood-safety-oil-spill.pdf. (Table II-2).

Gasoline is similar in many physical properties affecting distribution and trajectory in the marine environment. Although reformate and mixed xylenes are classified as flammable, both are less flammable than gasoline, as measured by flash point. Gasoline has an approximate flash point of -22°F (-30°C).[9]

Reformate and mixed xylenes have densities in the range of 0.85 to 0.88 g/cc. Gasoline has an approximate density of 0.75 g/cc. At this low density, all of these materials will behave similarly by quickly forming a floating layer on the surface of the water, likely to evaporate quickly.

Reformate and mixed xylenes are comprised of a limited number of components. Gasoline, as a mixture, contains more components than reformate and mixed xylenes, including some components that are lighter that more readily evaporate, along with a small amount of components that are heavier that may take longer to evaporate and degrade. However, the total time for reformate, mixed xylenes and gasoline to completely evaporate is similar (Figure 3-2). Additional detail on these and other relevant physical and chemical properties of reformate, mixed xylenes and gasoline is included in Appendix B.

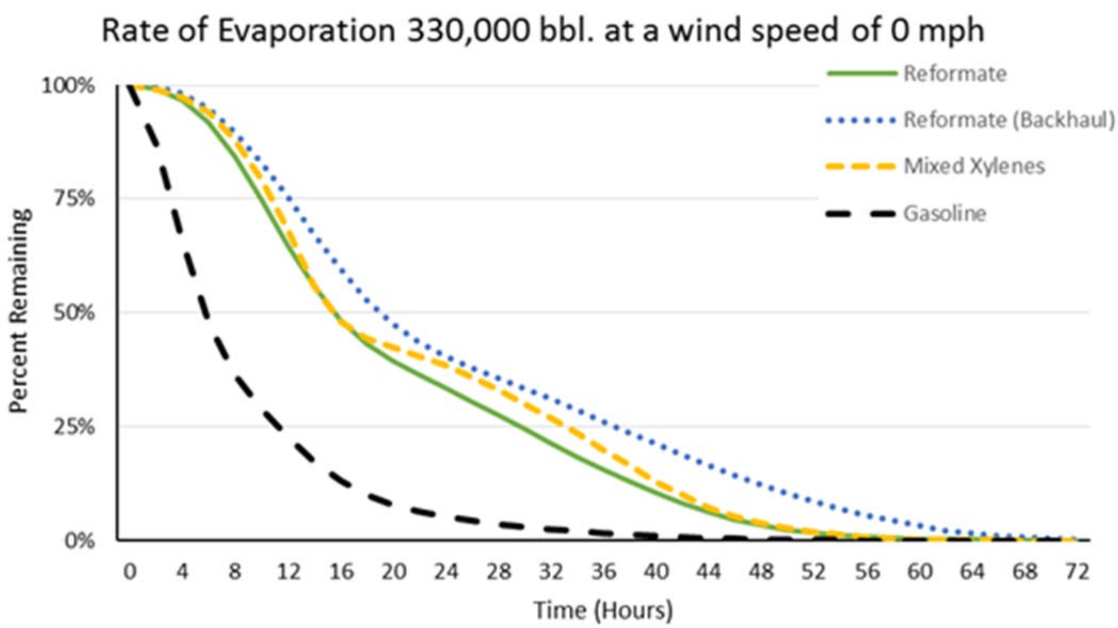


Figure 3-2. Plot of rate of evaporation 330,000 bbls of reformate, reformate (backhaul) mixed xylenes and gasoline.[10]

[9] Gasoline (Unleaded) Shell, from ADIOS 2.0 Oil Library – V2 1/27/2015

[10] Appendix E contains additional comparisons of evaporation rates to jet and diesel, further illustrating that gasoline is an appropriate material for modeling reformate and mixed xylenes.

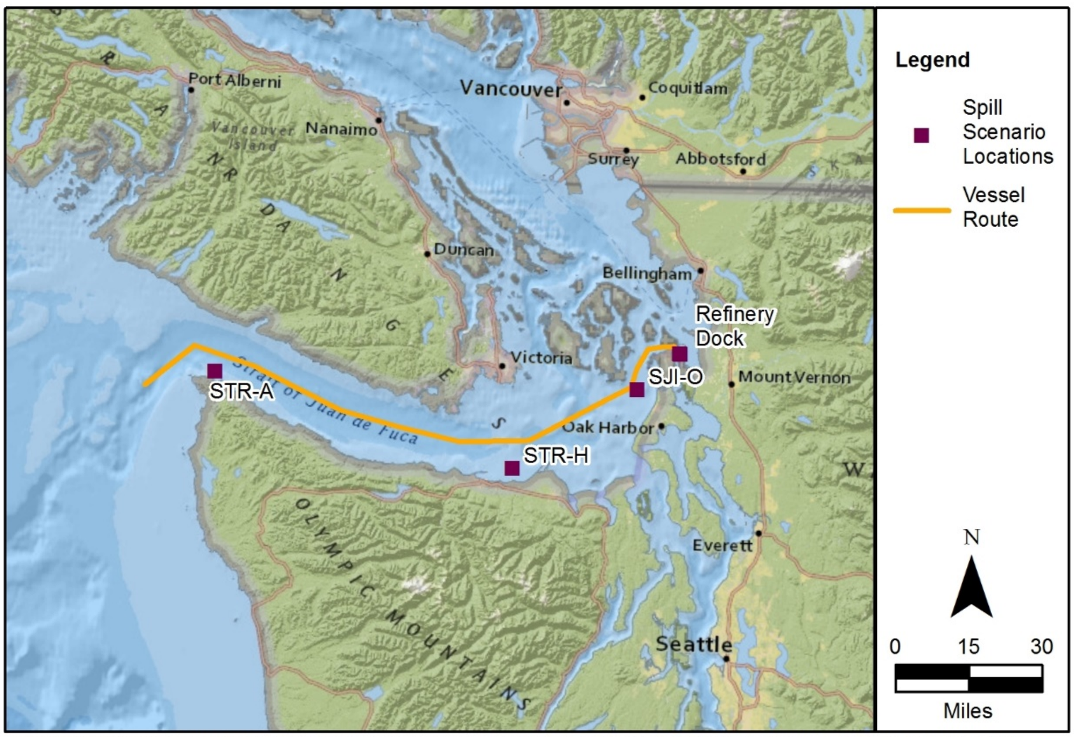
Spill Scenarios Examined

This section describes the process for selecting:

- Locations for spill scenario modeling
- Quantities for spill scenarios, and
- Meteorological data required for modeling

4.1 Spill Scenario Locations

Four (4) locations were selected for modeling the consequences of a potential spill of reformate or mixed xylenes. These locations are shown on Figure 4-1.



Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA,

Figure 4-1. Vessel Route to Refinery at March Point with Spill Scenario Locations

The scenarios were selected based upon the vessel route[11] through the Salish Sea to the Refinery Dock. It includes various broad-based areas of interest including the transfer facility at the refinery dock, along with the scenarios along the Salish Sea transit route, including West of Neah Bay, representing an open-water-type scenario; Northeast of Port Angeles, representing an area with a nearby port facility; and Rosario Strait, representing an island community along the transit path.

[11] Three "potential spill origin points" spaced along the vessel transit route were chosen from the Northwest Area Contingency Plan Spill Scenario Locations. These are theoretical points established to help spill responders to prepare and prioritize booming strategies to protect various coastal and stream locations before a spill occurs. They are created as part of Geographic Response Plans (GRPs).

1. Refinery Dock (transfer facility)
   - Tesoro Anacortes Refinery Wharf, 48.508367/-122.569229
2. STR-A - Neah Bay (nearby open-water scenario):
   - STR-A, W of Neah Bay, GRP: Strait of Juan de Fuca, 48.407989/-124.629782
3. STR-H - Port Angeles (nearby port facility scenario):
   - STR-H, NE of Port Angeles, GRP: Strait of Juan de Fuca, 48.156802/-123.296792
4. SJI-O- Rosario Strait (island community scenario):
   - SJI-O, San Juan Islands and North Puget Sound, 48.398877/-122.755066

In summary, there were three (3) spills scenario locations along the Salish Sea vessel traffic route[12], along with the transfer facility at the Refinery dock.

4.2 Spill Scenario Quantities

The quantities for the spill scenarios were informed by the Tesoro Oil Spill Contingency Plan (OSCP) approved by the Washington State Department of Ecology (Ecology) along with referencing federal rules that is the basis for the Federal Spill Planning Volumes.

4.2.1 Refinery Dock

Three spill scenario volumes are examined based upon those presented in the OSCP approved by Ecology and the USCG. [13]

- 50 barrels Average most probable discharge (AMPD)
- 1,200 barrels Maximum most probable discharge (MMPD)
- 5,045 barrels Worst-case discharge (WCD) [14]

For modeling purposes it was assumed that these quantities would be released instantaneously. The large spill scenarios (e.g. thousands of barrels) are highly improbable and would likely occur over time; a number of hours or longer. However, this report presents an analysis of the worst-case discharge (WCD).

4.2.2 Salish Sea

Two spill scenario volumes were selected for the Salish Sea based upon requirements set forth in the Federal Spill Planning Volumes which are described in 33 CFR 155.1020. [15]

- 2,500 barrels Maximum most probable discharge (MMPD)
- 330,000 barrels Worst-case discharge (WCD)[16]

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[12] Three “potential spill origin points” spaced along the vessel transit route were chosen from the Northwest Area Contingency Plan Spill Scenario Locations. These are theoretical points established to help spill responders to prepare and prioritize booming strategies to protect various coastal and stream locations before a spill occurs. They are created as part of Geographic Response Plans (GRPs).

[13] Volumes are based on the release volumes per 33 CFR 154 in the Tesoro Oil Spill Contingency Plan (OSCP), which was approved by the US Coast Guard (USCG), the Washington State Department of Ecology (Ecology) and EPA.

[14] Pipeline transfers of reformate and mixed xylenes at the dock will utilize the existing 10” or 12” lines rather than the 16” line that was used as the basis for the WCD. As a result the calculated WCD of 5,045 bbl over-estimates potential spill volumes of reformate or mixed xylenes.

[15] Volumes used in the vessel transit scenario are based on federal requirements.

[16] Mixed xylenes are planned to be hauled in vessels with a volume of about 330,000 barrels. It is expected that reformate will normally by hauled in 180,000 barrel volume vessels, but for planning purposes, reformate WCD was also evaluated at 330,000 barrels.

For modeling purposes it was assumed that these quantities would be released instantaneously. These large spill scenarios (e.g. thousands and hundreds-of-thousands of barrels) are highly improbable and would likely occur over time; a number of hours or perhaps days. However, this report presents an analysis of the worst-case discharge (WCD).

4.3 Meteorological Data

Meteorological data, especially wind speed and direction are important inputs into the models used for this study. Accordingly, NOAA Buoy wind data was surveyed and processed for 2015 to determine direction and mean speed. This analysis determined that wind speeds and direction vary significantly by season for each of the locations being modeled. Therefore, the data were separated into predominant summer and winter wind speeds and directions for Rosario, Port Angeles and Neah Bay. Tabular data along with graphic wind roses by season for each location are summarized in Section 6.0.

ADIOS Model Results

The fate and behavior of reformate and mixed xylenes and associated time frames for evaporation were evaluated utilizing ADIOS 2.0 (Automated Data Inquiry for Oil Spills) a standard recommended tool provided by National Oceanic and Atmospheric Administration (NOAA). ADIOS is a spill response model that estimates how different types of petroleum materials undergo physical and chemical changes in the marine environment based on a suite of their physical and chemical properties as well as local environmental parameters. ADIOS 2.0 is a modeling program designed to help decision-makers develop cleanup strategies based on estimates of how long spilled material will remain in the environment. Input information to ADIOS 2.0 includes environmental conditions such as wind speed, wave heights, water temperature, and water salinity; the type and amount of material or product spilled; and the rate and duration of the release. For the ADIOS 2.0 modeling, wind speeds of 0, 5 and 10 mph were used and data presented here.

5.1 Weathering Process Modeling Results

As described previously, both reformate and mixed xylenes evaporate quickly and do not persist in the environment. ADIOS modeling confirmed that only some of the early stage weathering processes and none of the late stage weathering processes interacted with reformate and mixed xylenes (ADIOS output and data files are included in Appendix C and D).

5.1.1 Spreading

The combined effects of the properties of a low viscosity, low density and low solubility assure that reformate and mixed xylenes will quickly form a thin floating layer during a spill event. Such behavior provides an opportunity for good contact with ambient winds to facilitate evaporation.

5.1.2 Evaporation

Wind is a predominant factor influencing evaporation for volatile materials such as reformate and mixed xylenes. ADIOS 2.0 modeling were performed to assess the impact of various conditions on the rate of evaporation for reformate and mixed xylenes. As expected, increasing wind conditions increases the rate at which evaporation occurs and decreases the time until the spilled material is completely evaporated. Modeling was also performed for gasoline under the same conditions for comparison. Similarly, gasoline is predicted to rapidly evaporate, with a rate increasing with wind speed while leaving no residue.

Wind is a significant environmental factor influencing the rate of evaporation for reformate and mixed xylenes, as confirmed by ADIOS 2.0. Using the Refinery Dock spill scenarios of 50, 1,200 and 5,045 bbls and Salish Sea scenarios of 2,500 bbls and 330,000 bbls, evaporation rates were estimated using wind speeds of 0, 5 and 10 mph. For the 5,045 bbls mixed xylenes Refinery Dock spill case, ADIOS predicts the material would evaporate during the initial 12 – 18 hours as predicted by ADIOS.

The spill scenarios show that as wind speed decreases the amount of time it takes for materials to completely evaporate increases. A volume of 50 bbls of mixed xylenes takes 4 hours to evaporate at 0 mph, but at 5 mph, the required time is reduced to 3 hours (Table 5-1 and Table 5-2). Overall, even though gasoline evaporates more quickly in the initial stages, the dissipation time for reformate and mixed xylenes are similar to gasoline. Refer to Figure 5-1 through Figure 5-4 that represent the evaporation rate of reformate, reformate (backhaul)[17], mixed xylenes and gasoline at Refinery Dock spill scenario volumes and Figure 5-5 through Figure 5-9 that represents the evaporation rate of these same materials for the Salish Sea spill scenario volumes.

Table 5-1. Time required for 50 percent and >99.5 percent[1] of material to evaporate Refinery Dock spill scenarios of 50, 1200, and 5045 bbl.

Stream	**Volume bbl**	**Amount of time (hrs) for spilled material to evaporate with varying wind speeds [hrs to evaporation of 50% and >99.5% of spill]**					
		0 mph		**5 mph**		**10 mph**	
		50% evaporation	>99.5% evaporation	50% evaporation	>99.5% evaporation	50% evaporation	>99.5% evaporation
		hrs	**hrs**	**hrs**	**hrs**	**hrs**	**hrs**
Reformate	50	2	6	1	4	1	3
	1,200	4	12	3	12	2	8
	5,045	6	20	6	16	4	12
Reformate (backhaul)[18]	50	2	8	2	5	2	8
	1,200	4	16	4	12	4	10
	5,045	8	24	6	20	4	14
Mixed Xylenes	50	2	4	1	3	1	3
	1,200	4	12	4	10	4	8
	5,045	6	18	6	16	4	12
Gasoline	50	1	13	1	7	1	3
	1,200	1	22	1	14	1	8
	5,045	2	34	2	14	1	14

Note: Refer to Figure 5-1 through Figure 5-4.
[1]Although ADIOS predicts the materials will be 100% dissipated, there is the potential for a portion of the spilled material to persist slightly longer if it gets trapped in shoreline locations without sunlight or oxygen.

[17] See footnote 1.

[18] See footnote 1.

Table 5-2. Time required for 50 percent and >99.5 percent[1] of material to evaporate Salish Sea Vessel Transit spill scenarios of 2,500 and 330,000 bbl.

Stream	Volume bbl	Amount of time (hrs) for spilled material to evaporate with varying wind speeds [hrs to evaporation of 50% and >99.5% of spill]					
		0 mph		5 mph		10 mph	
		50% evaporation	>99.5% evaporation	50% evaporation	>99.5% evaporation	50% evaporation	>99.5% evaporation
		hrs	hrs	hrs	hrs	hrs	hrs
Reformate	2,500 330,000	6 16	16 72	4 12	14 56	4 10	10 36
Reformate (backhaul)[19]	2,500 330,000	6 20	18 72	4 16	14 66	4 12	12 52
Mixed Xylenes	2,500 330,000	6 16	14 72	6 14	12 70	4 10	10 48
Gasoline	2,500 330,000	1 6	14 72	1 6	14 60	1 4	10 48

Note: Refer to Figure 5-5 through Figure 5-8.
[1]Although ADIOS predicts the materials will be 100% dissipated, there is the potential for a portion of the spilled material to get trapped in shoreline locations without sunlight or oxygen that could persist slightly longer. For the largest discharges at 0 mph (no wind), over 99.5% is predicted to be gone by natural weathering processes before 72 hours.

5.1.3 Dispersion

Dispersion is a dissipation process whereby oil droplets get trapped in to the water through turbulence, and will not resurface. As such, dispersion is influenced by the turbulence generated by the wind and wind-generated waves. In the case of reformate and mixed xylenes, as with gasoline, evaporation occurs rapidly whereby there is little material that is available to be dispersed. ADIOS 2.0 predicts that during calm seas with a wind speed of 0 to 5 mph, there is no dispersion of reformate or mixed xylenes due to these limiting conditions. As wind speed increases, minor amounts of dispersion are predicted by the model.

[19] See footnote 1.

Table 5-3. Cumulative Product dispersed into the water column Refinery Dock spill scenarios of 50, 1200 and 5045 bbl.

Stream	Volume bbl	Percent of Natural Dispersion due to Wind speed		
		0 mph	5 mph	10 mph
		%	%	%
Reformate	50	0	0	2.2
	1,200	0	0	1.5
	5,045	0	0	1.5
Reformate (backhaul)[20]	50	0	0	2.8
	1,200	0	0	2.3
	5,045	0	0	2.3
Mixed Xylenes	50	0	0	1.8
	1,200	0	0	1.3
	5,045	0	0	1.3
Gasoline	50	0	0	0.6
	1,200	0	0	0.5
	5,045	0	0	0.5

Table 5-4. Cumulative Product dispersed into the water column *Salish Sea Vessel Transit spill scenarios of 2,500 and 330,000 bbl.*

Stream	Volume bbl	Percent of Natural Dispersion due to Wind speed		
		0 mph	5mph	10 mph
		%	%	%
Reformate	2,500	0	0	1.5
	330,000	0	0	1.6
Reformate (backhaul)[21]	2,500	0	0	2.3
	330,000	0	0	2.6
Mixed Xylenes	2,500	0	0	1.3
	330,000	0	0	1.3
Gasoline	2,500	0	0	0.5
	330,000	0	0	0.4

[20] See footnote 1.

[21] See footnote 1.

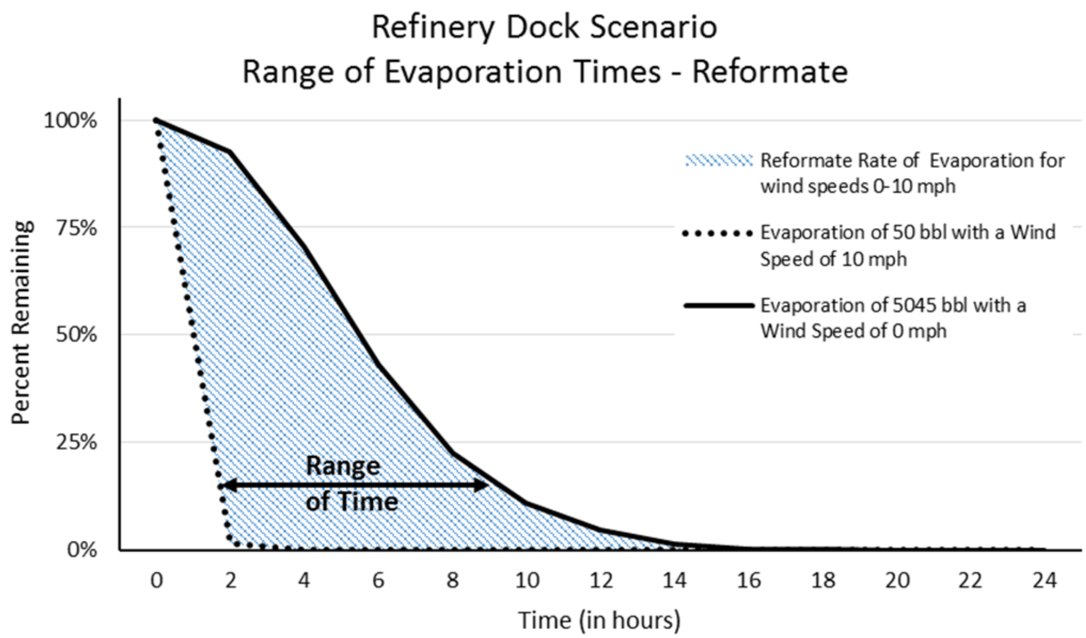


Figure 5-1. Predicted evaporation rates of reformate spill scenarios (50; 1020, 5045 bbl; @ 0, 5, 10 mph)

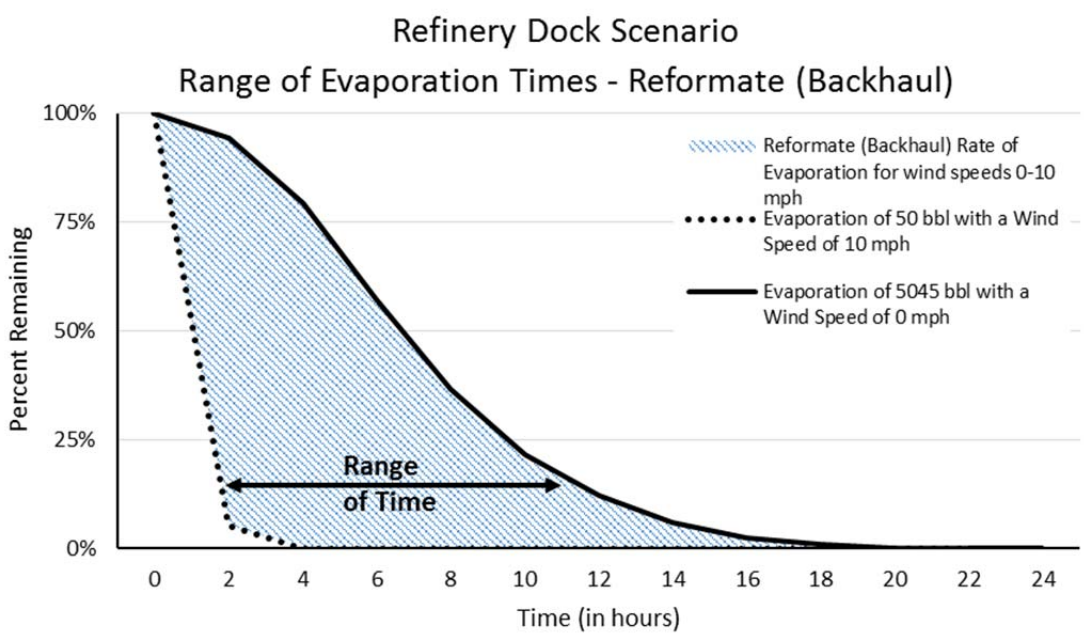


Figure 5-2. Predicted evaporation rates of reformate (backhaul) spill scenarios (50; 1020, 5045 bbl; @ 0, 5, 10 mph)

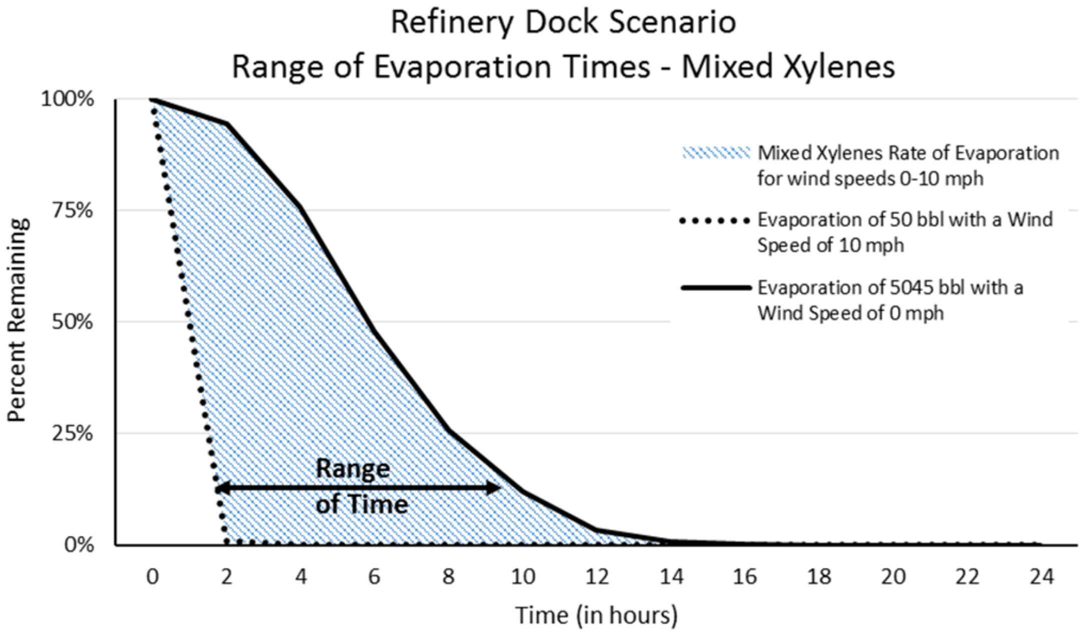


Figure 5-3. Predicted evaporation rates of mixed xylene spill scenarios (50; 1020, 5045 bbl; @ 0, 5, 10 mph)

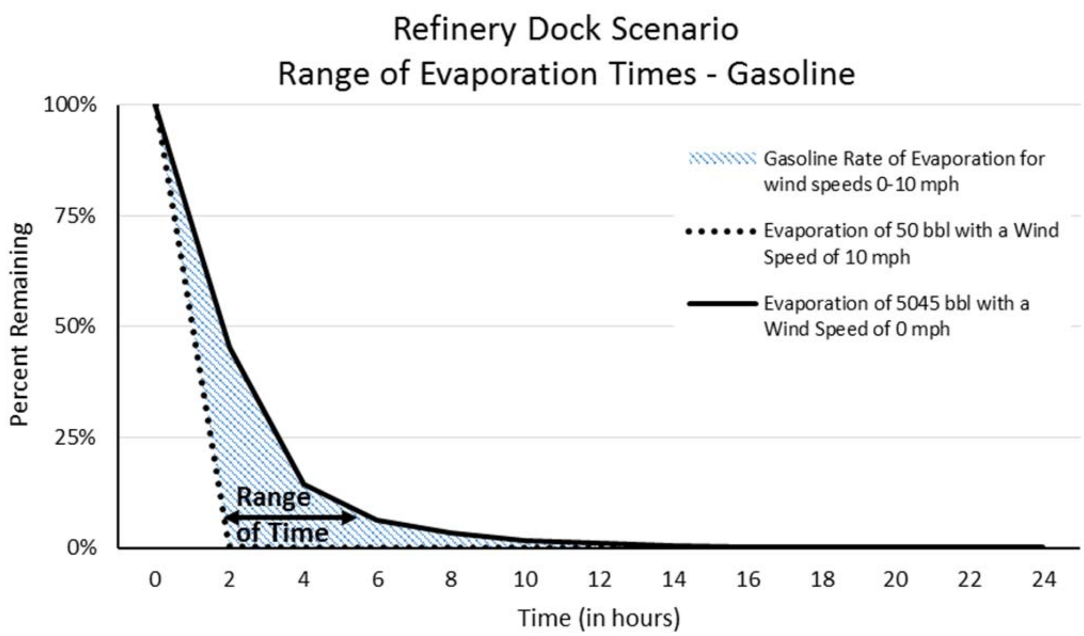


Figure 5-4. Predicted evaporation rates of gasoline spill scenarios (50; 1020, 5045 bbl; @ 0, 5, 10 mph).[22]

[22] Note the faster initial evaporation rate depicted by the steeper slope of the curve in Figure 5-4, but total time to evaporation is similar to the times shown in Figures 5-1 through 5-3.

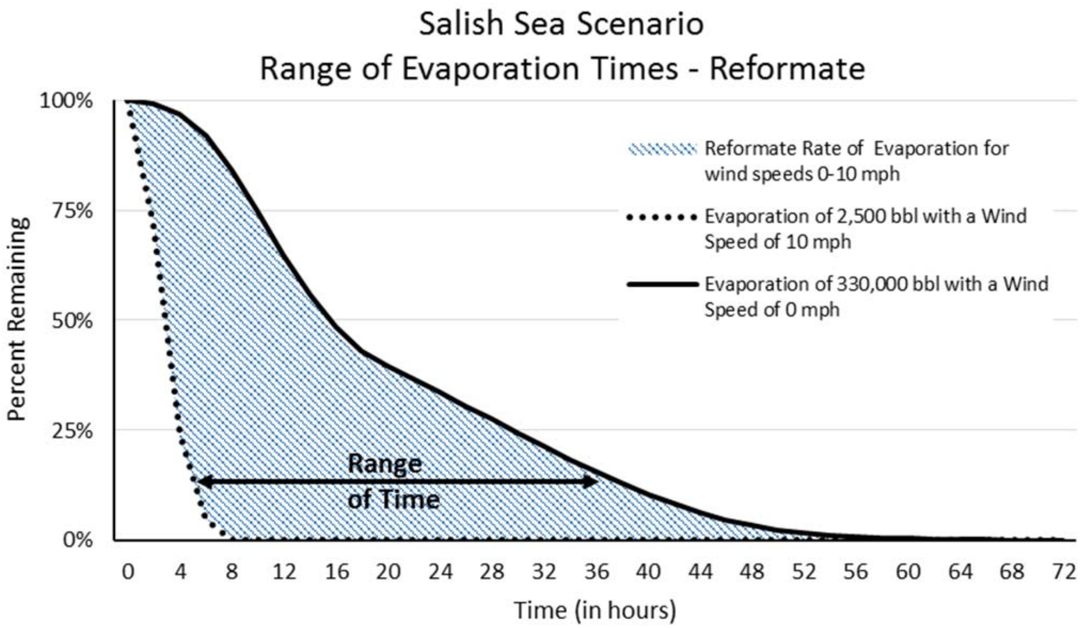


Figure 5-5. Predicted evaporation rates of reformate spill scenarios (2,500 and 330,000 bbl; @ 0, 5, 10 mph)

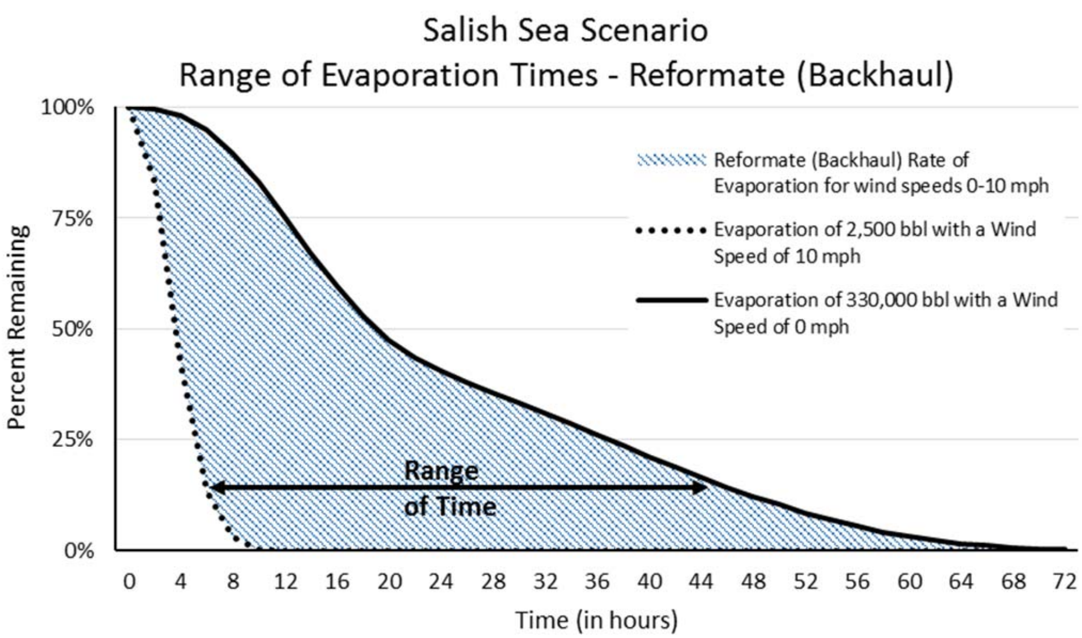


Figure 5-6. Predicted evaporation rates of reformate (backhaul) spill scenarios (2,500 and 330,000 bbl; @ 0, 5, 10 mph)

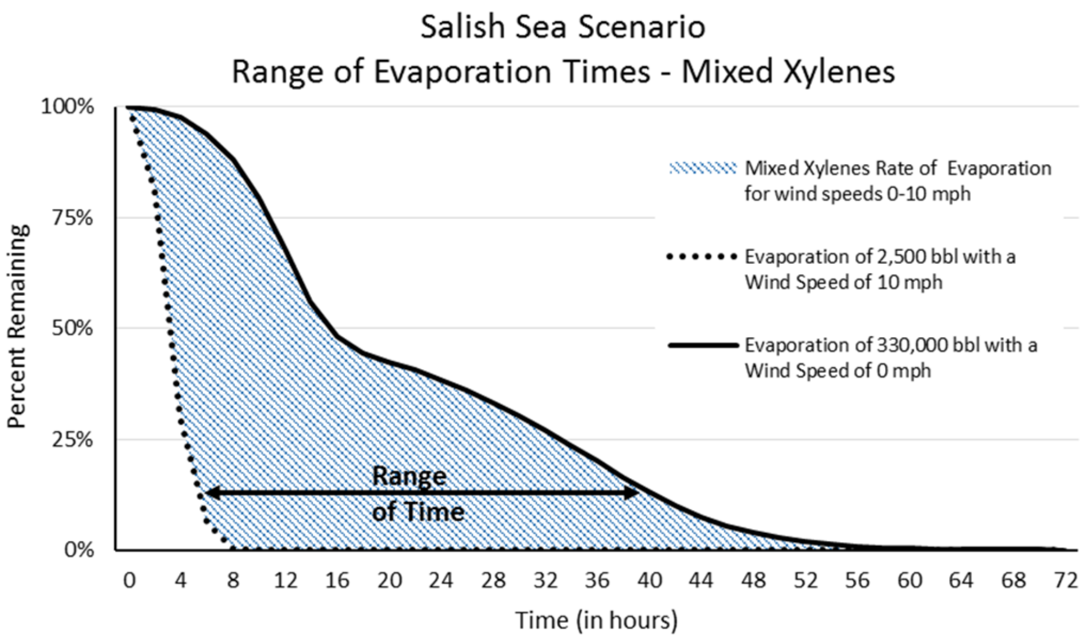


Figure 5-7. Predicted evaporation rates of mixed xylene spill scenarios (2,500 and 330,000 bbl; @ 0, 5, 10 mph)

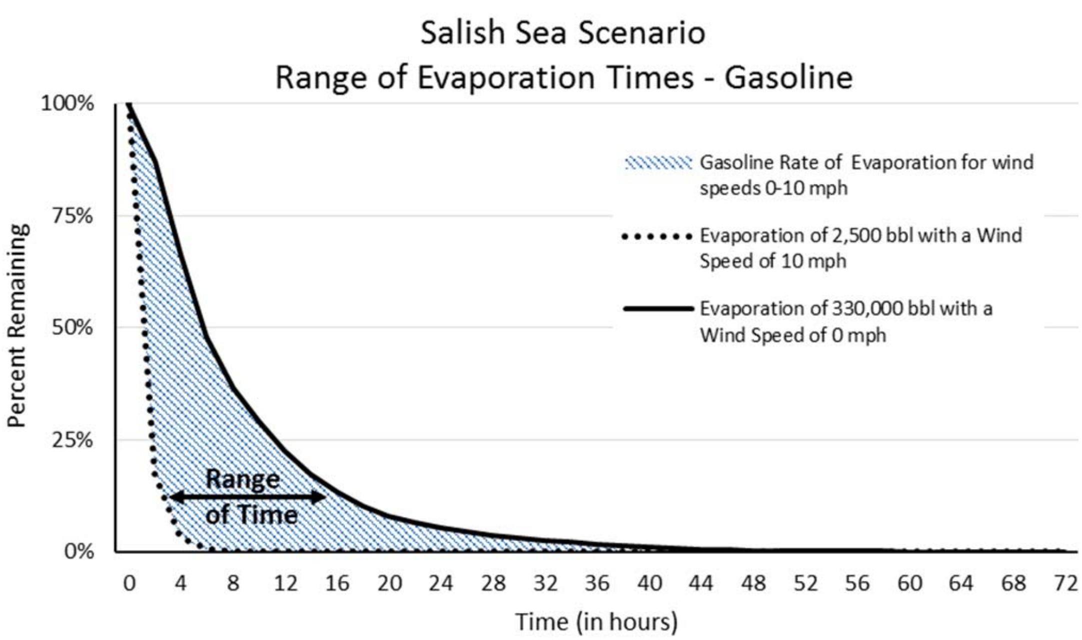


Figure 5-8. Predicted evaporation rates of gasoline spill scenarios (2,500 and 330,000 bbl; @ 0, 5, 10 mph)

5.1.4 Emulsification

Emulsification is a process in which water droplets are dispersed into oil and form a viscous floating *mousse*. While the formation of emulsions may occur in some crude oils or other materials it is typically associated with significant content of waxes, multi-ring asphaltenes and certain metals that are needed to stabilize emulsion droplets. Reformate and mixed xylenes do not contain these components and as such do not form stable emulsions. This behavior of reformate and mixed xylenes is similar to gasoline which also does not form emulsions.[23] ADIOS does not predict emulsification of reformate, mixed xylenes or gasoline using representative physical and chemical parameters provided for the specific mixtures.

5.1.5 Dissolution

Dissolution is a process where materials are dissolved from their original state: gases, liquids or solids into a new solution of gas, liquid or solid with a solvent. For example gasoline could evaporate into the surrounding atmosphere to form vapors or form a solution in water. However, xylene and ethylbenzene are considered hydrophobic or practically insoluble in water (more than 10,000 parts water needed to dissolve 1 part xylene). The solubility of the hydrocarbons: ethylbenzene, o-xylene, m-xylene and p-xylene at 25 degrees Celsius ranges from 162 mg/L to 213 mg/L[24]. The combination of the properties of low viscosity, low density and volatility, all resulting in rapid evaporation, would not allow reformate or mixed xylenes the necessary contact time to dissolve, even if soluble.

5.2 Summary of Weathering Processes for Reformate and Mixed Xylenes

In summary, the fate of reformate and mixed xylenes in a marine release is predicted by ADIOS 2.0 to be rapid volatilization in an early stage weathering process leaving no residue. This behavior is dictated by the physical properties of low density, low viscosity, high volatility and low solubility. Once evaporated, reformate and mixed xylenes would be consumed by photochemical oxidation in the atmosphere. Due to the high rate of evaporation, there is no material remaining to be involved in the later stages of weathering (oxidation, sedimentation, and biodegradation). The components in reformate and mixed xylenes degrade rapidly and do not bioaccumulate (see section 7). Shoreline contact would not alter the rapid volatilization since the material thickness would be thin and there are no heavier components that would persist.

[23] National Oceanic and Atmospheric Administration (NOAA) and American Petroleum Institute (API). 1994. Inland oil spills: Options for minimizing environmental impacts of freshwater spill response. American Petroleum Institute Publ. No. 4558. Seattle and Washington, D.C.: NOAA and API. 130 pp.

[24] Polak, Jiri, and Benjamin C.-Y. Lu. "Mutual Solubilities of Hydrocarbons and Water at 0 and 25 C." Canadian Journal of Chemistry 51, no. 24 (1973): 4018-023.

GNOME™ Model Results

This section includes an evaluation of the spill scenarios selected for study that includes the Refinery Dock worst-case discharge (WCD) spill scenario at 5,045 barrels along with the Salish Sea worst case spill scenario at 330,000 barrels. The average most probable discharge (AMPD) and maximum most probable discharge (MMPD) scenarios presented in Section 4.2.1 were modeled in ADIOS 2.0, but were not analyzed for trajectory analysis via GNOME™ since the WCD spill scenario would illustrate the worst-case impact.

6.1 GNOME™ Model Overview

Trajectory analysis was performed using the NOAA GNOME™ (General NOAA Operational Modeling Environment) modeling tool courtesy NOAA Office of Response and Restoration. GNOME™ is a component of the NOAA Trajectory Analysis Planner (TAP) used to predict the spread of a spill in certain areas given local bathymetry, shoreline configuration, and tide based currents, winds and volume and type of spilled product.

The GNOME™ model is used to provide a geographic extent of the potential size and duration of a spill. As such, when modeling trajectory, consideration is made to break off the transport for times when evaporation has completed of any remaining product at a specific time or location.

GNOME™ output was prepared showing the spill trajectory taken at least every 12 hours up to 4 days, unless the scenario terminates sooner (e.g. due to evaporation.) Simulations were within the 2-week tidal cycle at a spring tide and also at neap tide, to show the full range of the trajectories.

The GNOME™ modeling tool provides trajectories of both *Forecast* and *Uncertainty*. For conservative purposes, the graphics shown in Figures 6-2 to 6-20 show both the *Forecast* and *Uncertaint*y combined to illustrate the *Estimated Extents*, or the conservatively estimated geographic extents that is shown therein. The associated descriptive data included in Appendix G displays both the *Forecast* and *Uncertainty* spatial extents. The *Uncertainty* is designed to display the possible spatial extent of where spilled materials would be located using a 90% confidence interval given the uncertainties in the directions of currents and wind.

In some scenarios the GNOME™ modeling tool predicts that some spilled liquid will reach the shoreline. In that case a default value of 500 meters was used for the length of shoreline affected depicted for each splot. Given the quantities remaining when shoreline contact occurs (for example, in Figure 6-2, 1 barrel after 12 hours) the model likely overstates the length of shoreline where spilled material would actually be for each individual splot.

6.2 Spill Scenarios

Spill trajectories using the inputs outlined in Table 6-1 were evaluated for spreading and persistence on the water. Results are shown graphically for each location in the following section.

Table 6-1. Trajectory analysis results *Summarized 48-hour trajectory results of the GNOME™ modeling for the spill scenario locations.*

Figure Reference	Location	Volume (bbl)	Wind Speed (mph)	Season	Wind Direction	Tide	Shoreline[1] (miles)	(E+D) >99.5%[2] (hours)
Figure 6-2	Refinery Dock	5,045	9.2	Winter	SE	Spring	7.1	14
Figure 6-3			9.2	Winter	SE	Neap	6.8	14
Figure 6-4			7.5	Summer	SSW	Spring	6.5	16
Figure 6-5			7.5	Summer	SSW	Neap	11.1	16
Figure 6-7	Neah Bay	330,000	14.4	Winter	ESE	Spring	0.3	39
Figure 6-8			14.4	Winter	ESE	Neap	0.0	39
Figure 6-9			7.9	Summer	WSW	Spring	0.3	48
Figure 6-10			7.9	Summer	WSW	Neap	0.3	48
Figure 6-12	Port Angeles	330,000	4.9	Winter	SSW	Spring	0.0	60
Figure 6-13			4.9	Winter	SSW	Neap	0.3	60
Figure 6-14			7.5	Summer	NW	Spring	6.2	55
Figure 6-15			7.5	Summer	NW	Neap	9.3	55
Figure 6-17	Rosario Strait	330,000	12.0	Winter	SE	Spring	11.1	43
Figure 6-18			12.0	Winter	SE	Neap	11.5	43
Figure 6-19			10.4	Summer	WSW	Spring	9.0	48
Figure 6-20			10.4	Summer	SWS	Neap	8.7	48

1 Shoreline: Linear distance of modeled shoreline exposed to spilled material

2 (E+D) >99.5%: In this formula (E+D), E is evaporation and D is dispersion. Value represents number of hours for all spilled material (gasoline) to evaporate and disperse so that there is no material remaining. Although ADIOS predicts the materials will be 100% dissipated, there is the potential for a portion of the spilled material to persist slightly longer if is trapped in shoreline locations without sunlight or oxygen.

6.2.1 Spill Scenario – Refinery Dock Trajectory Modeling - GNOME™

Wind conditions for the GNOME™ Refinery Dock spill scenario were gathered from a 2001 to 2004 study which measured wind speed and direction in the area near the Refinery. The mean wind speed for that time period was 9.2 mph from the SE for the winter season (October through March) and 7.5 mph from the SSW for the summer season (April through September). Rose plots for the summer and winter seasons were used to determine the wind directions as shown in Figure 6-1.

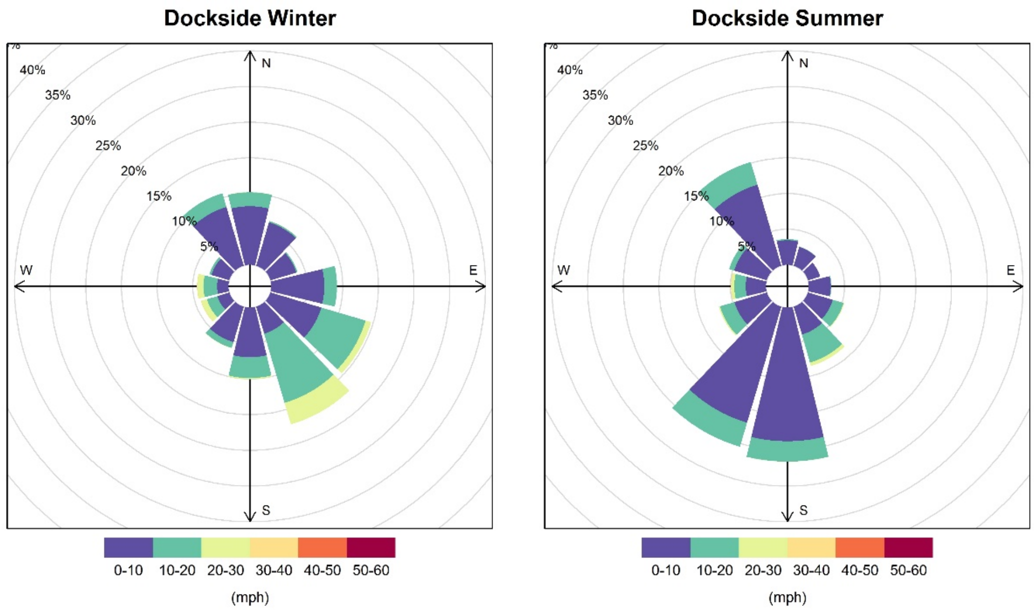
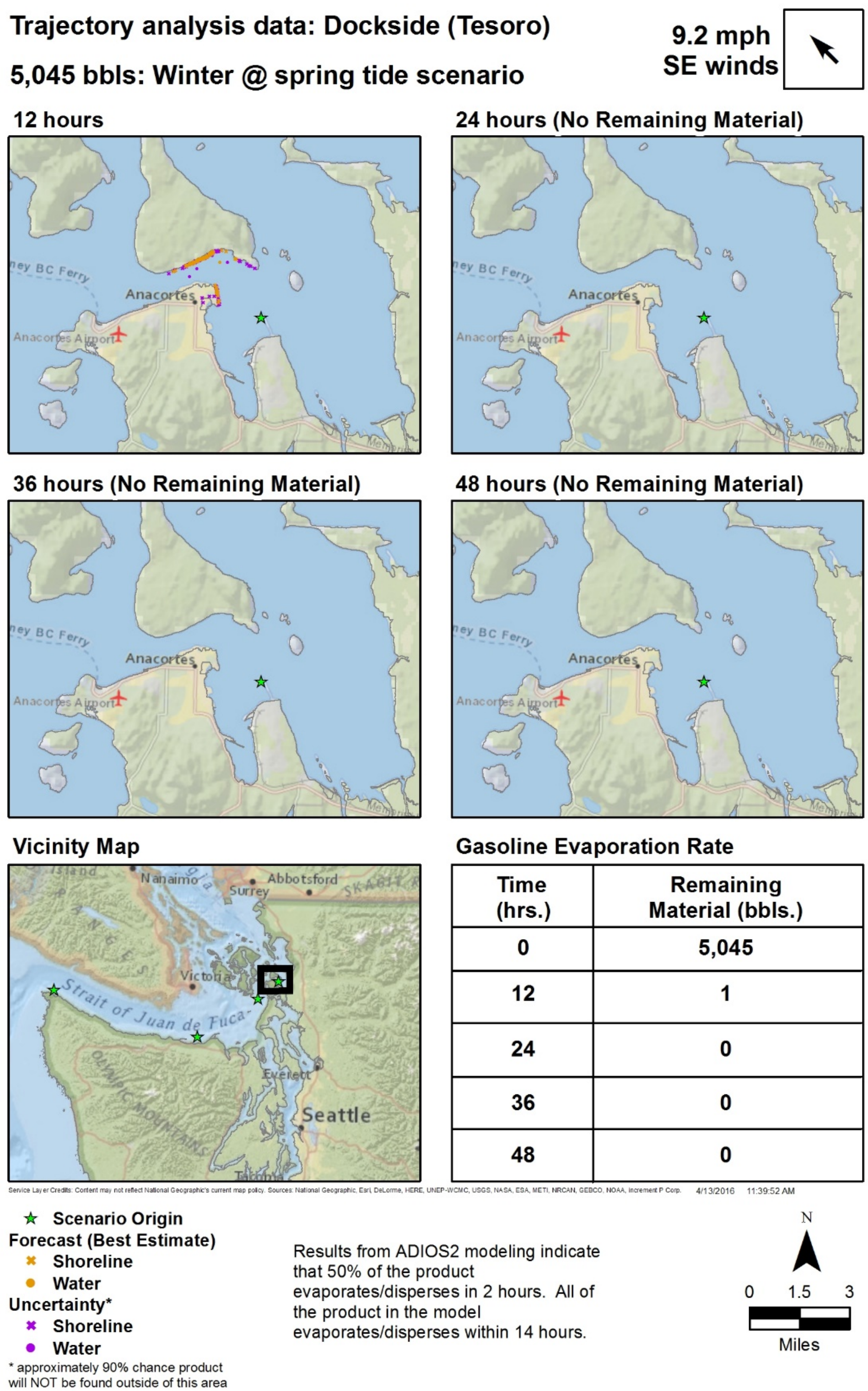


Figure 6-1. Wind Rose Plots: Refinery Dock – winter and summer seasons. Plots of wind directions gathered from the Refinery area for the years 2001 to 2004.

Tidal conditions for the GNOME™ Refinery Dock scenario were gathered from the NOAA tidal predictions information using the Cherry Point station (Station Id: 9449424). The variability in tidal conditions were captured using the winter month of February with a spring tide during February 6th – February 8th and a neap tide during February 25th – February 27th. The summer month of July was used with a spring tide of July 4th – July 6th and a neap tide during July 25th – July 27th [25].

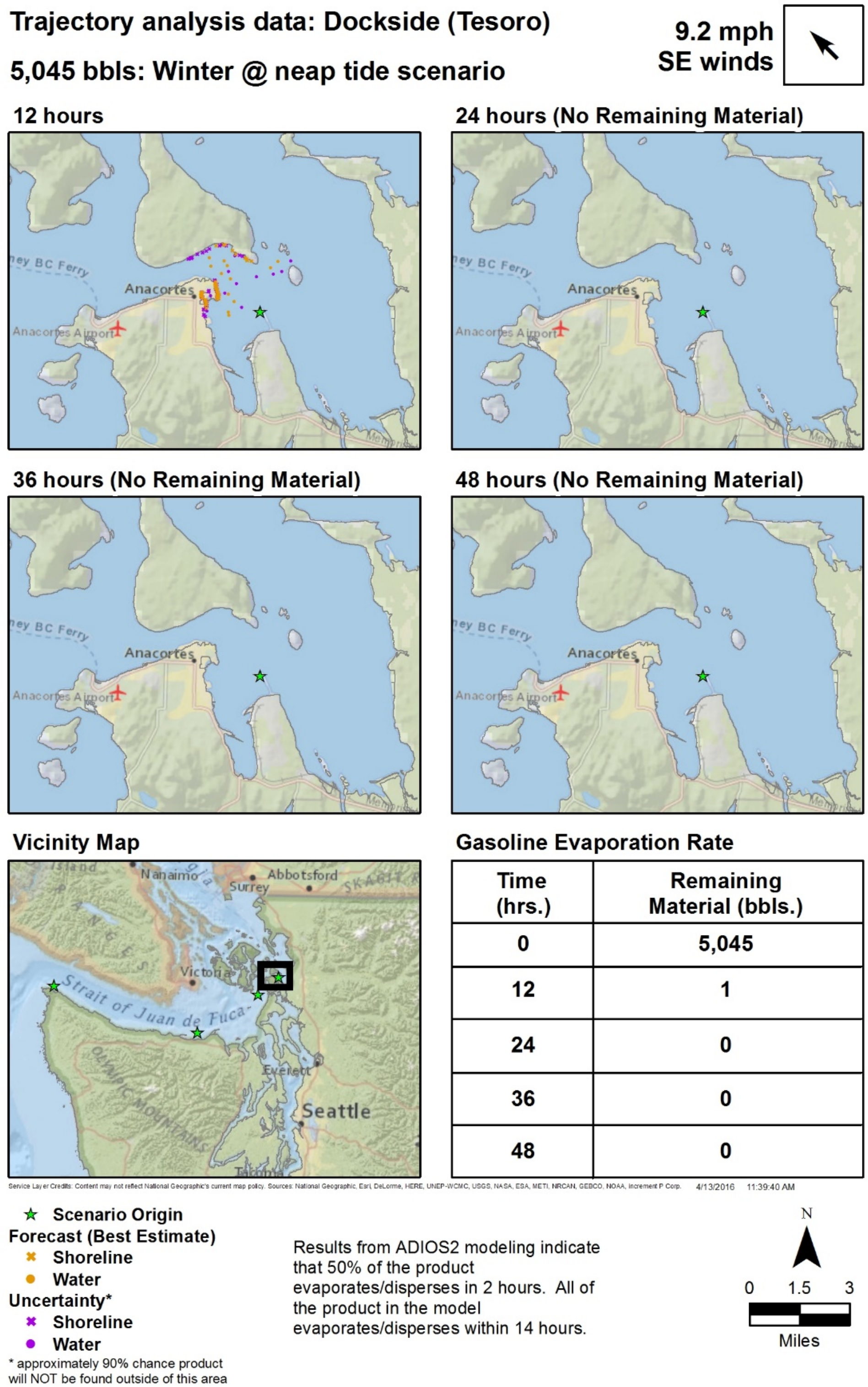
25 https://tidesandcurrents.noaa.gov/tide_predictions.html?gid=1415



Time (hrs.)	Remaining Material (bbls.)
0	5,045
12	1
24	0
36	0
48	0

Figure 6-2. Trajectory analysis data: Refinery Dock (gasoline) – winter season with spring tide 9.2 mph SE winds

Percent gasoline remaining floating through time for gasoline spill scenarios of 5045 bbl with relative influence of evaporation and dispersion.



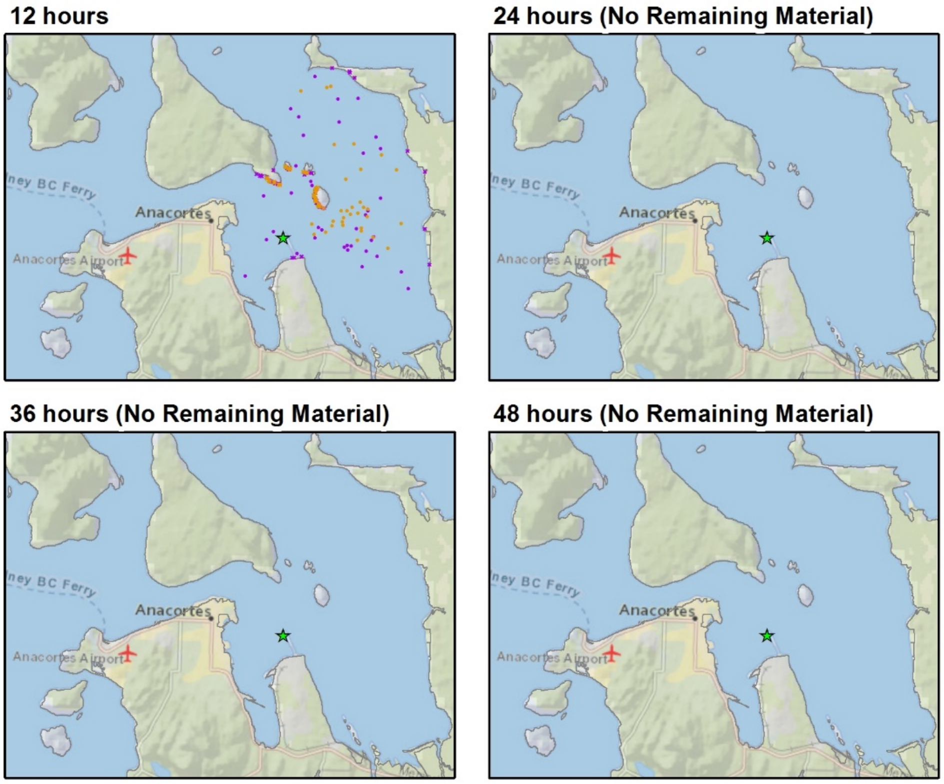
Time (hrs.)	Remaining Material (bbls.)
0	5,045
12	1
24	0
36	0
48	0

Figure 6-3. Trajectory analysis data: Refinery Dock (gasoline) – winter season with neap tide 9.2 mph SE winds
Percent gasoline remaining floating through time for gasoline spill scenarios of 5045 bbl with relative influence of evaporation and dispersion.

Trajectory analysis data: Dockside (Tesoro)

5,045 bbls: Summer @ spring tide scenario

7.5 mph SSW winds



Vicinity Map

Gasoline Evaporation Rate

Time (hrs.)	Remaining Material (bbls.)
0	5,045
12	3
24	0
36	0
48	0

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★ **Scenario Origin**
Forecast (Best Estimate)
✖ **Shoreline**
● **Water**
Uncertainty*
✖ **Shoreline**
● **Water**
* approximately 90% chance product will NOT be found outside of this area

Results from ADIOS2 modeling indicate that 50% of the product evaporates/disperses in 2 hours. All of the product in the model evaporates/disperses within 16 hours.

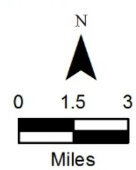


Figure 6-4. Trajectory analysis data: Refinery Dock (gasoline) – summer season with spring tide 7.5 mph SSW winds *Percent oil gasoline remaining floating through time for gasoline spill scenarios of 5045 bbl with relative influence of evaporation and dispersion.*

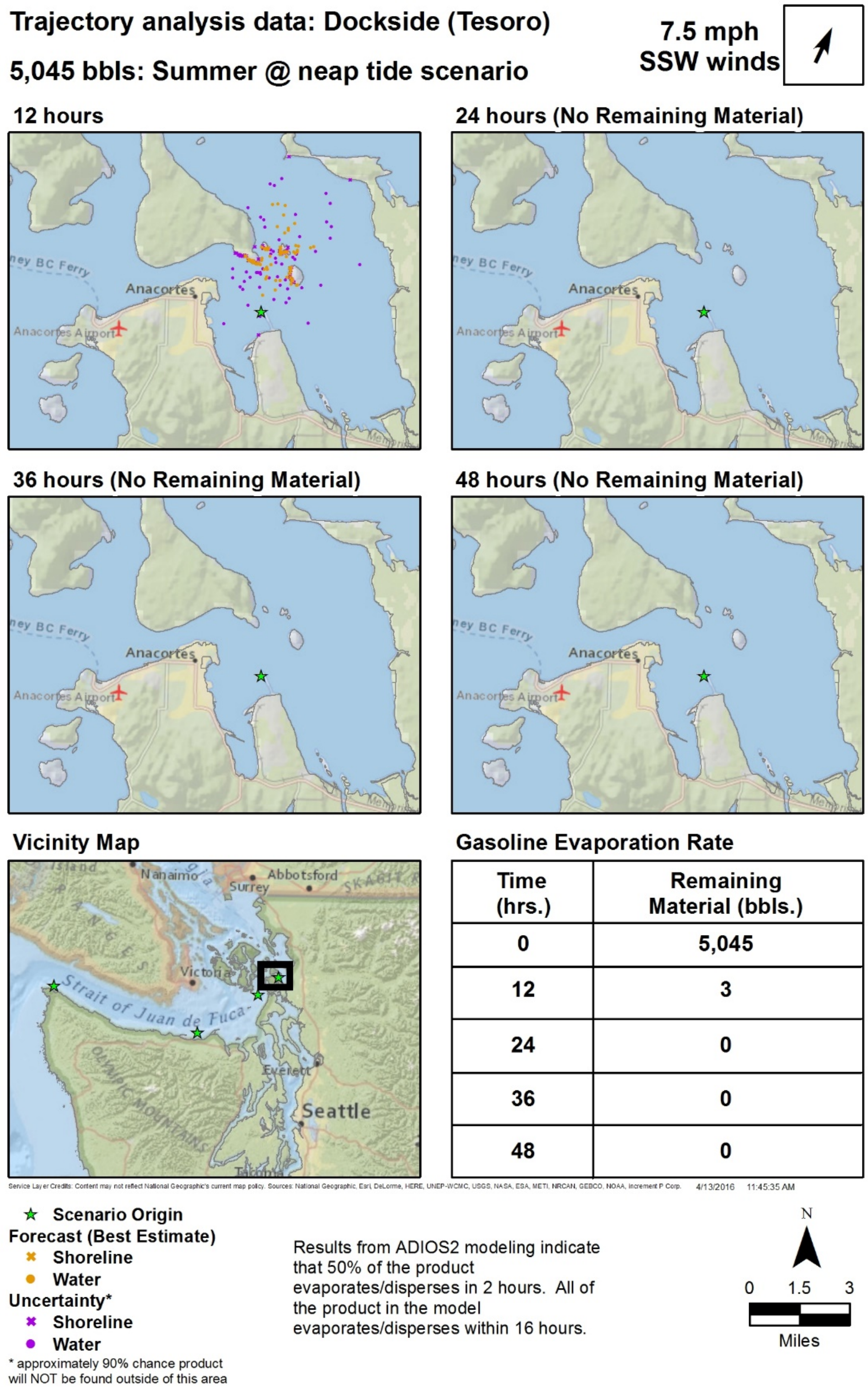


Figure 6-5. Trajectory analysis data: Refinery Dock (gasoline) – summer season with neap tide 7.5 mph SSW winds
Percent gasoline remaining floating through time for gasoline spill scenarios of 5045 bbl with relative influence of evaporation and dispersion.

6.2.2 Vessel Release Scenario Evaluation

Potential vessel releases were considered for three locations in the Salish Sea.

6.2.2.1 Neah Bay (STR A) Scenario Tidal and Wind Conditions

Wind conditions for the GNOME™ Neah Bay scenario were gathered from the NOAA buoy station located at the mouth of the Strait of Juan de Fuca (StationID 46087) using wind direction and speed readings from the years of 2012 to 2015. The mean wind speed for that time period was 14.4 mph from the ESE for the winter season (October through March) and 7.9 mph from the WSW for the summer season (April through September). Rose plots for the summer and winter seasons were used to determine the wind directions as shown in Figure 6-6.

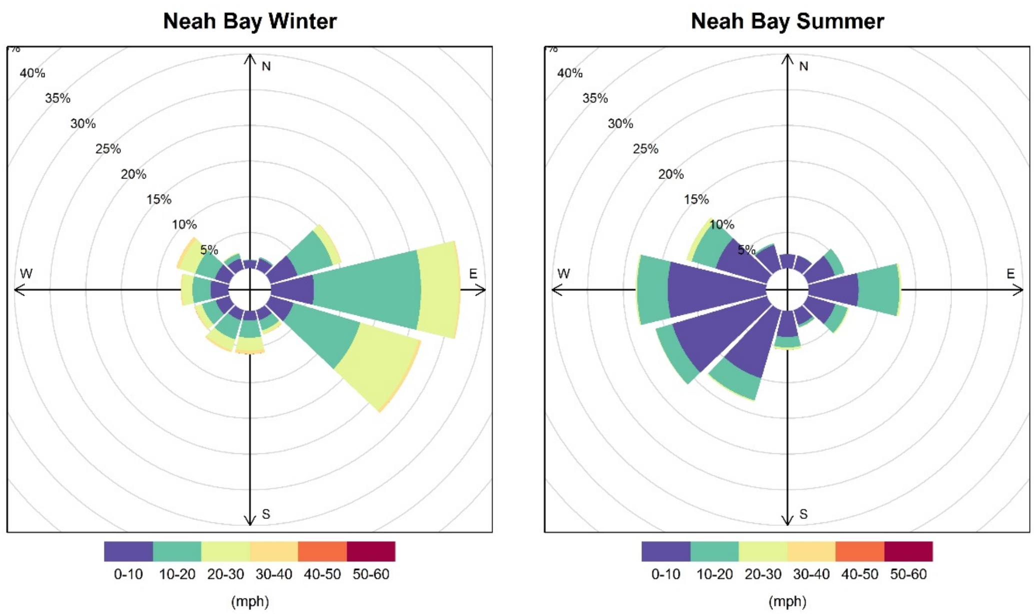


Figure 6-6. Wind Rose Plots: Neah Bay (STR-A) – winter and summer seasons. *Plots of wind directions gathered from the Neah Bay area for the years 2012 to 2015.*

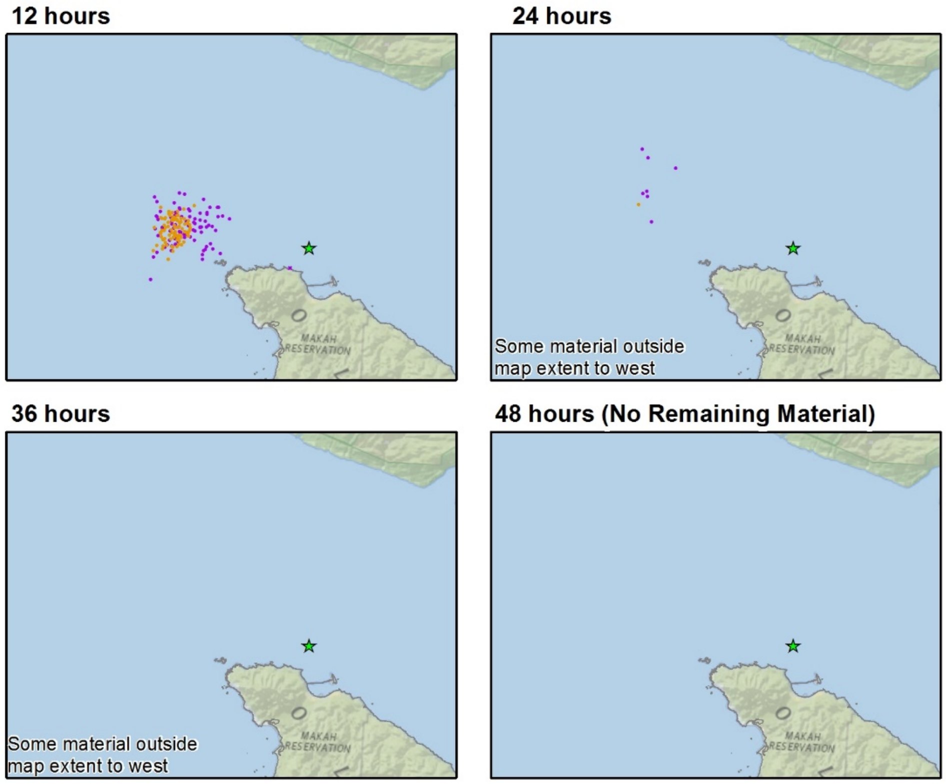
Tidal conditions for the GNOME™ Neah Bay scenario were gathered from the NOAA tidal predictions information using the Strait of Juan de Fuca (StationID 46087). The variability in tidal conditions were captured using the winter month of February with a spring tide during February 7th – February 9th and a neap tide during February 27th – February 29th. The summer month of July was used with a spring tide of July 4th – July 6th and a neap tide during July 11th – July 13th[26].

[26] https://tidesandcurrents.noaa.gov/tide_predictions.html?gid=1415

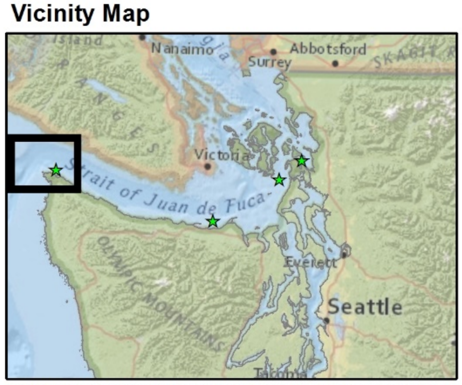
Trajectory analysis data: Neah Bay (STR-A)

330,000 bbls: Winter @ spring tide scenario

14.4 mph ESE winds



Vicinity Map



Gasoline Evaporation Rate

Time (hrs.)	Remaining Material (bbls.)
0	330,000
12	20,421
24	1,270
36	3
48	0

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★ Scenario Origin
Forecast (Best Estimate)
- ✖ Shoreline
- ● Water

Uncertainty*
- ✖ Shoreline
- ● Water

* approximately 90% chance product will NOT be found outside of this area

Results from ADIOS2 modeling indicate that 50% of the product evaporates/disperses in 4 hours. All of the product in the model evaporates/disperses within 39 hours.

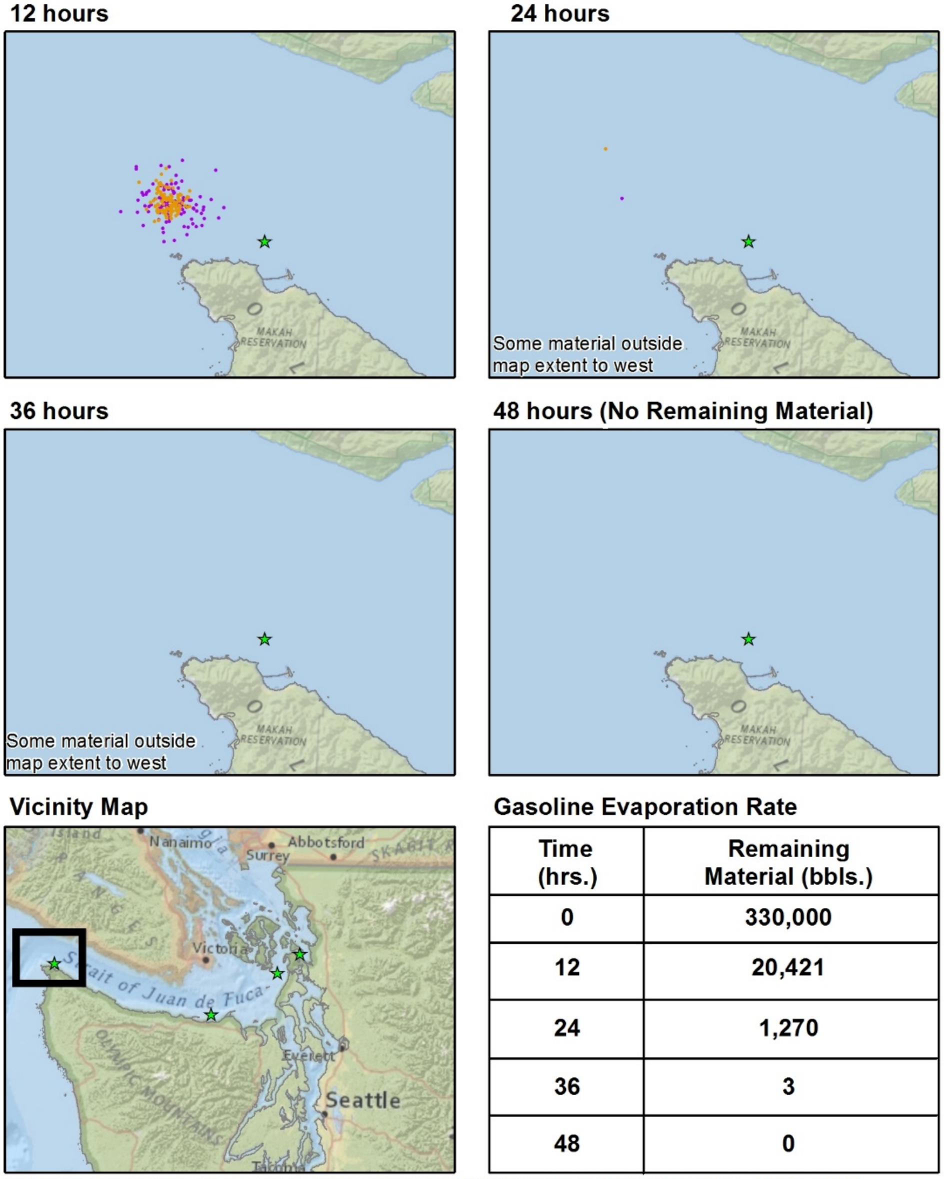
N
0 3.25 6.5
Miles

Figure 6-7. Trajectory analysis data: Neah Bay (gasoline) – winter season with spring tide 14.4 mph ESE winds
Percent gasoline remaining floating through time for gasoline spill scenarios of 330,000 bbl with relative influence of evaporation and dispersion.

Trajectory analysis data: Neah Bay (STR-A)

330,000 bbls: Winter @ neap tide scenario

14.4 mph ESE winds



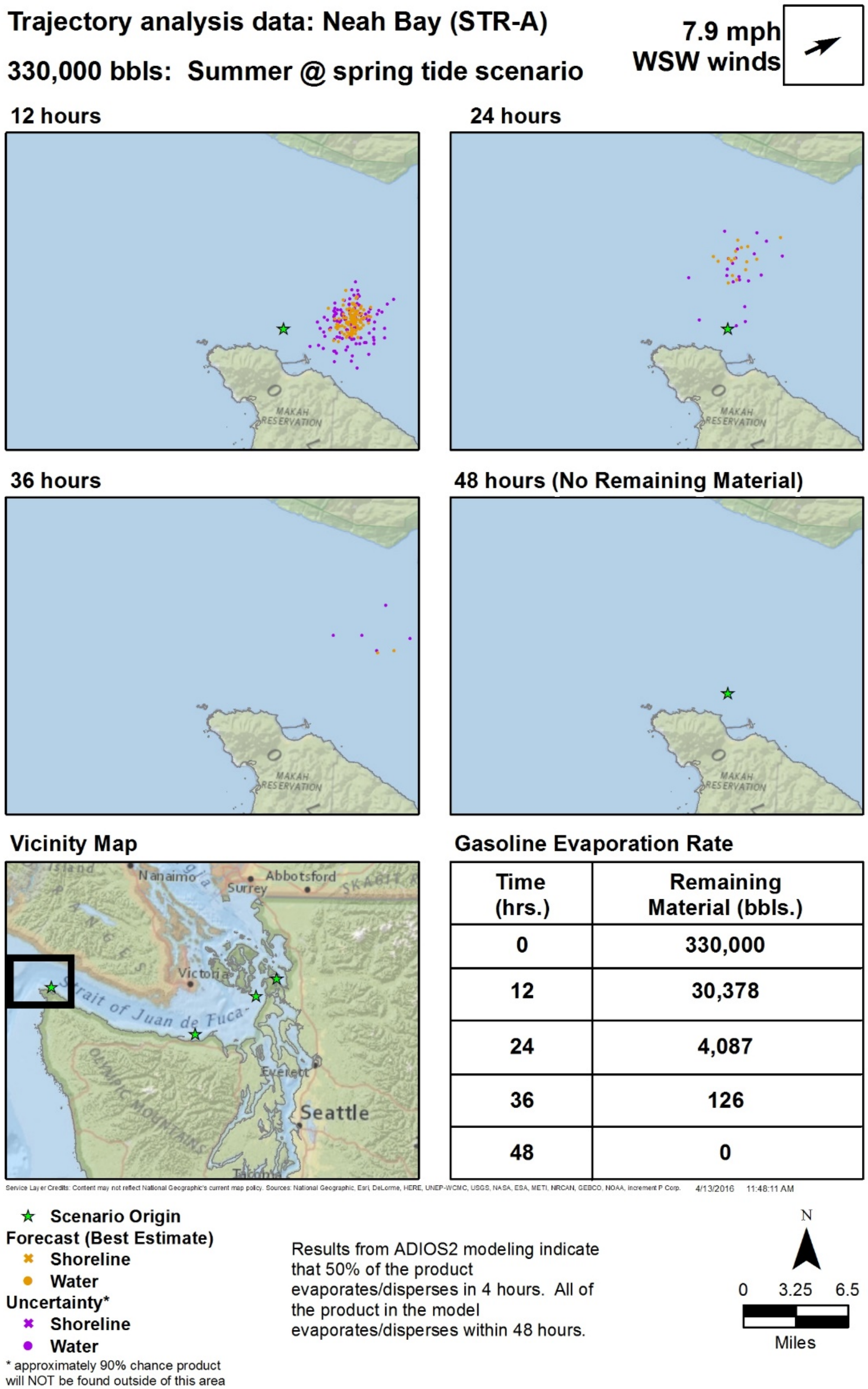
Time (hrs.)	Remaining Material (bbls.)
0	330,000
12	20,421
24	1,270
36	3
48	0

Scenario Origin
Forecast (Best Estimate)
Shoreline
Water
Uncertainty*
Shoreline
Water
* approximately 90% chance product will NOT be found outside of this area

Results from ADIOS2 modeling indicate that 50% of the product evaporates/disperses in 4 hours. All of the product in the model evaporates/disperses within 39 hours.

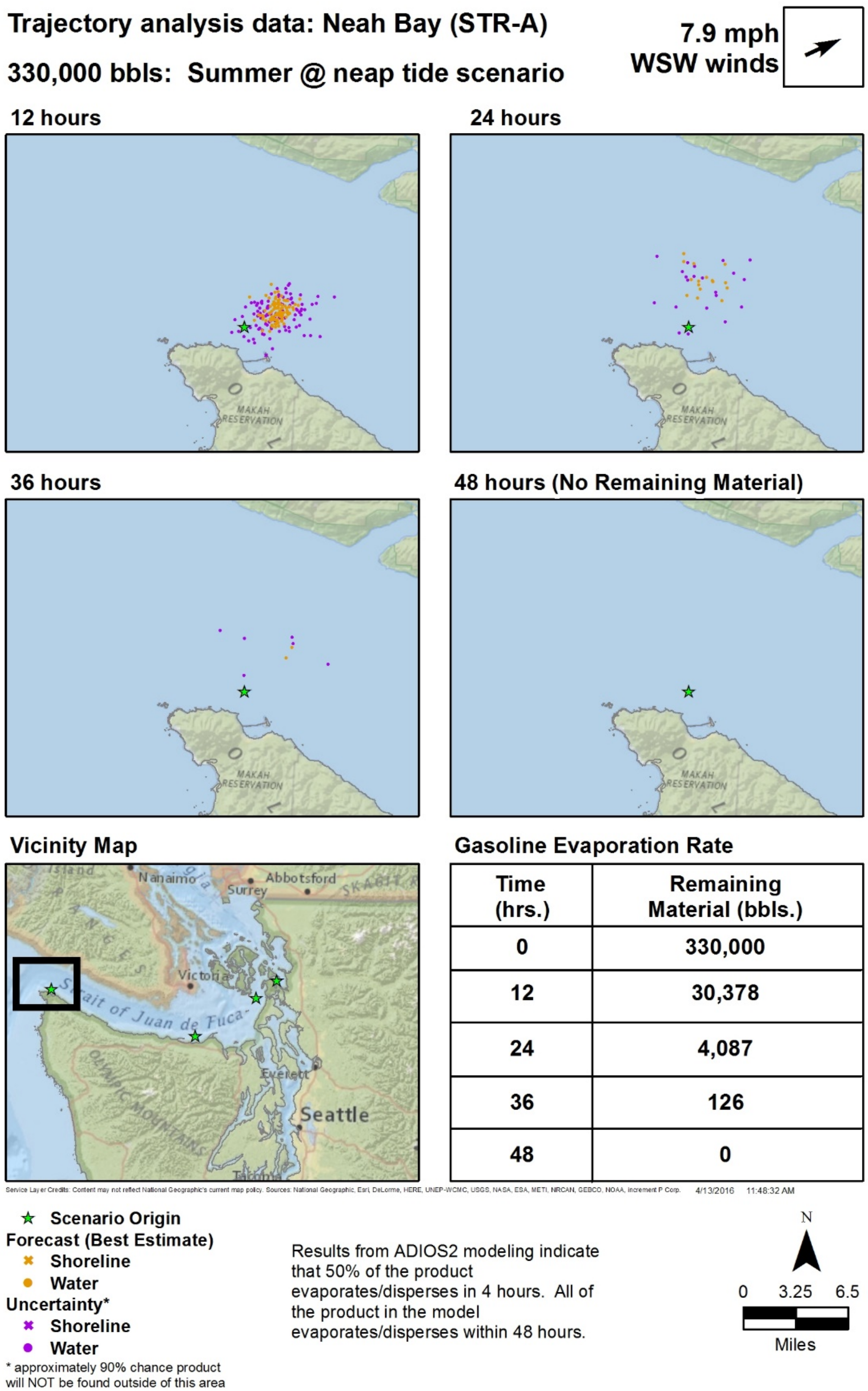
N
0 3.25 6.5
Miles

Figure 6-8. Trajectory analysis data: Neah Bay (gasoline) – winter season with neap tide 14.4 mph ESE winds
Percent gasoline remaining floating through time for gasoline spill scenarios of 330,000 bbl with relative influence of evaporation and dispersion.



Time (hrs.)	Remaining Material (bbls.)
0	330,000
12	30,378
24	4,087
36	126
48	0

Figure 6-9. Trajectory analysis data: Neah Bay (gasoline) – <u>summer season with spring tide 7.9 mph WSW winds</u>
Percent gasoline remaining floating through time for gasoline spill scenarios of 330,000 bbl with relative influence of evaporation and dispersion.



Time (hrs.)	Remaining Material (bbls.)
0	330,000
12	30,378
24	4,087
36	126
48	0

Figure 6-10. Trajectory analysis data: Neah Bay (gasoline) – <u>summer season with neap tide 7.9 mph WSW winds</u>
Percent gasoline remaining floating through time for gasoline spill scenarios of 330,000 bbl with relative influence of evaporation and dispersion.

6.2.2.2 Port Angeles (STR H) Scenario Tidal and Wind Conditions

Wind conditions for the GNOME™ Port Angeles scenario were gathered from the NOAA station located near the City of Port Angeles (StationID 944409) using wind direction and speed readings from the years of 2012 to 2015. The mean wind speed for that time period was 4.9 mph from the SSW for the winter season (October through March) and 7.5 mph from the NW for the summer season (April through September). Rose plots for the summer and winter seasons were used to determine the wind directions as shown in Figure 6-11.

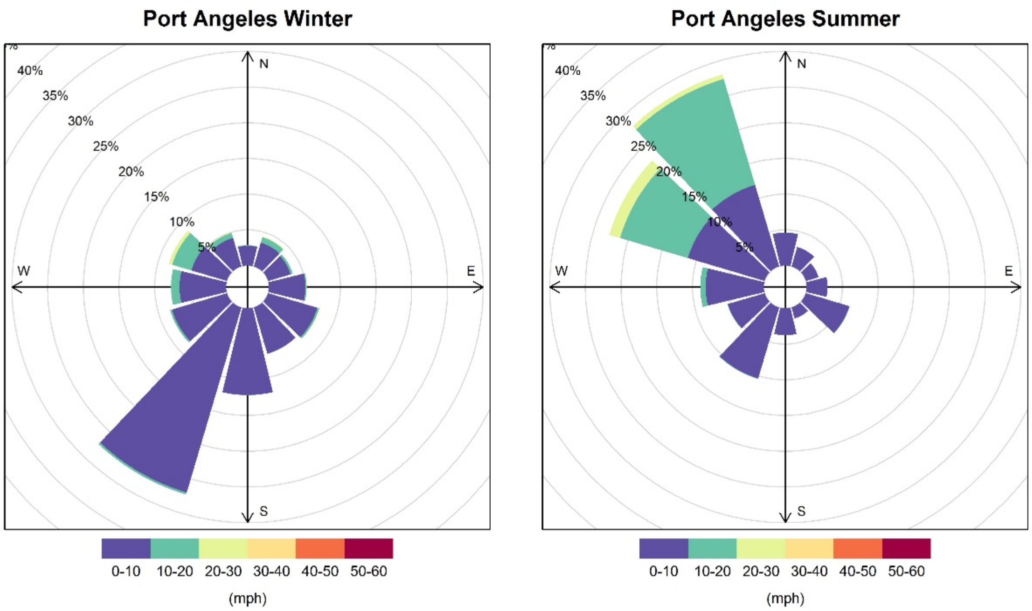
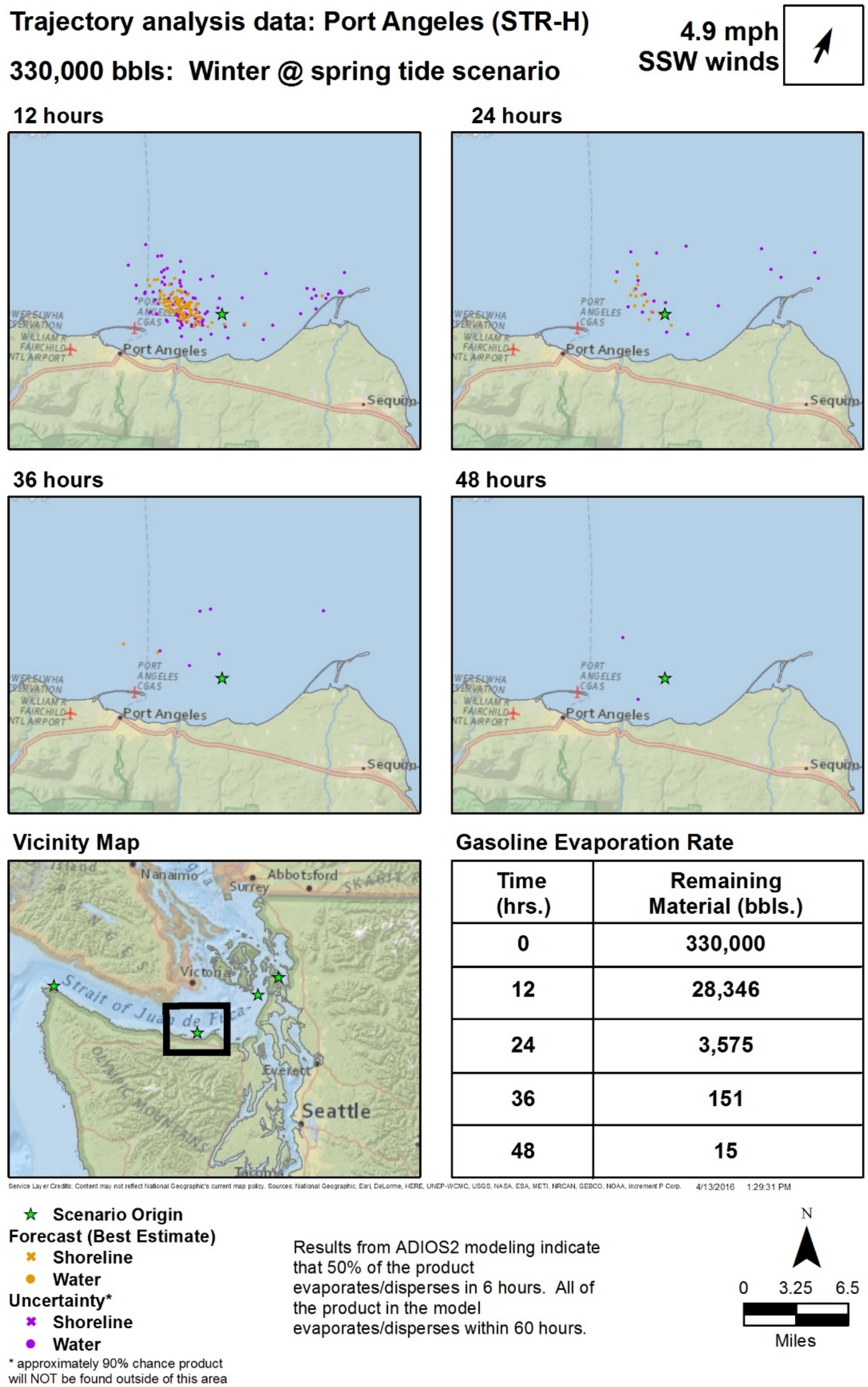


Figure 6-11. Wind Rose Plots: Plots of wind directions gathered from the Port Angeles area for the years 2012 to 2015. Port Angeles (STR-H) – winter and summer seasons

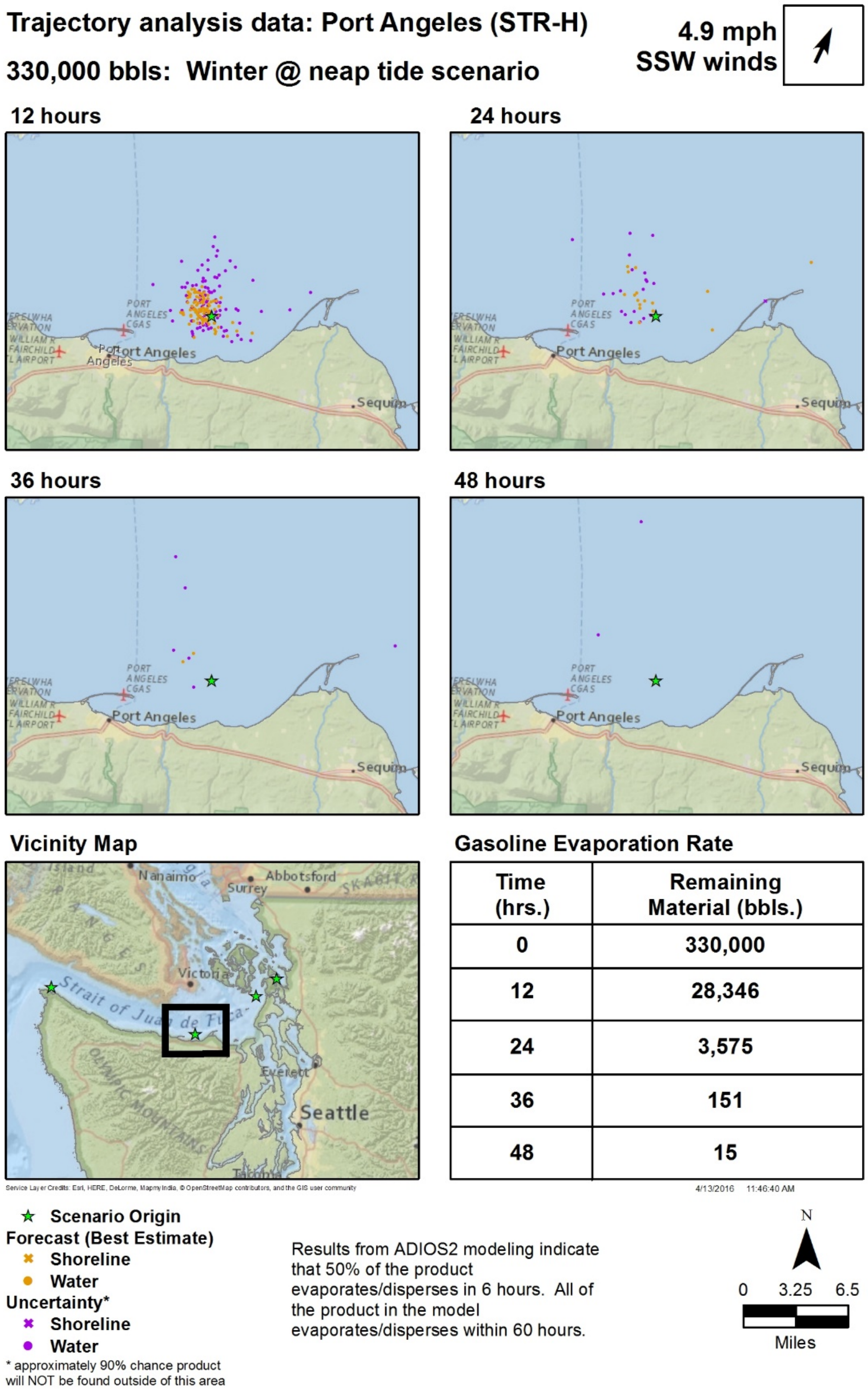
Tidal conditions for the GNOME™ Port Angeles scenario were gathered from the NOAA tidal predictions information using the station located near the City of Port Angeles (StationID 944409). The variability in tidal conditions were captured using the winter month of February with a spring tide during February 6th – February 8th and a neap tide during February 27th – February 29th. The summer month of July was used with a spring tide of July 3th – July 5th and a neap tide during July 23rd – July 25th[27].

[27] https://tidesandcurrents.noaa.gov/tide_predictions.html?gid=1415



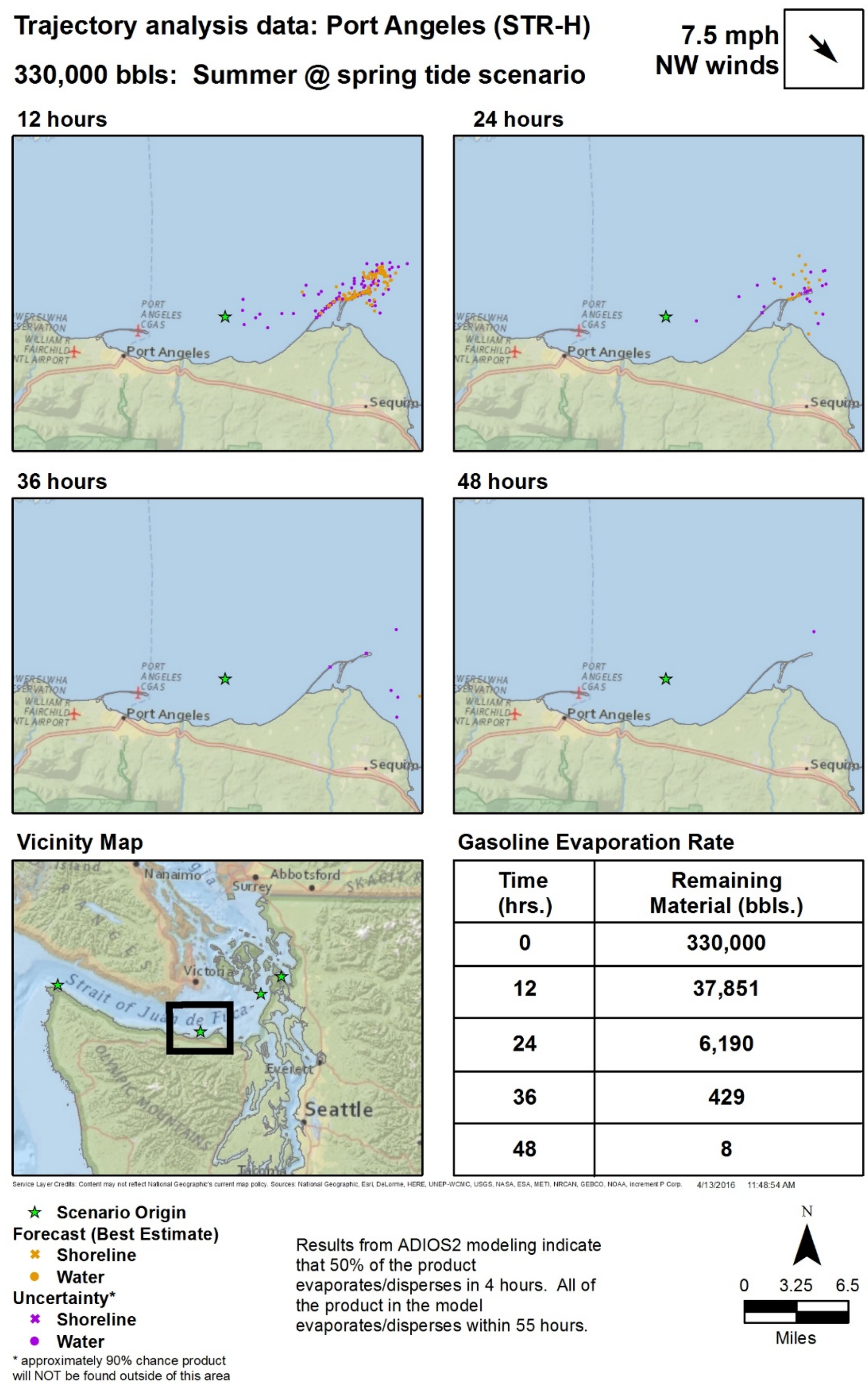
Time (hrs.)	Remaining Material (bbls.)
0	330,000
12	28,346
24	3,575
36	151
48	15

Figure 6-12. Trajectory analysis data: Port Angeles (gasoline) – <u>winter season with spring tide 4.9 mph SSW winds</u>
Percent gasoline remaining floating through time for gasoline spill scenarios of 330,000 bbl with relative influence of evaporation and dispersion.



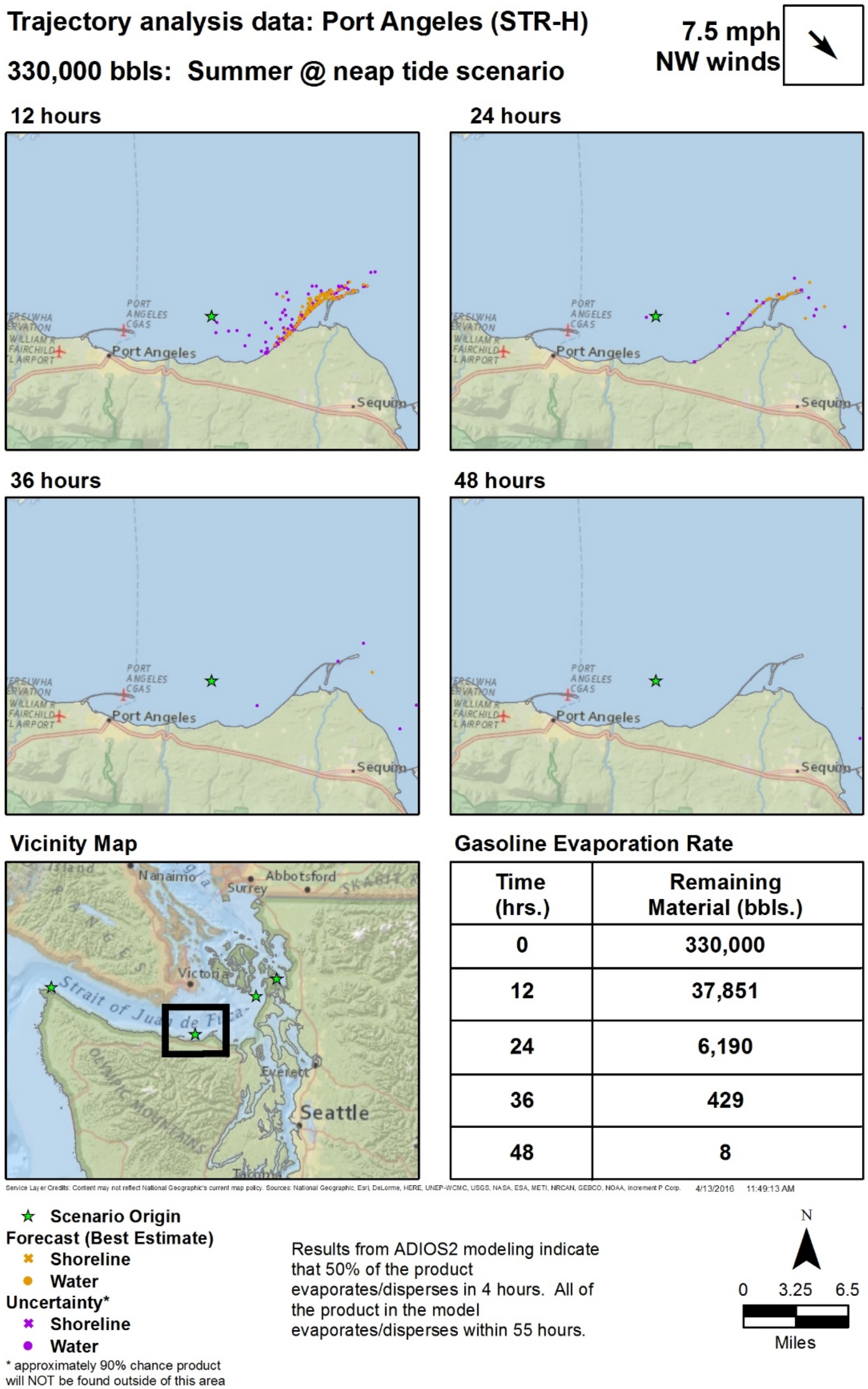
Time (hrs.)	Remaining Material (bbls.)
0	330,000
12	28,346
24	3,575
36	151
48	15

Figure 6-13. Trajectory analysis data: Port Angeles (gasoline) – <u>winter season with spring tide 4.9 mph SSW winds</u>
Percent gasoline remaining floating through time for gasoline spill scenarios of 330,000 bbl with relative influence of evaporation and dispersion.



Time (hrs.)	Remaining Material (bbls.)
0	330,000
12	37,851
24	6,190
36	429
48	8

Figure 6-14. Trajectory analysis data: Port Angeles (gasoline) – summer season with spring tide 7.5 mph NW winds *Percent gasoline remaining floating through time for gasoline spill scenarios of 330,000 bbl with relative influence of evaporation and dispersion.*



Time (hrs.)	Remaining Material (bbls.)
0	330,000
12	37,851
24	6,190
36	429
48	8

Figure 6-15. Trajectory analysis data: Port Angeles (gasoline) – summer season with neap tide 7.5 mph NW winds
Percent gasoline remaining floating through time for gasoline spill scenarios of 330,000 bbl with relative influence of evaporation and dispersion.

6.2.2.3 Rosario Strait (SJI O) Scenario Tidal and Wind Conditions

Wind conditions for the GNOME™ Rosario Strait scenario were gathered from the NOAA station located on Smith Island (StationID SISW1) using wind direction and speed readings from the years of 2012 to 2015. The mean wind speed for that time period was 12.0 mph from the SE for the winter season (October through March) and 10.4 mph from the WSW for the summer season (April through September). Rose plots for the summer and winter seasons were used to determine the wind directions as shown in Figure 6-16.

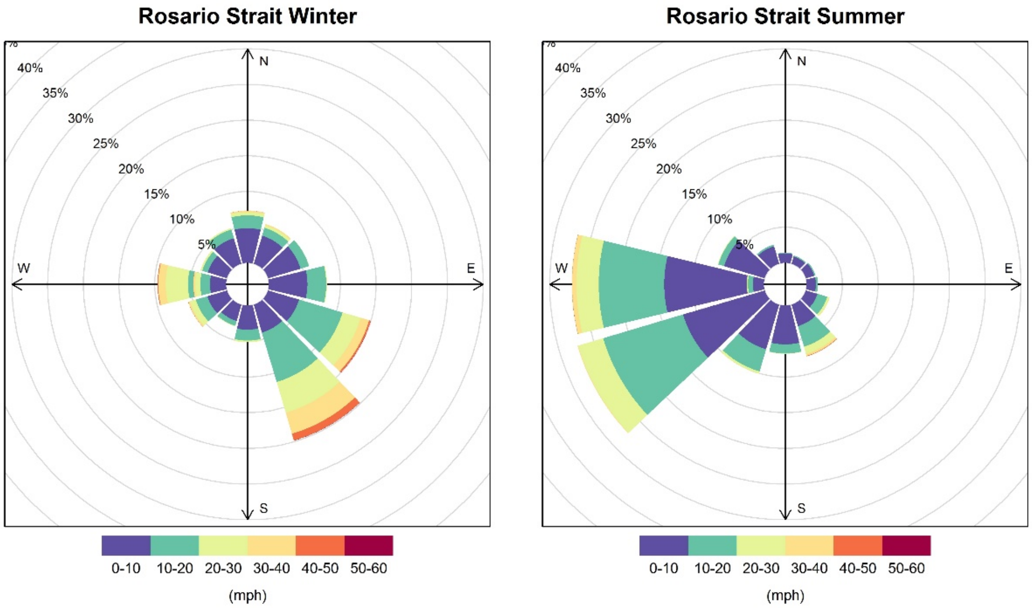


Figure 6-16. Wind Rose Plots: Rosario Strait (SJI-O) – winter and summer seasons Plots of wind directions gathered from the Rosario Strait area for the years 2012 to 2015.

Tidal conditions for the GNOME™ Rosario Strait scenario were gathered from the NOAA tidal predictions information using the station located on Smith Island (StationID SISW1). The variability in tidal conditions were captured using the winter month of February with a spring tide during February 6th – February 8th and a neap tide during February 27th – February 29th. The summer month of July was used with a spring tide of July 3rd – July 5th and a neap tide during July 24th – July 26th [28].

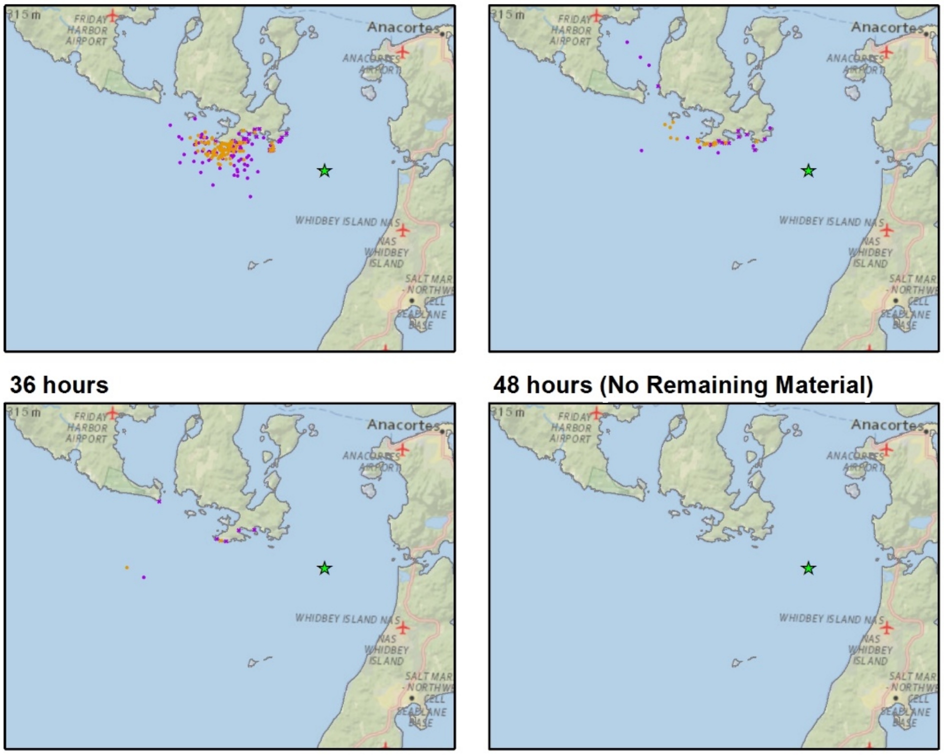
[28] https://tidesandcurrents.noaa.gov/tide_predictions.html?gid=1415

Trajectory analysis data: Rosario Strait (SJI-O)

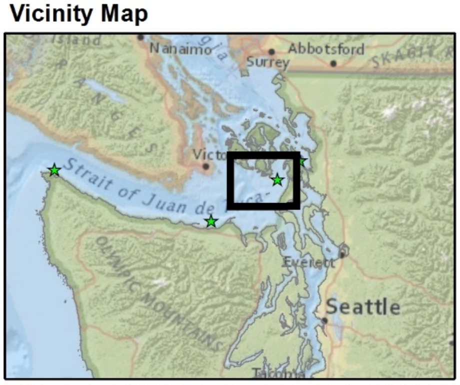
330,000 bbls: Winter @ spring tide scenario

12.0 mph SE winds

12 hours | **24 hours** | **36 hours** | **48 hours (No Remaining Material)**



Vicinity Map



Gasoline Evaporation Rate

Time (hrs.)	Remaining Material (bbls.)
0	330,000
12	24,180
24	2,132
36	27
48	0

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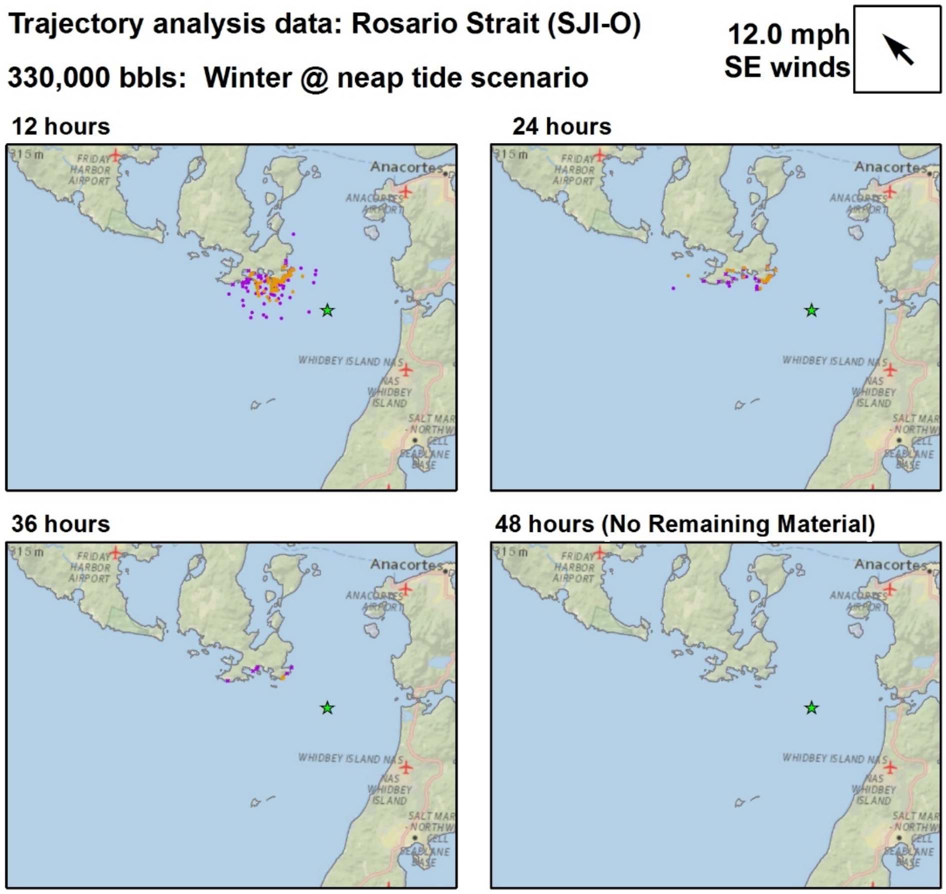
★ Scenario Origin
Forecast (Best Estimate)
✖ Shoreline
● Water
Uncertainty*
✖ Shoreline
● Water
* approximately 90% chance product will NOT be found outside of this area

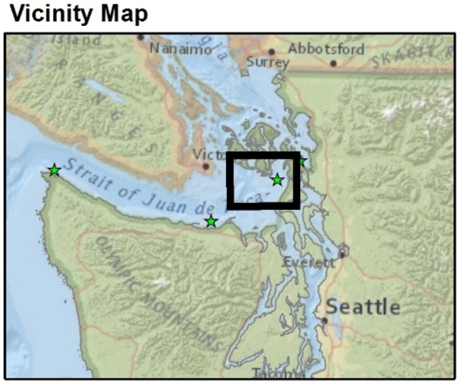
Results from ADIOS2 modeling indicate that 50% of the product evaporates/disperses in 4 hours. All of the product in the model evaporates/disperses within 43 hours.

N
0 3.25 6.5
Miles

Figure 6-17. Trajectory analysis data: Rosario Strait (gasoline) – winter season with spring tide 12.0 mph SE winds
Percent gasoline remaining floating through time for gasoline spill scenarios of 330,000 bbl with relative influence of evaporation and dispersion.



Vicinity Map



Gasoline Evaporation Rate

Time (hrs.)	Remaining Material (bbls.)
0	330,000
12	24,180
24	2,132
36	27
48	0

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp. 4/13/2016 11:50:21 AM

★ Scenario Origin
Forecast (Best Estimate)
✖ Shoreline
● Water
Uncertainty*
✖ Shoreline
● Water
* approximately 90% chance product will NOT be found outside of this area

Results from ADIOS2 modeling indicate that 50% of the product evaporates/disperses in 4 hours. All of the product in the model evaporates/disperses within 43 hours.

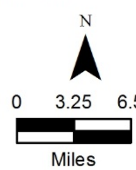
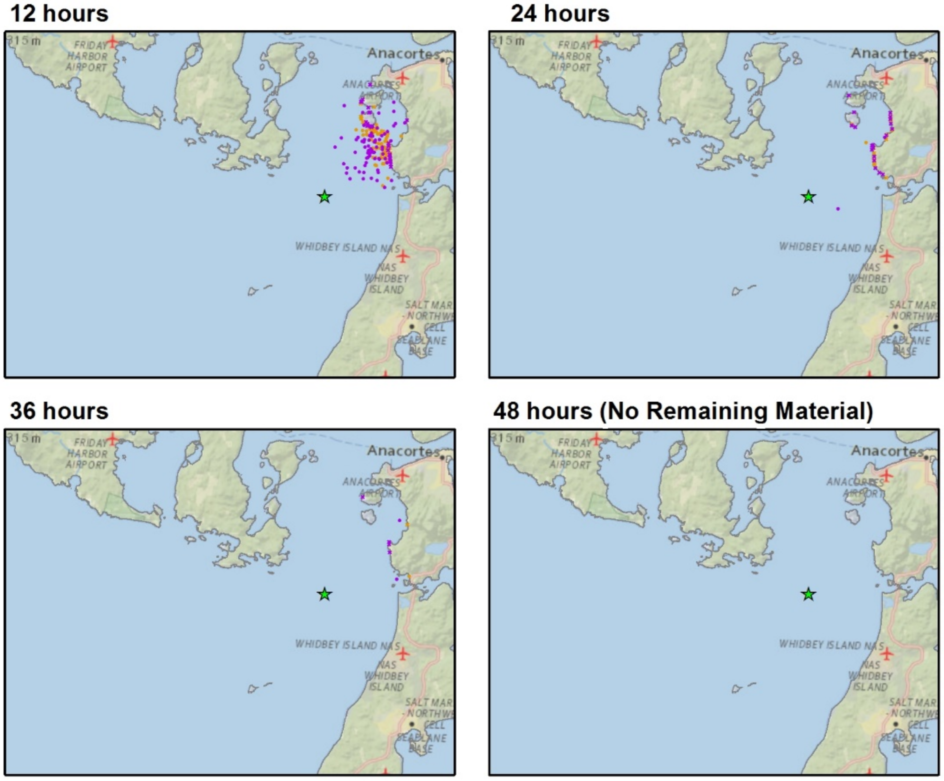


Figure 6-18. Trajectory analysis data: Rosario Strait (gasoline) – <u>winter season with neap tide 12.0 mph SE winds</u>
Percent gasoline remaining floating through time for gasoline spill scenarios of 330,000 bbl with relative influence of evaporation and dispersion.

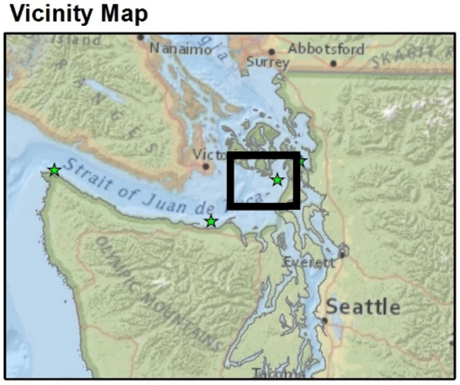
Trajectory analysis data: Rosario Strait (SJI-O)

330,000 bbls: Summer @ spring tide scenario

10.4 mph WSW winds



Vicinity Map



Gasoline Evaporation Rate

Time (hrs.)	Remaining Material (bbls.)
0	330,000
12	28,346
24	3,575
36	151
48	0

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp. 4/13/2016 11:50:03 AM

★ Scenario Origin
Forecast (Best Estimate)
- ✖ Shoreline
- ● Water

Uncertainty*
- ✖ Shoreline
- ● Water

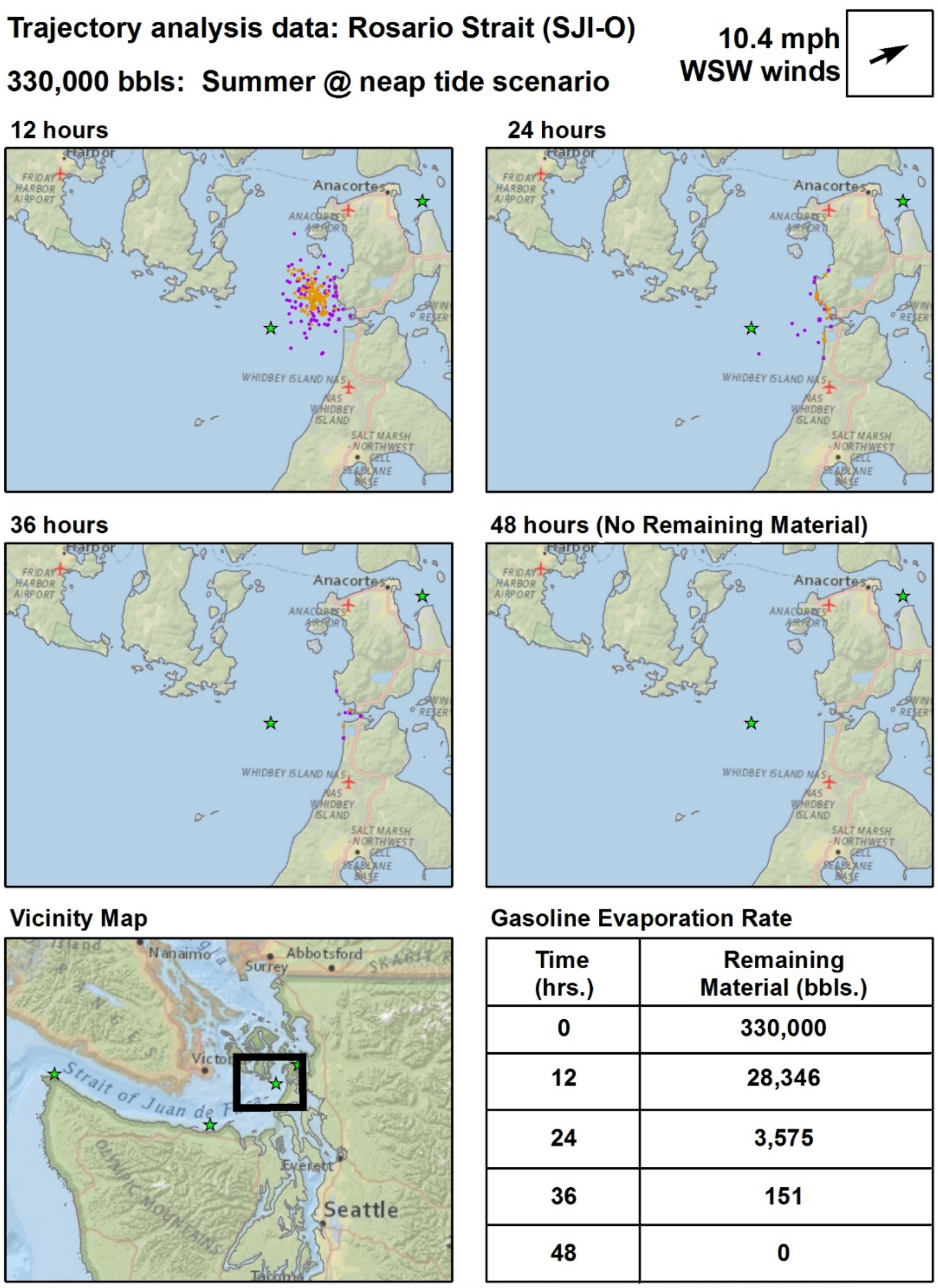
* approximately 90% chance product will NOT be found outside of this area

Results from ADIOS2 modeling indicate that 50% of the product evaporates/disperses in 4 hours. All of the product in the model evaporates/disperses within 48 hours.

N

0 3.25 6.5
Miles

Figure 6-19. Trajectory analysis data: Rosario Strait (gasoline) – summer season with spring tide 10.4 mph WSW winds
Percent gasoline remaining floating through time for gasoline spill scenarios of 330,000 bbl with relative influence of evaporation and dispersion.



Time (hrs.)	Remaining Material (bbls.)
0	330,000
12	28,346
24	3,575
36	151
48	0

Service Layer Credits: Content may not reflect National Geographic's current map policy. Sources: National Geographic, Esri, DeLorme, HERE, UNEP-WCMC, USGS, NASA, ESA, METI, NRCAN, GEBCO, NOAA, increment P Corp. 4/13/2016 1:38:04 PM

★ Scenario Origin
Forecast (Best Estimate)
✖ Shoreline
● Water
Uncertainty*
✖ Shoreline
● Water
* approximately 90% chance product will NOT be found outside of this area

Results from ADIOS2 modeling indicate that 50% of the product evaporates/disperses in 4 hours. All of the product in the model evaporates/disperses within 48 hours.

N
0 3.25 6.5
Miles

Figure 6-20. Trajectory analysis data: Rosario Strait (gasoline) – summer season with neap tide 10.4 mph WSW winds
Percent gasoline remaining floating through time for gasoline spill scenarios of 330,000 bbl with relative influence of evaporation and dispersion

6.3 GNOME™ Trajectory Summary

The GNOME™ trajectories indicate rapid spreading of light materials followed by dissipation primarily via evaporation. While shoreline contact occurs in certain combinations of meteorological and tidal conditions, it also dissipates rapidly and is non-persistent. Summer and winter seasons have differences in the prevailing winds that could result in exposure of different locations from similar spill scenarios. It should always be noted that a trajectory represents a point in time. A spill that occurs at high tide or low tide on the same day could also expose different areas to the materials. The trajectories are used as a planning tool to examine how much open water or shoreline area could be affected, for how long. These factors inform an evaluation of the risks to natural resources.

Potential Adverse Effects

This section reviews available information on the toxicity of reformate and mixed xylenes to humans and aquatic life and discusses potential environmental risks and exposure times associated with a spill scenario. It considers issues of uptake by aquatic life and considers the nature of these materials, which tend to be less dense than seawater and do not accumulate in the tissues of fish or other aquatic life.[29] It also presents Occupational, Safety and Health Administration (OSHA) and National Institute of Occupational Safety and Health (NIOSH) criteria for human health.

7.1 General Environmental Toxicity Information

Accumulation of reformate or mixed xylenes by marine life is dependent on the ability of the compound to be absorbed in the body, the length of exposure, and the organism's ability to metabolize the compound. Generally, chemicals in solution in water are considered more bioavailable than chemicals in solid or adsorbed forms. Reformate and mixed xylenes evaporate rapidly and have low solubility in water and will be less bioavailable. Once evaporated into air, reformate and mixed xylenes are broken down with a half-life of 16 – 28 hours. As such, in most instances potential exposure times would be considerably less than the times frequently used in laboratory exposure studies.

Many studies have examined the potential effect of reformate and xylenes in marine and terrestrial creatures. These studies range from hours of exposure to weeks at varying exposure levels. A number of studies analyzed components of reformate and xylenes in vertebrate and invertebrate animals such as fish, shrimp, and other crustaceans as well as rats, rabbits, mice, and guinea pigs (HSDB, 2009).

In general, these studies found that compounds in reformate and xylenes are metabolized and excreted in both groups of organisms in the short term. Long-term low-level exposures to reformate and mixed xylenes show low toxicity, whereas extremely high levels of exposure may cause localized short term acute effects.[30] The World Health Organization (WHO) determined that reformate and mixed xylenes is of moderate to low toxicity for aquatic organisms.[31] The aquatic toxicity of gasoline is higher in comparison to compounds such as ethylbenzene and xylenes (National Academy of Sciences 2003).[32] The overall toxicity of reformate and xylenes is lower than gasoline.

7.2 Human Health

Worker exposure limits (both recommended by NIOSH and permissible by OSHA) exist for reformate, xylenes, gasoline, or their individual components. The Time-Weighted Average (TWA) or the OSHA permissible exposure limit (PEL) indicates a concentration for up to a 10-hour workday during a 40-hour

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[29] Yender et al,.2002. Managing Seafood Safety after and Oil Spill. NOAA. Office of Response and Restoration.

[30] Morrow J. 1974. Effects of crude oil and some of its components on young coho and sockeye salmon. USEPA Office of Research and Development, Washington D.C. 36 p.

Welsh 1977. Residues of emulsified xylene in aquatic weed control and their impacts on juvenile rainbow trout. Bureau of Reclamation. Denver Colorado.

[31] Environmental Health Criteria 190: Xylenes pp. 1-2 (1997) by the International Programme on Chemical Safety (IPCS) under the joint sponsorship of the United Nations Environment Programme, the International Labour Organisation and the World Health Organization

[32] National Academy of Sciences. 2003. Oil in the Sea III: Inputs, Fates, and Effects (2003) 298 pages. The National Academies Press.

work week of 100 ppm (435 mg/m^3) for xylene and ethylbenzene, 200 ppm (750 mg/m^3) for toluene, and 50 ppm (245 mg/m^3) for cumene (isopropylbenzene), compared to 300 ppm for gasoline. While OSHA does not have a PEL for trimethylbenzene, NIOSH has established a recommended exposure limit (REL) of 25 ppm (125 mg/m^3). While these values are not directly applicable to an emergency situation, such as a spill, they are useful to ensure worker safety and appropriate respiratory protection. A Site Safety Plan would be implemented in response to a spill of reformate or mixed xylenes; it would list the appropriate worker exposure limits and actions to be taken when these are exceeded. Air monitoring during response operations will provide information to compare to the recommended exposure limits and ensure worker safety.

Community exposure limits have also been recommended by the EPA and the Agency for Toxic Substances and Disease Registry (ATSDR) and exist for reformate, mixed xylenes, gasoline, or their individual components. These values are based on varying times, ranging from 1 hour of exposure up to a lifetime (75 years) of exposure. These values establish levels that the general community can be exposed to without risk of adverse health effects. In the event of a spill of reformate or mixed xylenes, such as the scenarios discussed here, shorter exposure limits based on hours and days of exposure are most appropriate for comparison. A Site Safety Plan would be implemented during a spill response that would list these exposure limits during spills that may result in the potential for community exposure. Air monitoring during response operations will provide information to compare to these exposure limits and ensure public safety.

Actual experimental data from a simulated marine release provides some context to the above values. The highest vapor concentration of xylenes measured in an open water experiment at 1 meter above the seawater surface was higher than the Time-Weighted Average (TWA) concentration discussed above; however, the vapor concentration dissipated quickly, and in less than hour vapor concentrations were undetectable (Le Floch et al, 2010).

Additionally, Tesoro will be implementing the use of plume modeling software that integrates real-time weather and gas-sensor data to further determine the potential range and concentrations of airborne vapors as a result of a reformate or mixed xylenes spill. This will help predict the movement and concentration of components of reformate or mixed xylenes as it evaporates and allows for more efficient response operations and greater worker and public safety.

7.3 Resources Potentially at Risk in the Event of a Spill

Resources at risk will vary based on the scenario volume and oceanic conditions at the time of the spill. Comparing the results of the spill modeling scenarios conducted by Cedre (2007) and ADIOS 2.0 modeling of dispersion, evaporation and persistence for reformate, mixed xylenes, and gasoline, it is predicted that these products will only remain on the water surface for a short period of time; limiting the potential effects to the spreading of the material during the initial 6 to 72 hours depending on the volume spilled.

A number of resources at risk are outlined in the NWACP and associated GRPs. Additionally, as part of spill preparedness, it is an expectation that resources potentially at risk would be evaluated at the time of an incident to account for seasonal and real-time conditions. The following is a list of references that can assist responders in evaluating potential resources at risk:

- Environmental Sensitivity Index (ESI) Maps
- Environmental Response Management Application (ERMA) Northwest
- Washington State Coastal Atlas
- Washington Department of Fish &Wildlife (WDFW) Priority Habitat and Species
- Geographic Response Plans
- Threatened and Endangered Species

- Nautical Charts, other maps
- Tribal Reservation Lands and Usual & Accustomed areas

Habitats within proximity to the Refinery are diverse, including an array of both aquatic and terrestrial types. Ecology has identified Bald Eagle nests, special protection areas, wetland habitats, tidal pools, sensitive habitats, highly productive areas, kelp beds, eelgrass, general fish and wildlife resources, and habitat restoration and mitigation sites. These areas could be at greater risk from a spill event due to their sensitivity and species which utilize these areas for nesting and general habitat.

7.3.1 Threatened and Endangered Species

Several listed birds, marine mammals, sea turtles, and salmonids can be found within or off the coast of Washington State. Some of these species are in danger of becoming extinct and have been listed under the Endangered Species Act (ESA).

Endangered species that may occur within the geographic study area include:

- Georgia Basin/Puget Sound DPS Bocaccio Rockfish (Sebastes paucispinis),
- Humpback whale (Megaptera novaeangliae),
- Leatherback sea turtle (Dermochleys coriacea),
- Loggerhead sea turtle N. Pacific DPS (Caretta caretta),
- Olive ridley sea turtle (Lepidochelys olivacea),
- Southern Resident Killer Whale (Orcinus orca).

Some animals are rare to unlikely in the Puget Sound (i.e., green sturgeon) but Southern resident killer whales frequent the area.

Threatened species may include:

- Georgia Basin/Puget Sound DPS Canary Rockfish (Sebastes pinniger),
- Georgia Basin/Puget Sound DPS Yelloweye Rockfish (S. ruberrimus),
- Green sea turtle (Chelonia mydas),
- Hood Canal summer-run ESU chum salmon (O. keta),
- Puget Sound DPS steelhead (O. mykiss),
- Puget Sound ESU Chinook salmon (O. tshawytscha),
- Southern DPS of Green Sturgeon (Acipenser medirostris),
- Southern DPS of Pacific Eulachon (Thaleichthys pacificus) and
- Birds such as the marbled murrelet (Brachyramphus marmoratus)[33].

Critical Habitat is listed by NOAA, National Marine Fisheries Service (NMFS) and includes Hood Canal (Summer-run ESU chum salmon), Puget Sound (ESU Chinook salmon, DPS steelhead, Southern DPS of green sturgeon, Southern Resident Killer Whale, Yelloweye rockfish, Canary rockfish, Bocaccio rockfish, Pacific Eulachon.

7.3.2 Fish

Populations of fish which use the habitat in proximity of the Refinery and the Rosario Straits include species of baitfish, herring, smelt, salmonids (anadromous) and other resident species. Fish may be

33 http://www.nmfs.noaa.gov/pr/species/esa/listed.htm

exposed to spilled reformate and mixed xylenes to a limited extent through the low amounts of dispersion that may be involved in high wind and wave conditions. Exposure to high levels of reformate and mixed xylenes may acutely effect fish; however, as previously discussed, exposure studies are typically 96 hours or more and not directly comparable to the predicted behavior of reformate or mixed xylenes which dissipate more readily in the environment. Due to the volatile nature of these products and their limited persistence within water, there is a predicted short term exposure period. Furthermore, as reformate and mixed xylenes are relatively insoluble and less dense than seawater, the exposure and potential adverse effects would be limited to marine organisms on or near the surface or at the exposed shoreline, and would be limited in duration and geographic extent.

Toxicological benchmarks for ethylbenzene and xylene and other compounds in gasoline were developed after the 1999 Whatcom Creek pipeline explosion and spill of an estimated 5,475 barrels of unleaded gasoline in a small creek flowing into Bellingham Bay in Bellingham, Washington. The benchmark development used a toxic unit approach and was directed at levels protective of sensitive life stages of salmonids (juveniles in the creek and Bellingham Bay). Published contaminant thresholds for ethylbenzene and xylene were identified and the 96-hour LC50 (lethal concentration for 50% of the population) for coho salmon, sockeye salmon and rainbow trout[34] were converted to chronic sublethal values meant to be protective of all life stages.[35] Samples collected after the spill of pore water and surface water in the creek and at the mouth of the creek in Bellingham Bay were all below levels meant to be protective of salmonids and fish returned and spawned successfully in the same season as documented by field surveys.[36]

7.3.3 Birds

Populations of birds which use habitats within proximity of the Refinery include species of Herons and other wading birds, marine birds, seabird concentrations, shorebird concentrations and other water fowl. Birds that come into direct contact with reformate or mixed xylenes while trying to preen or eat contaminated food may be exposed by inhalation, ingestion or dermal absorption. The WHO has determined that the acute toxicity of xylenes to birds is low.[37] Exposure to high levels of reformate and mixed xylenes may acutely effect birds. There are no known studies focused on bird exposure. However other animals studied are typically exposed 96 hours or more and thus not easily comparable to the predicted behavior of reformate or mixed xylenes which dissipate quickly in the environment. As with other animals, the exposure extent and duration of a potential spill would be limited, which would limit potential adverse effects to large numbers of birds. Reformate and xylenes do not coat feathers, and will not affect a bird's ability to regulate their body temperature or ability to fly. As with some other organisms in the vicinity of a spill, acute effects could occur and would be localized and non-persistent.

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[34] Galassi, S., M. Mingazzini, L. Viagno, D. Cesareo, and M.L.Tosato. 1988. Approaches to modelling toxic responses of aquatic organisms to aromatic hydrocarbons. Ecotoxicol. Environ. Saf. 16:158–169.

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[35] Lange,M., Hutchinson, T.H., Sholz , N., and Solbe, J.. 1998. Analysis of the ECETOC aquatic toxicity database EAT Database II, Comparison of acute to chronic ratios for various aquatic organisms and chemical substances. Chemoshpere 36:115-127.

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[37] Environmental Health Criteria 190: Xylenes pp. 1-2 (1997) by the International Programme on Chemical Safety (IPCS) under the joint sponsorship of the United Nations Environment Programme, the International Labour Organisation and the World Health Organization.

7.3.4 Shellfish

Shellfish documented within proximity of the Refinery include Dungeness crab, hardshell clams and numerous other crab and mollusk species. Clams (*Gafrarium divaricatum*) in seawater showed small changes at high levels of reformate or mixed xylenes exposure, but there was no observable effect at lower concentrations[38]. As previously discussed, dissolved concentrations of reformate and mixed xylenes are likely to be low, short-lived, and confined to surface water layers - thus potential exposure to subtidal organisms would be anticipated to be minimal in situations other than contained areas and small rivers with substantial mixing.[39]

7.3.5 Marine Mammals and Sea Turtles

Due to the high evaporation rate of reformate and mixed xylenes during a spill event, marine mammals and turtles may become exposed either directly in water or through the inhalation of vapors. Marine mammals, upon exposure, share similar risks as land vertebrates and humans with potential symptoms of drunkenness and respiratory irritation. Some literature suggests spills affect only a small number of marine mammals due in part to their ability to detect and avoid spilled materials.[40,41] Given the limited aerial extent and duration, mammals are less likely to come into contact with reformate or mixed xylenes, which is non-persistent in the environment. Similar to birds, reformate and mixed xylenes do not coat fur, and will not affect marine mammals' ability to swim or insulate themselves. Additionally, mammals tend not to ingest contaminated water. [42] Localized and short term adverse effects to marine mammals and turtles could occur in the immediate area of the accident scenarios.[43] However, materials such as reformate, mixed xylenes and gasoline evaporate and dissipate quickly and are non-persistent in the aquatic or marine environment (typically no longer than a few days). As the spill spreads, the material will evaporate and dissipate quickly.

7.4 Seafood Safety

Hydrocarbons, such as reformate and mixed xylenes, are readily bio-transformed or metabolized and excreted (Beyer et al, 1996). The components of reformate and mixed xylenes do not accumulate in the body or tissues of humans or aquatic life. Based on the scientific information available regarding reformate, mixed xylenes, and gasoline, the risk is low of a spill resulting in seafood that is unsafe to eat. Material such as reformate and mixed xylenes are non-persistent in the environment due to evaporation and very limited dispersion, and are less likely to affect seafood safety unless in confined situations or

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38 Rocha, A.C, M. Reis-Henriques, V. Galhano, M. Ferreira, and L. Guimarães. 2016. Toxicity of seven priority hazardous and noxious substances (HNSs) to marine organisms: Current status, knowledge gaps and recommendations for future research. Sci Total Environ 2016;542:728.

39 Yender et al,.2002. Managing Seafood Safety after and Oil Spill. NOAA. Office of Response and Restoration.

40 Smith TG, JR Geraci, D St. Aubin J. 1983 Reaction of bottlenose dolphins, tursiops truncatus , to a controlled oil spill. Can J Fish Aquat Sci;40(9):1522-5.

41 St. Aubin D,J., JR Geraci, TG Smith, TG Friesen. 1985 How do bottlenose dolphins, tursiops truncatus , react to oil films under different light conditions? Can J Fish Aquat Sci;42(3):430-6.

42 Sittig M. ; 1981Handbook of toxic and hazardous chemicals. Park Ridge, N.J.: Park Ridge, N.J. : Noyes Publications.

43 http://response.restoration.noaa.gov/about/media/oil-spill-issues-salish-sea.html

small rivers with substantial mixing (Yender 2002). Of the priority hydrocarbon pollutants identified by the EPA and typically evaluated for seafood safety, none occur in reformate or mixed xylenes.

Components of reformate and mixed xylenes will enter the water column through dispersion to a limited extent under higher wind and wave conditions and rapidly evaporate, thus potential exposures to marine organisms are localized and short term. There is no reported scientific evidence that these components pose a risk to seafood consumption due to limited exposure and data on marine organism metabolism.

Precautionary procedures may be implemented out of caution. The Alaska Department of Environmental Conservation suggests a zero-tolerance policy whereby if you see or smell fuel on a fish removed from the water, it is not fit for consumption (NUKA, 2006).

7.5 Spill Case Histories

Case histories of spills discussed earlier also provide some insight into potential adverse effects to resources and humans. The Louisiana Department of Environmental Quality reported that nobody was seriously hurt during the 2007 T/V BOW LION xylene spill on the Mississippi River (1,000 bbls) and responders described the spill as hard to contain and locate on the water due to its evaporation rate. Tests showed that the xylene had evaporated within 2 days. No natural resource losses were reported.

The chemical tanker T/V GRAPE ONE spilled an unknown volume of xylenes when it sank after a ballast tank ruptured off the coast of Devon, UK in December 1993; the only response operation required and implemented was rescue of the entire crew onboard (Hooke, 1989). The xylene was unrecoverable in rough water and evaporated quickly. No natural resource losses were reported.

Mitigation Measures/Spill Response

This section summarizes measures and programs in place that Tesoro and the maritime industry implement to prevent spills, minimize spills if they occur, and prepare to respond in the event of a spill.

8.1 Measures to Prevent and Minimize Spills

The Refinery incorporates a broad array of engineering controls, procedures and practices to prevent spills at the Refinery dock. The effectiveness of these measures is evidenced by the fact that there have been no marine spills greater than 2 gallons, as evaluated from available spill data in the OSCP.

Engineering controls to prevent or mitigate spills include:

- A leak detection and alarming system that monitors the pipelines that service the dock via sonic flow meters and pressure transmitters located at the head of the causeway and at the east end of the dock. The output of the monitor is connected to the leak detection computer system and alarm panel which are located in the logistics control room on the board operator's control console. The leak detection system is equipped with a back-up computer that can be connected and placed in service should the primary computer fail.
- Block valves are installed in the pipelines connecting the Refinery to the dock to isolate the lines and limit potential volumes in the event of a leak.
- Secondary containment at the dock includes reinforced concrete sumps under the loading headers, marine loading arms and pump-out areas as well as steel sumps under the north dock manifold and north hydraulic crane. The sumps provide containment during connecting and disconnection operations and are outfitted with lights that alarm both at the dock and Logistics control house.

Procedural measures to prevent spills include regular inspection and maintenance of pipes, valves, hoses, gaskets and other components of the Refinery dock delivery systems. In addition, the Refinery follows a comprehensive and effective Wharf Operations Manual that prescribes in detail the operating equipment, procedures and maintenance activities to prevent spills.

The Refinery Spill Prevention Control and Countermeasures (SPCC) Plan includes procedures, methods, equipment and other preventive measures to prevent a spill. The SPCC also prescribes inspections, tests and records for tanks and piping. Inspections are performed monthly on all tanks, piping and associated containment. As with the Wharf Operations Manual, the SPCC requires ongoing training for Refinery employees to assure conformance and prevent releases.

In addition to these measures in place at the Refinery, the marine industry has implemented sophisticated measures and programs to prevent spills, including, but not limited to a comprehensive vessel traffic management systems for the study area, which include the joint USCG and Canadian Coast Guard (CCG) Cooperative Vessel Traffic Service (CVTS) and a Traffic Separation Scheme (TSS). These have proven to be effective in preventing accidents and have the capacity to accommodate the CPUP traffic. Additionally vessels are required to have a Vessel Response Plan (VRP) to respond to a spill, in accordance with USCG rules.

8.2 Spill Response Measures

A multi-layered, integrated and well developed program is in place for the Salish Sea to respond to a potential spill of petroleum materials. The relevant overarching document is the NWACP that covers the entire northwest region. Within the NWACP, specific GRPs focus on the geography, navigation channels, sensitive resources, and response equipment and personnel unique to a particular area. In the case of the Refinery Dock, the relevant GRP is the North Puget Sound/San Juan Islands. These plans assure that the properly trained, equipped and supplied spill incident responders are available in the event of a spill. As part of the NWACP, regular table-top and deployment drills are required to assure training and readiness.

Specific to the Refinery, Tesoro has a number of programs in place to assure proper response in the event of a spill. These include the OSCP as well as the Emergency Response Manual (ERM).

The OSCP complies with National Preparedness Response Exercise Program (NPREP) for both the EPA and USCG as well as Ecology's drill program. The objectives of the OSCP include:

- Defining alert and notification procedures,
- Documenting available equipment, personnel and other resources available (including outside resources),
- Establishing an oil spill response team,
- Defining lines of responsibility and
- Outlining response procedures.

The OSCP is coordinated with or incorporates by reference, the Wharf Operations Manual, SPCC Plan and overall ERM. The OSCP is approved by the USCG, EPA and Ecology.

The Refinery ERM is also part of spill response measures. The objectives of the ERM includes establishing the response actions, organization, strategies, training and resources for all types of emergencies including fires, spills, medical response, rescue, terrorist incident, bomb threat, natural disaster.

The ERM utilizes the Incident Command System (ICS) structure and incorporates other plans such as the OSCP and SPCC Plan. It also documents coordination with other emergency plans in the surrounding community.

For vessels that will transport reformate or mixed xylenes, each vessel will be of a double-hull design and be required by USCG regulation to have on board and maintain up-to-date training prescribed by a Vessel Response Plan (VRP). Each VRP must be tailored to be appropriate for the type of material the ship will be carrying. Tesoro supplements this requirement by vetting each vessel and crew for regulatory compliance prior to allowing one to call at their dock.

Conclusions

In the event of a release to the marine environment, the fate of reformate and mixed xylenes involves rapid evaporation with no residual material, and thereby beach impacts would be temporary and unlikely to require shoreline clean up. This behavior is dictated by the physical properties of low density, low viscosity, high volatility and low solubility. Once evaporated, reformate and mixed xylenes will quickly disperse and be consumed by photochemical oxidation in the atmosphere.

When evaluating the worst-case release to the marine environment, there is a possibility that natural resources in the proximity of the spill could be at risk of exposure. However, since reformate, mixed xylenes, and gasoline will only remain on the water surface for a short period of time, the potential adverse effects would be geographically limited to the spreading of the spill during the initial 6 to 72 hours (depending on the volume spilled), weather conditions and the amount of exposure with those resources.

Reformate and mixed xylenes do not pose a significant risk to seafood consumption due to limited exposure resulting from the rapid evaporation rate and very limited quantities that disperse into the water. This is supported by observations and data collected from prior mixed xylenes spills elsewhere in the world.

A multi-layered, integrated and well developed program is in place for the Salish Sea to respond to a potential spill of petroleum. The Northwest Area Contingency Plan (NWACP) has guidance and procedures in place that encompass responding to a spill of reformate and mixed xylenes.

The Refinery currently has in place an Oil Spill Contingency Plan (OSCP) approved by the USCG and Ecology. The plan currently includes responding to a potential spill of reformate and gasoline. The properties of mixed xylenes are similar to reformate and gasoline, whereby the response strategies currently in place are directly applicable to mixed xylenes. Regardless, the OSCP will be updated prior to start-up to specifically address mixed xylenes, and will include any special safety and material handling/compatibility requirements that might be unique to mixed xylenes.

The Refinery participates in the National Preparedness Response Exercise Program (NPREP) as well as Ecology's drill program that is designed to demonstrate the capability to respond and manage a coordinated response to petroleum spills.

As part of the OSCP, in the event of a spill, the incident command system is utilized, and includes establishing a Site Safety Plan to ensure the safety of workers and the public.

The marine industry has implemented sophisticated measures and programs to prevent spills, including, but not limited to a comprehensive vessel traffic management systems for the study area as well as a Traffic Separation Scheme (TSS) that directs vessels into controlled one-way traffic lanes. Double-hulled vessels will be used to transport reformate and mixed xylenes; these vessels are required to have a vessel response plan (VRP) to respond to a potential spill, in accordance with USCG rules.

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Appendix A: Reserved

Appendix B: Chemical and Physical Properties of Reformate, Mixed Xylenes and Gasoline

Appendix C: ADIOS 2.0 Graphic Presentation of Modeling Predictions

Appendix D: ADIOS 2.0 Modeling Outputs of Evaporation and Dispersion – Individual Runs (Input/Output) Results

Appendix E: ADIOS Modeling Comparison of Other Fuels

Appendix F: Reserved

Appendix G: GNOME™ Modeling Results

Appendix B: Chemical and Physical Properties of Reformate, Mixed Xylenes and Gasoline

The following appendix includes chemical and physical data of reformate, mixed xylenes and gasoline used to support the analysis in this report. Table B-1 includes the components (or chemical compounds) in reformate and mixed xylenes. Table B-2 includes additional chemical and physical properties used to support the modeling analysis.

Table B-1. Components of Reformate and Mixed Xylenes

Component	Reformate[1] wt%	Reformate (backhaul) [2] wt%	Mixed Xylenes wt%
Xylene Isomers	55	0	82
Toluene	7	21	0
Trimethylbenzene	21	64	0
Benzene	0	0	0
Ethylbenzene	12	0	18
Octane (and isomers)	4	12	0
Isopropylbenzene (Cumene)	1	3	0
Total (%)	100	100	100

Note: Data based upon a combination of material testing and product specification targets

[1] Reformate – estimated inbound reformate composition
[2] Reformate (backhaul) – estimated composition of outbound gasoline blendstocks after xylenes and ethylbenzene are removed.

Table B-2. Properties of Reformate, Mixed Xylenes and Gasoline
(used as ADIOS 2.0 Model Input Parameters)

Parameter		Reformate[3]	Reformate (backhaul)[4]	Mixed Xylenes	Gasoline	Comments
		(custom input)	(custom input)	(custom input)	(ADIOS 2.0 default[5])	
Product Type		Refined	Refined	Refined	Refined	
Oil Class		Group 1	Group 1	Group 1	Group 1	
Flash Point (°C)		24.7	22.3	27.9	-30	
(°F)		76.5	72.1	82.2	-22	
Pour Point (°C)		-18.0	-18.0	-18.0	--	
Density (*) (g/cc @ 10 °C)	0% evaporated	0.86	0.85	0.87	0.75 @ 15°C	Starting material.
	50% Evaporated	0.87	0.86	0.88	--	Remaining liquid fraction.
	95% Evaporated	0.87	0.87	0.88	--	Remaining liquid fraction.
	99% Evaporated	0.87	0.87	0.88	--	Remainging liquid fraction.
Viscosity (cP @ 10 °C)	0% Evaporated	0.79	0.94	0.74	0.75 @ 38 °C (†)	Starting material.
	50% Evaporated	0.82	0.98	0.75	--	Remaining liquid fraction.
	95% Evaporated	0.85	1.03	0.75	--	Remaining liquid fraction.
	99% Evaporated	0.85	1.03	0.75	--	Remaining liquid fraction.
Distillation Vapor Temp (°C)	0% Evaporated	99	101	134	40 @ 26% 60 @ 30% 80 @ 44% 100 @ 70%	. ADIOS 2.0 data points for Unleaded Gasoline distillation are evenly spaced by temperature, not by % evaporated.
	50% Evaporated	139	160	139	120 @ 84% 140 @ 85% 160 @ 88%	
	95% Evaporated	168	173	145	180 @ 95%	
	99% Evaporated	172	176	146	200 @ 98%	Indicates that at the point where evaporation approaches completion (i.e. 99%) no residue will remain.
Adhesion (g/in2)		0	0	0	--	Reformate and Mixed Xylenes are light hydrocarbons.
Maximum water content % of the emulsion		0	0	0	--	Reformate and Mixed Xylenes contain no emulsifying components.
Emulsification Constant (% evaporated)		100	100	100	--	ADIOS indicates that "light refined products generally will not emulsify" because they don't have waxes, asphaltenes or metals needed to stabilize droplets.
Interfacial Tension (Dynes/cm)	Oil Water @ 10 °C	42.5	42.5	42.5	--	ADIOS uses 42.5 in standard product (Aviation Gasoline 80).
	Oil-Seawater @ 10 °C	40	40	40	--	ADIOS uses 40 in standard product (Aviation Gasoline 80).
Metals (ppm)	Nickel	0	0	0	--	
	Vanadium	0	0	0	--	
Group Analysis %	Aromatics	96	88	100	--	
	Asphaltenes	0	0	0	--	
	Benzene	0	0	0	--	
	Naphthalene	0	0	0	--	
	Paraffins	4	12	0	--	
	Polars	0	0	0	--	
	Resins	0	0	0	--	
	Saturates	4	12	0	--	
	Sulfur	0	0	0	--	
	Wax	0	0	0	--	ADIOS refers to waxes as a high molecular weight (MW) paraffin.

(*) The densities of freshwater and seawater are 1.0 g/cc and 1.03 g/cc, respectively.
(†) ADIOS 2.O lists a value of 1.0 cSt @ 38 °C. The value for gasoline (in units of cP) is obtained by multiplying by the respective density.

Note: Detailed distillation, viscosity and related physical property data input to ADIOS 2.0 were generated for the reformate and mixed xylenes streams using HYSYS[6], a modeling and property estimation tool widely used in the petroleum refining industry.

[3] Reformate - estimated inbound reformate composition
[4] Reformate (backhaul) - estimated composition of outbound gasoline blendstocks after xylenes and ethylbenzene are removed.
[5] Gasoline (Unleaded) Shell, from ADIOS 2.0 Oil Library – V2 1/27/2015.
[6] http://www.aspentech.com/products/aspen-hysys/

Appendix C: ADIOS 2.0 Graphic Presentation of Modeling Predictions

The following appendix includes ADIOS 2.0 Modeling of Evaporation Rates for various spill scenarios including reformate, reformate (backhaul), mixed xylenes, and gasoline, each at three (3) dockside spill scenario volumes (50 bbl; 1200 bbl; 5045 bbl) and two (2) Salish Sea spill scenarios volumes (2,500 bbl; 330,000 bbl) for a total of five (5) spill scenarios. Each scenario includes results for three (3) different wind speeds (0 mph; 5 mph; 10 mph).

Table C-1 provides a list of figures that illustrate each of the five (5) spill scenarios.

Table C-1. List of Figures - Evaporation Rates (0 mph; 5 mph; 10 mph)

Figure #	Stream	Location	Volume bbl
Figure C-1 Figure C-2 Figure C-3 Figure C-4	Reformate Reformate (backhaul) Mixed Xylenes Gasoline	Dock	50
Figure C-5 Figure C-6 Figure C-7 Figure C-8	Reformate Reformate (backhaul) Mixed Xylenes Gasoline	Dock	1,200
Figure C-9 Figure C-10 Figure C-11 Figure C-12	Reformate Reformate (backhaul) Mixed Xylenes Gasoline	Dock	5,045
Figure C-13 Figure C-14 Figure C-15 Figure C-16	Reformate Reformate (backhaul) Mixed Xylenes Gasoline	Salish Sea	2,500
Figure C-17 Figure C-18 Figure C-19 Figure C-20	Reformate Reformate (backhaul) Mixed Xylenes Gasoline	Salish Sea	330,000

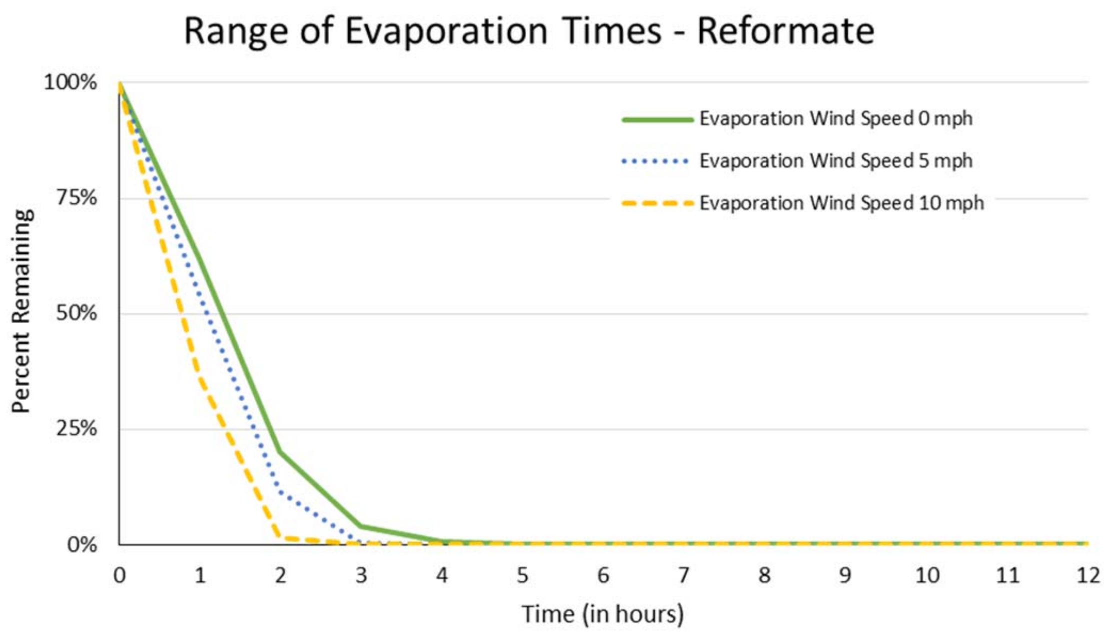

Figure C-1: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Reformate; 50 bbl; wind speed @ 0; 5; 10 mph.

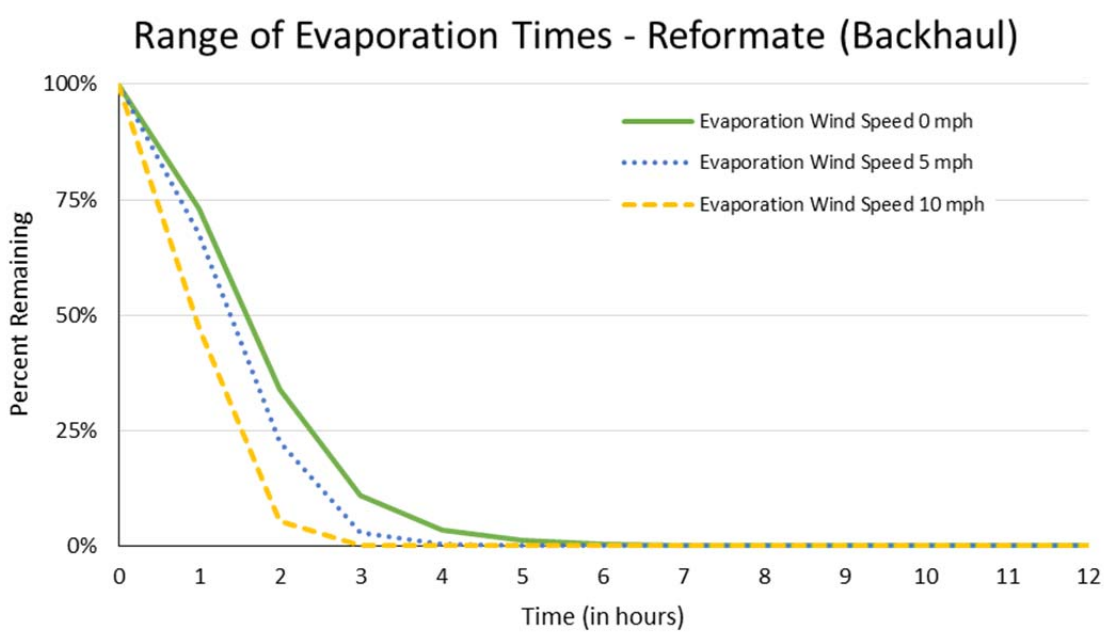

Figure C-2: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Reformate (backhaul); 50 bbl; wind speed @ 0; 5; 10 mph.

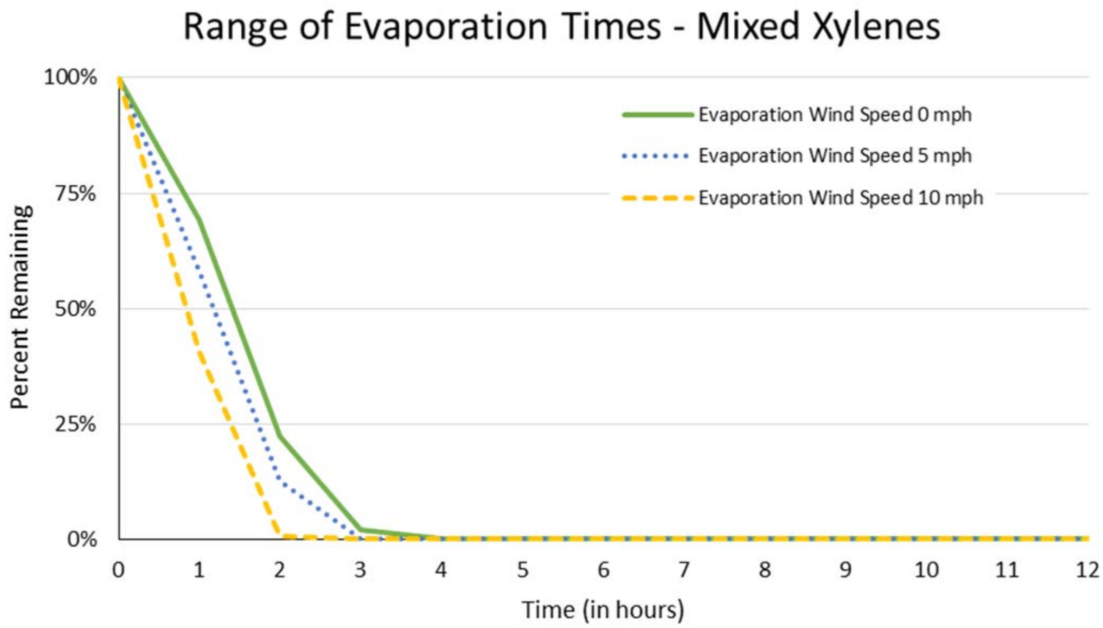

Figure C-3: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Mixed Xylenes; 50 bbl; wind speed @ 0; 5; 10 mph.

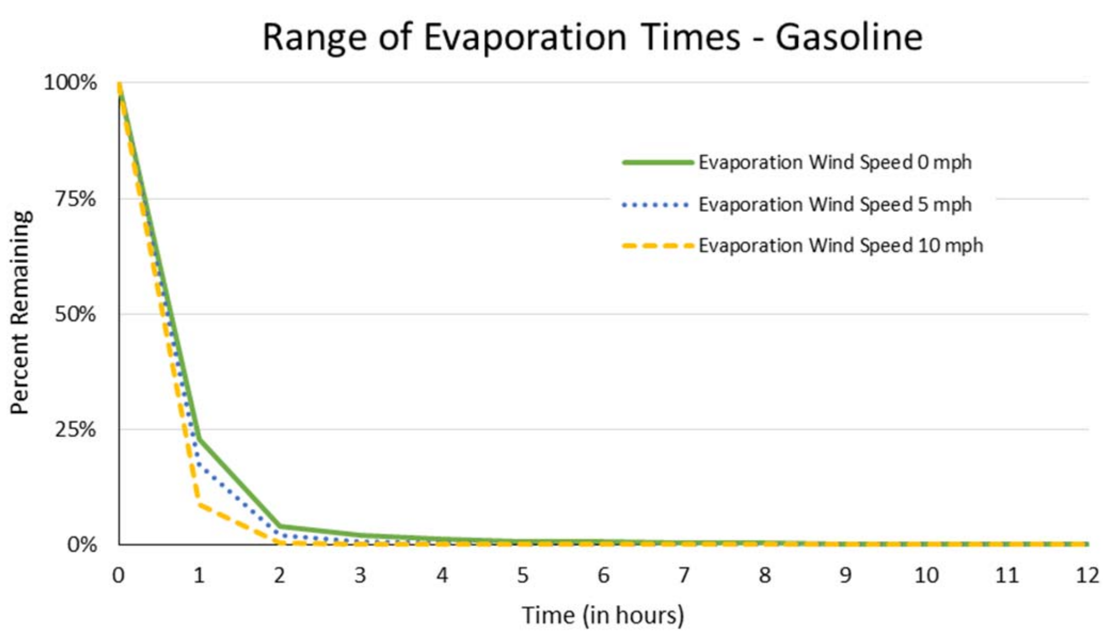

Figure C-4 Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Gasoline; 50 bbl; wind speed @ 0; 5; 10 mph.

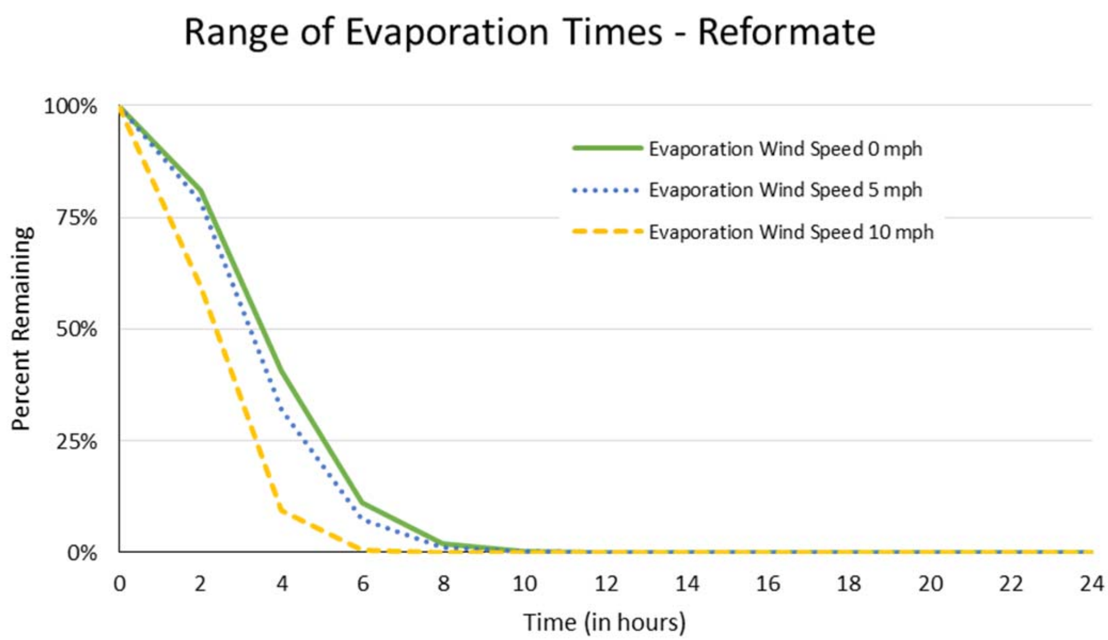

Figure C-5: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Reformate; 1,200 bbl; wind speed @ 0; 5; 10 mph.

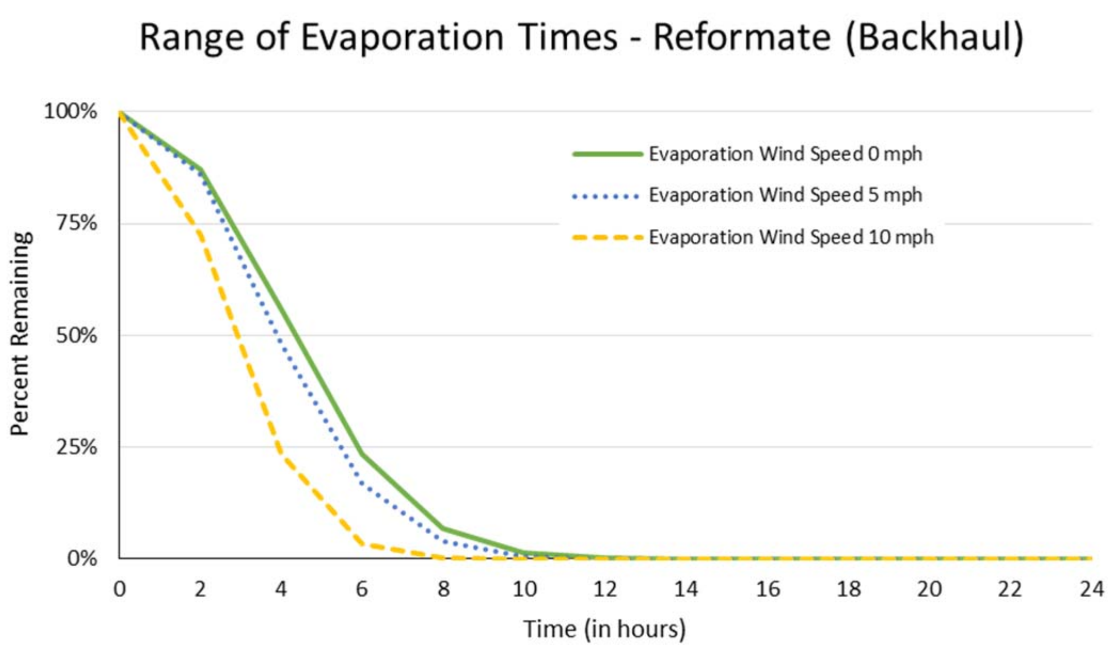

Figure C-6: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Reformate (backhaul); 1,200 bbl; wind speed @ 0; 5; 10 mph.

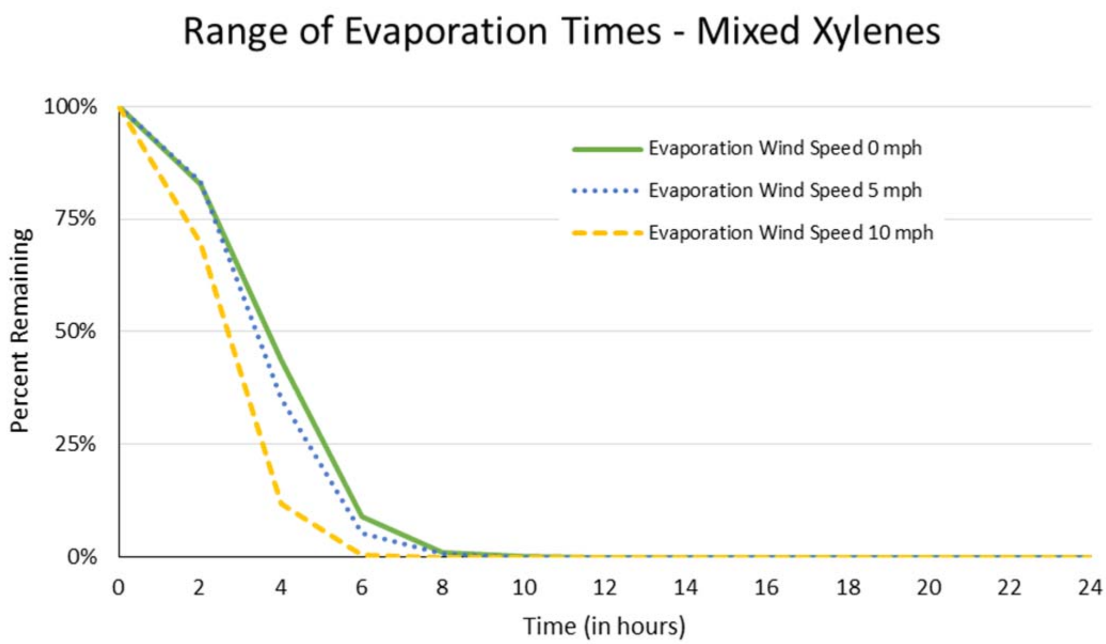

Figure C-7: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Mixed Xylenes; 1,200 bbl; wind speed @ 0; 5; 10 mph.

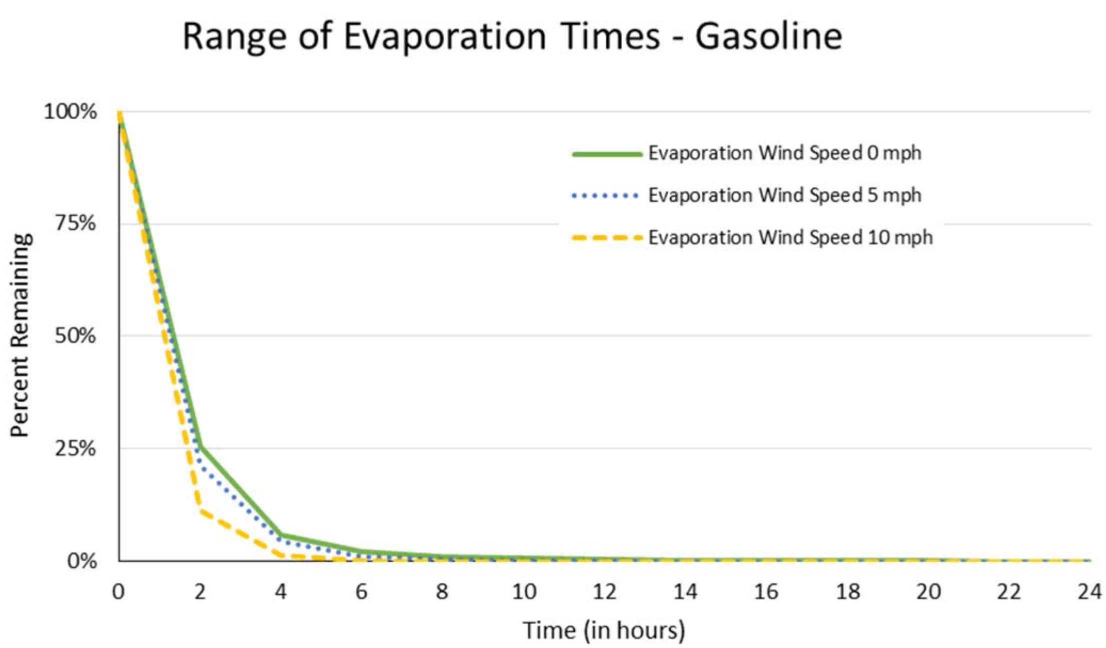

Figure C-8: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Gasoline; 1,200 bbl; wind speed @ 0; 5; 10 mph.

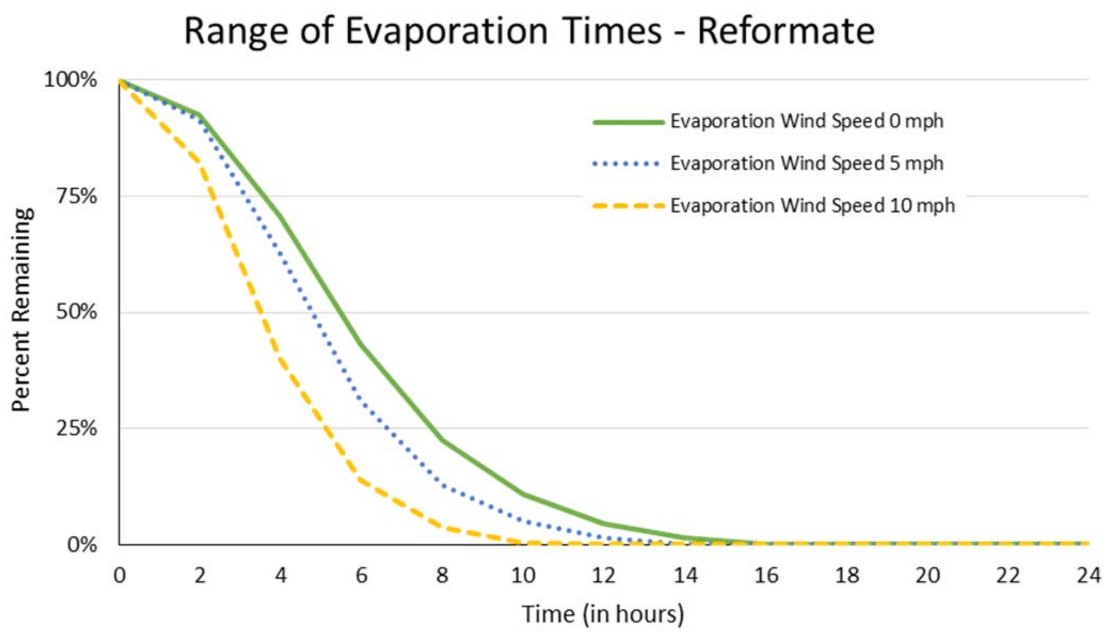

Figure C-9: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Reformate; 5,045 bbl; wind speed @ 0; 5; 10 mph.

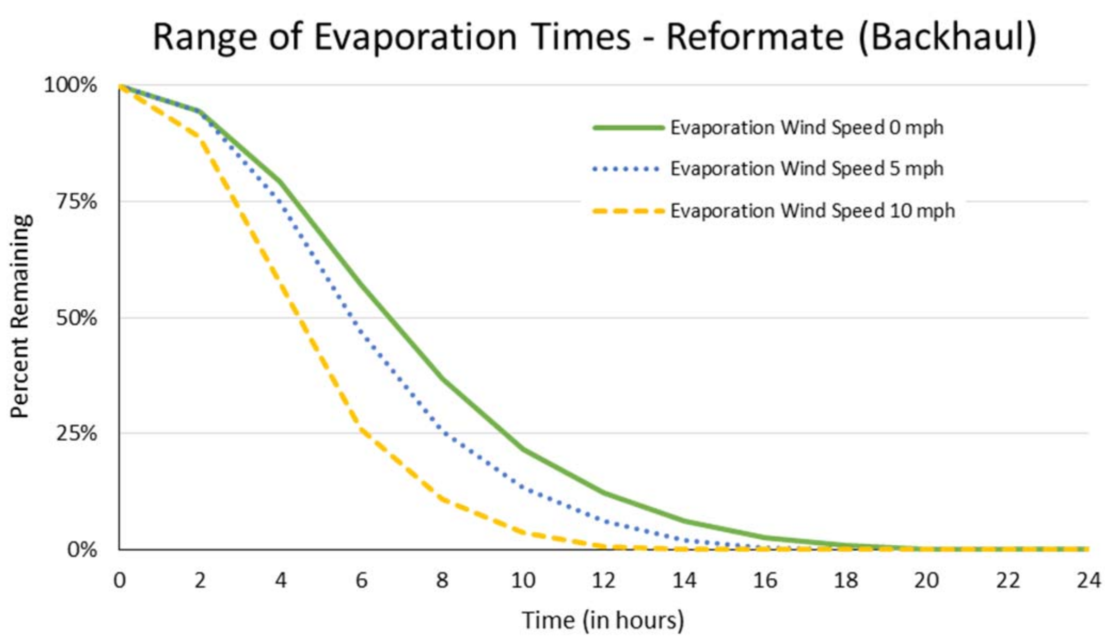

Figure C-10: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Reformate (backhaul); 5,045 bbl; wind speed @ 0; 5; 10 mph.

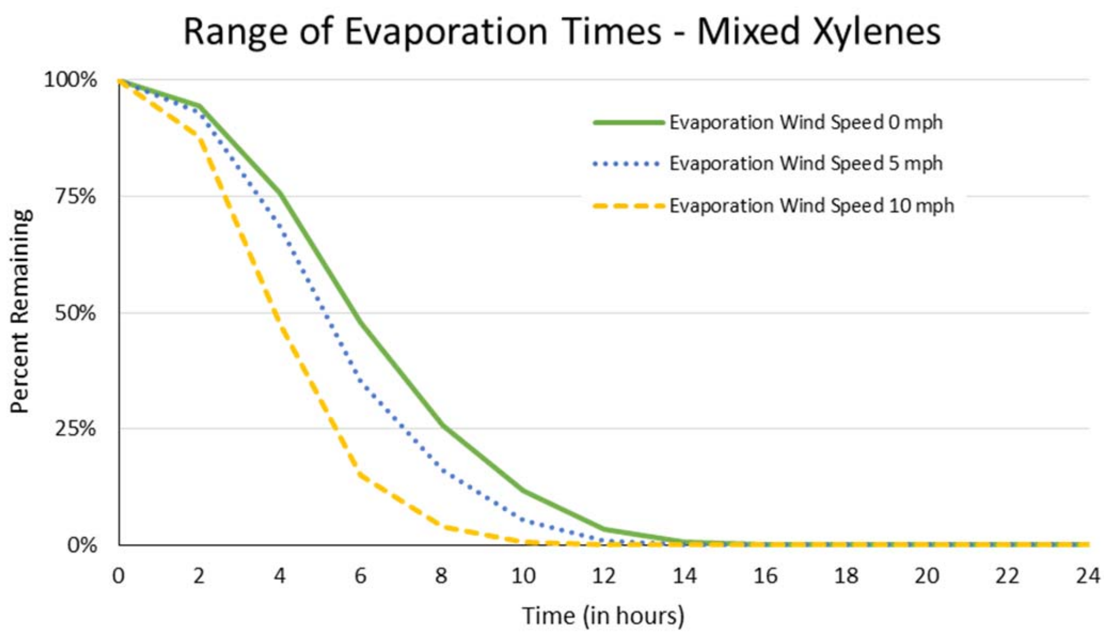

Figure C-11: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Mixed Xylenes; 5,045 bbl; wind speed @ 0; 5; 10 mph.

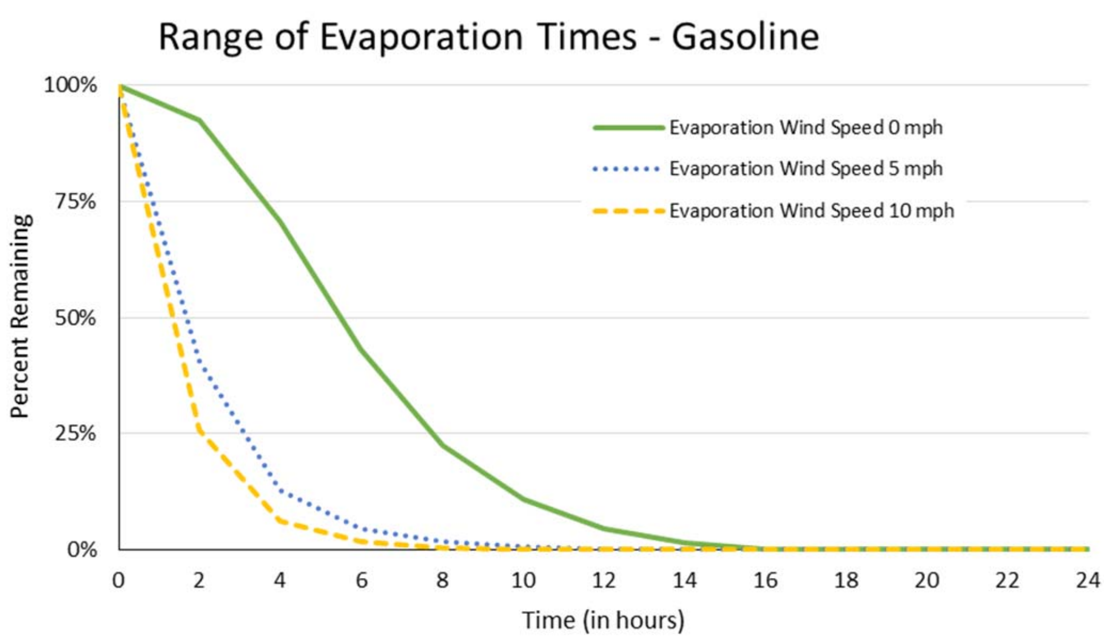

Figure C-12: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Gasoline; 5,045 bbl; wind speed @ 0; 5; 10 mph.

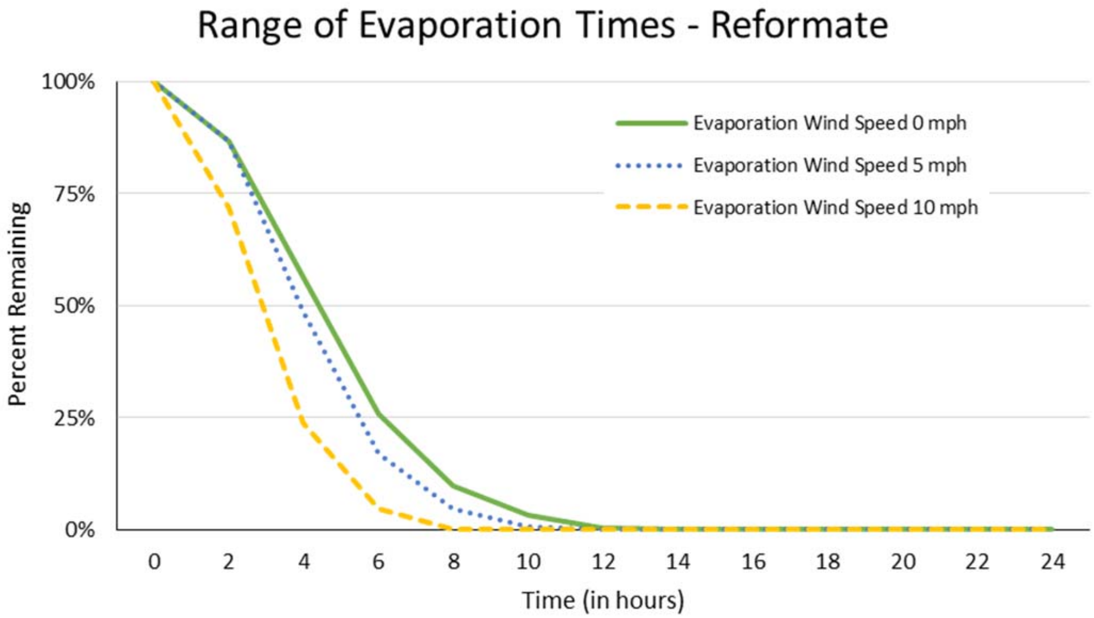

Figure C-13: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Reformate; 2,500 bbl; wind speed @ 0; 5; 10 mph.

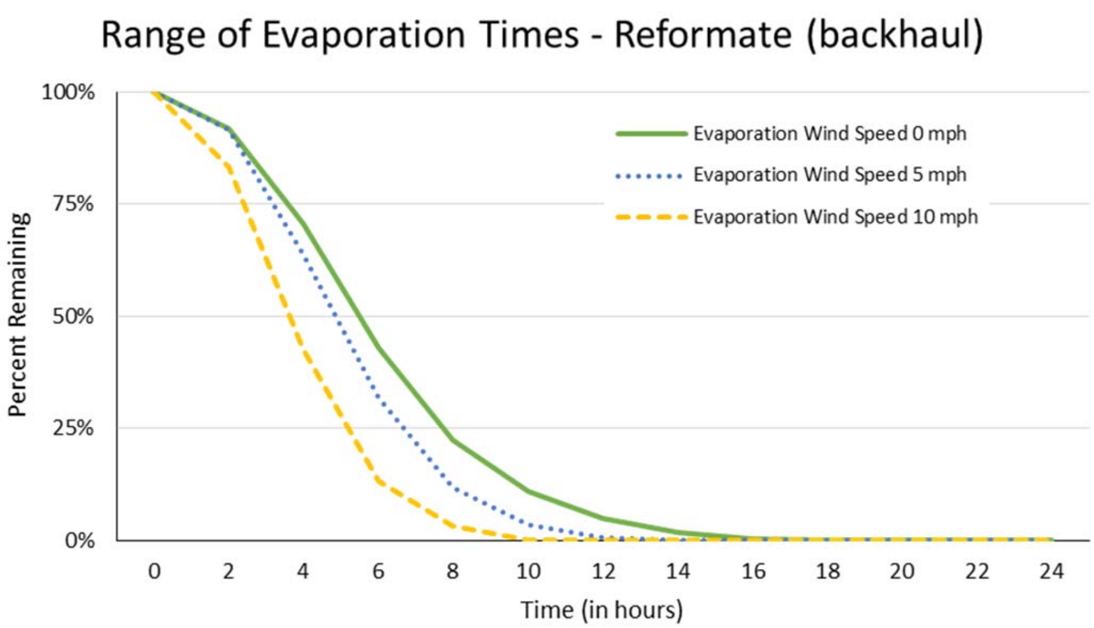

Figure C-14: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Reformate (backhaul); 2,500 bbl; wind speed @ 0; 5; 10 mph.

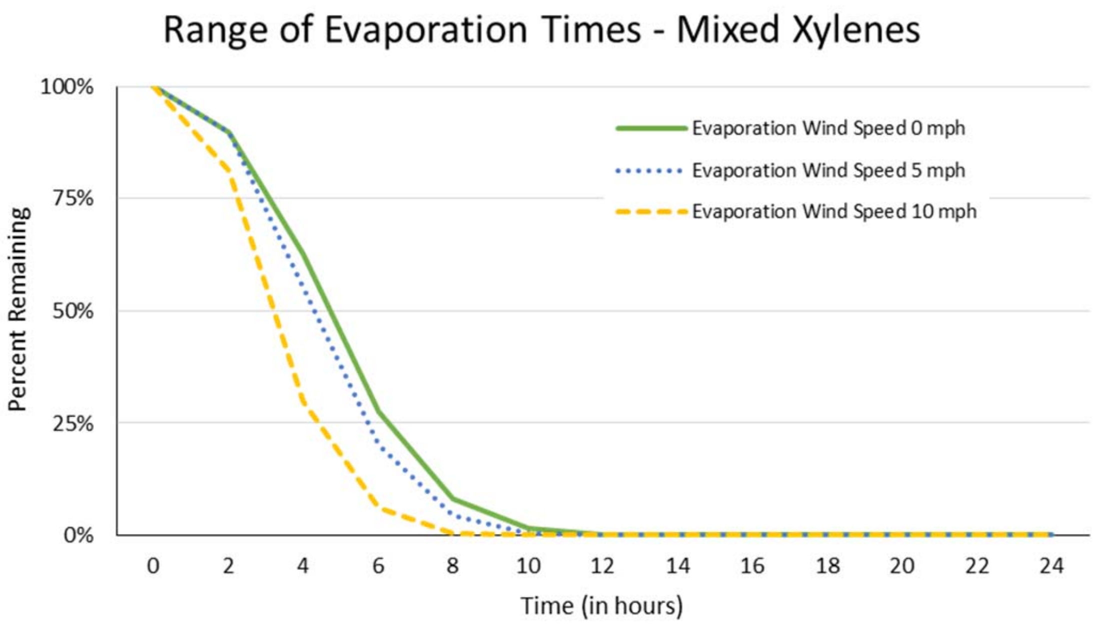

Figure C-15: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Mixed Xylenes; 2,500 bbl; wind speed @ 0; 5; 10 mph.

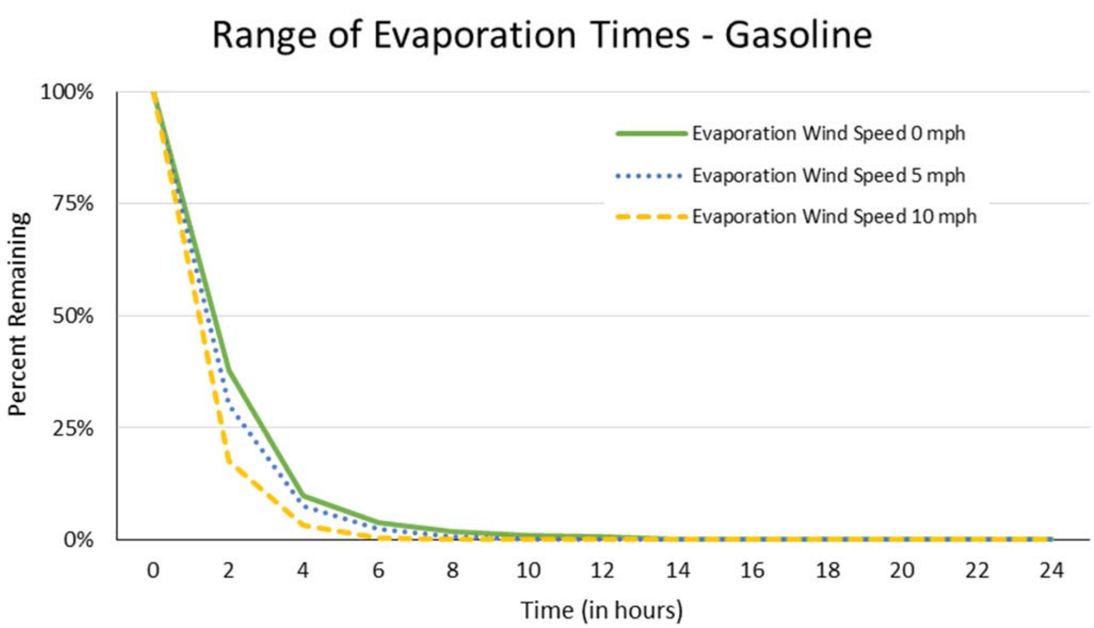

Figure C-16: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Gasoline; 2,500 bbl; wind speed @ 0; 5; 10 mph.

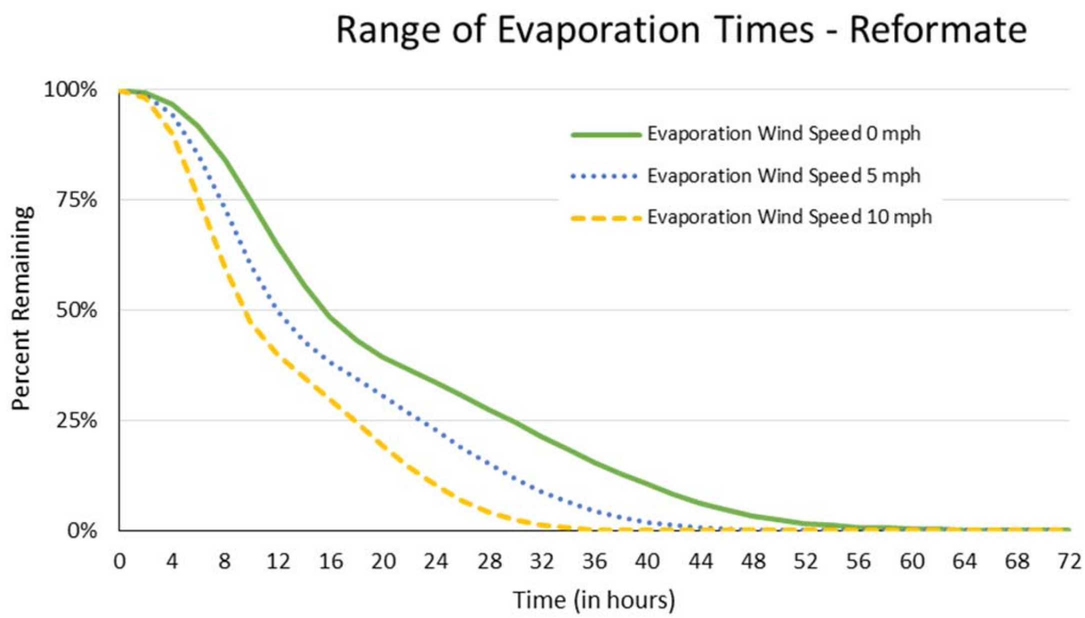

Figure C-17: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Reformate; 330,000 bbl; wind speed @ 0; 5; 10 mph.

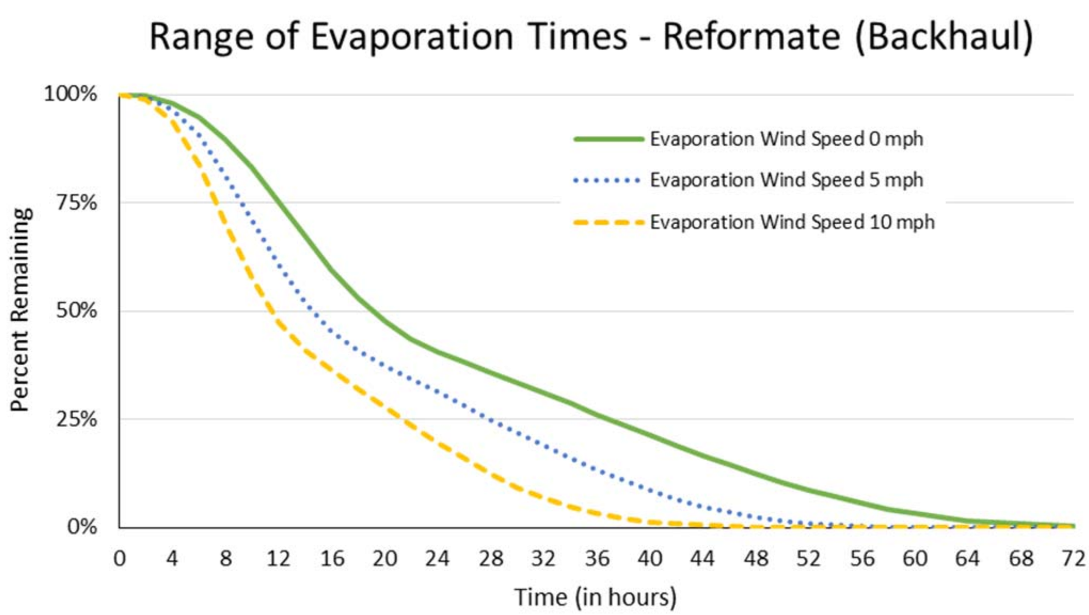

Figure C-18: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Reformate (backhaul); 330,000 bbl; wind speed @ 0; 5; 10 mph.

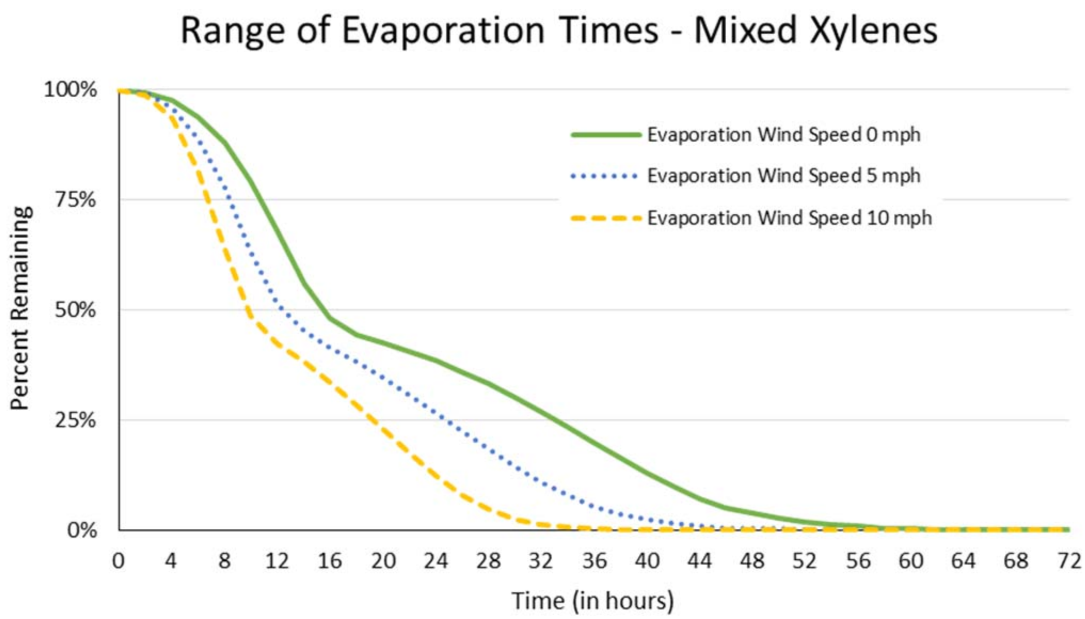

Figure C-19: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Mixed Xylenes; 330,000 bbl; wind speed @ 0; 5; 10 mph.

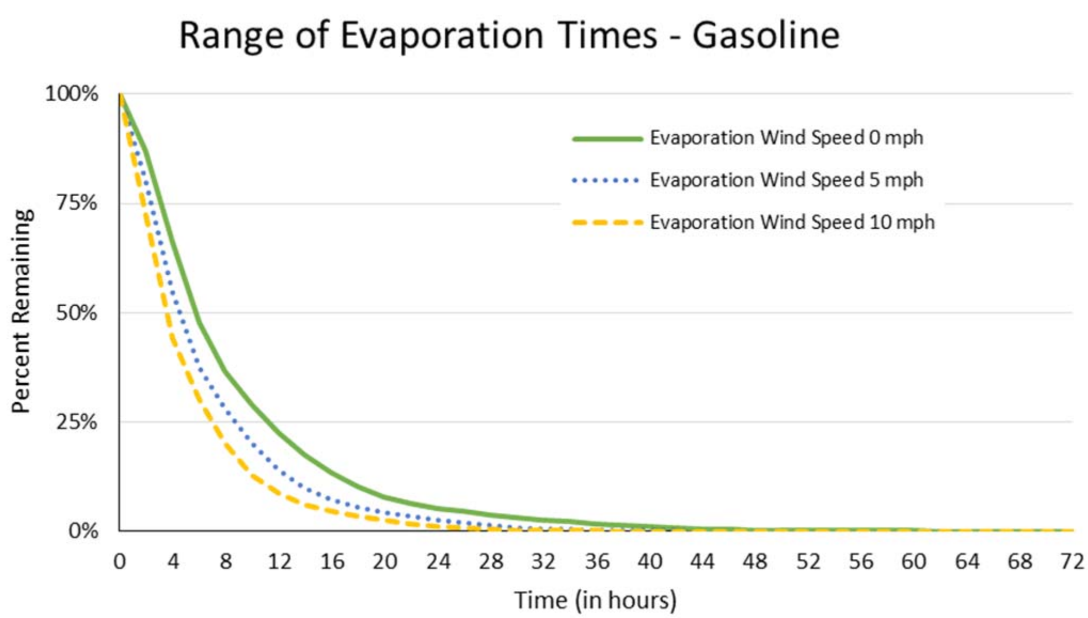

Figure C-20: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Gasoline; 330,000 bbl; wind speed @ 0; 5; 10 mph.

Appendix D: ADIOS 2.0 Modeling Outputs of Evaporation and Dispersion – Individual Runs (Input/Output) Results

The following appendix includes ADIOS 2.0 Modeling of Evaporation and Dispersion - Individual Runs input/output results for various CPUP spill scenarios including reformate, reformate (backhaul), mixed xylenes, and gasoline, each at three (3) dockside spill scenario volumes (50 bbl; 1200 bbl; 5045 bbl) and two (2) Salish Sea spill scenarios volumes (2,500 bbl; 330,000 bbl) for a total of five (5) spill scenarios. Each scenario includes results for three (3) different wind speeds (0 mph; 5 mph; 10 mph). Additionally, the 330,000 bbl spill scenarios release case for gasoline (see Table D-6) was evaluated at 7 mph, 8 mph, 12 mph and 14 mph[1] wind speeds to support the trajectory analysis conducted at the seasonal average wind speeds outlined in Section 6.

Table D-2 through Table D-6 provides a list of figures that illustrate each of the five (5) spill scenario input/output files.

Table D-1. List of Tables for Spill Scenarios
ADIOS 2.0 Modeling of Evaporation and Dispersion Individual Runs (Input/Output) Results

Table #	Location	Volume (bbl)
Table D-2	Dockside	50
Table D-3		1,020
Table D-4		5,045
Table D-5	Salish Sea	2,500
Table D-6		330,000

[1] ADIOS input file requires wind speed data to be entered as whole numbers.

Table D-2. List of Figures for Dockside Spill Scenario - 50 bbls
ADIOS 2.0 Modeling of Evaporation and Dispersion Individual Runs (Input/Output) Results

Figure #	Stream	Volume bbl	Wind Speed* mph	File Type
Figure D-1 (a)	Reformate	50	0	Input
Figure D-1 (b)			0	Output
Figure D-1 (c)			5	Input
Figure D-1 (d)			5	Output
Figure D-1 (e)			10	Input
Figure D-1 (f)			10	Output
Figure D-2 (a)	Reformate (backhaul)	50	0	Input
Figure D-2 (b)			0	Output
Figure D-2 (c)			5	Input
Figure D-2 (d)			5	Output
Figure D-2 (e)			10	Input
Figure D-2 (f)			10	Output
Figure D-3 (a)	Mixed Xylenes	50	0	Input
Figure D-3 (b)			0	Output
Figure D-3 (c)			5	Input
Figure D-3 (d)			5	Output
Figure D-3 (e)			10	Input
Figure D-3 (f)			10	Output
Figure D-4 (a)	Gasoline	50	0	Input
Figure D-4 (b)			0	Output
Figure D-4 (c)			5	Input
Figure D-4 (d)			5	Output
Figure D-4 (e)			10	Input
Figure D-4 (f)			10	Output

***** ADIOS 2.0 accepts a minimum wind speed of 2 mph. To simulate zero wind speed, a 2 mph wind is used in combination with a 2 mph current speed in the opposite direction.

Dock Scenarios.

Spill Scenario 50 bbl w/3 wind speeds and 4 streams:

Oil Type
- REFORMATE (custom oil)
- Location = Anacortes Washington
- Synonyms = REFORMATE
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 25 deg C
- Density = 0.785 g/cc at 50 deg F
- Viscosity = 0.8 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 96 weight %

Emulsification
- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions
- Wind Speed = 2 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties
- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 2.0 mph towards 180 degrees

Release Information
- **Instantaneous Release**
  - Time of Release = March 20, 0000 hours
  - Amount Spilled = 50 bbl

Figure D-1 (a): ADIOS 2.0 Model Input Parameters – 50 bbl Reformate with 0 mph wind speed.

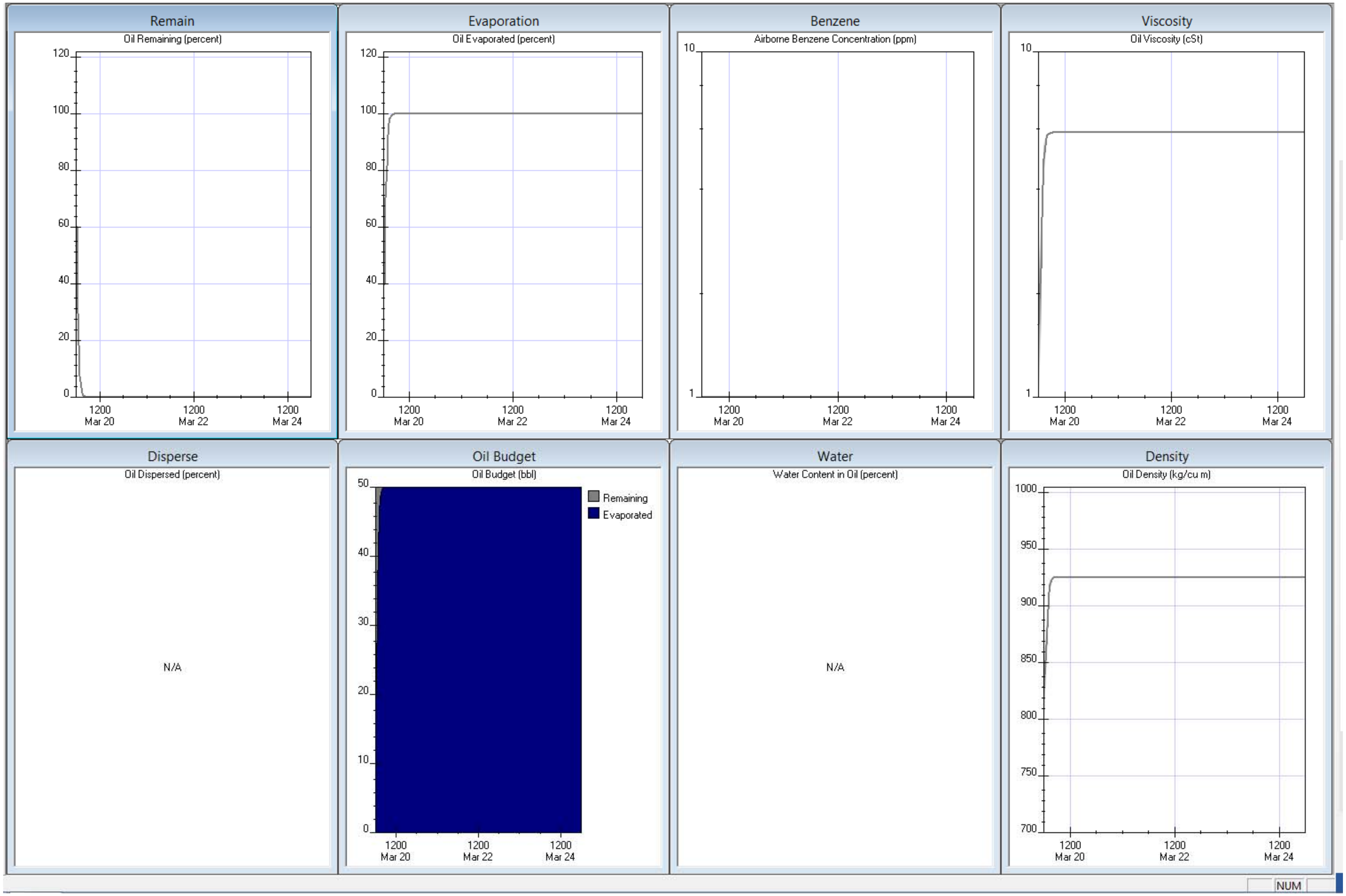

Figure D-1 (b): ADIOS 2.0 Model Output – 50 bbl Reformate with 0 mph wind speed.

Oil Type

REFORMATE (custom oil)

Location = Anacortes Washington

Synonyms = REFORMATE

Product Type = refined

API = --

Pour Point = -18 deg C

Flash Point = 25 deg C

Density = 0.785 g/cc at 50 deg F

Viscosity = 0.8 cSt at 50 deg F

Adhesion = 0.00g/m2

Aromatics = 96 weight %

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 5 mph from 0 degrees

Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F

Salinity = 32 ppt

Sediment Load = 5 g/m3 (ocean)

Current = 0 mph

Release Information

Instantaneous Release

Time of Release = March 20, 0000 hours

Amount Spilled = 50 bbl

Figure D-1 (c): ADIOS 2.0 Model Input Parameters – 50 bbl Reformate with 5 mph wind speed.

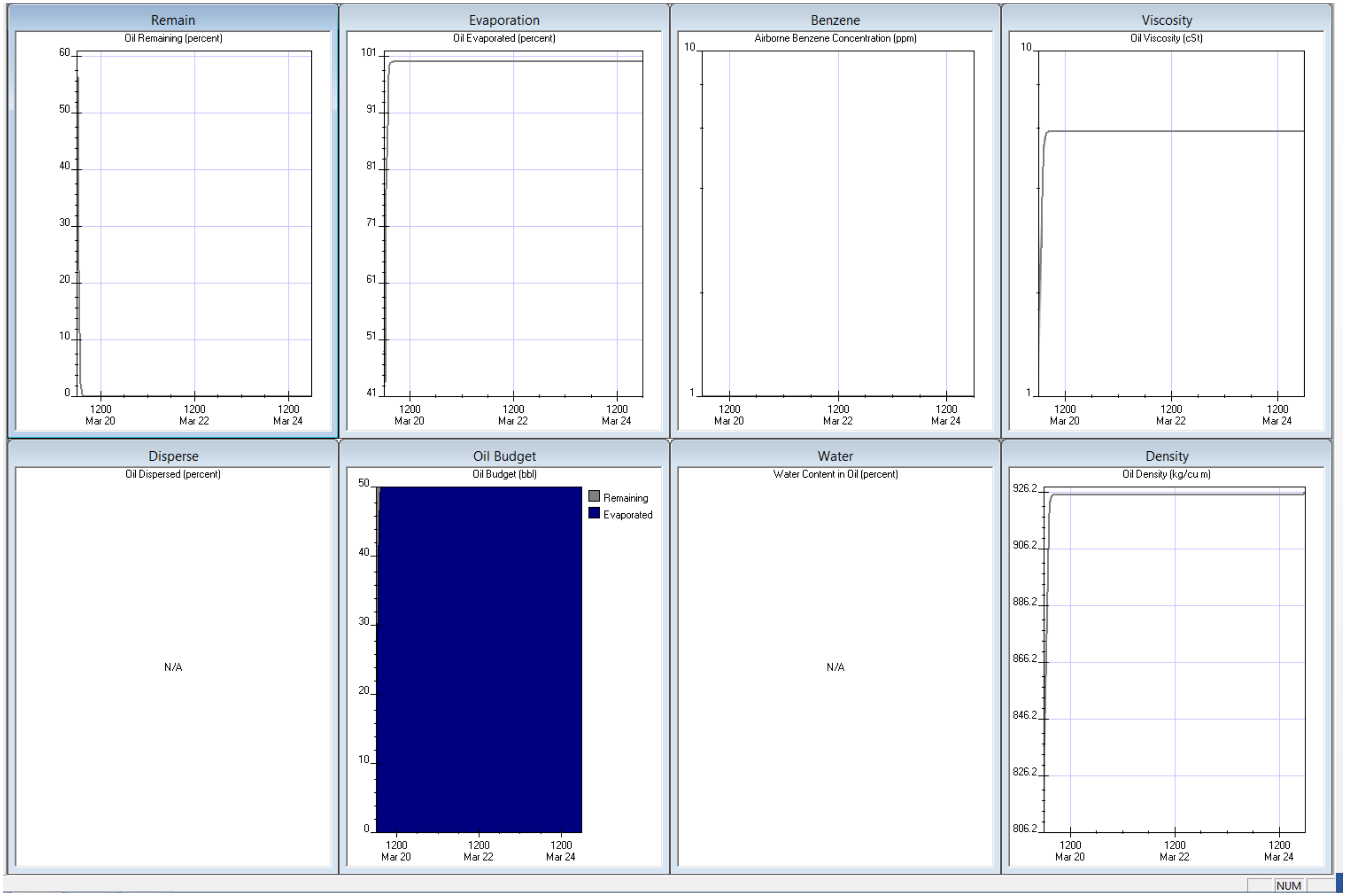

Figure D-1 (d): ADIOS 2.0 Model Output – 50 bbl Reformate with 5 mph wind speed.

Oil Type

REFORMATE (custom oil)
Location = Anacortes Washington
Synonyms = REFORMATE
Product Type = refined
API = --
Pour Point = -18 deg C
Flash Point = 25 deg C
Density = 0.785 g/cc at 50 deg F
Viscosity = 0.8 cSt at 50 deg F
Adhesion = 0.00g/m2
Aromatics = 96 weight %

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 10 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 0 mph

Release Information

Instantaneous Release

Time of Release = March 20, 0000 hours
Amount Spilled = 50 bbl

Figure D-1 (e): ADIOS 2.0 Model Input Parameters – 50 bbl Reformate with 10 mph wind speed.

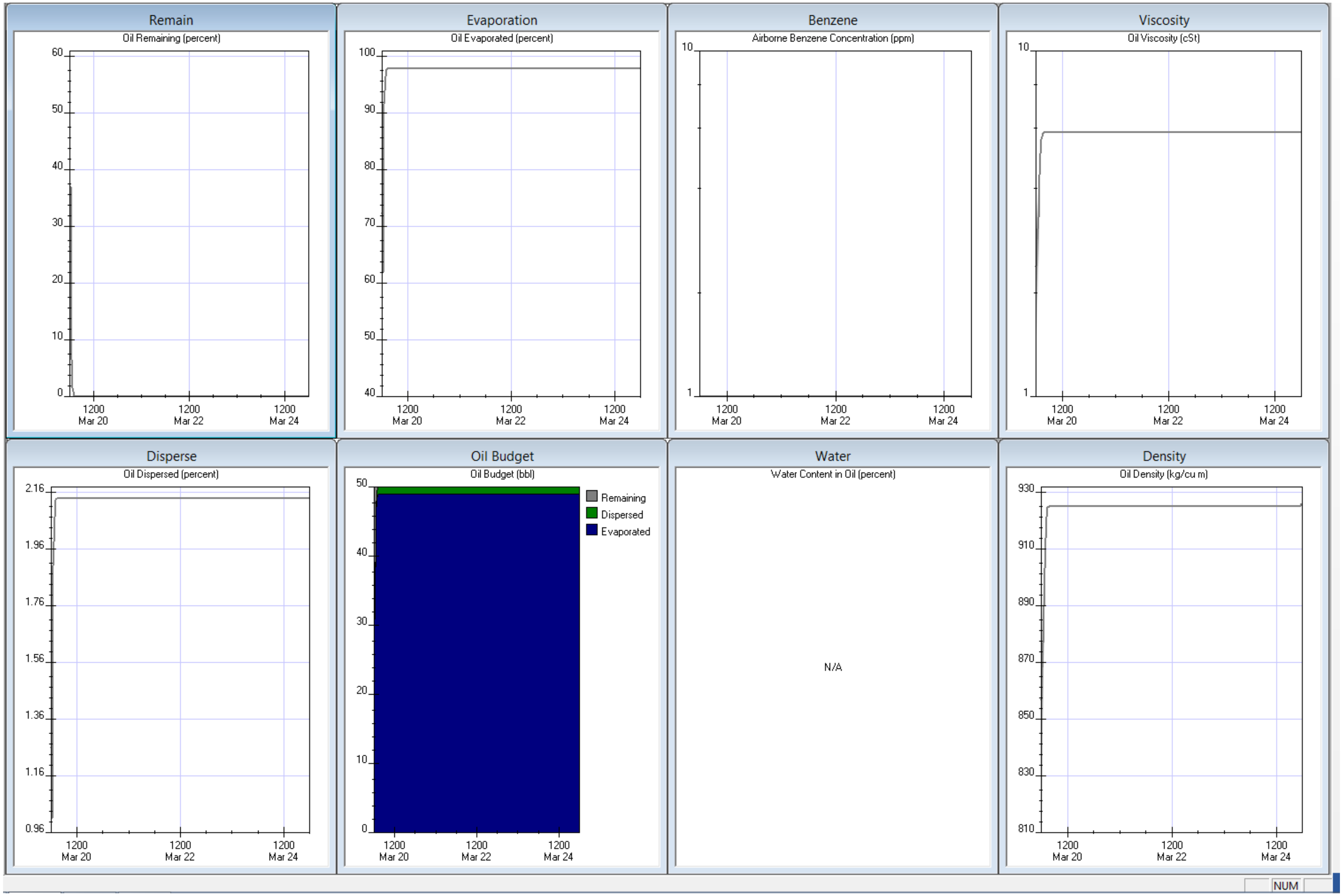

Figure D-1 (f): ADIOS 2.0 Model Output – 50 bbl Reformate with 10 mph wind speed.

Oil Type

- REFORMATE (BACKHAUL) (custom oil)
- Location = Anacortes Washington
- Synonyms = Reformate with xylenes removed
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 22 deg C
- Density = 0.780 g/cc at 50 deg F
- Viscosity = 1.2 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 88 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 2 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 2.0 mph towards 180 degrees

Release Information

- **Instantaneous Release**
  - Time of Release = March 20, 0000 hours
  - Amount Spilled = 50 bbl

Figure D-2 (a): ADIOS 2.0 Model Input Parameters – 50 bbl Reformate (Backhaul) with 0 mph wind speed.

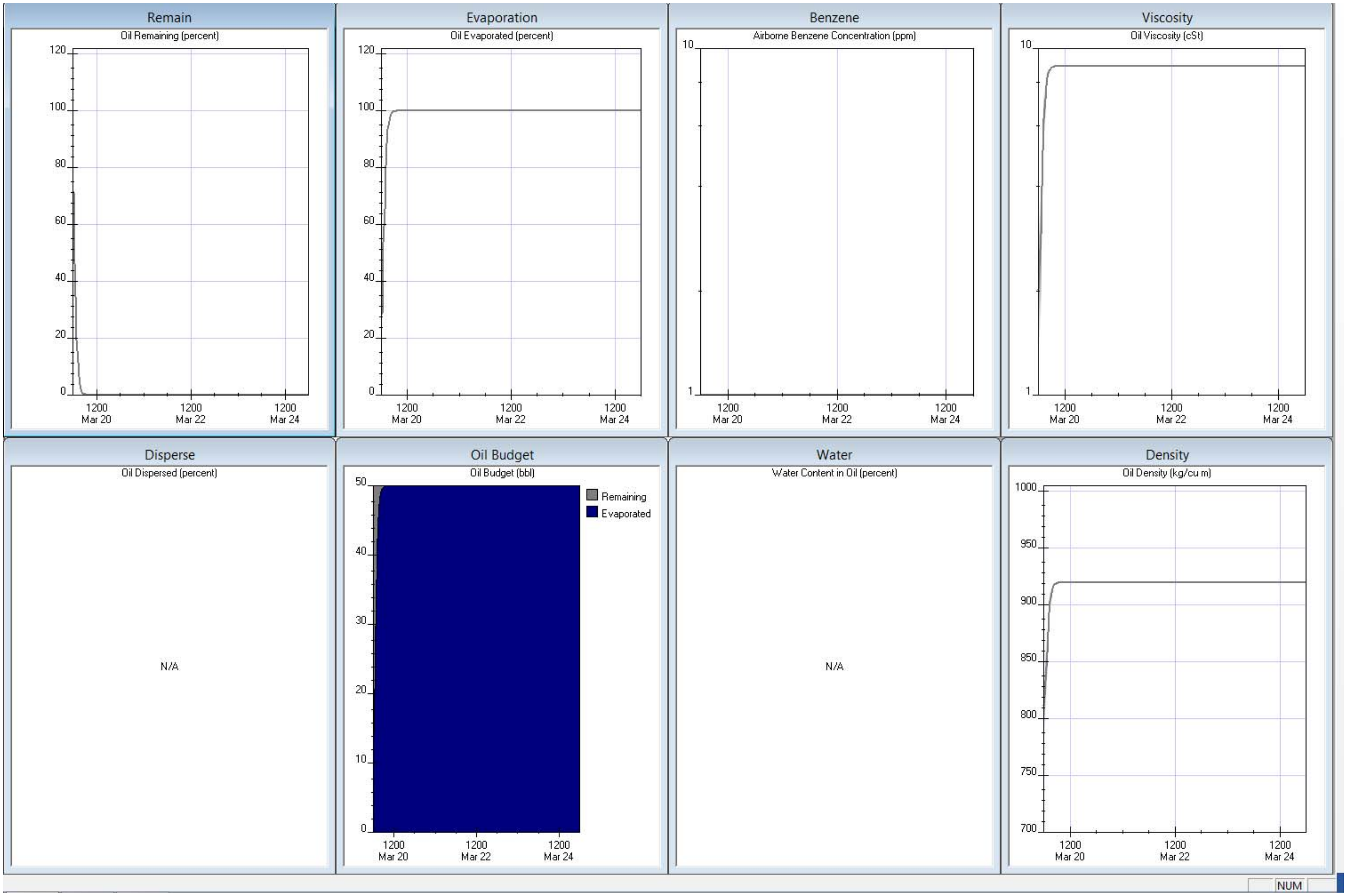

Figure D-2 (b): ADIOS 2.0 Model Output – 50 bbl Reformate (Backhaul) with 0 mph wind speed.

Oil Type

- REFORMATE (BACKHAUL) (custom oil)
- Location = Anacortes Washington
- Synonyms = Reformate with xylenes removed
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 22 deg C
- Density = 0.780 g/cc at 50 deg F
- Viscosity = 1.2 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 88 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 5 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 20, 0000 hours
  - Amount Spilled = 50 bbl

Figure D-2 (c): ADIOS 2.0 Model Input Parameters – 50 bbl Reformate (Backhaul) with 5 mph wind speed.

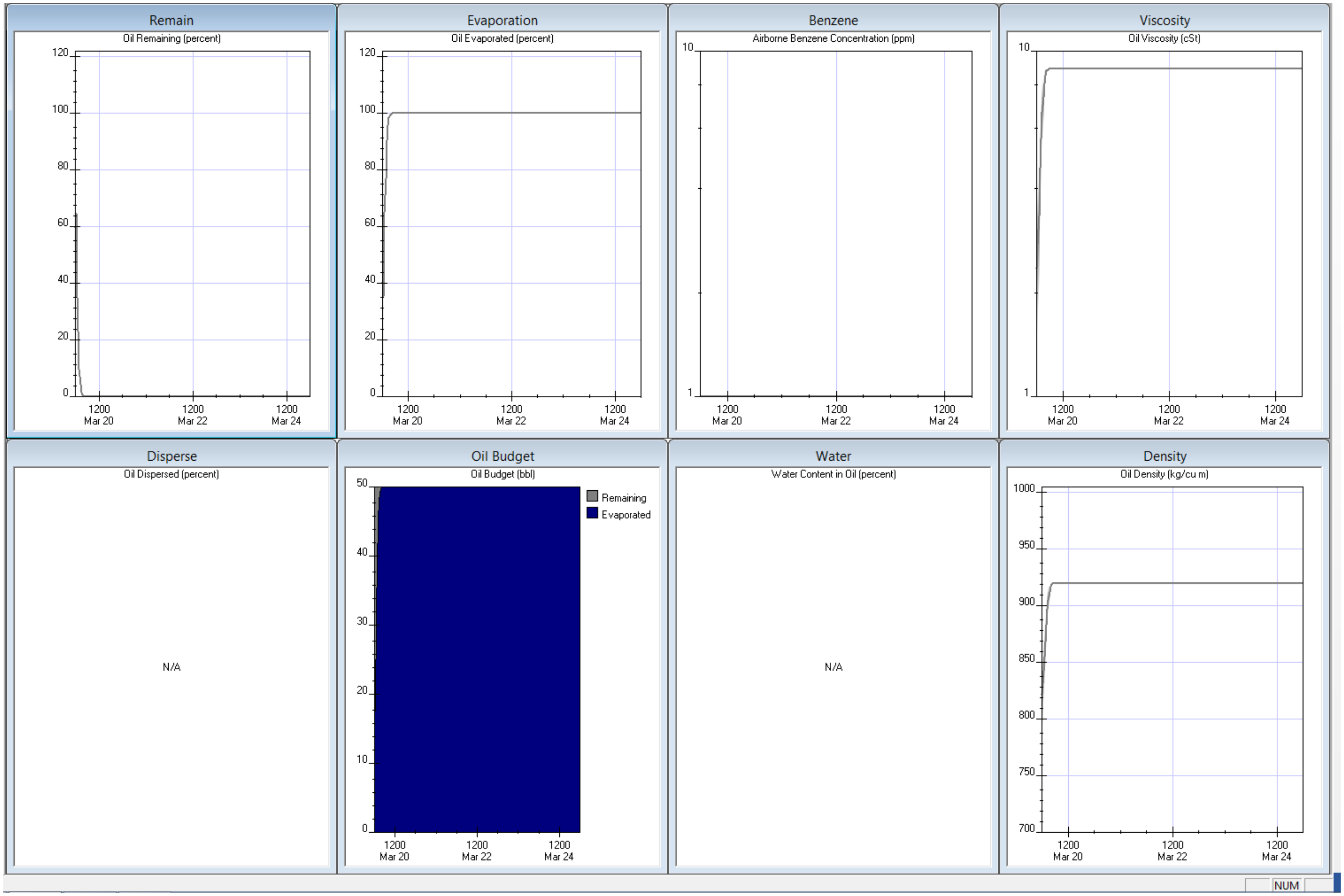

Figure D-2 (d): ADIOS 2.0 Model Output – 50 bbl Reformate (Backhaul) with 5 mph wind speed.

Oil Type

- REFORMATE (BACKHAUL) (custom oil)
- Location = Anacortes Washington
- Synonyms = Reformate with xylenes removed
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 22 deg C
- Density = 0.780 g/cc at 50 deg F
- Viscosity = 1.2 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 88 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 10 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 20, 0000 hours
  - Amount Spilled = 50 bbl

Figure D-2 (e): ADIOS 2.0 Model Input Parameters – 50 bbl Reformate (Backhaul) with 10 mph wind speed.

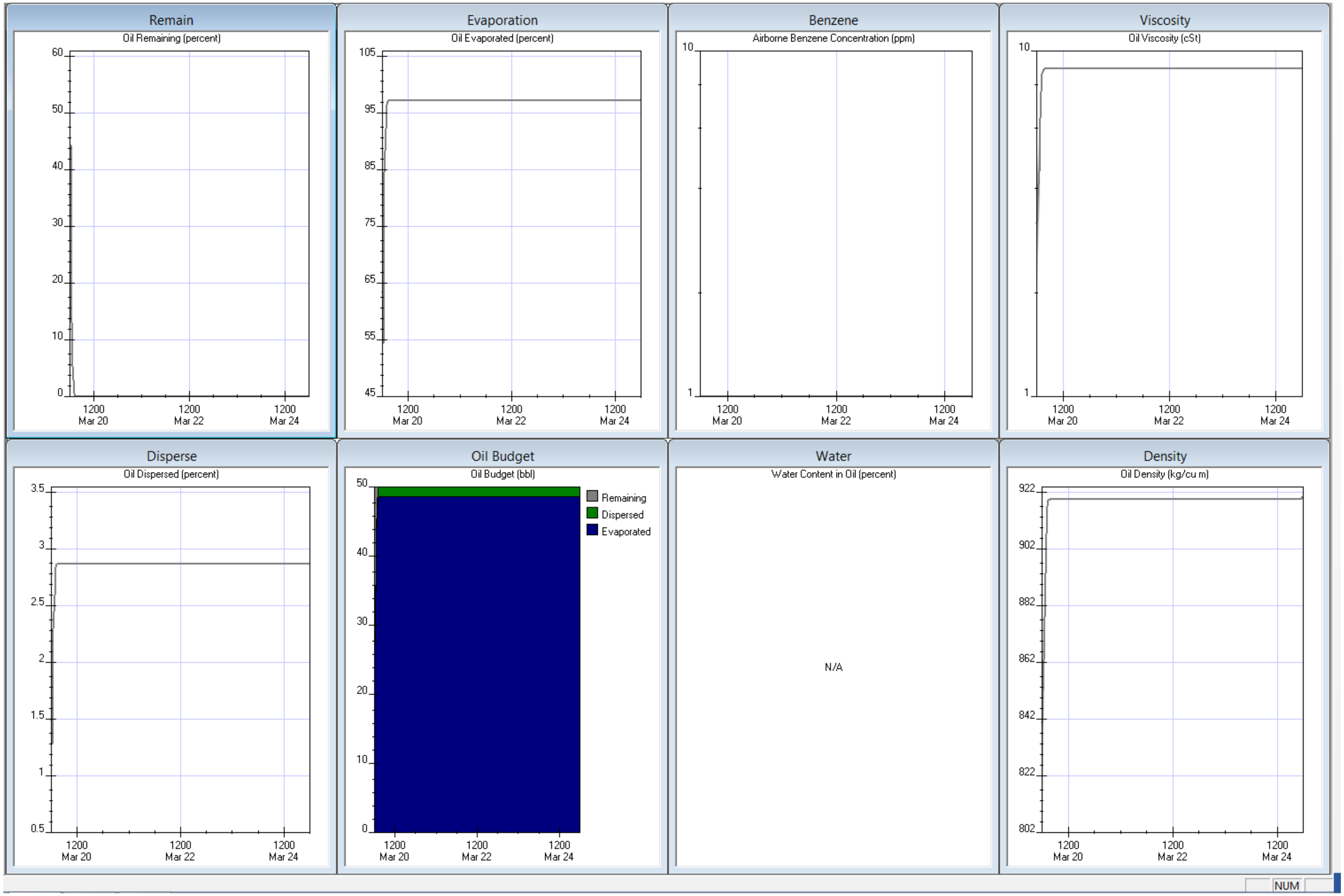

Figure D-2 (f): ADIOS 2.0 Model Output – 50 bbl Reformate (Backhaul) with 10 mph wind speed.

- **Oil Type**
  - MIXED XYLENES (custom oil)
  - Location = Anacortes Washington
  - Synonyms = Mixed Xylenes
  - Product Type = refined
  - API = --
  - Pour Point = -18 deg C
  - Flash Point = 28 deg C
  - Density = 0.794 g/cc at 50 deg F
  - Viscosity = 0.9 cSt at 50 deg F
  - Adhesion = 0.00g/m2
  - Aromatics = 100 weight %
- **Emulsification**
  - Mousse begins to form when 100% of the oil has evaporated.
- **Wind and Wave Conditions**
  - Wind Speed = 2 mph from 0 degrees
  - Wave Height = computed from wind speed, unlimited fetch (default)
- **Water Properties**
  - Temperature = 50 deg F
  - Salinity = 32 ppt
  - Sediment Load = 5 g/m3 (ocean)
  - Current = 2.0 mph towards 180 degrees
- **Release Information**
  - **Instantaneous Release**
    - Time of Release = March 20, 0000 hours
    - Amount Spilled = 50 bbl

Figure D-3 (a): ADIOS 2.0 Model Input Parameters – 50 bbl Mixed Xylenes with 0 mph wind speed.

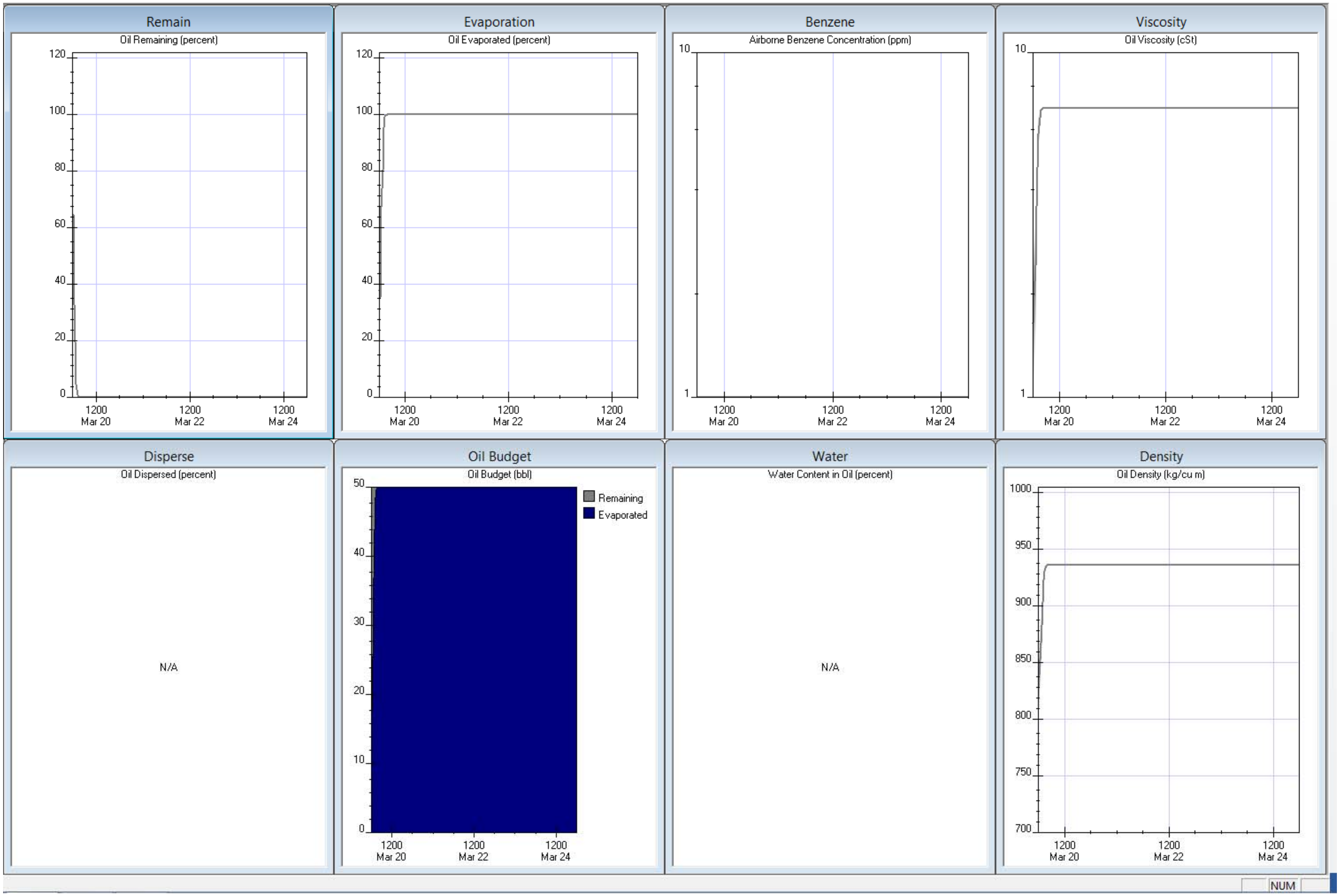

Figure D-3 (b): ADIOS 2.0 Model Output – 50 bbl Mixed Xylenes with 0 mph wind speed.

Oil Type

MIXED XYLENES (custom oil)
Location = Anacortes Washington
Synonyms = Mixed Xylenes
Product Type = refined
API = --
Pour Point = -18 deg C
Flash Point = 28 deg C
Density = 0.794 g/cc at 50 deg F
Viscosity = 0.9 cSt at 50 deg F
Adhesion = 0.00g/m2
Aromatics = 100 weight %

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 5 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 0 mph

Release Information

Instantaneous Release

Time of Release = March 20, 0000 hours
Amount Spilled = 50 bbl

Figure D-3 (c): ADIOS 2.0 Model Input Parameters – 50 bbl Mixed Xylenes with 5 mph wind speed.

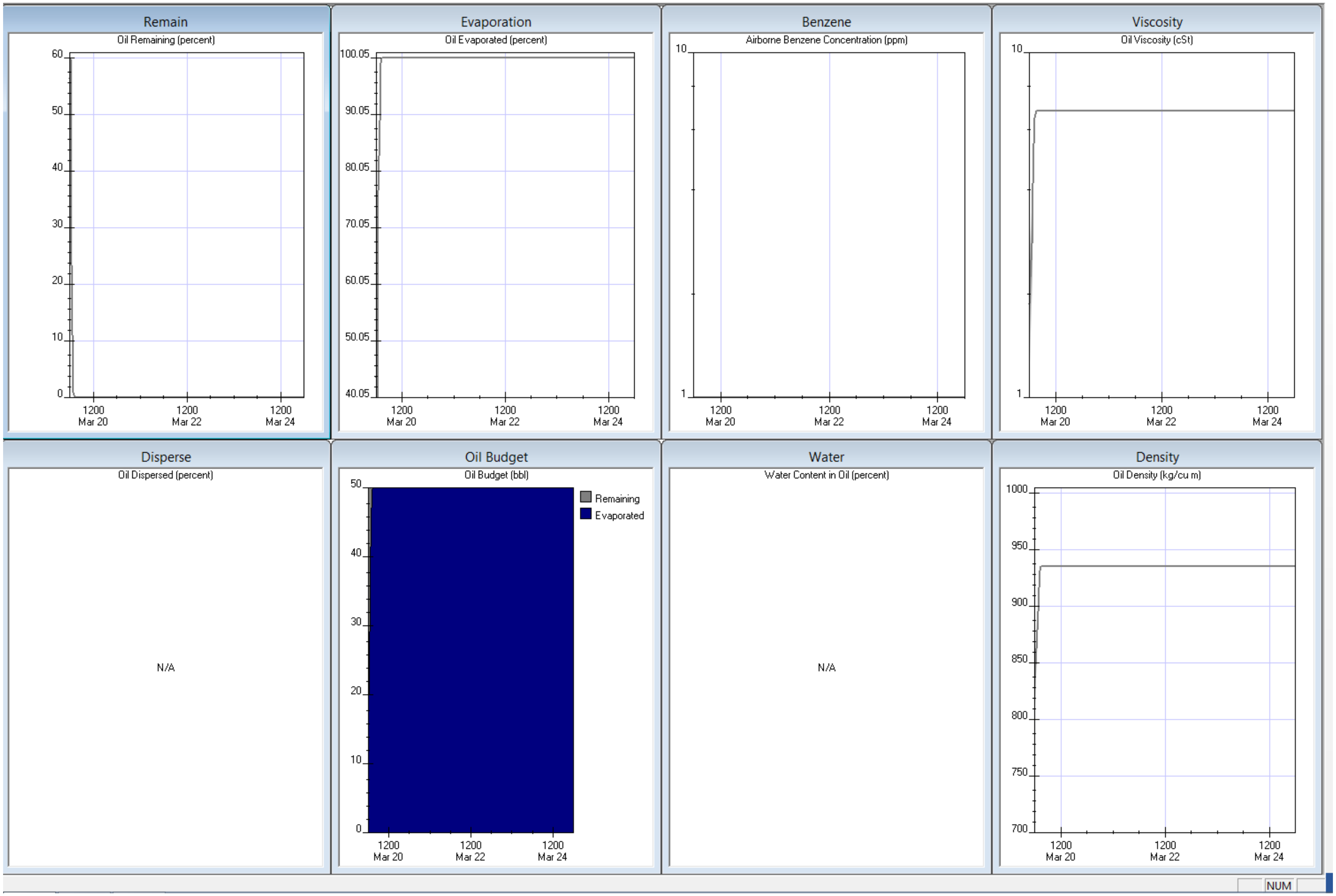

Figure D-3 (d): ADIOS 2.0 Model Output – 50 bbl Mixed Xylenes with 5 mph wind speed.

- **Oil Type**
  - MIXED XYLENES (custom oil)
  - Location = Anacortes Washington
  - Synonyms = Mixed Xylenes
  - Product Type = refined
  - API = --
  - Pour Point = -18 deg C
  - Flash Point = 28 deg C
  - Density = 0.794 g/cc at 50 deg F
  - Viscosity = 0.9 cSt at 50 deg F
  - Adhesion = 0.00g/m2
  - Aromatics = 100 weight %
- **Emulsification**
  - Mousse begins to form when 100% of the oil has evaporated.
- **Wind and Wave Conditions**
  - Wind Speed = 10 mph from 0 degrees
  - Wave Height = computed from wind speed, unlimited fetch (default)
- **Water Properties**
  - Temperature = 50 deg F
  - Salinity = 32 ppt
  - Sediment Load = 5 g/m3 (ocean)
  - Current = 0 mph
- **Release Information**
  - **Instantaneous Release**
    - Time of Release = March 20, 0000 hours
    - Amount Spilled = 50 bbl

Figure D-3 (e): ADIOS 2.0 Model Input Parameters – 50 bbl Mixed Xylenes with 10 mph wind speed.

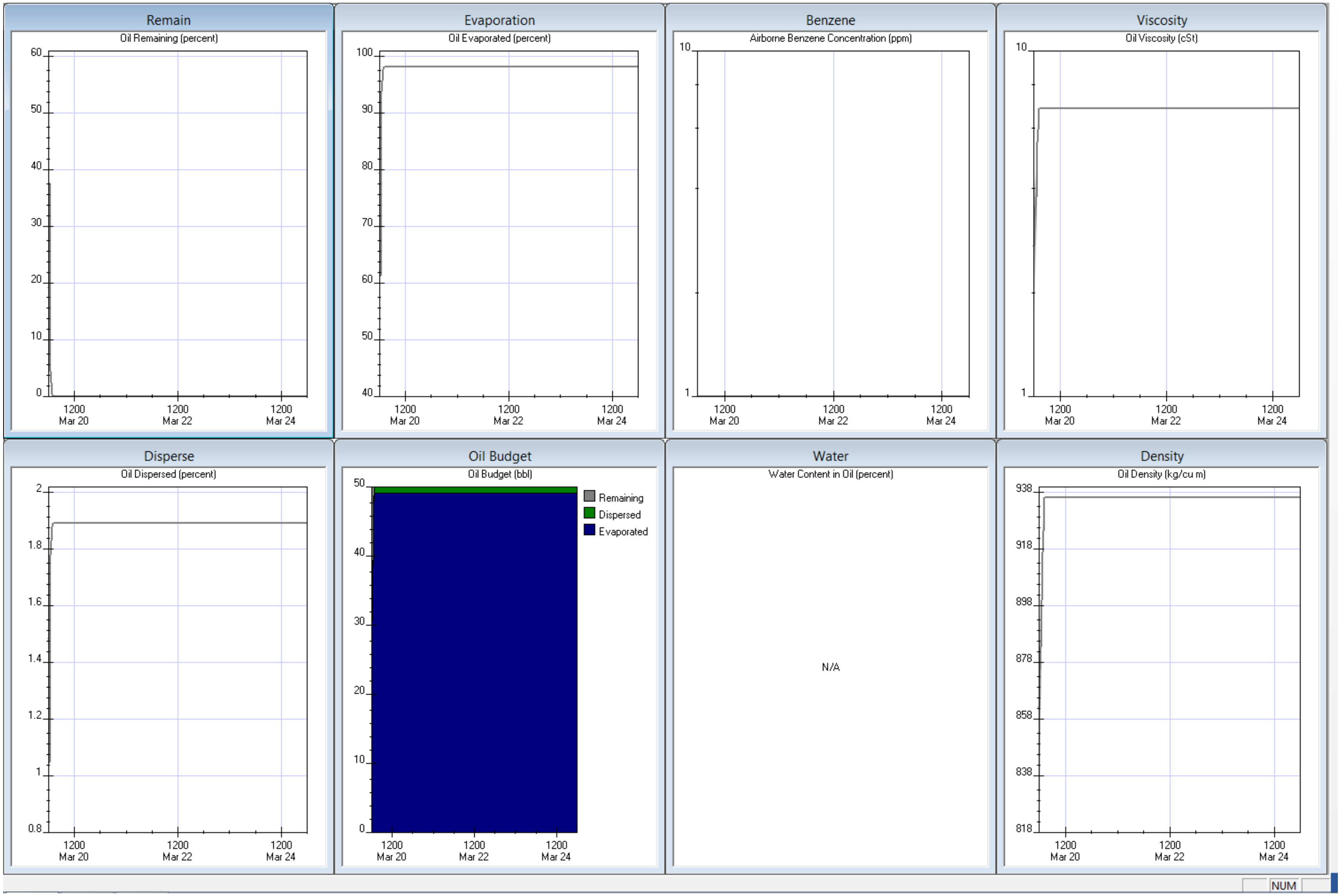

Figure D-3 (f): ADIOS 2.0 Model Output – 50 bbl Mixed Xylenes with 10 mph wind speed.

Oil Type

- GASOLINE (UNLEADED), SHELL
- Location = none listed
- Synonyms = AUTOMOTIVE FUEL, PETROL
- Product Type = refined
- API = --
- Pour Point = unknown
- Flash Point = -30 deg C
- Density = 0.753 g/cc at 50 deg F
- Viscosity = 4.9 cSt at 50 deg F
- Adhesion = unknown
- Aromatics = unknown
- WARNING! Benzene graph for this product may be unreliable.

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 2 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 2.0 mph towards 180 degrees

Release Information

- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 50 bbl

Figure D-4 (a): ADIOS 2.0 Model Input Parameters – 50 bbl Gasoline with 0 mph wind speed.

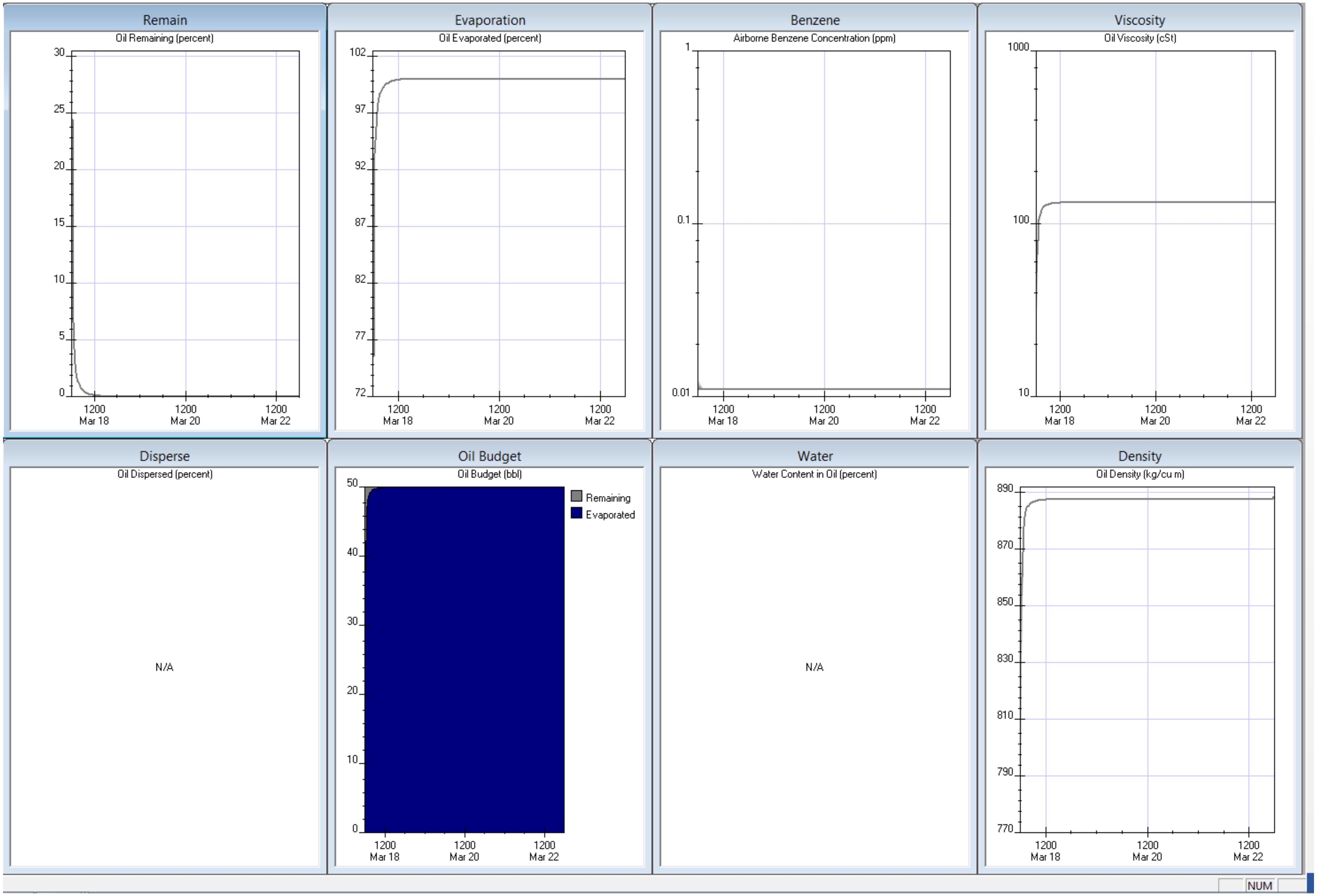

Figure D-4 (b): ADIOS 2.0 Model Output – 50 bbl Gasoline with 0 mph wind speed.

Oil Type

- GASOLINE (UNLEADED), SHELL
- Location = none listed
- Synonyms = AUTOMOTIVE FUEL, PETROL
- Product Type = refined
- API = --
- Pour Point = unknown
- Flash Point = -30 deg C
- Density = 0.753 g/cc at 50 deg F
- Viscosity = 4.9 cSt at 50 deg F
- Adhesion = unknown
- Aromatics = unknown
- WARNING! Benzene graph for this product may be unreliable.

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 5 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 50 bbl

Figure D-4 (c): ADIOS 2.0 Model Input Parameters – 50 bbl Gasoline with 5 mph wind speed.

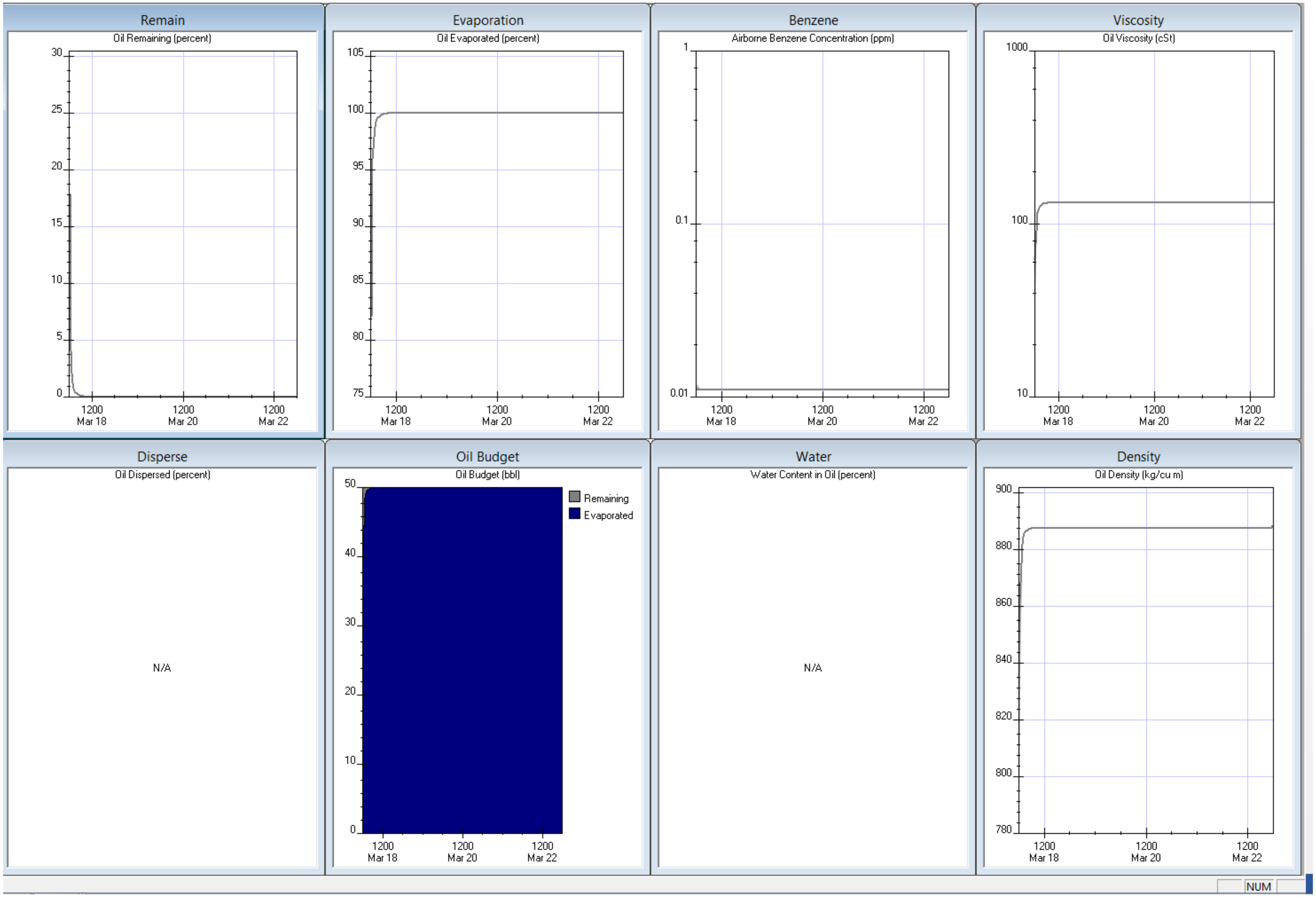

Figure D-4 (d): ADIOS 2.0 Model Output – 50 bbl Gasoline with 5 mph wind speed.

Oil Type

- GASOLINE (UNLEADED), SHELL
- Location = none listed
- Synonyms = AUTOMOTIVE FUEL, PETROL
- Product Type = refined
- API = --
- Pour Point = unknown
- Flash Point = -30 deg C
- Density = 0.753 g/cc at 50 deg F
- Viscosity = 4.9 cSt at 50 deg F
- Adhesion = unknown
- Aromatics = unknown
- WARNING! Benzene graph for this product may be unreliable.

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 10 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 20, 0000 hours
  - Amount Spilled = 50 bbl

Figure D-4 (e): ADIOS 2.0 Model Input Parameters – 50 bbl Gasoline with 10 mph wind speed.

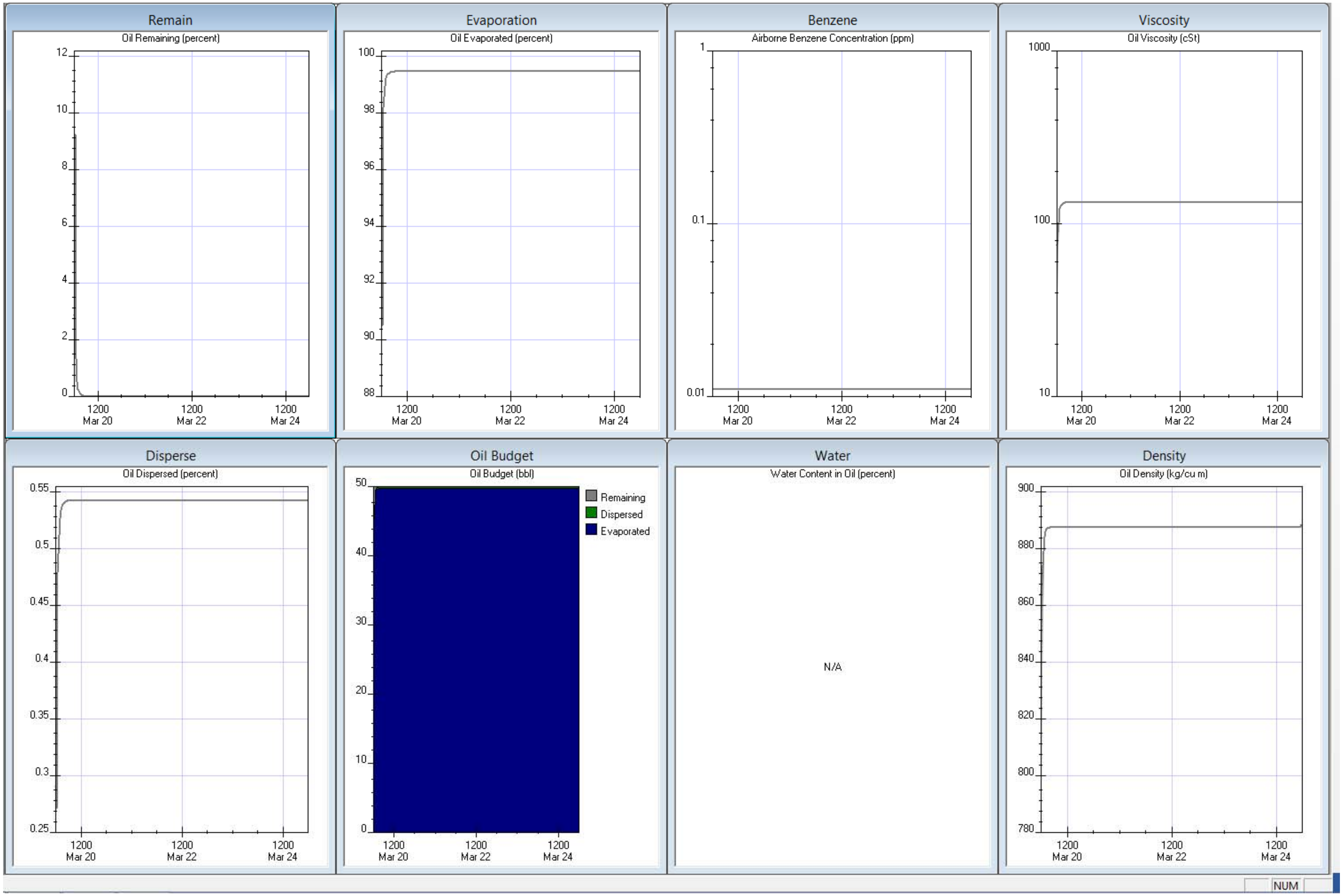

Figure D-4 (f): ADIOS 2.0 Model Output – 50 bbl Gasoline with 10 mph wind speed.

Table D-3. List of Figures for Dockside Spill Scenario– 1200 bbl
ADIOS 2.0 Modeling of Evaporation and Dispersion Individual Runs (Input/Output) Results

Figure #	Stream	Volume bbl	Wind Speed* mph	File Type
Figure D-5 (a)	Reformate	1,200	0	Input
Figure D-5 (b)			0	Output
Figure D-5 (c)			5	Input
Figure D-5 (d)			5	Output
Figure D-5 (e)			10	Input
Figure D-5 (f)			10	Output
Figure D-6 (a)	Reformate (backhaul)	1,200	0	Input
Figure D-6 (b)			0	Output
Figure D-6 (c)			5	Input
Figure D-6 (d)			5	Output
Figure D-6 (e)			10	Input
Figure D-6 (f)			10	Output
Figure D-7 (a)	Mixed Xylenes	1,200	0	Input
Figure D-7 (b)			0	Output
Figure D-7 (c)			5	Input
Figure D-7 (d)			5	Output
Figure D-7 (e)			10	Input
Figure D-7 (f)			10	Output
Figure D-8 (a)	Gasoline	1,200	0	Input
Figure D-8 (b)			0	Output
Figure D-8 (c)			5	Input
Figure D-8 (d)			5	Output
Figure D-8 (e)			10	Input
Figure D-8 (f)			10	Output

***** ADIOS 2.0 accepts a minimum wind speed of 2 mph. To simulate zero wind speed, a 2 mph wind is used in combination with a 2 mph current speed in the opposite direction.

Spill Scenario 1200 bbl w/3 wind speeds and 4 streams:

Oil Type

- REFORMATE (custom oil)
- Location = Anacortes Washington
- Synonyms = REFORMATE
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 25 deg C
- Density = 0.785 g/cc at 50 deg F
- Viscosity = 0.8 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 96 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 2 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 2.0 mph towards 180 degrees

Release Information

- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 1200 bbl

Figure D-5 (a): ADIOS 2.0 Model Input Parameters – 1,200 bbl Reformate with 0 mph wind speed.

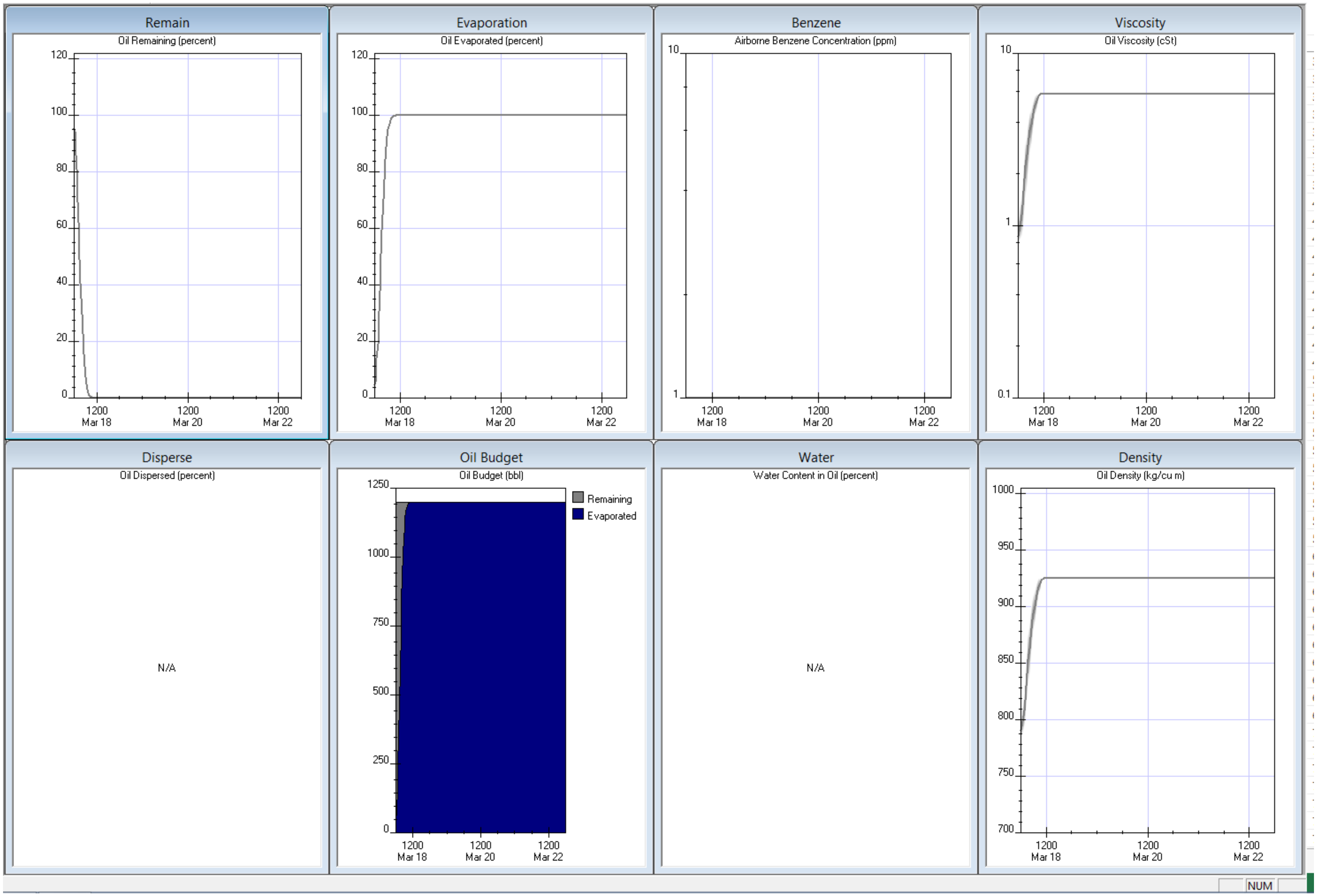

Figure D-5 (b): ADIOS 2.0 Model Output – 1,200 bbl Reformate with 0 mph wind speed.

Oil Type

REFORMATE (custom oil)
Location = Anacortes Washington
Synonyms = REFORMATE
Product Type = refined
API = --
Pour Point = -18 deg C
Flash Point = 25 deg C
Density = 0.785 g/cc at 50 deg F
Viscosity = 0.8 cSt at 50 deg F
Adhesion = 0.00g/m2
Aromatics = 96 weight %

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 5 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 0 mph

Release Information

Instantaneous Release

Time of Release = March 18, 0000 hours
Amount Spilled = 1200 bbl

Figure D-5 (c): ADIOS 2.0 Model Input Parameters – 1,200 bbl Reformate with 5 mph wind speed.

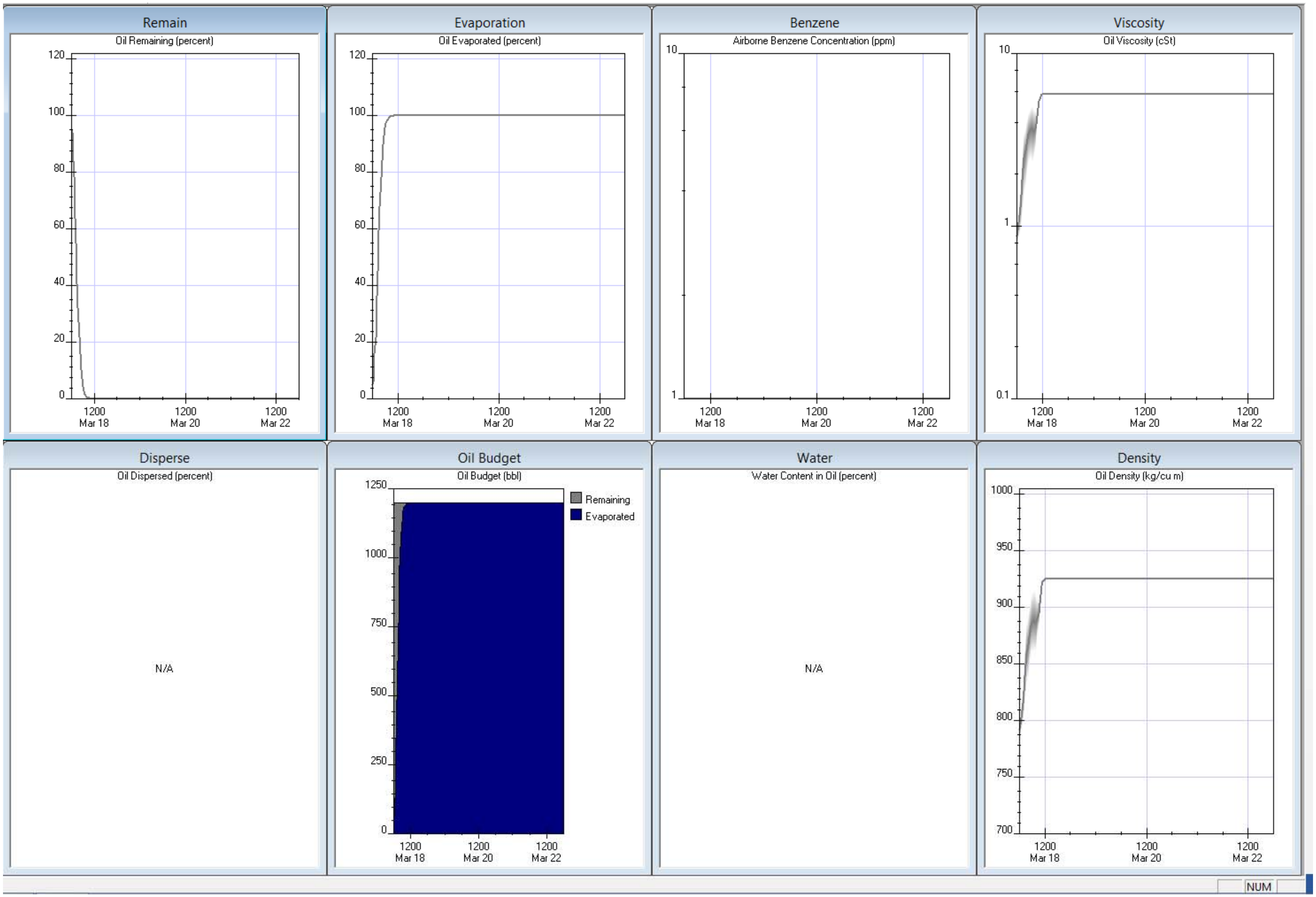

Figure D-5 (d): ADIOS 2.0 Model Output – 1,200 bbl Reformate with 5 mph wind speed.

Oil Type

- REFORMATE (custom oil)
- Location = Anacortes Washington
- Synonyms = REFORMATE
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 25 deg C
- Density = 0.785 g/cc at 50 deg F
- Viscosity = 0.8 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 96 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 10 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 1200 bbl

Figure D-5 (e): ADIOS 2.0 Model Input Parameters – 1,200 bbl Reformate with 10 mph wind speed.

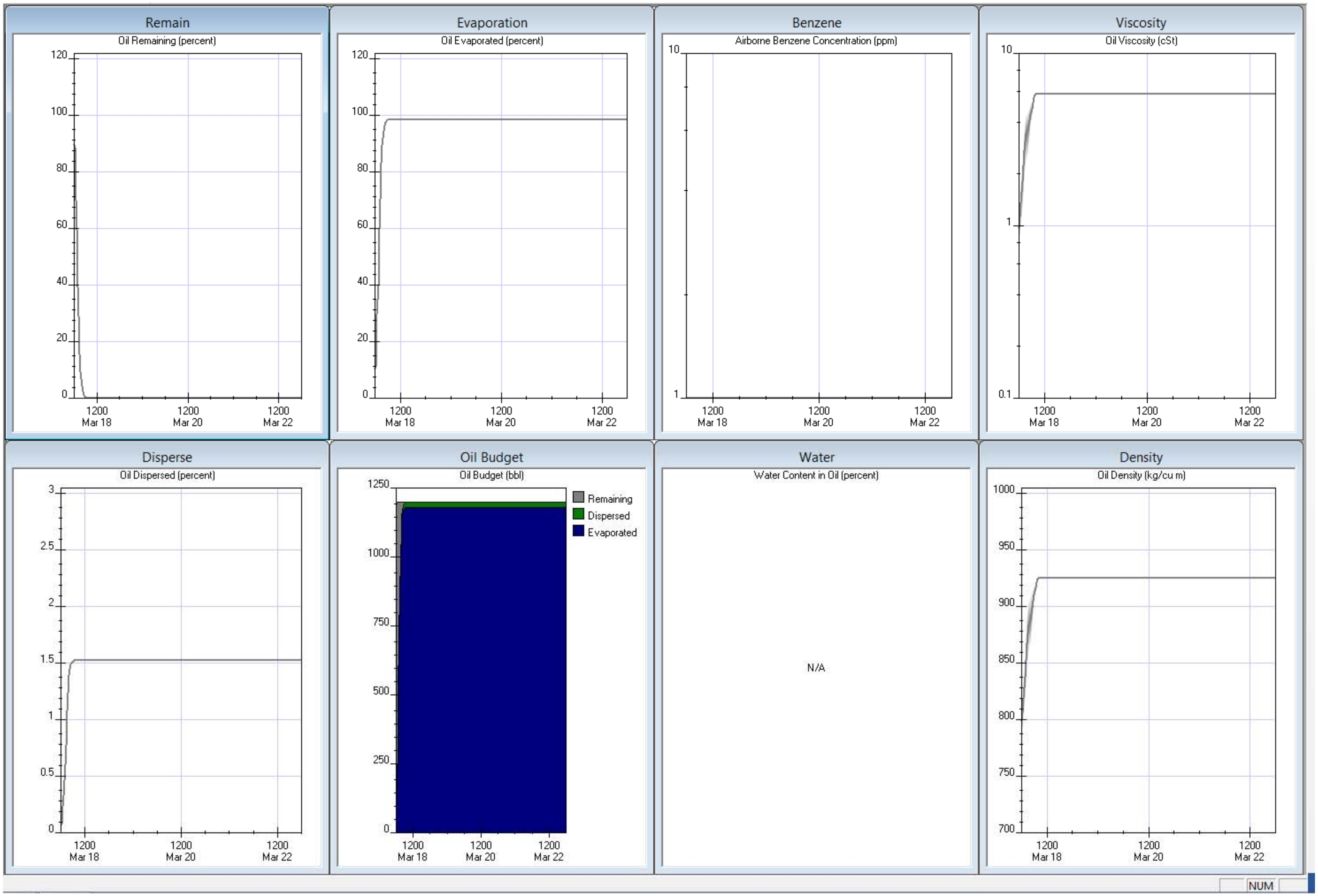

Figure D-5 (f): ADIOS 2.0 Model Output – 1,200 bbl Reformate with 10 mph wind speed.

Oil Type

- REFORMATE (XYLENES REMOVED) (custom oil)
- Location = Anacortes Washington
- Synonyms = Reformate with xylenes removed
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 22 deg C
- Density = 0.780 g/cc at 50 deg F
- Viscosity = 1.2 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 88 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 2 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 2.0 mph towards 180 degrees

Release Information

- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 1200 bbl

Figure D-6 (a): ADIOS 2.0 Model Input Parameters – 1,200 bbl Reformate (Backhaul) with 0 mph wind speed.

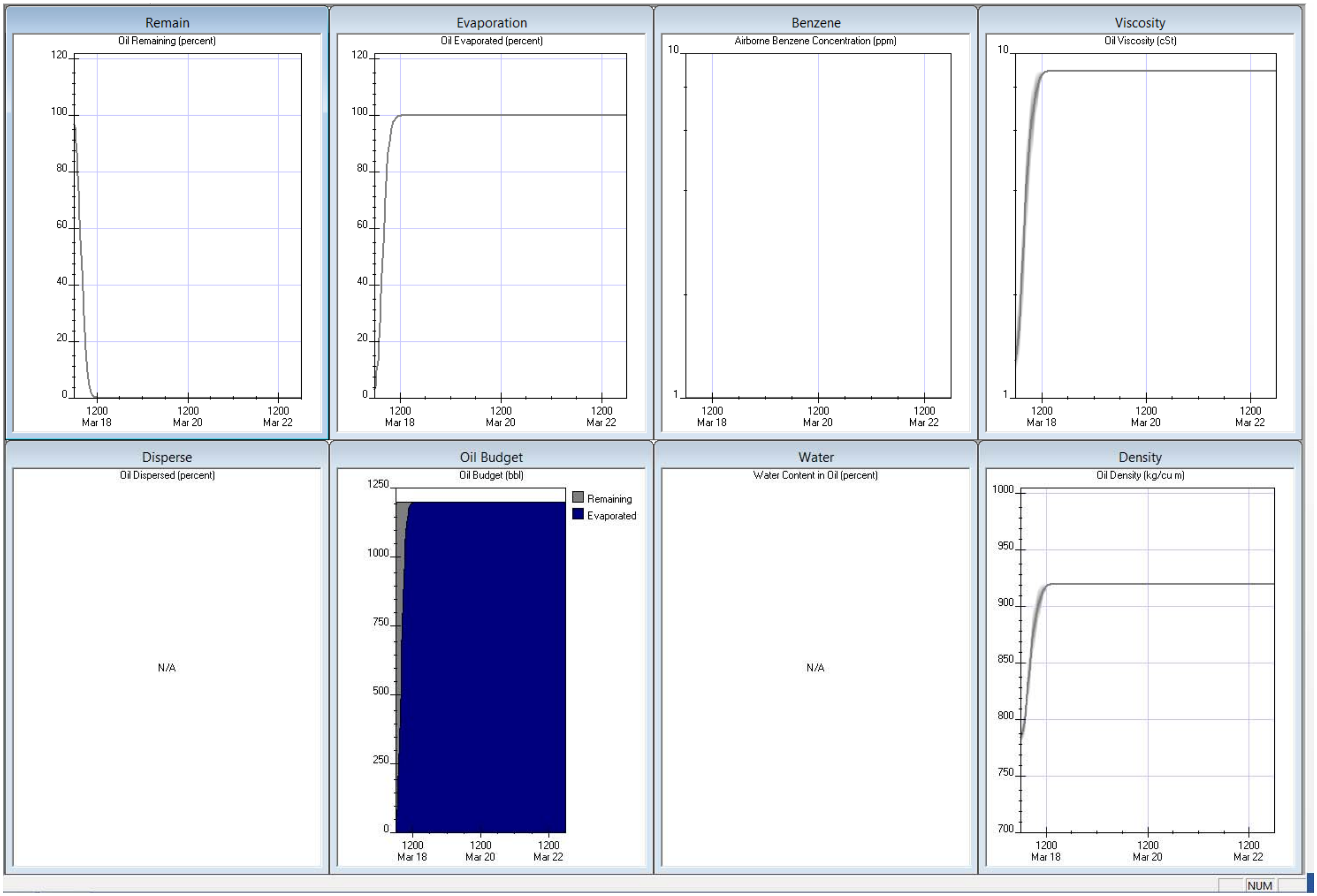

Figure D-6 (b): ADIOS 2.0 Model Output – 1,200 bbl Reformate (Backhaul) with 0 mph wind speed.

⊟ **Oil Type**

REFORMATE (XYLENES REMOVED) (custom oil)
Location = Anacortes Washington
Synonyms = Reformate with xylenes removed
Product Type = refined
API = --
Pour Point = -18 deg C
Flash Point = 22 deg C
Density = 0.780 g/cc at 50 deg F
Viscosity = 1.2 cSt at 50 deg F
Adhesion = 0.00g/m2
Aromatics = 88 weight %

⊟ **Emulsification**

Mousse begins to form when 100% of the oil has evaporated.

⊟ **Wind and Wave Conditions**

Wind Speed = 5 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

⊟ **Water Properties**

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 0 mph

⊟ **Release Information**

⊟ **Instantaneous Release**

Time of Release = March 18, 0000 hours
Amount Spilled = 1200 bbl

Figure D-6 (c): ADIOS 2.0 Model Input Parameters – 1,200 bbl Reformate (Backhaul) with 5 mph wind speed.

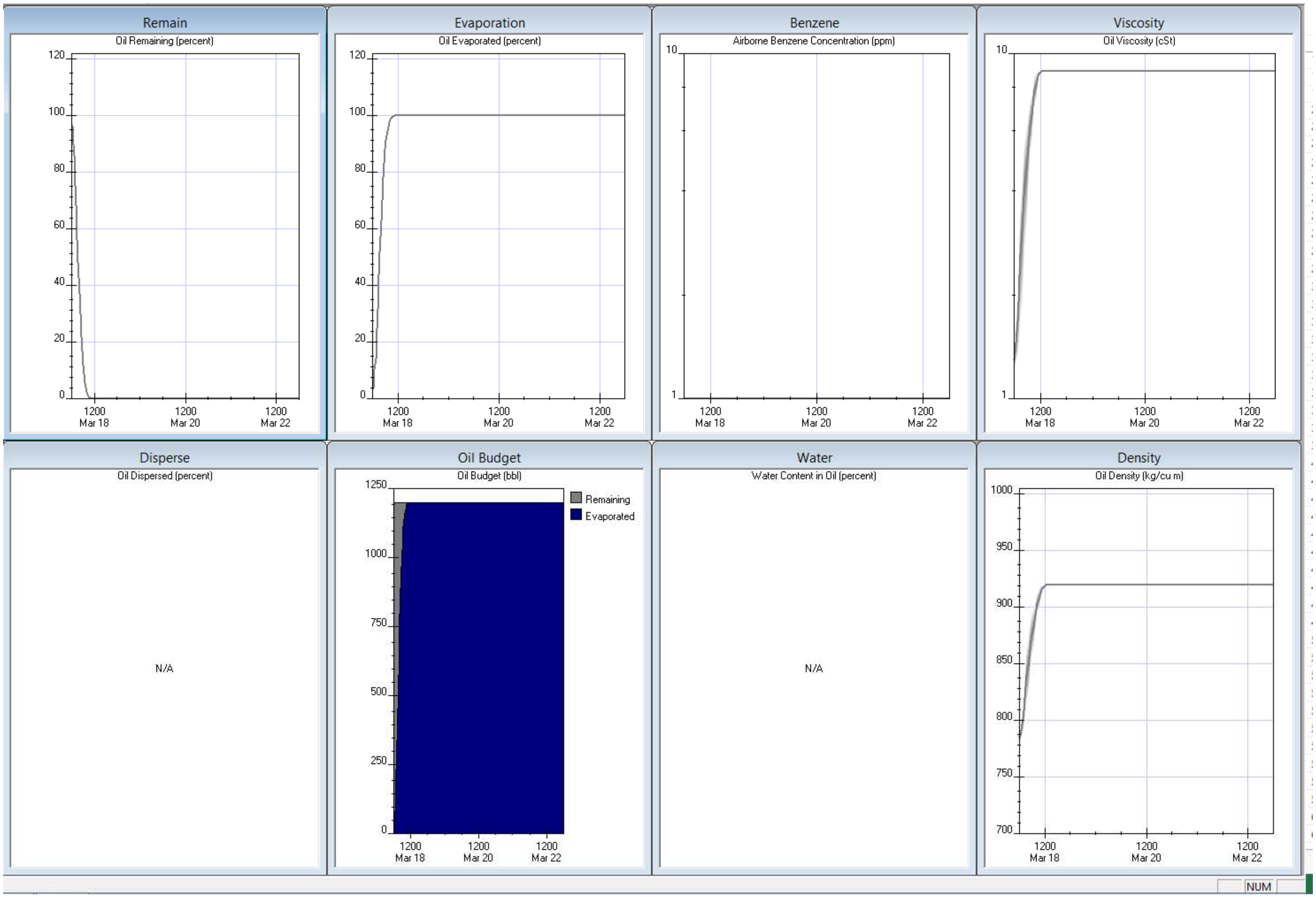

Figure D-6 (d): ADIOS 2.0 Model Output – 1,200 bbl Reformate (Backhaul) with 5 mph wind speed.

Oil Type

REFORMATE (XYLENES REMOVED) (custom oil)
Location = Anacortes Washington
Synonyms = Reformate with xylenes removed
Product Type = refined
API = --
Pour Point = -18 deg C
Flash Point = 22 deg C
Density = 0.780 g/cc at 50 deg F
Viscosity = 1.2 cSt at 50 deg F
Adhesion = 0.00g/m2
Aromatics = 88 weight %

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 10 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 0 mph

Release Information

Instantaneous Release

Time of Release = March 18, 0000 hours
Amount Spilled = 1200 bbl

Figure D-6 (e): ADIOS 2.0 Model Input Parameters – 1,200 bbl Reformate (Backhaul) with 10 mph wind speed.

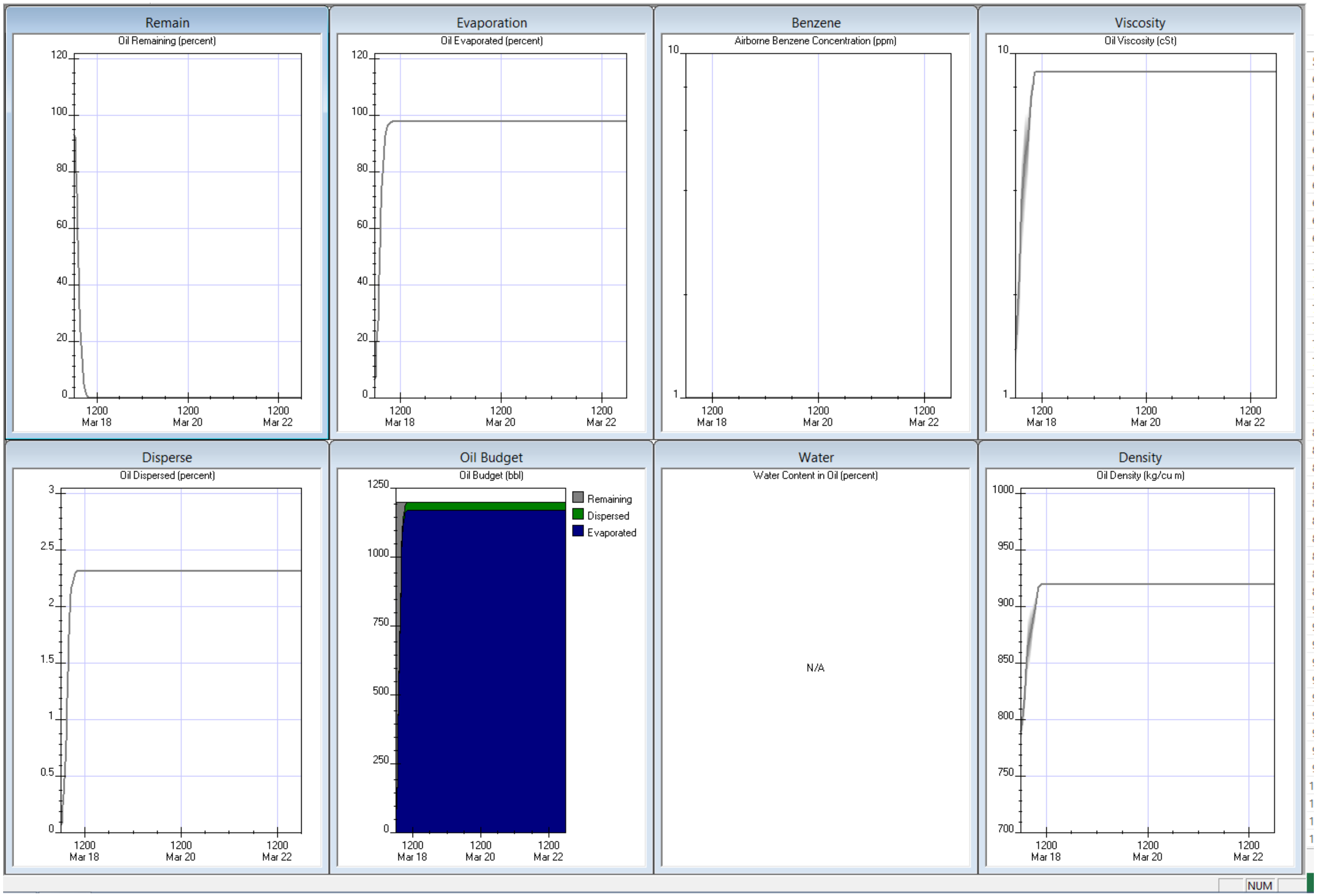

Figure D-6 (f): ADIOS 2.0 Model Output – 1,200 bbl Reformate (Backhaul) with 10 mph wind speed.

Oil Type

- MIXED XYLENES (custom oil)
- Location = Anacortes Washington
- Synonyms = Mixed Xylenes
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 28 deg C
- Density = 0.794 g/cc at 50 deg F
- Viscosity = 0.9 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 100 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 2 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 2.0 mph towards 180 degrees

Release Information

- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 1200 bbl

Figure D-7 (a): ADIOS 2.0 Model Input Parameters – 1,200 bbl Mixed Xylenes with 0 mph wind speed.

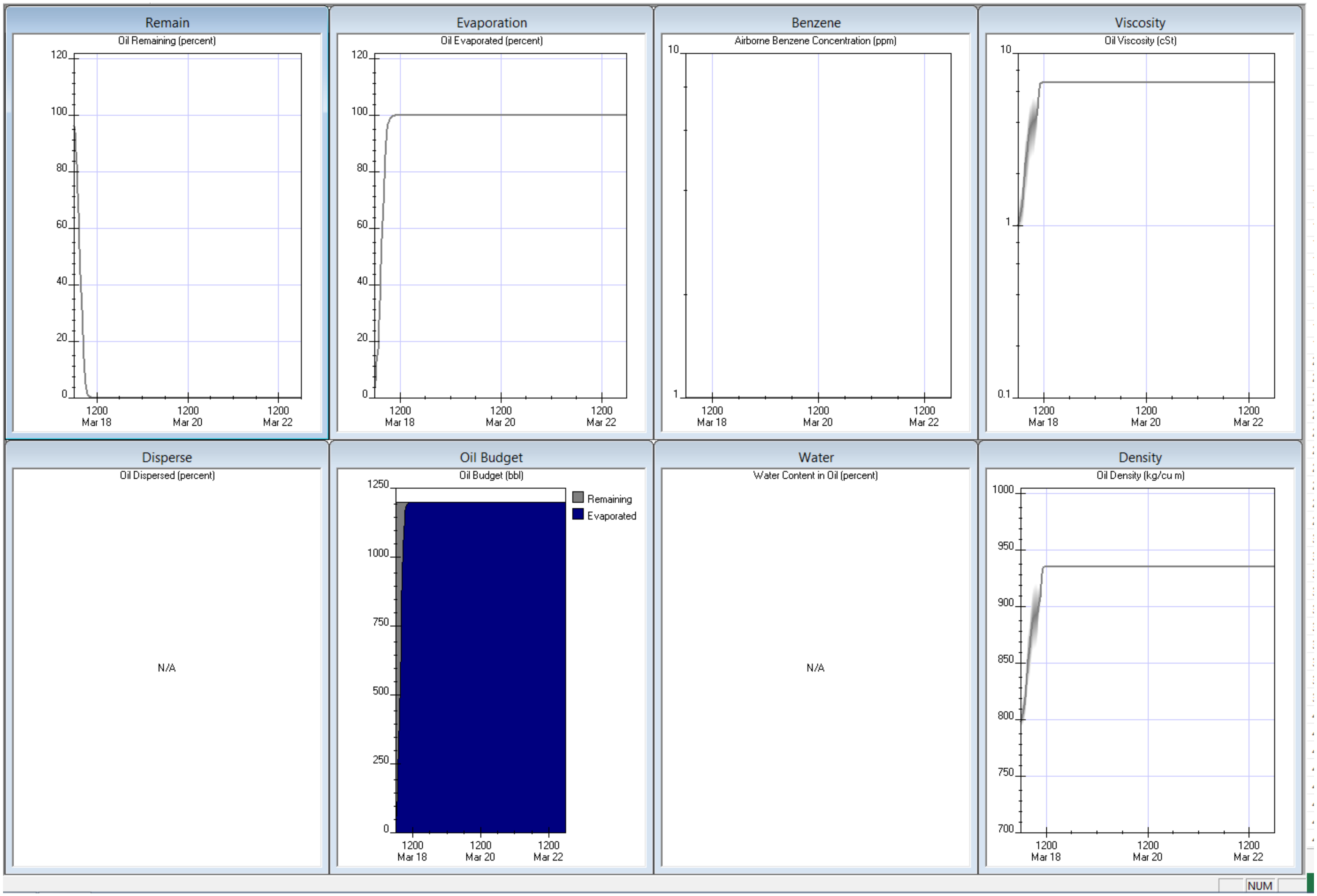

Figure D-7 (b): ADIOS 2.0 Model Output – 1,200 bbl Mixed Xylenes with 0 mph wind speed.

Oil Type
- MIXED XYLENES (custom oil)
- Location = Anacortes Washington
- Synonyms = Mixed Xylenes
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 28 deg C
- Density = 0.794 g/cc at 50 deg F
- Viscosity = 0.9 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 100 weight %

Emulsification
- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions
- Wind Speed = 5 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties
- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information
- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 1200 bbl

Figure D-7 (c): ADIOS 2.0 Model Input Parameters – 1,200 bbl Mixed Xylenes with 5 mph wind speed.

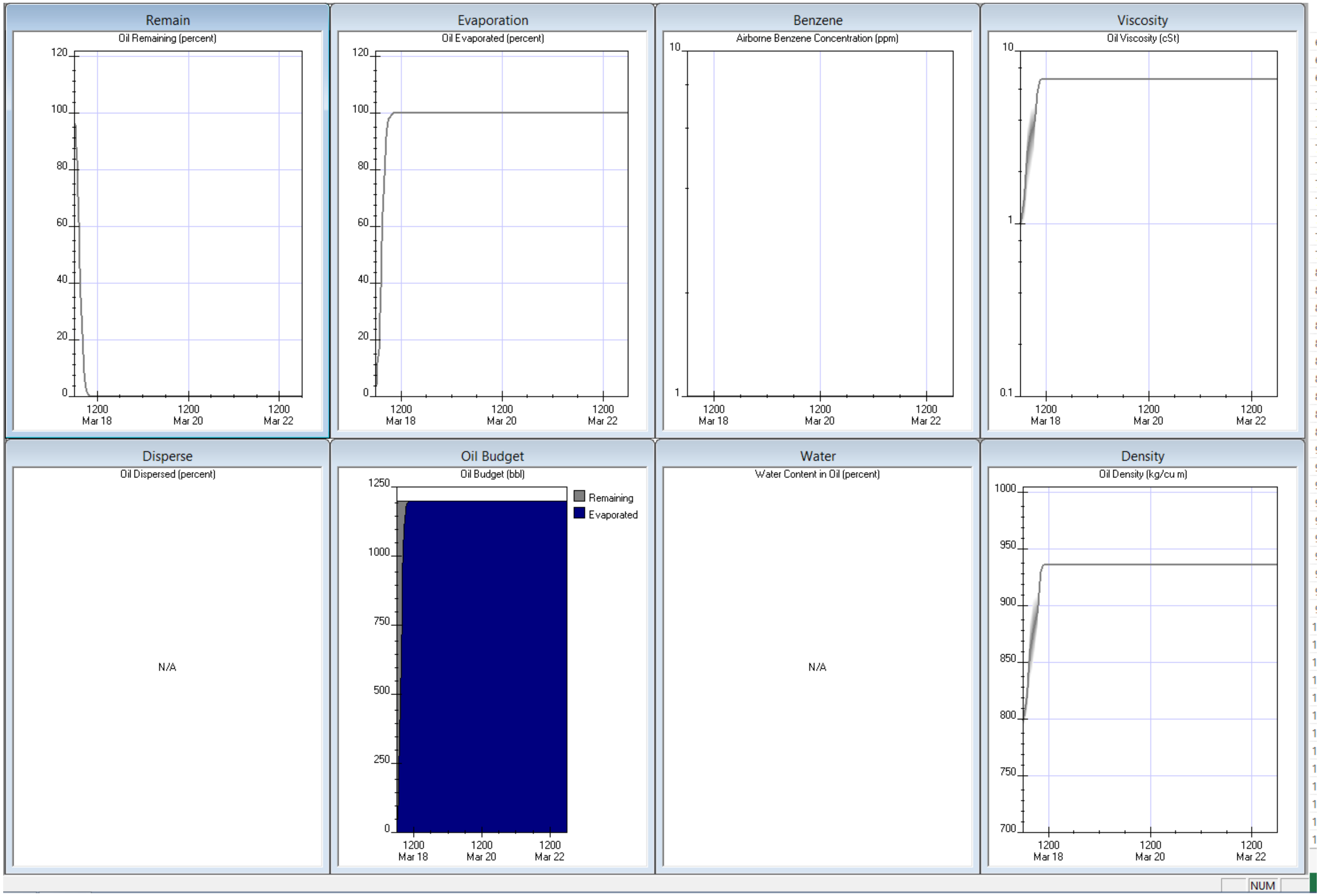

Figure D-7 (d): ADIOS 2.0 Model Output – 1,200 bbl Mixed Xylenes with 5 mph wind speed.

Oil Type

- MIXED XYLENES (custom oil)
- Location = Anacortes Washington
- Synonyms = Mixed Xylenes
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 28 deg C
- Density = 0.794 g/cc at 50 deg F
- Viscosity = 0.9 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 100 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 10 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

Instantaneous Release

- Time of Release = March 18, 0000 hours
- Amount Spilled = 1200 bbl

Figure D-7 (e): ADIOS 2.0 Model Input Parameters – 1,200 bbl Mixed Xylenes with 10 mph wind speed.

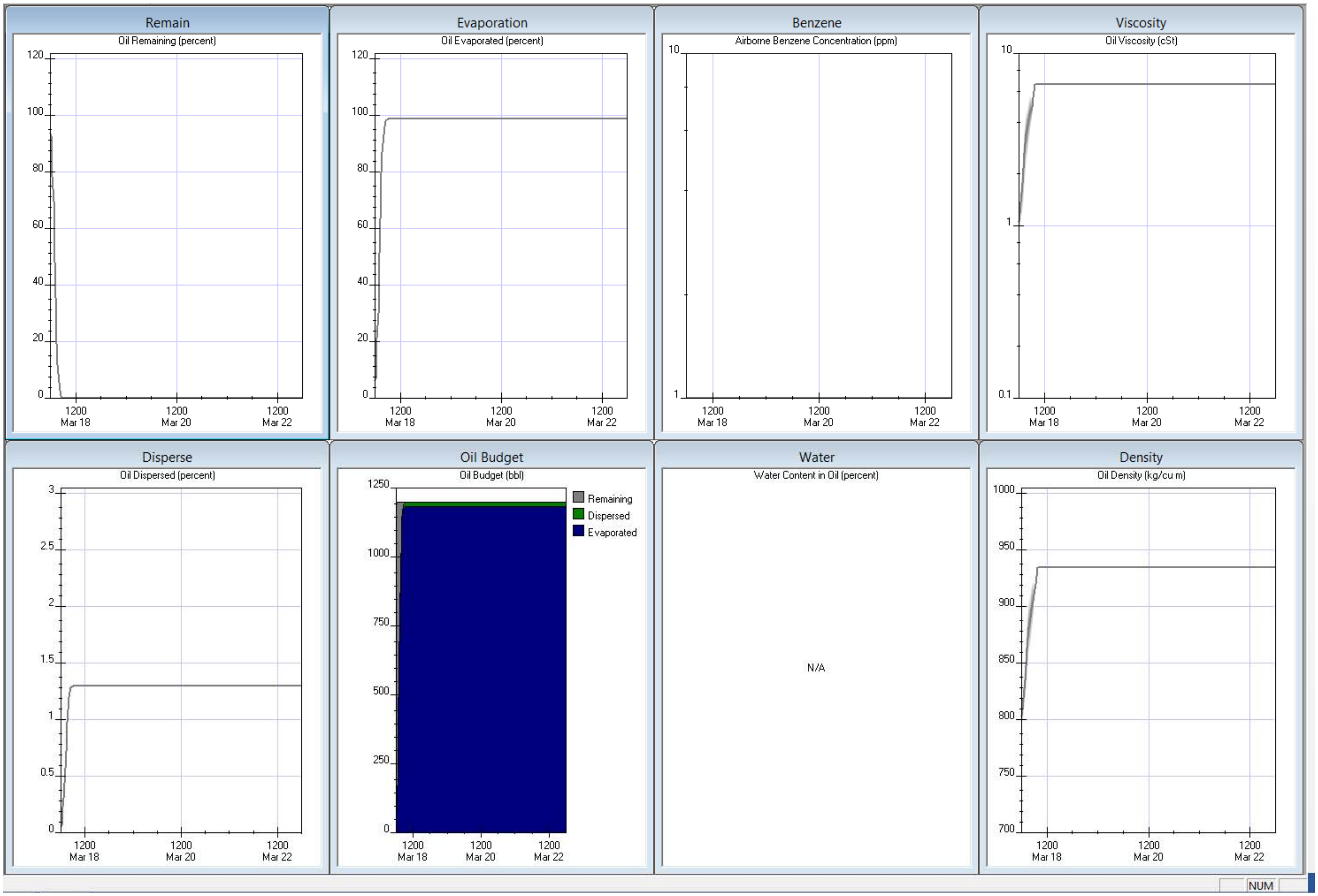

Figure D-7 (f): ADIOS 2.0 Model Output – 1,200 bbl Mixed Xylenes with 10 mph wind speed.

Oil Type

- GASOLINE (UNLEADED), SHELL
- Location = none listed
- Synonyms = AUTOMOTIVE FUEL, PETROL
- Product Type = refined
- API = --
- Pour Point = unknown
- Flash Point = -30 deg C
- Density = 0.753 g/cc at 50 deg F
- Viscosity = 4.9 cSt at 50 deg F
- Adhesion = unknown
- Aromatics = unknown
- WARNING! Benzene graph for this product may be unreliable.

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 2 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 2.0 mph towards 180 degrees

Release Information

- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 1200 bbl

Figure D-8 (a): ADIOS 2.0 Model Input Parameters – 1,200 bbl Gasoline with 0 mph wind speed.

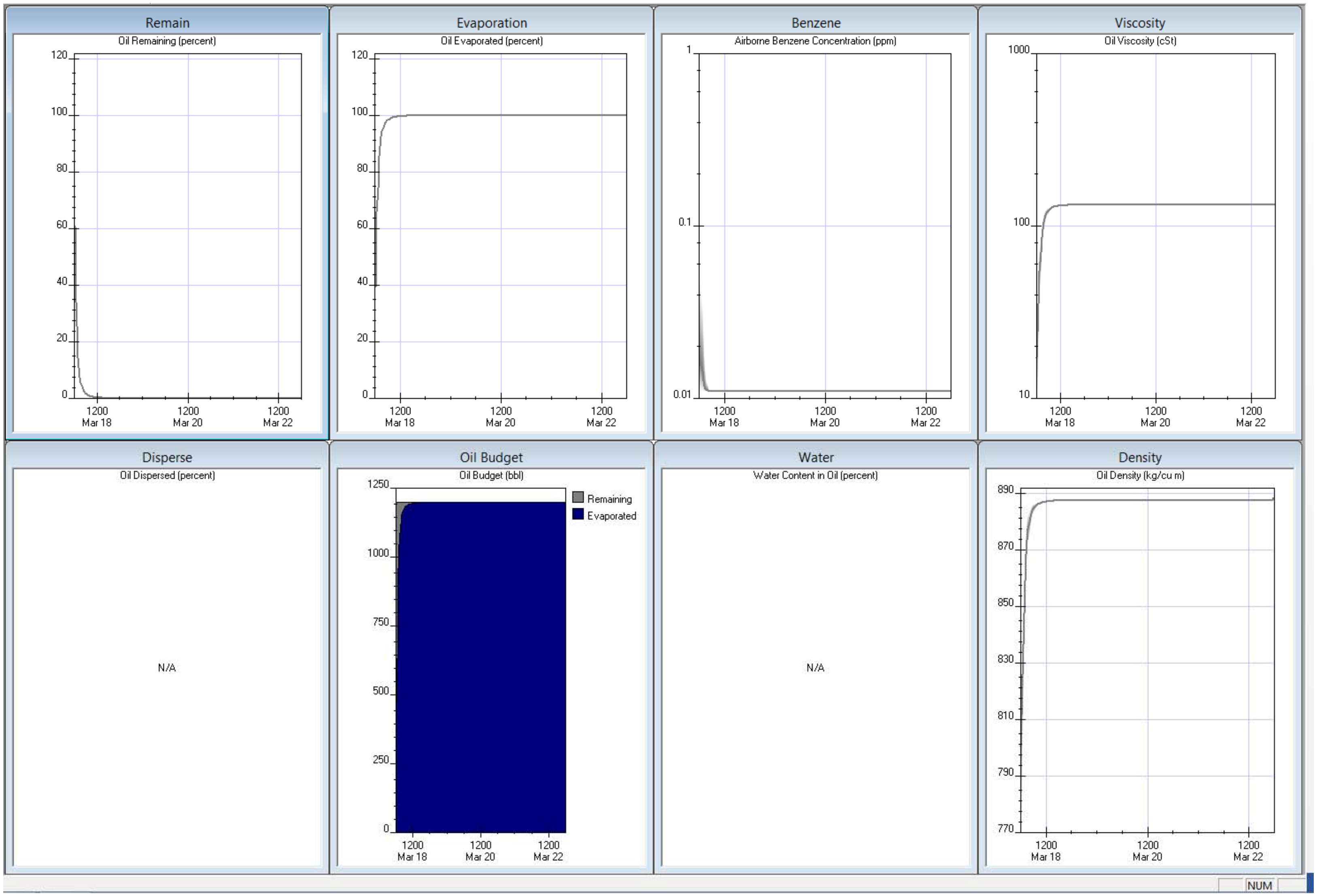

Figure D-8 (b): ADIOS 2.0 Model Output – 1,200 bbl Gasoline with 0 mph wind speed.

Oil Type

- GASOLINE (UNLEADED), SHELL
- Location = none listed
- Synonyms = AUTOMOTIVE FUEL, PETROL
- Product Type = refined
- API = --
- Pour Point = unknown
- Flash Point = -30 deg C
- Density = 0.753 g/cc at 50 deg F
- Viscosity = 4.9 cSt at 50 deg F
- Adhesion = unknown
- Aromatics = unknown
- WARNING! Benzene graph for this product may be unreliable.

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 5 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 1200 bbl

Figure D-8 (c): ADIOS 2.0 Model Input Parameters – 1,200 bbl Gasoline with 5 mph wind speed.

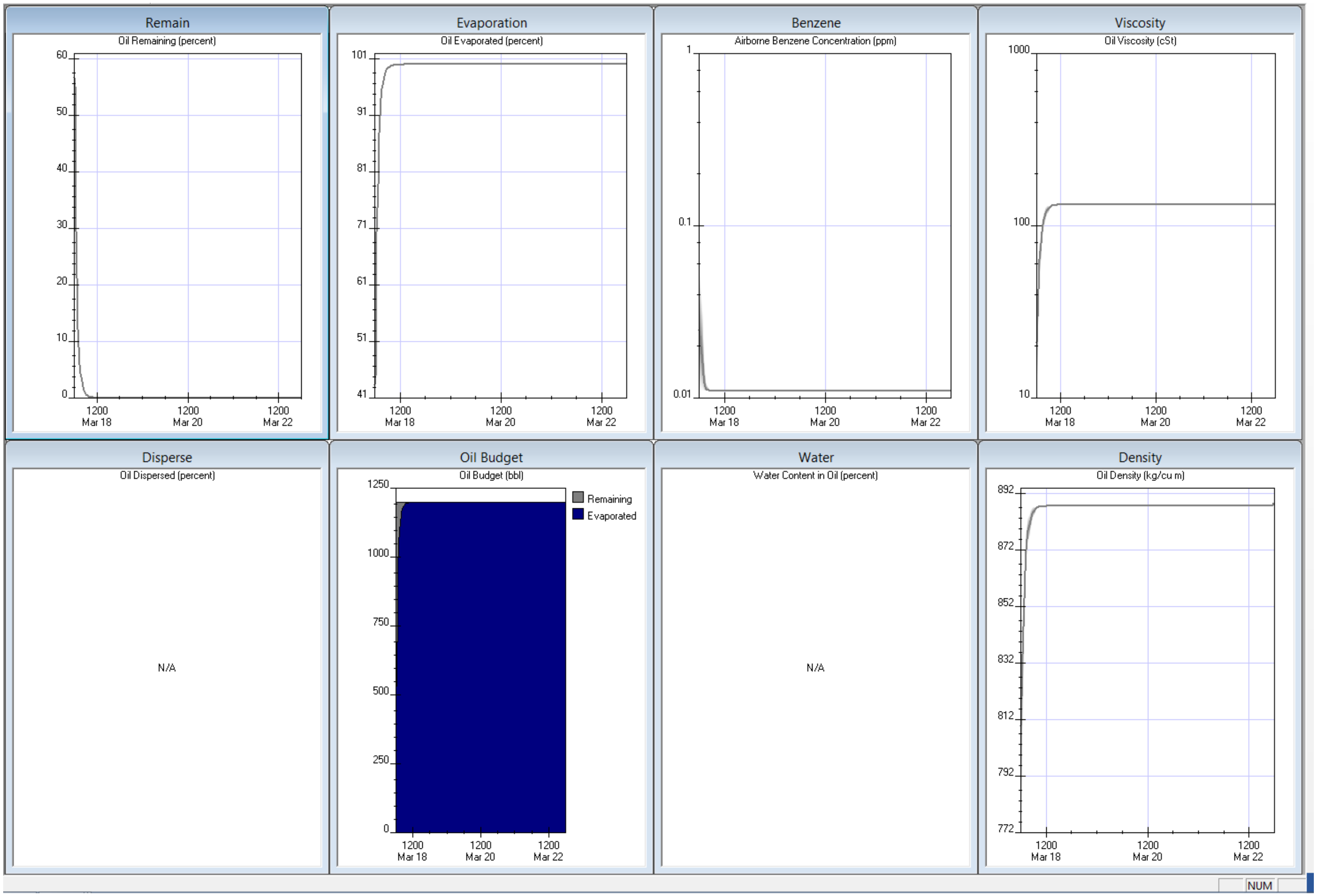

Figure D-8 (d): ADIOS 2.0 Model Output – 1,200 bbl Gasoline with 5 mph wind speed.

Oil Type

- GASOLINE (UNLEADED), SHELL
- Location = none listed
- Synonyms = AUTOMOTIVE FUEL, PETROL
- Product Type = refined
- API = --
- Pour Point = unknown
- Flash Point = -30 deg C
- Density = 0.753 g/cc at 50 deg F
- Viscosity = 4.9 cSt at 50 deg F
- Adhesion = unknown
- Aromatics = unknown
- WARNING! Benzene graph for this product may be unreliable.

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 10 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 1200 bbl

Figure D-8 (e): ADIOS 2.0 Model Input Parameters – 1,200 bbl Gasoline with 10 mph wind speed.

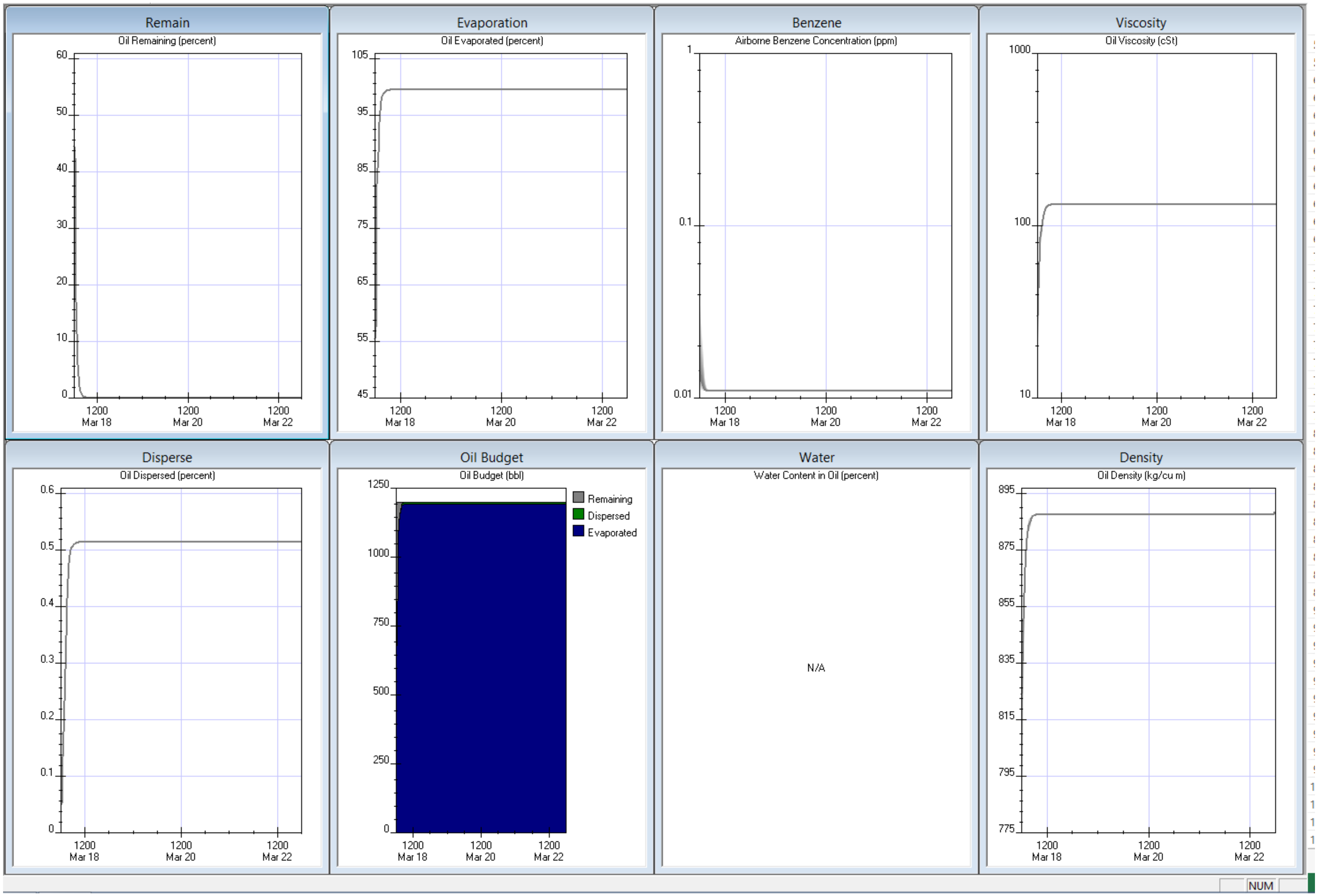

Figure D-8 (f): ADIOS 2.0 Model Output – 1,200 bbl Gasoline with 10 mph wind speed.

Table D-4. List of Figures Dockside Spill Scenario– 5045 bbl *ADIOS 2.0 Modeling of Evaporation and Dispersion Individual Runs (Input/Output) Results*				
Figure #	**Stream**	**Volume (bbl)**	**Wind Speed* (mph)**	**File Type**
Figure D-9 (a)	Reformate	5,045	0	Input
Figure D-9 (b)			0	Output
Figure D-9 (c)			5	Input
Figure D-9 (d)			5	Output
Figure D-9 (e)			10	Input
Figure D-9 (f)			10	Output
Figure D-10 (a)	Reformate (backhaul)	5,045	0	Input
Figure D-10 (b)			0	Output
Figure D-10 (c)			5	Input
Figure D-10 (d)			5	Output
Figure D-10 (e)			10	Input
Figure D-10 (f)			10	Output
Figure D-11 (a)	Mixed Xylenes	5,045	0	Input
Figure D-11 (b)			0	Output
Figure D-11 (c)			5	Input
Figure D-11 (d)			5	Output
Figure D-11 (e)			10	Input
Figure D-11 (f)			10	Output
Figure D-12 (a)	Gasoline	5,045	0	Input
Figure D-12 (b)			0	Output
Figure D-12 (c)			5	Input
Figure D-12 (d)			5	Output
Figure D-12 (e)			7	Input
Figure D-12 (f)			7	Output
Figure D-12 (g)			9	Input
Figure D-12 (h)			9	Output
Figure D-12 (i)			10	Input
Figure D-12 (j)			10	Output
***** ADIOS 2.0 accepts a minimum wind speed of 2 mph. To simulate zero wind speed, a 2 mph wind is used in combination with a 2 mph current speed in the opposite direction.				

Spill Scenario 5045 bbl w/3 wind speeds and 4 streams:

File Edit Spill Removal Output Help

Solve | Density | Viscosity | Water | Benzene | Budget | Evap | Disperse

Oil Type
- REFORMATE (custom oil)
- Location = Anacortes Washington
- Synonyms = REFORMATE
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 25 deg C
- Density = 0.785 g/cc at 50 deg F
- Viscosity = 0.8 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 96 weight %

Emulsification
- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions
- Wind Speed = 2 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties
- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 2.0 mph towards 180 degrees

Release Information
- **Instantaneous Release**
  - Time of Release = March 17, 0000 hours
  - Amount Spilled = 5045 bbl

Figure D-9 (a): ADIOS 2.0 Model Input Parameters – 5,045 bbl Reformate with 0 mph wind speed.

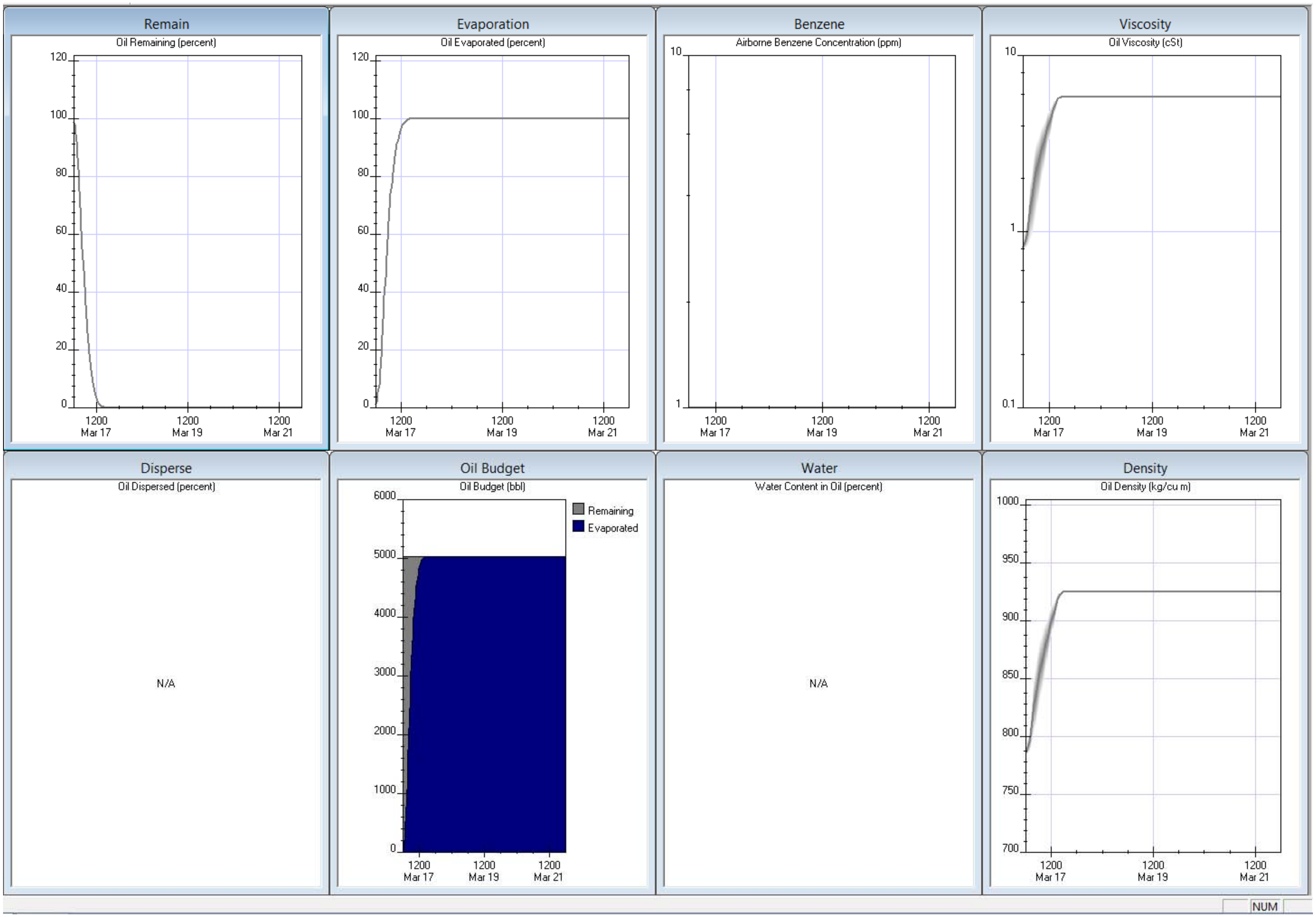

Figure D-9 (b): ADIOS 2.0 Model Output – 5,045 bbl Reformate with 0 mph wind speed.

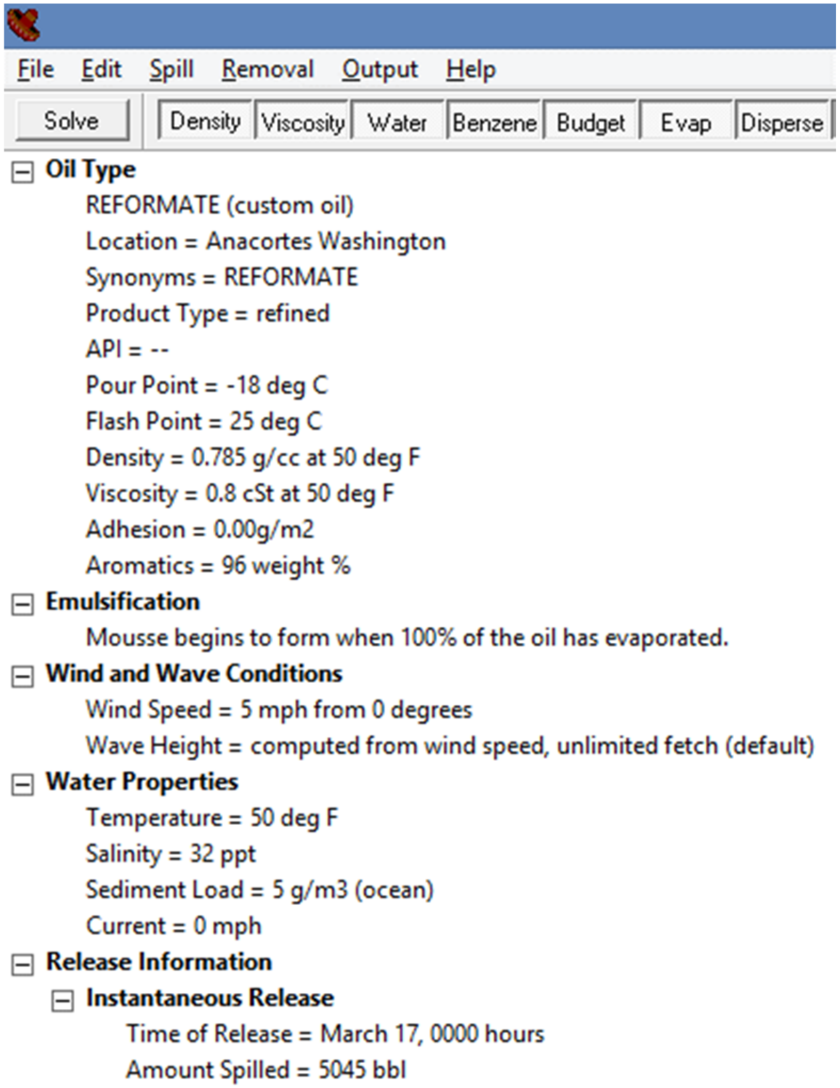

Figure D-9 (c): ADIOS 2.0 Model Input Parameters – 5,045 bbl Reformate with 5 mph wind speed.

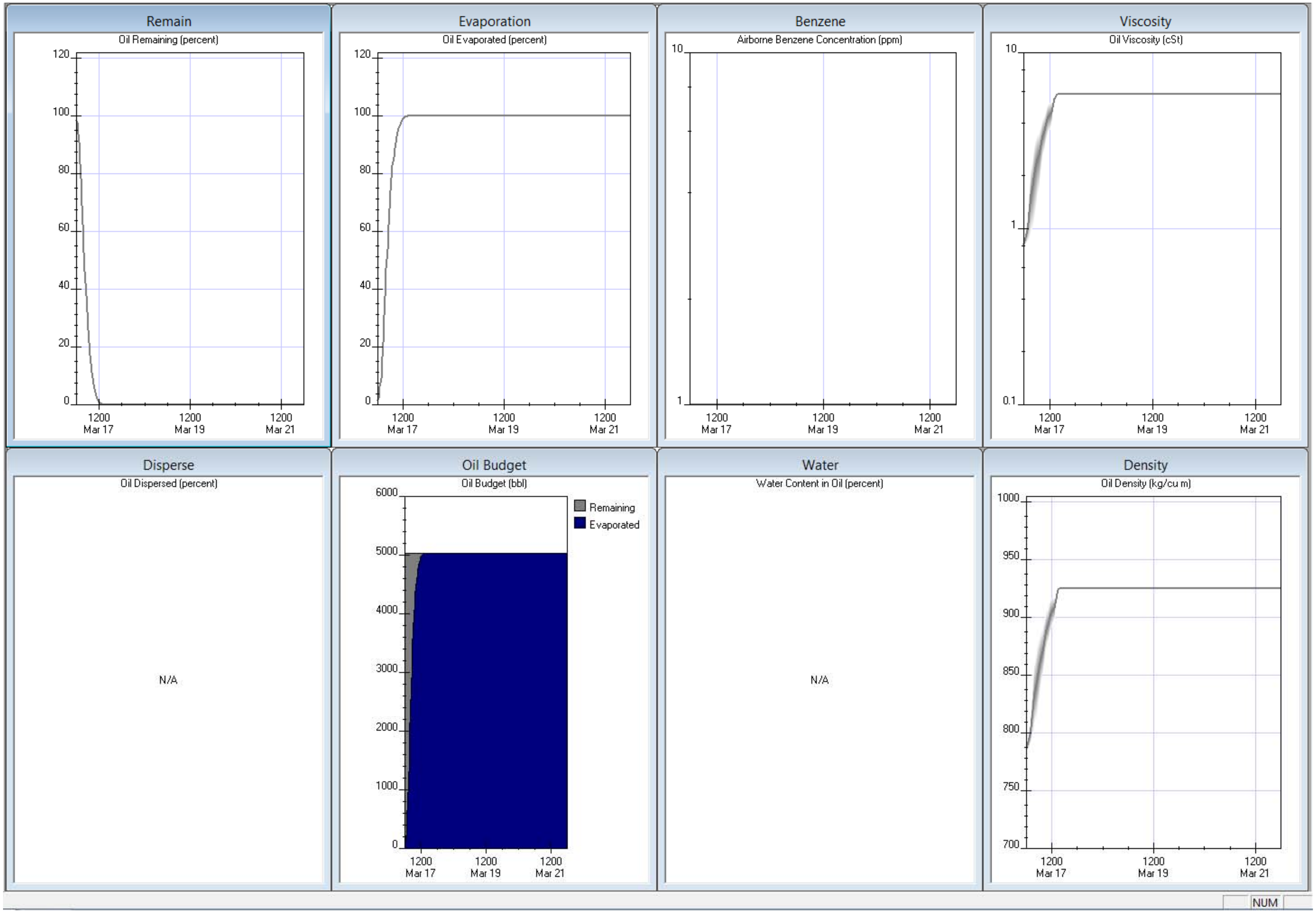

Figure D-9 (d): ADIOS 2.0 Model Output – 5,045 bbl Reformate with 5 mph wind speed.

- **Oil Type**
  - REFORMATE (custom oil)
  - Location = Anacortes Washington
  - Synonyms = REFORMATE
  - Product Type = refined
  - API = --
  - Pour Point = -18 deg C
  - Flash Point = 25 deg C
  - Density = 0.785 g/cc at 50 deg F
  - Viscosity = 0.8 cSt at 50 deg F
  - Adhesion = 0.00g/m2
  - Aromatics = 96 weight %
- **Emulsification**
  - Mousse begins to form when 100% of the oil has evaporated.
- **Wind and Wave Conditions**
  - Wind Speed = 10 mph from 0 degrees
  - Wave Height = computed from wind speed, unlimited fetch (default)
- **Water Properties**
  - Temperature = 50 deg F
  - Salinity = 32 ppt
  - Sediment Load = 5 g/m3 (ocean)
  - Current = 0 mph
- **Release Information**
  - **Instantaneous Release**
    - Time of Release = March 18, 0000 hours
    - Amount Spilled = 5045 bbl

Figure D-9 (e): ADIOS 2.0 Model Input Parameters – 5,045 bbl Reformate with 10 mph wind speed.

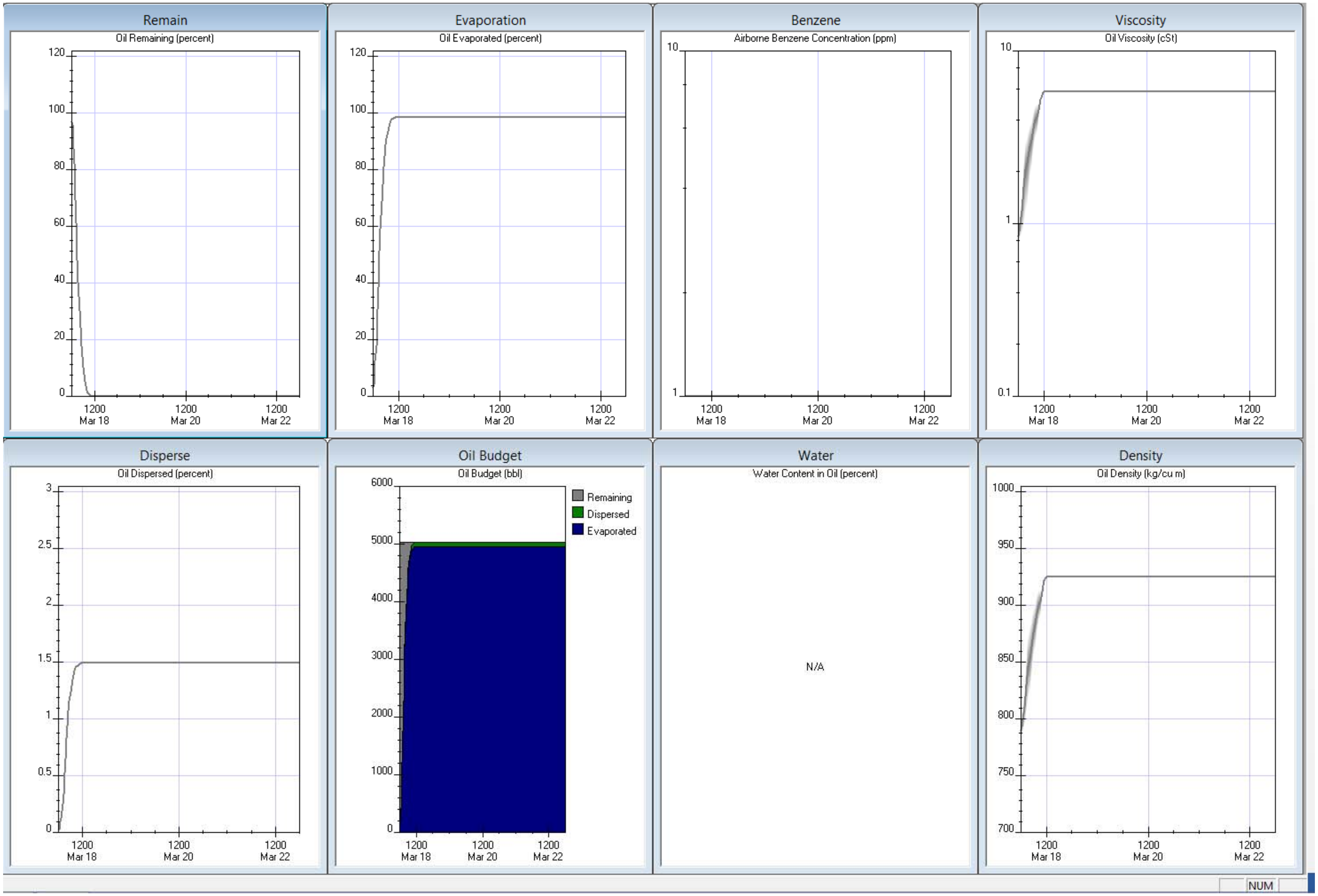

Figure D-9 (f): ADIOS 2.0 Model Output – 5,045 bbl Reformate with 10 mph wind speed.

Oil Type

REFORMATE (XYLENES REMOVED) (custom oil)

Location = Anacortes Washington

Synonyms = Reformate with xylenes removed

Product Type = refined

API = --

Pour Point = -18 deg C

Flash Point = 22 deg C

Density = 0.780 g/cc at 50 deg F

Viscosity = 1.2 cSt at 50 deg F

Adhesion = 0.00g/m2

Aromatics = 88 weight %

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 2 mph from 0 degrees

Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F

Salinity = 32 ppt

Sediment Load = 5 g/m3 (ocean)

Current = 2.0 mph towards 180 degrees

Release Information

Instantaneous Release

Time of Release = March 18, 0000 hours

Amount Spilled = 5045 bbl

Figure D-10 (a): ADIOS 2.0 Model Input Parameters – 5,045 bbl Reformate (Backhaul) with 0 mph wind speed.

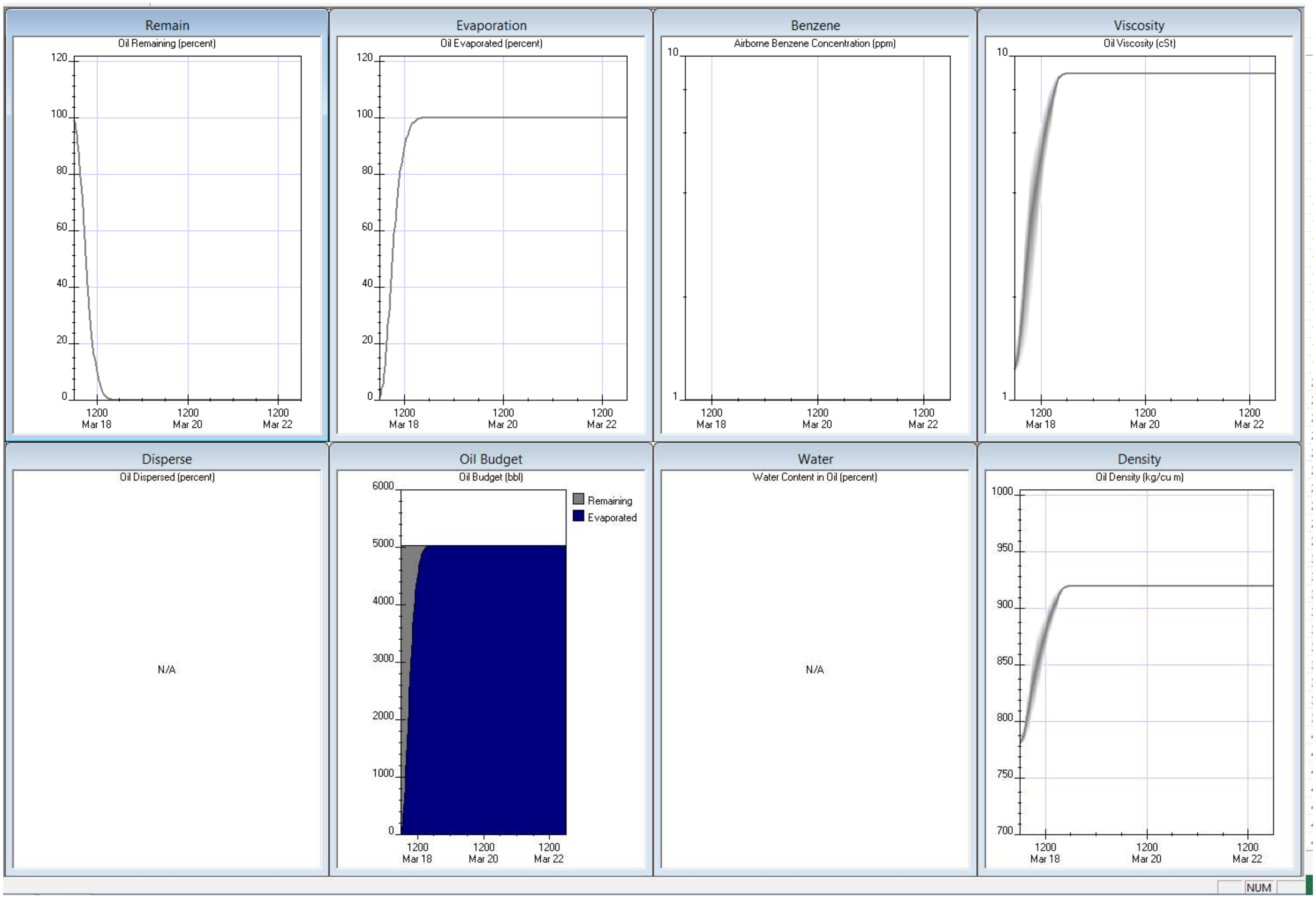

Figure D-10 (b): ADIOS 2.0 Model Output – 5,045 bbl Reformate (Backhaul) with 0 mph wind speed.

Oil Type

- REFORMATE (XYLENES REMOVED) (custom oil)
- Location = Anacortes Washington
- Synonyms = Reformate with xylenes removed
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 22 deg C
- Density = 0.780 g/cc at 50 deg F
- Viscosity = 1.2 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 88 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 5 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 5045 bbl

Figure D-10 (c): ADIOS 2.0 Model Input Parameters – 5,045 bbl Reformate (Backhaul) with 5 mph wind speed.

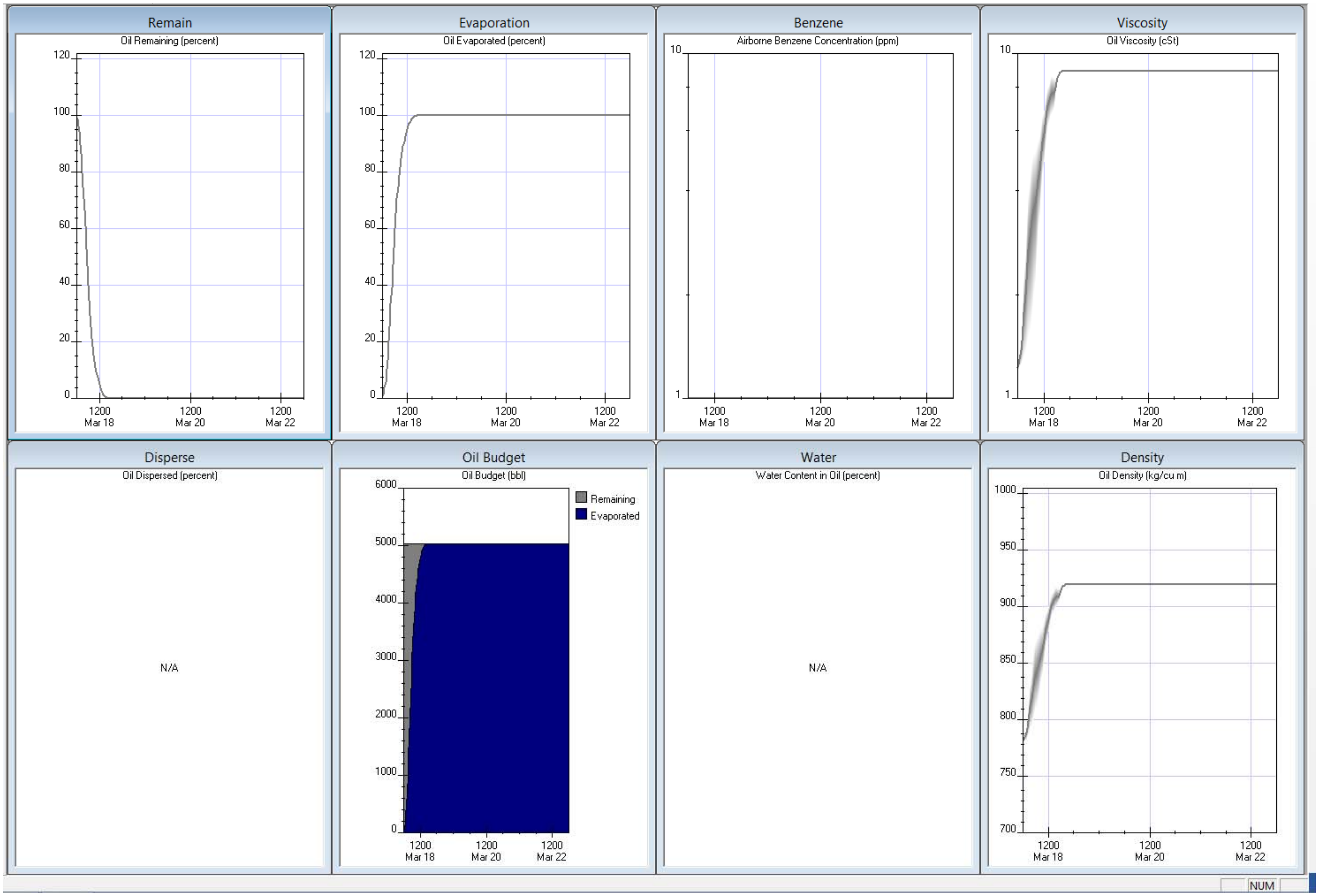

Figure D-10 (d): ADIOS 2.0 Model Output – 5,045 bbl Reformate (Backhaul) with 5 mph wind speed.

Oil Type

- REFORMATE (XYLENES REMOVED) (custom oil)
- Location = Anacortes Washington
- Synonyms = Reformate with xylenes removed
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 22 deg C
- Density = 0.780 g/cc at 50 deg F
- Viscosity = 1.2 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 88 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 10 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

Instantaneous Release

- Time of Release = March 18, 0000 hours
- Amount Spilled = 5045 bbl

Figure D-10 (e): ADIOS 2.0 Model Input Parameters – 5,045 bbl Reformate (Backhaul) with 10 mph wind speed.

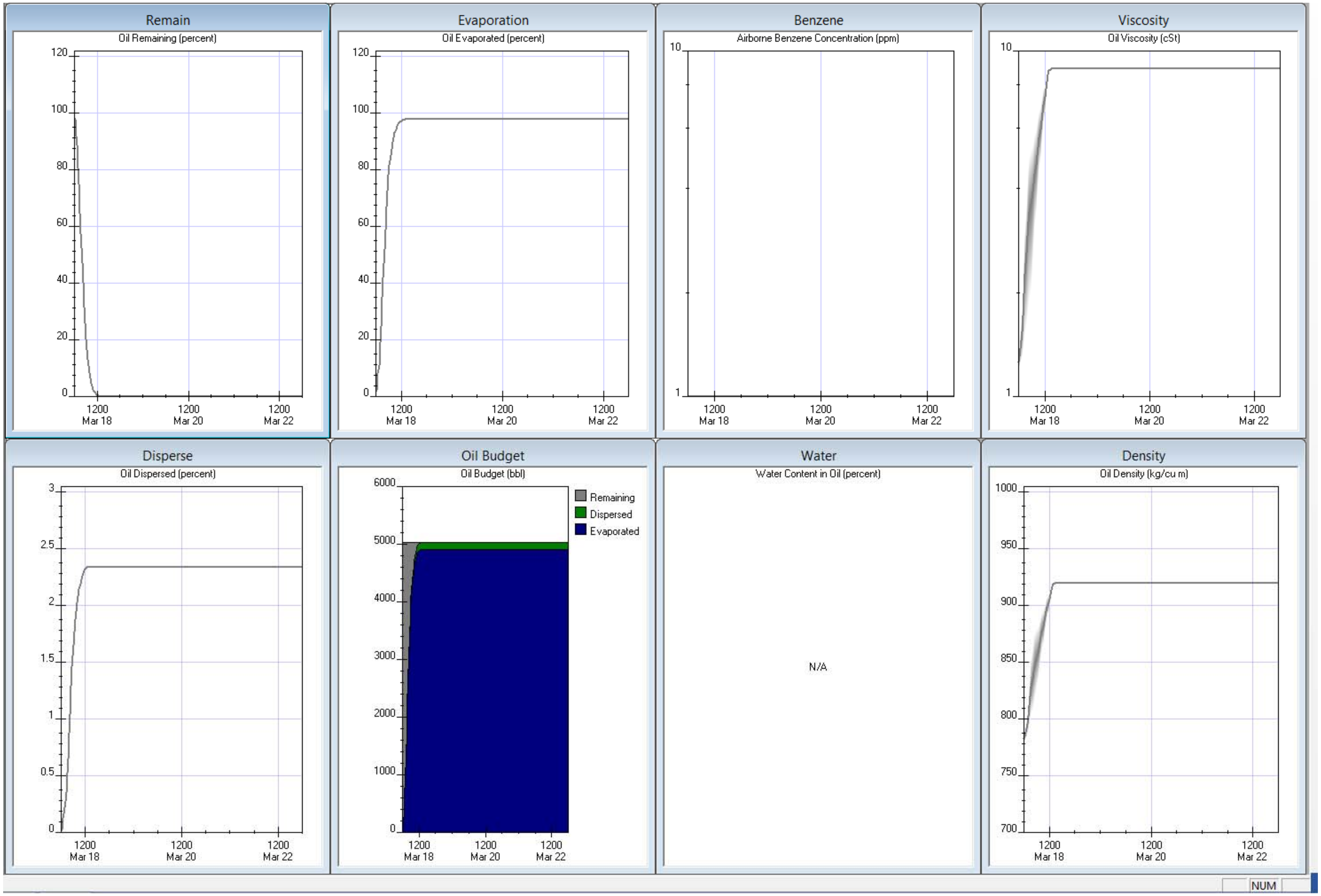

Figure D-10 (f): ADIOS 2.0 Model Output – 5,045 bbl Reformate (Backhaul) with 10 mph wind speed.

Oil Type

MIXED XYLENES (custom oil)
Location = Anacortes Washington
Synonyms = Mixed Xylenes
Product Type = refined
API = --
Pour Point = -18 deg C
Flash Point = 28 deg C
Density = 0.794 g/cc at 50 deg F
Viscosity = 0.9 cSt at 50 deg F
Adhesion = 0.00g/m2
Aromatics = 100 weight %

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 2 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 2.0 mph towards 180 degrees

Release Information

Instantaneous Release

Time of Release = March 20, 0000 hours
Amount Spilled = 5045 bbl

Figure D-11 (a): ADIOS 2.0 Model Input Parameters – 5,045 bbl Mixed Xylenes with 0 mph wind speed.

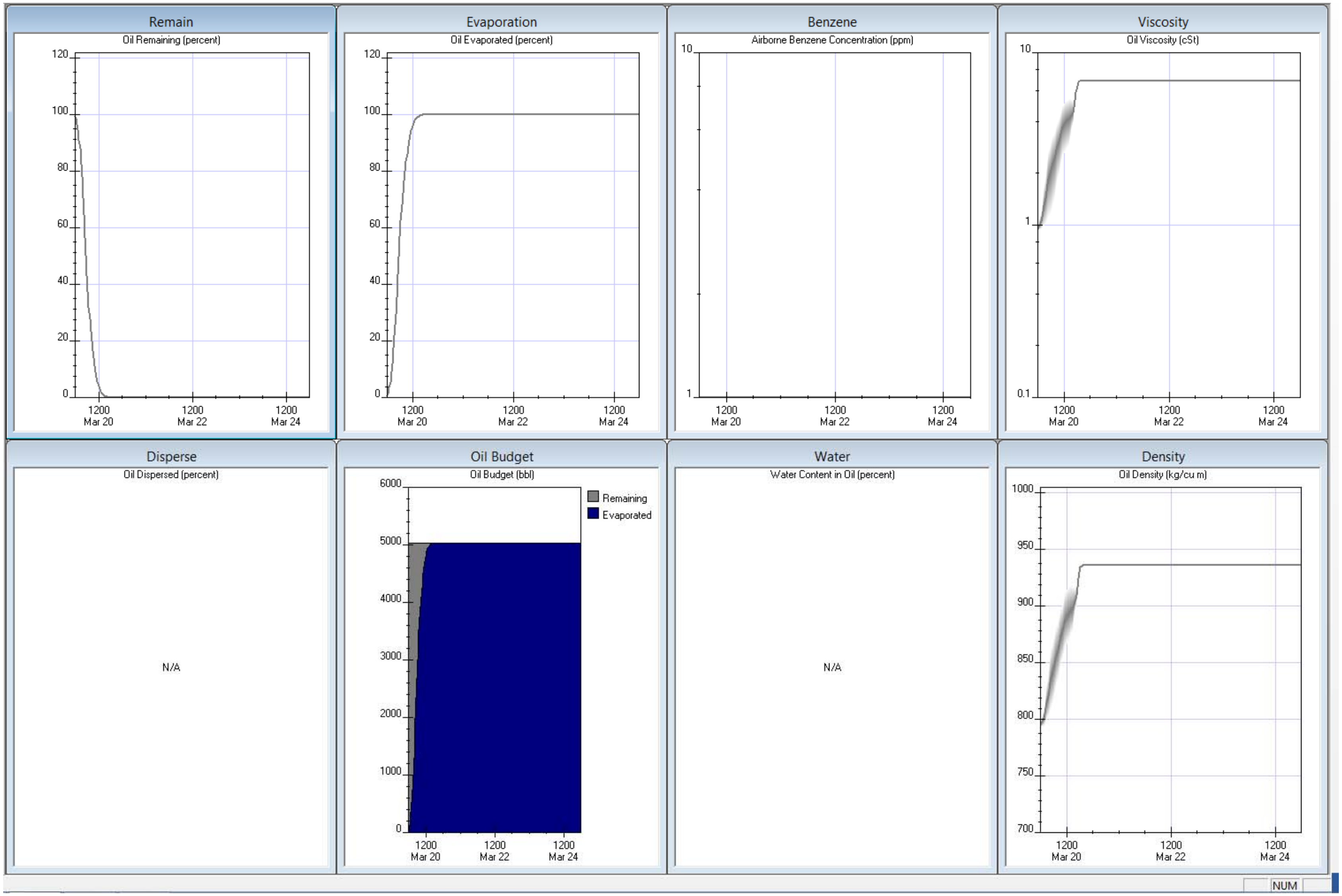

Figure D-11 (b): ADIOS 2.0 Model Output – 5,045 bbl Mixed Xylenes with 0 mph wind speed.

Oil Type

MIXED XYLENES (custom oil)
Location = Anacortes Washington
Synonyms = Mixed Xylenes
Product Type = refined
API = --
Pour Point = -18 deg C
Flash Point = 28 deg C
Density = 0.794 g/cc at 50 deg F
Viscosity = 0.9 cSt at 50 deg F
Adhesion = 0.00g/m2
Aromatics = 100 weight %

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 5 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 0 mph

Release Information

Instantaneous Release

Time of Release = March 20, 0000 hours
Amount Spilled = 5045 bbl

Figure D-11 (c): ADIOS 2.0 Model Input Parameters – 5,045 bbl Mixed Xylenes with 5 mph wind speed.

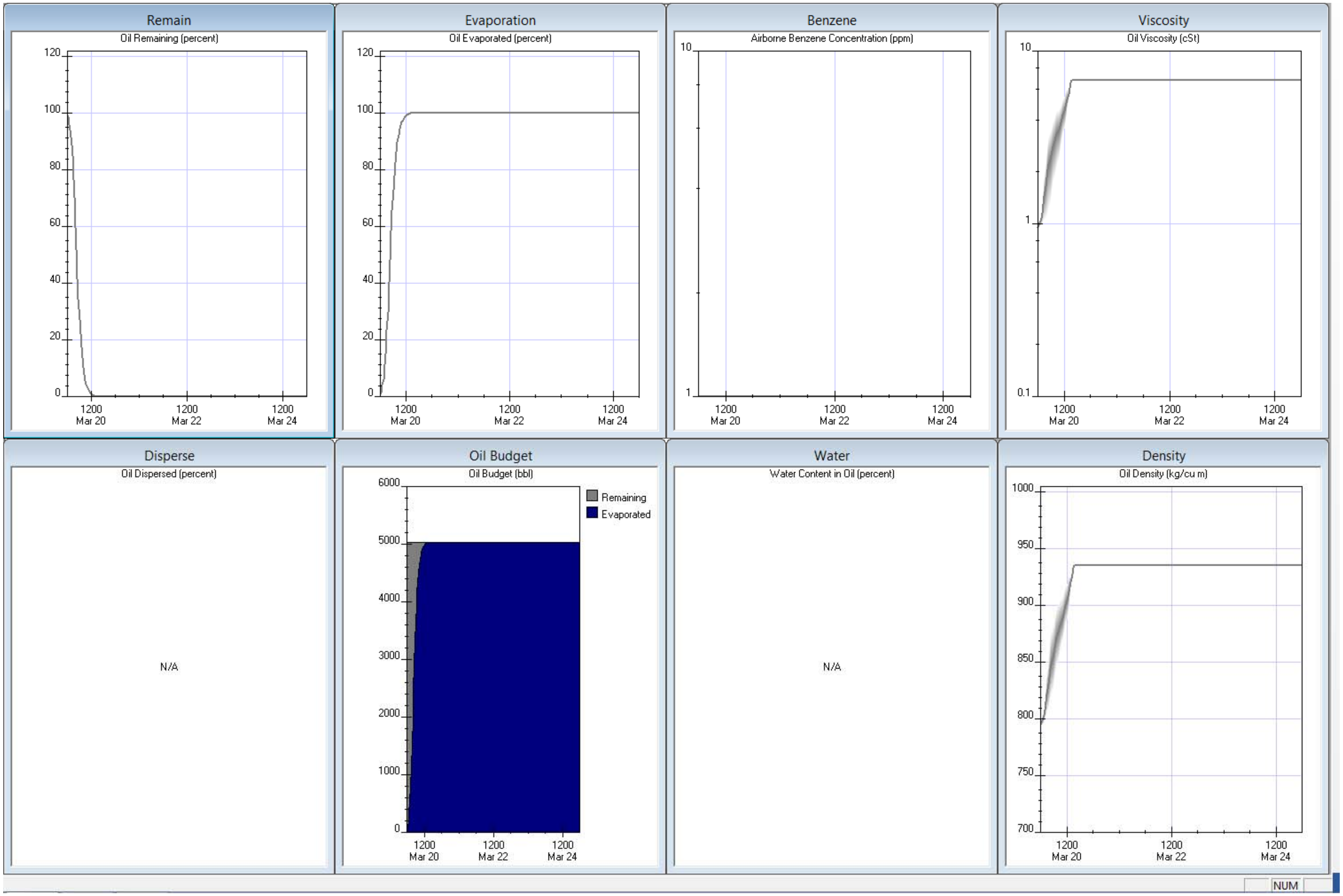

Figure D-11 (d): ADIOS 2.0 Model Output – 5,045 bbl Mixed Xylenes with 5 mph wind speed.

⊟ Oil Type

- MIXED XYLENES (custom oil)
- Location = Anacortes Washington
- Synonyms = Mixed Xylenes
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 28 deg C
- Density = 0.794 g/cc at 50 deg F
- Viscosity = 0.9 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 100 weight %

⊟ Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

⊟ Wind and Wave Conditions

- Wind Speed = 10 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

⊟ Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

⊟ Release Information

- **⊟ Instantaneous Release**
  - Time of Release = March 20, 0000 hours
  - Amount Spilled = 5045 bbl

Figure D-11 (e): ADIOS 2.0 Model Input Parameters – 5,045 bbl Mixed Xylenes with 10 mph wind speed.

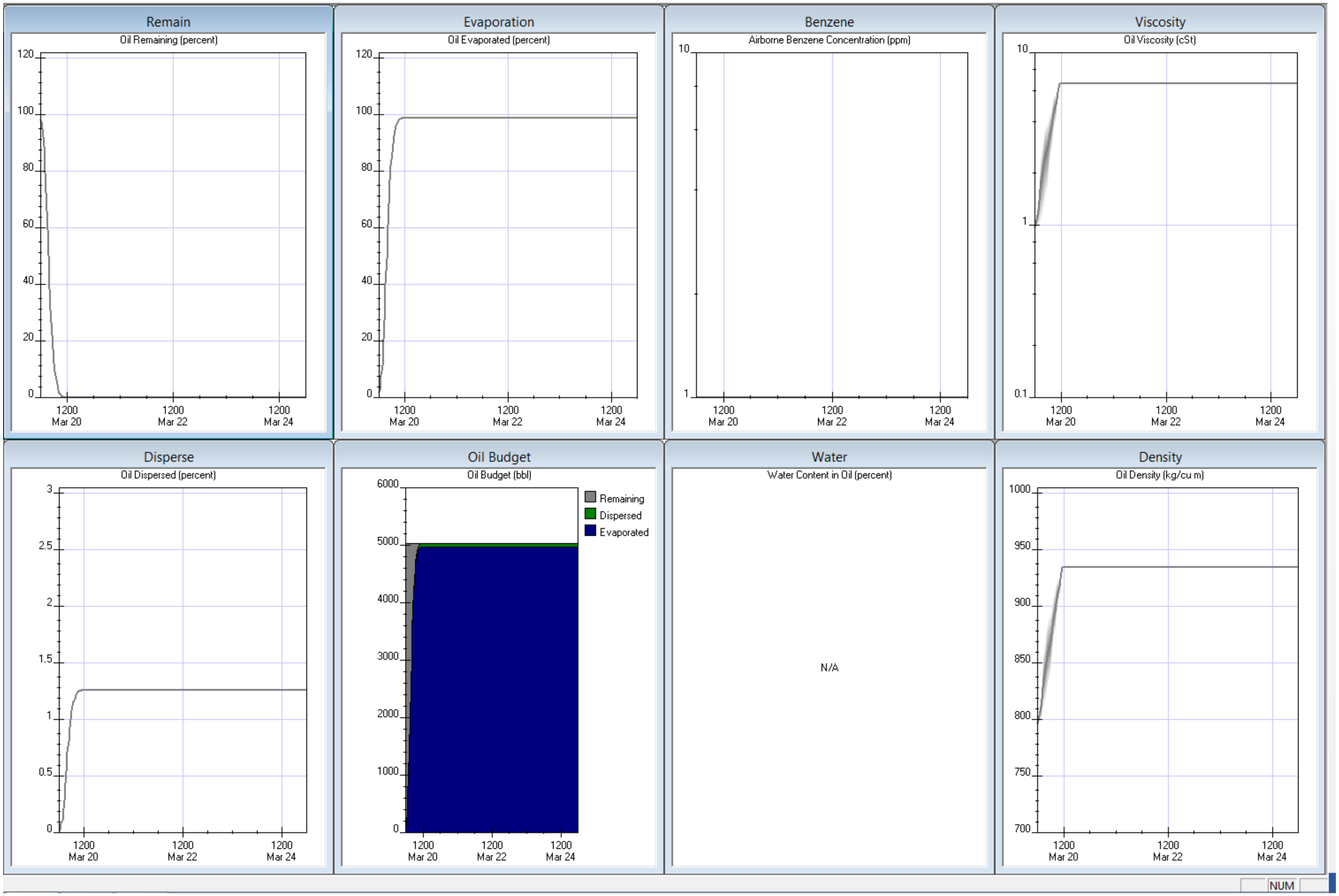

Figure D-11 (f): ADIOS 2.0 Model Output – 5,045 bbl Mixed Xylenes with 10 mph wind speed.

- **Oil Type**
  - GASOLINE (UNLEADED), SHELL
  - Location = none listed
  - Synonyms = AUTOMOTIVE FUEL, PETROL
  - Product Type = refined
  - API = --
  - Pour Point = unknown
  - Flash Point = -30 deg C
  - Density = 0.753 g/cc at 50 deg F
  - Viscosity = 4.9 cSt at 50 deg F
  - Adhesion = unknown
  - Aromatics = unknown
  - WARNING! Benzene graph for this product may be unreliable.
- **Emulsification**
  - Mousse begins to form when 100% of the oil has evaporated.
- **Wind and Wave Conditions**
  - Wind Speed = 2 mph from 0 degrees
  - Wave Height = computed from wind speed, unlimited fetch (default)
- **Water Properties**
  - Temperature = 50 deg F
  - Salinity = 32 ppt
  - Sediment Load = 5 g/m3 (ocean)
  - Current = 2.0 mph towards 180 degrees
- **Release Information**
  - **Instantaneous Release**
    - Time of Release = March 18, 0000 hours
    - Amount Spilled = 5045 bbl

Figure D-12 (a): ADIOS 2.0 Model Input Parameters – 5,045 bbl Gasoline with 0 mph wind speed.

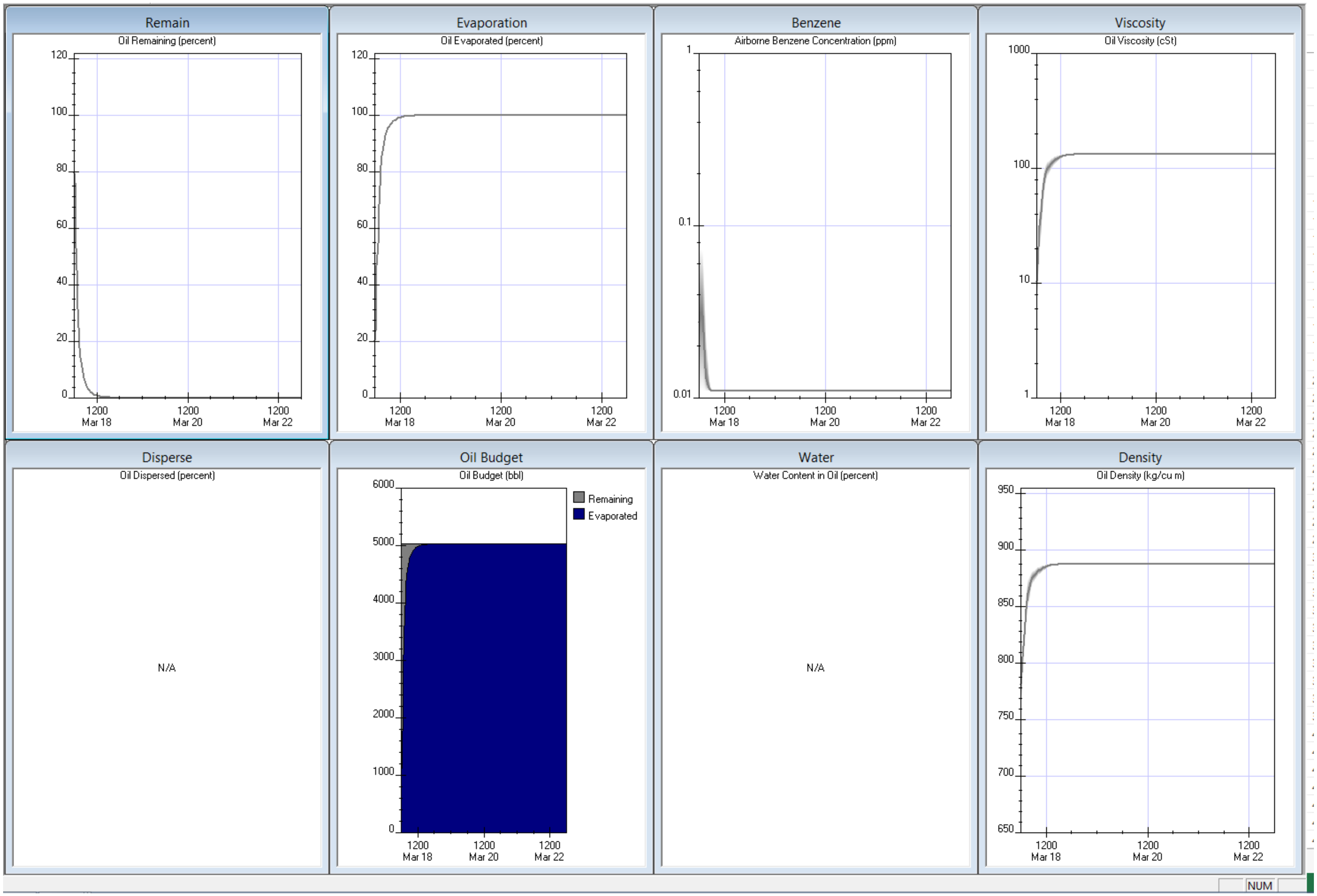

Figure D-12 (b): ADIOS 2.0 Model Output – 5,045 bbl Gasoline with 0 mph wind speed.

Oil Type

- GASOLINE (UNLEADED), SHELL
- Location = none listed
- Synonyms = AUTOMOTIVE FUEL, PETROL
- Product Type = refined
- API = --
- Pour Point = unknown
- Flash Point = -30 deg C
- Density = 0.753 g/cc at 50 deg F
- Viscosity = 4.9 cSt at 50 deg F
- Adhesion = unknown
- Aromatics = unknown
- WARNING! Benzene graph for this product may be unreliable.

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 5 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 5045 bbl

Figure D-12 (c): ADIOS 2.0 Model Input Parameters – 5,045 bbl Gasoline with 5 mph wind speed.

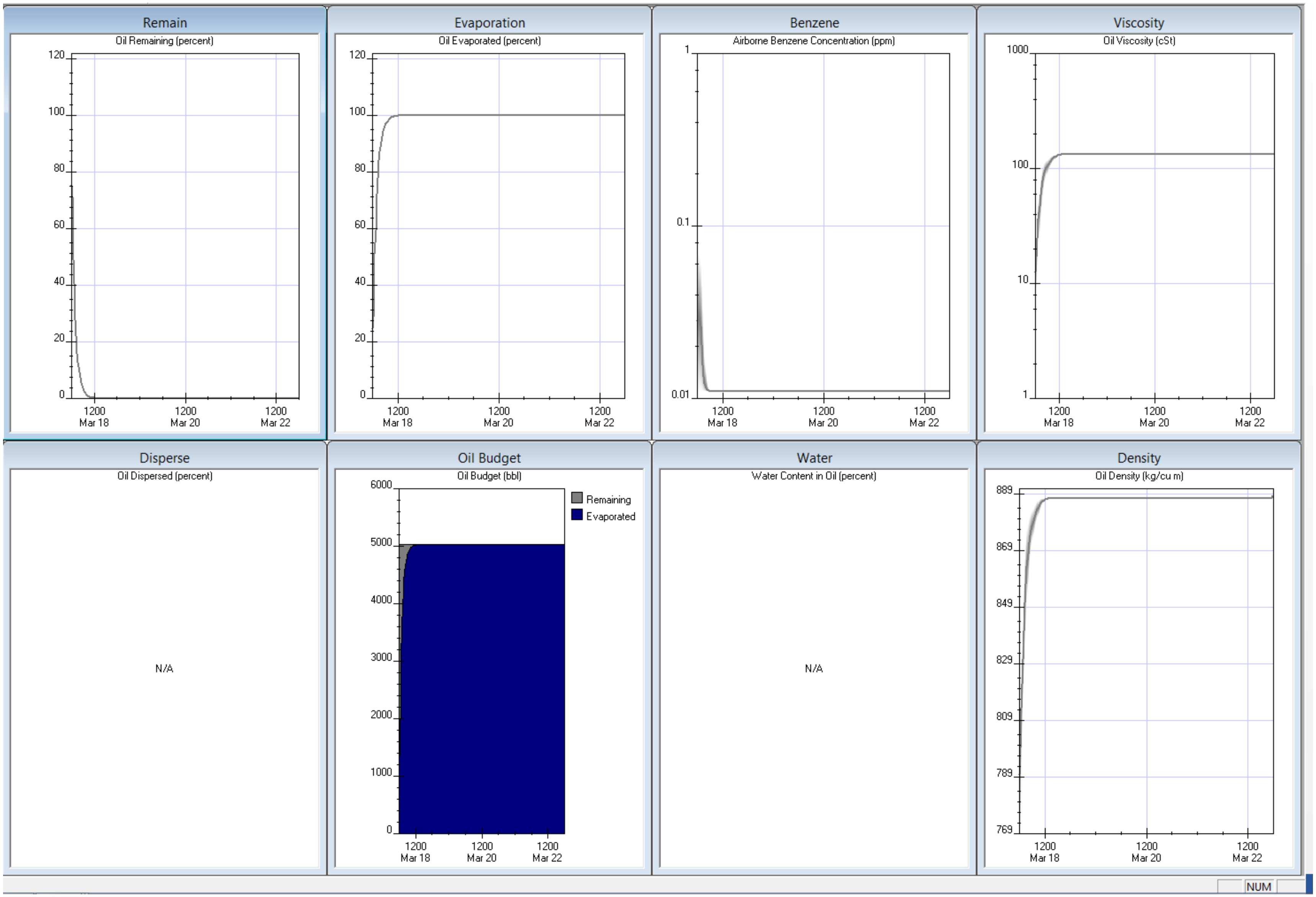

Figure D-12 (d): ADIOS 2.0 Model Output – 5,045 bbl Gasoline with 5 mph wind speed.

Oil Type

- GASOLINE (UNLEADED), SHELL
- Location = none listed
- Synonyms = AUTOMOTIVE FUEL, PETROL
- Product Type = refined
- API = --
- Pour Point = unknown
- Flash Point = -30 deg C
- Density = 0.753 g/cc at 50 deg F
- Viscosity = 4.9 cSt at 50 deg F
- Adhesion = unknown
- Aromatics = unknown
- WARNING! Benzene graph for this product may be unreliable.

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 7 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = April 14, 0000 hours
  - Amount Spilled = 5045 bbl

Figure D-12 (e): ADIOS 2.0 Model Input Parameters – 5,045 bbl Gasoline with 7 mph wind speed.

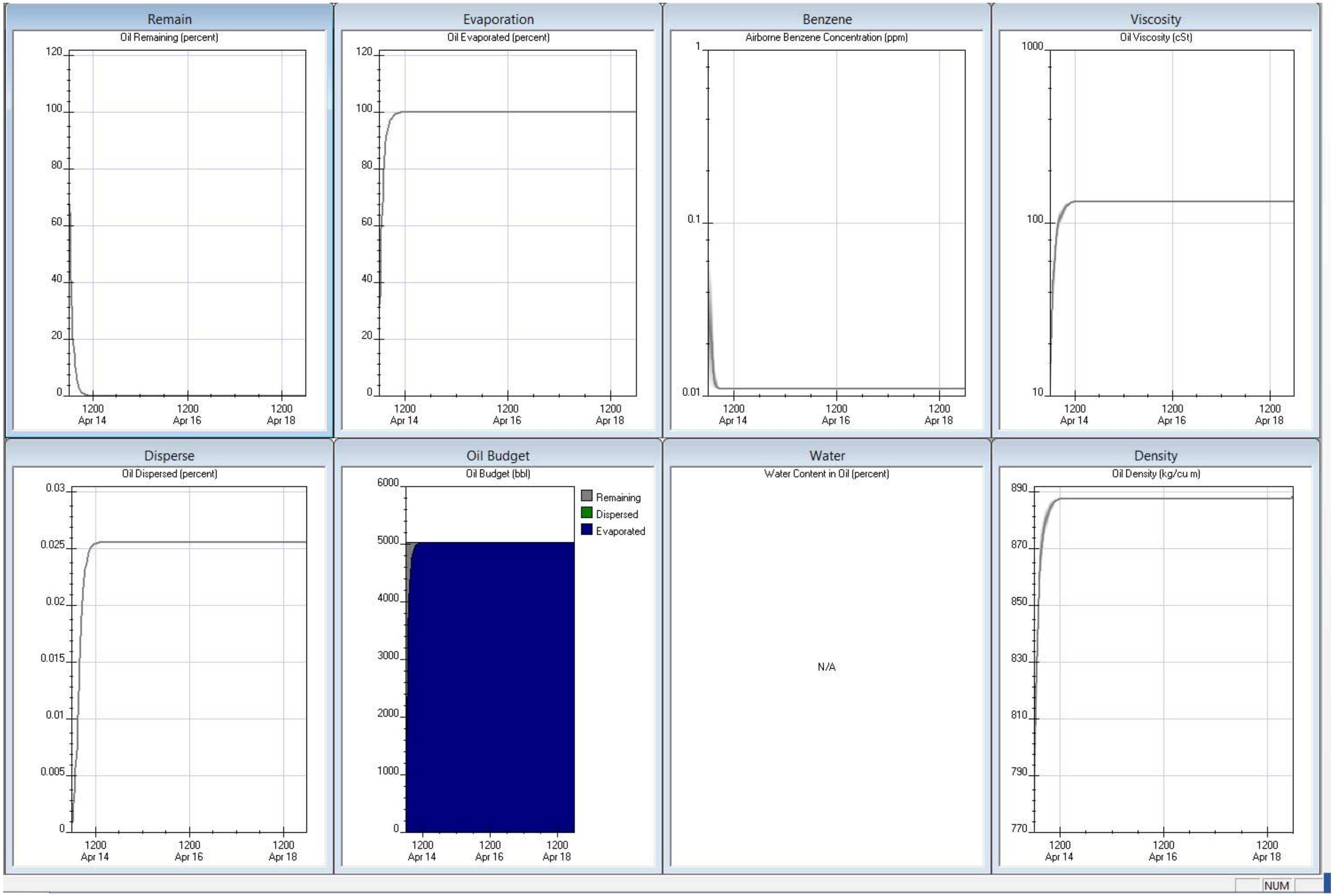

Figure D-12 (f): ADIOS 2.0 Model Output – 5,045 bbl Gasoline with 7 mph wind speed.

Oil Type

GASOLINE (UNLEADED), SHELL
Location = none listed
Synonyms = AUTOMOTIVE FUEL, PETROL
Product Type = refined
API = --
Pour Point = unknown
Flash Point = -30 deg C
Density = 0.753 g/cc at 50 deg F
Viscosity = 4.9 cSt at 50 deg F
Adhesion = unknown
Aromatics = unknown
WARNING! Benzene graph for this product may be unreliable.

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 9 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 0 mph

Release Information

Instantaneous Release

Time of Release = April 14, 0000 hours
Amount Spilled = 5045 bbl

Figure D-12 (g): ADIOS 2.0 Model Input Parameters – 5,045 bbl Gasoline with 9 mph wind speed.

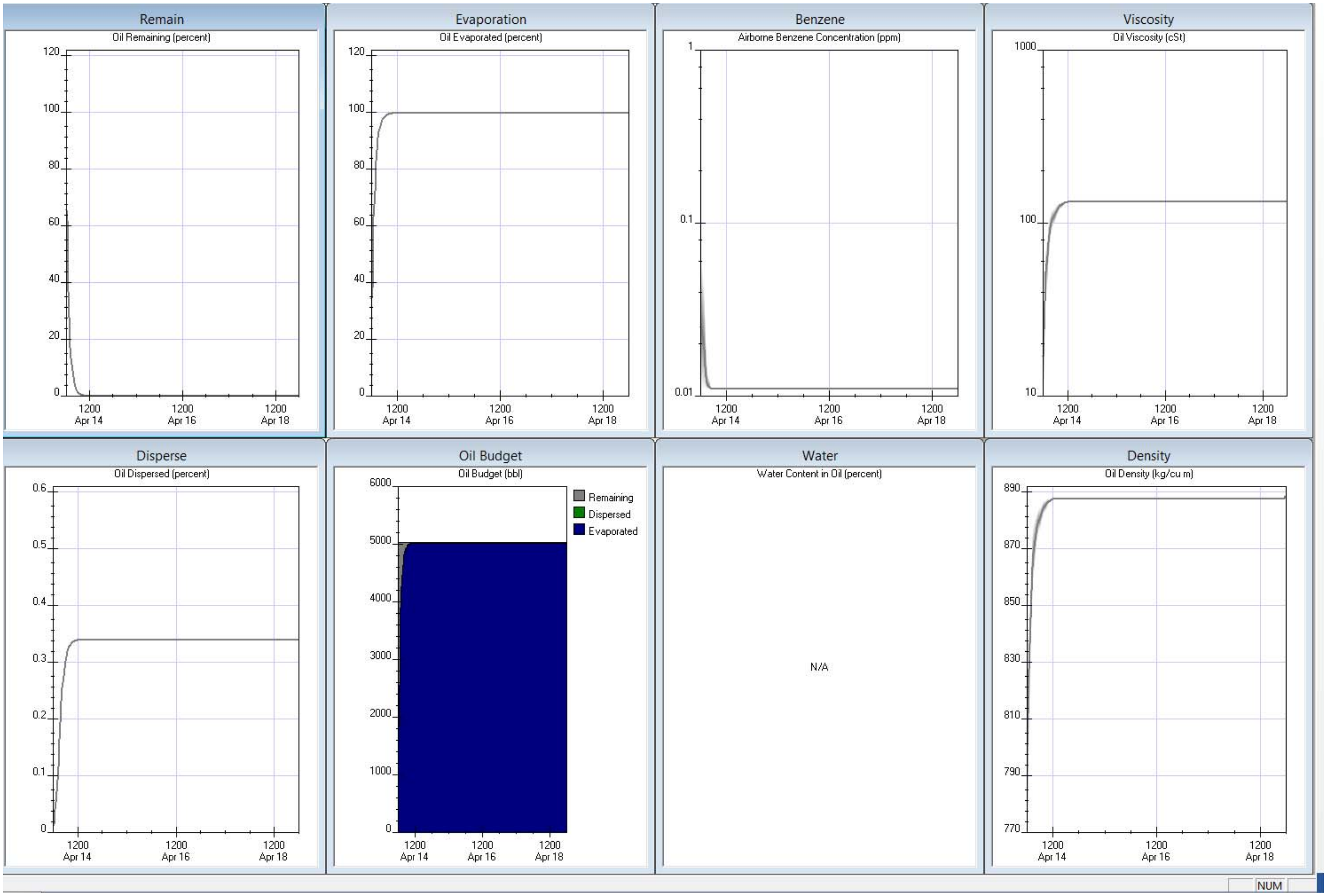

Figure D-12 (h): ADIOS 2.0 Model Output – 5,045 bbl Gasoline with 9 mph wind speed.

Oil Type

- GASOLINE (UNLEADED), SHELL
- Location = none listed
- Synonyms = AUTOMOTIVE FUEL, PETROL
- Product Type = refined
- API = --
- Pour Point = unknown
- Flash Point = -30 deg C
- Density = 0.753 g/cc at 50 deg F
- Viscosity = 4.9 cSt at 50 deg F
- Adhesion = unknown
- Aromatics = unknown
- WARNING! Benzene graph for this product may be unreliable.

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 10 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 18, 0000 hours
  - Amount Spilled = 5045 bbl

Figure D-12 (i): ADIOS 2.0 Model Input Parameters – 5,045 bbl Gasoline with 10 mph wind speed.

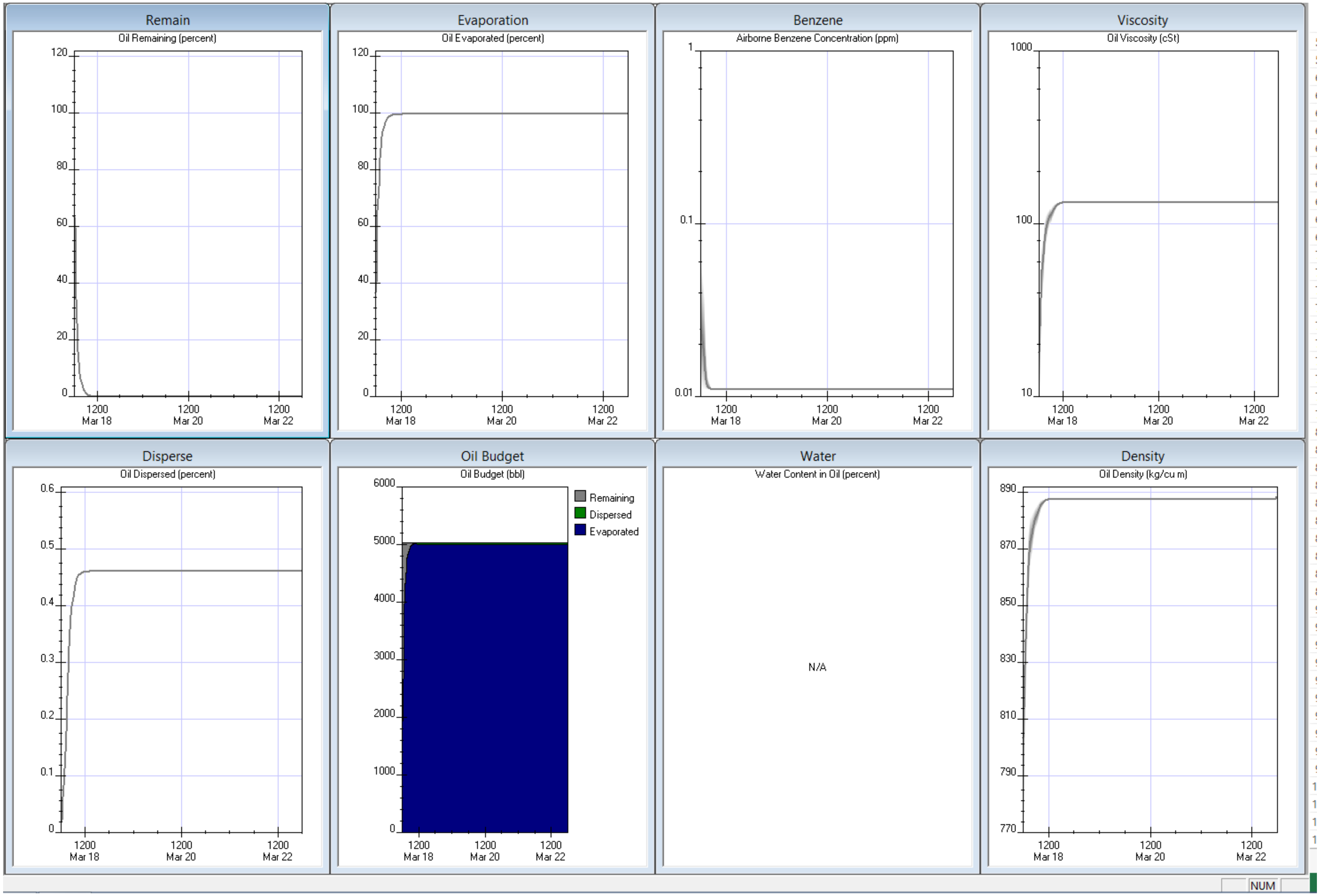

Figure D-12 (j): ADIOS 2.0 Model Output – 5,045 bbl Gasoline with 10 mph wind speed.

Table D-5. List of Figures Salish Sea Spill Scenario – 2,500 bbl
ADIOS 2.0 Modeling of Evaporation and Dispersion Individual Runs (Input/Output) Results

Figure #	Stream	Volume bbl	Wind speed* mph	File Type
Figure D-13 (a)	Reformate	2,500	0	Input
Figure D-13 (b)			0	Output
Figure D-13 (c)			5	Input
Figure D-13 (d)			5	Output
Figure D-13 (e)			10	Input
Figure D-13 (f)			10	Output
Figure D-14 (a)	Reformate (backhaul)	2,500	0	Input
Figure D-14 (b)			0	Output
Figure D-14 (c)			5	Input
Figure D-14 (d)			5	Output
Figure D-14 (e)			10	Input
Figure D-14 (f)			10	Output
Figure D-15 (a)	Mixed Xylenes	2,500	0	Input
Figure D-15 (b)			0	Output
Figure D-15 (c)			5	Input
Figure D-15 (d)			5	Output
Figure D-15 (e)			10	Input
Figure D-15 (f)			10	Output
Figure D-16 (a)	Gasoline	2,500	0	Input
Figure D-16 (b)			0	Output
Figure D-16 (c)			5	Input
Figure D-16 (d)			5	Output
Figure D-16 (e)			10	Input
Figure D-16 (f)			10	Output

***** ADIOS 2.0 accepts a minimum wind speed of 2 mph. To simulate zero wind speed, a 2 mph wind is used in combination with a 2 mph current speed in the opposite direction.

Salish Sea Scenarios.

Spill Scenario 2,500 bbl w/3 wind speeds and 4 streams:

⊟ **Oil Type**

REFORMATE (custom oil)

Location = Anacortes Washington

Synonyms = REFORMATE

Product Type = refined

API = --

Pour Point = -18 deg C

Flash Point = 25 deg C

Density = 0.785 g/cc at 50 deg F

Viscosity = 0.8 cSt at 50 deg F

Adhesion = 0.00g/m2

Aromatics = 96 weight %

⊟ **Emulsification**

Mousse begins to form when 100% of the oil has evaporated.

⊟ **Wind and Wave Conditions**

Wind Speed = 2 mph from 0 degrees

Wave Height = computed from wind speed, unlimited fetch (default)

⊟ **Water Properties**

Temperature = 50 deg F

Salinity = 32 ppt

Sediment Load = 5 g/m3 (ocean)

Current = 2.0 mph towards 180 degrees

⊟ **Release Information**

⊟ **Instantaneous Release**

Time of Release = March 23, 0000 hours

Amount Spilled = 2500 bbl

Figure D-13 (a): ADIOS 2.0 Model Input Parameters – 2,500 bbl Reformate with 0 mph wind speed.

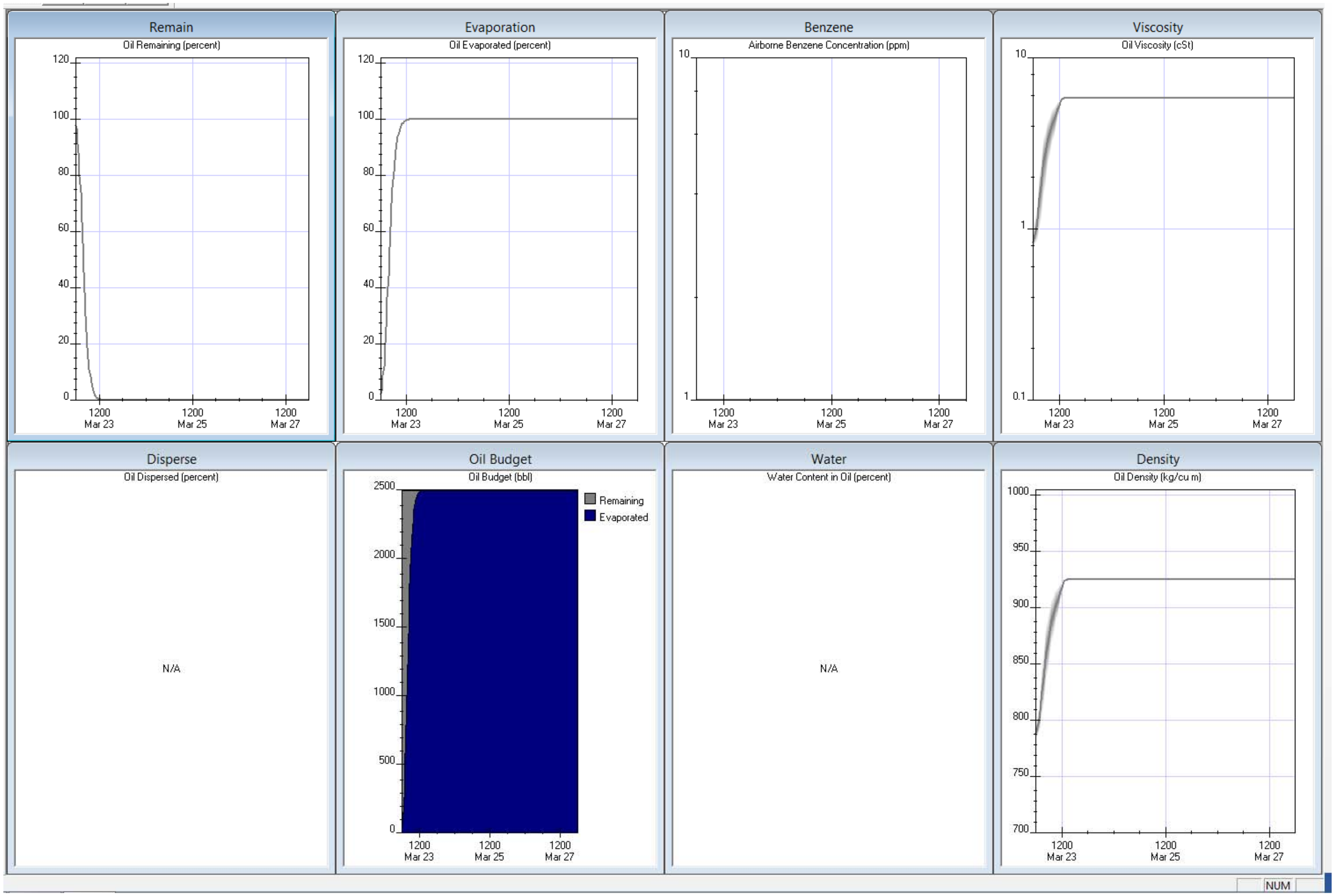

Figure D-13 (b): ADIOS 2.0 Model Output – 2,500 bbl Reformate with 0 mph wind speed.

Oil Type

REFORMATE (custom oil)

Location = Anacortes Washington

Synonyms = REFORMATE

Product Type = refined

API = --

Pour Point = -18 deg C

Flash Point = 25 deg C

Density = 0.785 g/cc at 50 deg F

Viscosity = 0.8 cSt at 50 deg F

Adhesion = 0.00g/m2

Aromatics = 96 weight %

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 5 mph from 0 degrees

Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F

Salinity = 32 ppt

Sediment Load = 5 g/m3 (ocean)

Current = 0 mph

Release Information

Instantaneous Release

Time of Release = March 23, 0000 hours

Amount Spilled = 2500 bbl

Figure D-13 (c): ADIOS 2.0 Model Input Parameters – 2,500 bbl Reformate with 5 mph wind speed.

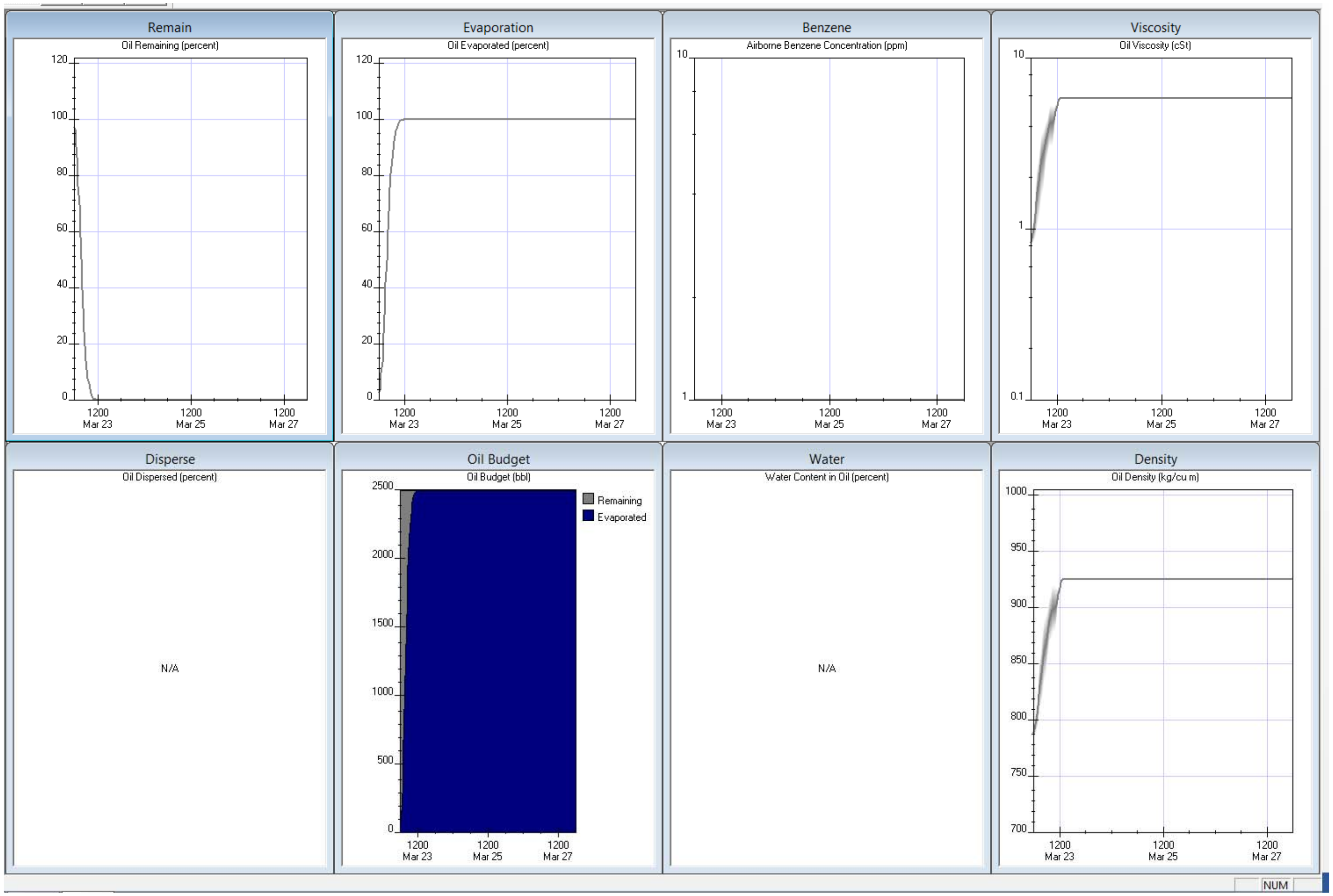

Figure D-13 (d): ADIOS 2.0 Model Output – 2,500 bbl Reformate with 5 mph wind speed.

Oil Type

- REFORMATE (custom oil)
- Location = Anacortes Washington
- Synonyms = REFORMATE
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 25 deg C
- Density = 0.785 g/cc at 50 deg F
- Viscosity = 0.8 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 96 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 10 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 23, 0000 hours
  - Amount Spilled = 2500 bbl

Figure D-13 (e): ADIOS 2.0 Model Input Parameters – 2,500 bbl Reformate with 10 mph wind speed.

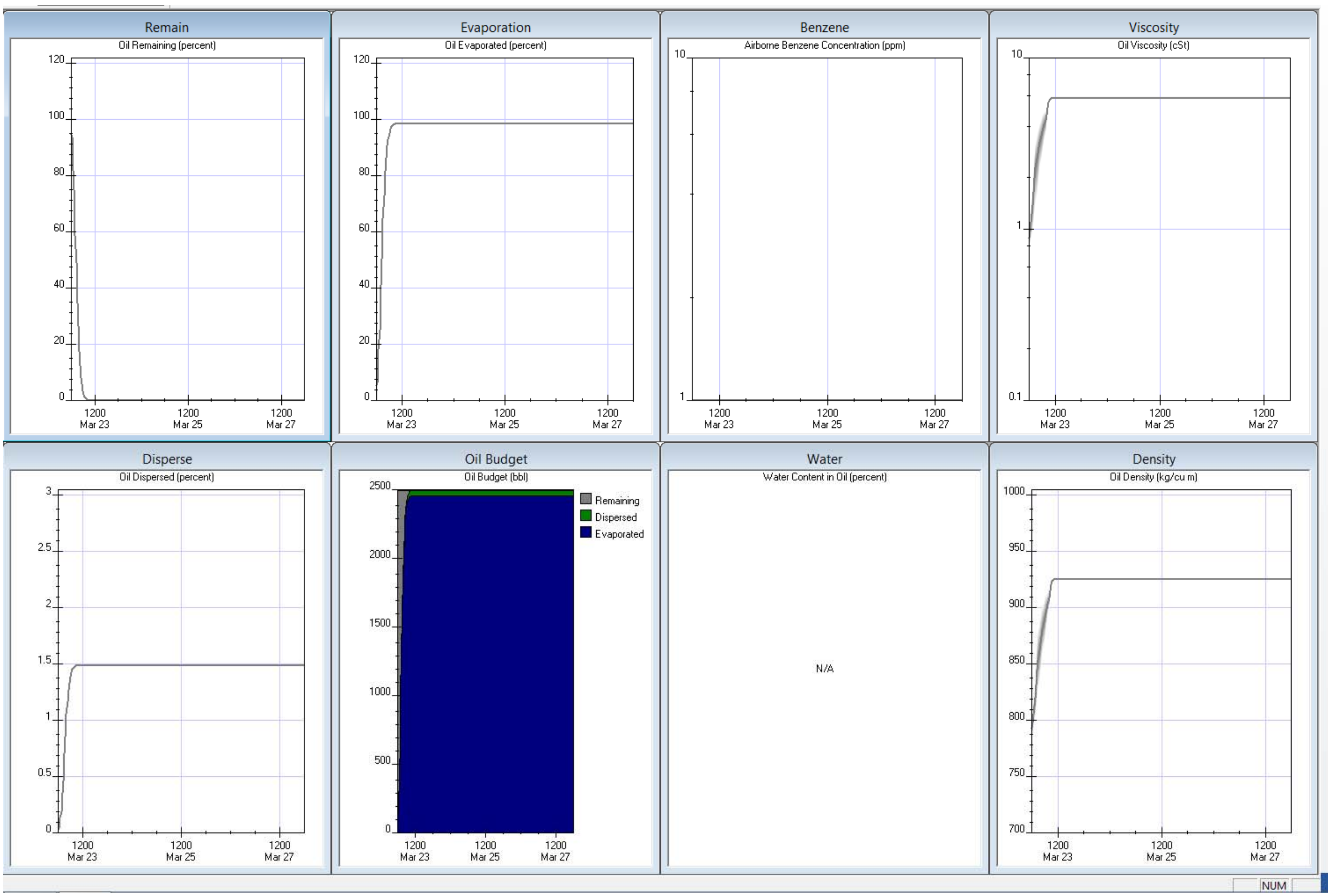

Figure D-13 (f): ADIOS 2.0 Model Output – 2,500 bbl Reformate with 10 mph wind speed.

⊟ **Oil Type**

REFORMATE (BACKHAUL) (custom oil)
Location = Anacortes Washington
Synonyms = Reformate with xylenes removed
Product Type = refined
API = --
Pour Point = -18 deg C
Flash Point = 22 deg C
Density = 0.780 g/cc at 50 deg F
Viscosity = 1.2 cSt at 50 deg F
Adhesion = 0.00g/m2
Aromatics = 88 weight %

⊟ **Emulsification**

Mousse begins to form when 100% of the oil has evaporated.

⊟ **Wind and Wave Conditions**

Wind Speed = 2 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

⊟ **Water Properties**

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 2.0 mph towards 180 degrees

⊟ **Release Information**

⊟ **Instantaneous Release**

Time of Release = March 23, 0000 hours
Amount Spilled = 2500 bbl

Figure D-14 (a): ADIOS 2.0 Model Input Parameters – 2,500 bbl Reformate (Backhaul) with 0 mph wind speed.

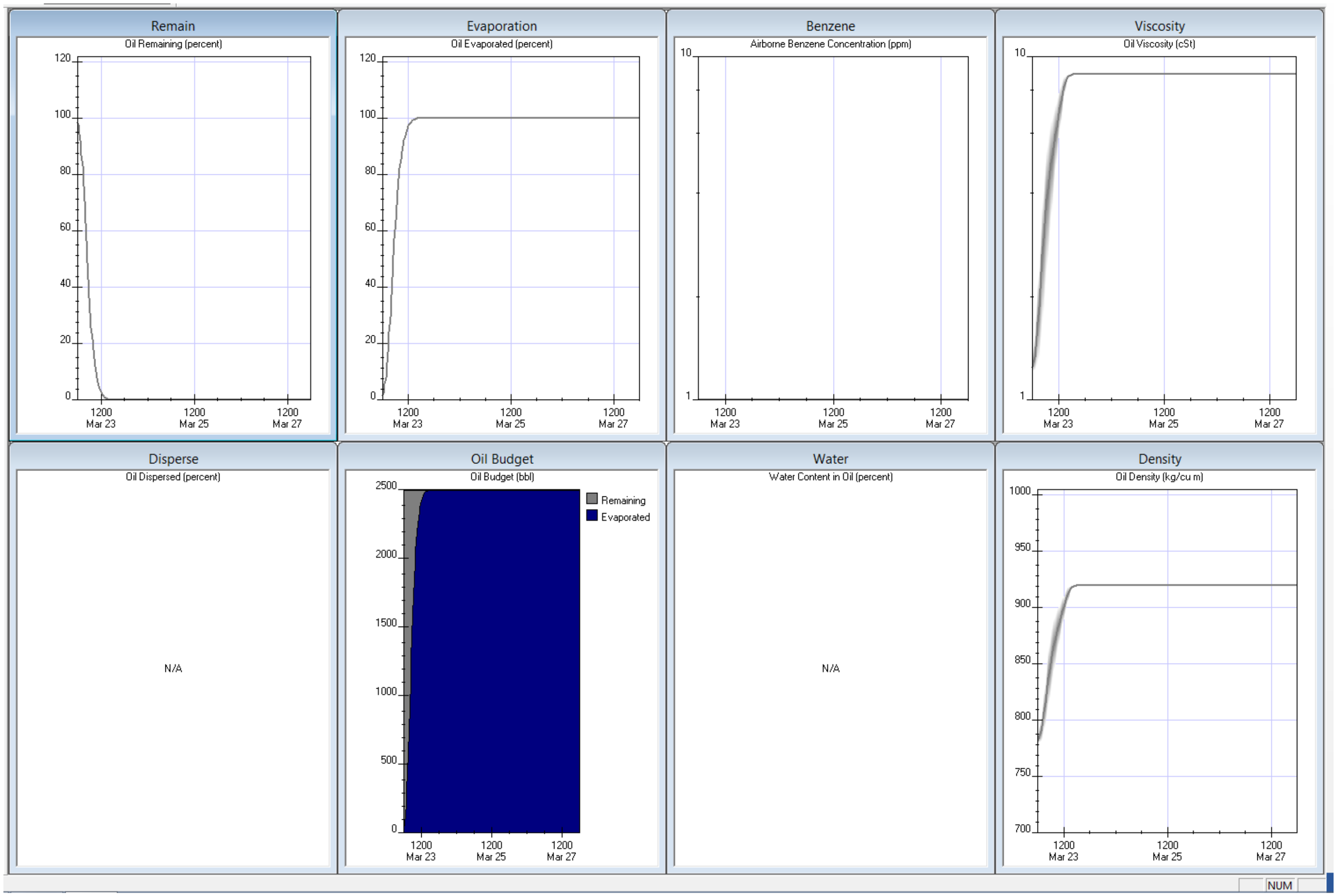

Figure D-14 (b): ADIOS 2.0 Model Output – 2,500 bbl Reformate (Backhaul) with 0 mph wind speed.

- **Oil Type**
  - REFORMATE (BACKHAUL) (custom oil)
  - Location = Anacortes Washington
  - Synonyms = Reformate with xylenes removed
  - Product Type = refined
  - API = --
  - Pour Point = -18 deg C
  - Flash Point = 22 deg C
  - Density = 0.780 g/cc at 50 deg F
  - Viscosity = 1.2 cSt at 50 deg F
  - Adhesion = 0.00g/m2
  - Aromatics = 88 weight %
- **Emulsification**
  - Mousse begins to form when 100% of the oil has evaporated.
- **Wind and Wave Conditions**
  - Wind Speed = 5 mph from 0 degrees
  - Wave Height = computed from wind speed, unlimited fetch (default)
- **Water Properties**
  - Temperature = 50 deg F
  - Salinity = 32 ppt
  - Sediment Load = 5 g/m3 (ocean)
  - Current = 0 mph
- **Release Information**
  - **Instantaneous Release**
    - Time of Release = March 23, 0000 hours
    - Amount Spilled = 2500 bbl

Figure D-14 (c): ADIOS 2.0 Model Input Parameters – 2,500 bbl Reformate (Backhaul) with 5 mph wind speed.

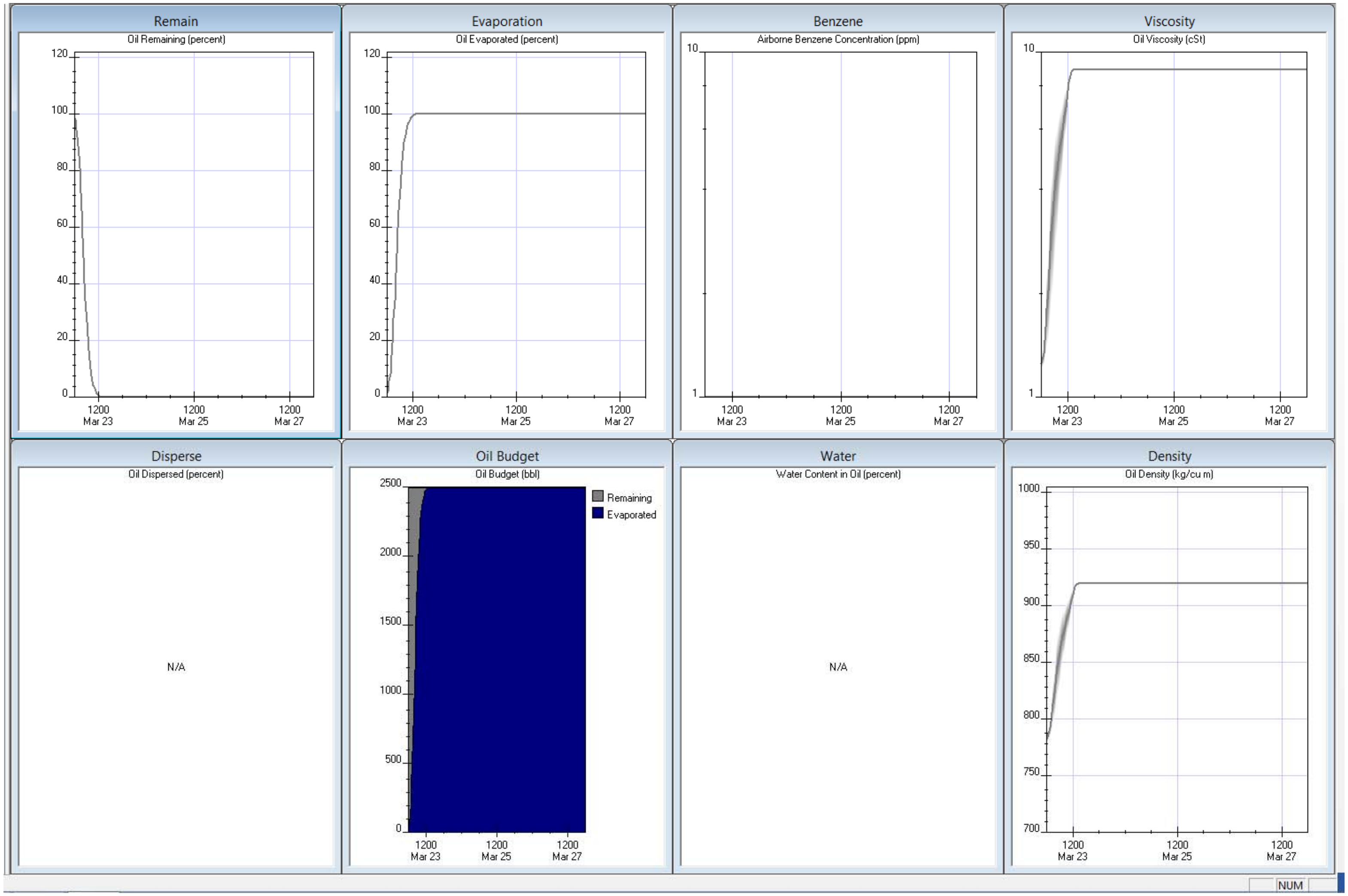

Figure D-14 (d): ADIOS 2.0 Model Output – 2,500 bbl Reformate (Backhaul) with 5 mph wind speed.

- **Oil Type**
  - REFORMATE (BACKHAUL) (custom oil)
  - Location = Anacortes Washington
  - Synonyms = Reformate with xylenes removed
  - Product Type = refined
  - API = --
  - Pour Point = -18 deg C
  - Flash Point = 22 deg C
  - Density = 0.780 g/cc at 50 deg F
  - Viscosity = 1.2 cSt at 50 deg F
  - Adhesion = 0.00g/m2
  - Aromatics = 88 weight %
- **Emulsification**
  - Mousse begins to form when 100% of the oil has evaporated.
- **Wind and Wave Conditions**
  - Wind Speed = 10 mph from 0 degrees
  - Wave Height = computed from wind speed, unlimited fetch (default)
- **Water Properties**
  - Temperature = 50 deg F
  - Salinity = 32 ppt
  - Sediment Load = 5 g/m3 (ocean)
  - Current = 0 mph
- **Release Information**
  - **Instantaneous Release**
    - Time of Release = March 23, 0000 hours
    - Amount Spilled = 2500 bbl

Figure D-14 (e): ADIOS 2.0 Model Input Parameters – 2,500 bbl Reformate (Backhaul) with 10 mph wind speed.

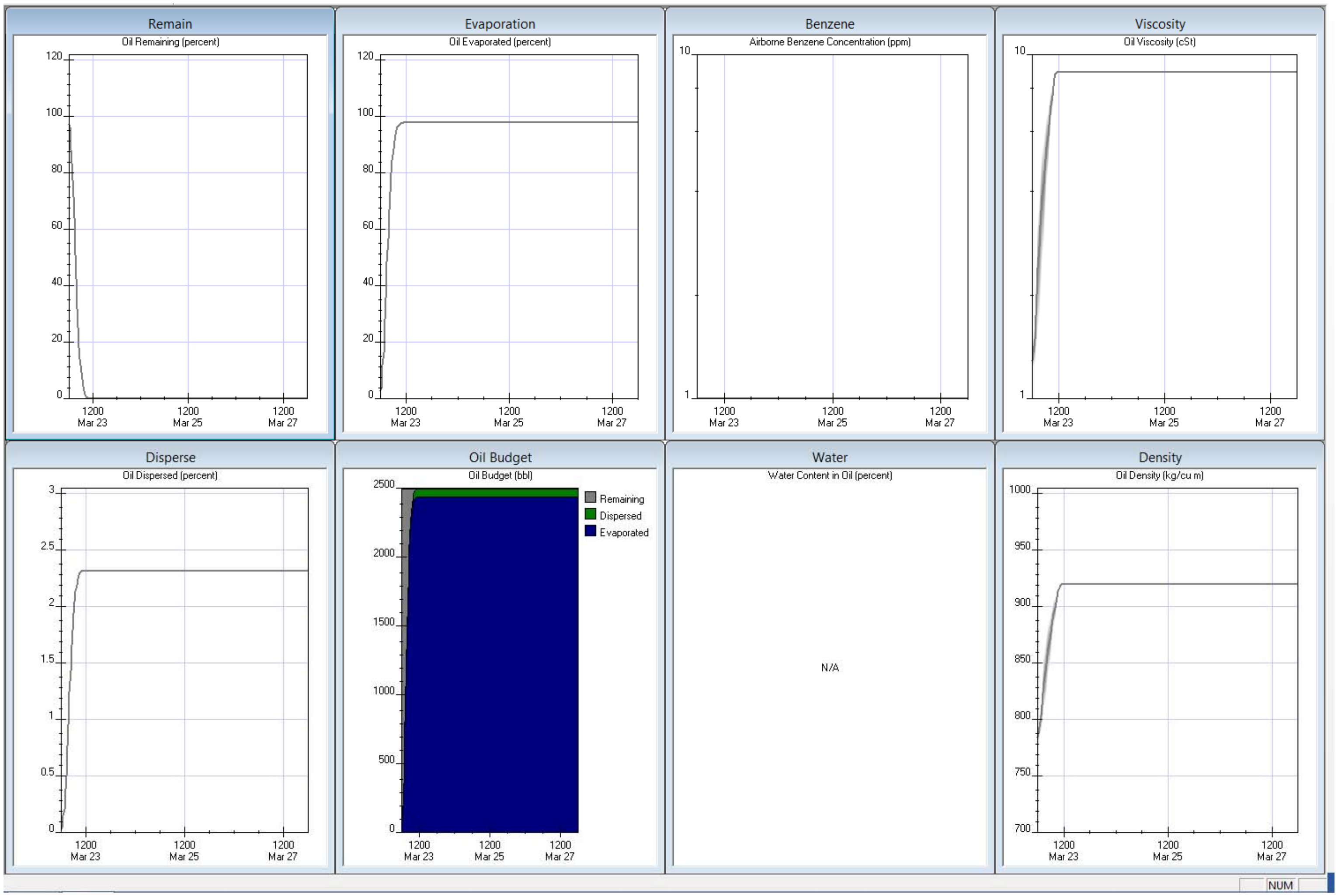

Figure D-14 (f): ADIOS 2.0 Model Output – 2,500 bbl Reformate (Backhaul) with 10 mph wind speed.

⊟ **Oil Type**

MIXED XYLENES (custom oil)

Location = Anacortes Washington

Synonyms = Mixed Xylenes

Product Type = refined

API = --

Pour Point = -18 deg C

Flash Point = 28 deg C

Density = 0.794 g/cc at 50 deg F

Viscosity = 0.9 cSt at 50 deg F

Adhesion = 0.00g/m2

Aromatics = 100 weight %

⊟ **Emulsification**

Mousse begins to form when 100% of the oil has evaporated.

⊟ **Wind and Wave Conditions**

Wind Speed = 2 mph from 0 degrees

Wave Height = computed from wind speed, unlimited fetch (default)

⊟ **Water Properties**

Temperature = 50 deg F

Salinity = 32 ppt

Sediment Load = 5 g/m3 (ocean)

Current = 2.0 mph towards 180 degrees

⊟ **Release Information**

⊟ **Instantaneous Release**

Time of Release = March 23, 0000 hours

Amount Spilled = 2500 bbl

Figure D-15 (a): ADIOS 2.0 Model Input Parameters – 2,500 bbl Mixed Xylenes with 0 mph wind speed.

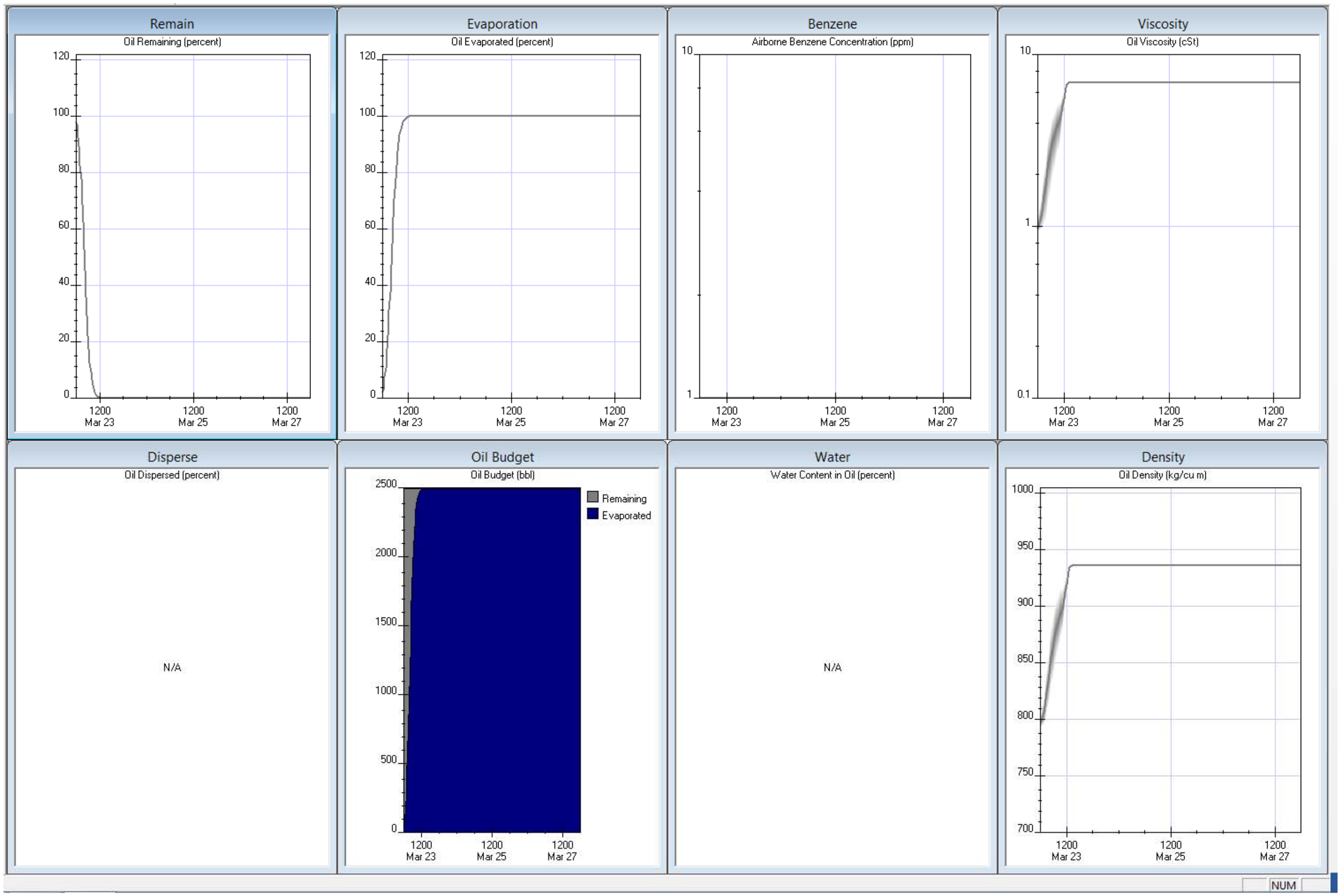

Figure D-15 (b): ADIOS 2.0 Model Output – 2,500 bbl Mixed Xylenes with 0 mph wind speed.

Oil Type

MIXED XYLENES (custom oil)

Location = Anacortes Washington

Synonyms = Mixed Xylenes

Product Type = refined

API = --

Pour Point = -18 deg C

Flash Point = 28 deg C

Density = 0.794 g/cc at 50 deg F

Viscosity = 0.9 cSt at 50 deg F

Adhesion = 0.00g/m2

Aromatics = 100 weight %

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 5 mph from 0 degrees

Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F

Salinity = 32 ppt

Sediment Load = 5 g/m3 (ocean)

Current = 0 mph

Release Information

Instantaneous Release

Time of Release = March 23, 0000 hours

Amount Spilled = 2500 bbl

Figure D-15 (c): ADIOS 2.0 Model Input Parameters – 2,500 bbl Mixed Xylenes with 5 mph wind speed.

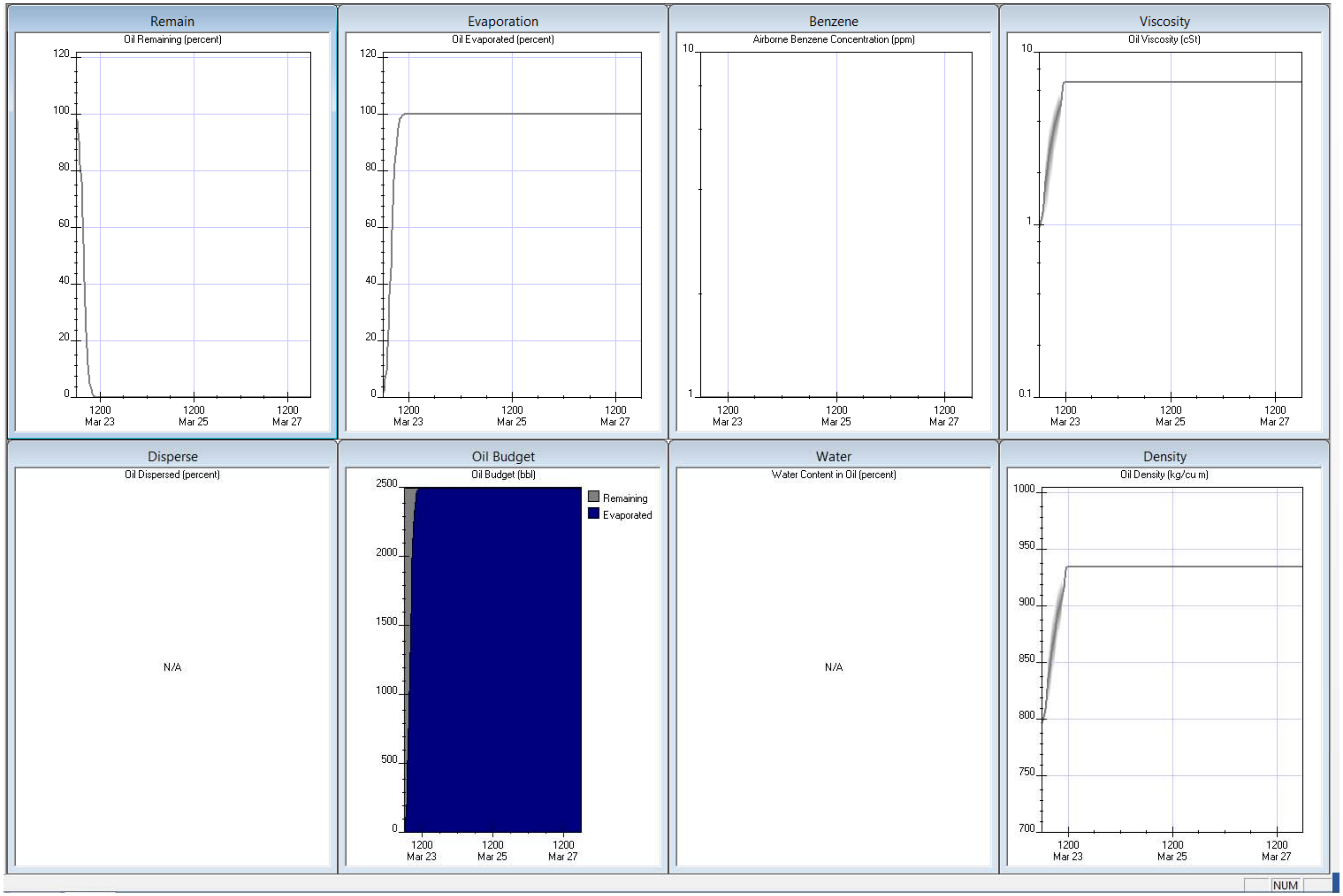

Figure D-15 (d): ADIOS 2.0 Model Output – 2,500 bbl Mixed Xylenes with 5 mph wind speed.

Oil Type

- MIXED XYLENES (custom oil)
- Location = Anacortes Washington
- Synonyms = Mixed Xylenes
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 28 deg C
- Density = 0.794 g/cc at 50 deg F
- Viscosity = 0.9 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 100 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 10 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 23, 0000 hours
  - Amount Spilled = 2500 bbl

Figure D-15 (e): ADIOS 2.0 Model Input Parameters – 2,500 bbl Mixed Xylenes with 10 mph wind speed.

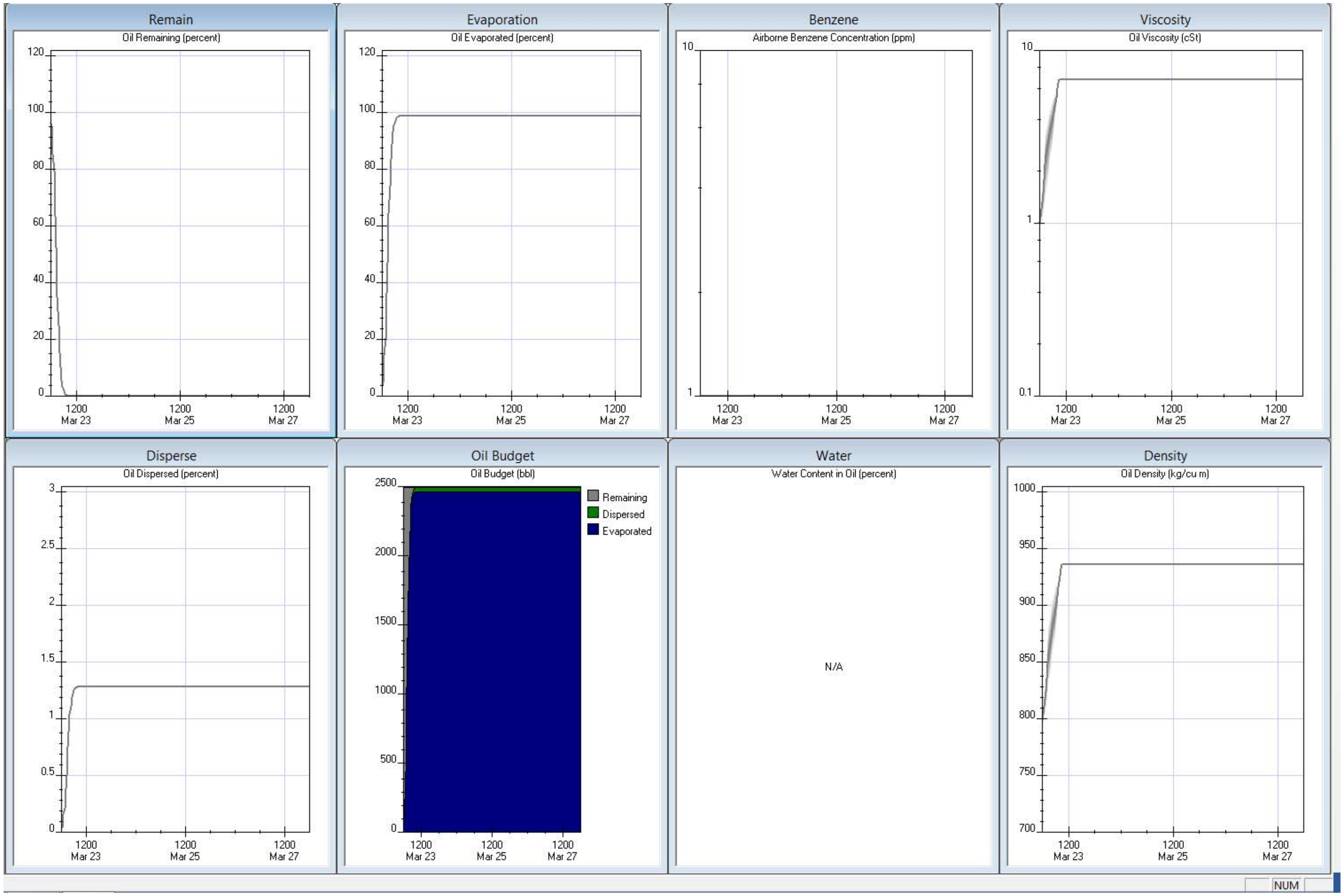

Figure D-15 (f): ADIOS 2.0 Model Output – 2,500 bbl Mixed Xylenes with 10 mph wind speed.

Oil Type

- GASOLINE (UNLEADED), SHELL
- Location = none listed
- Synonyms = AUTOMOTIVE FUEL, PETROL
- Product Type = refined
- API = --
- Pour Point = unknown
- Flash Point = -30 deg C
- Density = 0.753 g/cc at 50 deg F
- Viscosity = 4.9 cSt at 50 deg F
- Adhesion = unknown
- Aromatics = unknown
- WARNING! Benzene graph for this product may be unreliable.

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 2 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 2.0 mph towards 180 degrees

Release Information

- **Instantaneous Release**
  - Time of Release = March 23, 0000 hours
  - Amount Spilled = 2500 bbl

Figure D-16 (a): ADIOS 2.0 Model Input Parameters – 2,500 bbl Gasoline with 0 mph wind speed.

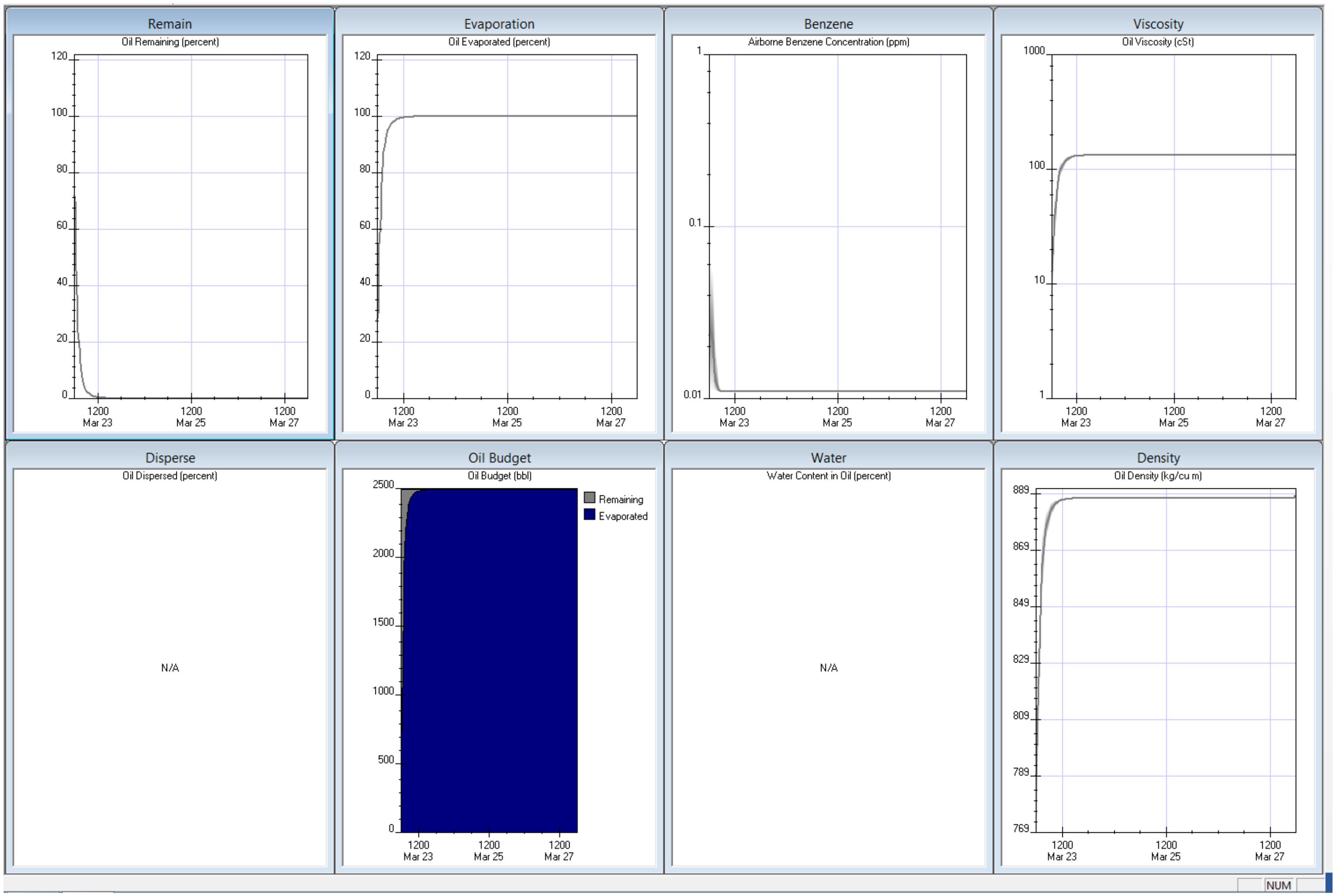

Figure D-16 (b): ADIOS 2.0 Model Output – 2,500 bbl Gasoline with 0 mph wind speed.

Oil Type

GASOLINE (UNLEADED), SHELL
Location = none listed
Synonyms = AUTOMOTIVE FUEL, PETROL
Product Type = refined
API = --
Pour Point = unknown
Flash Point = -30 deg C
Density = 0.753 g/cc at 50 deg F
Viscosity = 4.9 cSt at 50 deg F
Adhesion = unknown
Aromatics = unknown
WARNING! Benzene graph for this product may be unreliable.

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 5 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 0 mph

Release Information

Instantaneous Release

Time of Release = March 23, 0000 hours
Amount Spilled = 2500 bbl

Figure D-16 (c): ADIOS 2.0 Model Input Parameters – 2,500 bbl Gasoline with 5 mph wind speed.

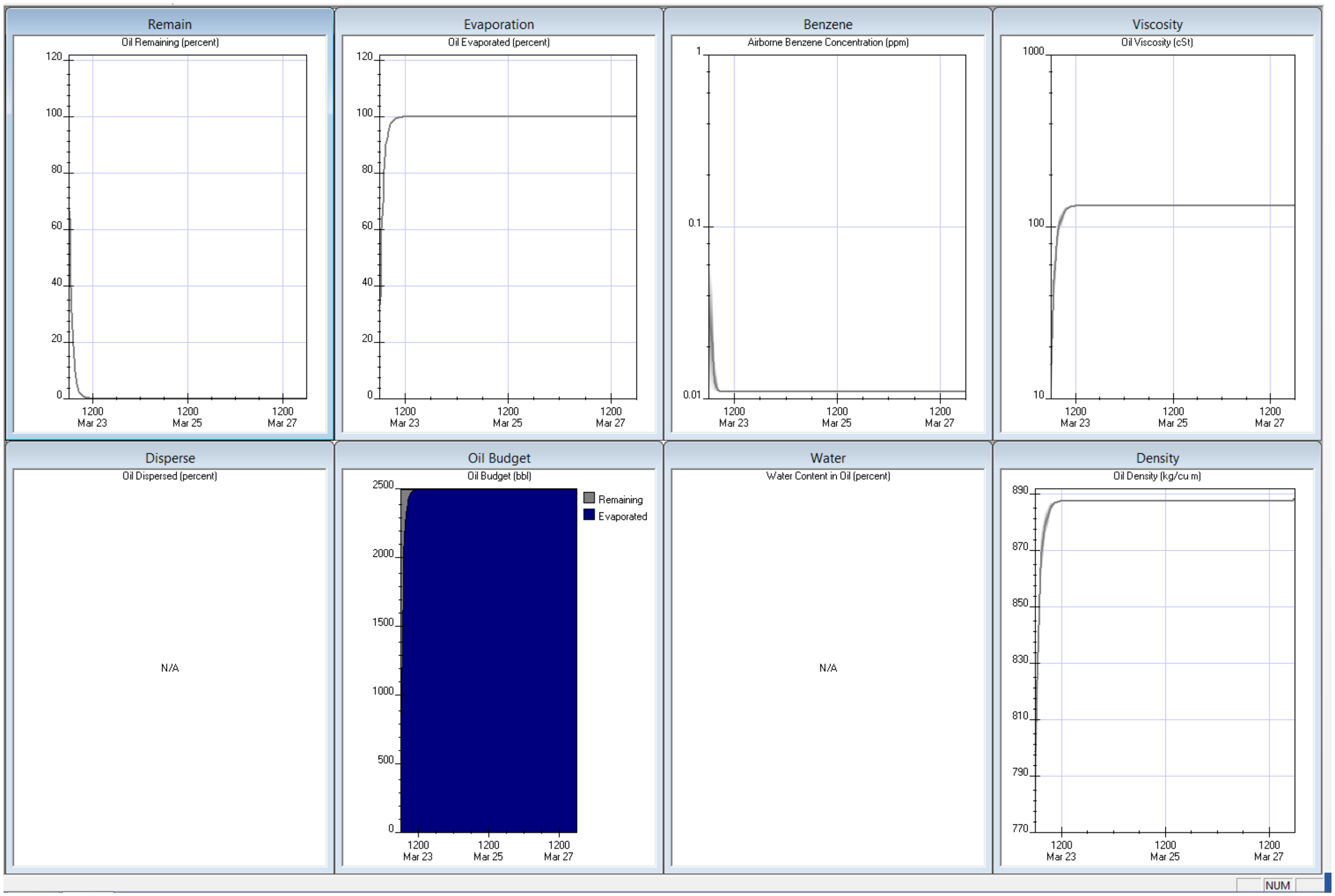

Figure D-16 (d): ADIOS 2.0 Model Output – 2,500 bbl Gasoline with 5 mph wind speed.

Oil Type

GASOLINE (UNLEADED), SHELL

Location = none listed

Synonyms = AUTOMOTIVE FUEL, PETROL

Product Type = refined

API = --

Pour Point = unknown

Flash Point = -30 deg C

Density = 0.753 g/cc at 50 deg F

Viscosity = 4.9 cSt at 50 deg F

Adhesion = unknown

Aromatics = unknown

WARNING! Benzene graph for this product may be unreliable.

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 10 mph from 0 degrees

Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F

Salinity = 32 ppt

Sediment Load = 5 g/m3 (ocean)

Current = 0 mph

Release Information

Instantaneous Release

Time of Release = March 23, 0000 hours

Amount Spilled = 2500 bbl

Figure D-16 (e): ADIOS 2.0 Model Input Parameters – 2,500 bbl Gasoline with 10 mph wind speed.

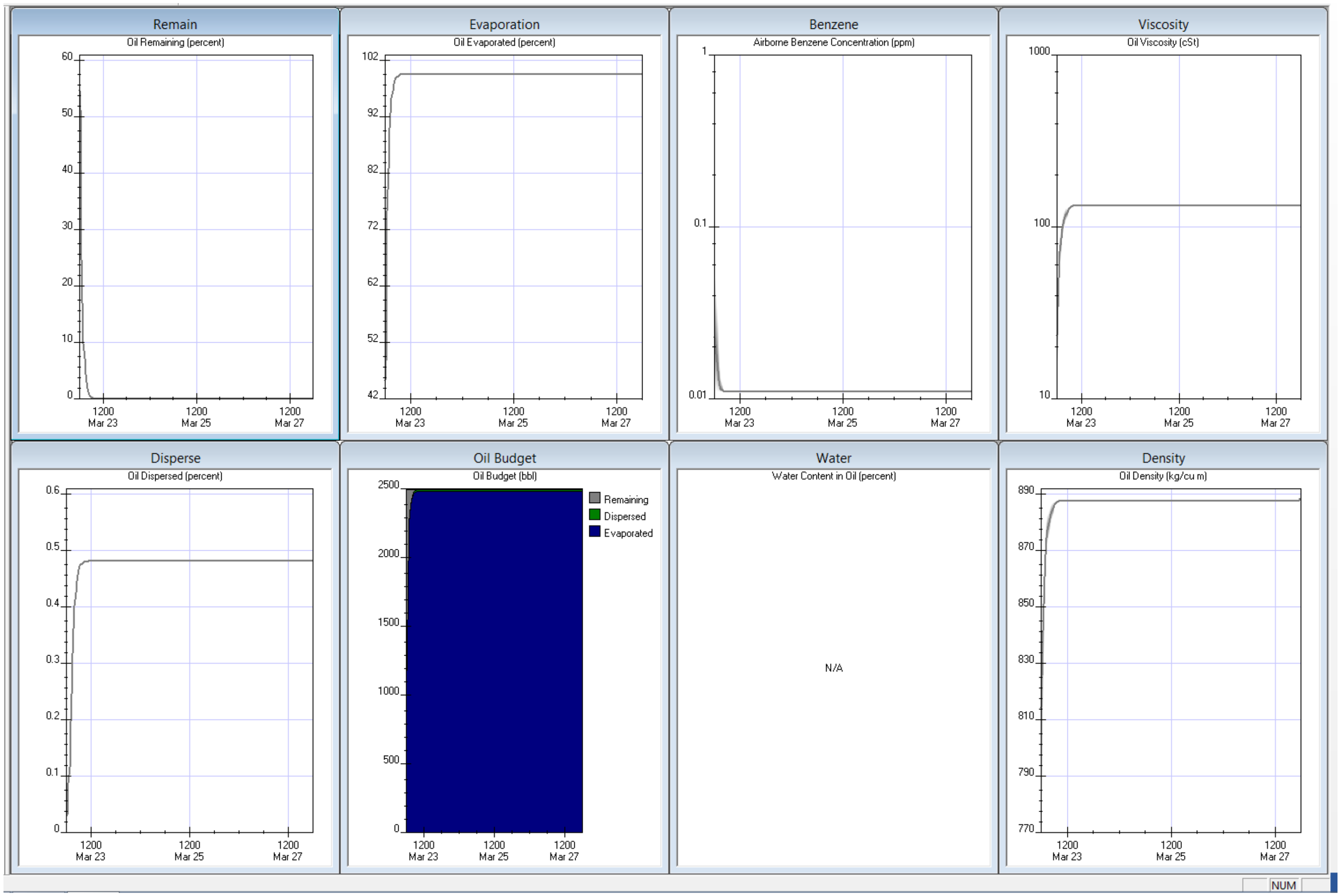

Figure D-16 (f): ADIOS 2.0 Model Output – 2,500 bbl Gasoline with 10 mph wind speed.

Table D-6. List of Figures Salish Sea Spill Scenario – 330,000 bbl
ADIOS 2.0 Modeling of Evaporation and Dispersion Individual Runs (Input/Output) Results

Figure #	Stream	Volume bbl	Wind speed* mph	File Type
Figure D-17 (a)	Reformate	330,000	0	Input
Figure D-17 (b)			0	Output
Figure D-17 (c)			5	Input
Figure D-17 (d)			5	Output
Figure D-17 (e)			10	Input
Figure D-17 (f)			10	Output
Figure D-18 (a)	Reformate (backhaul)	330,000	0	Input
Figure D-18 (b)			0	Output
Figure D-18 (c)			5	Input
Figure D-18 (d)			5	Output
Figure D-18 (e)			10	Input
Figure D-18 (f)			10	Output
Figure D-19 (a)	Mixed Xylenes	330,000	0	Input
Figure D-19 (b)			0	Output
Figure D-19 (c)			5	Input
Figure D-19 (d)			5	Output
Figure D-19 (e)			10	Input
Figure D-19 (f)			10	Output
Figure D-20 (a)	Gasoline	330,000	0	Input
Figure D-20 (b)			0	Output
Figure D-20 (c)			5	Input
Figure D-20 (d)			5	Output
Figure D-20 (e)			7	Input
Figure D-20 (f)			7	Output
Figure D-20 (g)			8	Input
Figure D-20 (h)			8	Output
Figure D-20 (i)			10	Input
Figure D-20 (j)			10	Output
Figure D-20 (k)			12	Input
Figure D-20 (l)			12	Output
Figure D-20 (m)			14	Input
Figure D-20 (n)			14	Output

***** ADIOS 2.0 accepts a minimum wind speed of 2 mph. To simulate zero wind speed, a 2 mph wind is used in combination with a 2 mph current speed in the opposite direction.

Spill Scenario 330,000 bbl w/3 wind speeds and 4 streams:

- **Oil Type**
  - REFORMATE (custom oil)
  - Location = Anacortes Washington
  - Synonyms = REFORMATE
  - Product Type = refined
  - API = --
  - Pour Point = -18 deg C
  - Flash Point = 25 deg C
  - Density = 0.785 g/cc at 50 deg F
  - Viscosity = 0.8 cSt at 50 deg F
  - Adhesion = 0.00g/m2
  - Aromatics = 96 weight %
- **Emulsification**
  - Mousse begins to form when 100% of the oil has evaporated.
- **Wind and Wave Conditions**
  - Wind Speed = 2 mph from 0 degrees
  - Wave Height = computed from wind speed, unlimited fetch (default)
- **Water Properties**
  - Temperature = 50 deg F
  - Salinity = 32 ppt
  - Sediment Load = 5 g/m3 (ocean)
  - Current = 2.0 mph towards 180 degrees
- **Release Information**
  - **Instantaneous Release**
    - Time of Release = March 17, 0000 hours
    - Amount Spilled = 330000 bbl

Figure D-17 (a): ADIOS 2.0 Model Input Parameters – 330,000 bbl Reformate with 0 mph wind speed.

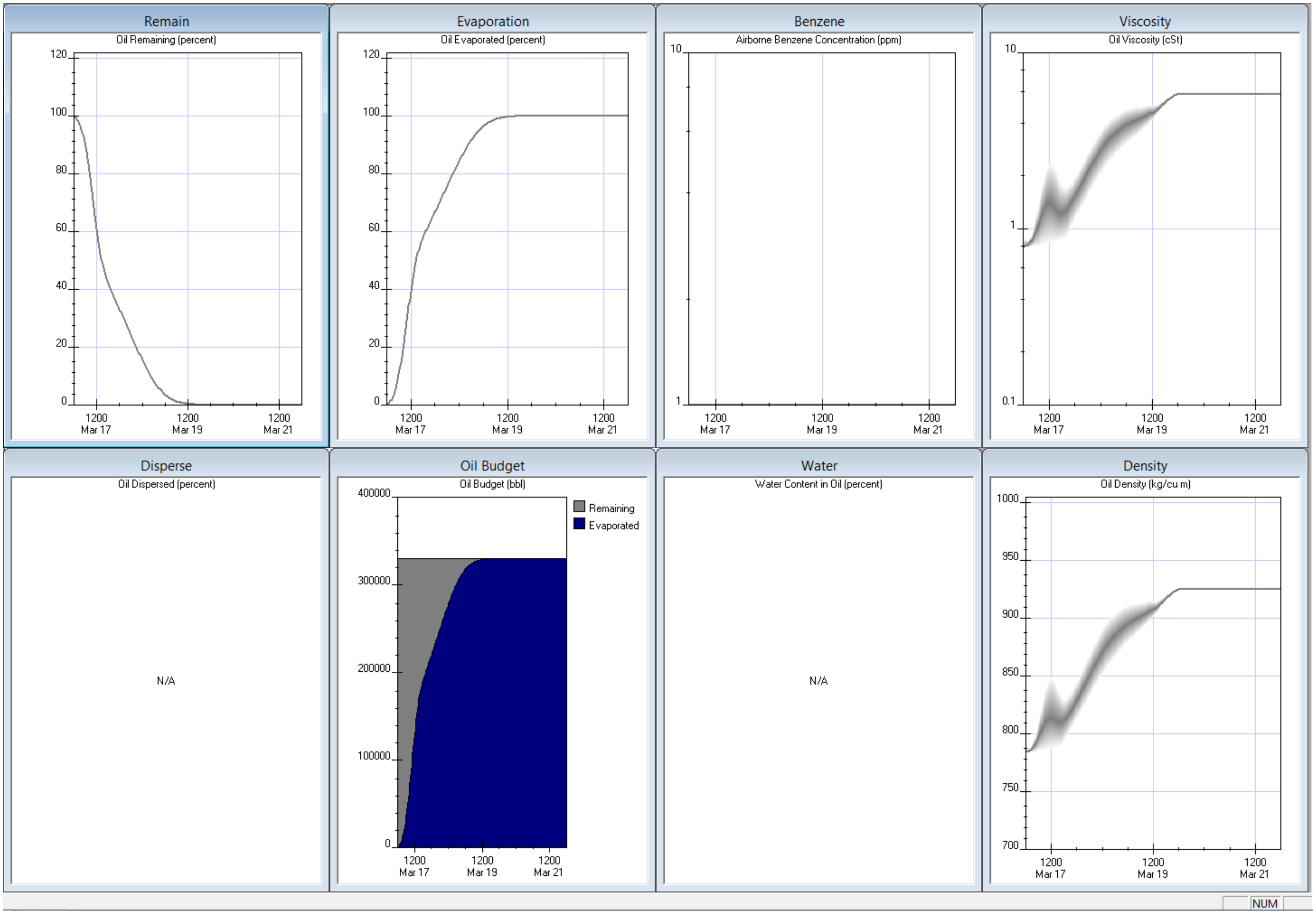

Figure D-17 (b): ADIOS 2.0 Model Output – 330,000 bbl Reformate with 0 mph wind speed.

Oil Type

- REFORMATE (custom oil)
- Location = Anacortes Washington
- Synonyms = REFORMATE
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 25 deg C
- Density = 0.785 g/cc at 50 deg F
- Viscosity = 0.8 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 96 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 5 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 17, 0000 hours
  - Amount Spilled = 330000 bbl

Figure D-17 (c): ADIOS 2.0 Model Input Parameters – 330,000 bbl Reformate with 5 mph wind speed.

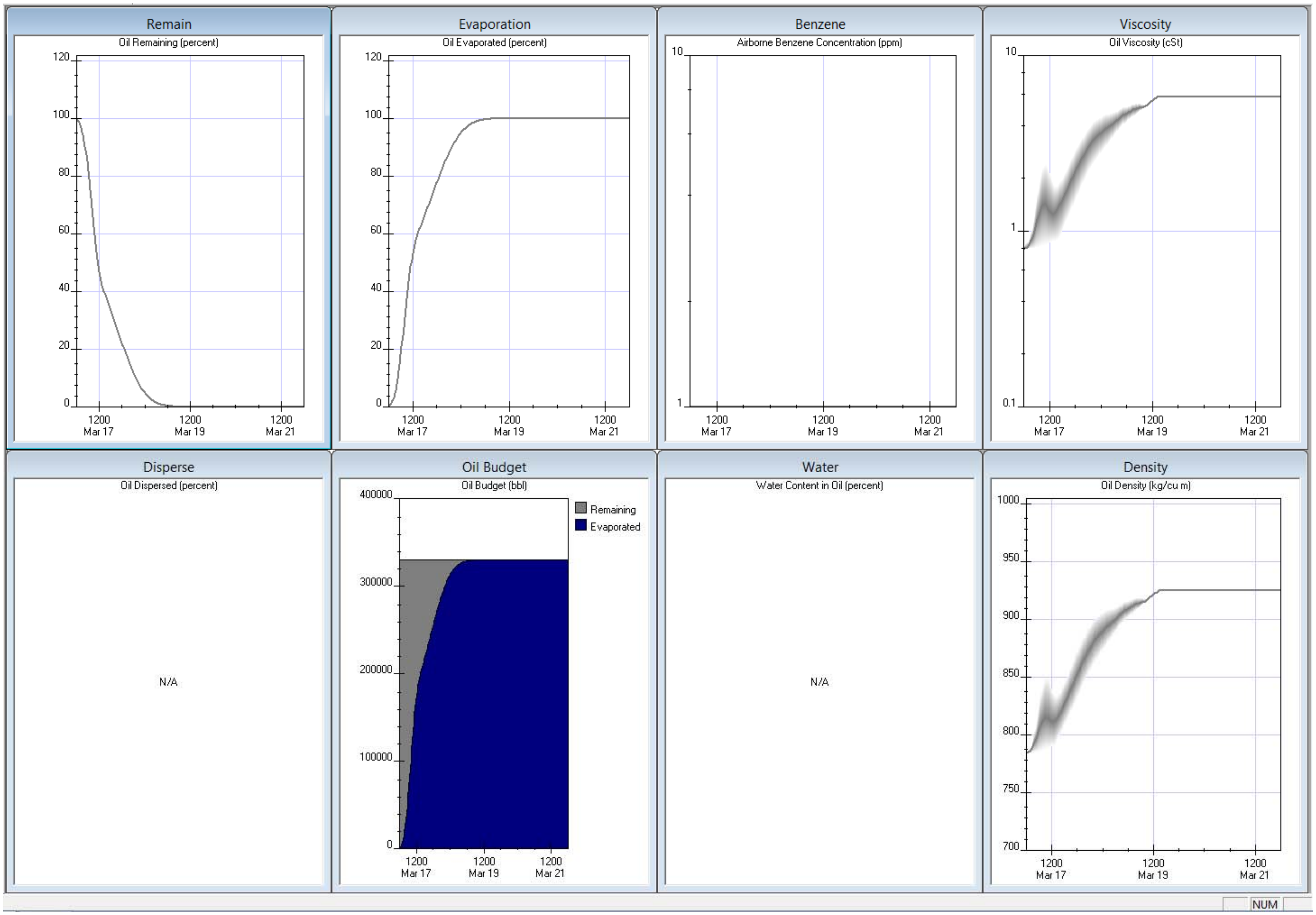

Figure D-17 (d): ADIOS 2.0 Model Output – 330,000 bbl Reformate with 5 mph wind speed.

Oil Type

- REFORMATE (custom oil)
- Location = Anacortes Washington
- Synonyms = REFORMATE
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 25 deg C
- Density = 0.785 g/cc at 50 deg F
- Viscosity = 0.8 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 96 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 10 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 20, 0000 hours
  - Amount Spilled = 330000 bbl

Figure D-17 (e): ADIOS 2.0 Model Input Parameters – 330,000 bbl Reformate with 10 mph wind speed.

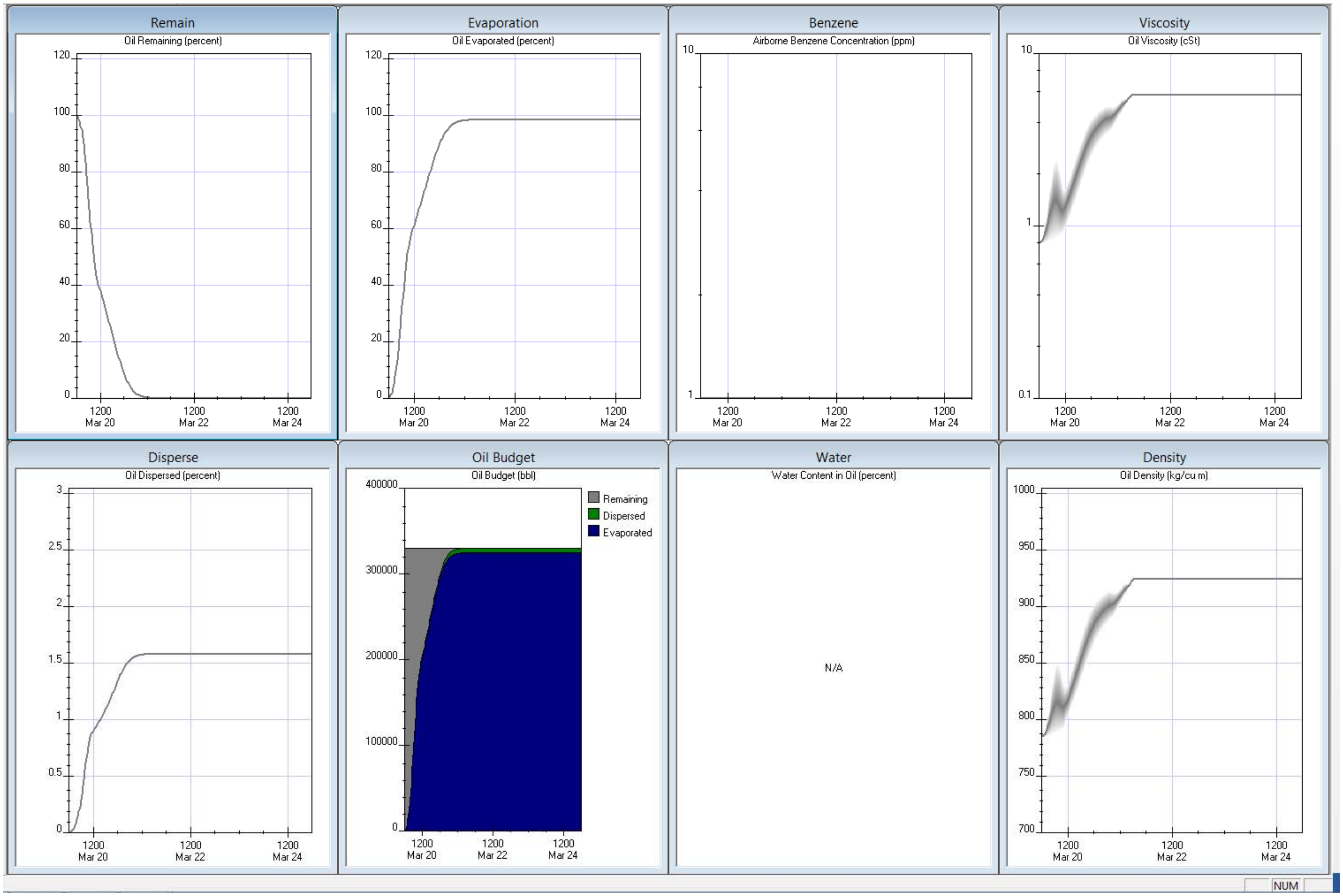

Figure D-17 (f): ADIOS 2.0 Model Output – 330,000 bbl Reformate with 10 mph wind speed.

Oil Type

REFORMATE (XYLENES REMOVED) (custom oil)
Location = Anacortes Washington
Synonyms = Reformate with xylenes removed
Product Type = refined
API = --
Pour Point = -18 deg C
Flash Point = 22 deg C
Density = 0.780 g/cc at 50 deg F
Viscosity = 1.2 cSt at 50 deg F
Adhesion = 0.00g/m2
Aromatics = 88 weight %

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 2 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 2.0 mph towards 180 degrees

Release Information

Instantaneous Release

Time of Release = March 17, 0000 hours
Amount Spilled = 330000 bbl

Figure D-18 (a): ADIOS 2.0 Model Input Parameters – 330,000 bbl Reformate (Backhaul) with 0 mph wind speed.

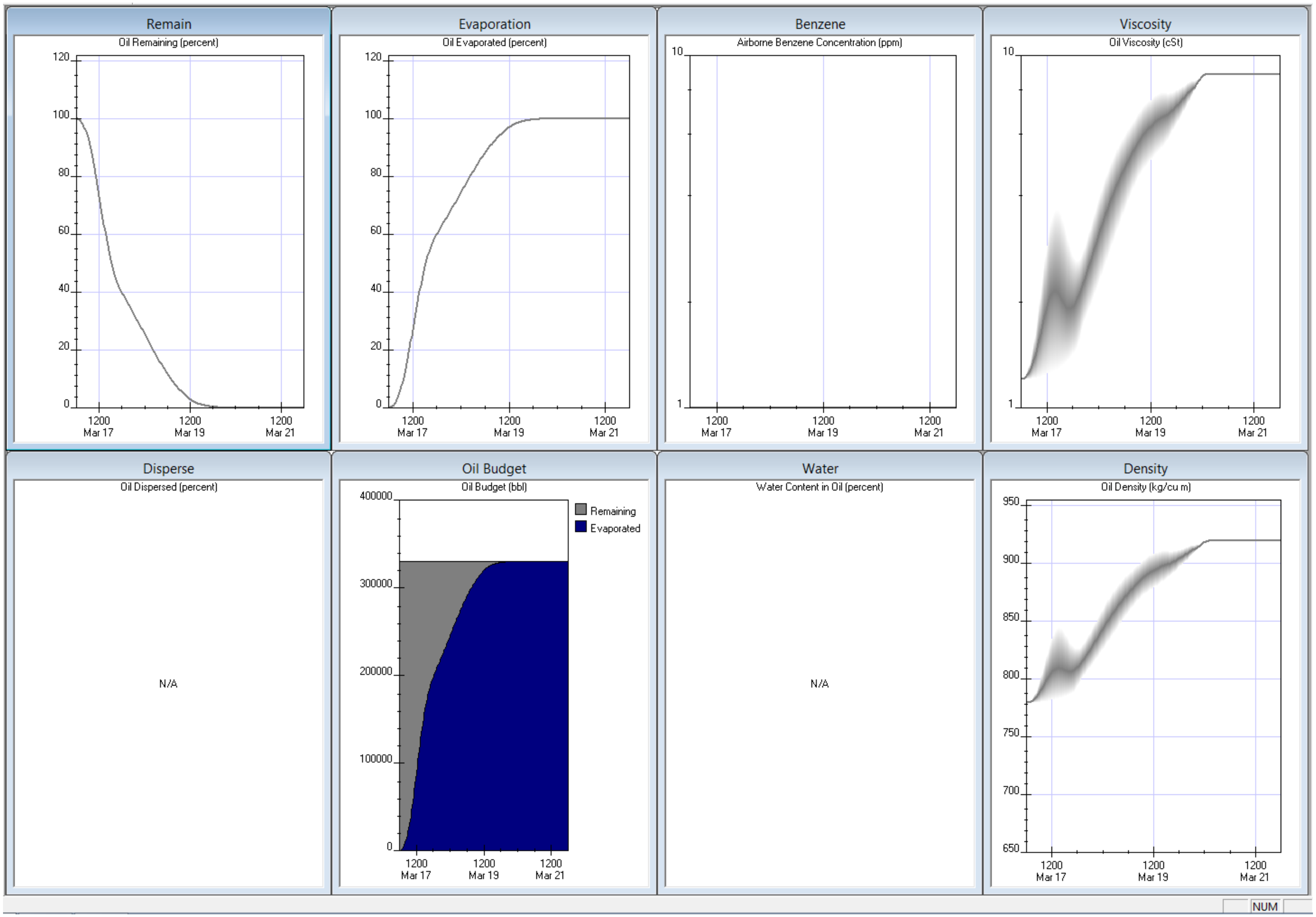

Figure D-18 (b): ADIOS 2.0 Model Output – 330,000 bbl Reformate (Backhaul) with 0 mph wind speed.

- **Oil Type**
  - REFORMATE (XYLENES REMOVED) (custom oil)
  - Location = Anacortes Washington
  - Synonyms = Reformate with xylenes removed
  - Product Type = refined
  - API = --
  - Pour Point = -18 deg C
  - Flash Point = 22 deg C
  - Density = 0.780 g/cc at 50 deg F
  - Viscosity = 1.2 cSt at 50 deg F
  - Adhesion = 0.00g/m2
  - Aromatics = 88 weight %
- **Emulsification**
  - Mousse begins to form when 100% of the oil has evaporated.
- **Wind and Wave Conditions**
  - Wind Speed = 5 mph from 0 degrees
  - Wave Height = computed from wind speed, unlimited fetch (default)
- **Water Properties**
  - Temperature = 50 deg F
  - Salinity = 32 ppt
  - Sediment Load = 5 g/m3 (ocean)
  - Current = 0 mph
- **Release Information**
  - **Instantaneous Release**
    - Time of Release = March 17, 0000 hours
    - Amount Spilled = 330000 bbl

Figure D-18 (c): ADIOS 2.0 Model Input Parameters – 330,000 bbl Reformate (Backhaul) with 5 mph wind speed.

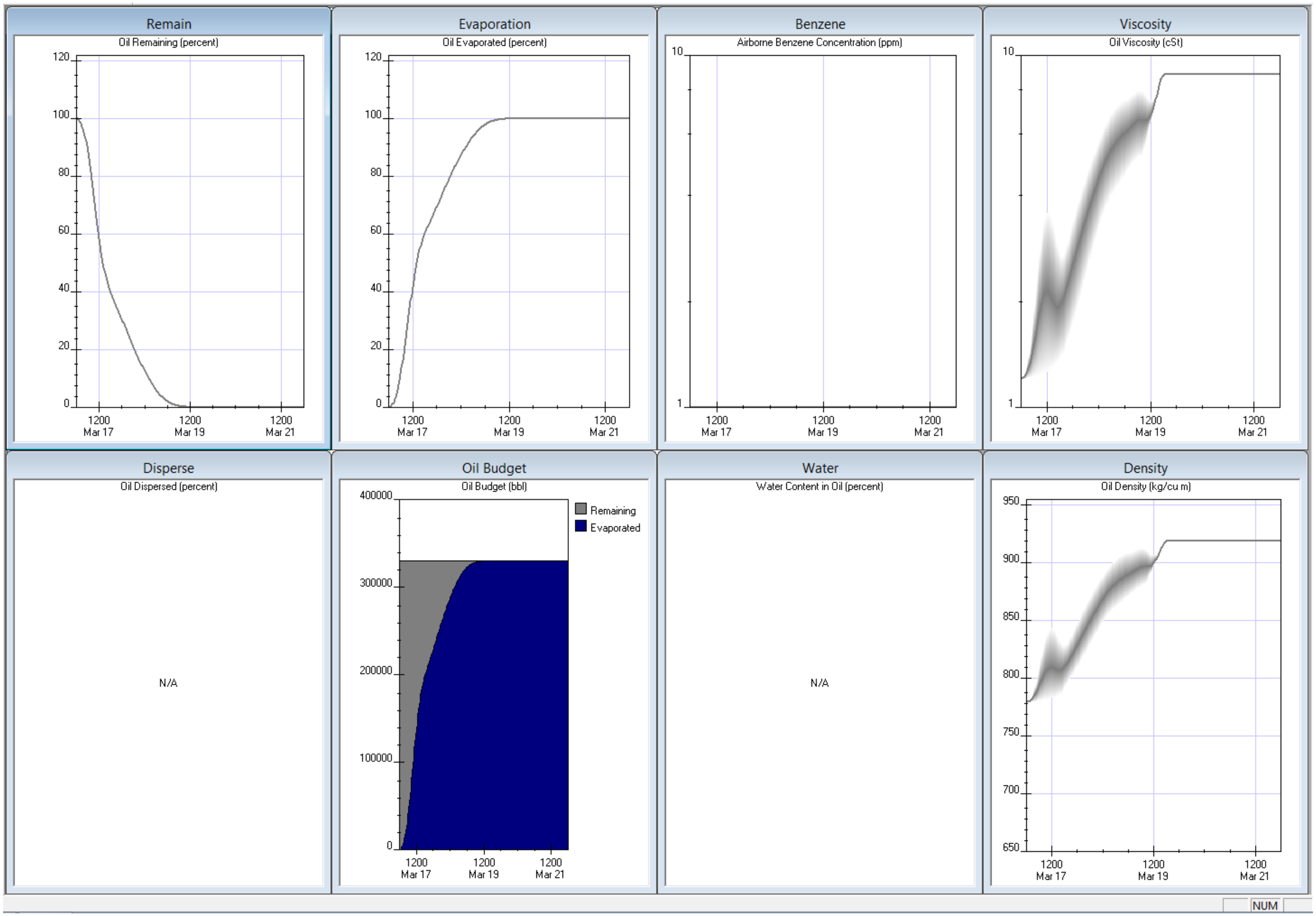

Figure D-18 (d): ADIOS 2.0 Model Output – 330,000 bbl Reformate (Backhaul) with 5 mph wind speed.

Oil Type

- REFORMATE (BACKHAUL) (custom oil)
- Location = Anacortes Washington
- Synonyms = Reformate with xylenes removed
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 22 deg C
- Density = 0.780 g/cc at 50 deg F
- Viscosity = 1.2 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 88 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 10 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 20, 0000 hours
  - Amount Spilled = 330000 bbl

Figure D-18 (e): ADIOS 2.0 Model Input Parameters – 330,000 bbl Reformate (Backhaul) with 10 mph wind speed.

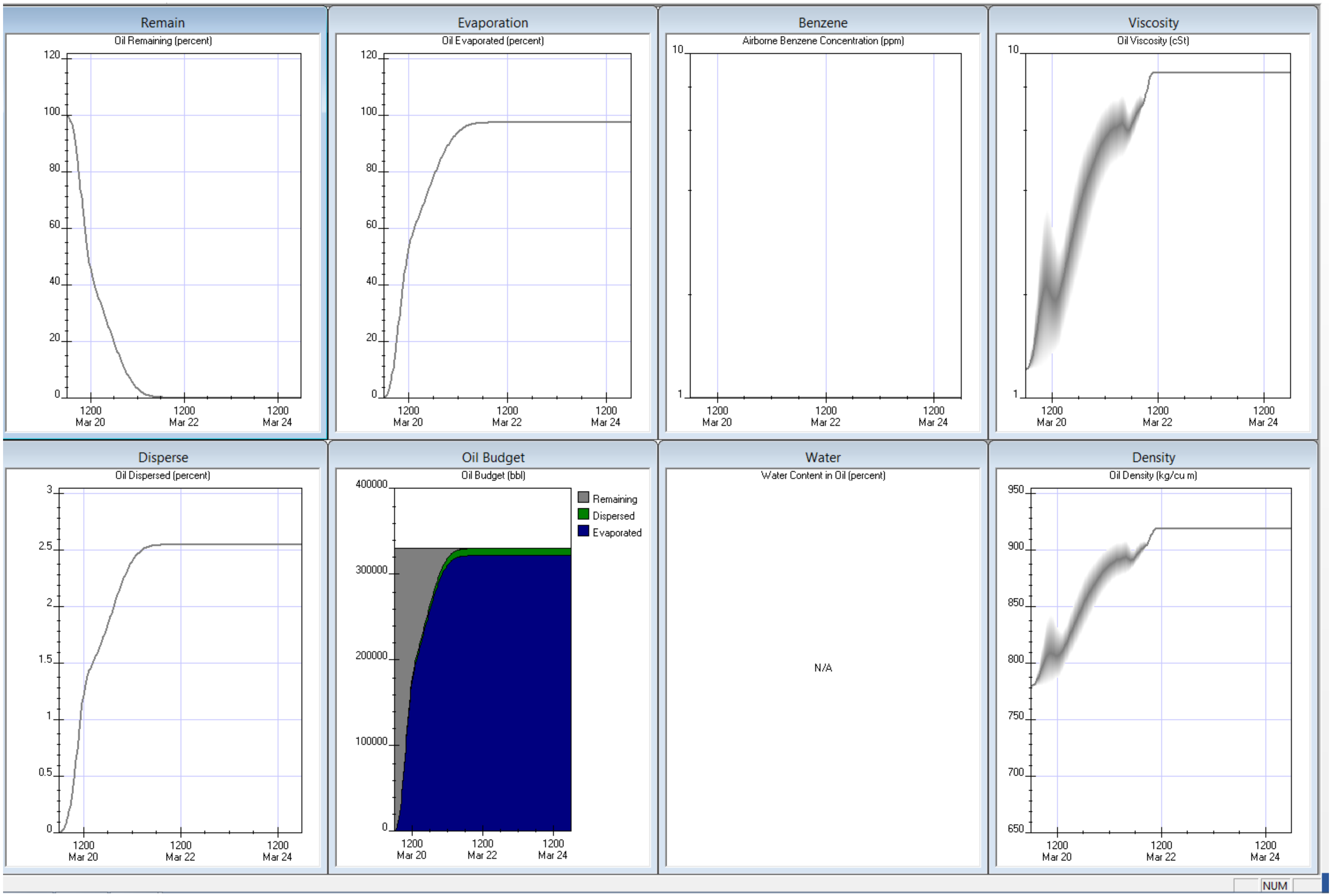

Figure D-18 (f): ADIOS 2.0 Model Output – 330,000 bbl Reformate (Backhaul) with 10 mph wind speed.

Oil Type

- MIXED XYLENES (custom oil)
- Location = Anacortes Washington
- Synonyms = Mixed Xylenes
- Product Type = refined
- API = --
- Pour Point = -18 deg C
- Flash Point = 28 deg C
- Density = 0.794 g/cc at 50 deg F
- Viscosity = 0.9 cSt at 50 deg F
- Adhesion = 0.00g/m2
- Aromatics = 100 weight %

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 2 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 2.0 mph towards 180 degrees

Release Information

- **Instantaneous Release**
  - Time of Release = March 17, 0000 hours
  - Amount Spilled = 330000 bbl

Figure D-19 (a): ADIOS 2.0 Model Input Parameters – 330,000 bbl Mixed Xylenes with 0 mph wind speed.

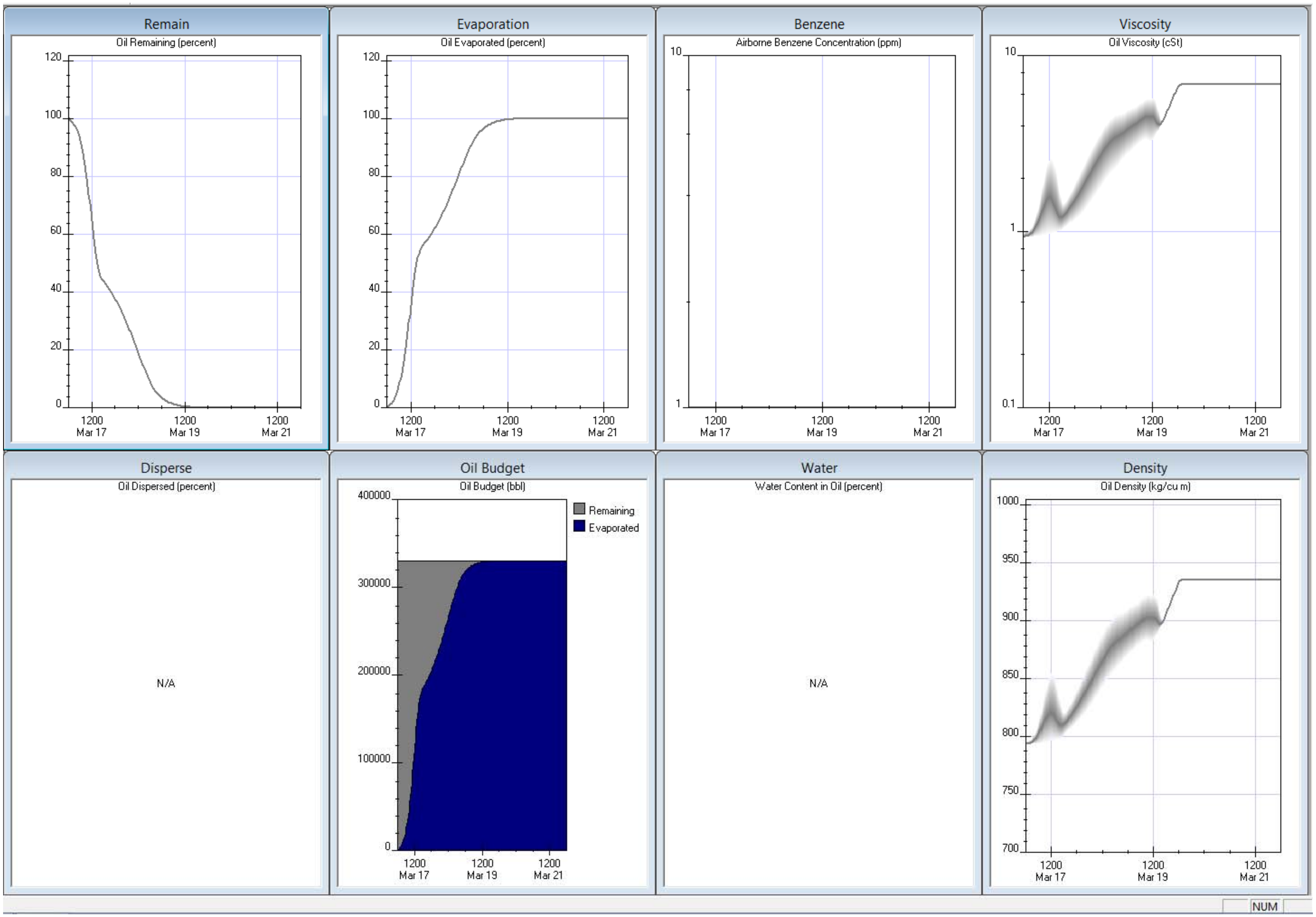

Figure D-19 (b): ADIOS 2.0 Model Output – 330,000 bbl Mixed Xylenes with 0 mph wind speed.

- **Oil Type**
  - MIXED XYLENES (custom oil)
  - Location = Anacortes Washington
  - Synonyms = Mixed Xylenes
  - Product Type = refined
  - API = --
  - Pour Point = -18 deg C
  - Flash Point = 28 deg C
  - Density = 0.794 g/cc at 50 deg F
  - Viscosity = 0.9 cSt at 50 deg F
  - Adhesion = 0.00g/m2
  - Aromatics = 100 weight %
- **Emulsification**
  - Mousse begins to form when 100% of the oil has evaporated.
- **Wind and Wave Conditions**
  - Wind Speed = 5 mph from 0 degrees
  - Wave Height = computed from wind speed, unlimited fetch (default)
- **Water Properties**
  - Temperature = 50 deg F
  - Salinity = 32 ppt
  - Sediment Load = 5 g/m3 (ocean)
  - Current = 0 mph
- **Release Information**
  - **Instantaneous Release**
    - Time of Release = March 17, 0000 hours
    - Amount Spilled = 330000 bbl

Figure D-19 (c): ADIOS 2.0 Model Input Parameters – 330,000 bbl Mixed Xylenes with 5 mph wind speed.

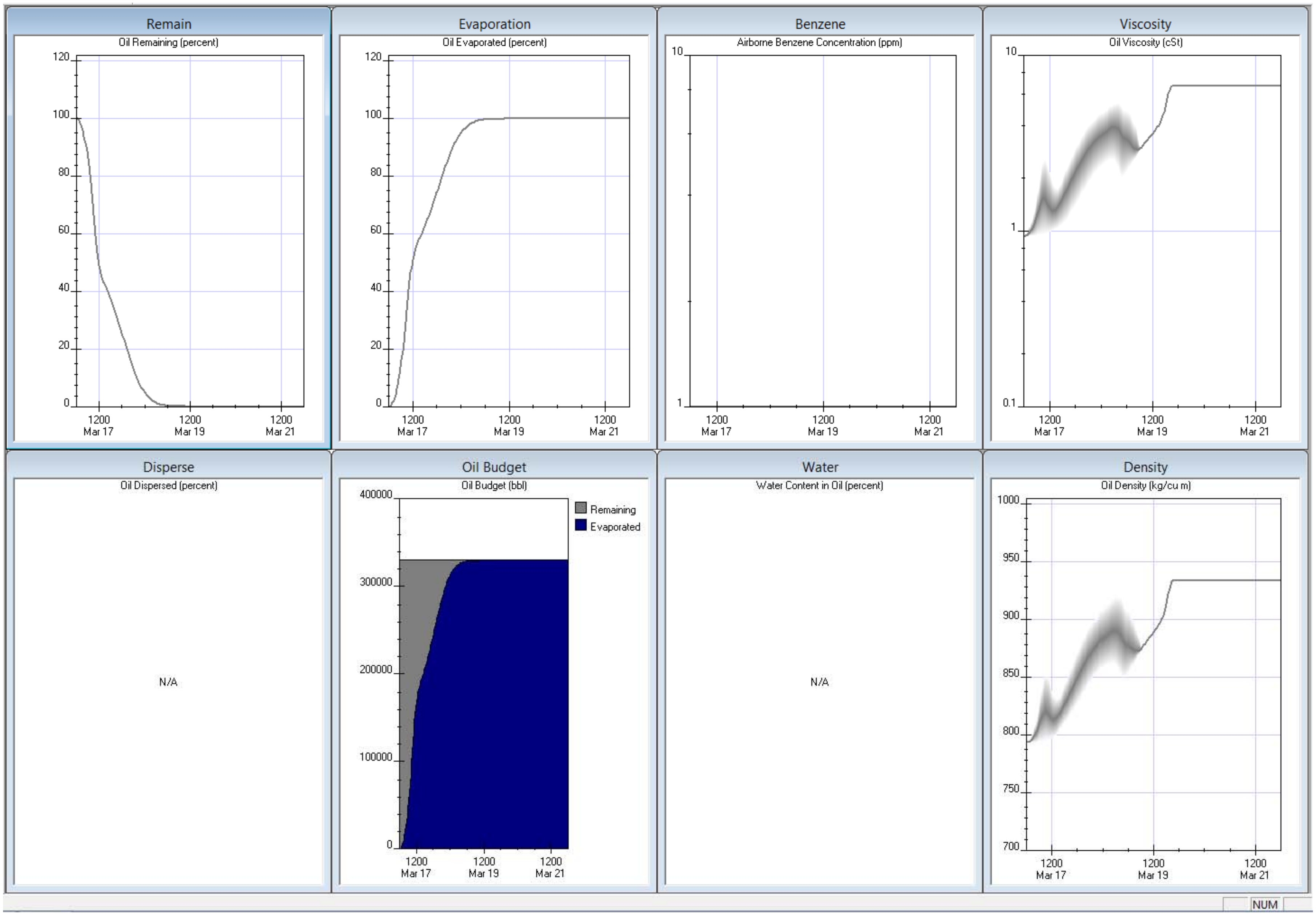

Figure D-19 (d): ADIOS 2.0 Model Output – 330,000 bbl Mixed Xylenes with 5 mph wind speed.

Oil Type

MIXED XYLENES (custom oil)
Location = Anacortes Washington
Synonyms = Mixed Xylenes
Product Type = refined
API = --
Pour Point = -18 deg C
Flash Point = 28 deg C
Density = 0.794 g/cc at 50 deg F
Viscosity = 0.9 cSt at 50 deg F
Adhesion = 0.00g/m2
Aromatics = 100 weight %

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 10 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 0 mph

Release Information

Instantaneous Release

Time of Release = March 20, 0000 hours
Amount Spilled = 330000 bbl

Figure D-19 (e): ADIOS 2.0 Model Input Parameters – 330,000 bbl Mixed Xylenes with 10 mph wind speed.

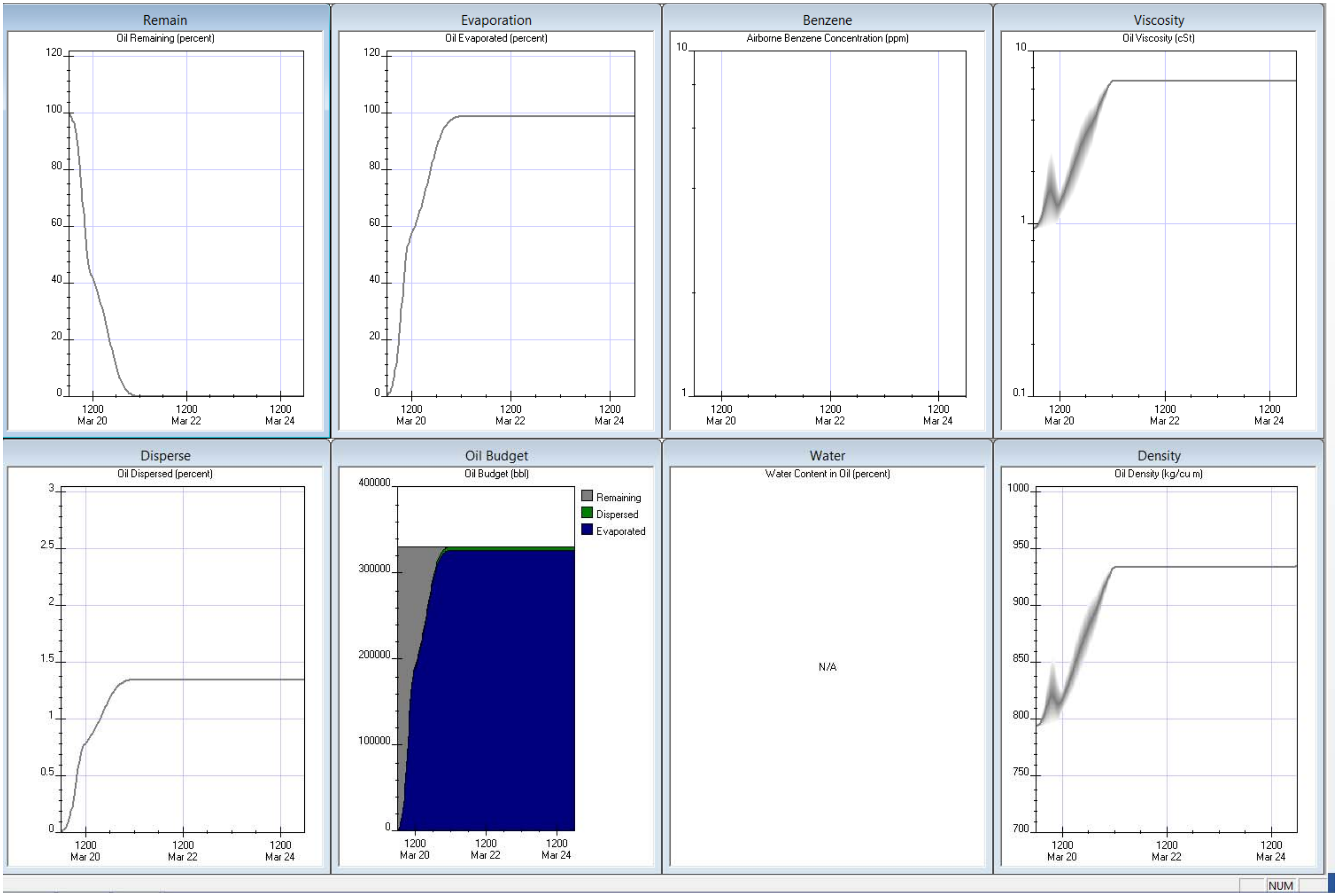

Figure D-19 (f): ADIOS 2.0 Model Output – 330,000 bbl Mixed Xylenes with 10 mph wind speed.

Oil Type

GASOLINE (UNLEADED), SHELL

Location = none listed

Synonyms = AUTOMOTIVE FUEL, PETROL

Product Type = refined

API = --

Pour Point = unknown

Flash Point = -30 deg C

Density = 0.753 g/cc at 50 deg F

Viscosity = 4.9 cSt at 50 deg F

Adhesion = unknown

Aromatics = unknown

WARNING! Benzene graph for this product may be unreliable.

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 2 mph from 0 degrees

Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F

Salinity = 32 ppt

Sediment Load = 5 g/m3 (ocean)

Current = 2.0 mph towards 180 degrees

Release Information

Instantaneous Release

Time of Release = March 17, 0000 hours

Amount Spilled = 330000 bbl

Figure D-20 (a): ADIOS 2.0 Model Input Parameters – 330,000 bbl Gasoline with 0 mph wind speed.

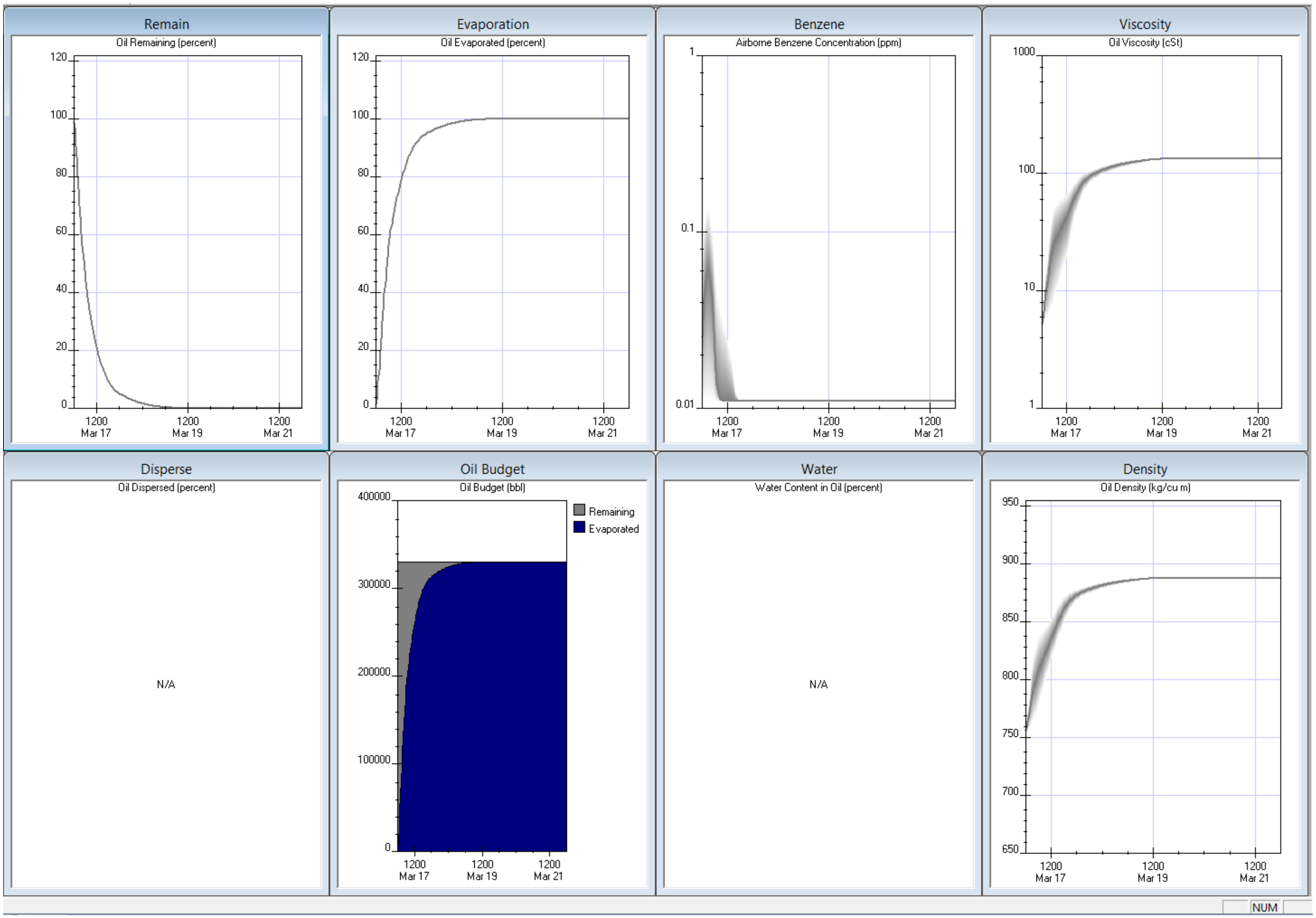

Figure D-20 (b): ADIOS 2.0 Model Output – 330,000 bbl Gasoline with 0 mph wind speed.

Oil Type

- GASOLINE (UNLEADED), SHELL
- Location = none listed
- Synonyms = AUTOMOTIVE FUEL, PETROL
- Product Type = refined
- API = --
- Pour Point = unknown
- Flash Point = -30 deg C
- Density = 0.753 g/cc at 50 deg F
- Viscosity = 4.9 cSt at 50 deg F
- Adhesion = unknown
- Aromatics = unknown
- WARNING! Benzene graph for this product may be unreliable.

Emulsification

- Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

- Wind Speed = 5 mph from 0 degrees
- Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

- Temperature = 50 deg F
- Salinity = 32 ppt
- Sediment Load = 5 g/m3 (ocean)
- Current = 0 mph

Release Information

- **Instantaneous Release**
  - Time of Release = March 17, 0000 hours
  - Amount Spilled = 330000 bbl

Figure D-20 (c): ADIOS 2.0 Model Input Parameters – 330,000 bbl Gasoline with 5 mph wind speed.

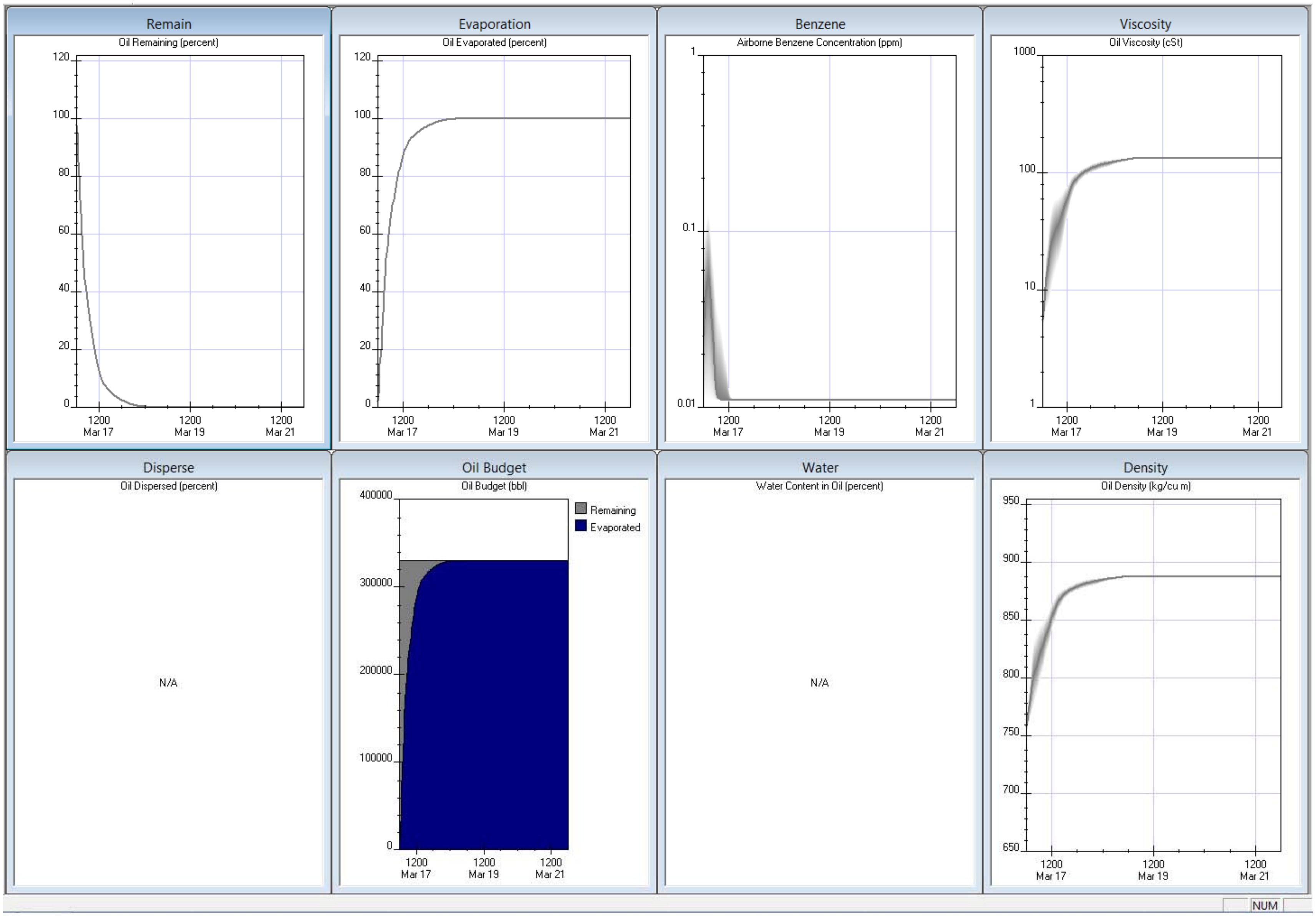

Figure D-20 (d): ADIOS 2.0 Model Output – 330,000 bbl Gasoline with 5 mph wind speed.

Oil Type

GASOLINE (UNLEADED), SHELL
Location = none listed
Synonyms = AUTOMOTIVE FUEL, PETROL
Product Type = refined
API = --
Pour Point = unknown
Flash Point = -30 deg C
Density = 0.753 g/cc at 50 deg F
Viscosity = 4.9 cSt at 50 deg F
Adhesion = unknown
Aromatics = unknown
WARNING! Benzene graph for this product may be unreliable.

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 7 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 0 mph

Release Information

Instantaneous Release

Time of Release = April 14, 0000 hours
Amount Spilled = 330000 bbl

Figure D-20 (e): ADIOS 2.0 Model Input Parameters – 330,000 bbl Gasoline with 7 mph wind speed.

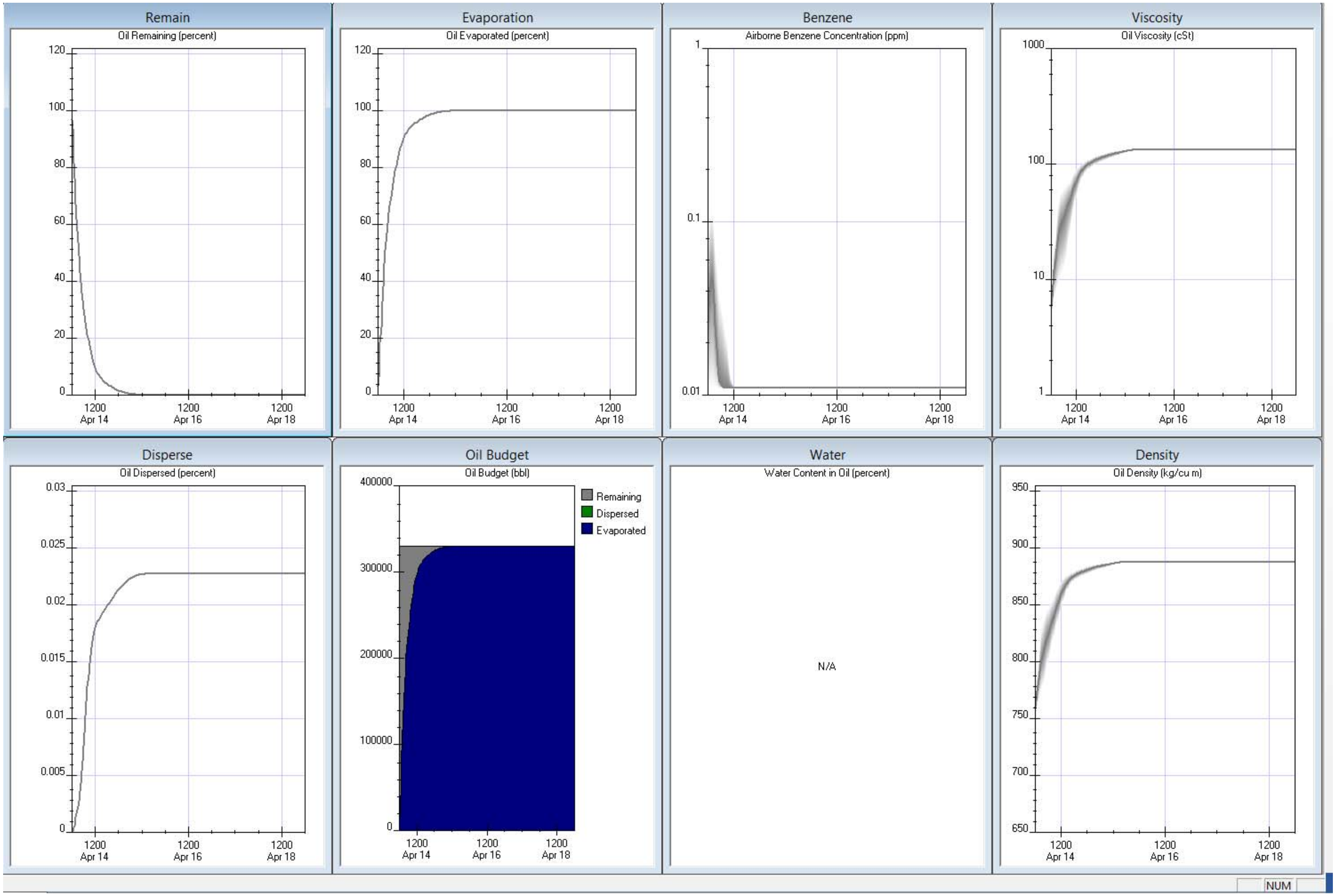

Figure D-20 (f): ADIOS 2.0 Model Output – 330,000 bbl Gasoline with 7 mph wind speed.

Oil Type

GASOLINE (UNLEADED), SHELL
Location = none listed
Synonyms = AUTOMOTIVE FUEL, PETROL
Product Type = refined
API = --
Pour Point = unknown
Flash Point = -30 deg C
Density = 0.753 g/cc at 50 deg F
Viscosity = 4.9 cSt at 50 deg F
Adhesion = unknown
Aromatics = unknown
WARNING! Benzene graph for this product may be unreliable.

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 8 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 0 mph

Release Information

Instantaneous Release

Time of Release = April 14, 0000 hours
Amount Spilled = 330000 bbl

Figure D-20 (g): ADIOS 2.0 Model Input Parameters – 330,000 bbl Gasoline with 8 mph wind speed.

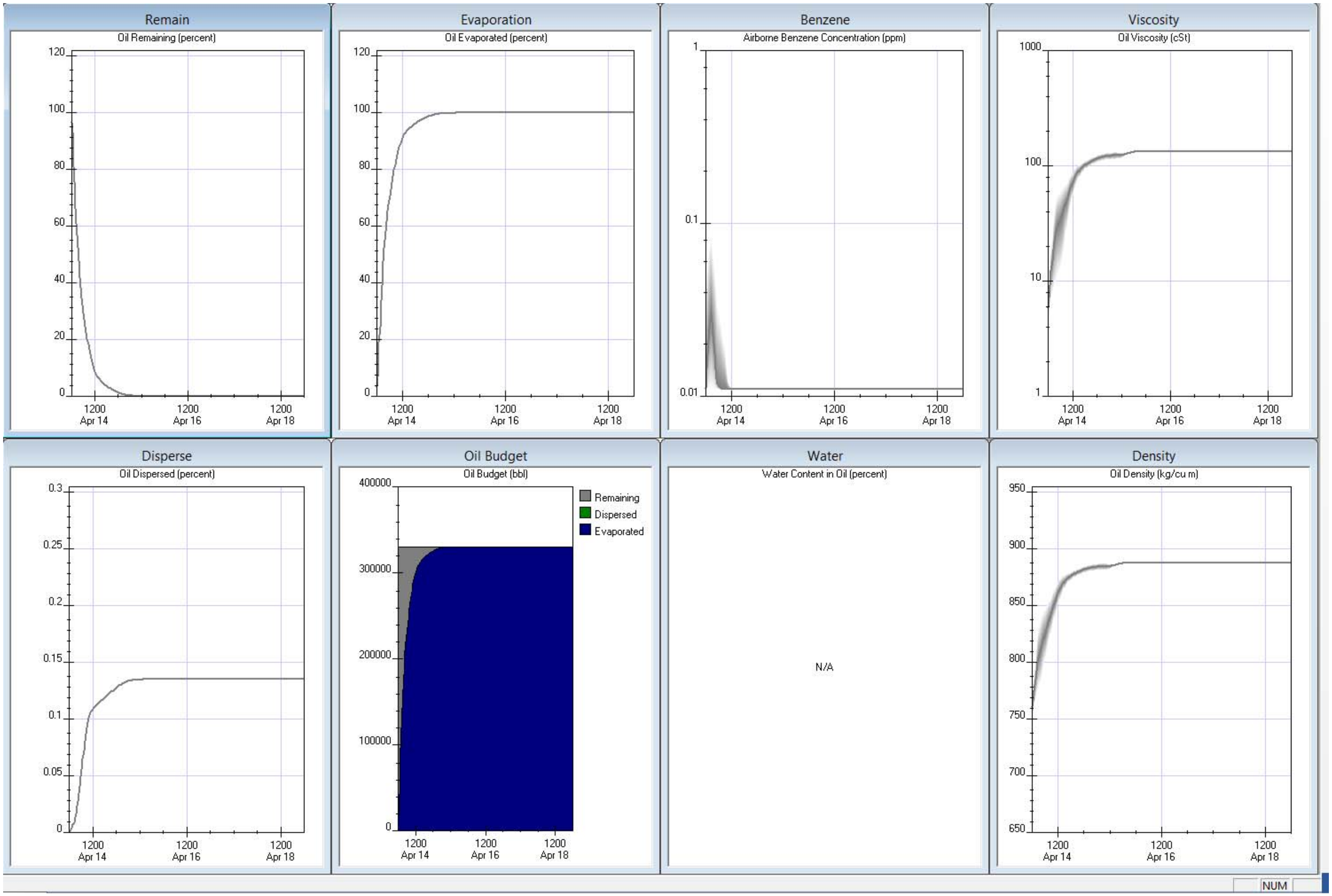

Figure D-20 (h): ADIOS 2.0 Model Output – 330,000 bbl Gasoline with 8 mph wind speed.

- **Oil Type**
  - GASOLINE (UNLEADED), SHELL
  - Location = none listed
  - Synonyms = AUTOMOTIVE FUEL, PETROL
  - Product Type = refined
  - API = --
  - Pour Point = unknown
  - Flash Point = -30 deg C
  - Density = 0.753 g/cc at 50 deg F
  - Viscosity = 4.9 cSt at 50 deg F
  - Adhesion = unknown
  - Aromatics = unknown
  - WARNING! Benzene graph for this product may be unreliable.
- **Emulsification**
  - Mousse begins to form when 100% of the oil has evaporated.
- **Wind and Wave Conditions**
  - Wind Speed = 10 mph from 0 degrees
  - Wave Height = computed from wind speed, unlimited fetch (default)
- **Water Properties**
  - Temperature = 50 deg F
  - Salinity = 32 ppt
  - Sediment Load = 5 g/m3 (ocean)
  - Current = 0 mph
- **Release Information**
  - **Instantaneous Release**
    - Time of Release = March 20, 0000 hours
    - Amount Spilled = 330000 bbl

Figure D-20 (i): ADIOS 2.0 Model Input Parameters – 330,000 bbl Gasoline with 10 mph wind speed.

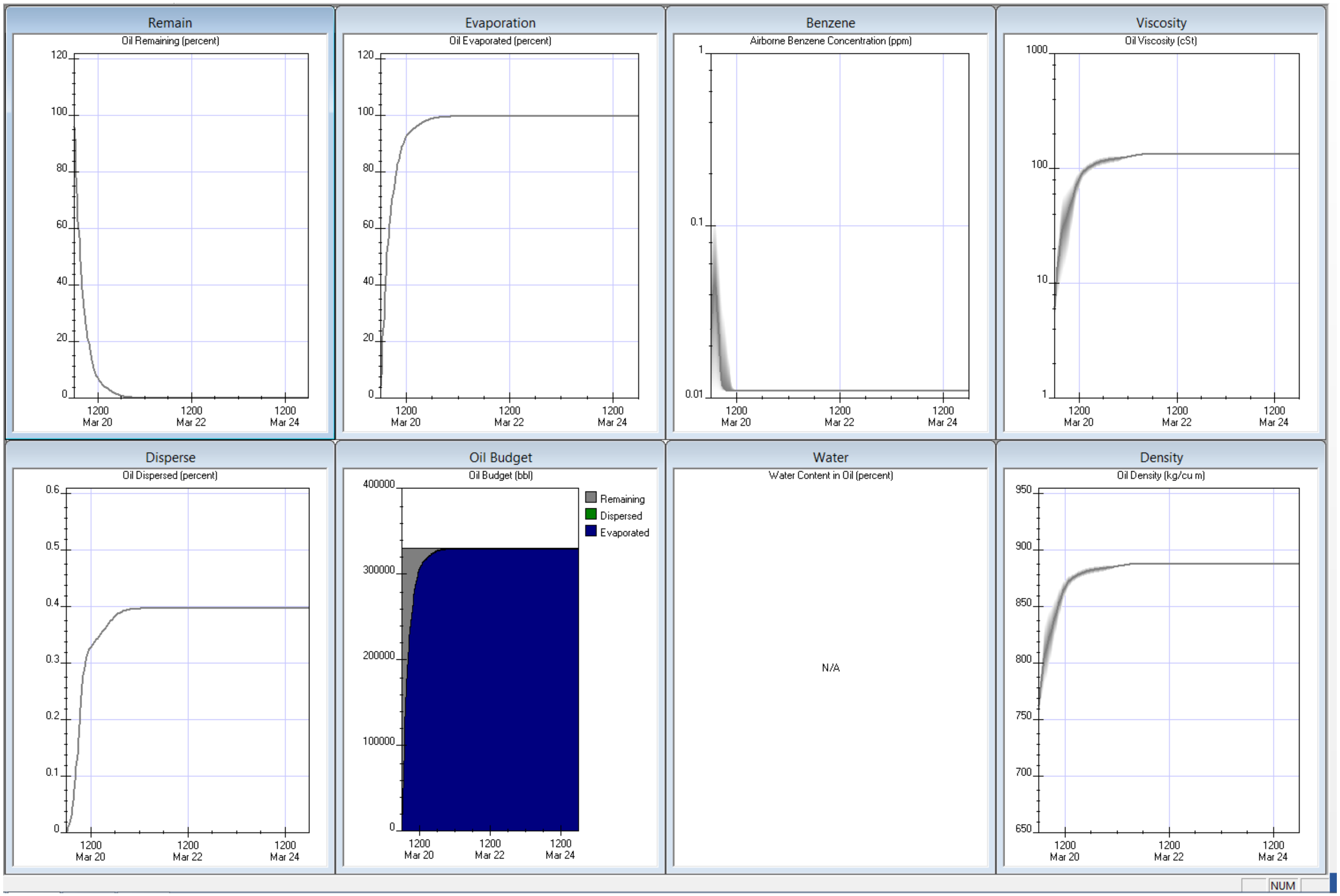

Figure D-20 (j): ADIOS 2.0 Model Output – 330,000 bbl Gasoline with 10 mph wind speed.

⊟ **Oil Type**

GASOLINE (UNLEADED), SHELL

Location = none listed

Synonyms = AUTOMOTIVE FUEL, PETROL

Product Type = refined

API = --

Pour Point = unknown

Flash Point = -30 deg C

Density = 0.753 g/cc at 50 deg F

Viscosity = 4.9 cSt at 50 deg F

Adhesion = unknown

Aromatics = unknown

WARNING! Benzene graph for this product may be unreliable.

⊟ **Emulsification**

Mousse begins to form when 100% of the oil has evaporated.

⊟ **Wind and Wave Conditions**

Wind Speed = 12 mph from 0 degrees

Wave Height = computed from wind speed, unlimited fetch (default)

⊟ **Water Properties**

Temperature = 50 deg F

Salinity = 32 ppt

Sediment Load = 5 g/m3 (ocean)

Current = 0 mph

⊟ **Release Information**

⊟ **Instantaneous Release**

Time of Release = April 14, 0000 hours

Amount Spilled = 330000 bbl

Figure D-20 (k): ADIOS 2.0 Model Input Parameters – 330,000 bbl Gasoline with 12 mph wind speed.

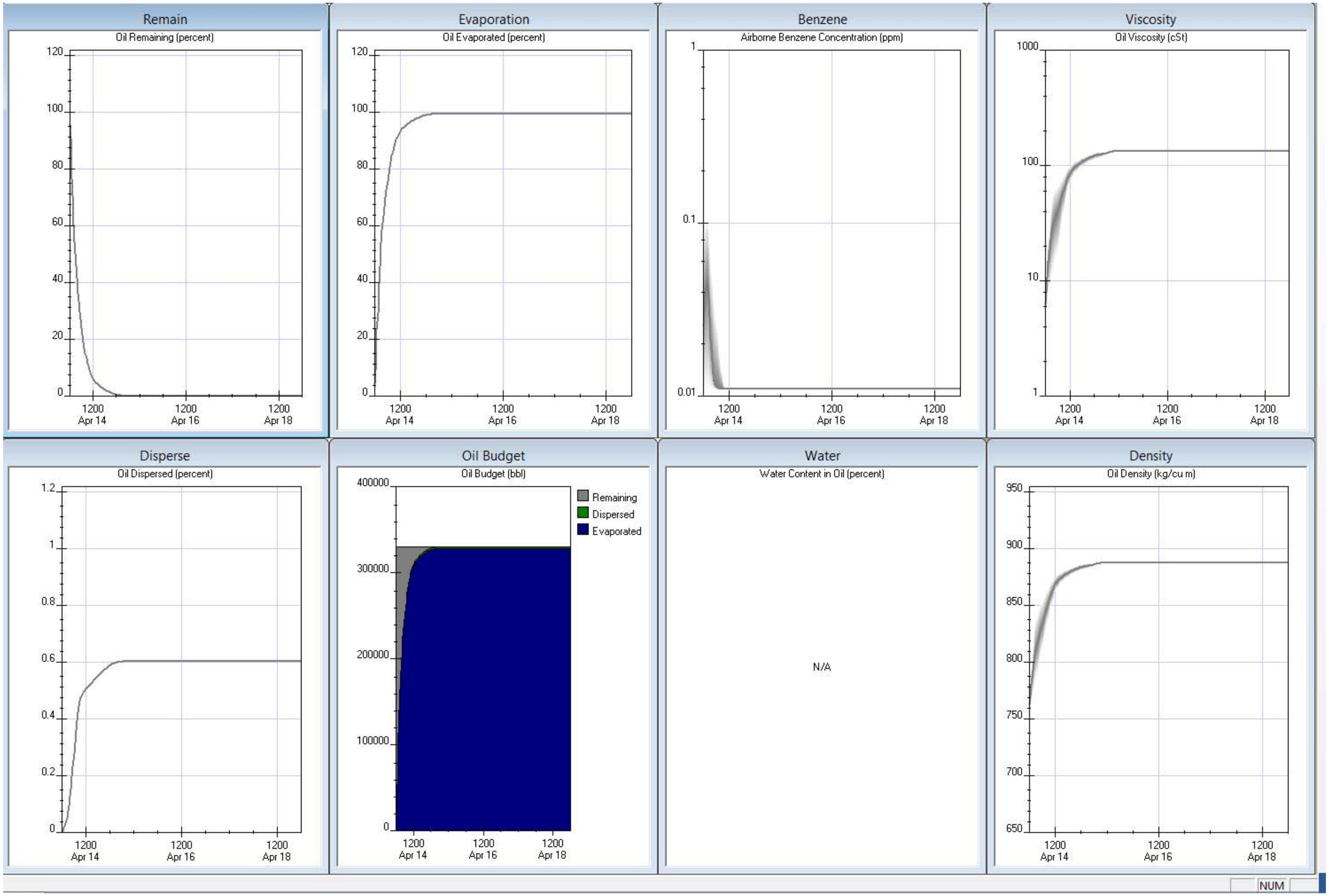

Figure D-20 (l): ADIOS 2.0 Model Output – 330,000 bbl Gasoline with 12 mph wind speed.

Oil Type

GASOLINE (UNLEADED), SHELL
Location = none listed
Synonyms = AUTOMOTIVE FUEL, PETROL
Product Type = refined
API = --
Pour Point = unknown
Flash Point = -30 deg C
Density = 0.753 g/cc at 50 deg F
Viscosity = 4.9 cSt at 50 deg F
Adhesion = unknown
Aromatics = unknown
WARNING! Benzene graph for this product may be unreliable.

Emulsification

Mousse begins to form when 100% of the oil has evaporated.

Wind and Wave Conditions

Wind Speed = 14 mph from 0 degrees
Wave Height = computed from wind speed, unlimited fetch (default)

Water Properties

Temperature = 50 deg F
Salinity = 32 ppt
Sediment Load = 5 g/m3 (ocean)
Current = 0 mph

Release Information

Instantaneous Release

Time of Release = April 14, 0000 hours
Amount Spilled = 330000 bbl

Figure D-20 (m): ADIOS 2.0 Model Input Parameters – 330,000 bbl Gasoline with 14 mph wind speed.

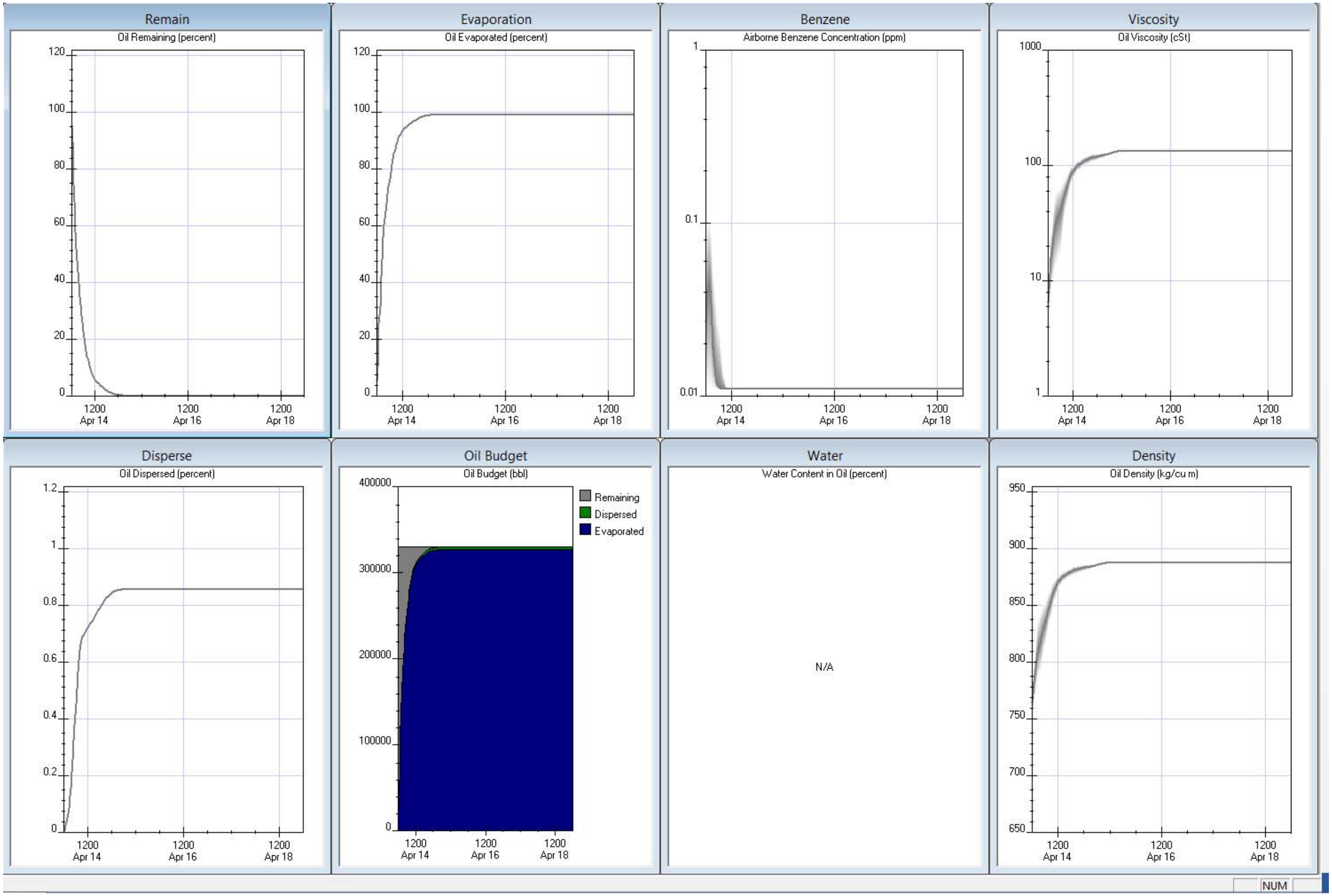

Figure D-20 (n): ADIOS 2.0 Model Output – 330,000 bbl Gasoline with 14 mph wind speed.

Appendix E. ADIOS Modeling Comparison of Other Fuels

The following appendix includes ADIOS 2.0 Modeling of Evaporation Rates for various spill scenarios including reformate, reformate (backhaul), mixed xylenes, gasoline, jet fuel, and diesel fuel at a Salish Sea spill scenario volume of 330,000 bbl. Each of the 6 streams was modeled for 2 wind speed (0 mph; 10 mph).

Table E-1 provides a list of figures that illustrate the spill volume scenario.

Table E-1. List of Figures - Evaporation and Dispersion Rates

Figure #	Stream	Wind Speed Mph	Location	Volume bbl
Figure E-1	All	0	Salish Sea	330,000
Figure E-2	All	10		
Figure E-3	Reformate	0;10		
Figure E-4	Reformate (backhaul)	0;10		
Figure E-5	Mixed Xylenes	0;10		
Figure E-6	Gasoline	0;10		
Figure E-7	Jet Fuel	0;10		
Figure E-8	Diesel	0;10		

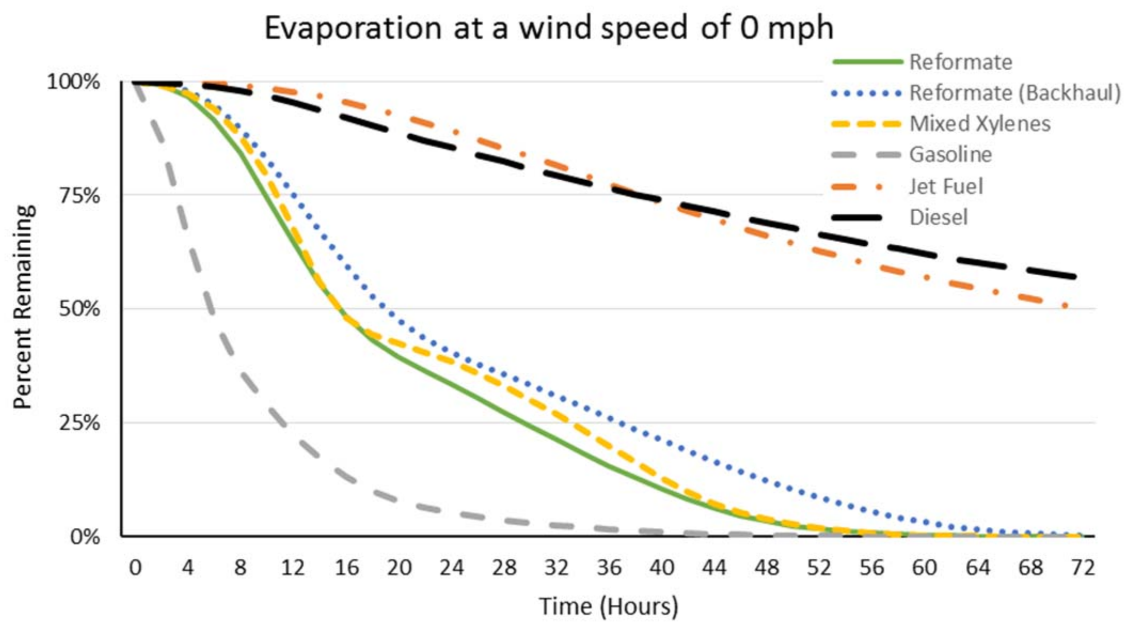

Figure E-1: Predicted evaporation rates (ADIOS 2.0)
Comparison of 6 materials; 330,000 bbl; wind speed @ 0 mph.

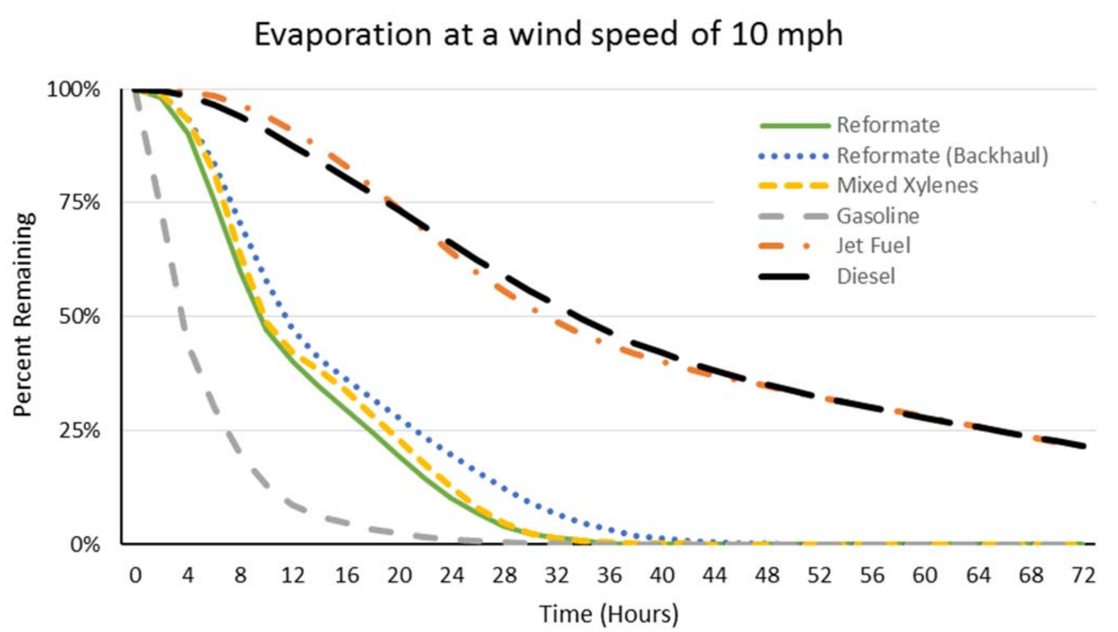

Figure E-2: Predicted evaporation rates (ADIOS 2.0)
Comparison of 6 materials; 330,000 bbl; wind speed @ 10 mph.

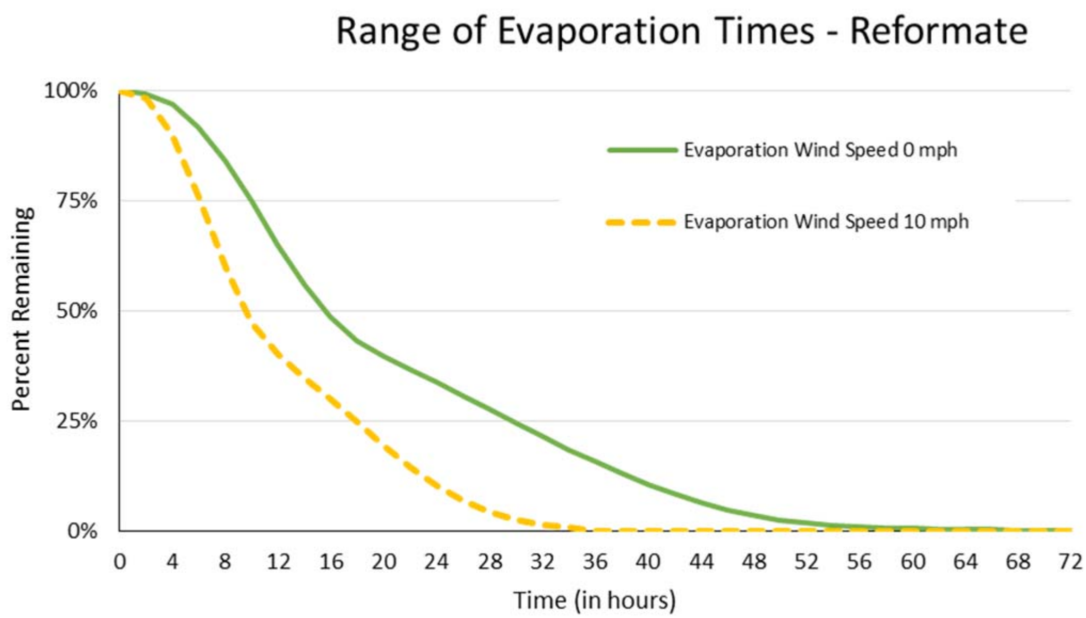

Figure E-3: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Reformate; 330,000 bbl; wind speed @ 0 and 10 mph.

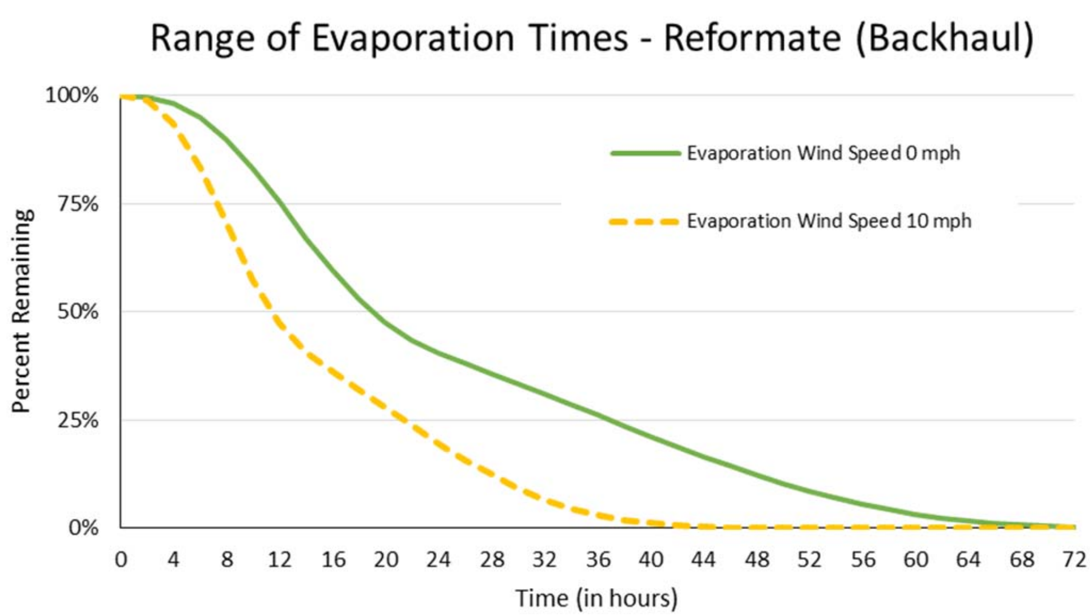

Figure E-4: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Reformate (backhaul); 330,000 bbl; wind speed @ 0 and 10 mph.

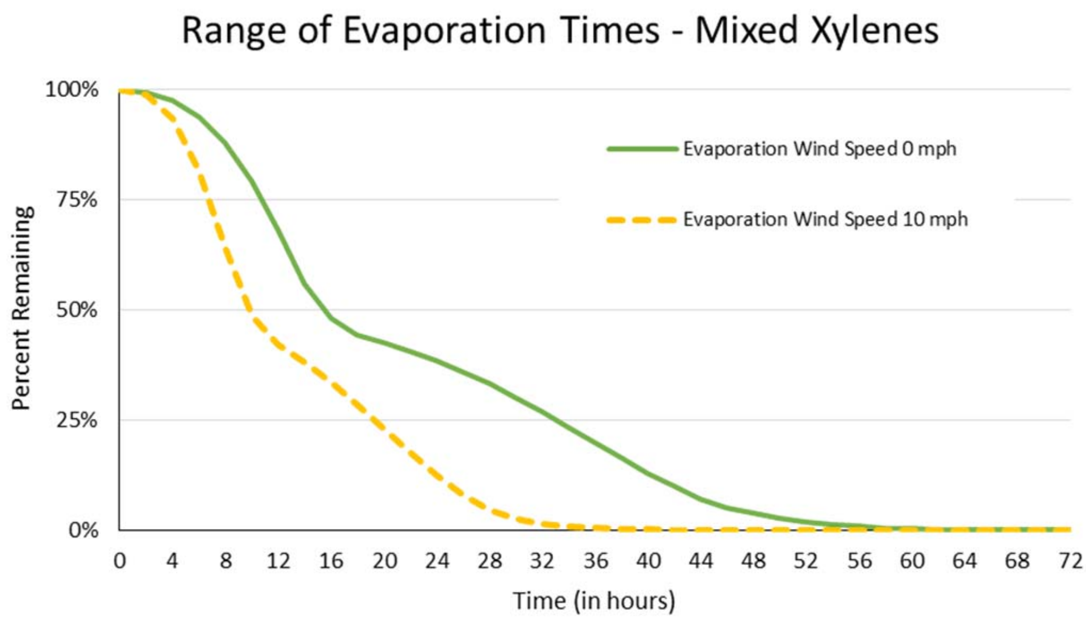

Figure E-5: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Mixed Xylenes; 330,000 bbl; wind speed @ 0 and 10 mph.

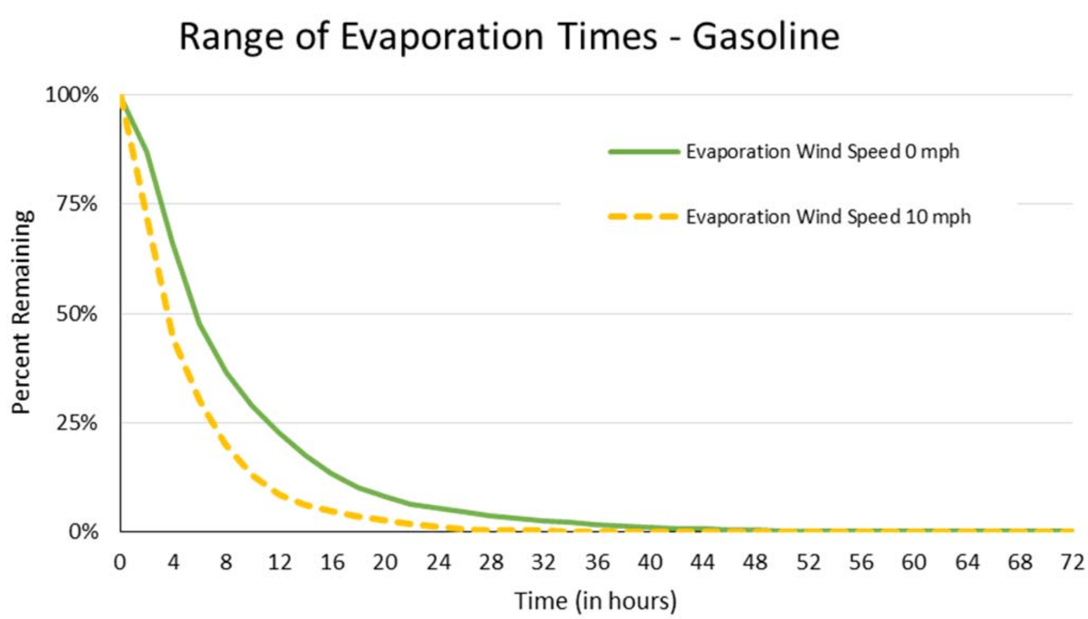

Figure E-6: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Gasoline; 330,000 bbl; wind speed @ 0 and10 mph.

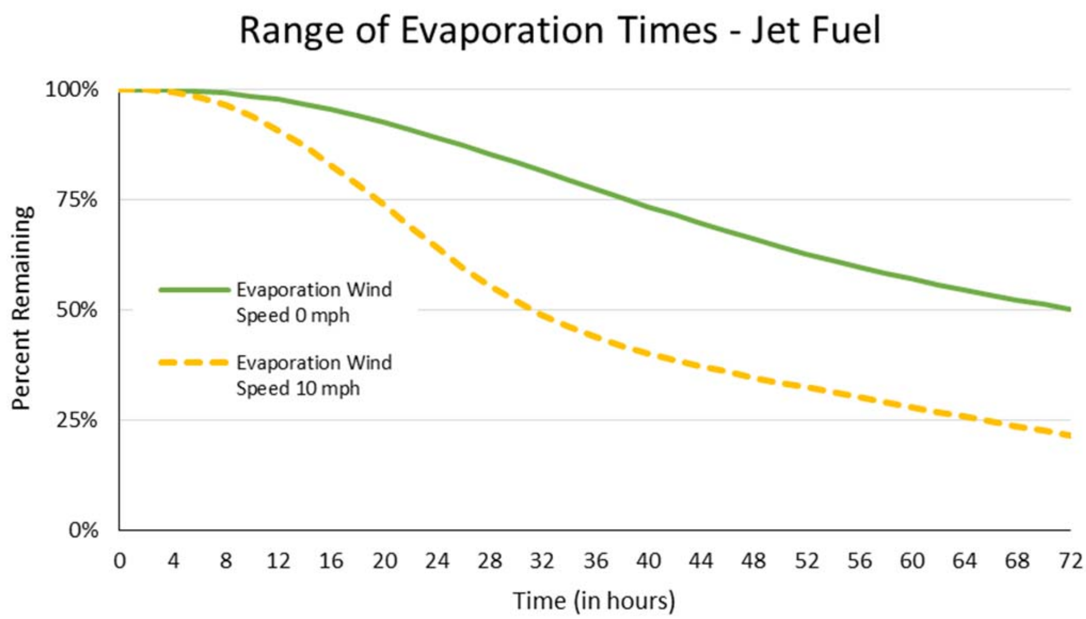

Figure E-7: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Jet Fuel; 330,000 bbl; wind speed @ 0 and 10 mph.

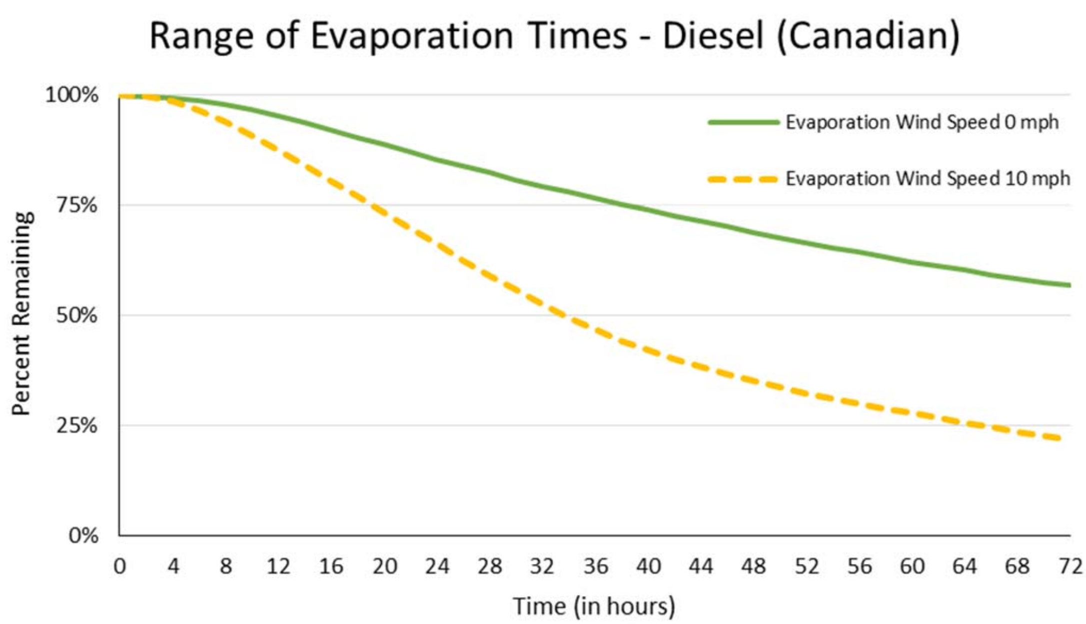

Figure E-8: Predicted evaporation rates (ADIOS 2.0)
Spill Scenario: Gasoline; 330,000 bbl; wind speed @ 0 and 10 mph.

Appendix G – GNOME Modeling Results

The following appendix includes GNOME modeling of spill scenario trajectories using gasoline at four (4) different geographic locations. Spill scenario parameters took into account two (2) seasons (winter; summer) to capture the variability of wind speeds and direction for each geographic location and two (2) different tidal conditions (spring; neap) to represent the monthly tide variability. The progression of each GNOME model was captured every six hours (0; 6; 12; 18; 24; 30; 36; 48 hours) ending at 48 hours.

Table G-1 provides a list of subsequent tables for the four (4) scenario locations. Table G-2 provides a list of figures for the Tesoro Dockside scenarios. Table G-3 provides a list of figures for the W of Neah Bay (STR-A) scenarios. Table G-4 provides a list of figures for NE of Port Angeles (STR-H). Table G-5 provides a list of figures for near Rosario Strait (SJI-O).

Table G-1. List of Tables for Gasoline Trajectory Scenario Locations

GNOME Modeling of Gasoline Individual Runs (Input/Output) Results

Table #	Location
Table G-2	Dockside (Tesoro)
Table G-4	W of Neah Bay (STR-A)
Table G-5	NE of Port Angeles (STR-H)
Table G-6	Rosario Strait (SJI-O)

Table G-2. List of Figures for Dockside Scenario at the Tesoro Dock
GNOME Modeling of Gasoline Trajectories Individual Run Results

Figure #	Season	Tidal Influence	Wind Speed (mph) /Wind Direction	Volume bbl	Date/Time	Hour into model run
Figure G-1 (a)	Winter	Spring	9.2/SE	5045	06-Feb-16 12:00	0
Figure G-1 (b)					06-Feb-16 18:00	6
Figure G-1 (c)					07-Feb-16 00:00	12
Figure G-1 (d)					07-Feb-16 06:00	18
Figure G-1 (e)					07-Feb-16 12:00	24
Figure G-1 (f)					07-Feb-16 18:00	30
Figure G-1 (g)					08-Feb-16 00:00	36
Figure G-1 (h)					08-Feb-16 06:00	42
Figure G-1 (i)					08-Feb-16 12:00	48
Figure G-2 (a)	Winter	Neap	9.2/SE	5045	25-Feb-16 12:00	0
Figure G-2 (b)					25-Feb-16 18:00	6
Figure G-2 (c)					26-Feb-16 00:00	12
Figure G-2 (d)					26-Feb-16 06:00	18
Figure G-2 (e)					26-Feb-16 12:00	24
Figure G-2 (f)					26-Feb-16 18:00	30
Figure G-2 (g)					27-Feb-16 00:00	36
Figure G-2 (h)					27-Feb-16 06:00	42
Figure G-2 (i)					27-Feb-16 12:00	48
Figure G-3 (a)	Summer	Spring	7.5/SSW	5045	04-Jul-16 12:00	0
Figure G-3 (b)					04-Jul -16 18:00	6
Figure G-3 (c)					05-Jul -16 00:00	12
Figure G-3 (d)					05-Jul -16 06:00	18
Figure G-3 (e)					05-Jul -16 12:00	24
Figure G-3 (f)					05-Jul -16 18:00	30
Figure G-3 (g)					06-Jul -16 00:00	36
Figure G-3 (h)					06-Jul -16 06:00	42
Figure G-3 (i)					06-Jul -16 12:00	48
Figure G-4 (a)	Summer	Neap	7.5/SSW	5045	25-Jul-16 12:00	0
Figure G-4 (b)					25-Jul -16 18:00	6
Figure G-4 (c)					26-Jul -16 00:00	12
Figure G-4 (d)					26-Jul -16 06:00	18
Figure G-4 (e)					26-Jul -16 12:00	24
Figure G-4 (f)					26-Jul -16 18:00	30
Figure G-4 (g)					27-Jul -16 00:00	36
Figure G-4 (h)					27-Jul -16 06:00	42
Figure G-4 (i)					27-Jul -16 12:00	48

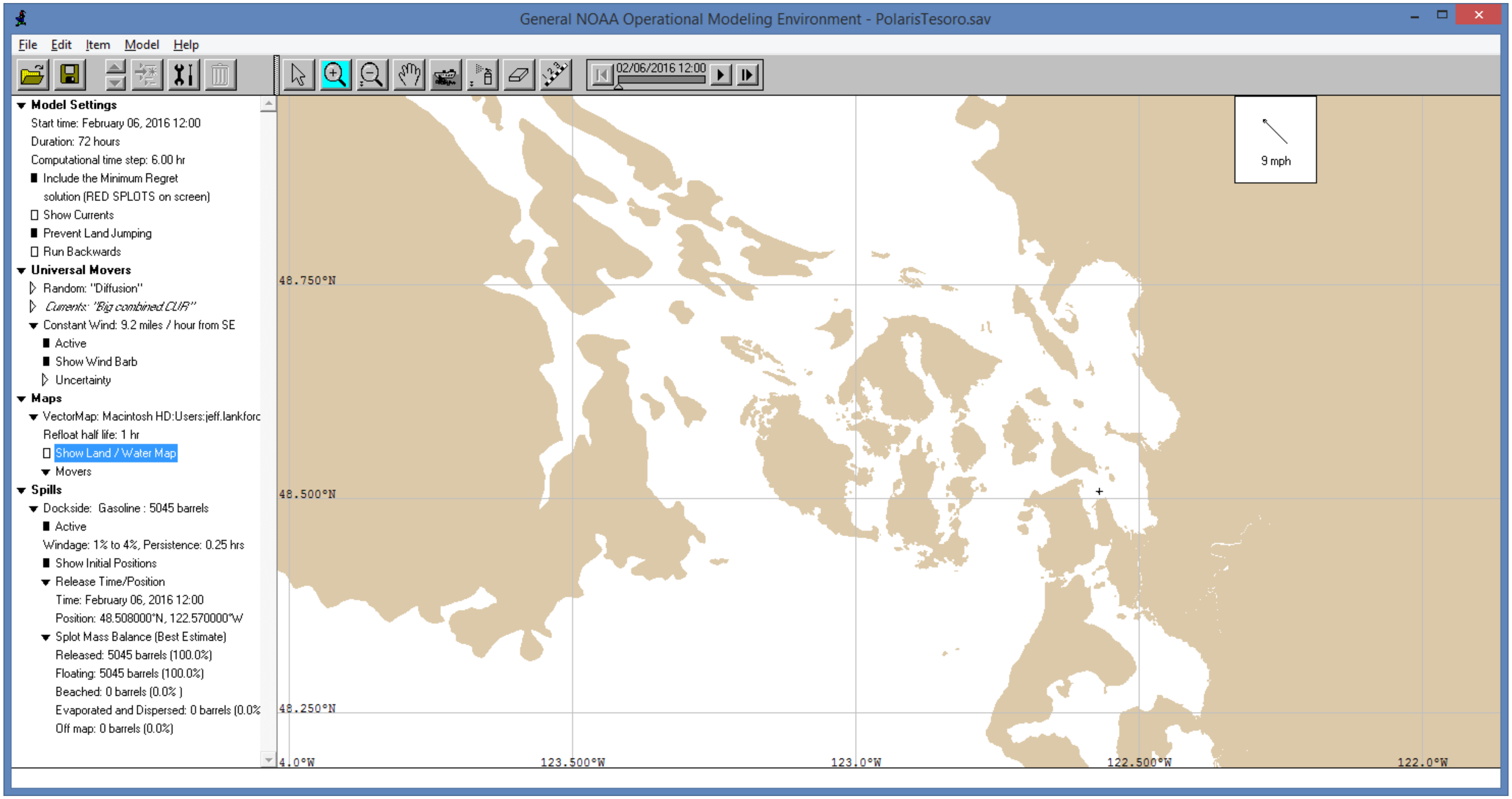

Figure G-1 (a). GNOME Model Output, Dockside, 5045 bbls, winter @ spring tide scenario: Hour 0.

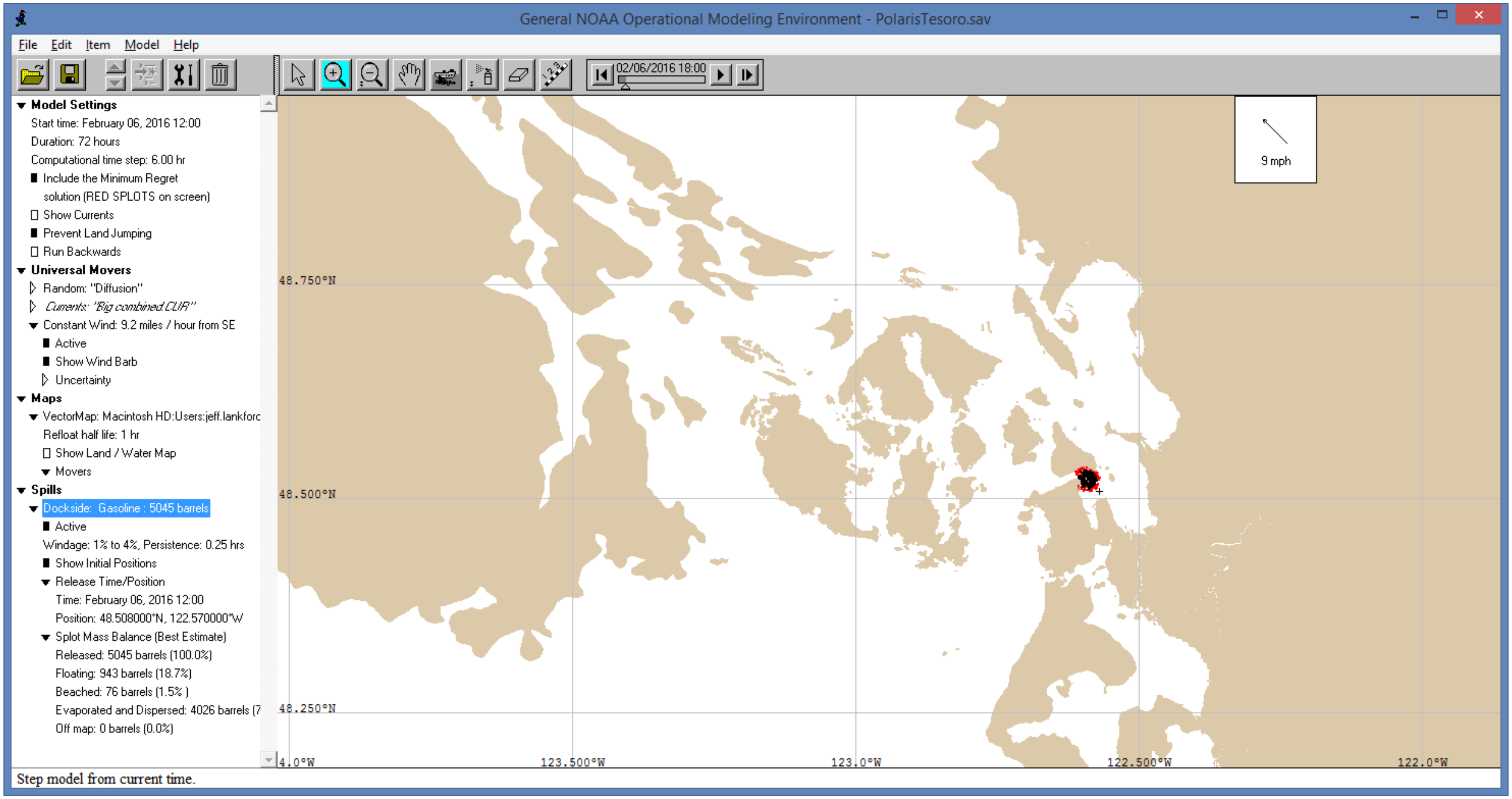

Figure G-1 (b). GNOME Model Output, Dockside, 5045 bbls, winter @ spring tide scenario: Hour 6.

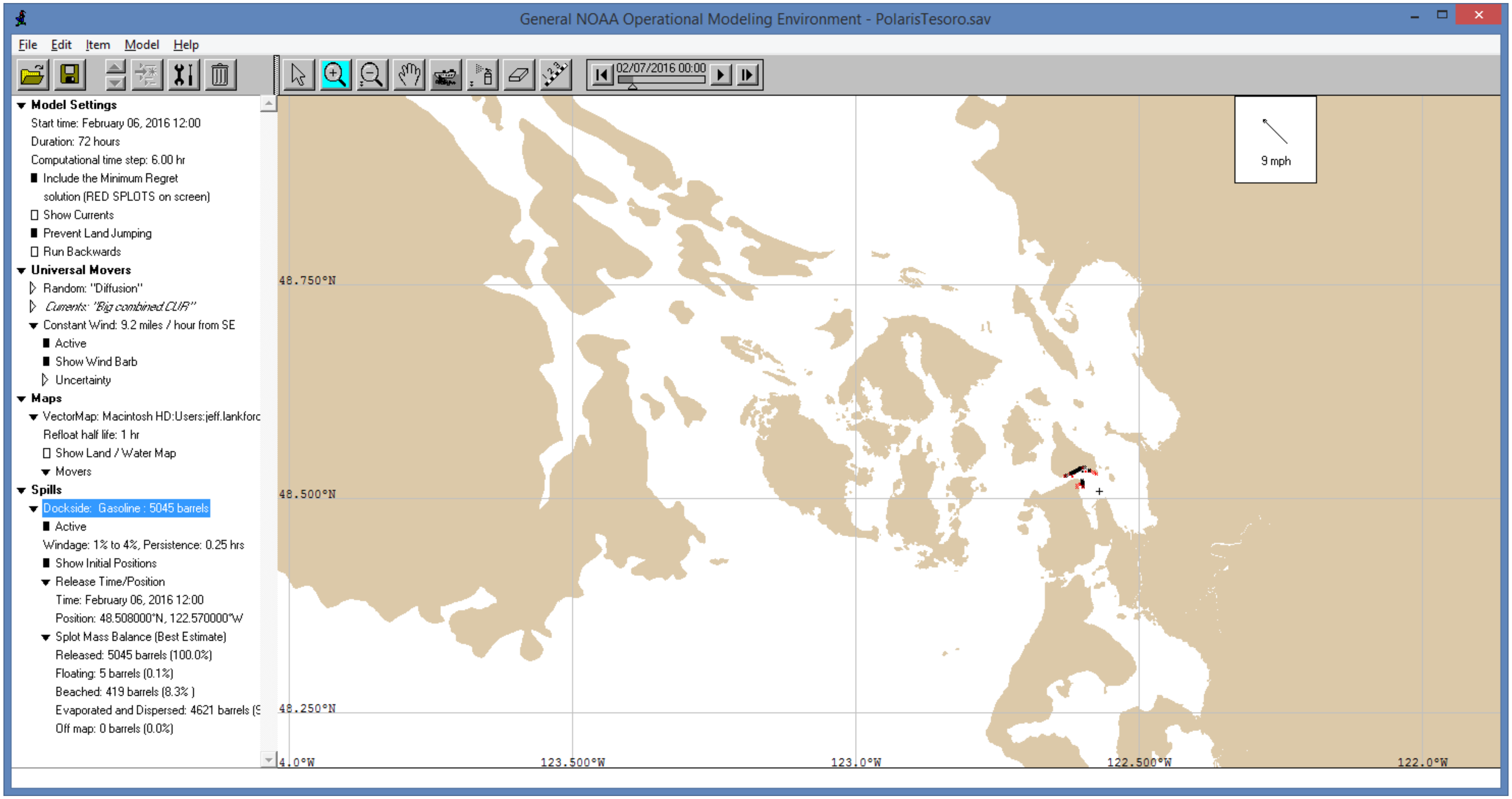

Figure G-1 (c). GNOME Model Output, Dockside, 5045 bbls, winter @ spring tide scenario: Hour 12.

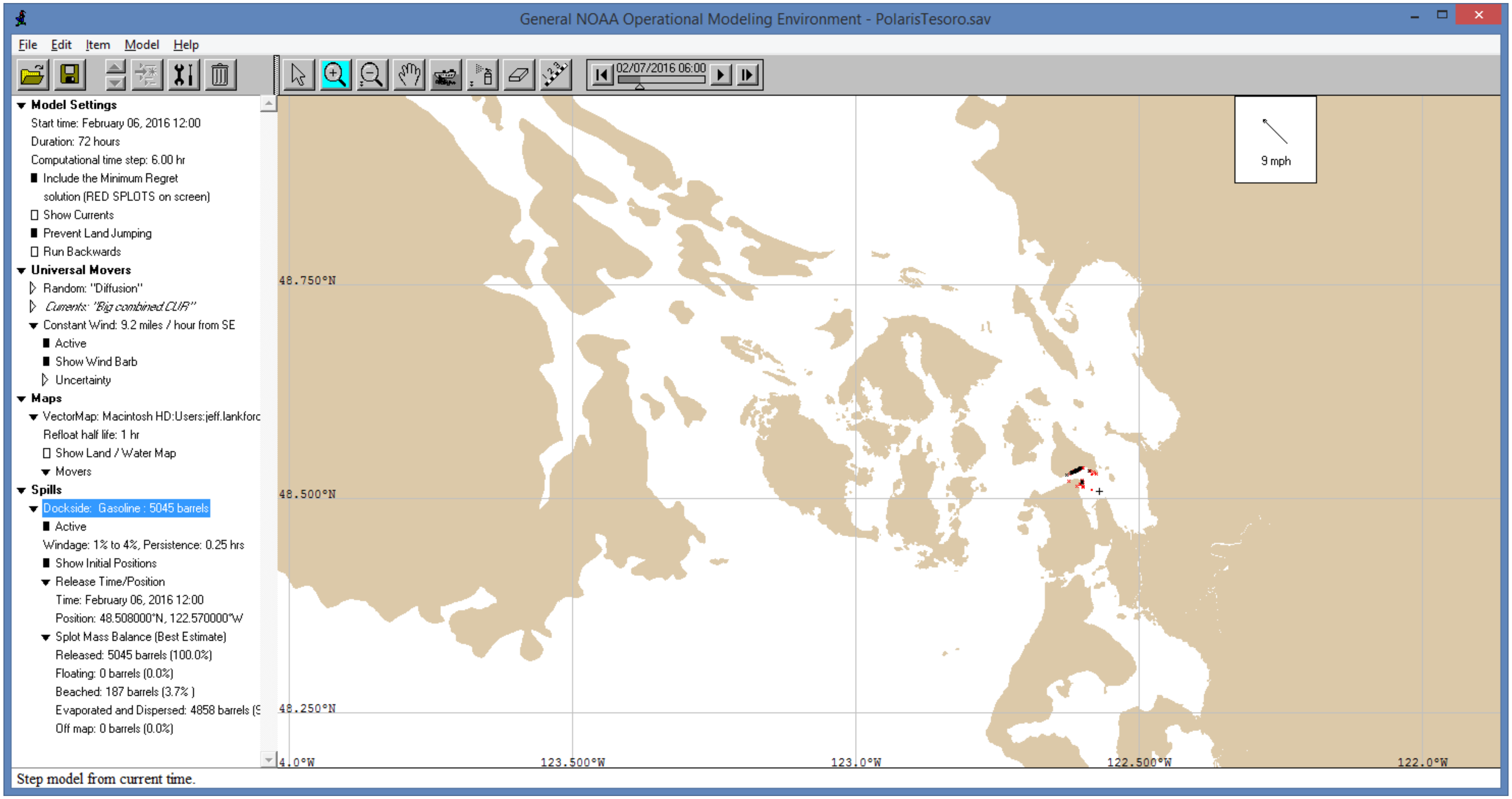

Figure G-1 (d). GNOME Model Output, Dockside, 5045 bbls, winter @ spring tide scenario: Hour 18.

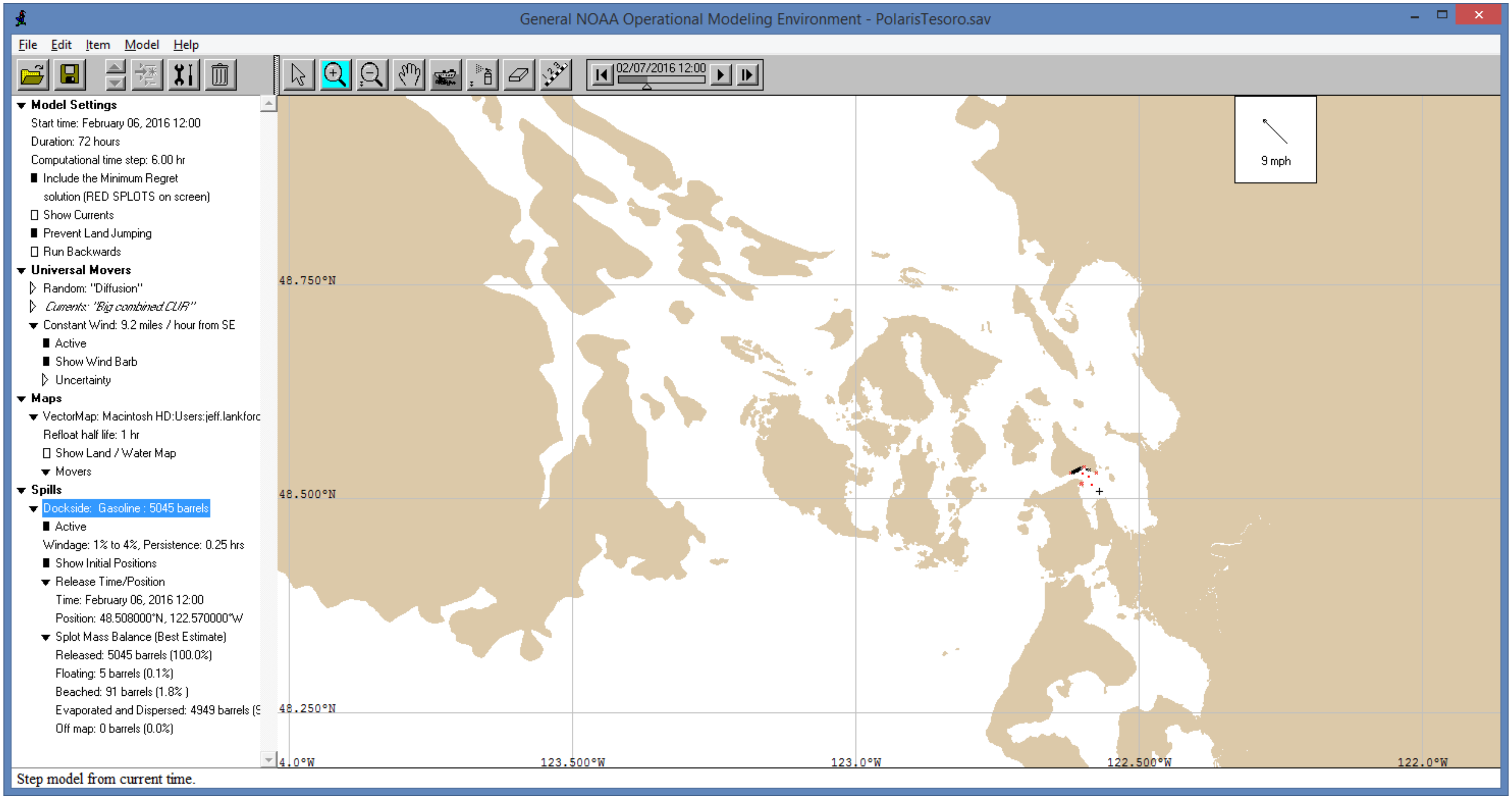

Figure G-1 (e). GNOME Model Output, Dockside, 5045 bbls, winter @ spring tide scenario: Hour 24.

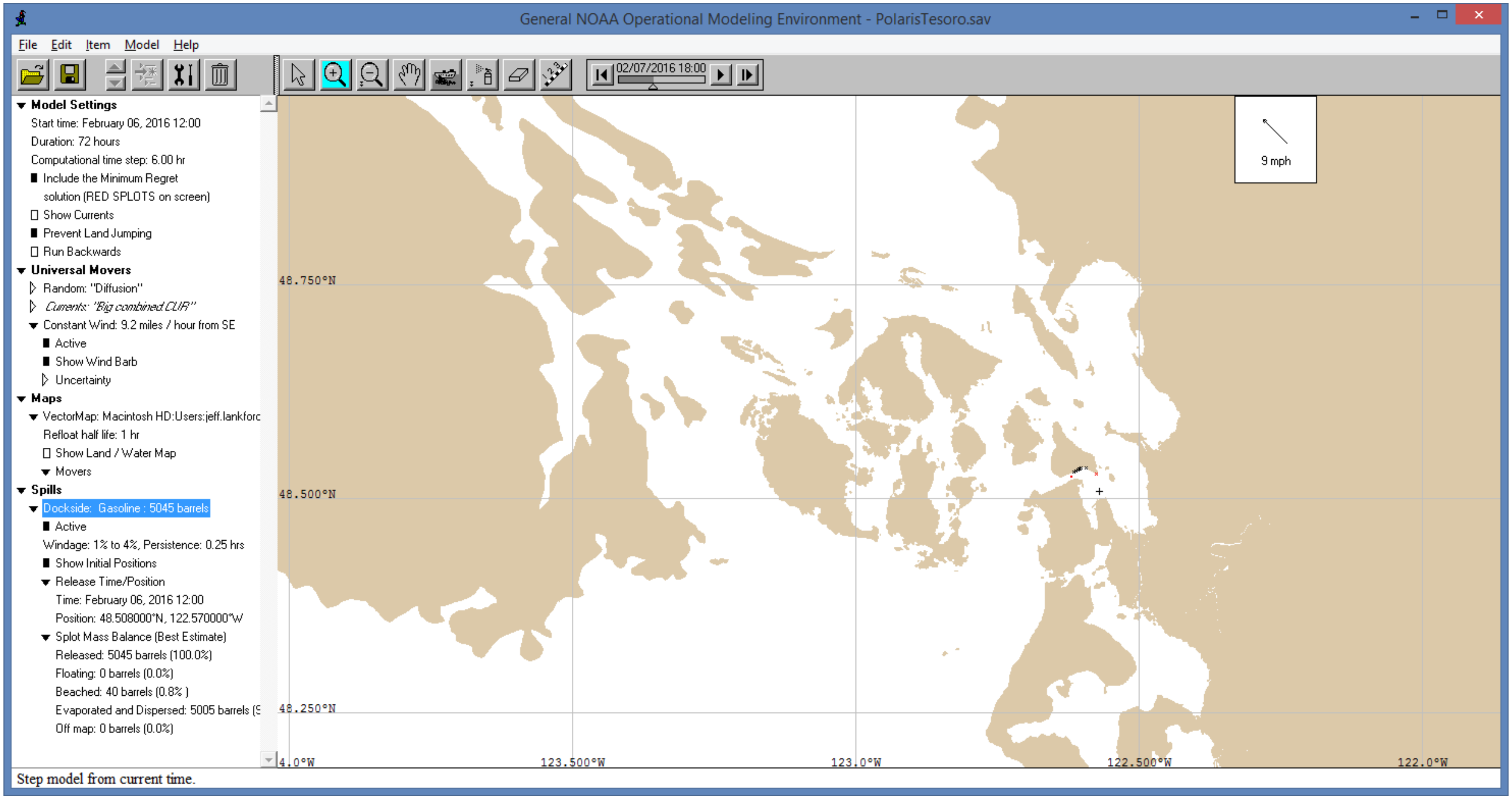

Figure G-1 (f). GNOME Model Output, Dockside, 5045 bbls, winter @ spring tide scenario: Hour 30.

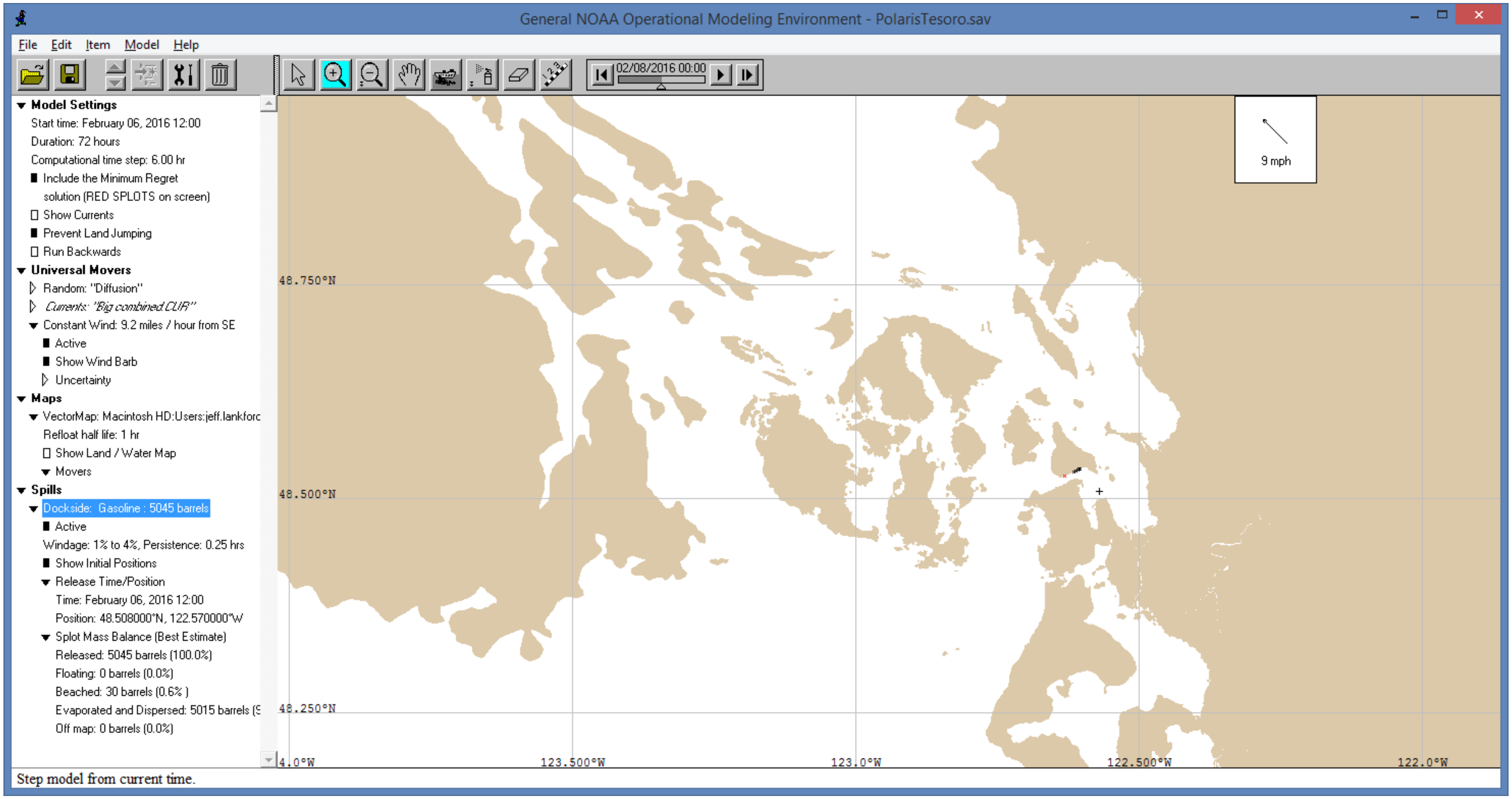

Figure G-1 (g). GNOME Model Output, Dockside, 5045 bbls, winter @ spring tide scenario: Hour 36.

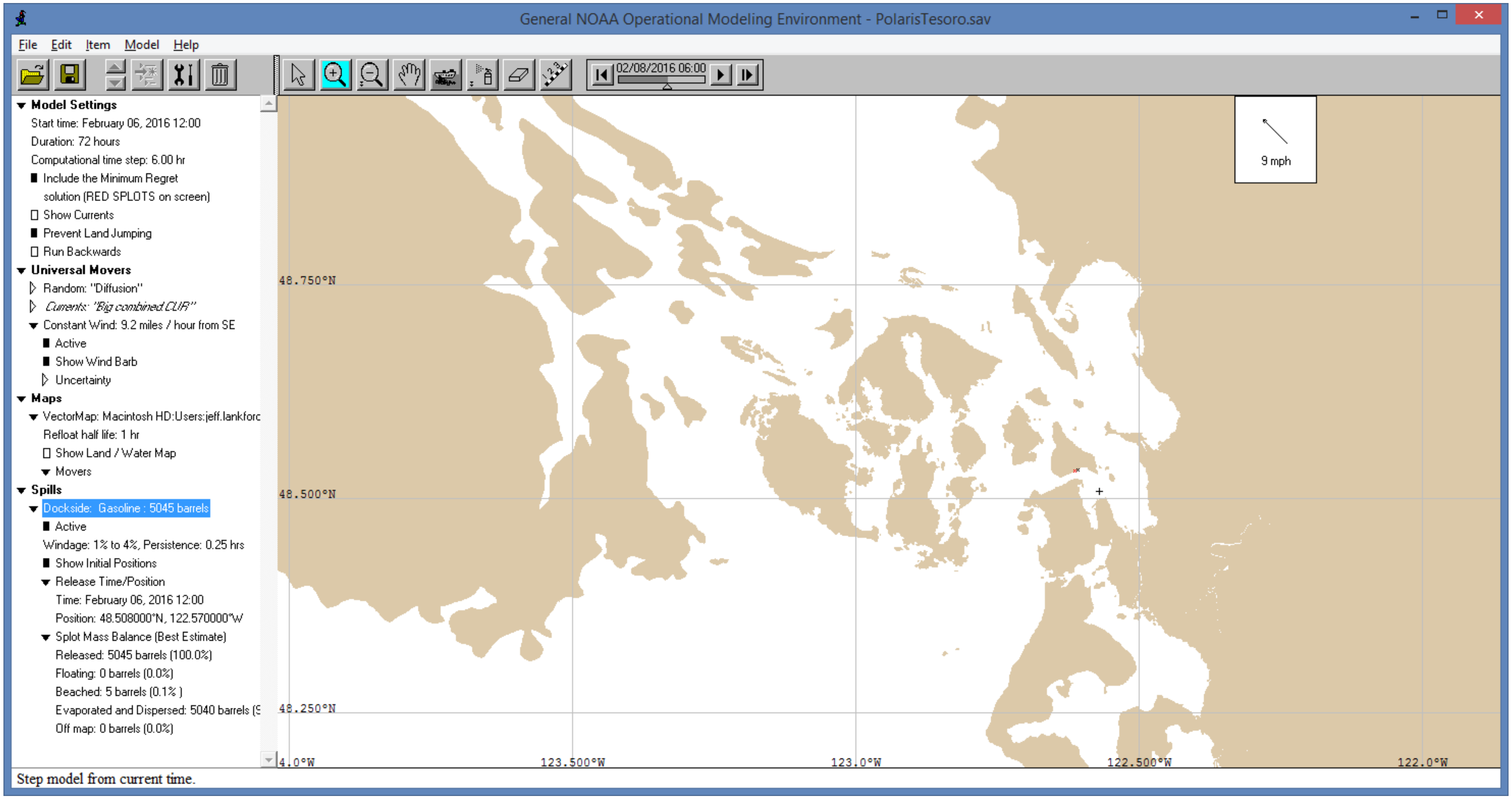

Figure G-1 (h). GNOME Model Output, Dockside, 5045 bbls, winter @ spring tide scenario: Hour 42.

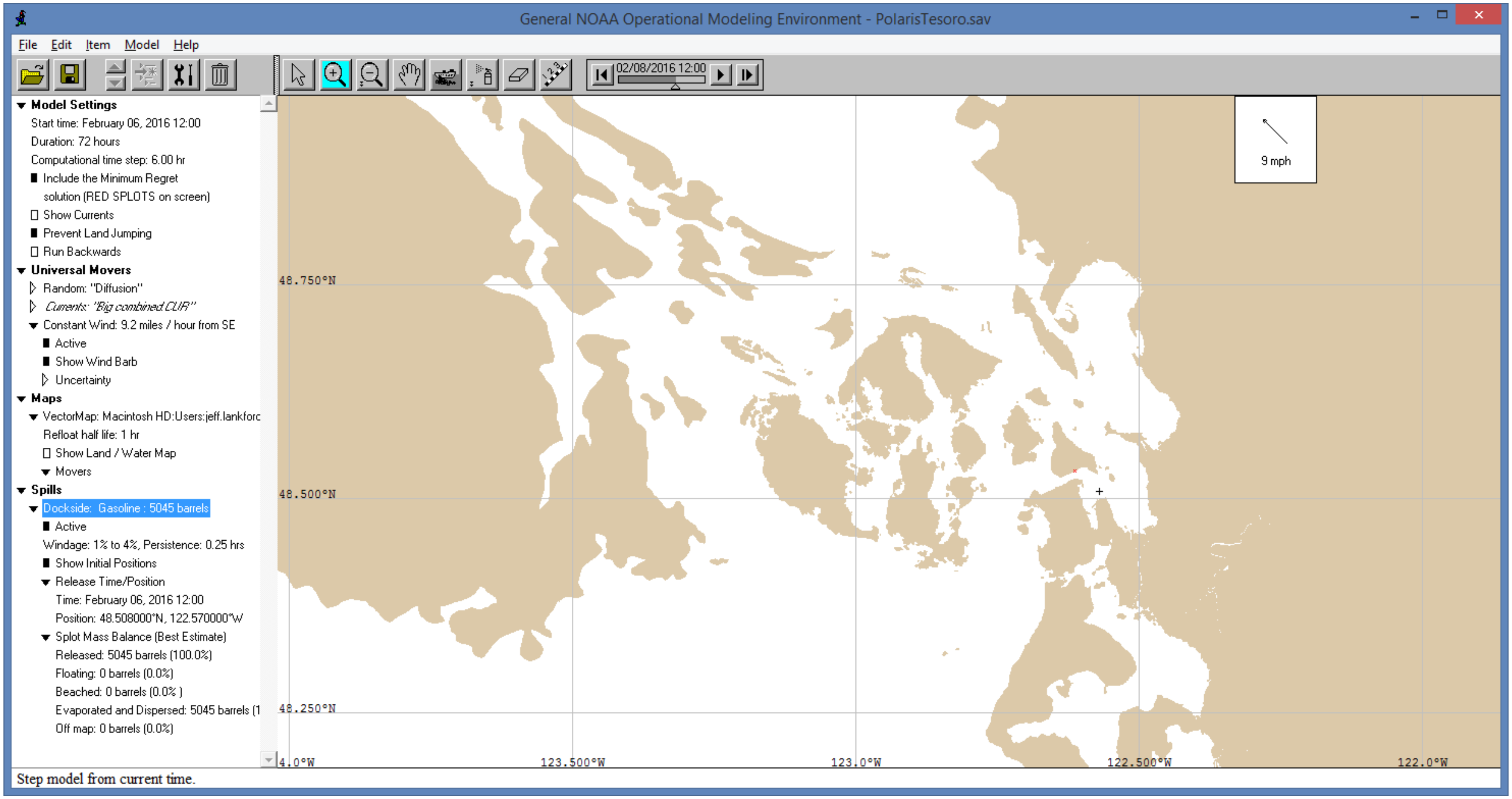

Figure G-1 (i). GNOME Model Output, Dockside, 5045 bbls, winter @ spring tide scenario: Hour 48.

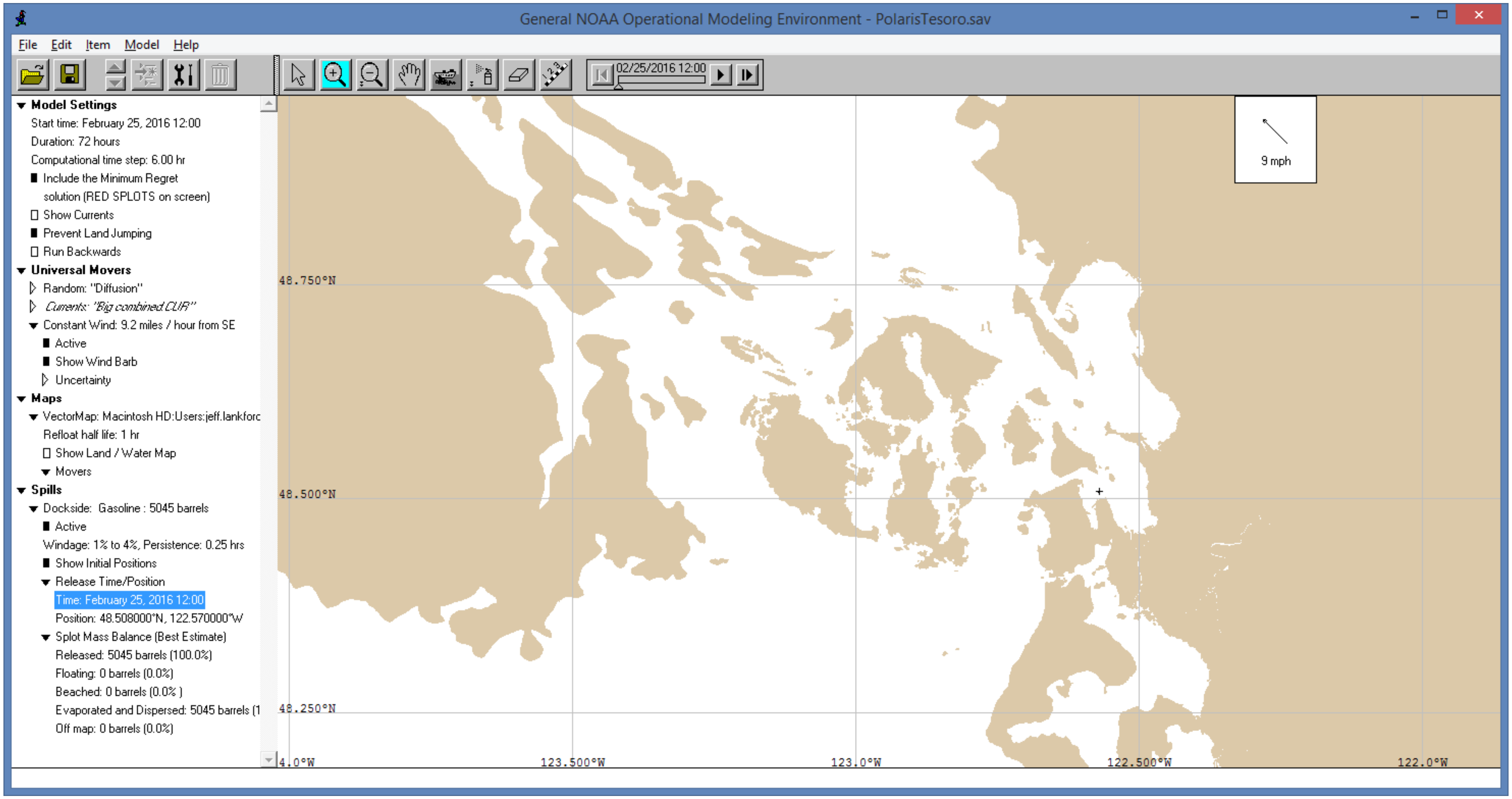

Figure G-2 (a). GNOME Model Output, Dockside, 5045 bbls, winter @ neap tide scenario: Hour 0.

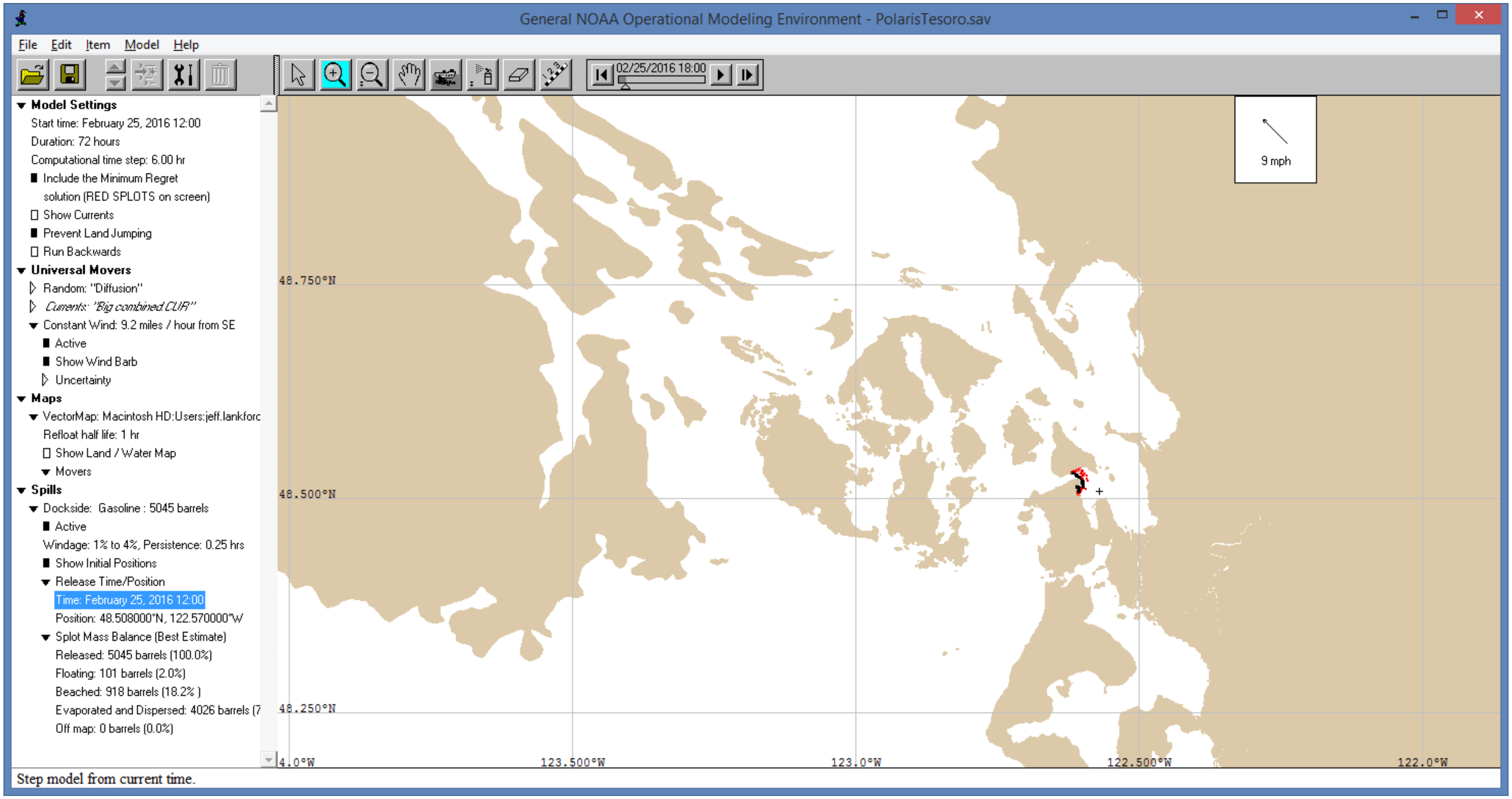

Figure G-2 (b). GNOME Model Output, Dockside, 5045 bbls, winter @ neap tide scenario: Hour 6.

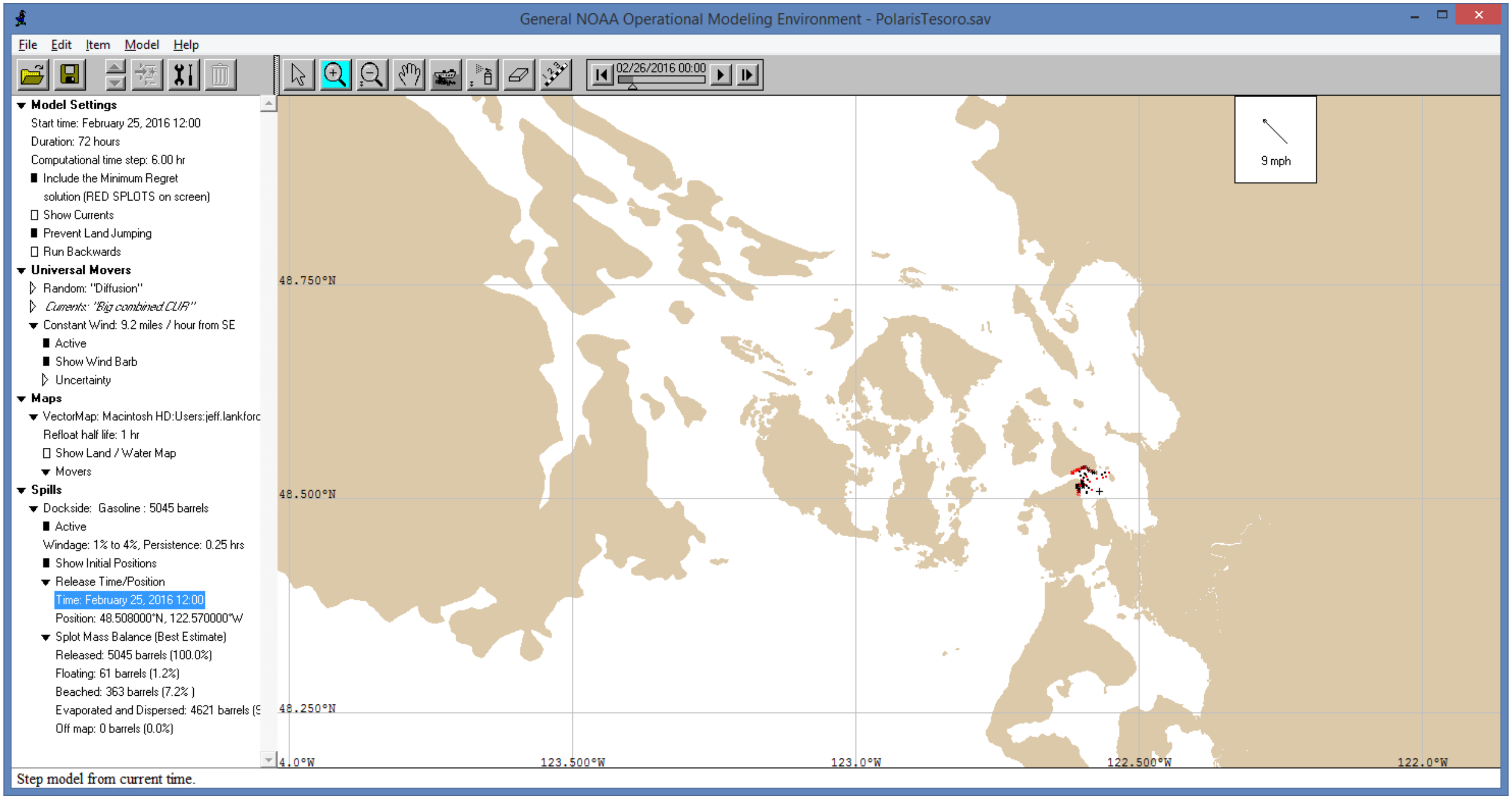

Figure G-2 (c). GNOME Model Output, Dockside, 5045 bbls, winter @ neap tide scenario: Hour 12.

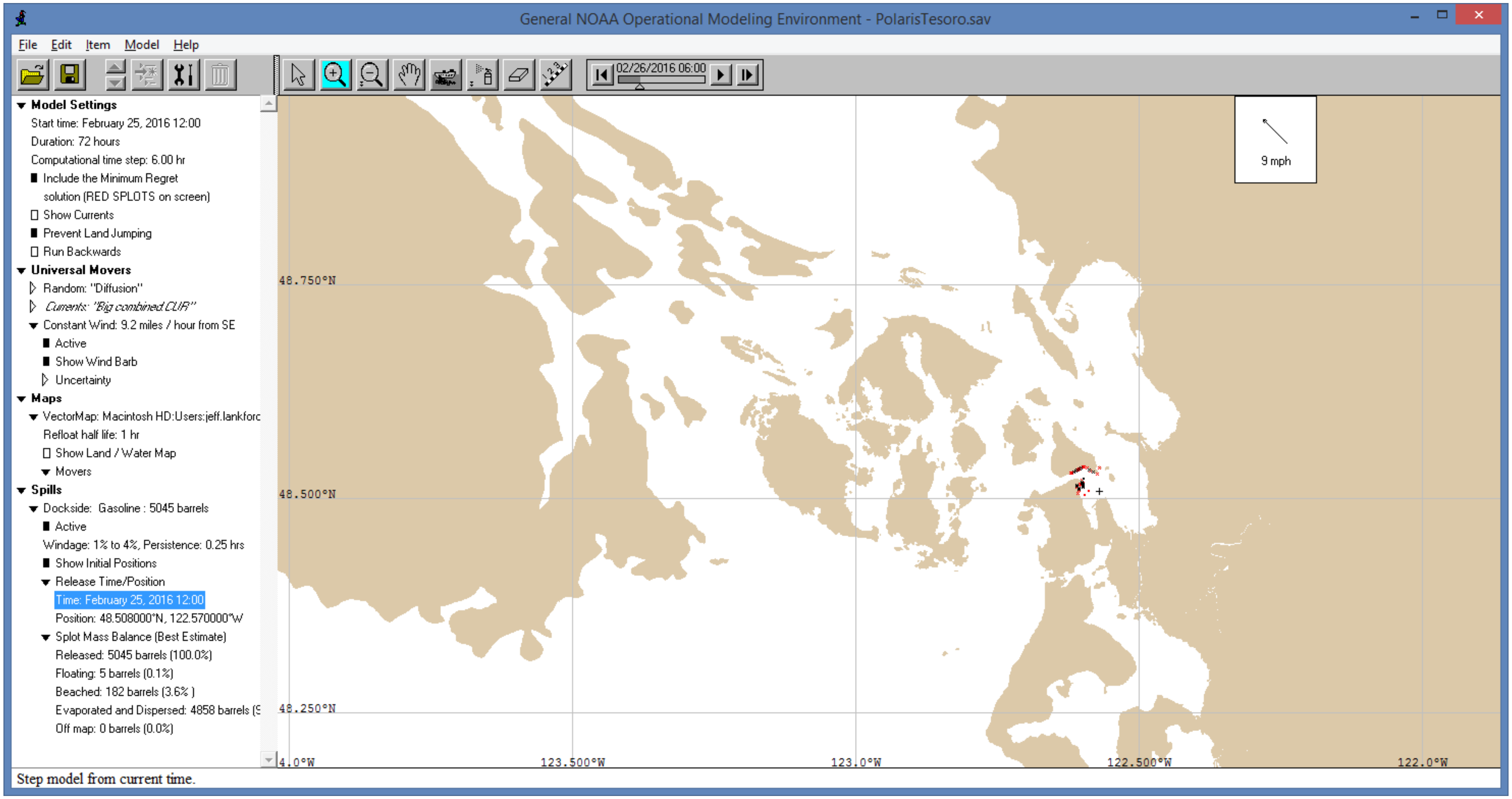

Figure G-2 (d). GNOME Model Output, Dockside, 5045 bbls, winter @ neap tide scenario: Hour 18.

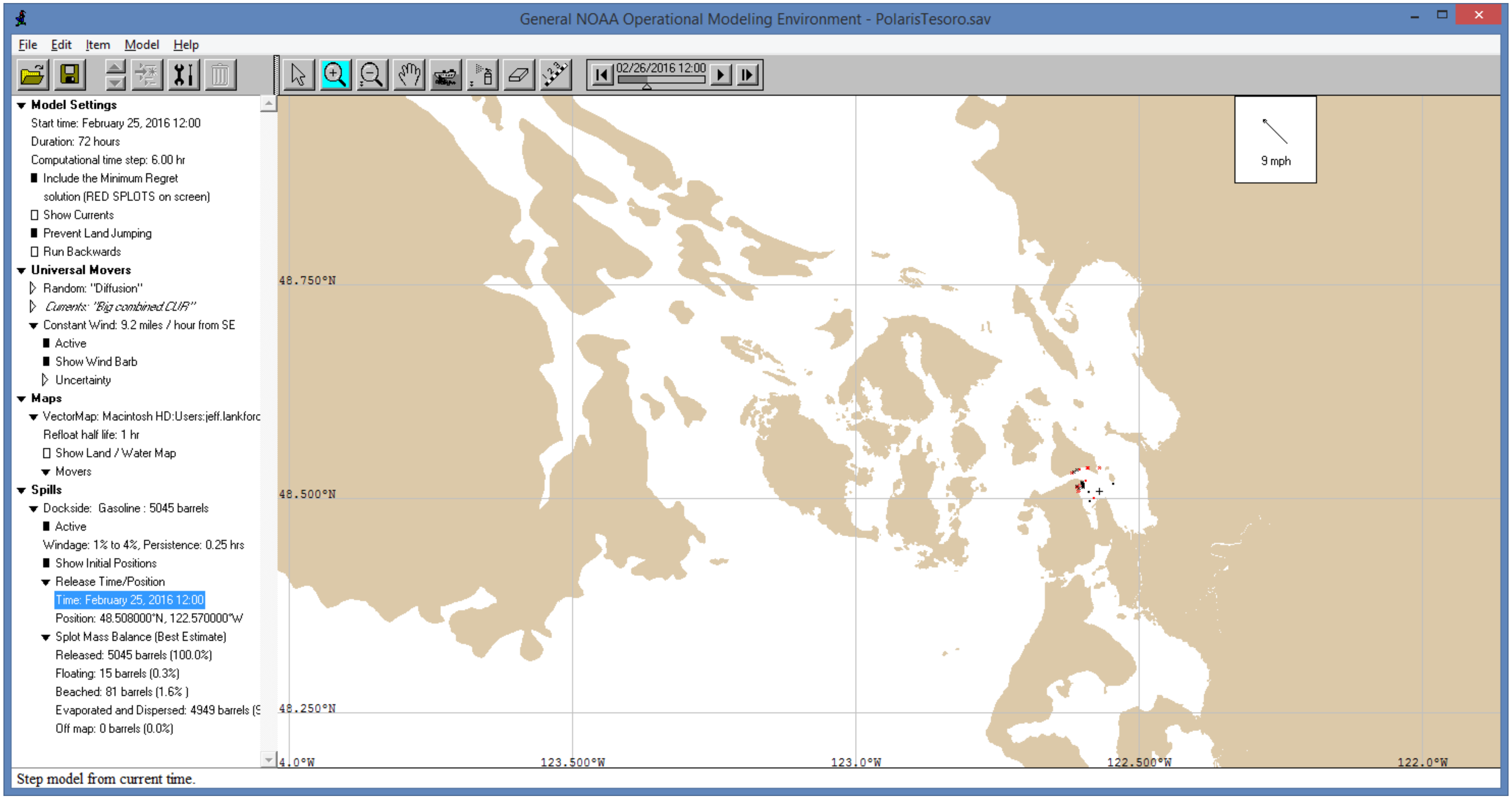

Figure G-2 (e). GNOME Model Output, Dockside, 5045 bbls, winter @ neap tide scenario: Hour 24.

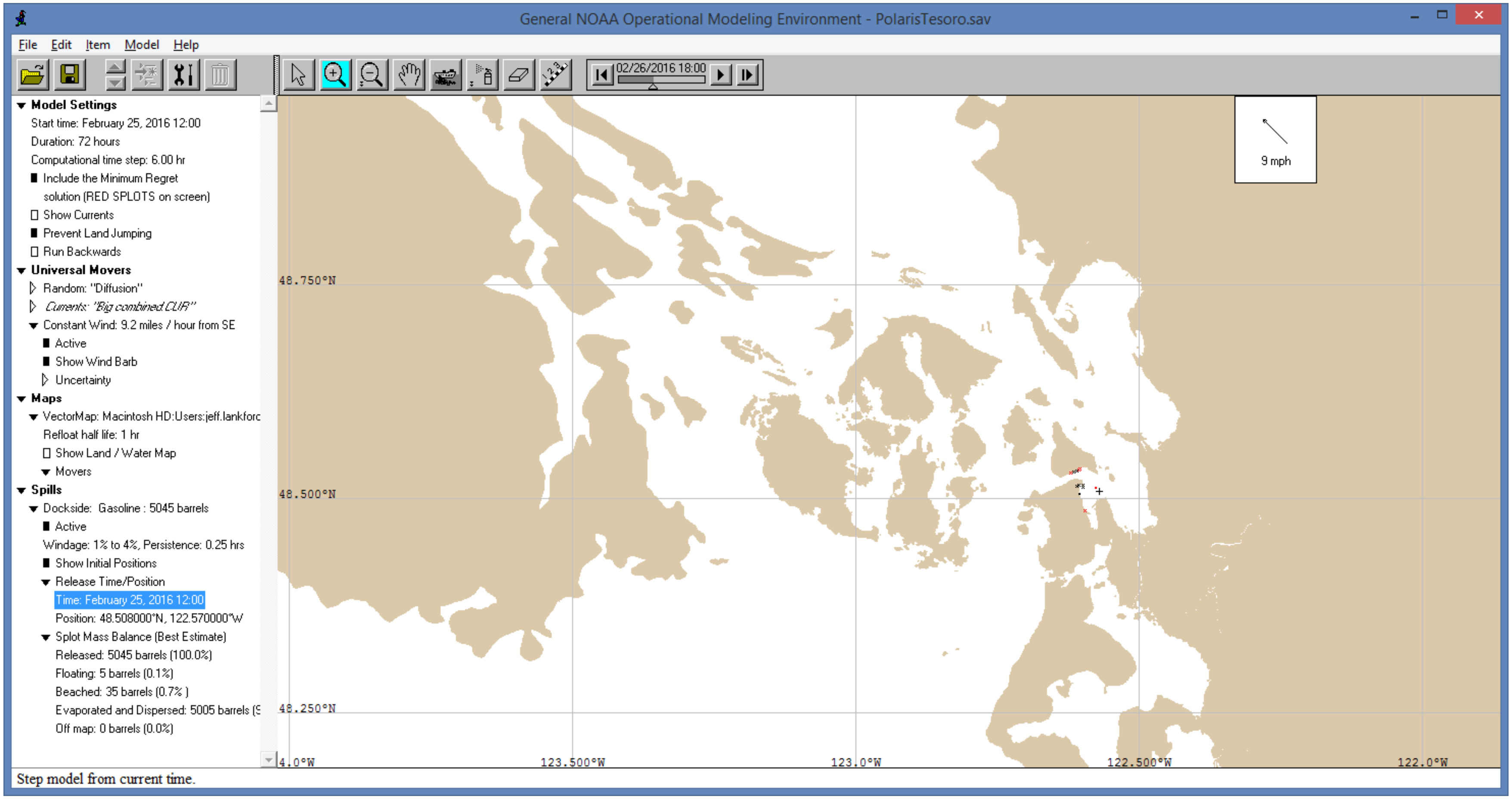

Figure G-2 (f). GNOME Model Output, Dockside, 5045 bbls, winter @ neap tide scenario: Hour 30.

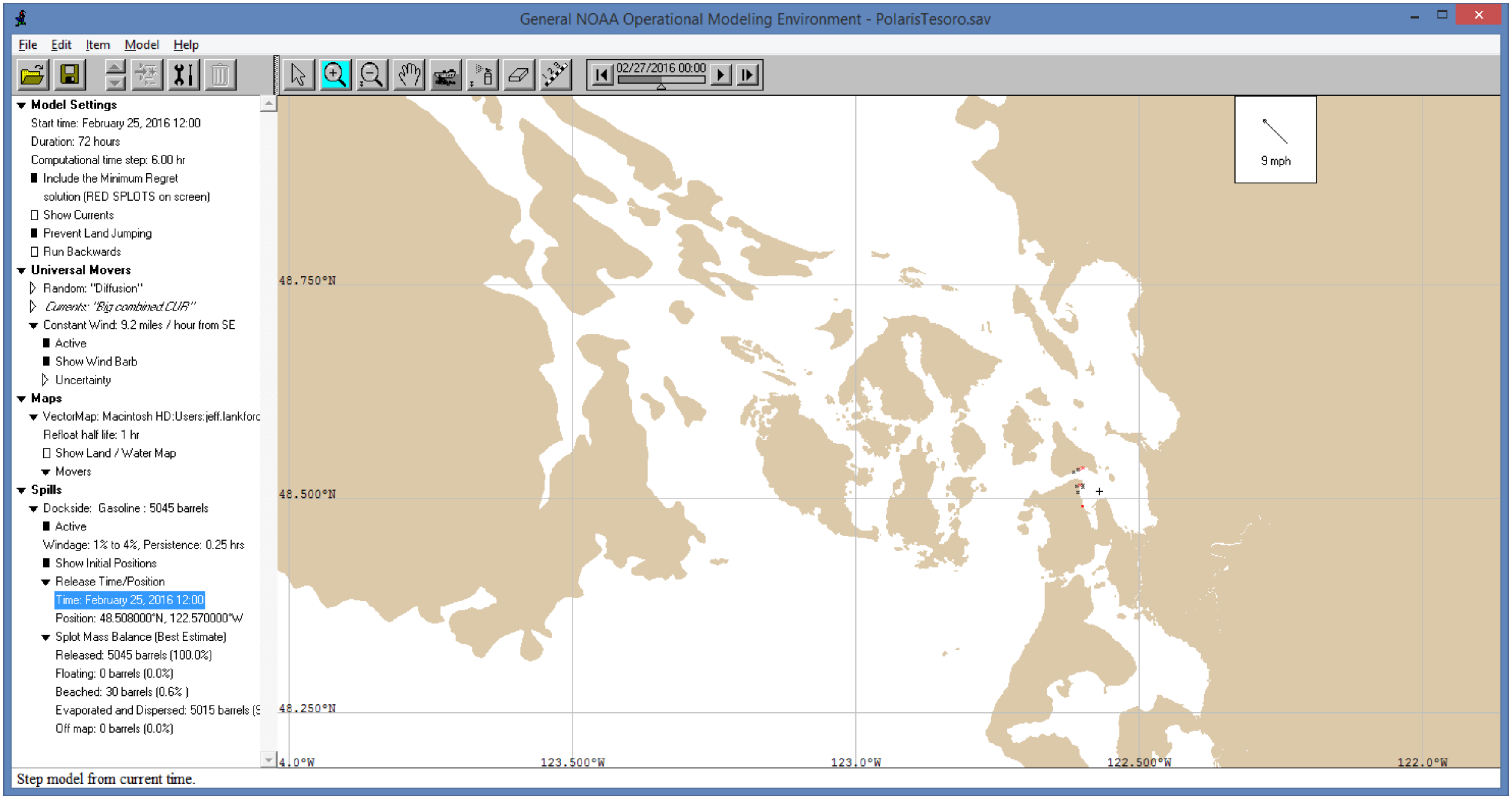

Figure G-2 (g). GNOME Model Output, Dockside, 5045 bbls, winter @ neap tide scenario: Hour 36.

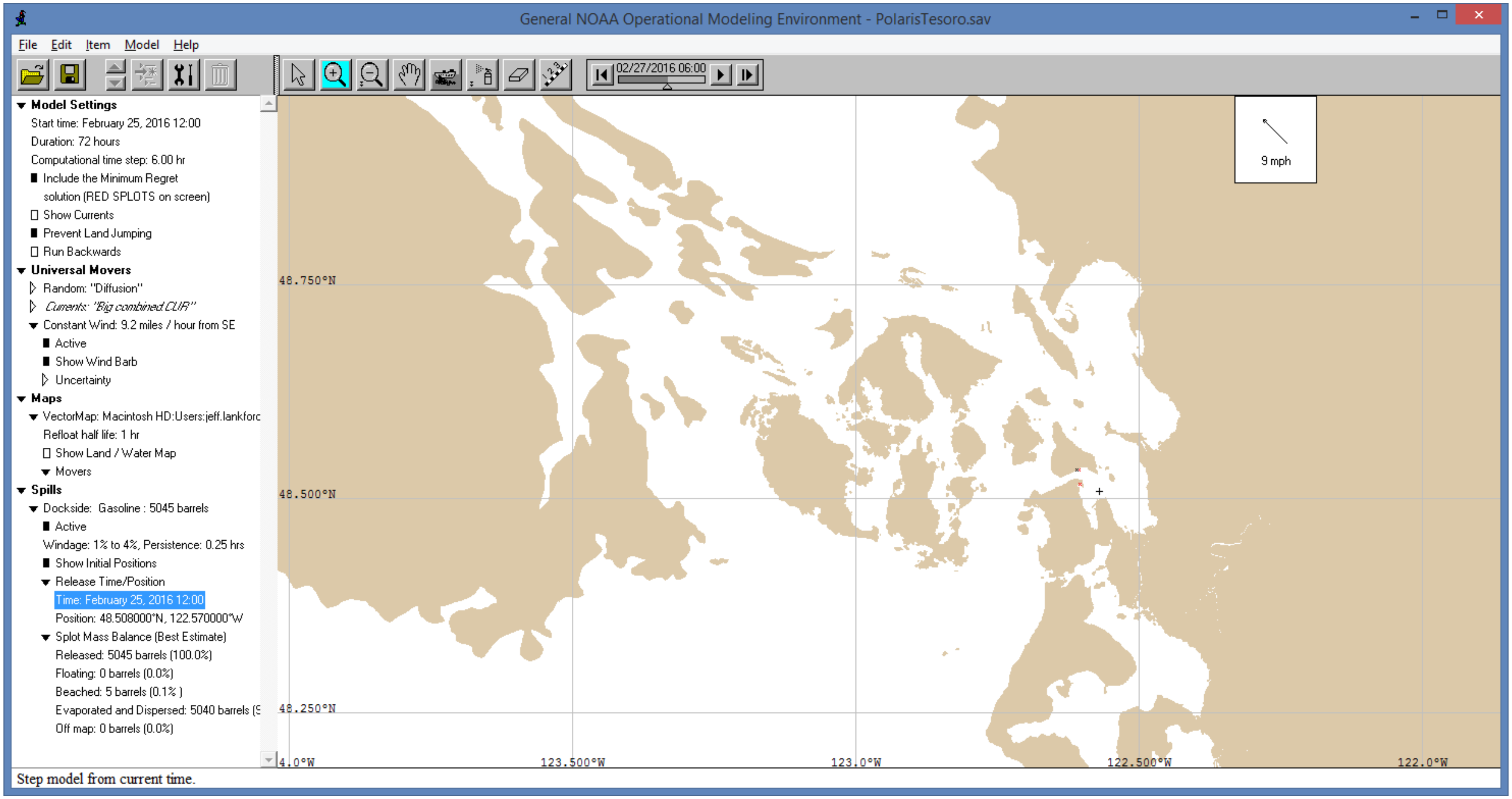

Figure G-2 (h). GNOME Model Output, Dockside, 5045 bbls, winter @ neap tide scenario: Hour 42.

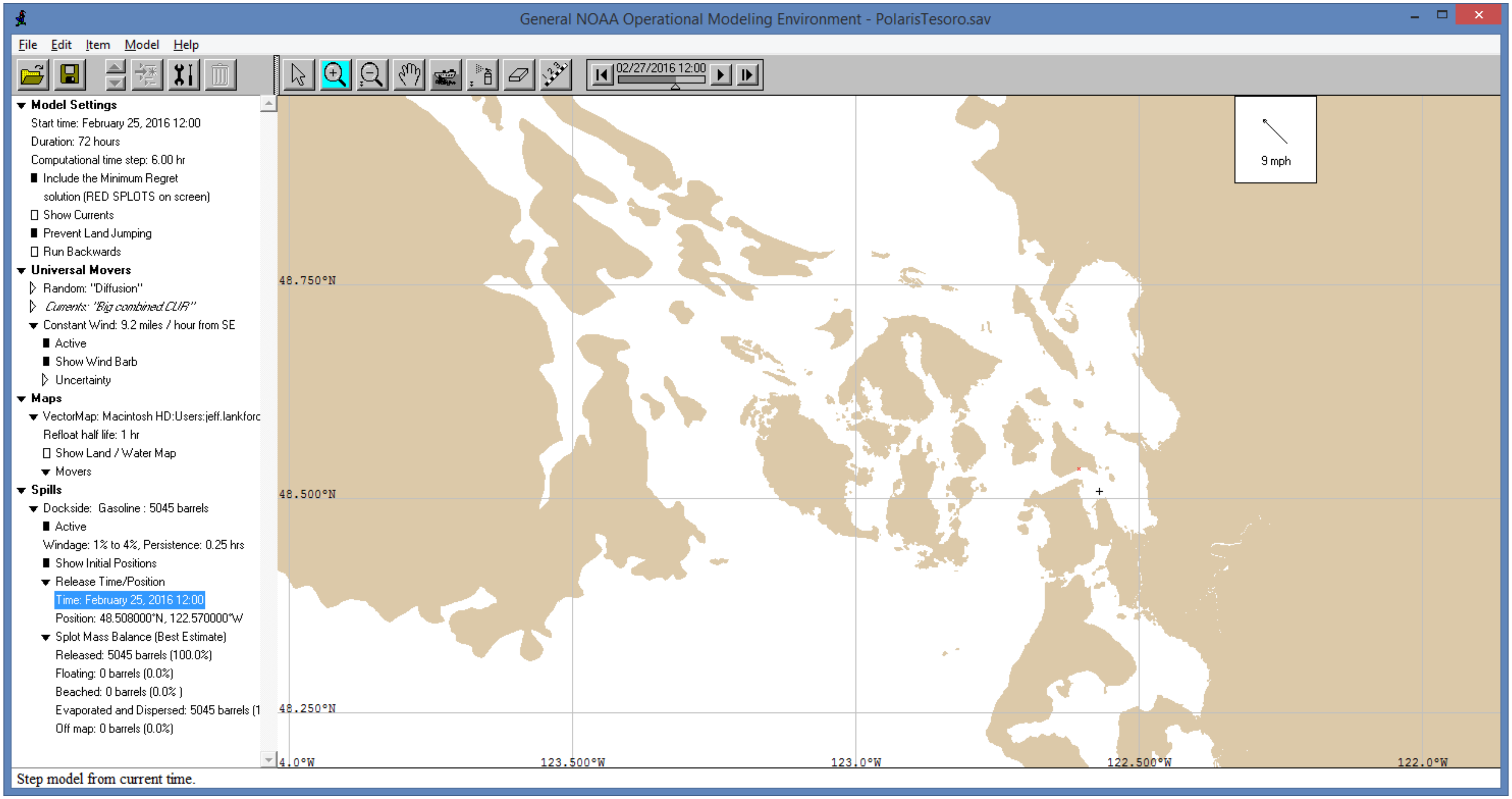

Figure G-2 (i). GNOME Model Output, Dockside, 5045 bbls, winter @ neap tide scenario: Hour 48.

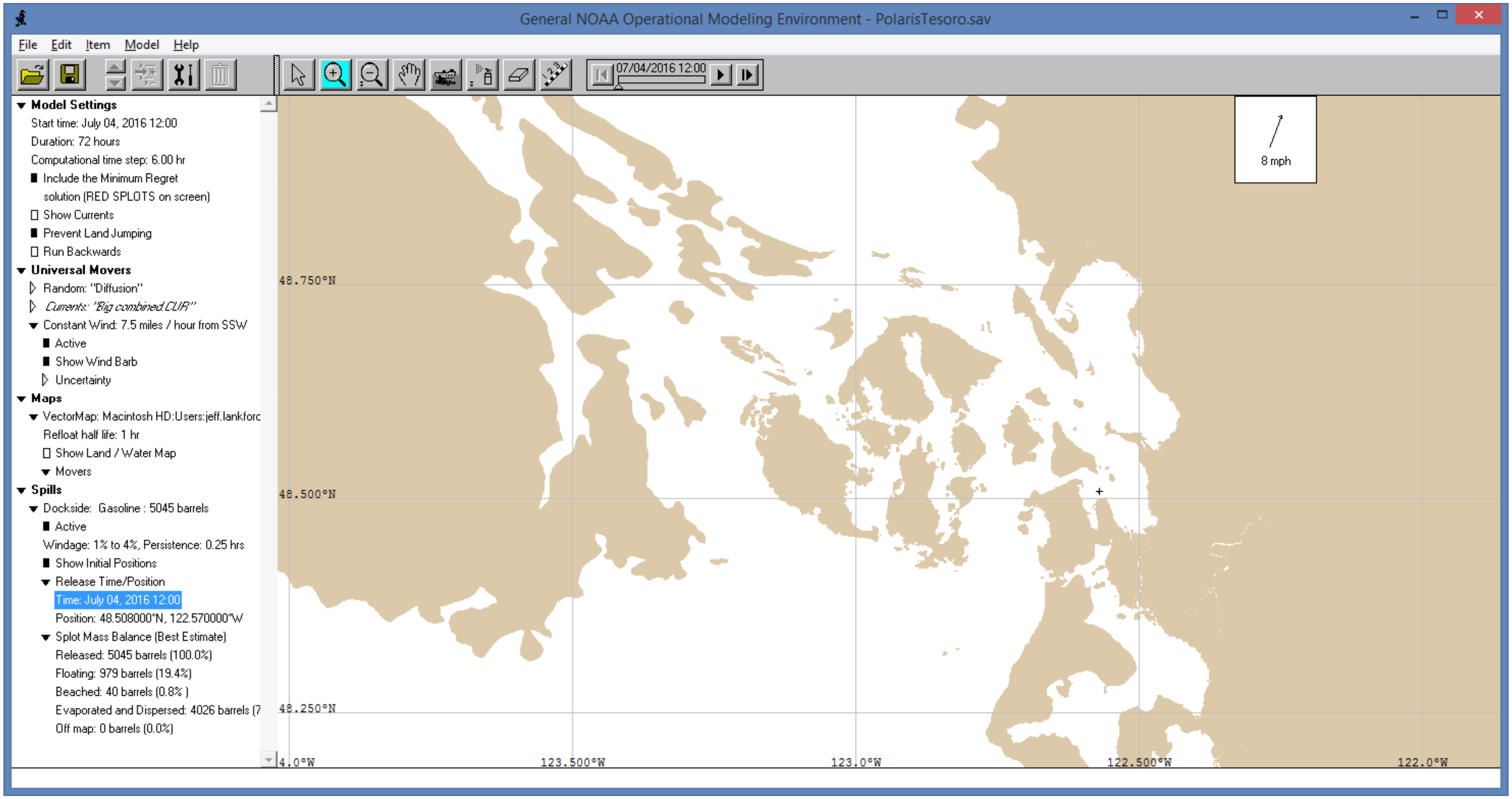

Figure G-3 (a). GNOME Model Output, Dockside, 5045 bbls, summer @spring tide scenario: Hour 0.

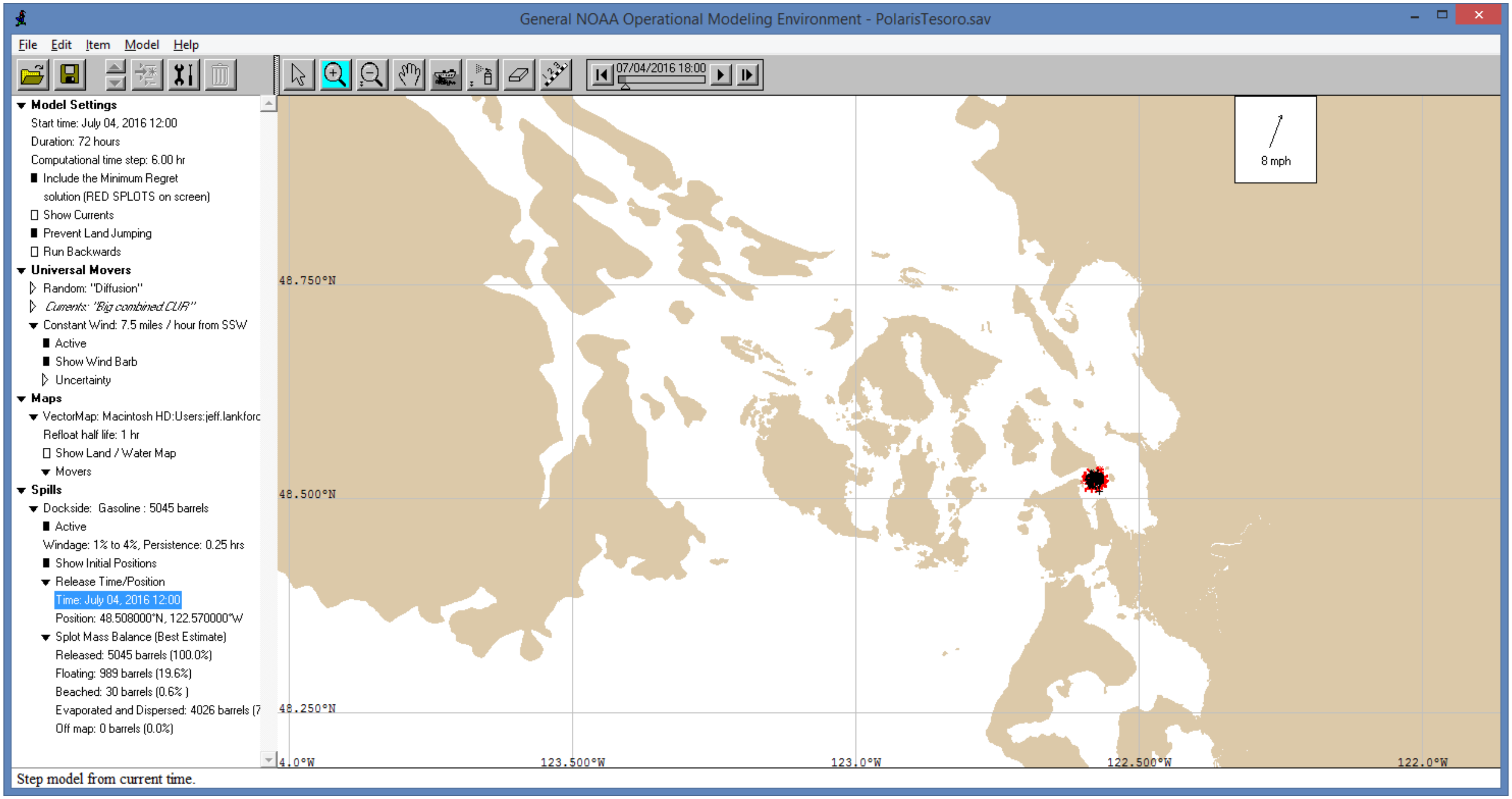

Figure G-3 (b). GNOME Model Output, Dockside, 5045 bbls, summer @spring tide scenario: Hour 6.

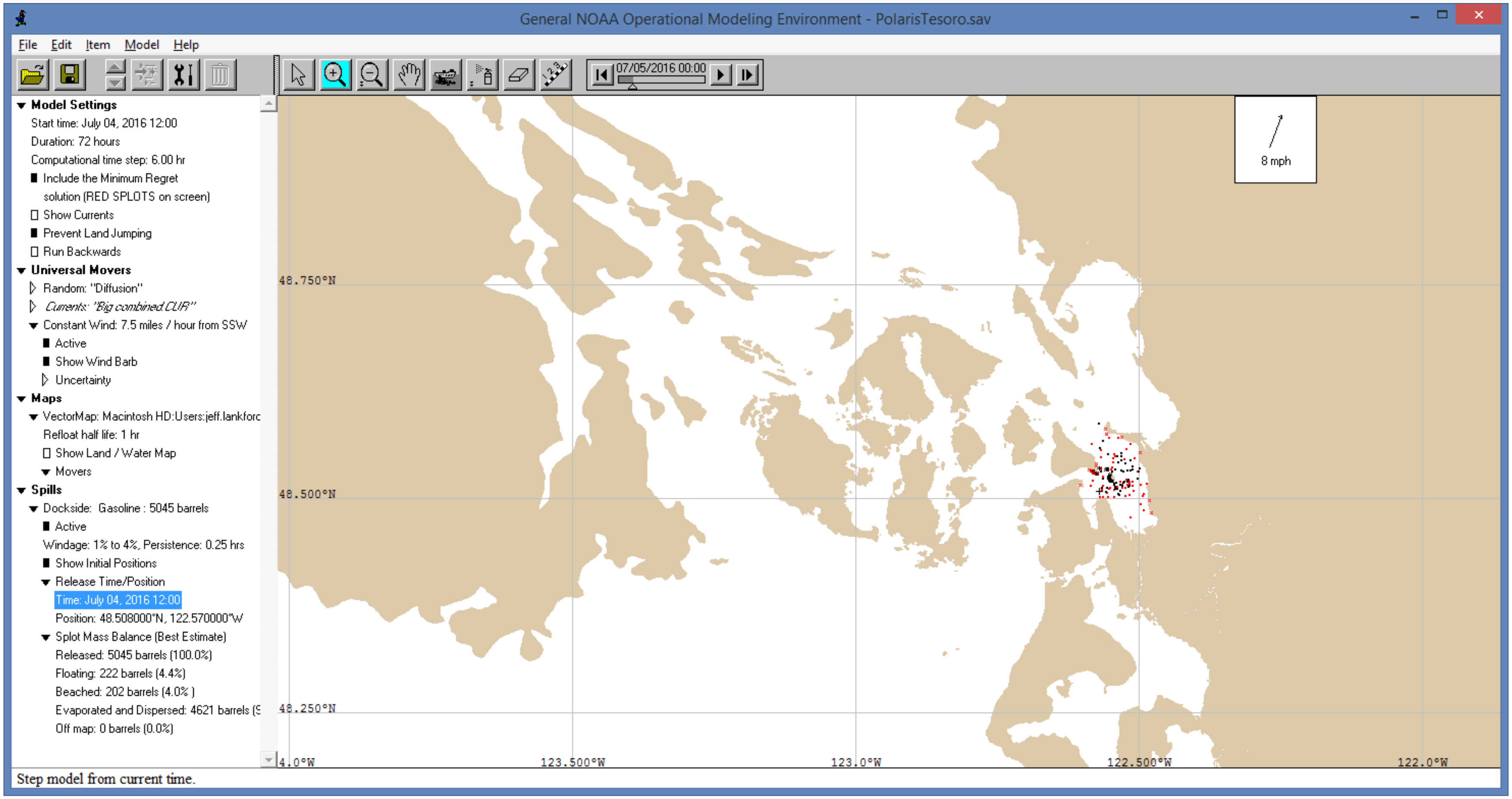

Figure G-3 (c). GNOME Model Output, Dockside, 5045 bbls, summer @spring tide scenario: Hour 12.

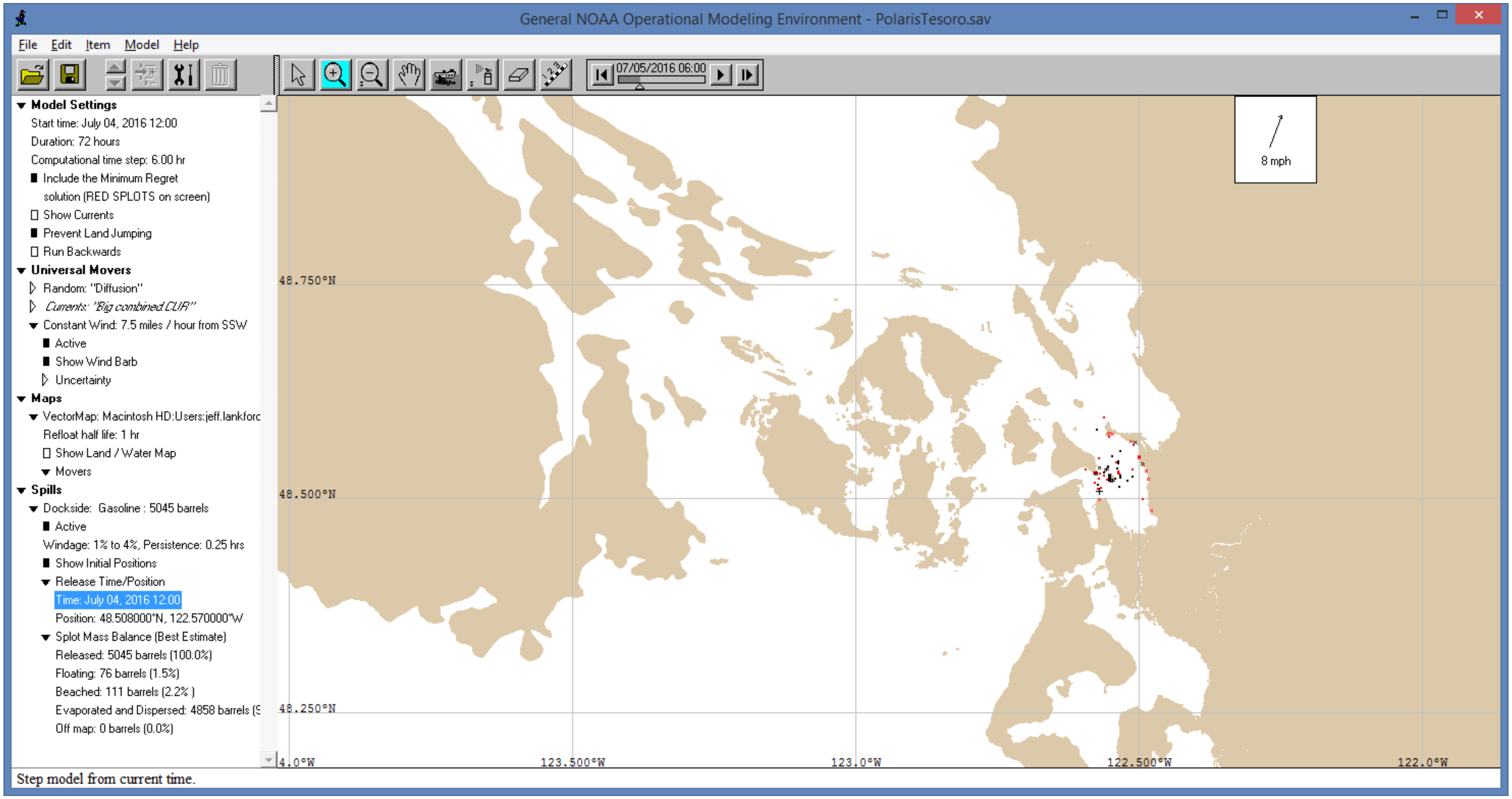

Figure G-3 (d). GNOME Model Output, Dockside, 5045 bbls, summer @ spring tide scenario: Hour 18.

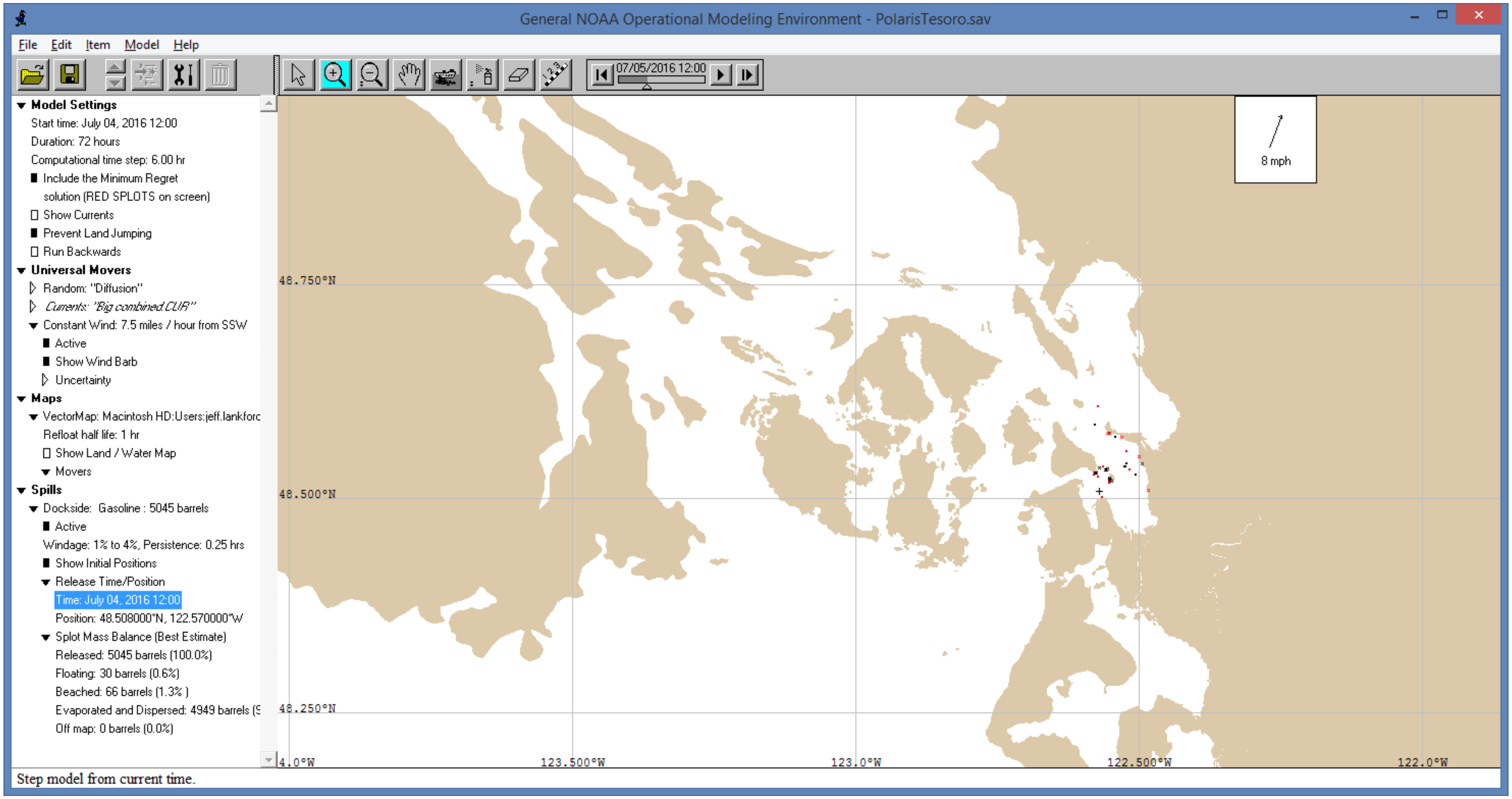

Figure G-3 (e). GNOME Model Output, Dockside, 5045 bbls, summer @ spring tide scenario: Hour 24.

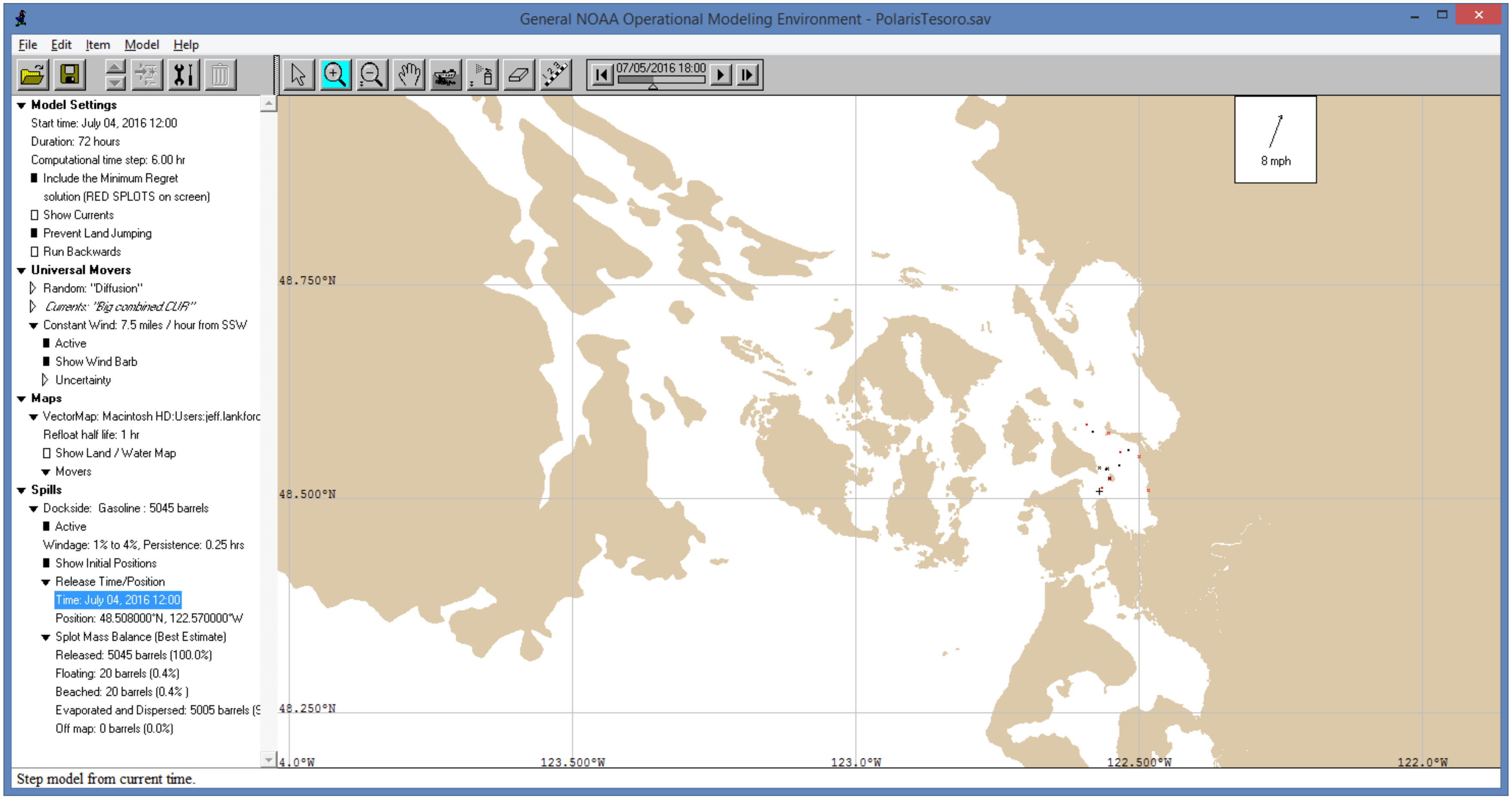

Figure G-3 (f). GNOME Model Output, Dockside, 5045 bbls, summer @spring tide scenario: Hour 30.

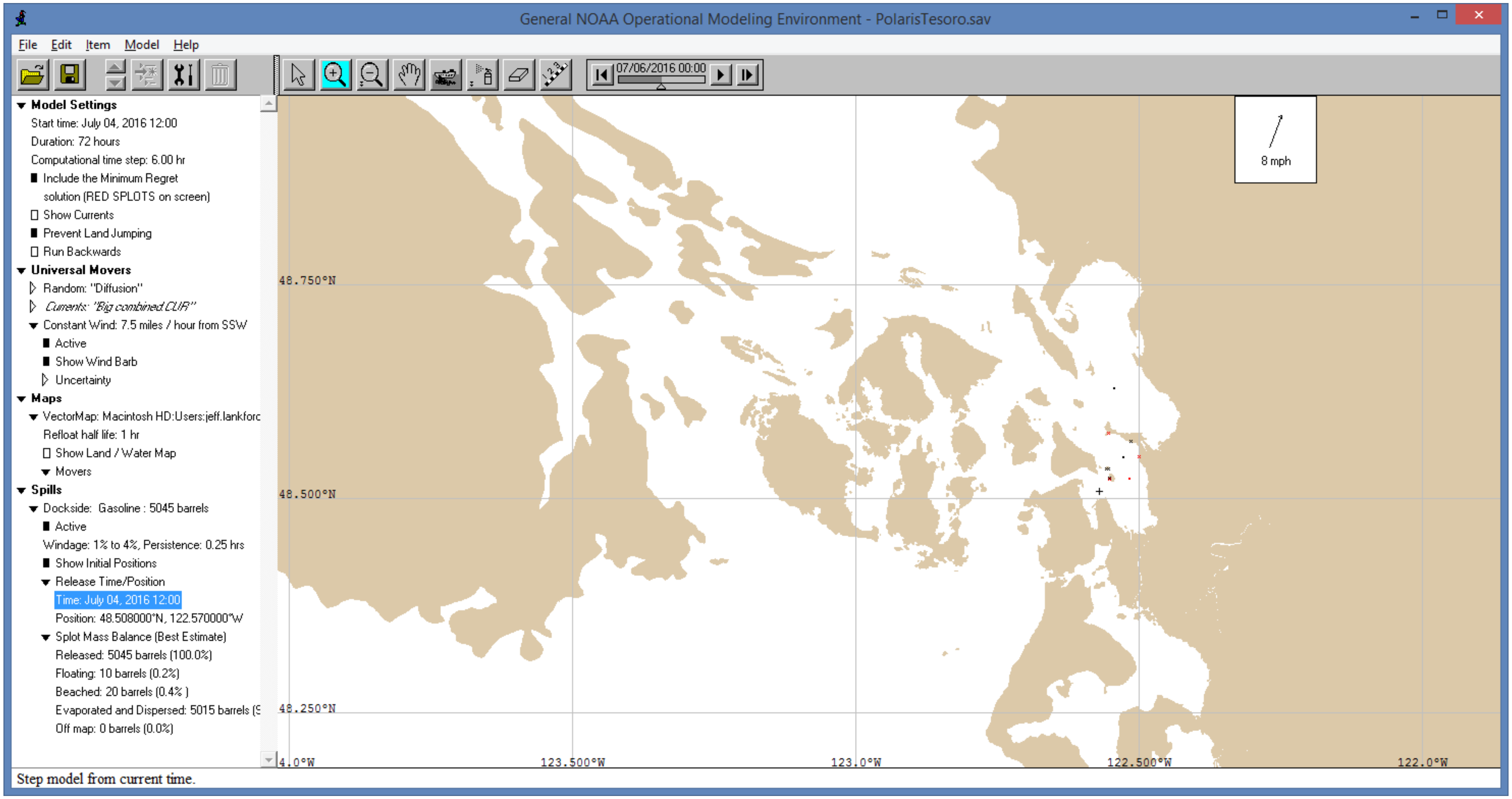

Figure G-3 (g). GNOME Model Output, Dockside, 5045 bbls, summer @ spring tide scenario: Hour 36.

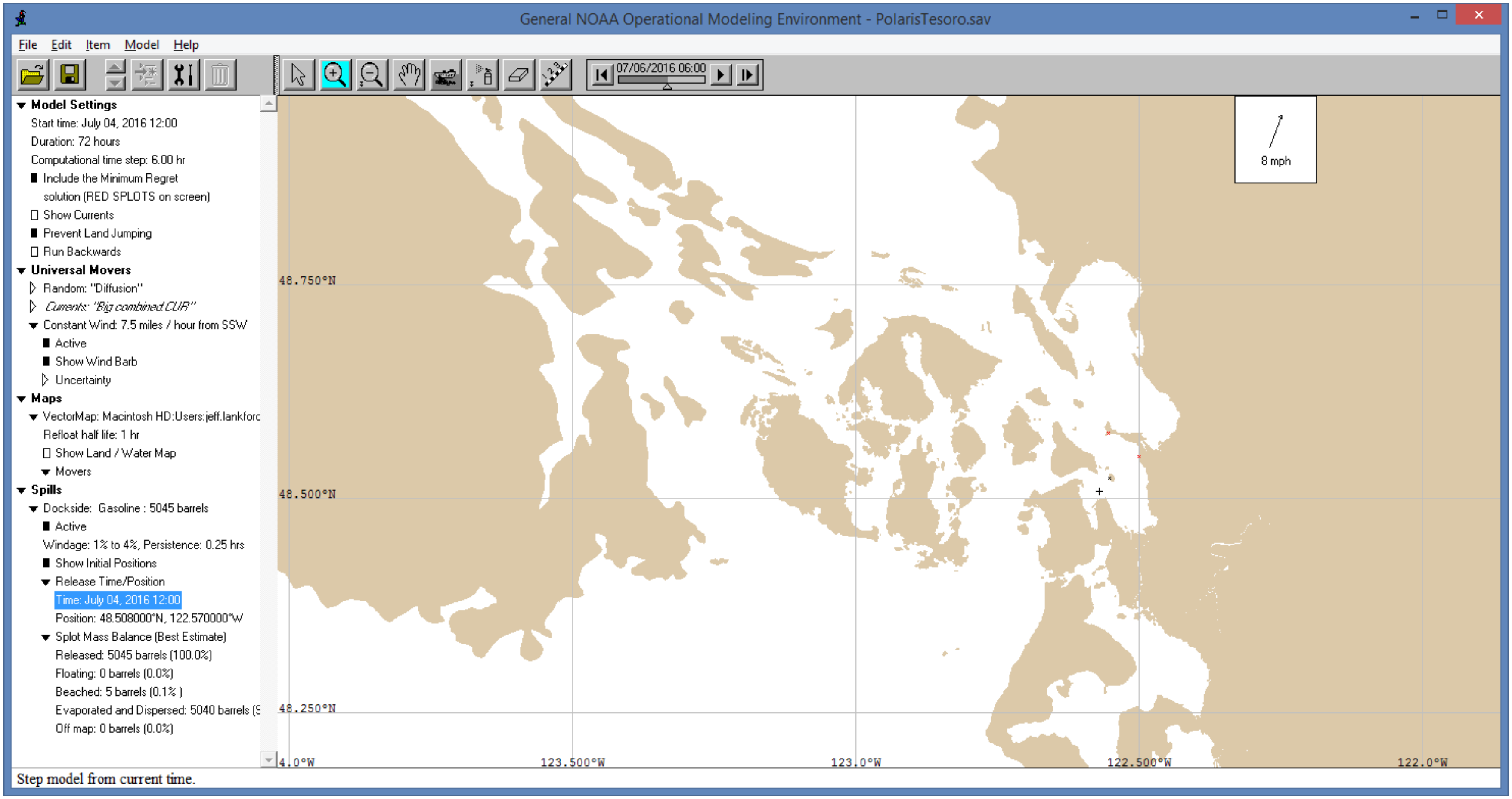

Figure G-3 (h). GNOME Model Output, Dockside, 5045 bbls, summer @ spring tide scenario: Hour 42.

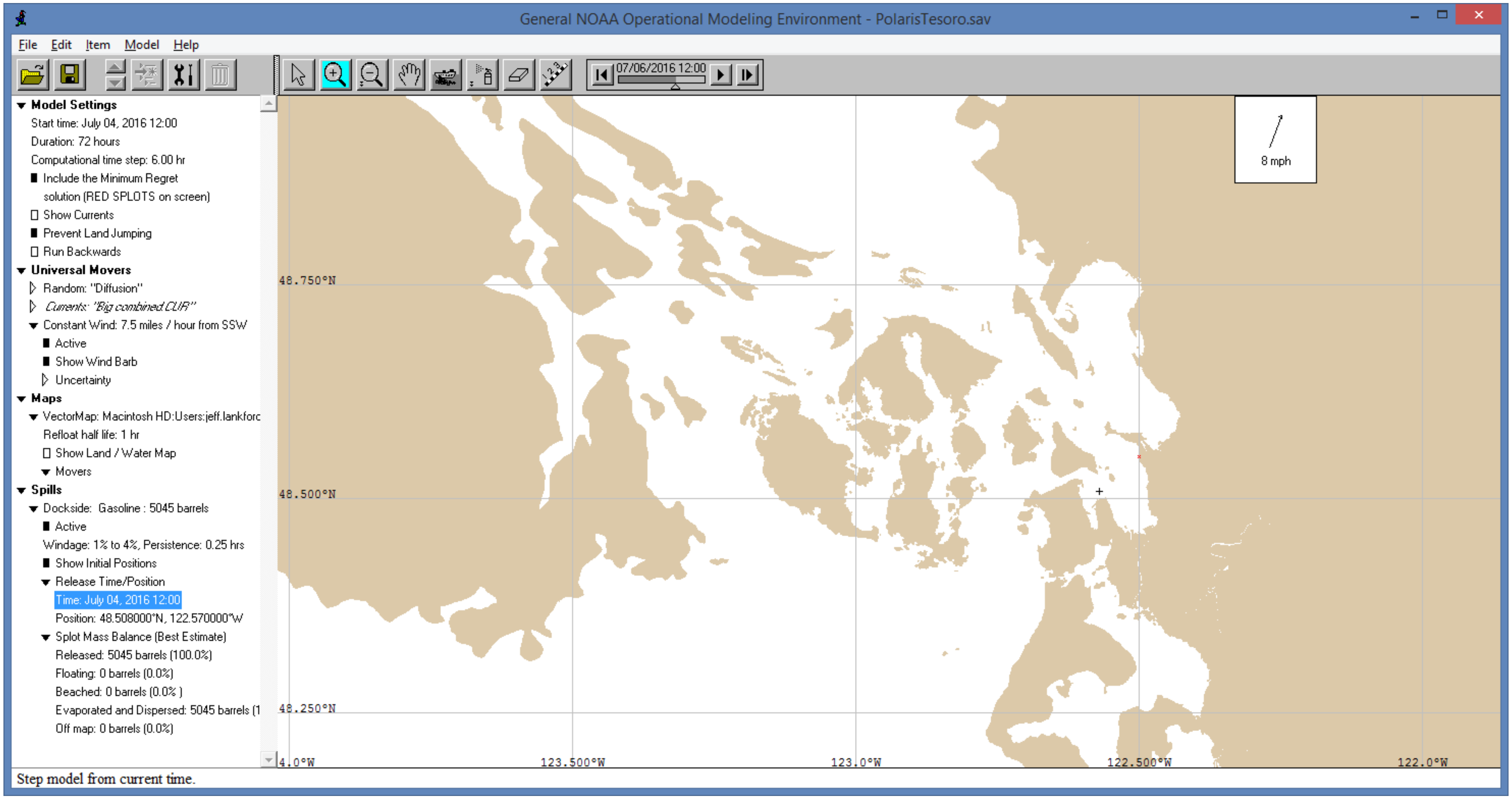

Figure G-3 (i). GNOME Model Output, Dockside, 5045 bbls, summer @ spring tide scenario: Hour 48.

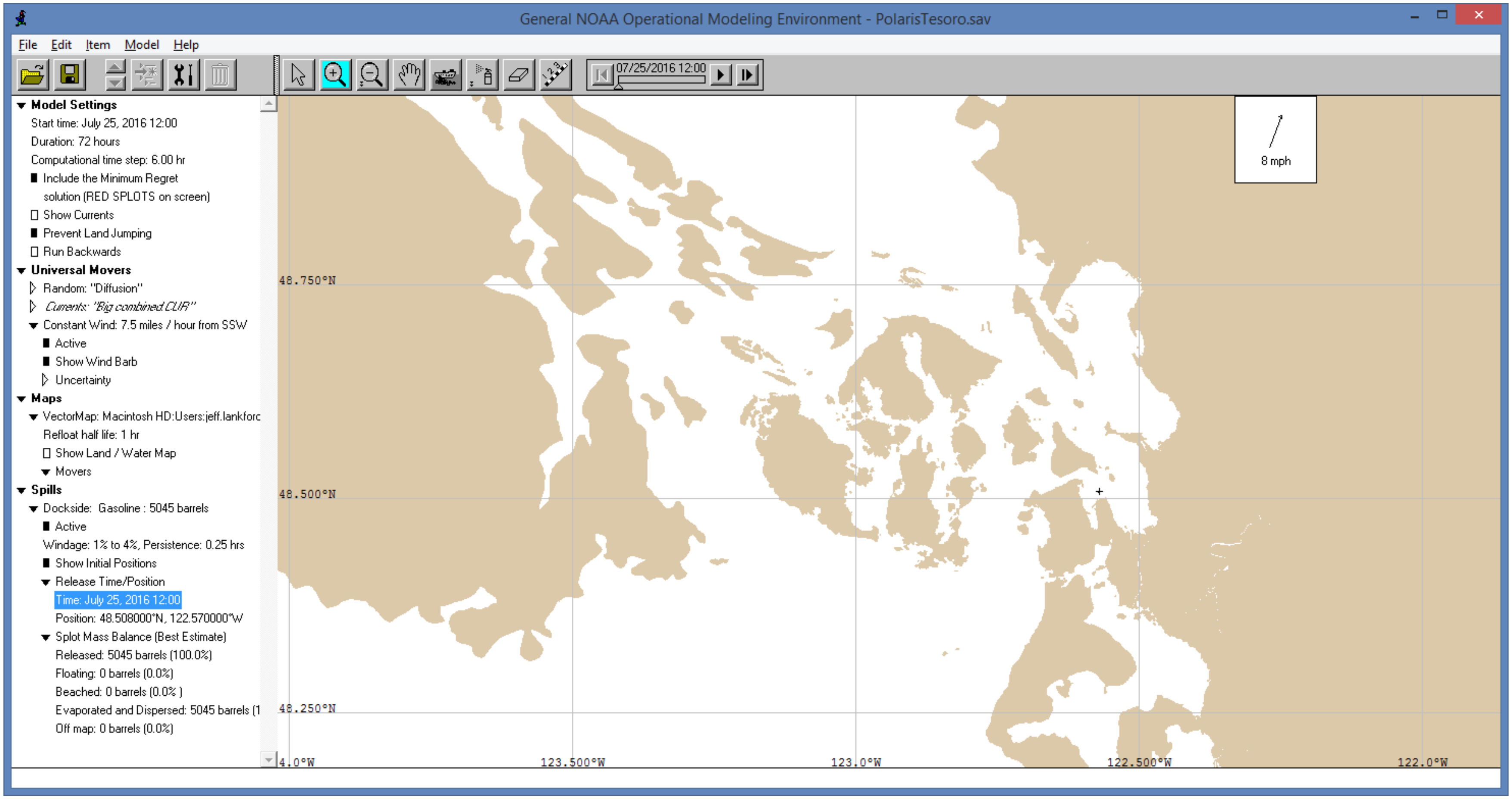

Figure G-4 (a). GNOME Model Output, Dockside, 5045 bbls, summer @ neap tide scenario: Hour 0.

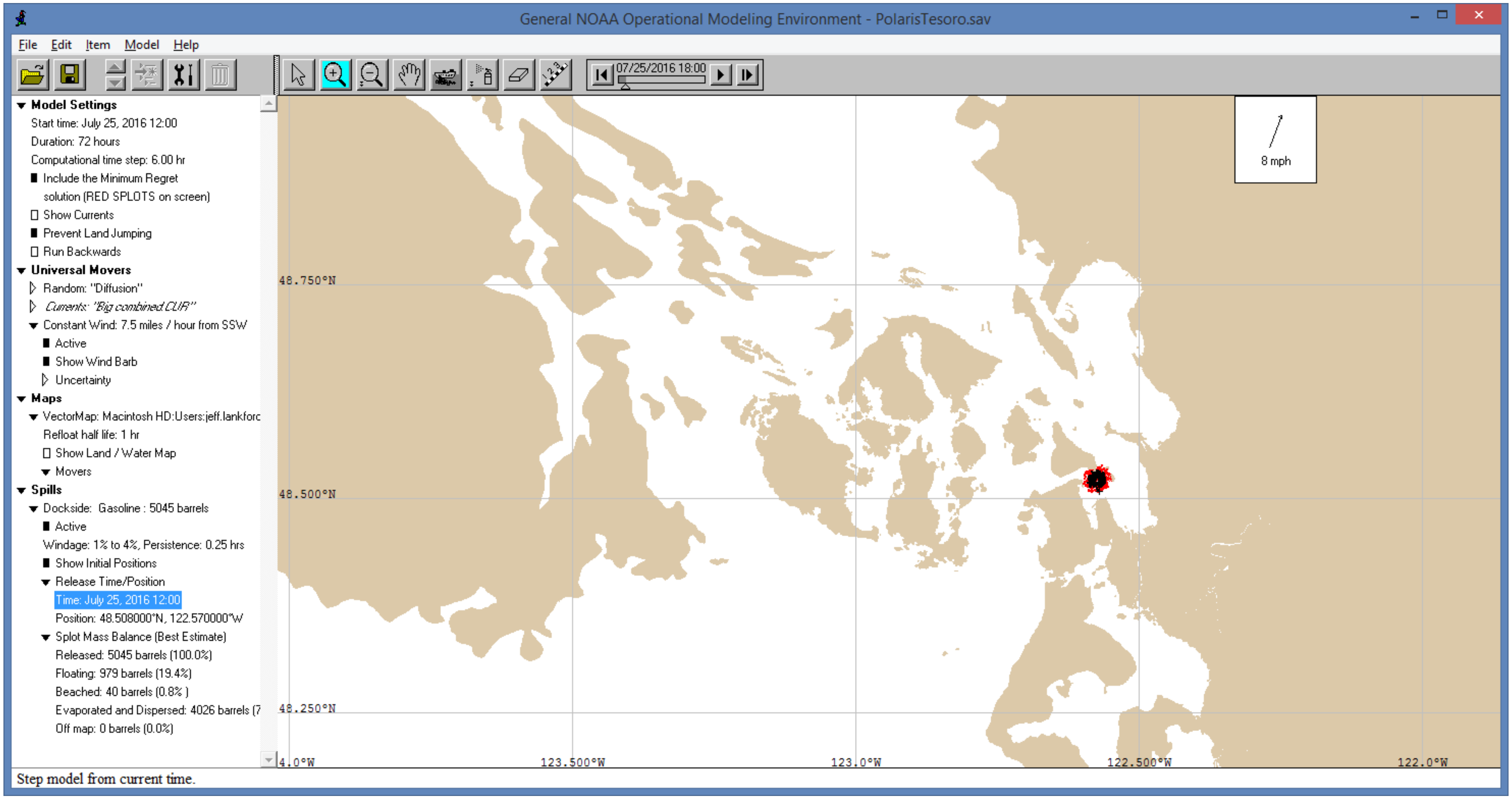

Figure G-4 (b). GNOME Model Output, Dockside, 5045 bbls, summer @ neap tide scenario: Hour 6.

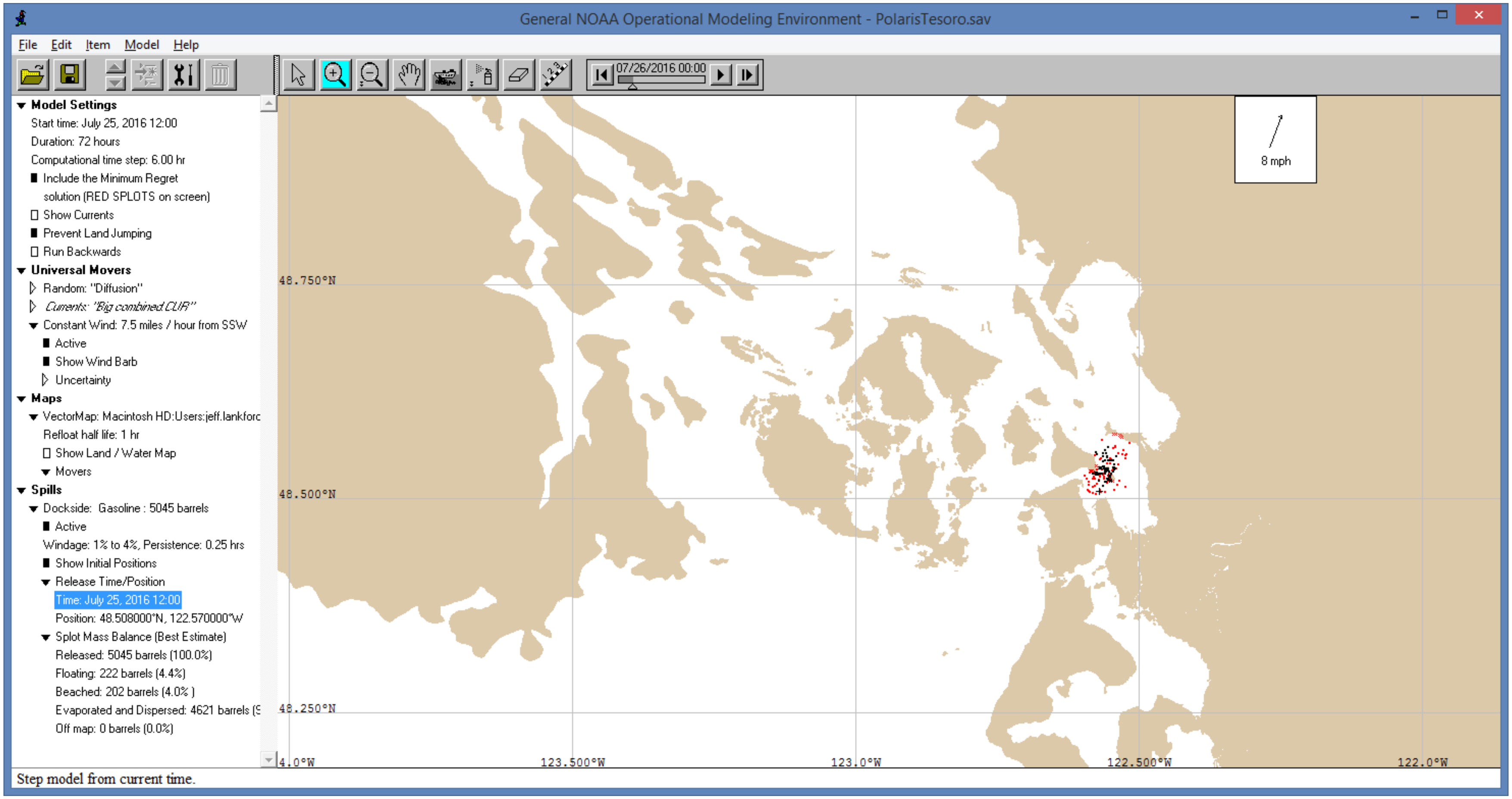

Figure G-4 (c). GNOME Model Output, Dockside, 5045 bbls, summer @ neap tide scenario: Hour 12.

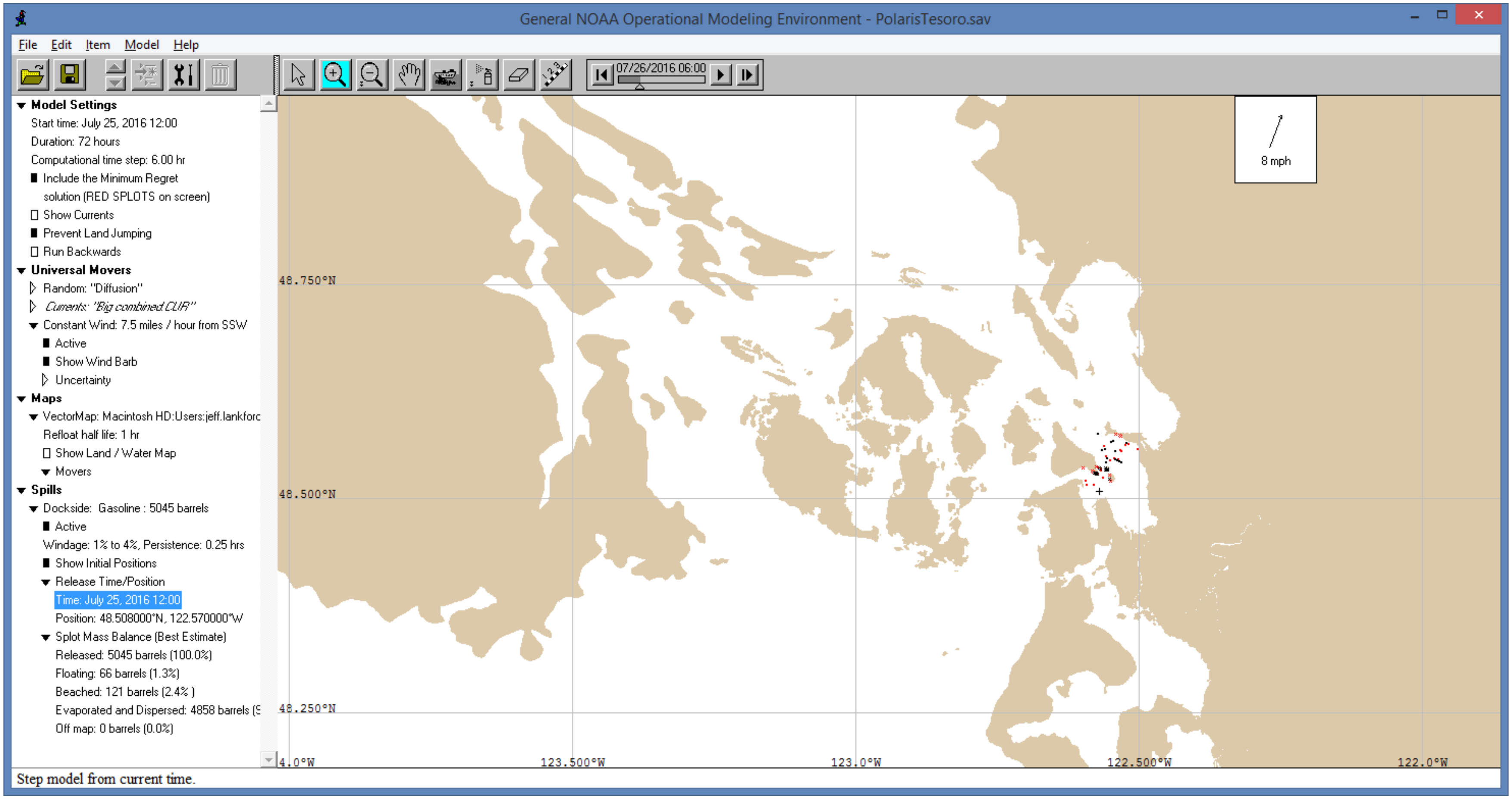

Figure G-4 (d). GNOME Model Output, Dockside, 5045 bbls, summer @ neap tide scenario: Hour 18.

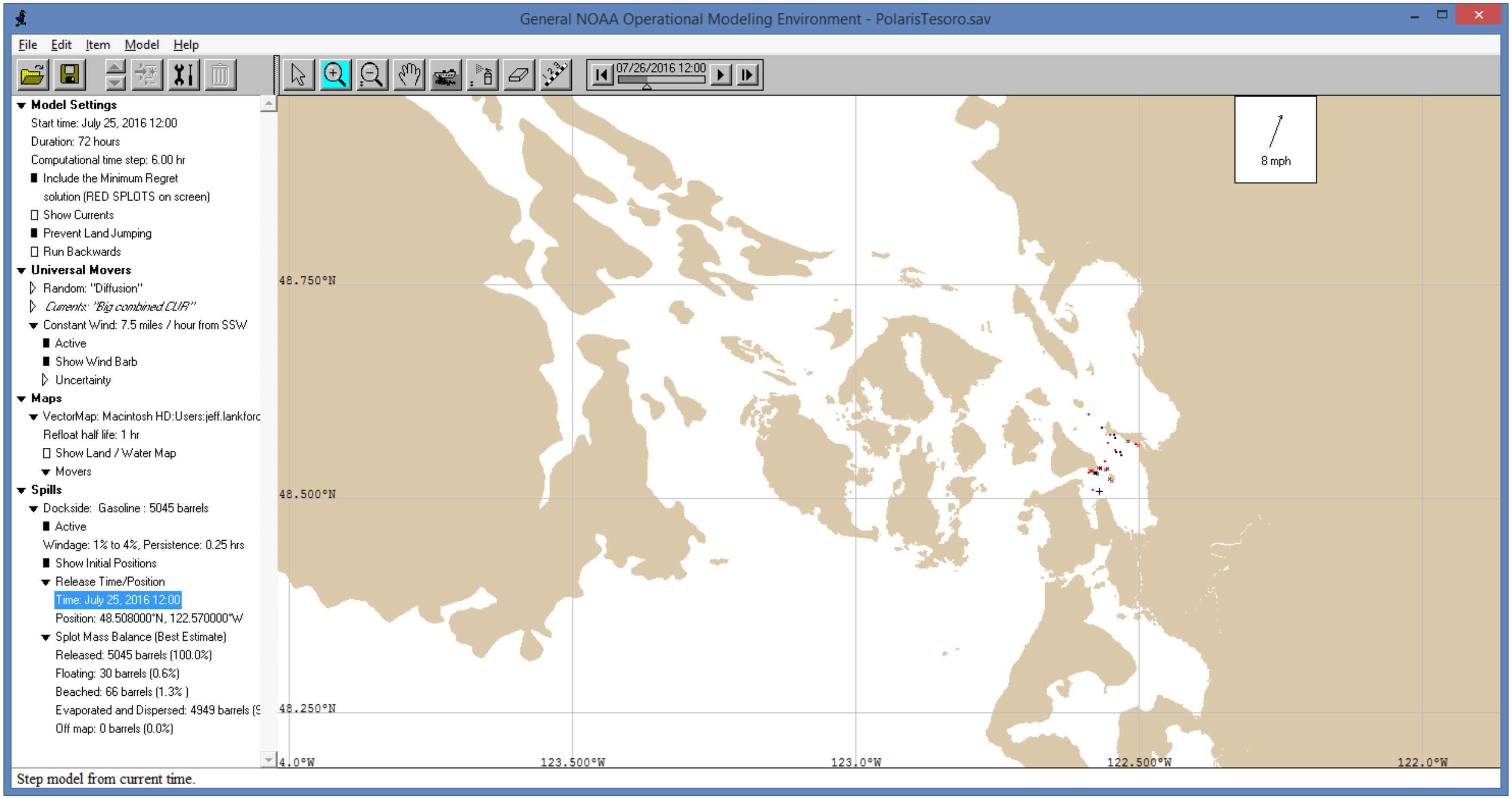

Figure G-4 (e). GNOME Model Output, Dockside, 5045 bbls, summer @ neap tide scenario: Hour 24.

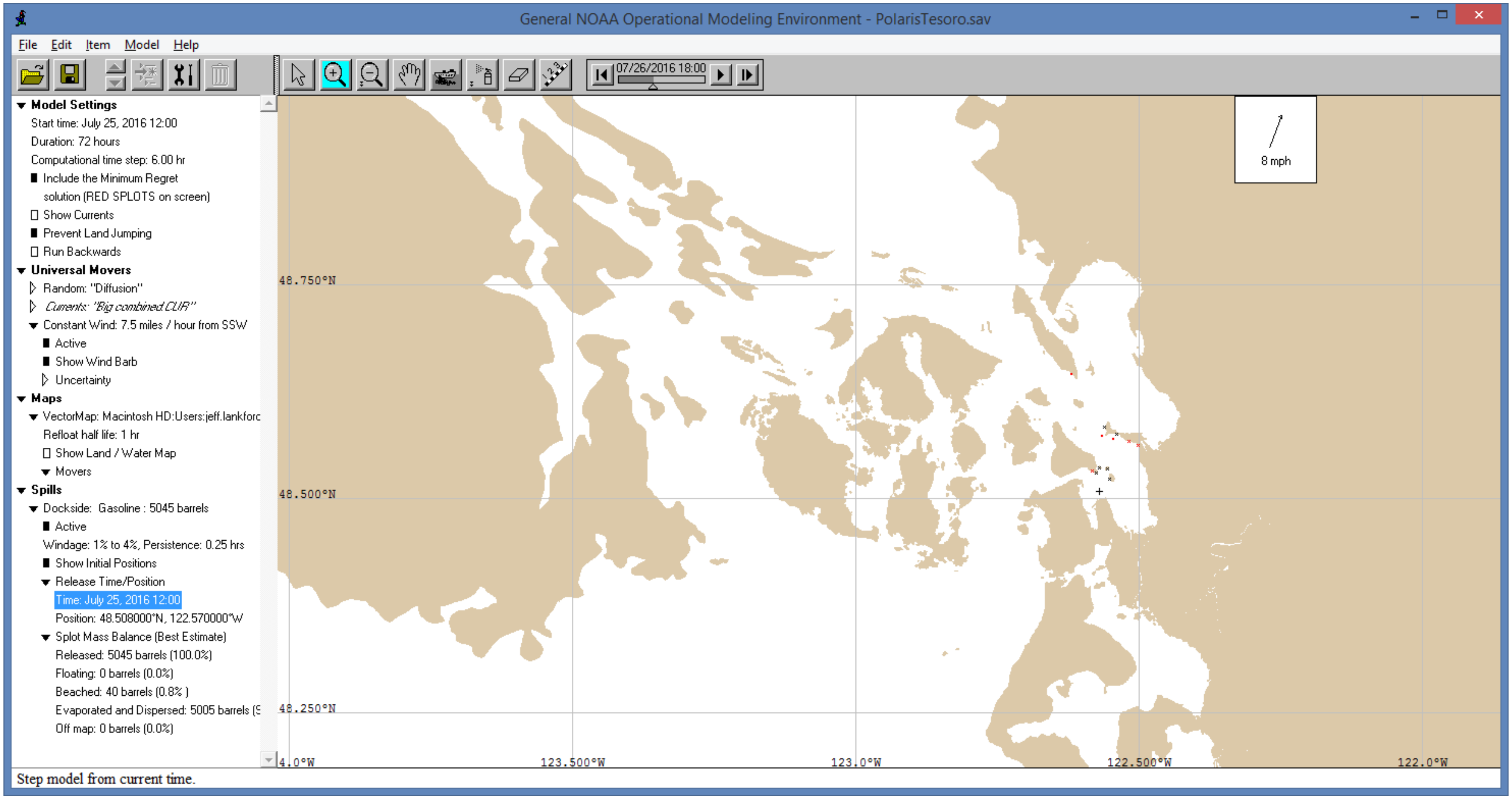

Figure G-4 (f). GNOME Model Output, Dockside, 5045 bbls, summer @ neap tide scenario: Hour 30.

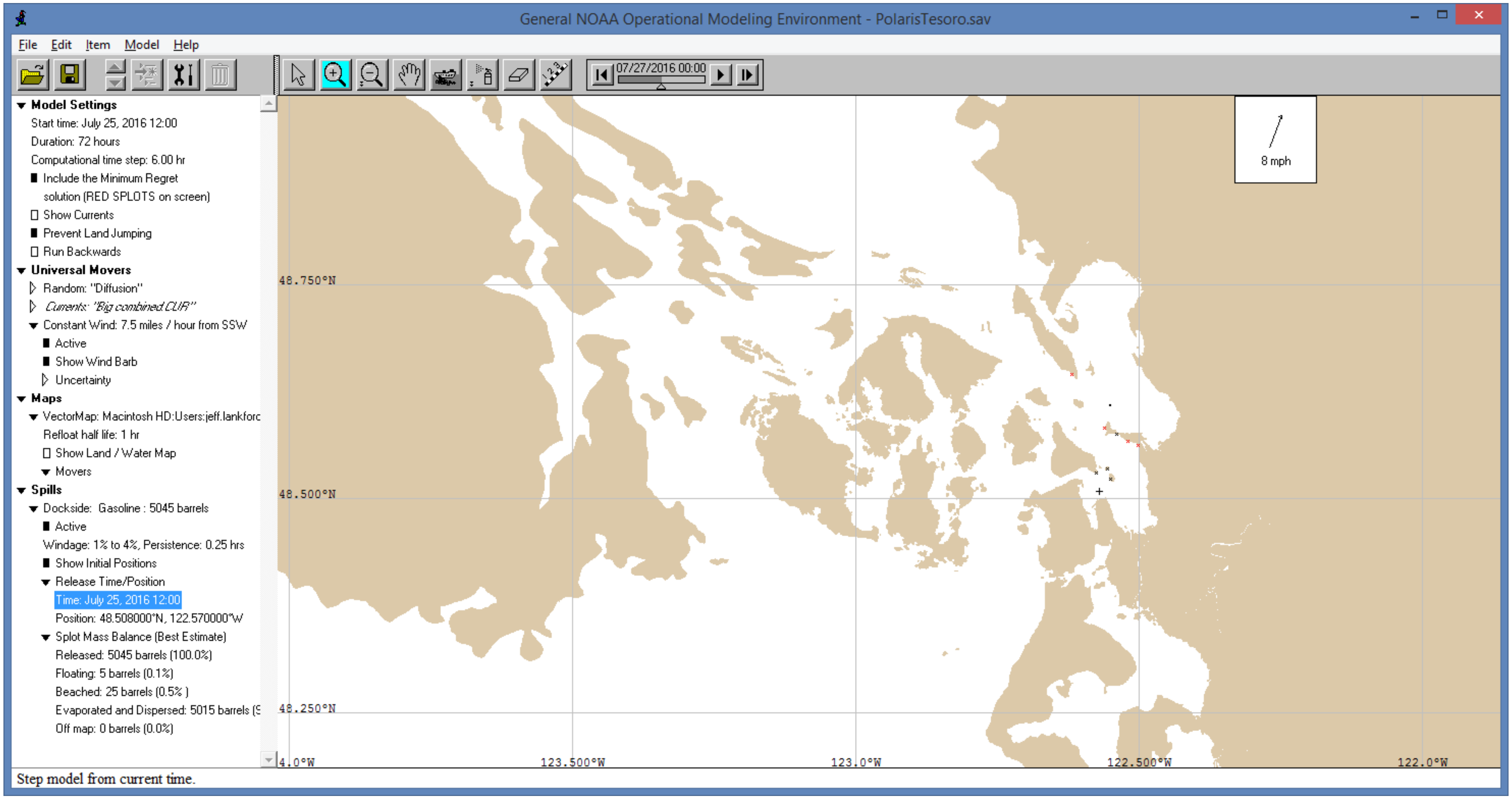

Figure G-4 (g). GNOME Model Output, Dockside, 5045 bbls, summer @ neap tide scenario: Hour 36.

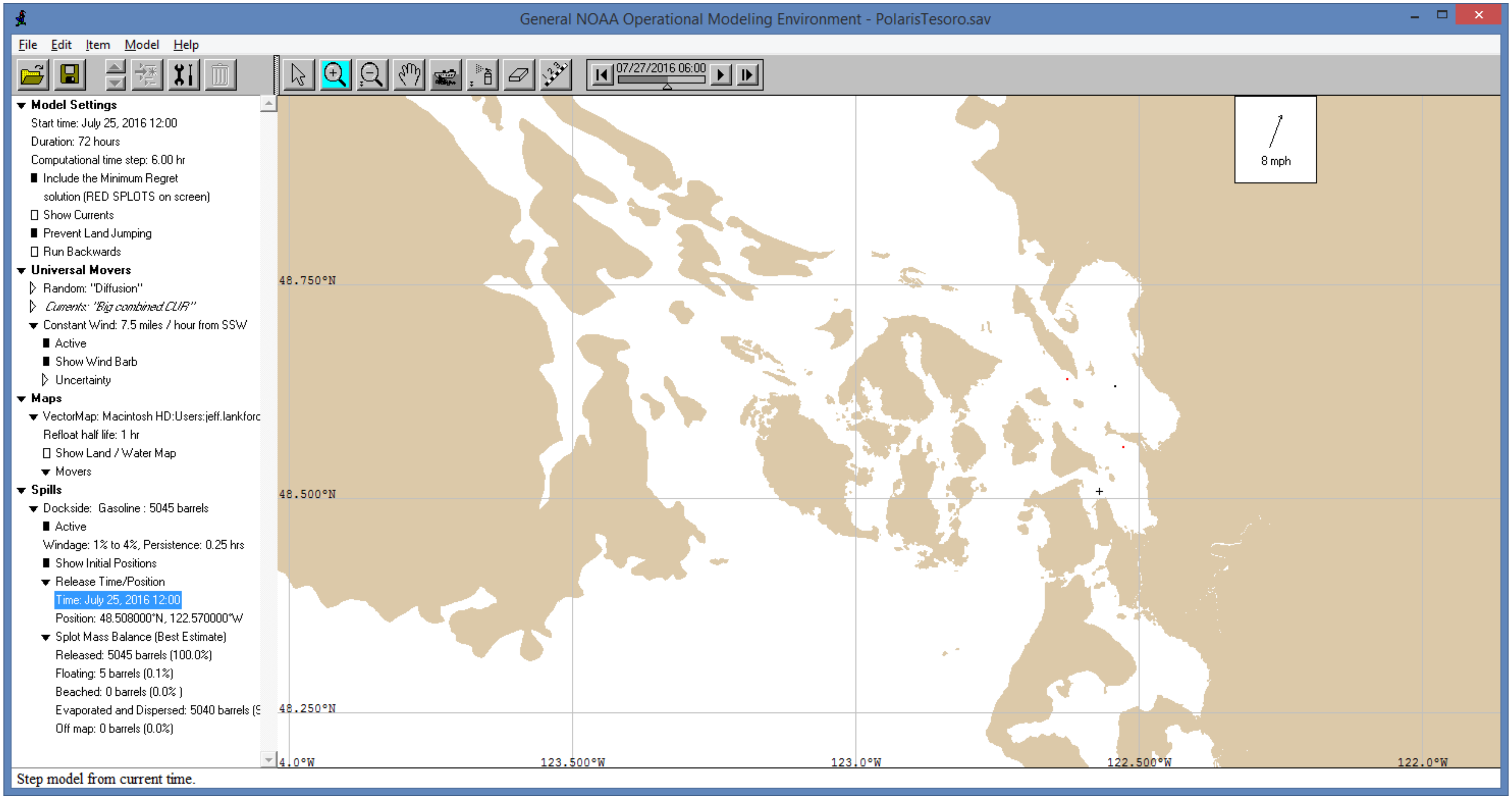

Figure G-4 (h). GNOME Model Output, Dockside, 5045 bbls, summer@ neap tide scenario: Hour 42.

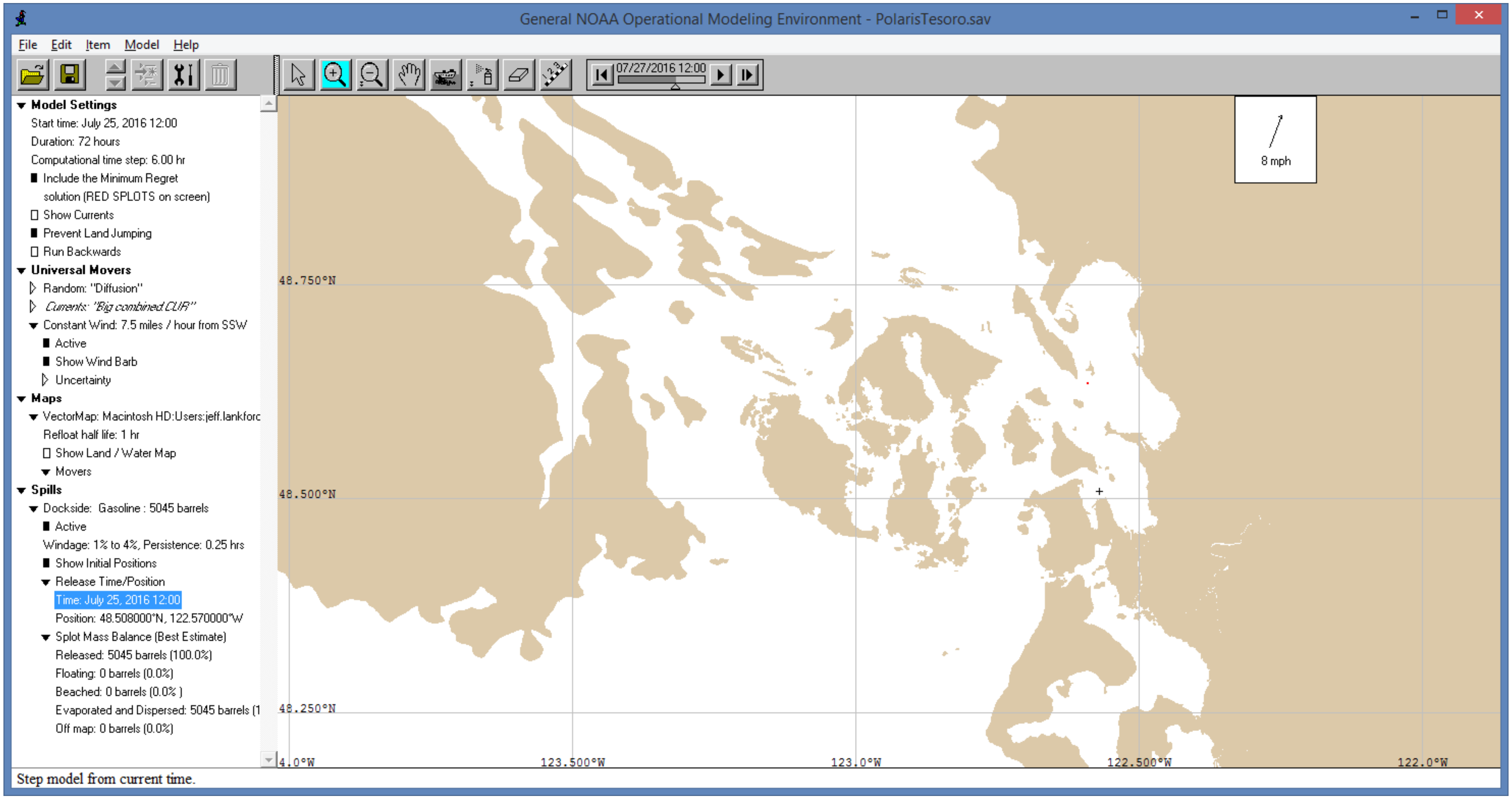

Figure G-4 (i). GNOME Model Output, Dockside, 5045 bbls, summer@ neap tide scenario: Hour 48.

Table G-3. List of Figures for Vessel Transit Scenario W of Neah Bay (STR-A)
GNOME Modeling of Gasoline Trajectories Individual Run Results

Figure #	Season	Tidal Influence	Wind Speed (mph) /Wind Direction	Volume bbl	Date/Time	Hour into model run
Figure G-5 (a)	Winter	Spring	14.4/ESE	330,000	07-Feb-16 12:00	0
Figure G-5 (b)					07-Feb-16 18:00	6
Figure G-5 (c)					08-Feb-16 00:00	12
Figure G-5 (d)					08-Feb-16 06:00	18
Figure G-5 (e)					08-Feb-16 12:00	24
Figure G-5 (f)					08-Feb-16 18:00	30
Figure G-5 (g)					09-Feb-16 00:00	36
Figure G-5 (h)					09-Feb-16 06:00	42
Figure G-5 (i)					09-Feb-16 12:00	48
Figure G-6 (a)	Winter	Neap	14.4/ESE	330,000	27-Feb-16 12:00	0
Figure G-6 (b)					27-Feb-16 18:00	6
Figure G-6 (c)					28-Feb-16 00:00	12
Figure G-6 (d)					28-Feb-16 06:00	18
Figure G-6 (e)					28-Feb-16 12:00	24
Figure G-6 (f)					28-Feb-16 18:00	30
Figure G-6 (g)					29-Feb-16 00:00	36
Figure G-6 (h)					29-Feb-16 06:00	42
Figure G-6 (i)					29-Feb-16 12:00	48
Figure G-7 (a)	Summer	Spring	7.9/WSW	330,000	04-Jul-16 12:00	0
Figure G-7 (b)					04-Jul -16 18:00	6
Figure G-7 (c)					05-Jul -16 00:00	12
Figure G-7 (d)					05-Jul -16 06:00	18
Figure G-7 (e)					05-Jul -16 12:00	24
Figure G-7 (f)					05-Jul -16 18:00	30
Figure G-7 (g)					06-Jul -16 00:00	36
Figure G-7 (h)					06-Jul -16 06:00	42
Figure G-7 (i)					06-Jul -16 12:00	48
Figure G-8 (a)	Summer	Neap	7.9/WSW	330,000	11-Jul-16 12:00	0
Figure G-8 (b)					11-Jul -16 18:00	6
Figure G-8 (c)					12-Jul -16 00:00	12
Figure G-8 (d)					12-Jul -16 06:00	18
Figure G-8 (e)					12-Jul -16 12:00	24
Figure G-8 (f)					12-Jul -16 18:00	30
Figure G-8 (g)					13-Jul -16 00:00	36
Figure G-8 (h)					13-Jul -16 06:00	42
Figure G-8 (i)					13-Jul -16 12:00	48

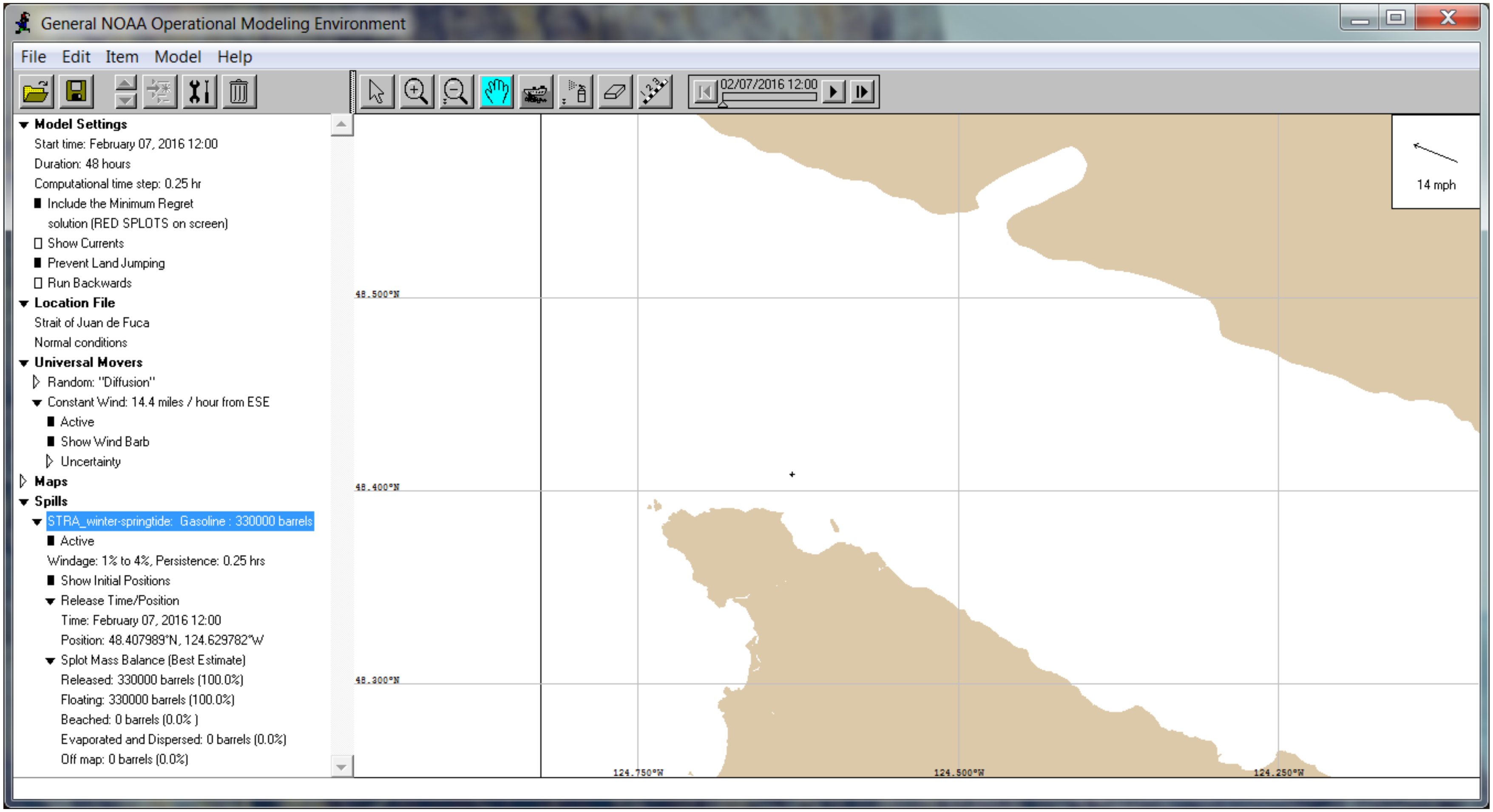

Figure G-5 (a). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ spring tide scenario: Hour 0.

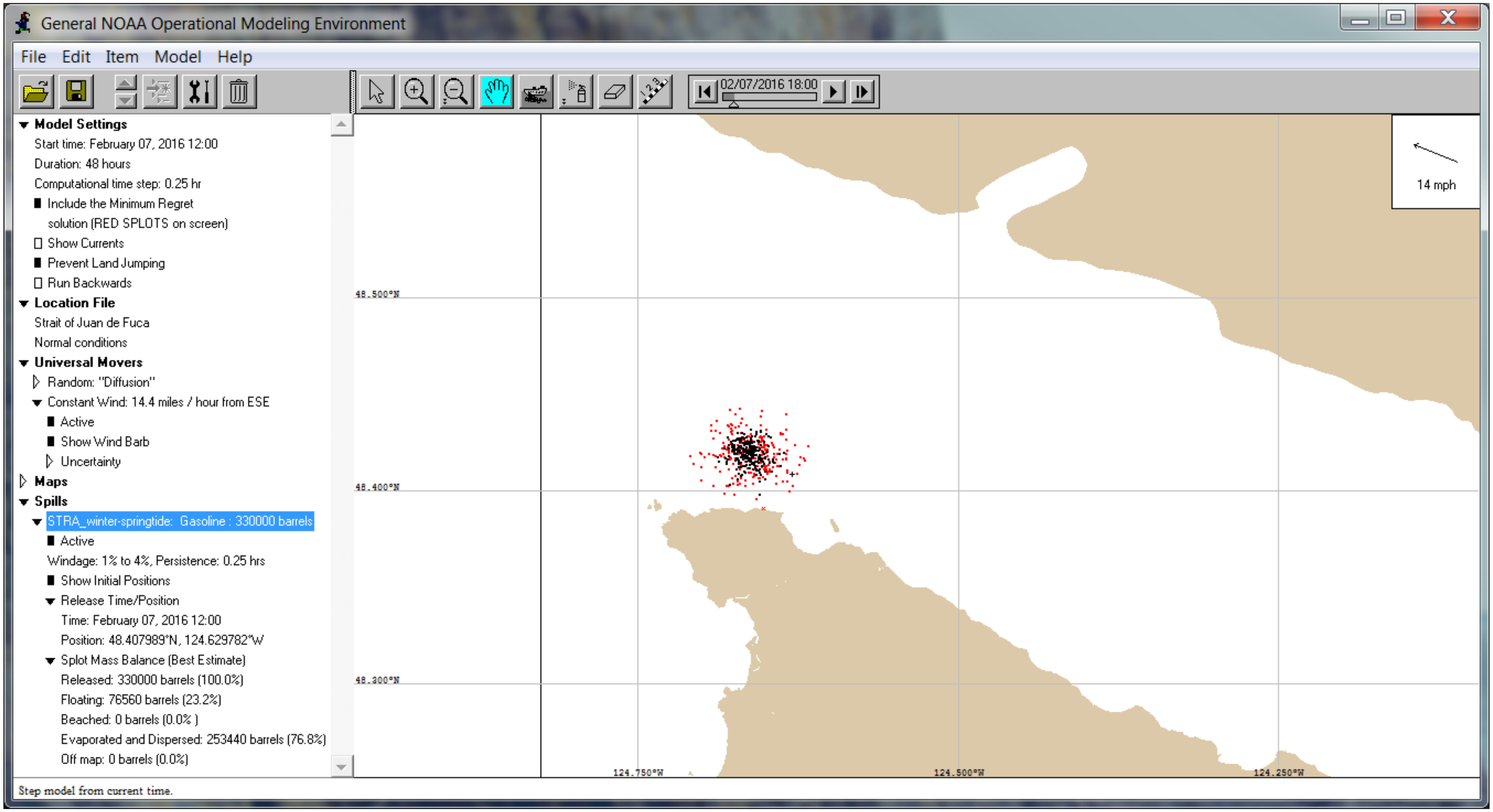

Figure G-5 (b). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ spring tide scenario: Hour 6.

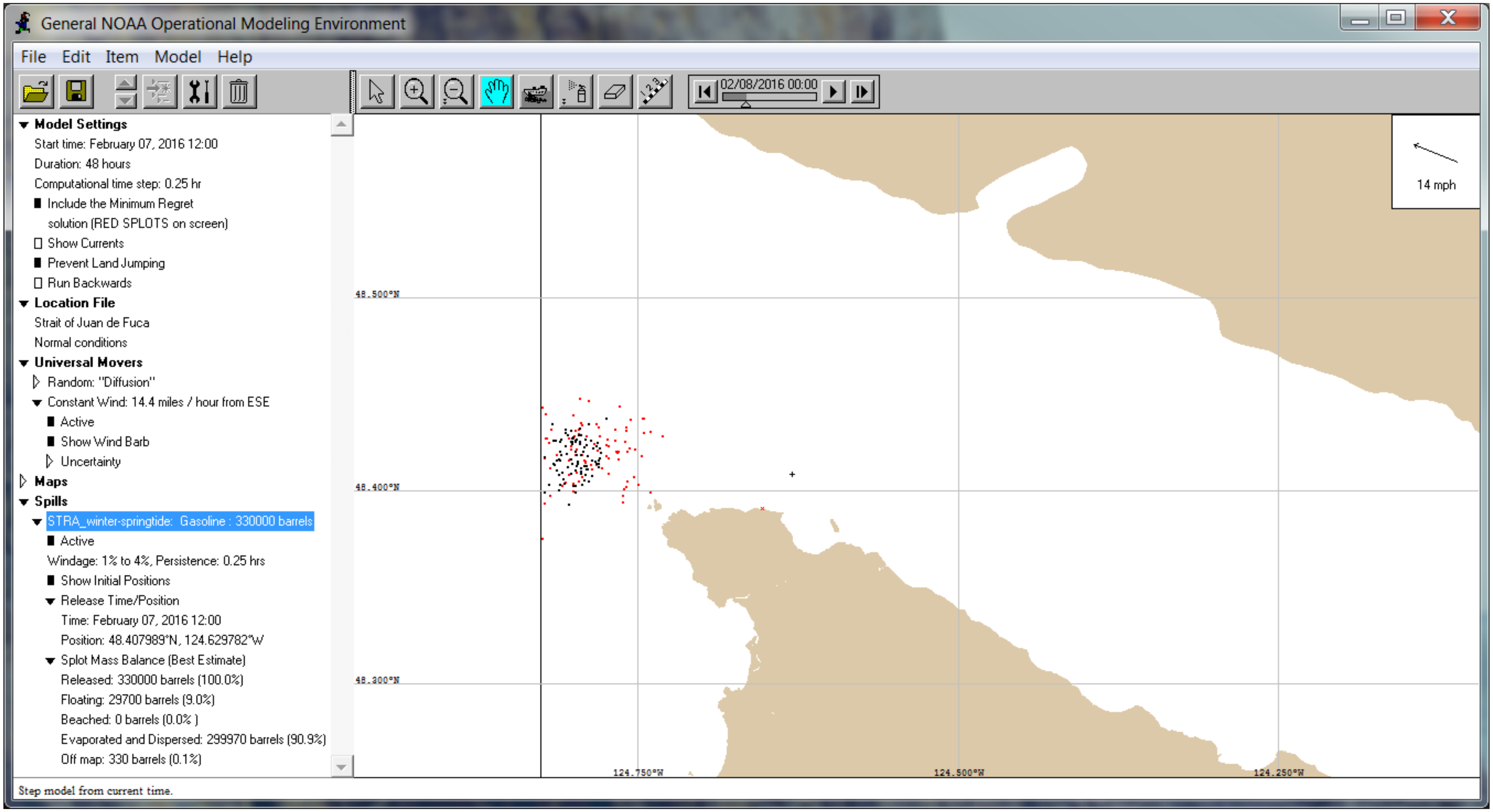

Figure G-5 (c). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ spring tide scenario: Hour 12.

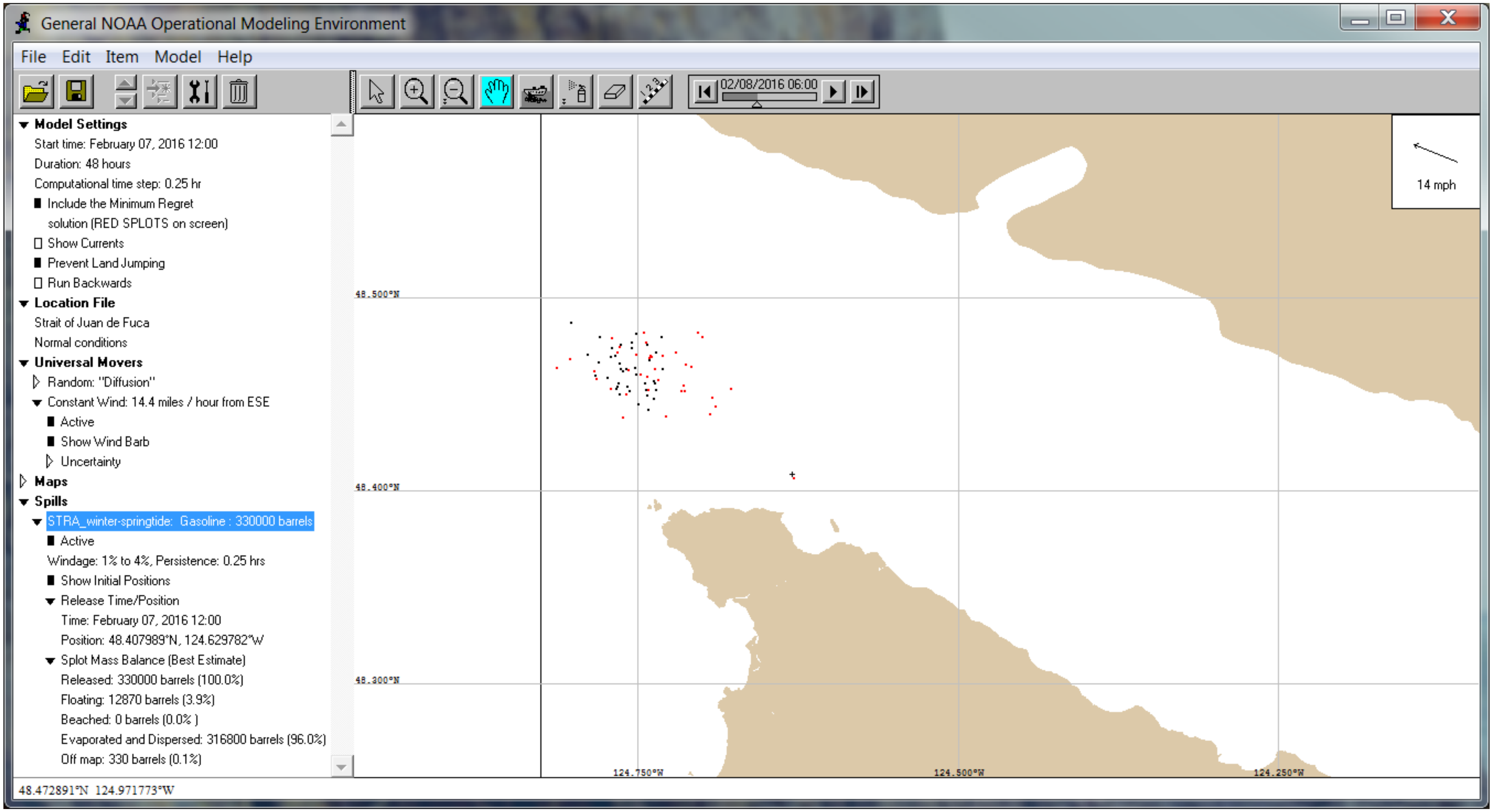

Figure G-5 (d). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ spring tide scenario: Hour 18.

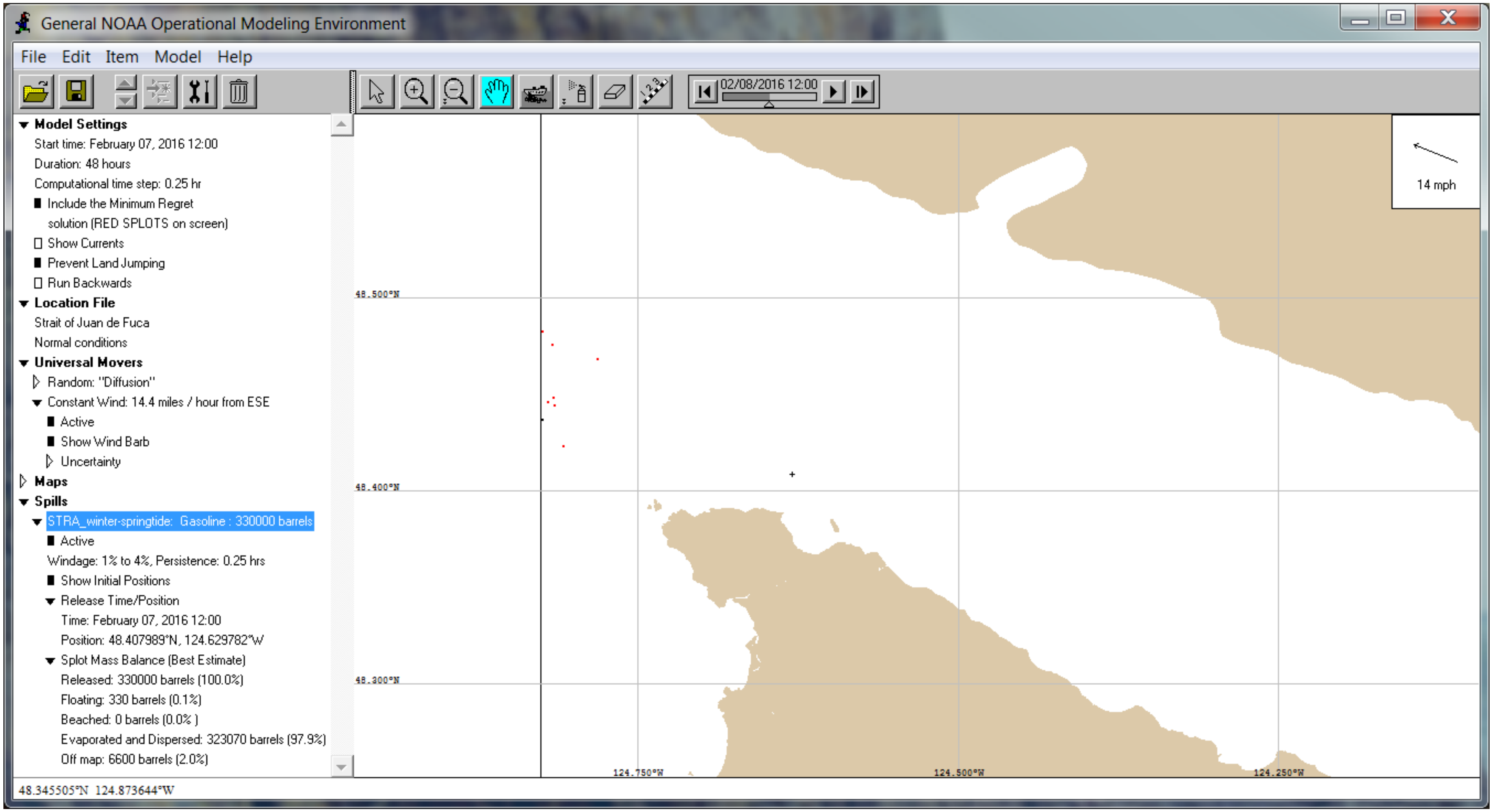

Figure G-5 (e). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ spring tide scenario: Hour 24.

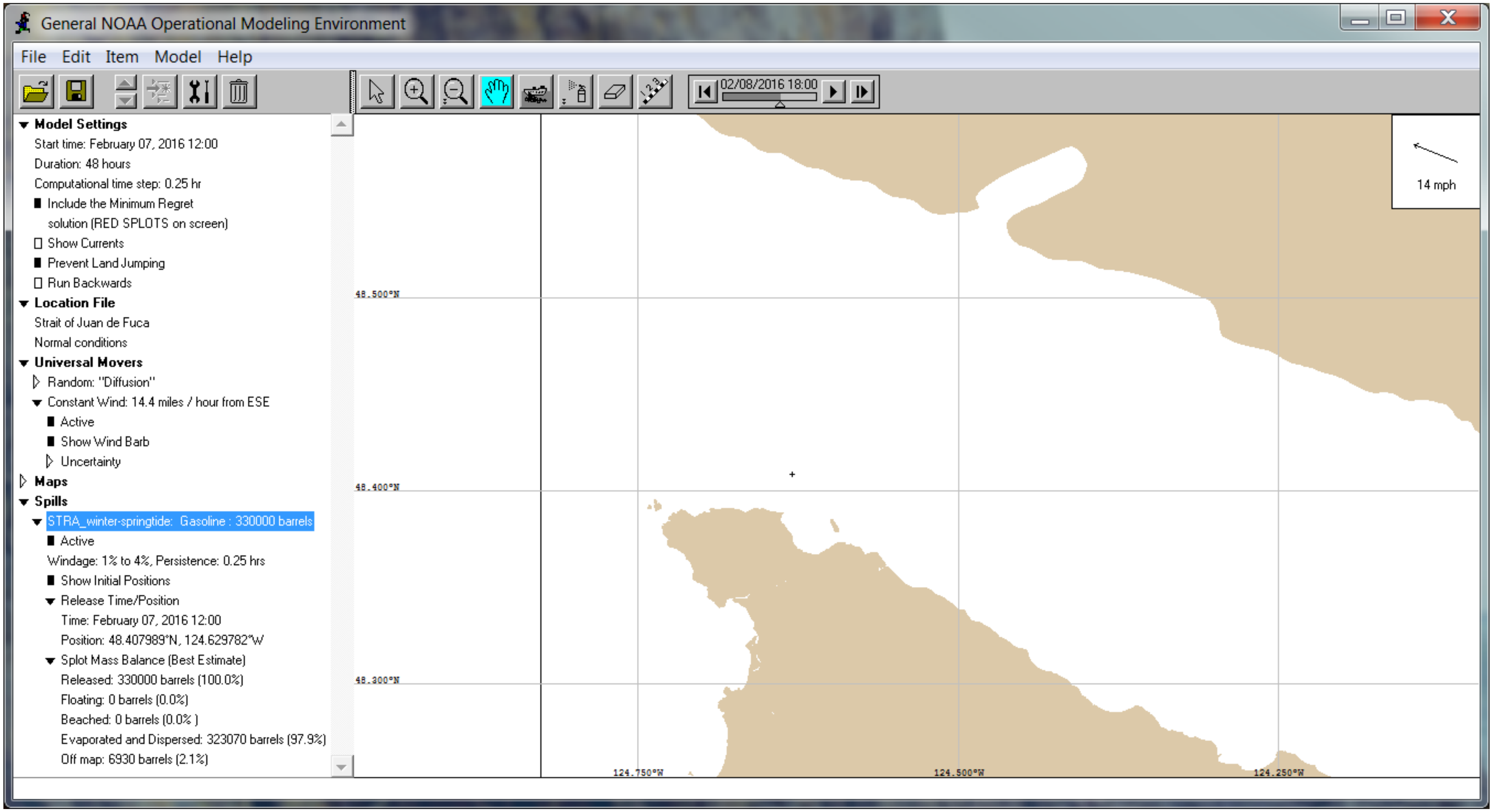

Figure G-5 (f). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ spring tide scenario: Hour 30.

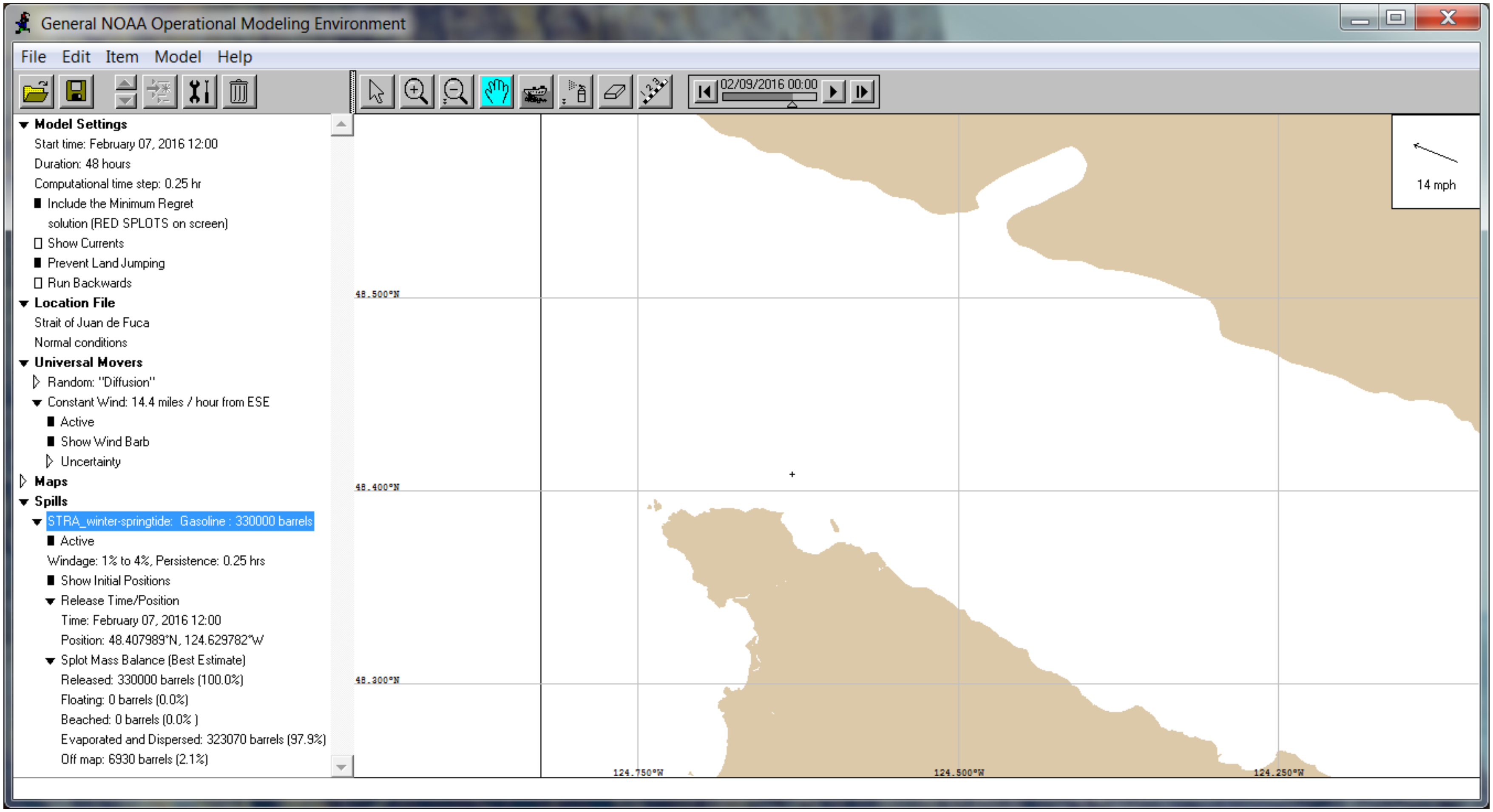

Figure G-5 (g). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ spring tide scenario: Hour 36.

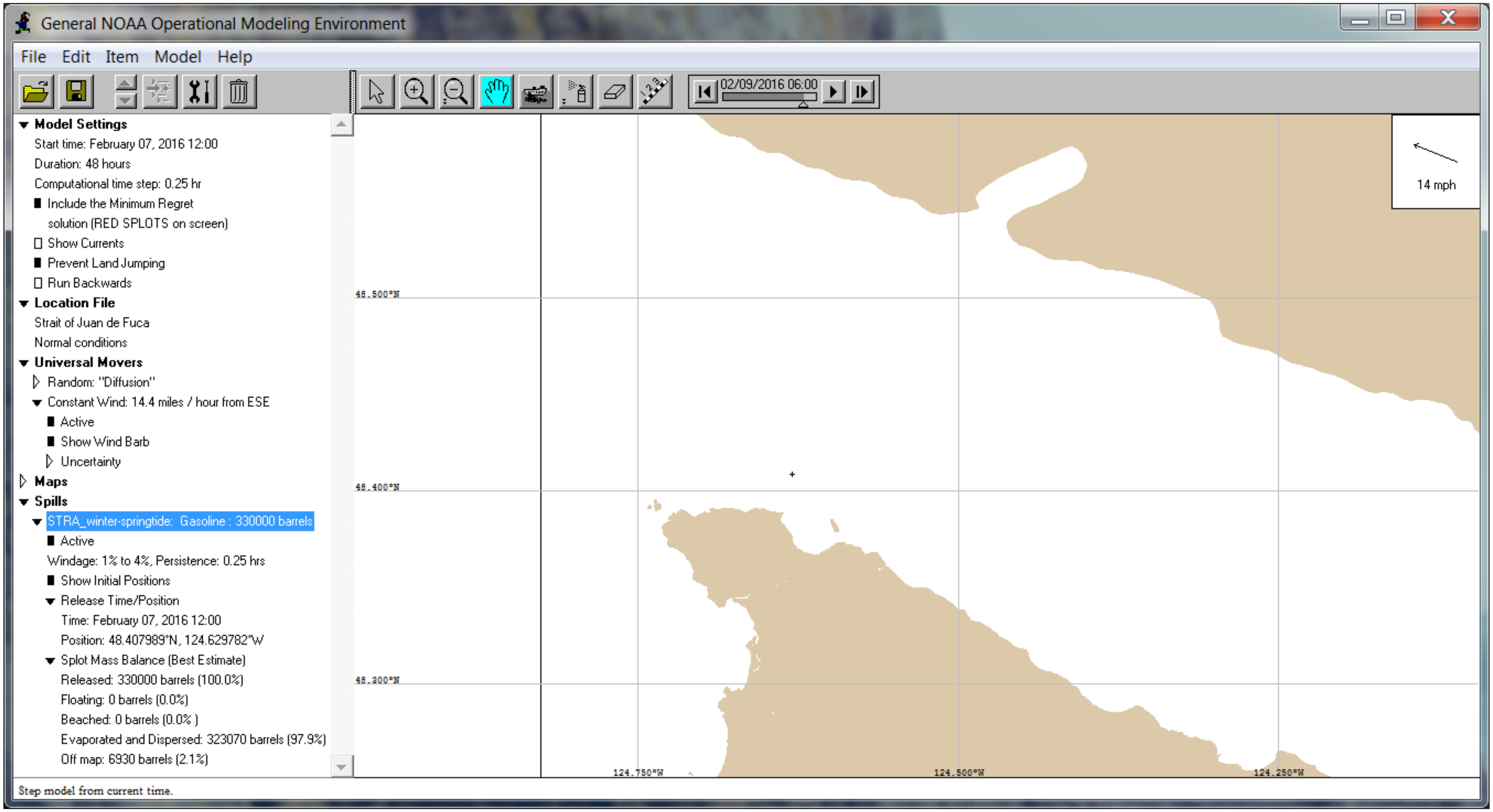

Figure G-5 (h). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ spring tide scenario: Hour 42.

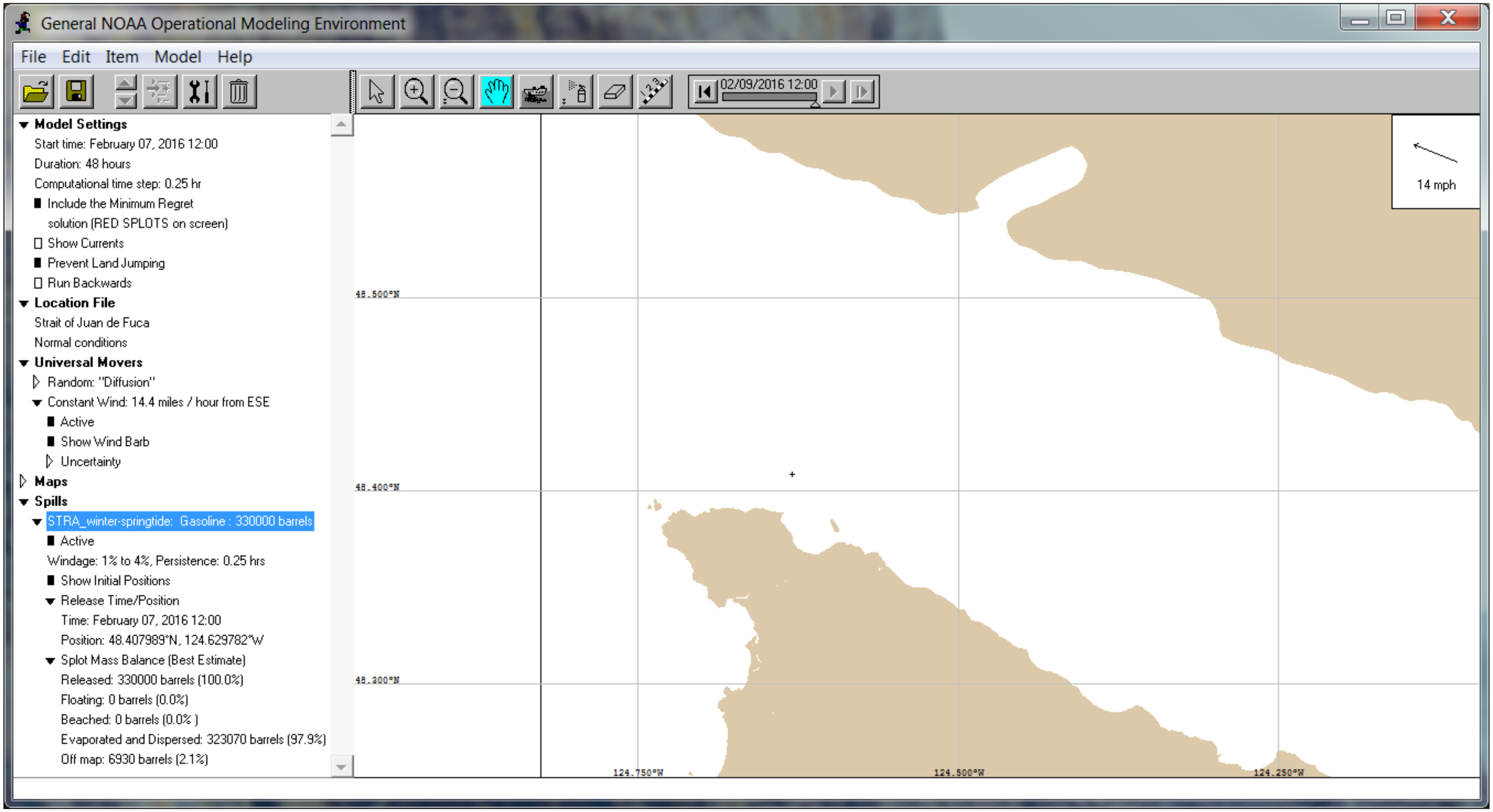

Figure G-5 (i). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ spring tide scenario: Hour 48.

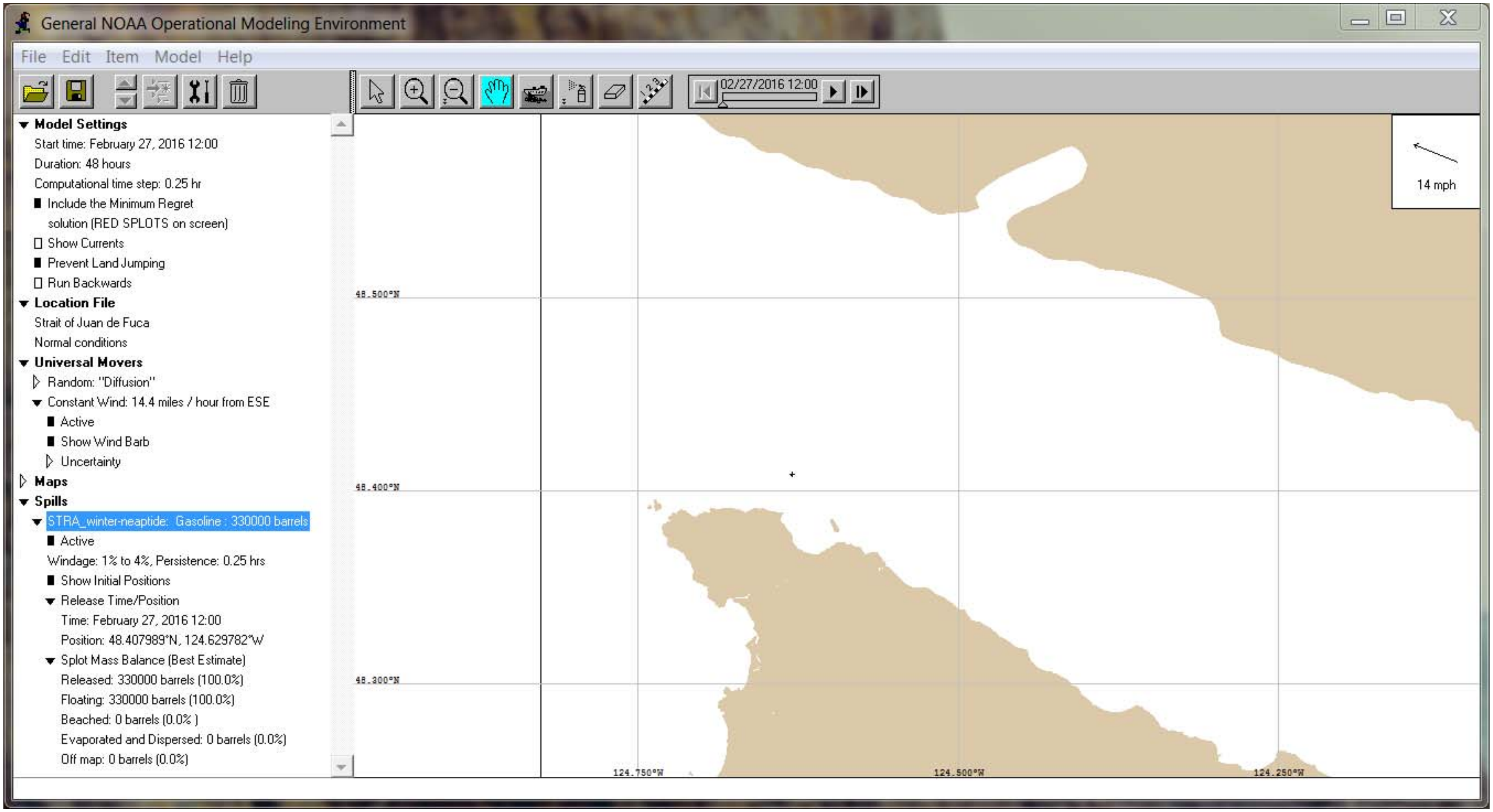

Figure G-6 (a). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ neap tide scenario: Hour 0.

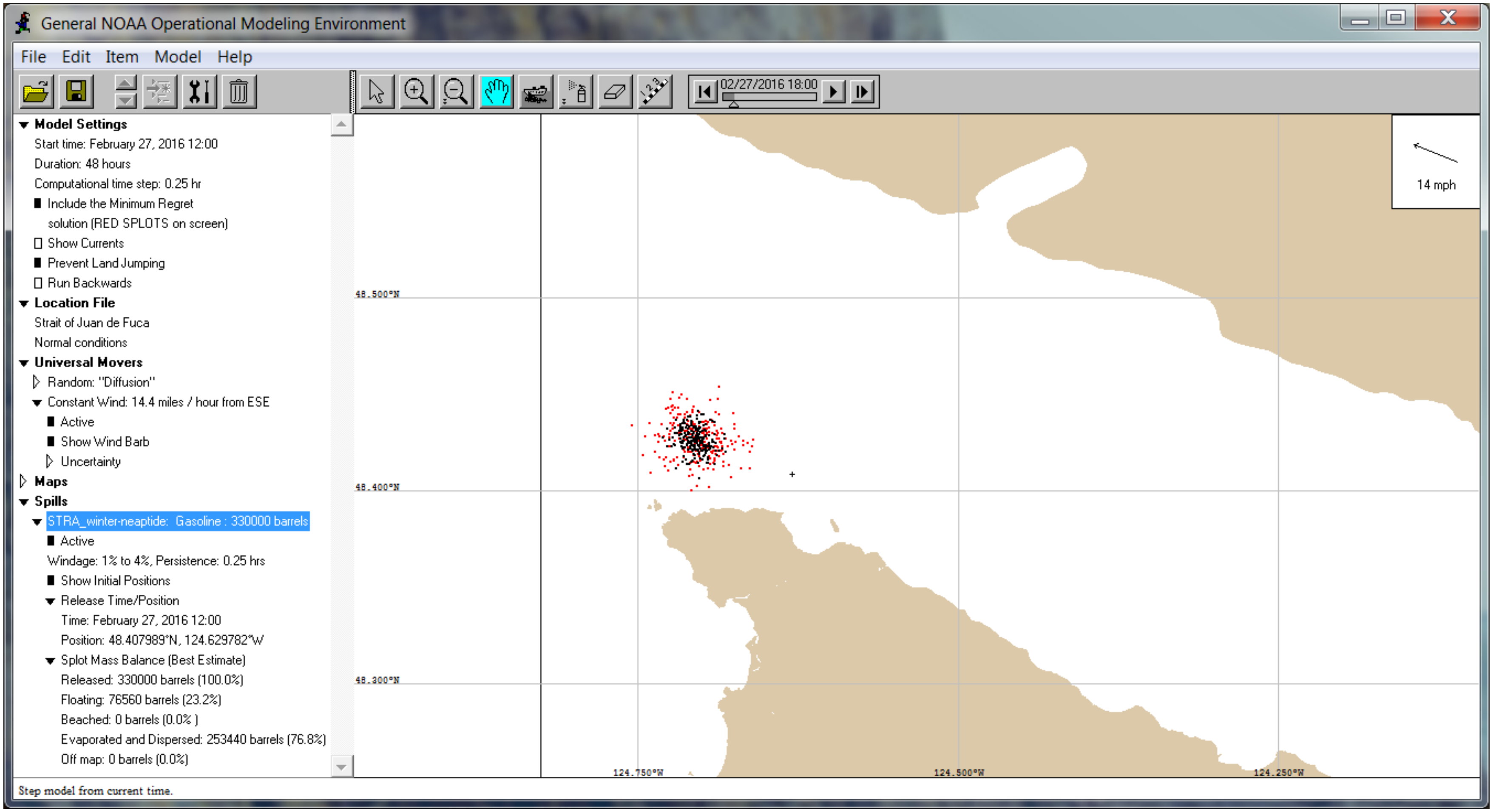

Figure G-6 (b). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ neap tide scenario: Hour 6.

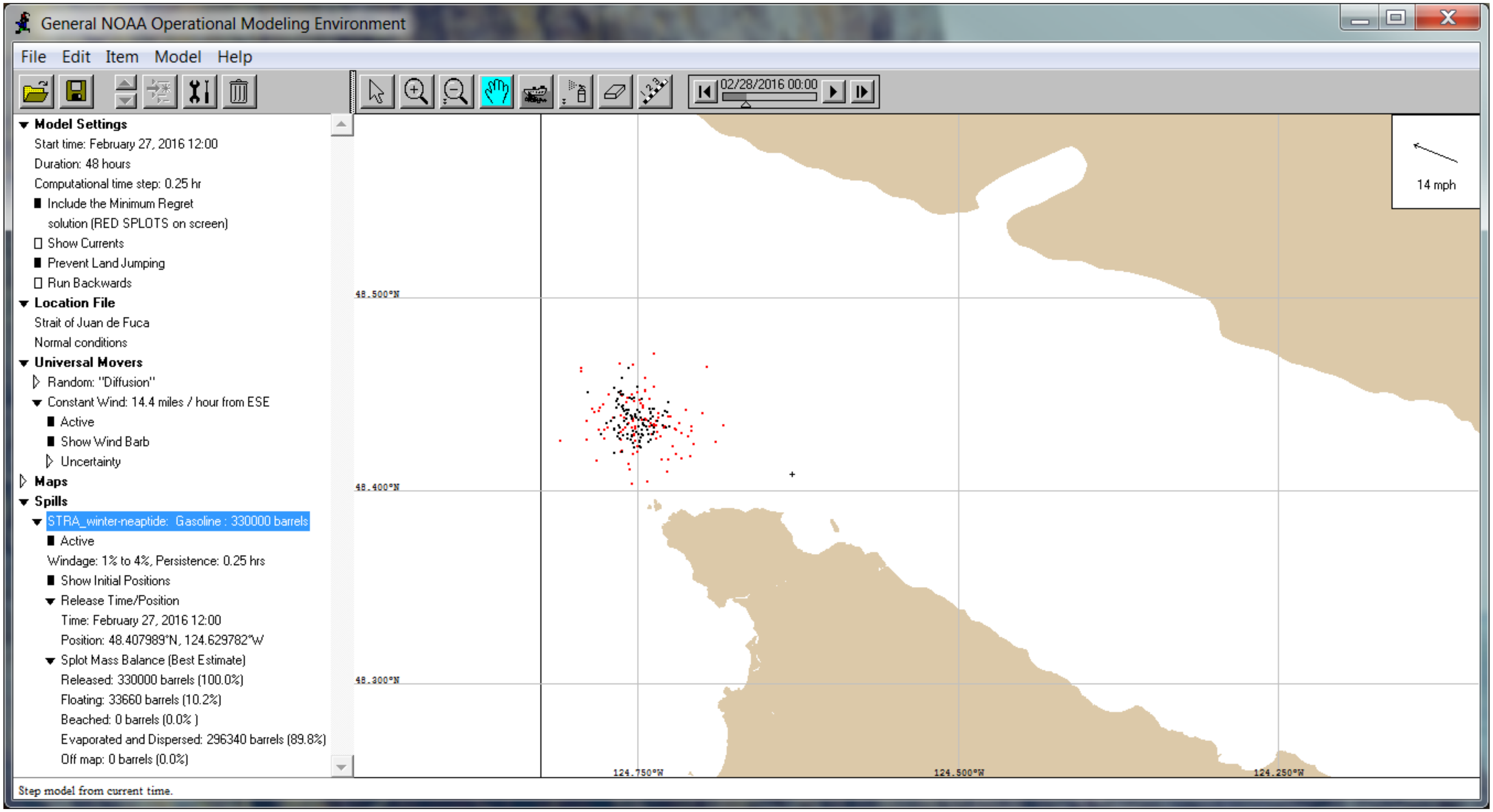

Figure G-6 (c). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ neap tide scenario: Hour 12.

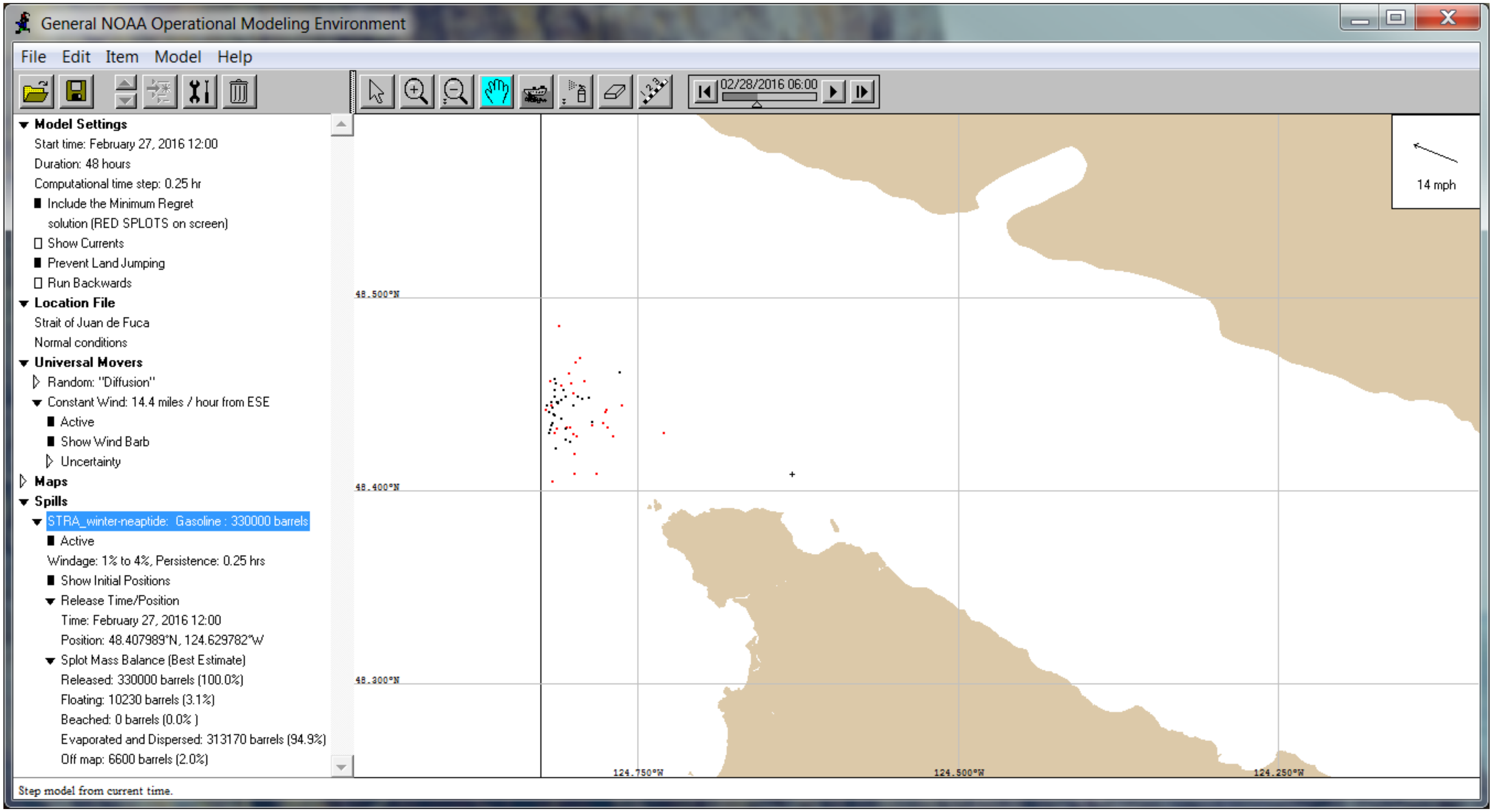

Figure G-6 (d). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ neap tide scenario: Hour 18.

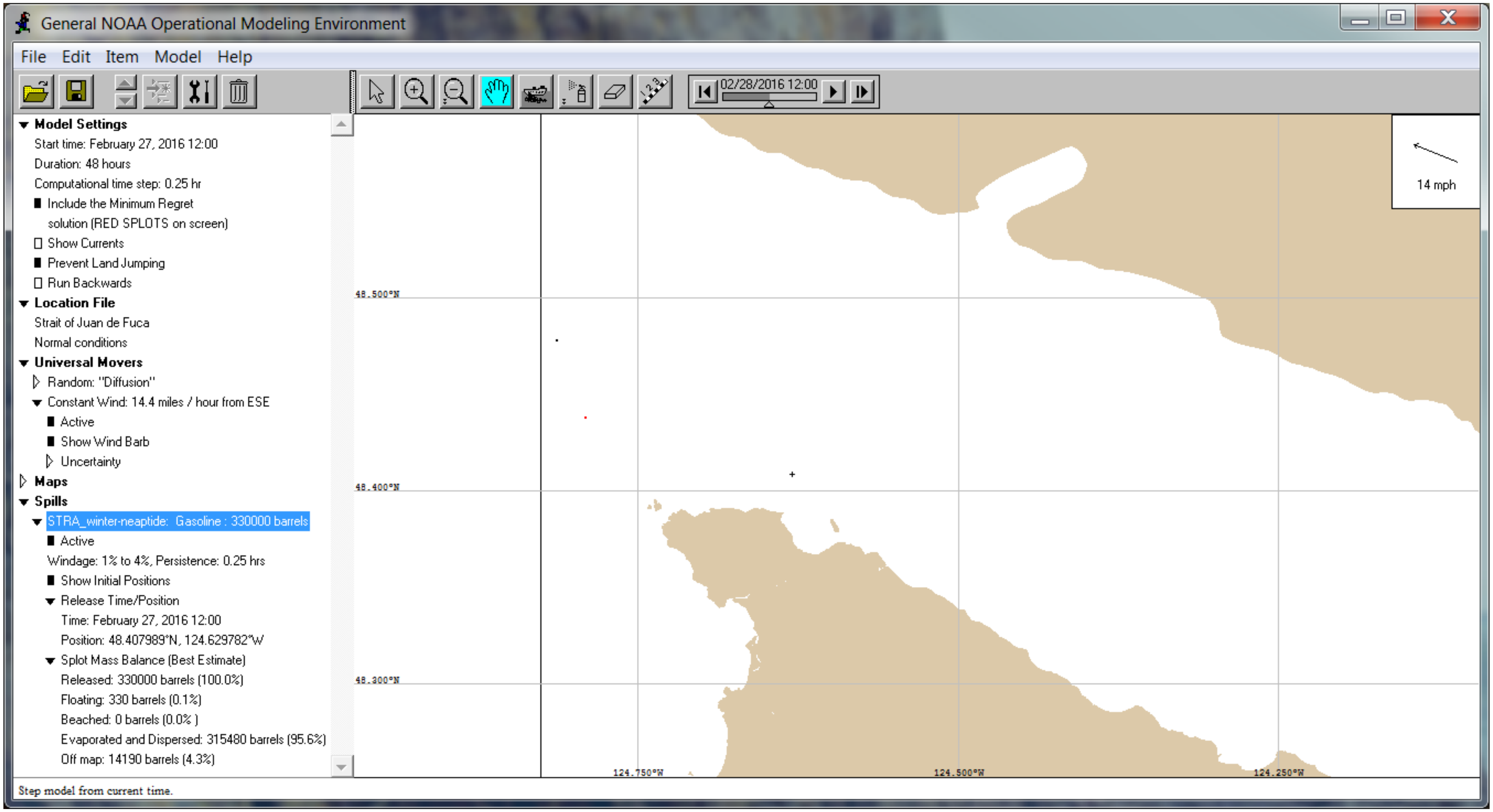

Figure G-6 (e). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ neap tide scenario: Hour 24.

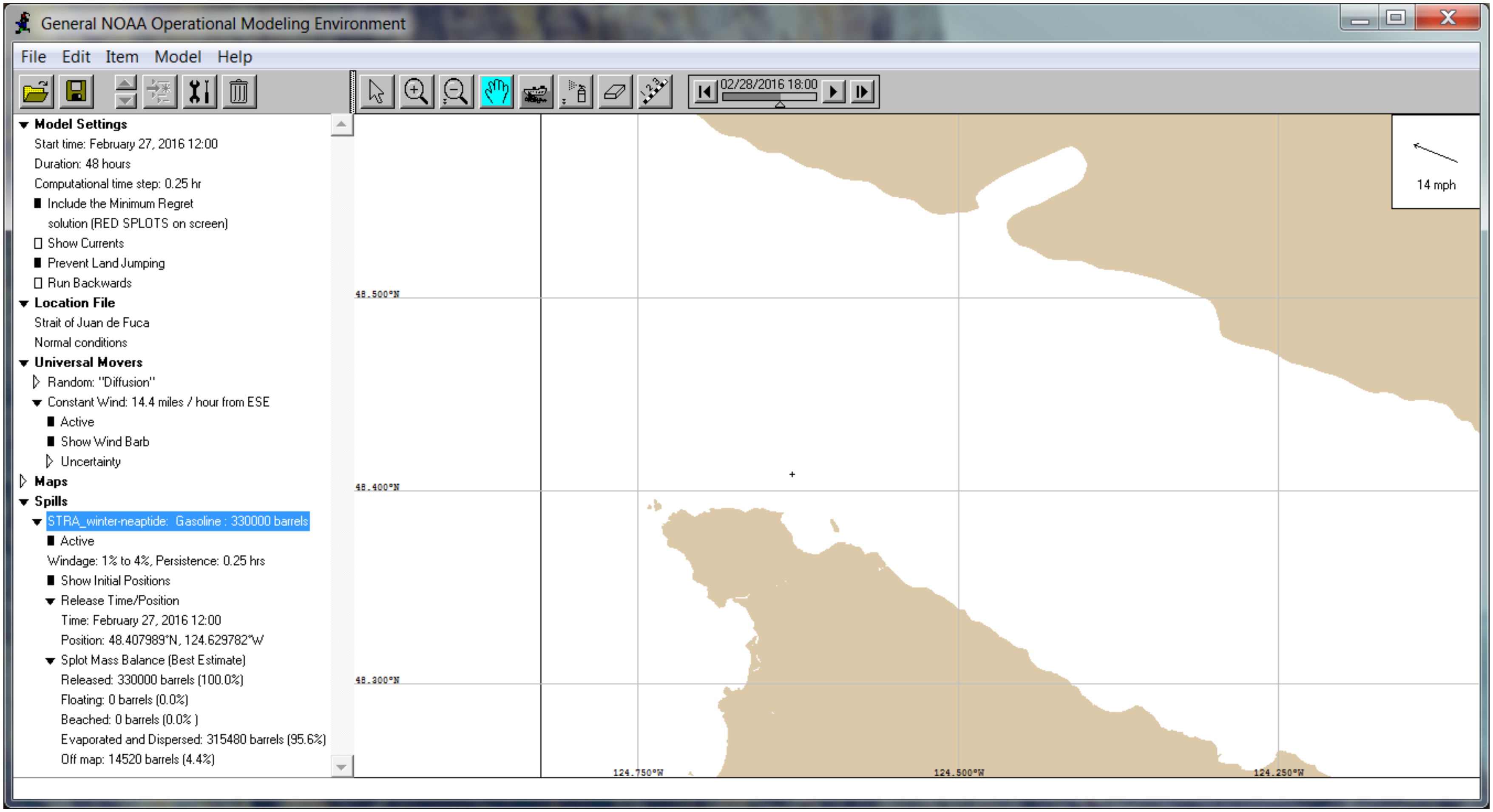

Figure G-6 (f). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ neap tide scenario: Hour 30.

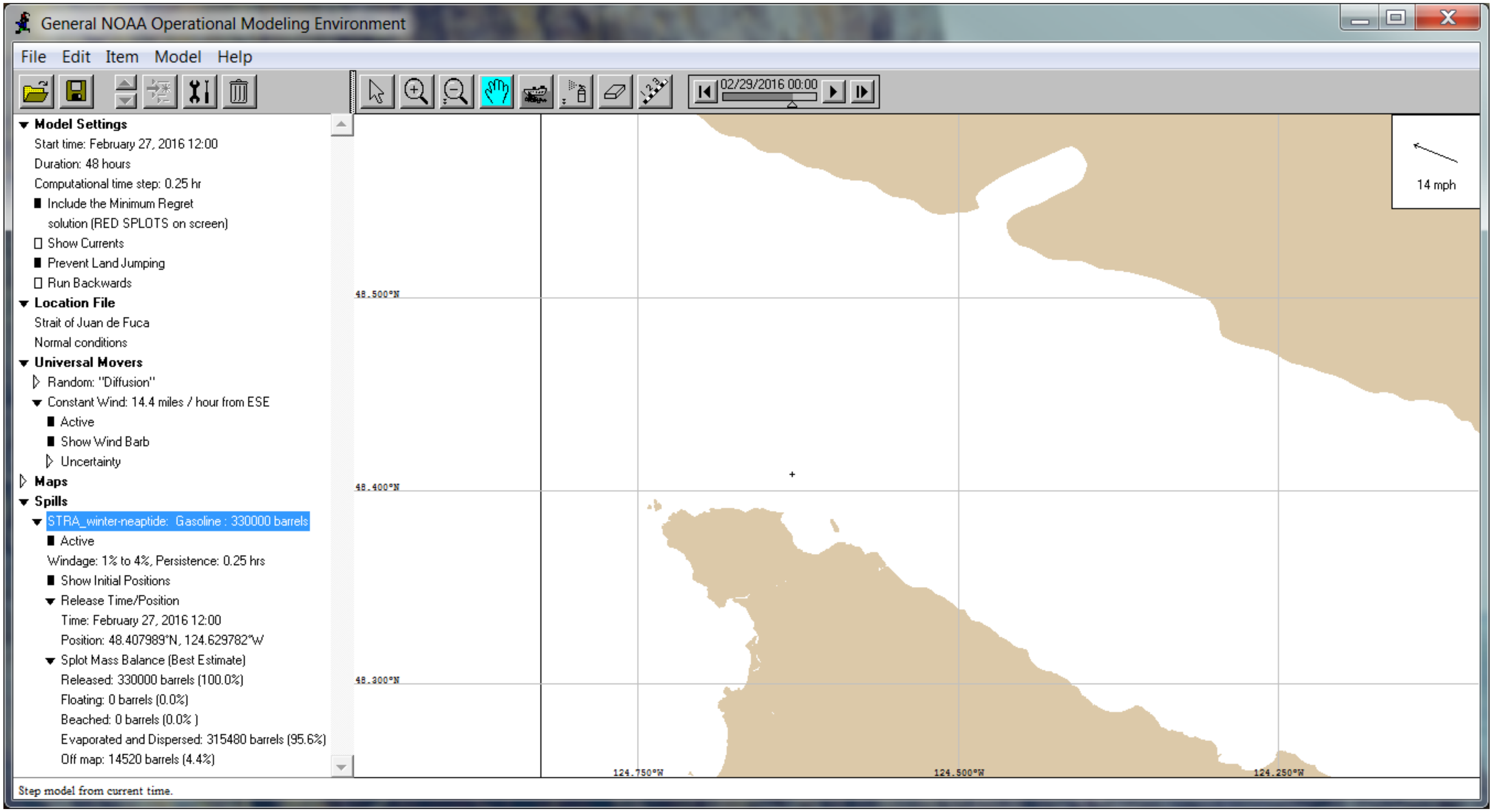

Figure G-6 (g). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ neap tide scenario: Hour 36.

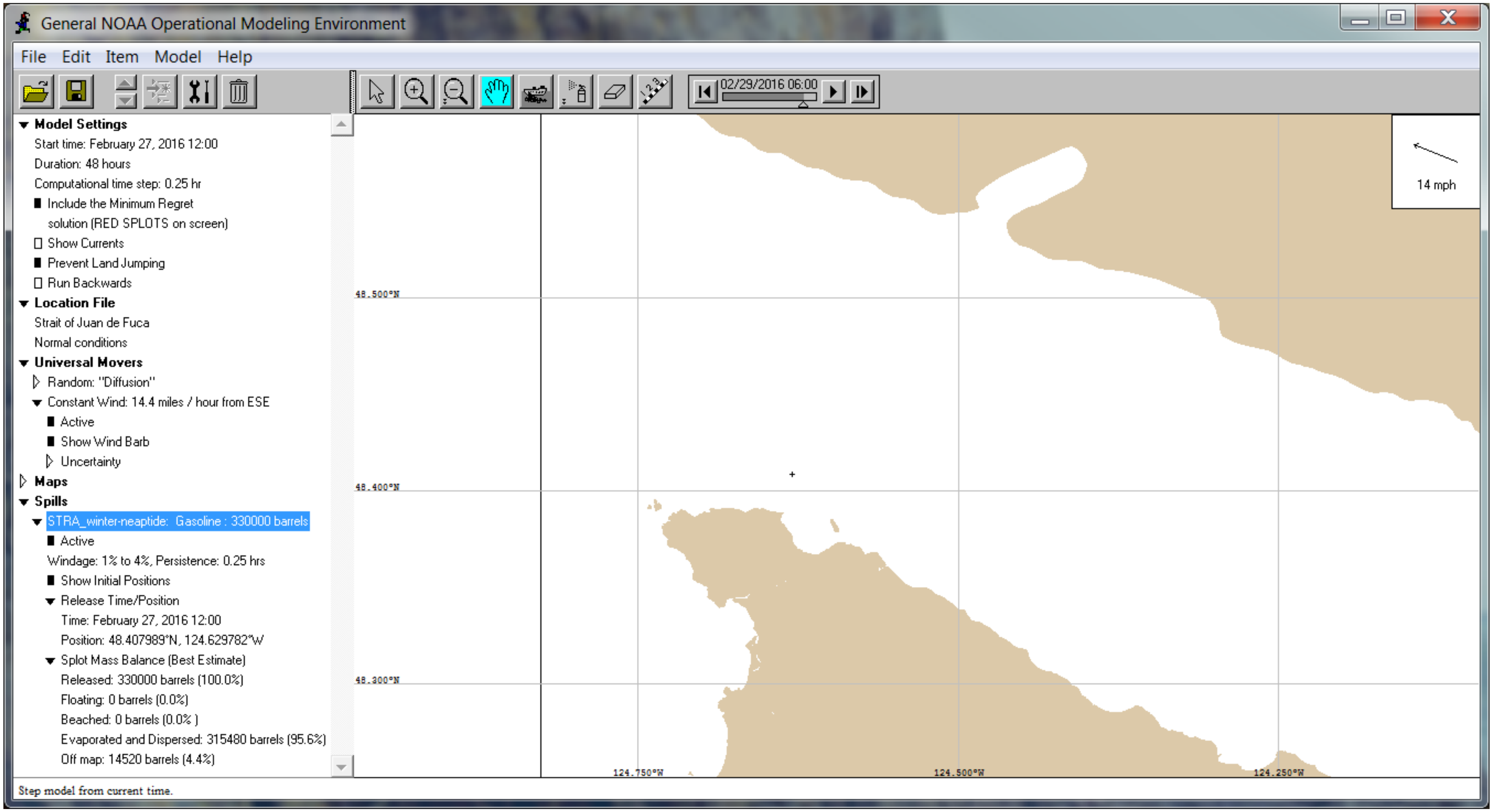

Figure G-6 (h). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ neap tide scenario: Hour 42.

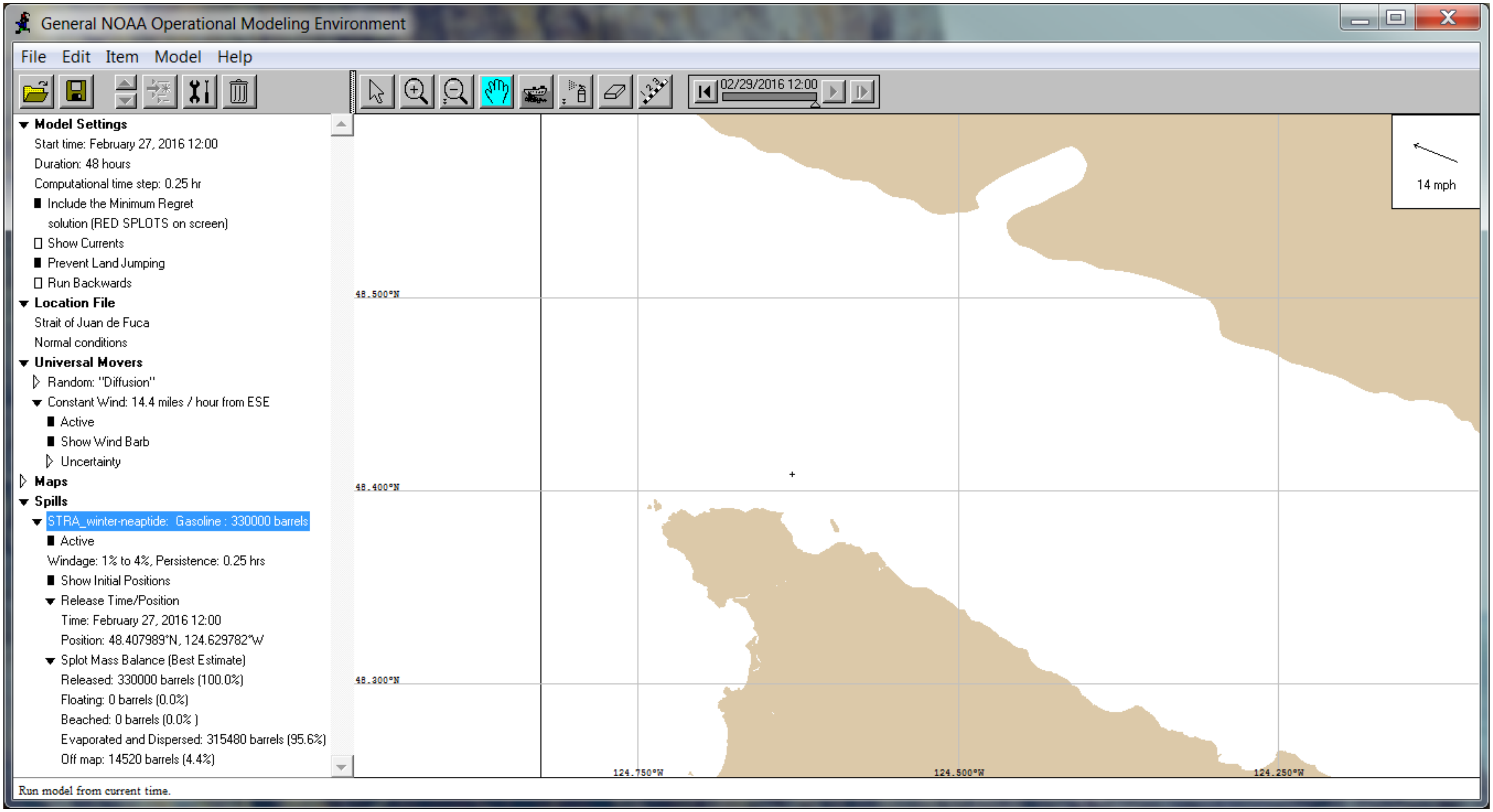

Figure G-6 (i). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, winter@ neap tide scenario: Hour 48.

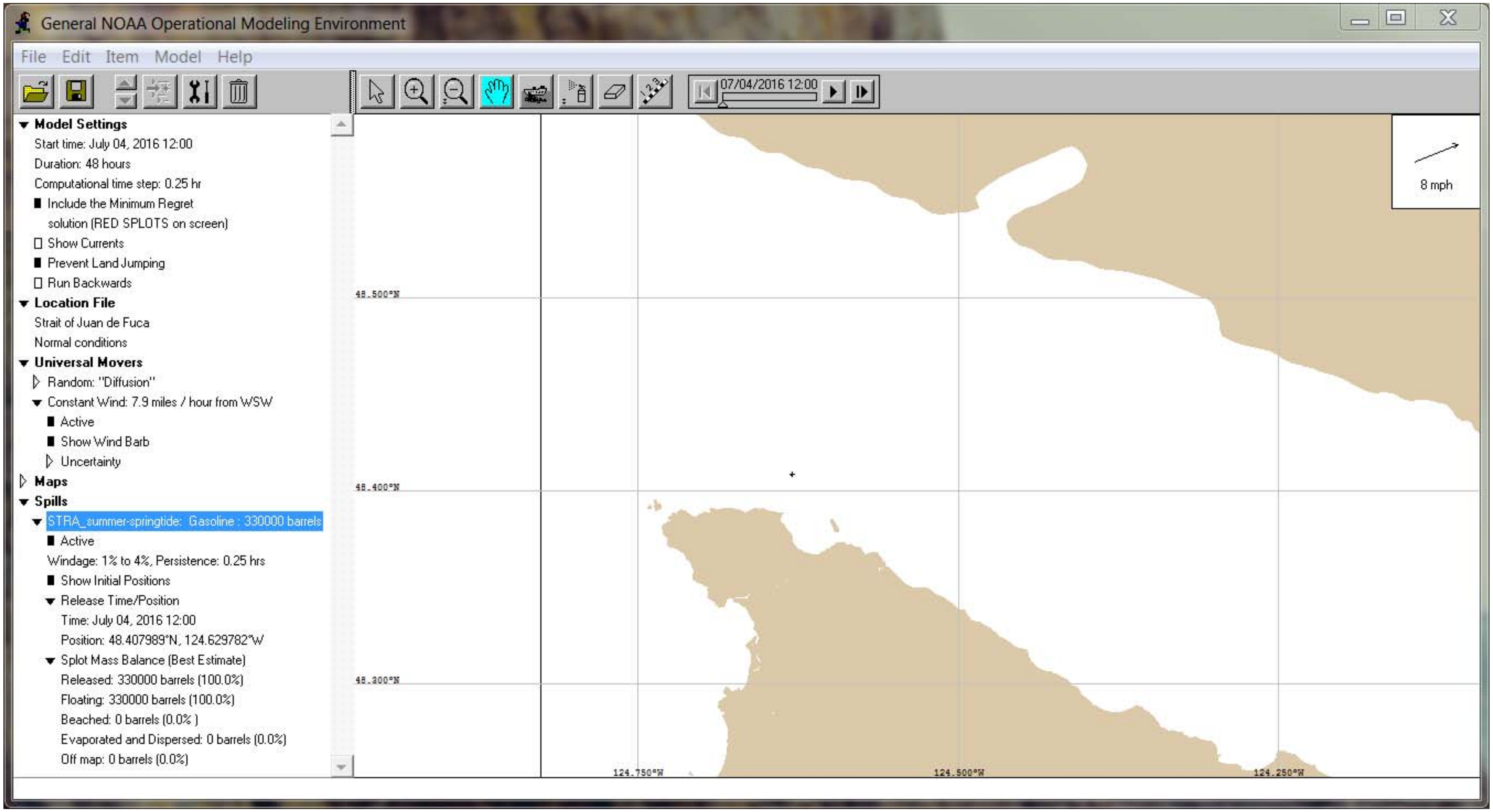

Figure G-7 (a). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ spring tide scenario: Hour 0.

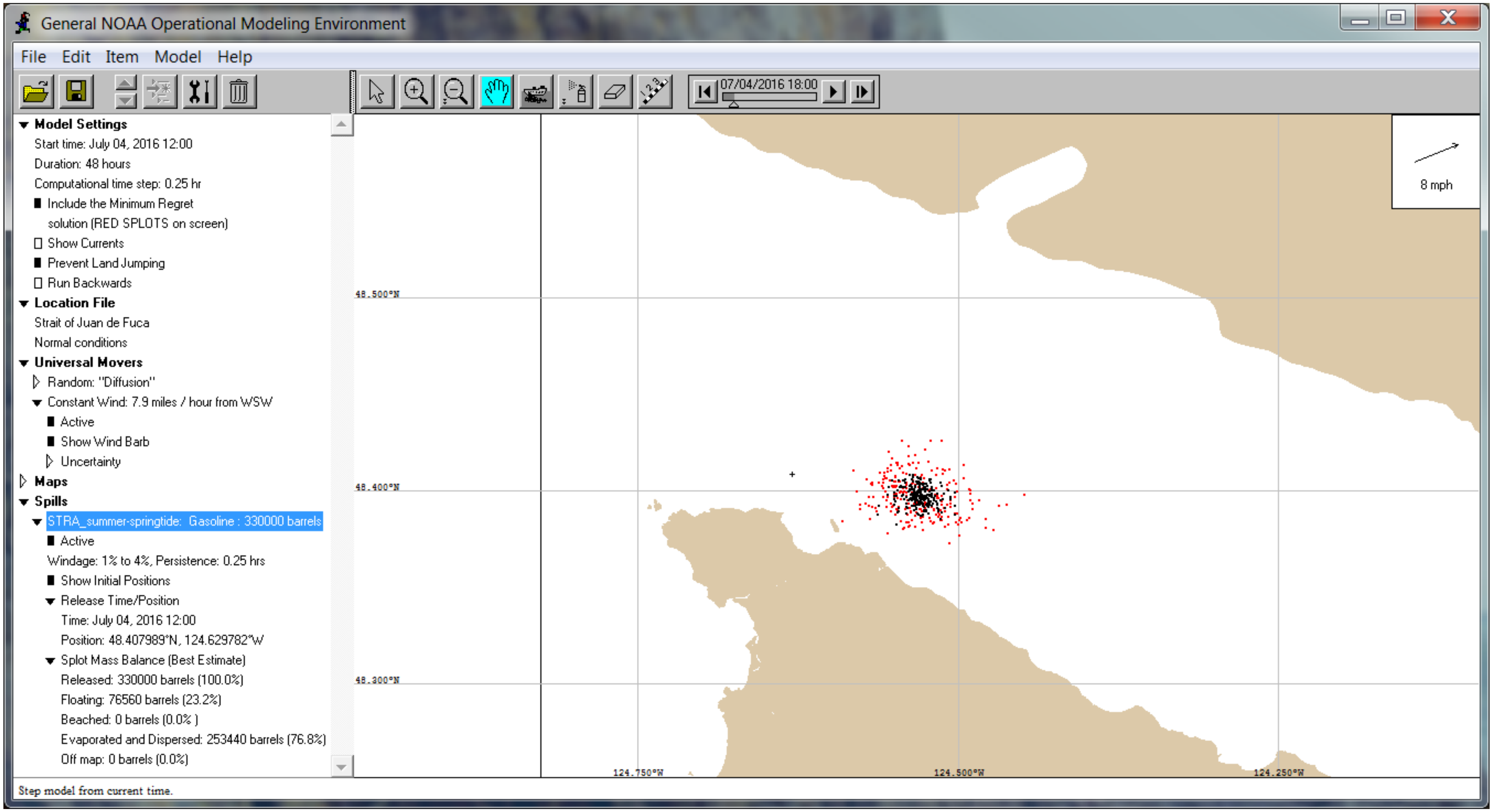

Figure G-7 (b). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ spring tide scenario: Hour 6.

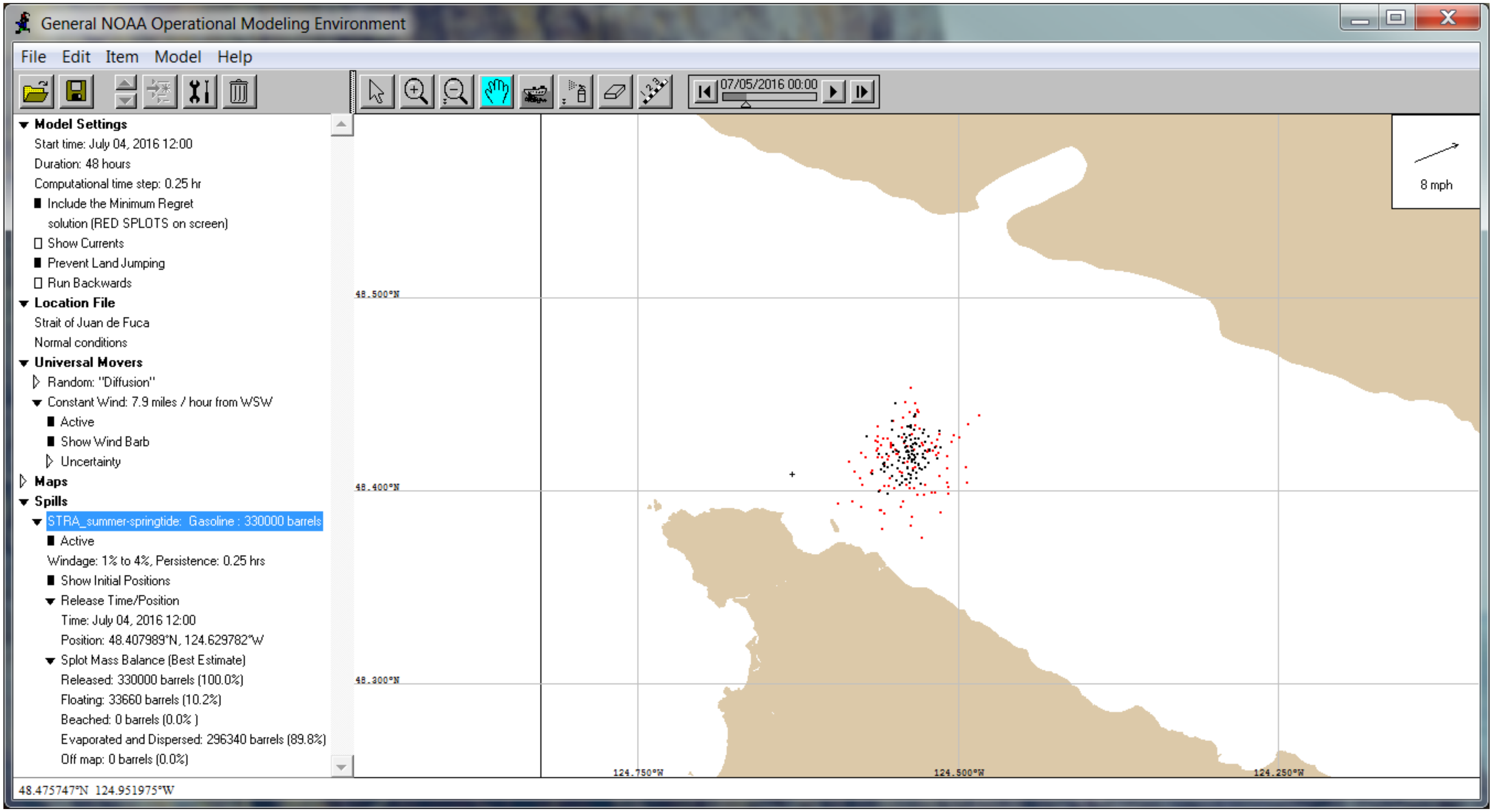

Figure G-7 (c). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ spring tide scenario: Hour 12.

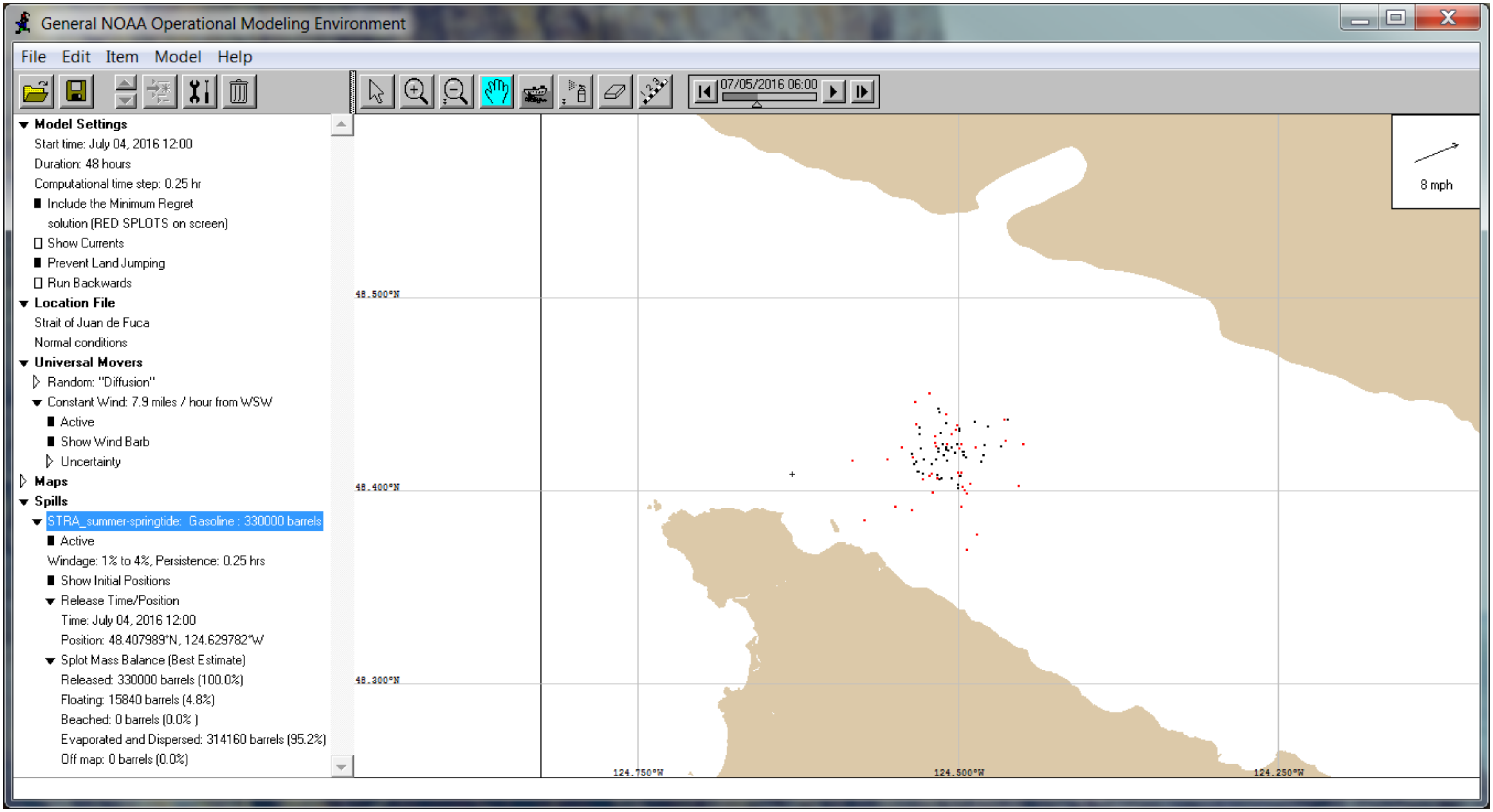

Figure G-7 (d). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ spring tide scenario: Hour 18.

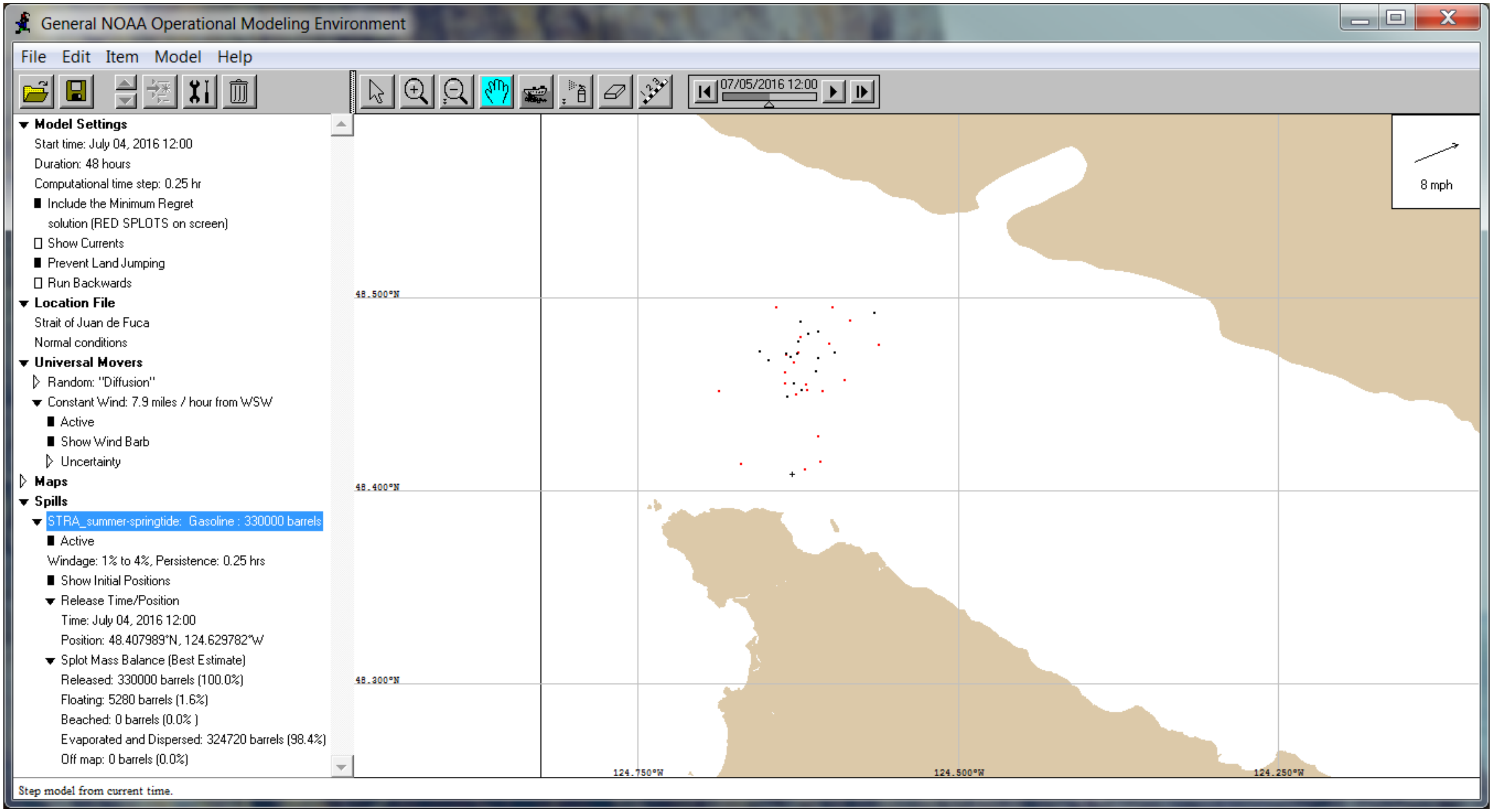

Figure G-7 (e). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ spring tide scenario: Hour 24.

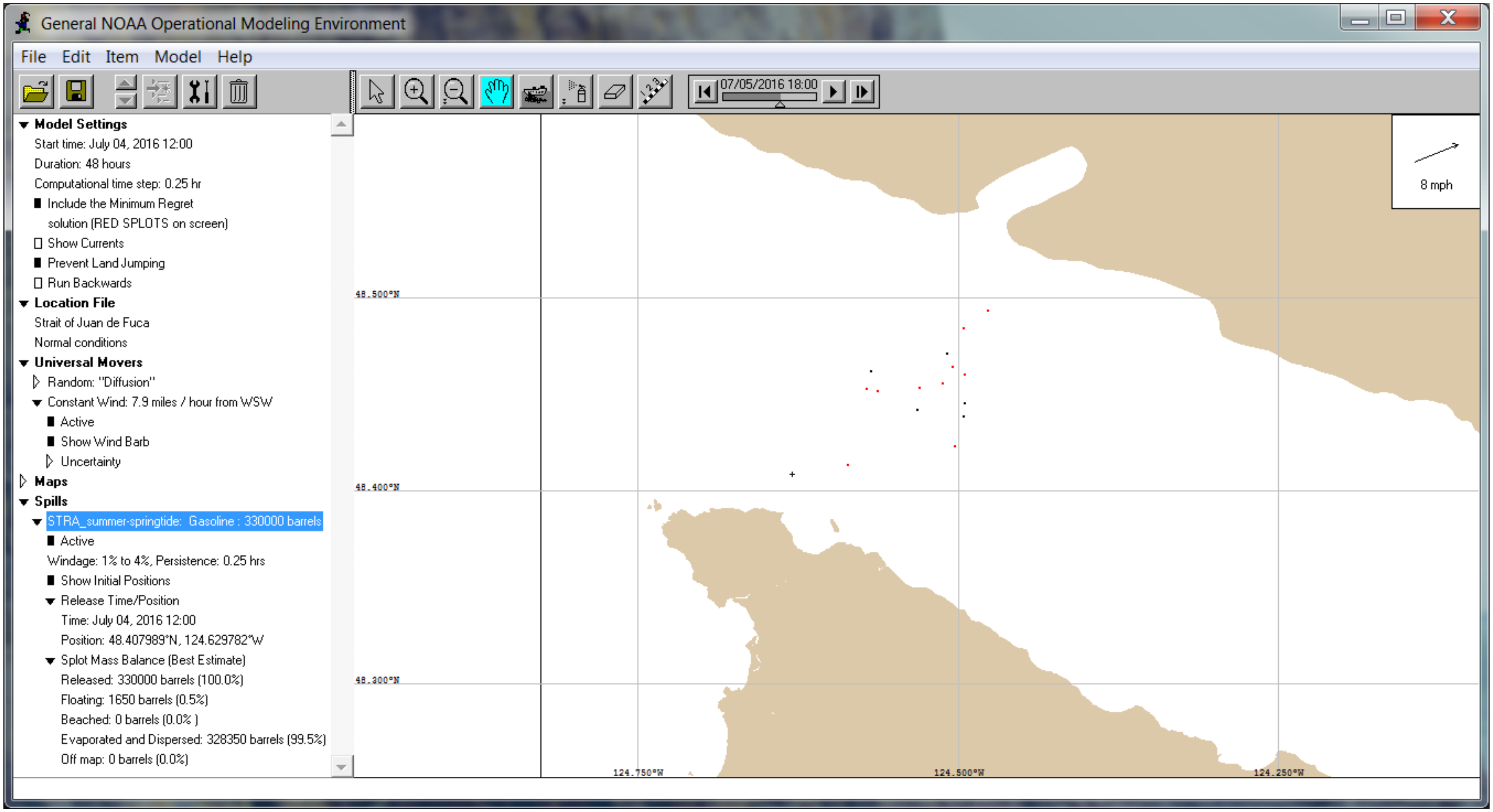

Figure G-7 (f). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ spring tide scenario: Hour 30.

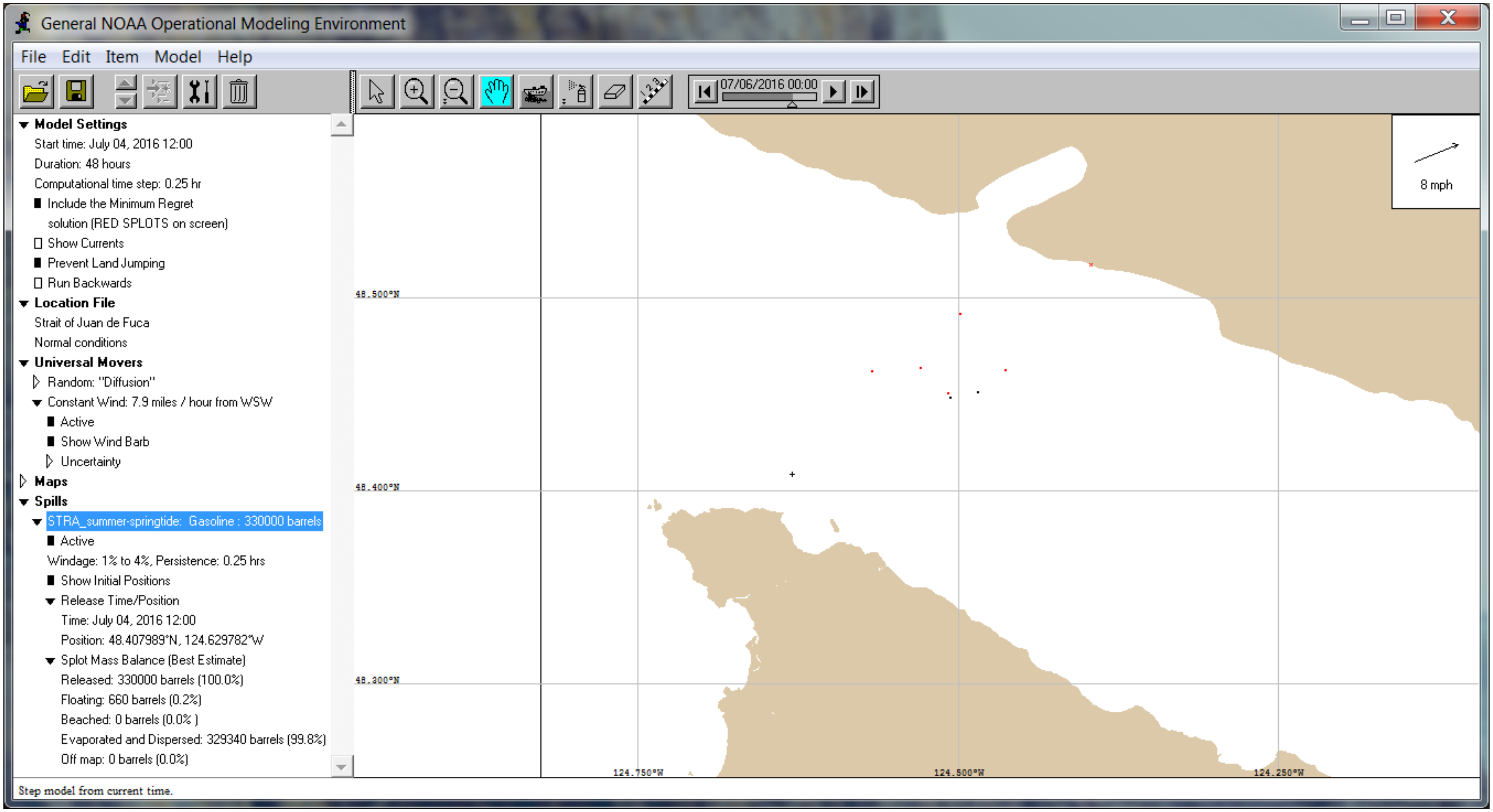

Figure G-7 (g). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ spring tide scenario: Hour 36.

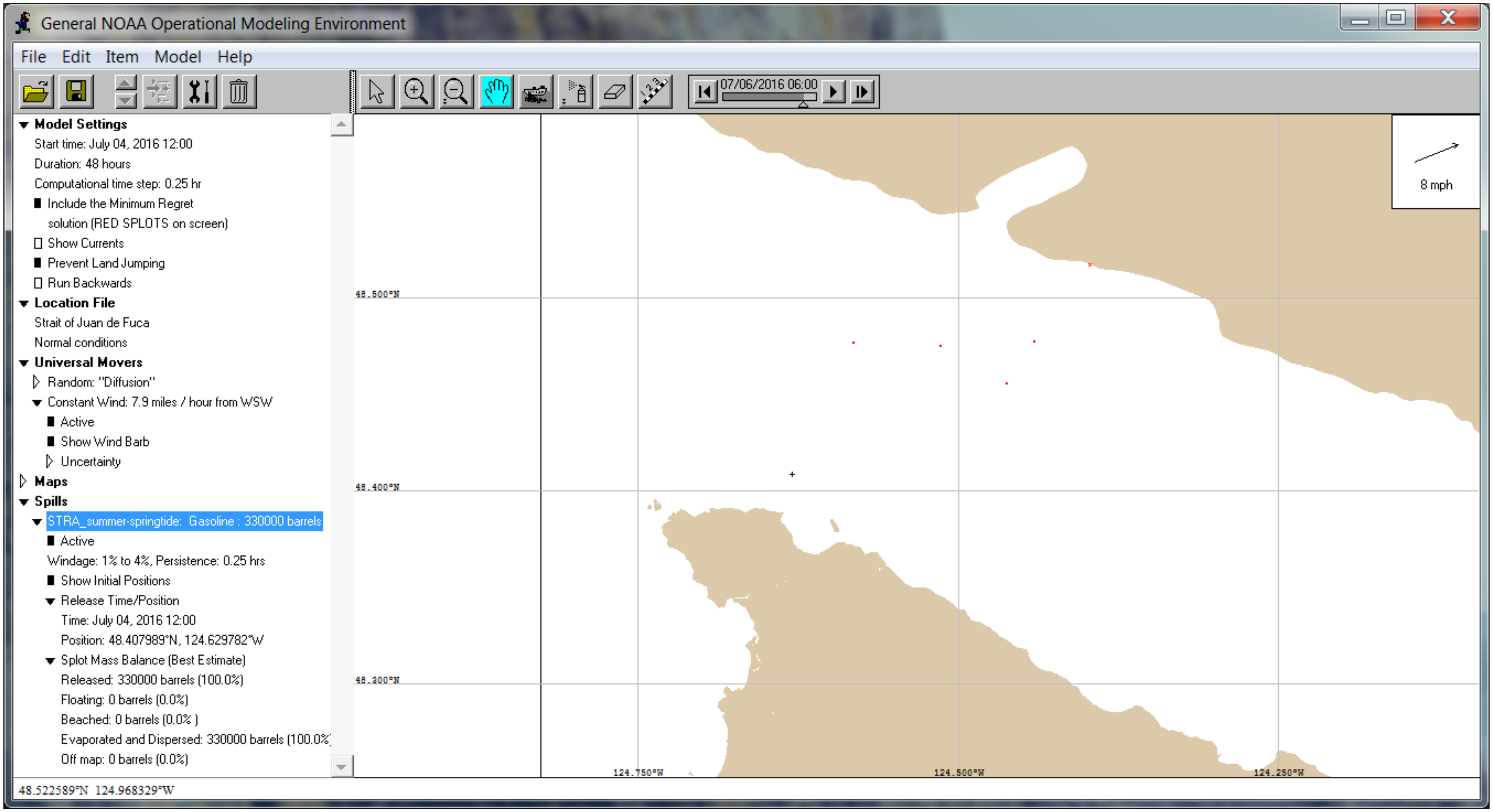

Figure G-7 (h). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ spring tide scenario: Hour 42.

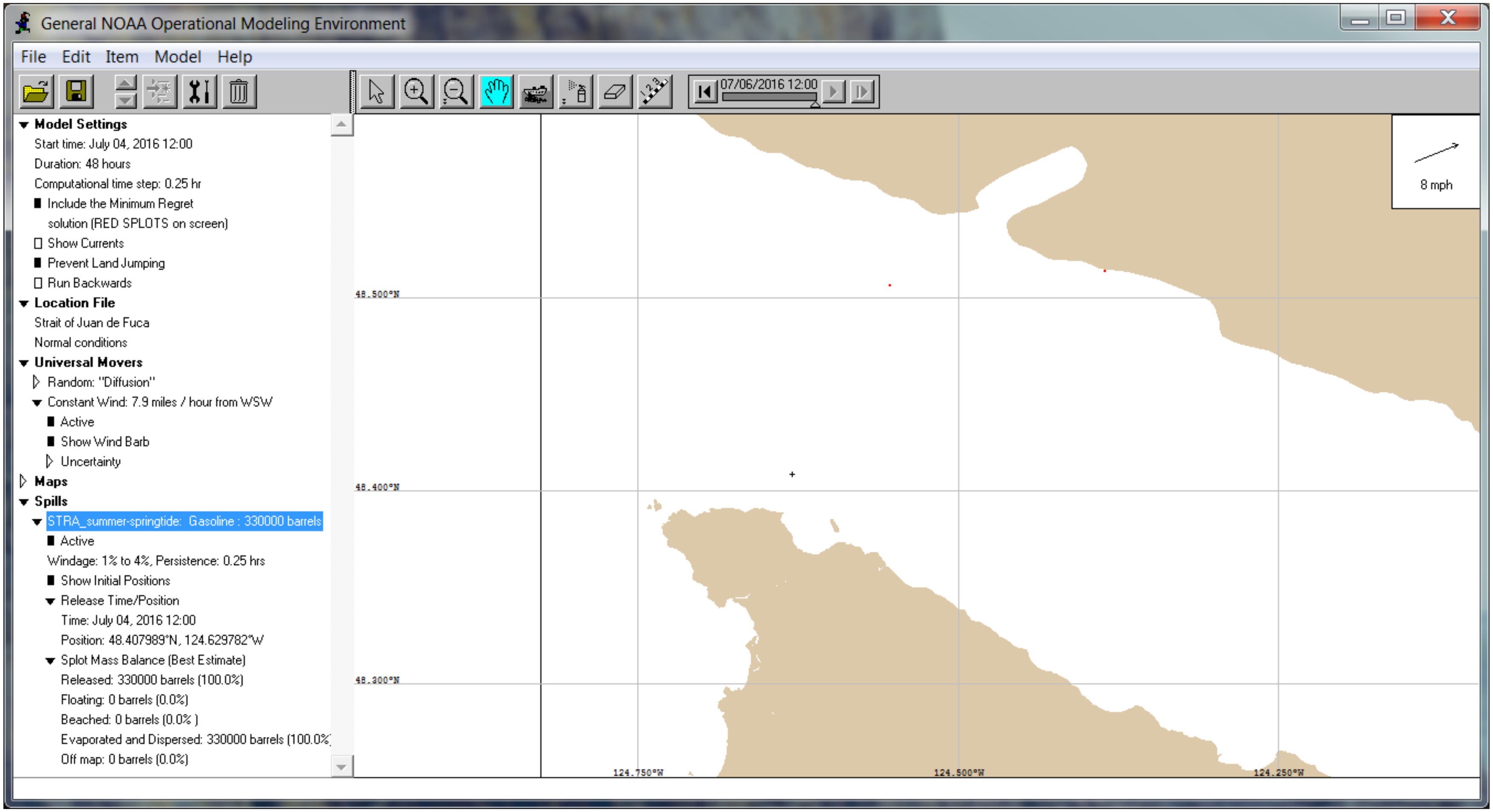

Figure G-7 (i). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ spring tide scenario: Hour 48.

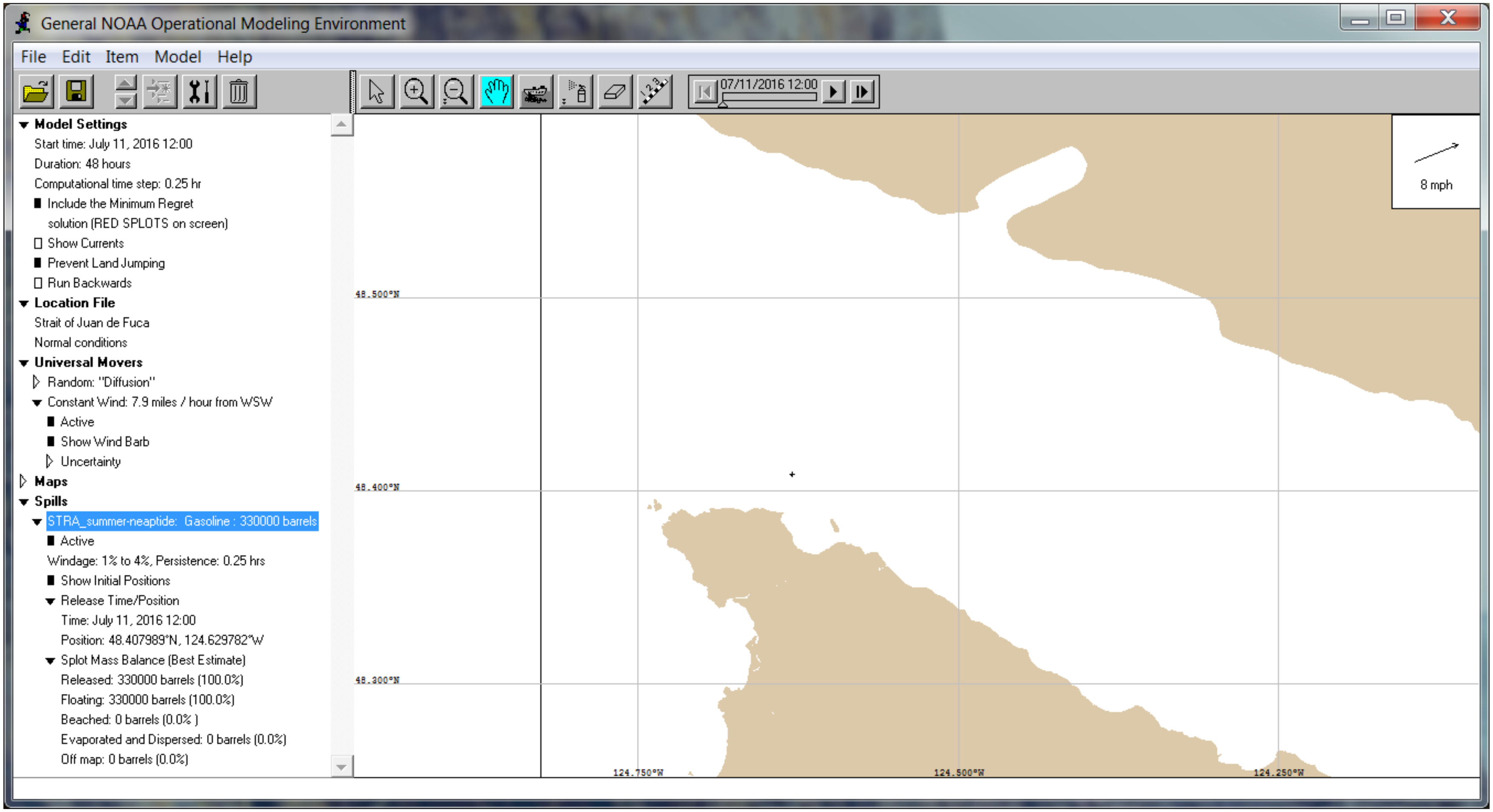

Figure G-8 (a). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ neap tide scenario: Hour 0.

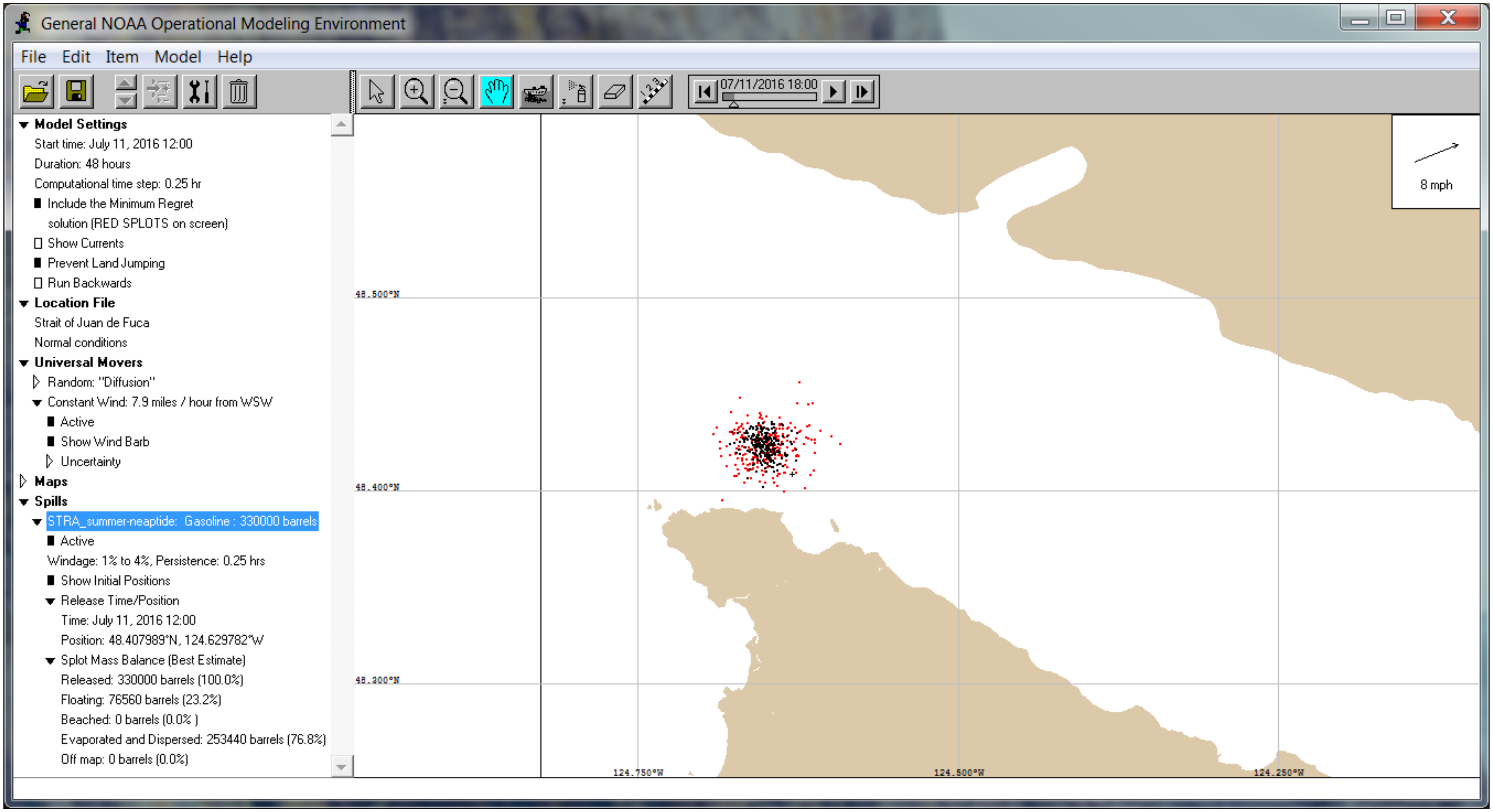

Figure G-8 (b). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ neap tide scenario: Hour 6.

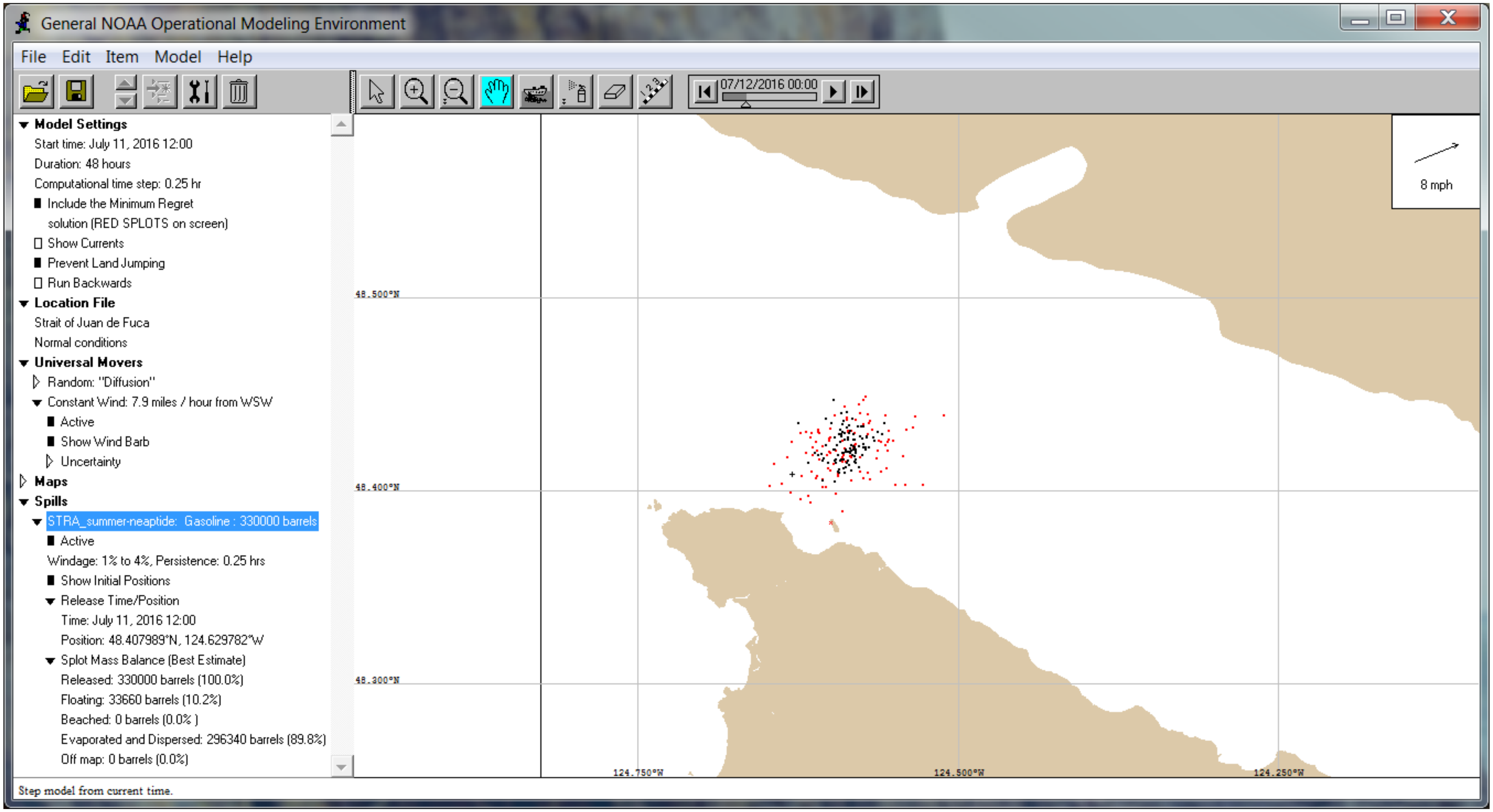

Figure G-8 (c). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ neap tide scenario: Hour 12.

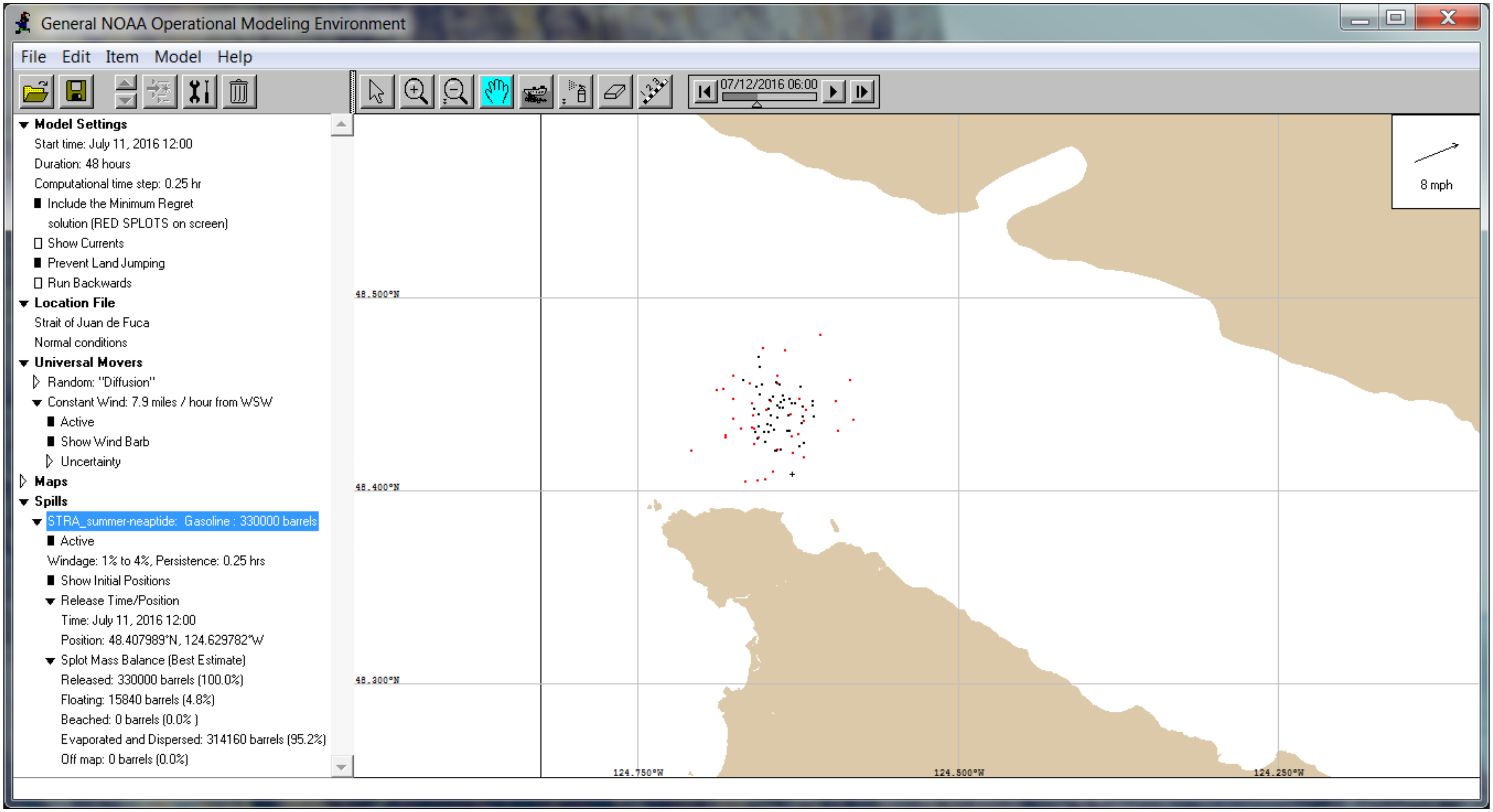

Figure G-8 (d). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ neap tide scenario: Hour 18.

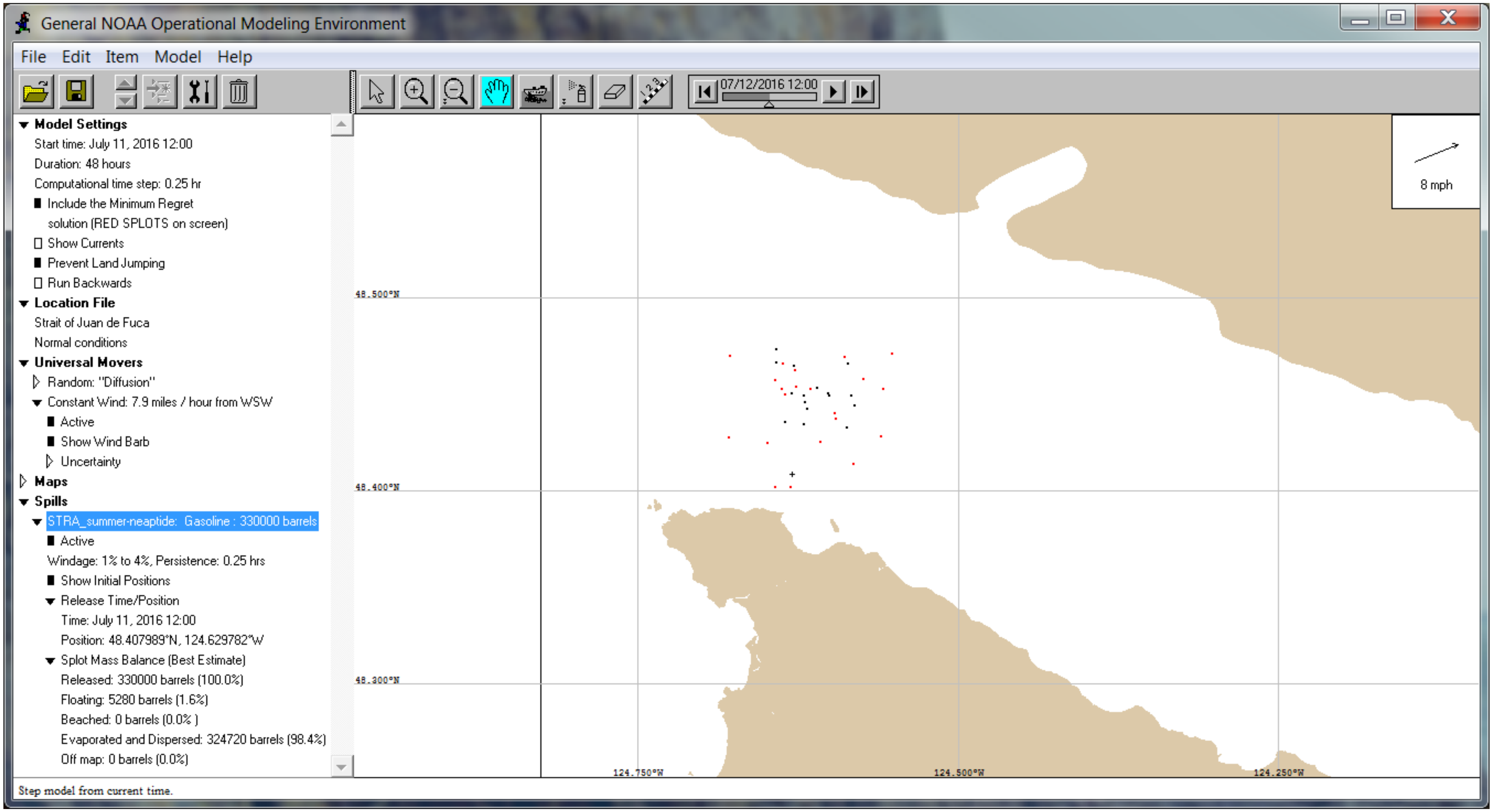

Figure G-8 (e). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ neap tide scenario: Hour 24.

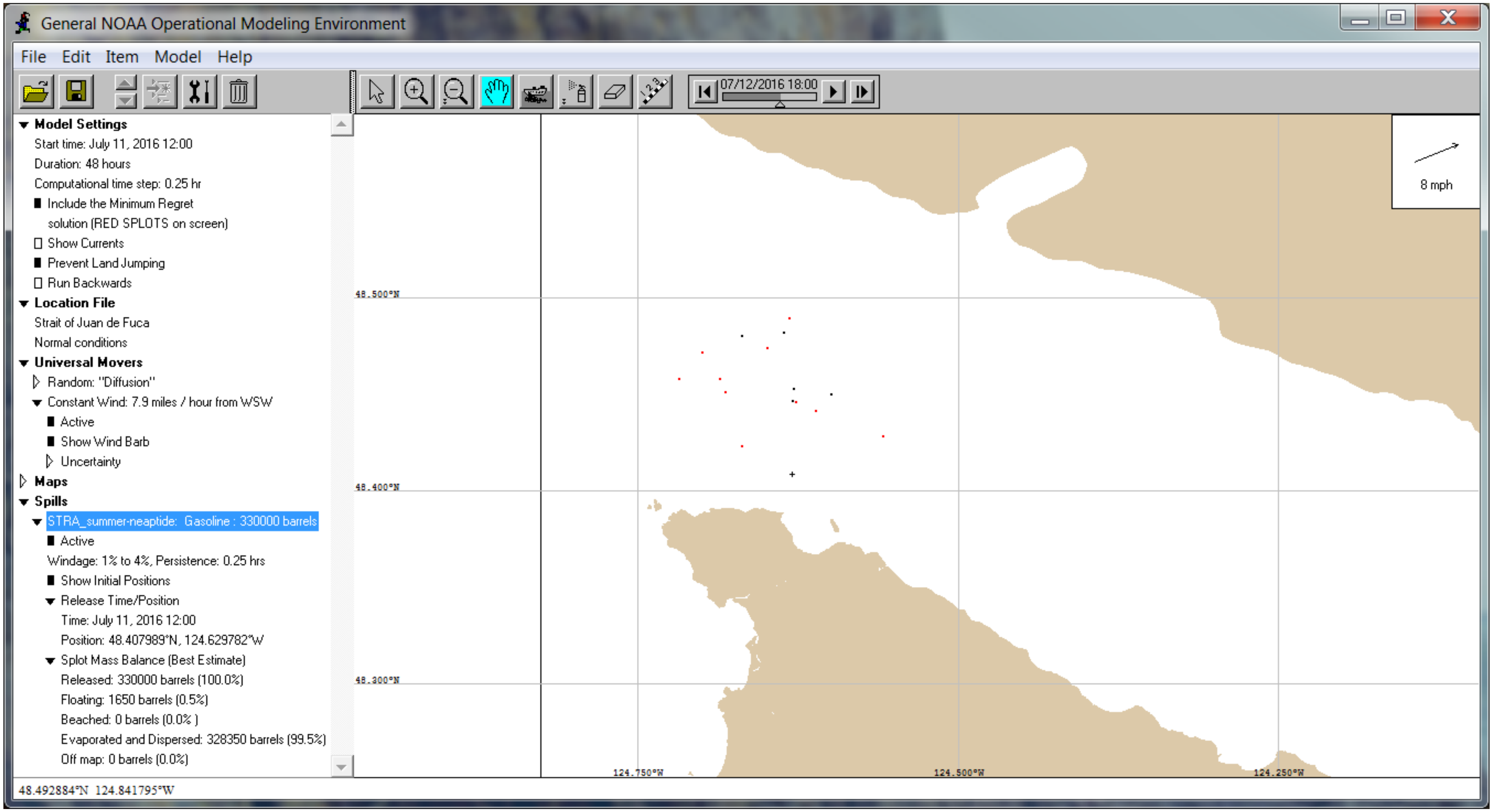

Figure G-8 (f). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ neap tide scenario: Hour 30.

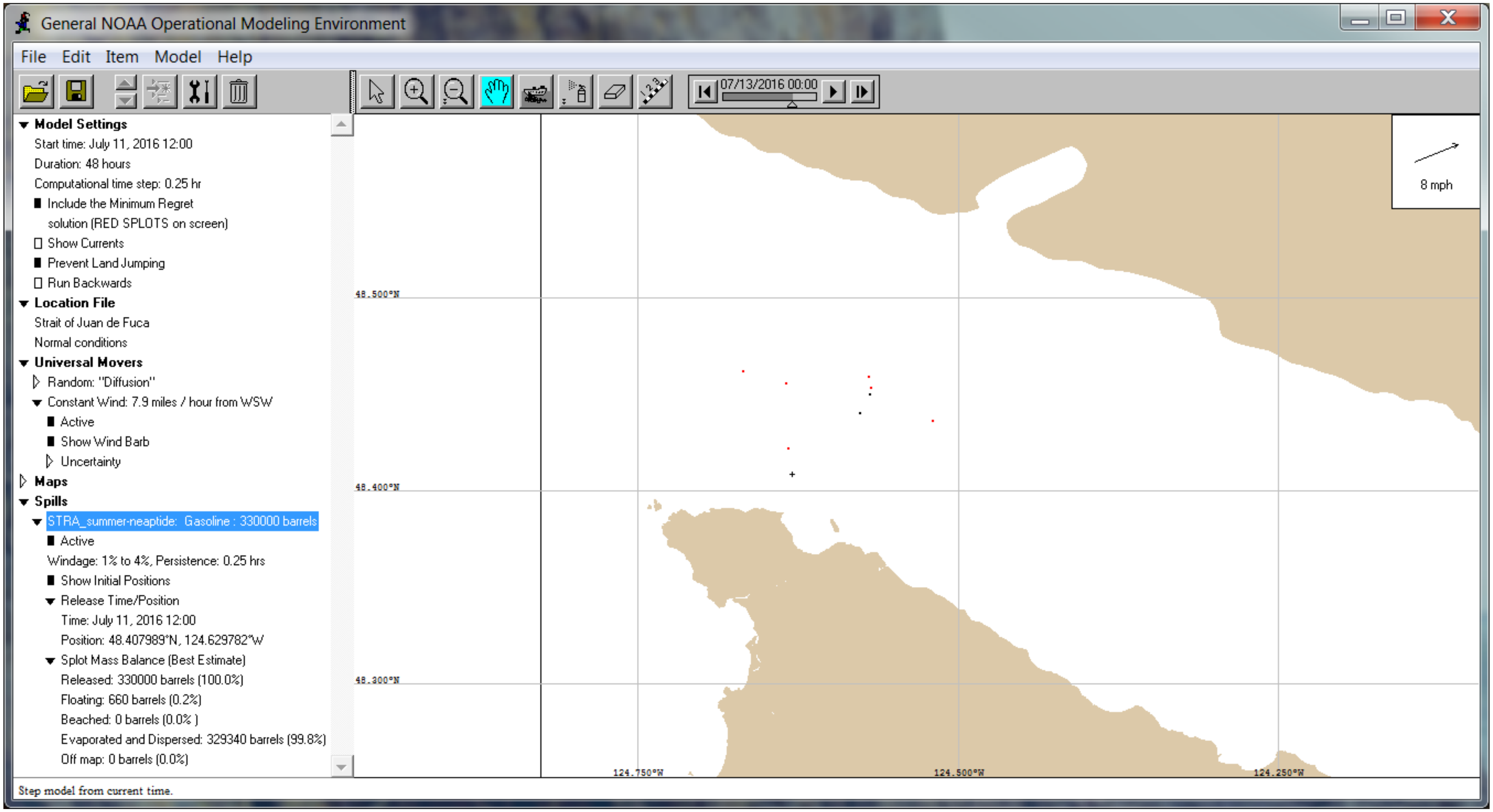

Figure G-8 (g). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ neap tide scenario: Hour 36.

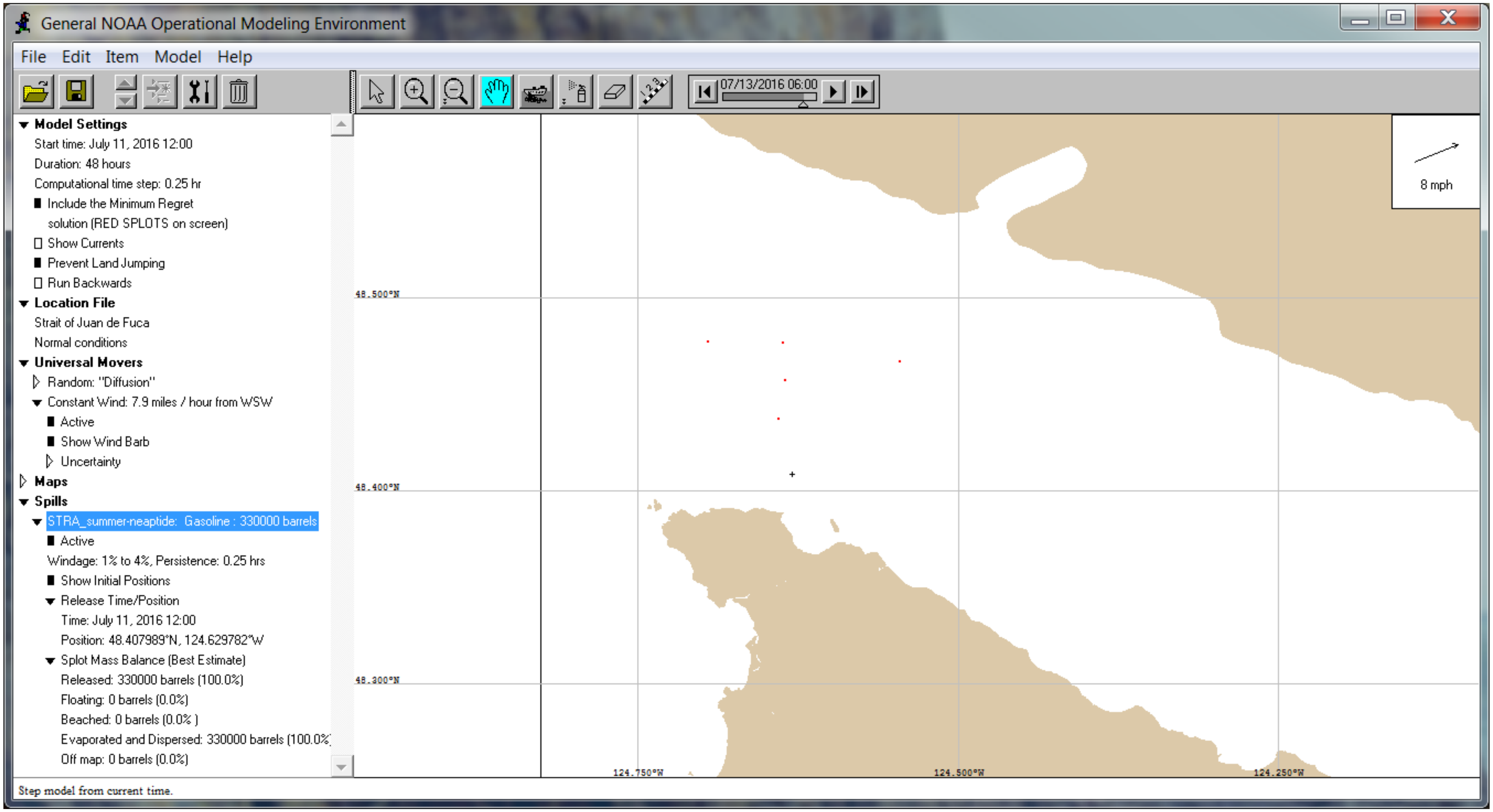

Figure G-8 (h). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ neap tide scenario: Hour 42.

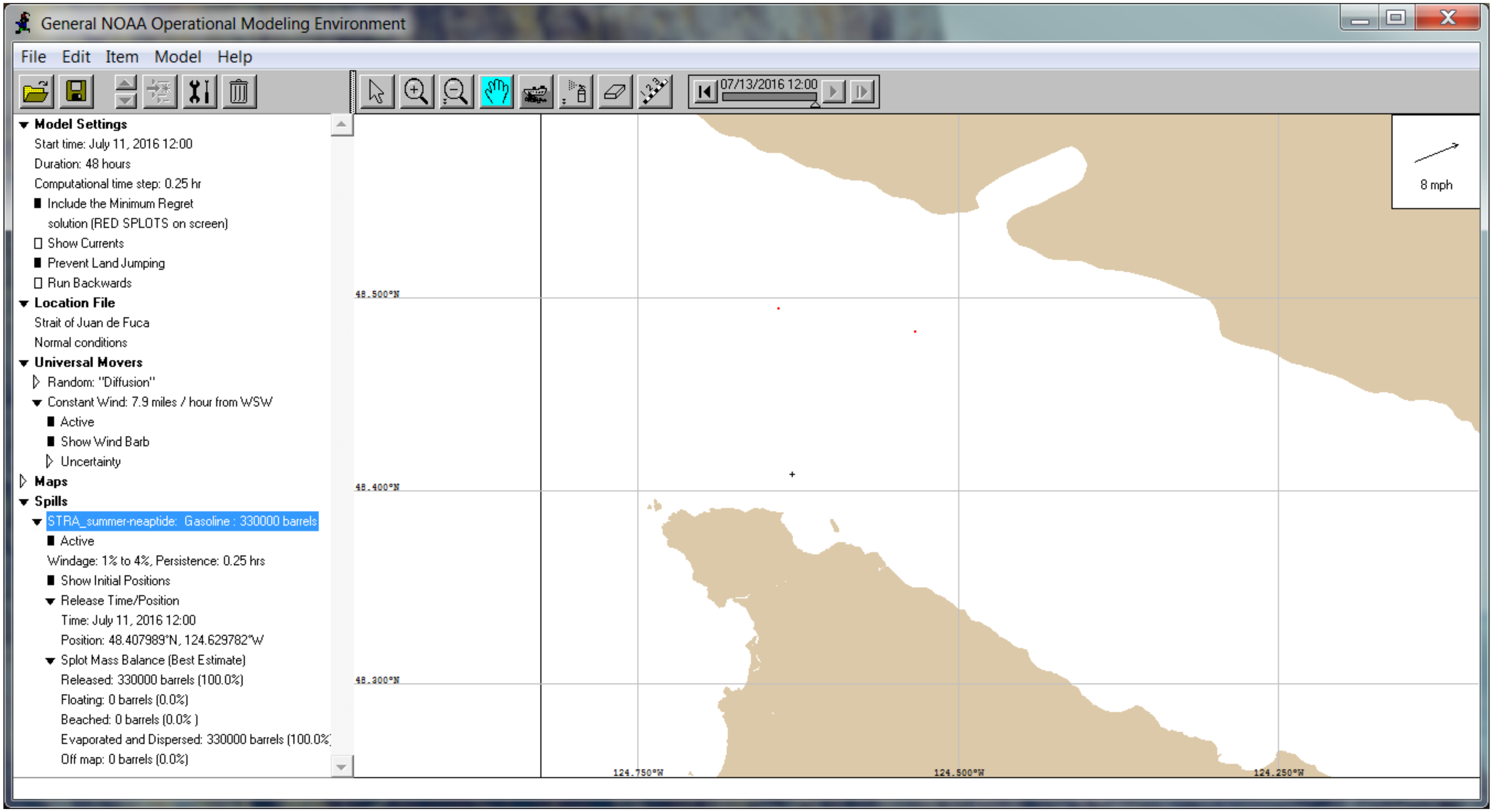

Figure G-8 (i). GNOME Model Output, Neah Bay (STR-A), 330,000 bbls, summer@ neap tide scenario: Hour 48.

Table G-4. List of Figures for Vessel Transit Scenario NE of Port Angeles (STR-H)
GNOME Modeling of Gasoline Trajectories Individual Run Results

Figure #	Season	Tidal Influence	Wind Speed (mph) /Wind Direction	Volume bbl	Date/Time	Hour into model run
Figure G-9 (a)	Winter	Spring	4.9/SSW	330,000	06-Feb-16 12:00	0
Figure G-9 (b)					06-Feb-16 18:00	6
Figure G-9 (c)					07-Feb-16 00:00	12
Figure G-9 (d)					07-Feb-16 06:00	18
Figure G-9 (e)					07-Feb-16 12:00	24
Figure G-9 (f)					07-Feb-16 18:00	30
Figure G-9 (g)					08-Feb-16 00:00	36
Figure G-9 (h)					08-Feb-16 06:00	42
Figure G-9 (i)					08-Feb-16 12:00	48
Figure G-10 (a)	Winter	Neap	4.9/SSW	330,000	27-Feb-16 12:00	0
Figure G-10 (b)					27-Feb-16 18:00	6
Figure G-10 (c)					28-Feb-16 00:00	12
Figure G-10 (d)					28-Feb-16 06:00	18
Figure G-10 (e)					28-Feb-16 12:00	24
Figure G-10 (f)					28-Feb-16 18:00	30
Figure G-10 (g)					29-Feb-16 00:00	36
Figure G-10 (h)					29-Feb-16 06:00	42
Figure G-10 (i)					29-Feb-16 12:00	48
Figure G-11 (a)	Summer	Spring	7.5/NW	330,000	03-Jul-16 12:00	0
Figure G-11 (b)					03-Jul -16 18:00	6
Figure G-11 (c)					04-Jul -16 00:00	12
Figure G-11 (d)					04-Jul -16 06:00	18
Figure G-11 (e)					04-Jul -16 12:00	24
Figure G-11 (f)					04-Jul -16 18:00	30
Figure G-11 (g)					05-Jul -16 00:00	36
Figure G-11 (h)					05-Jul -16 06:00	42
Figure G-11 (i)					05-Jul -16 12:00	48
Figure G-12 (a)	Summer	Neap	7.5/NW	330,000	23-Jul-16 12:00	0
Figure G-12 (b)					23-Jul -16 18:00	6
Figure G-12 (c)					24-Jul -16 00:00	12
Figure G-12 (d)					24-Jul -16 06:00	18
Figure G-12 (e)					24-Jul -16 12:00	24
Figure G-12 (f)					24-Jul -16 18:00	30
Figure G-12 (g)					25-Jul -16 00:00	36
Figure G-12 (h)					25-Jul -16 06:00	42
Figure G-12 (i)					25-Jul -16 12:00	48

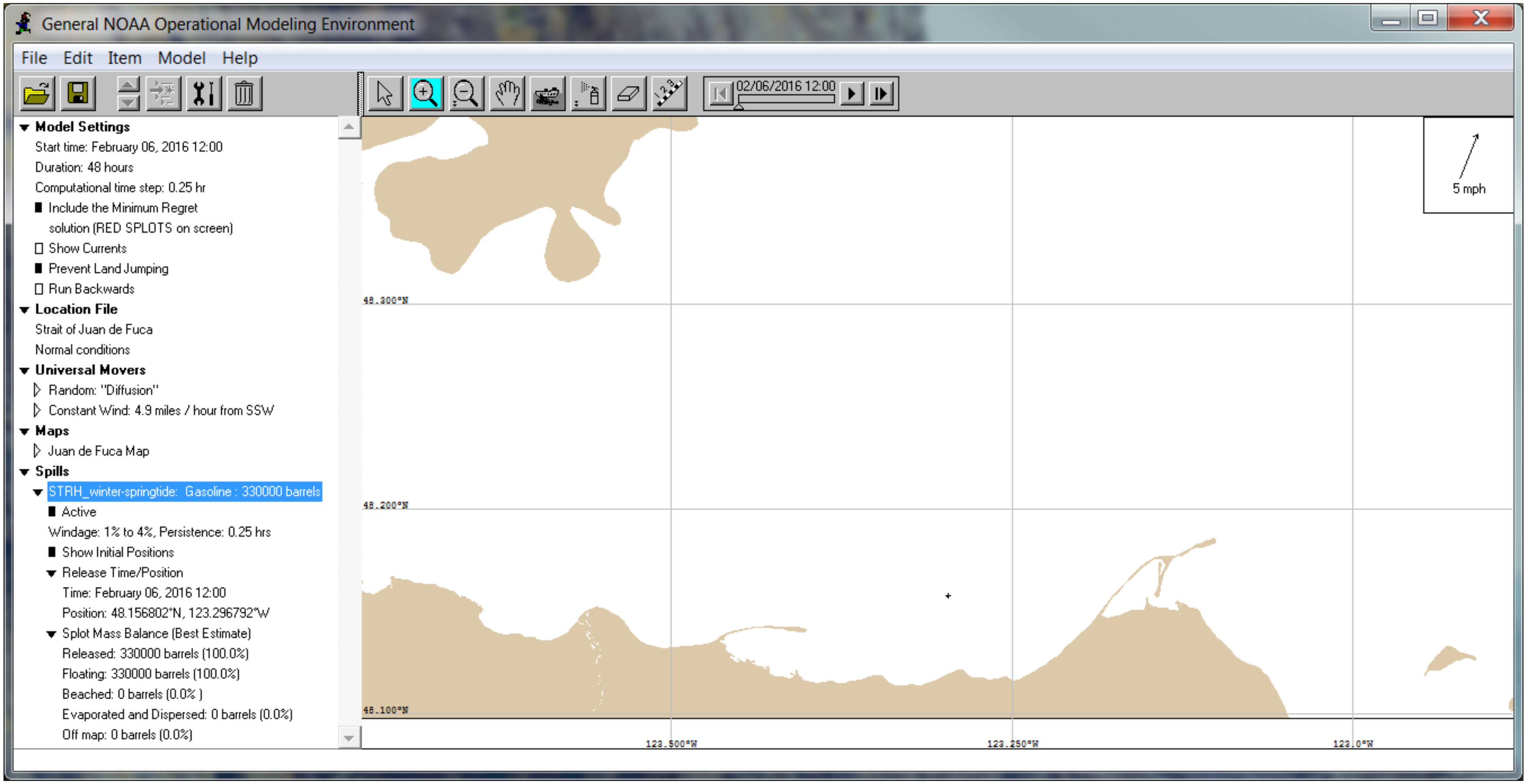

Figure G-9 (a). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ spring tide scenario: Hour 0.

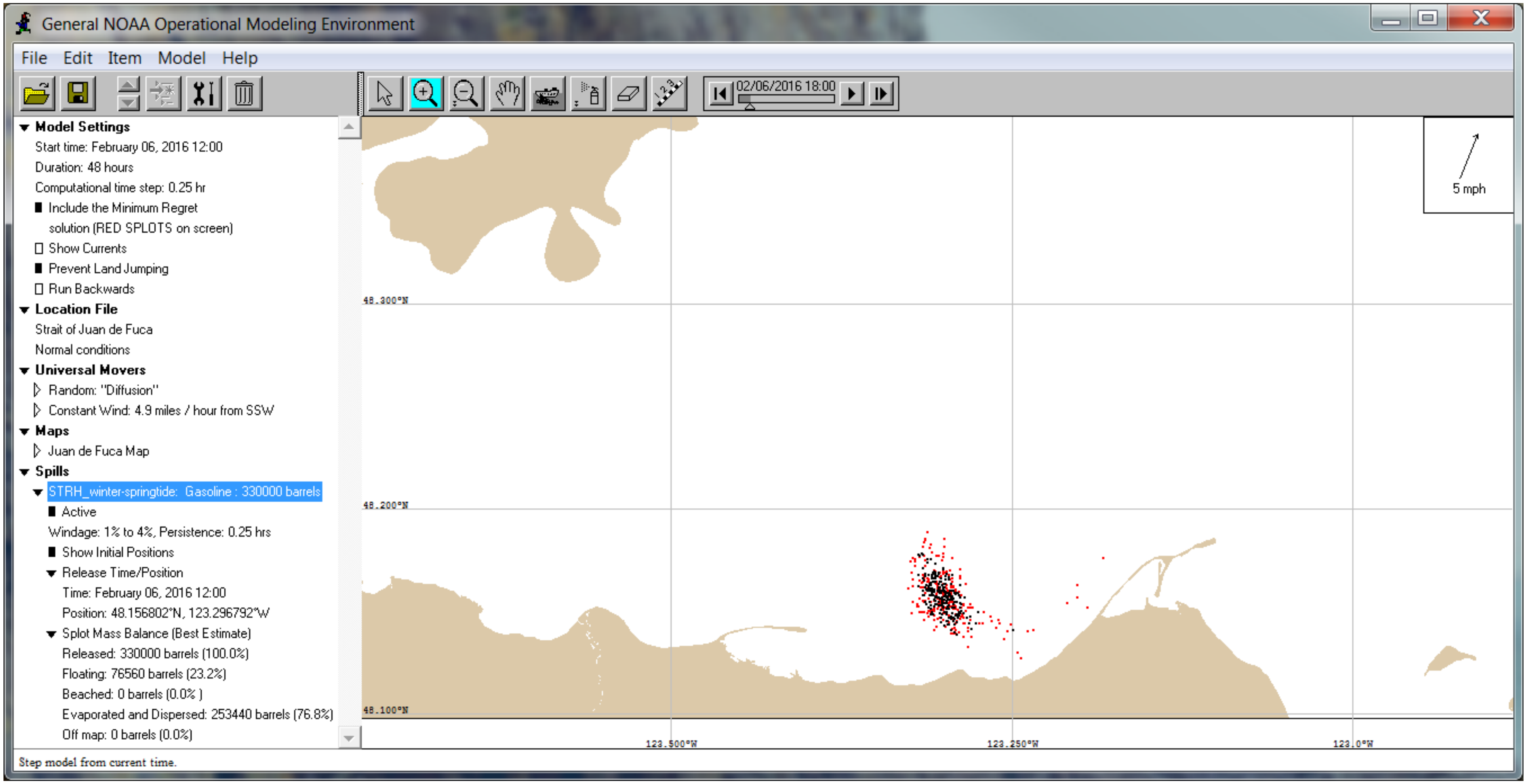

Figure G-9 (b). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ spring tide scenario: Hour 6.

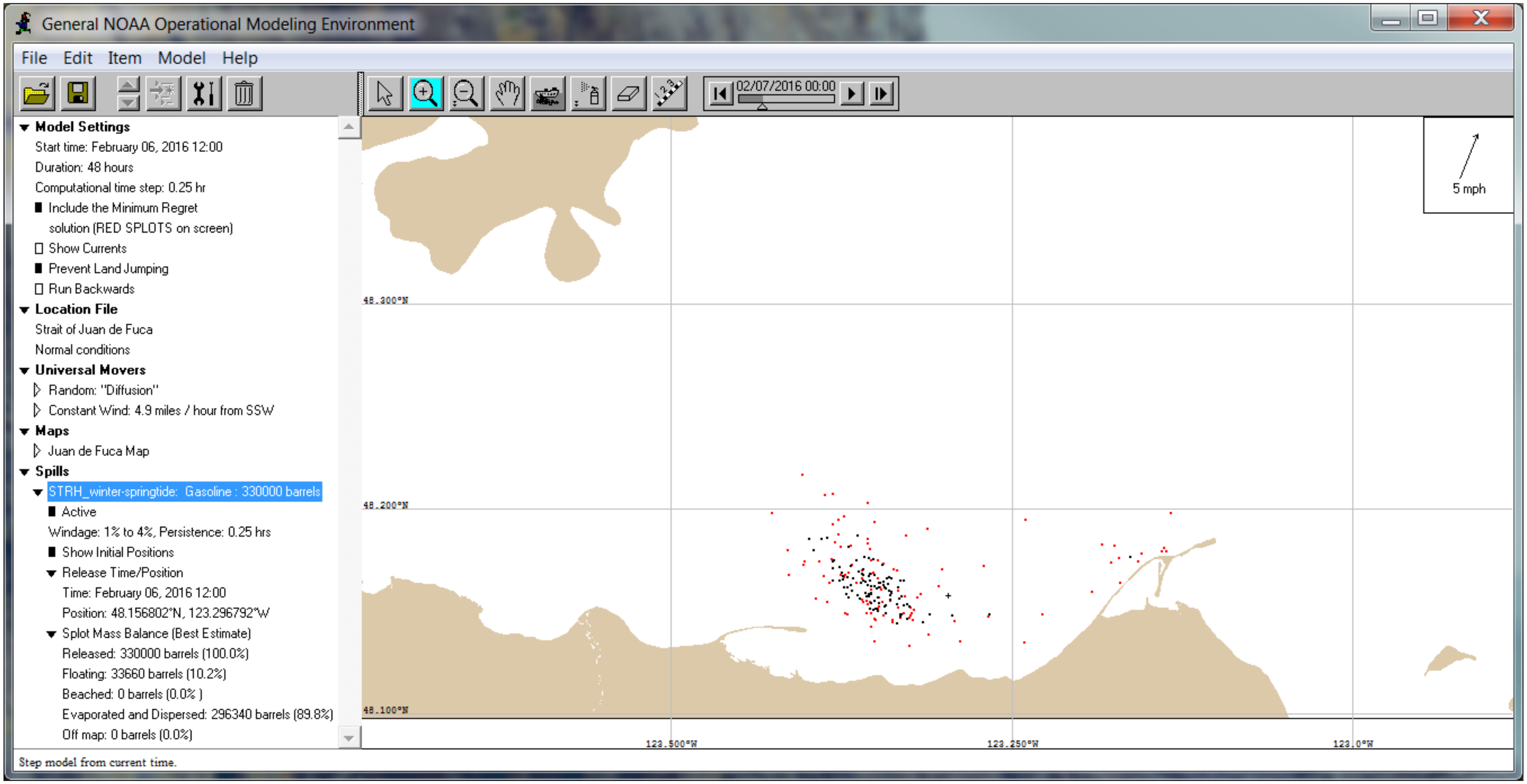

Figure G-9 (c). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ spring tide scenario: Hour 12.

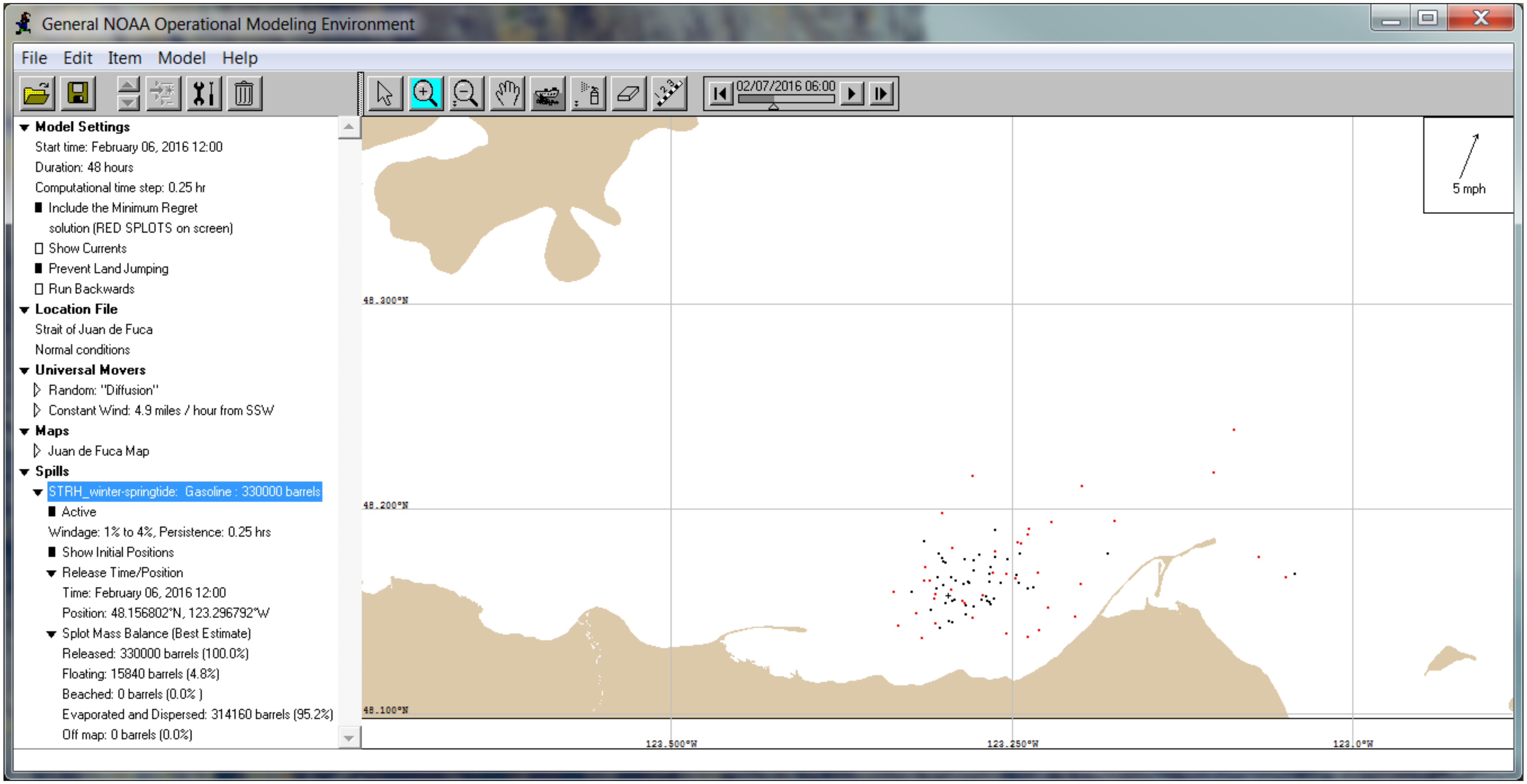

Figure G-9 (d). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ spring tide scenario: Hour 18.

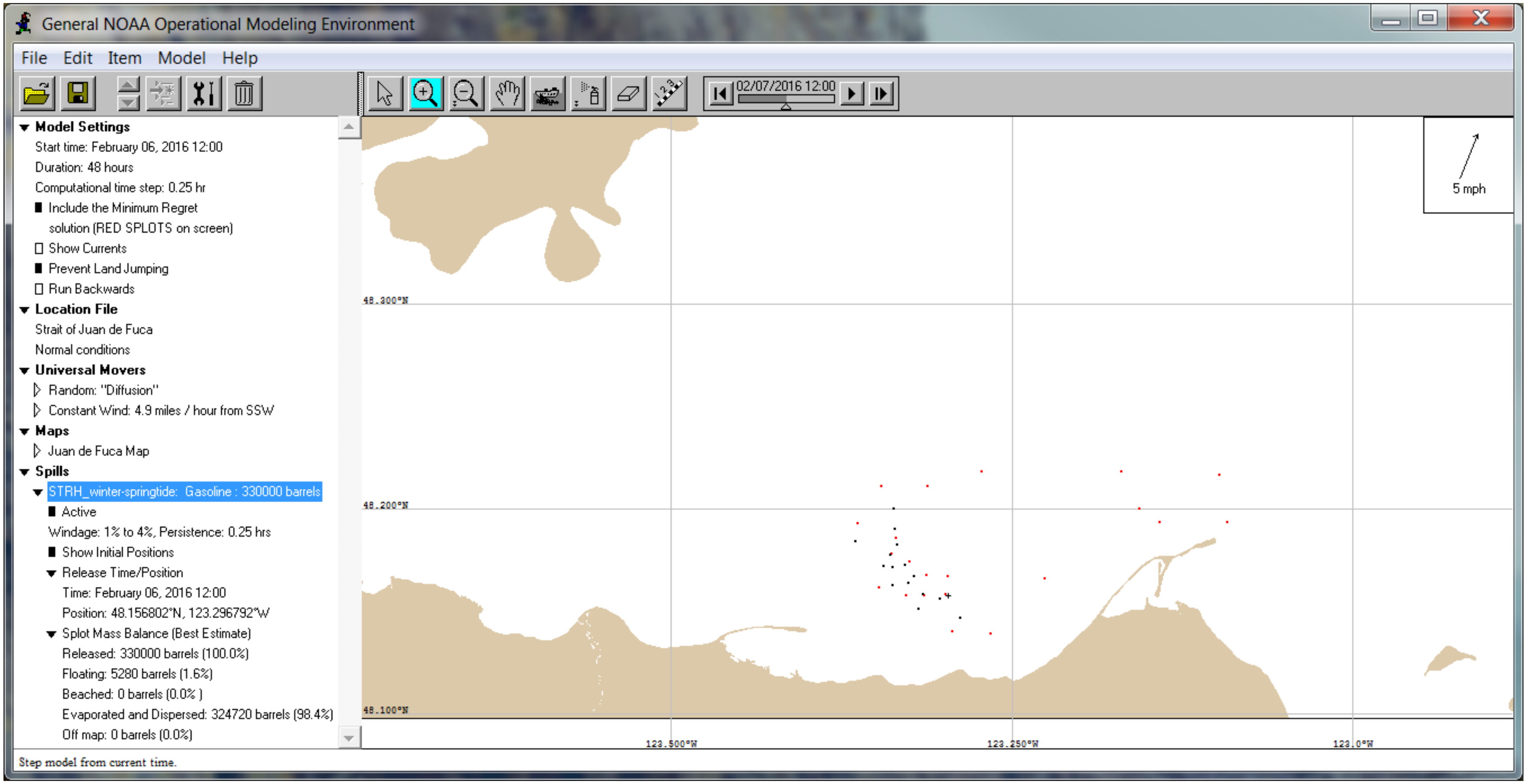

Figure G-9 (e). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ spring tide scenario: Hour 24.

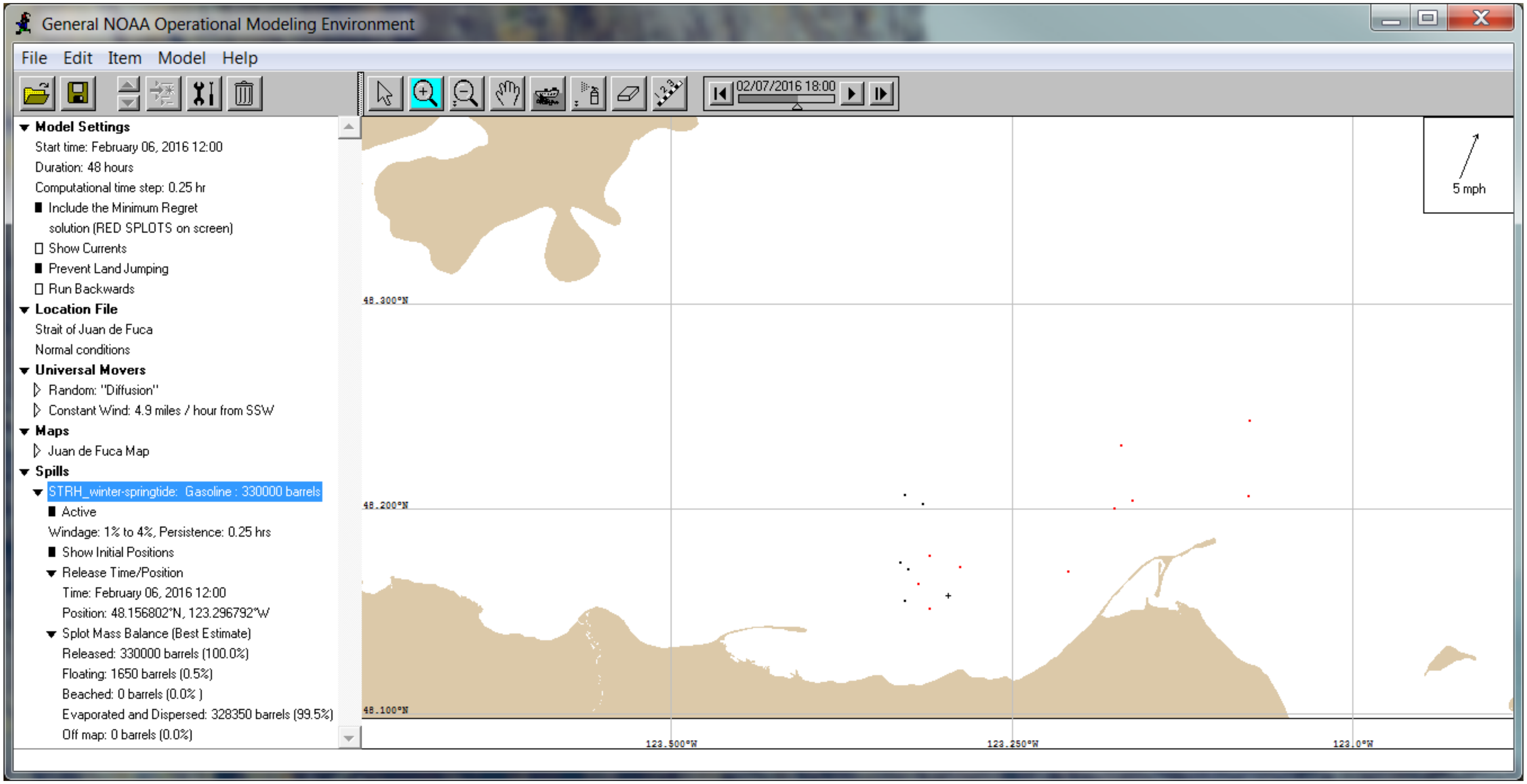

Figure G-9 (f). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ spring tide scenario: Hour 30.

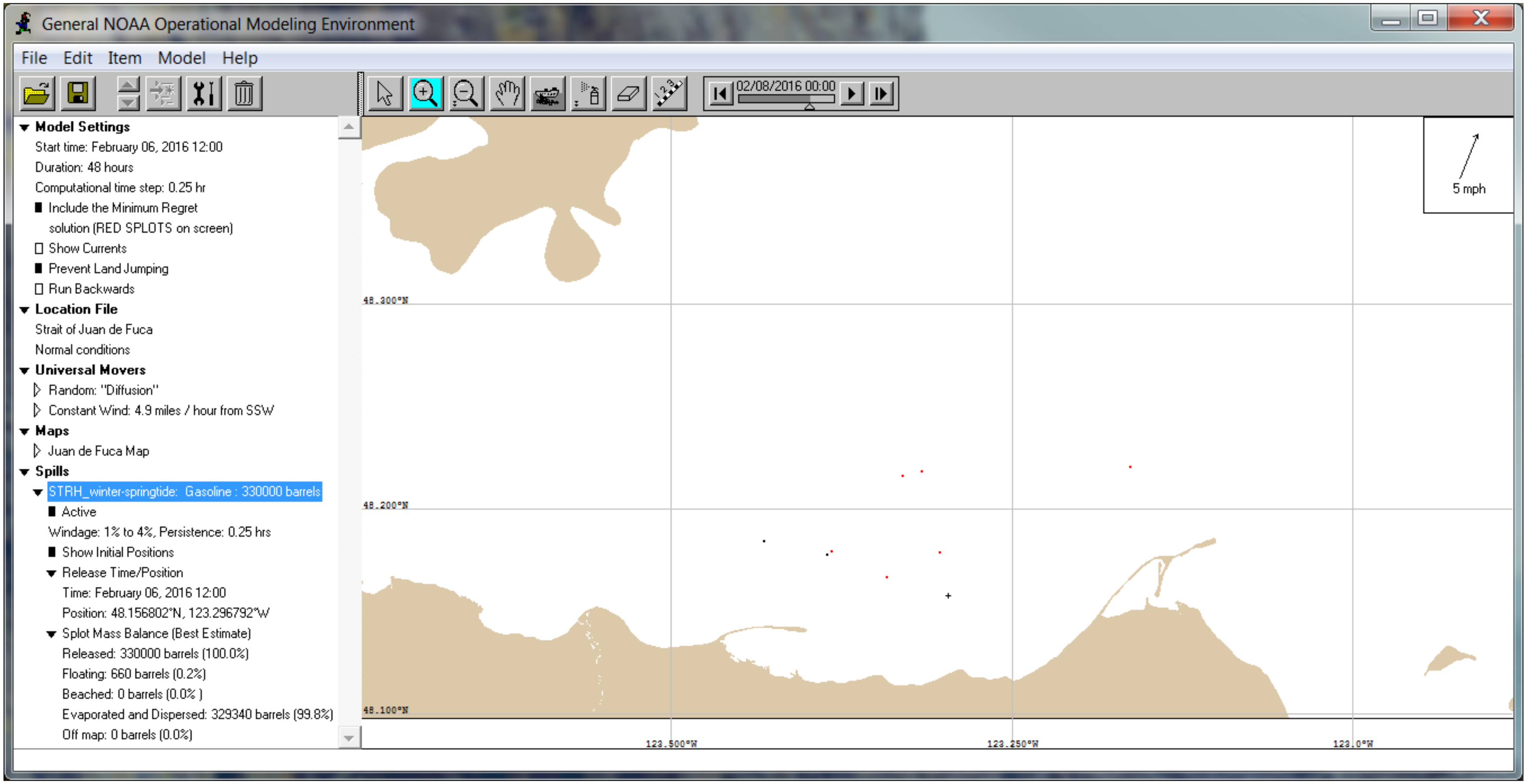

Figure G-9 (g). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ spring tide scenario: Hour 36

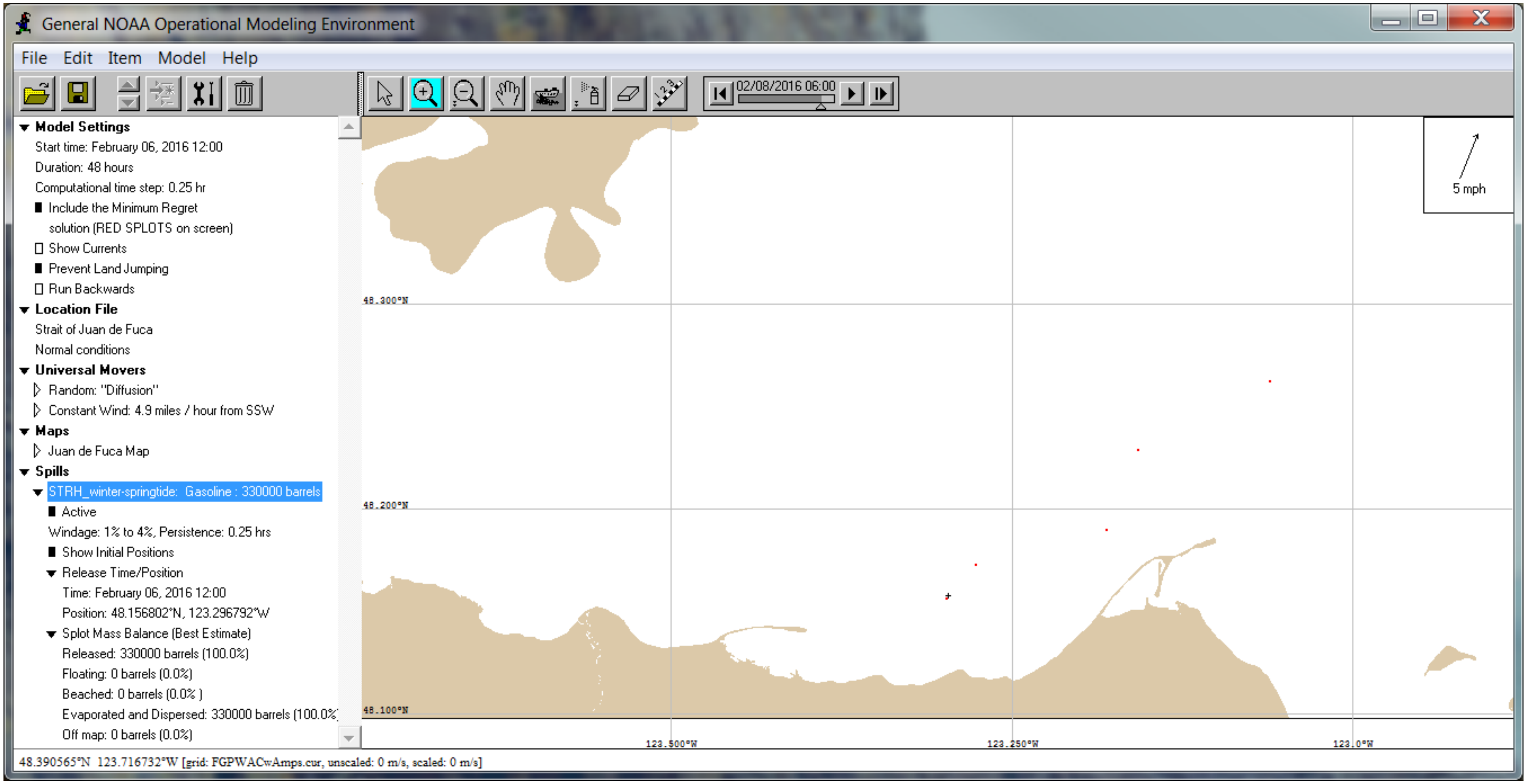

Figure G-9 (h). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ spring tide scenario: Hour 42.

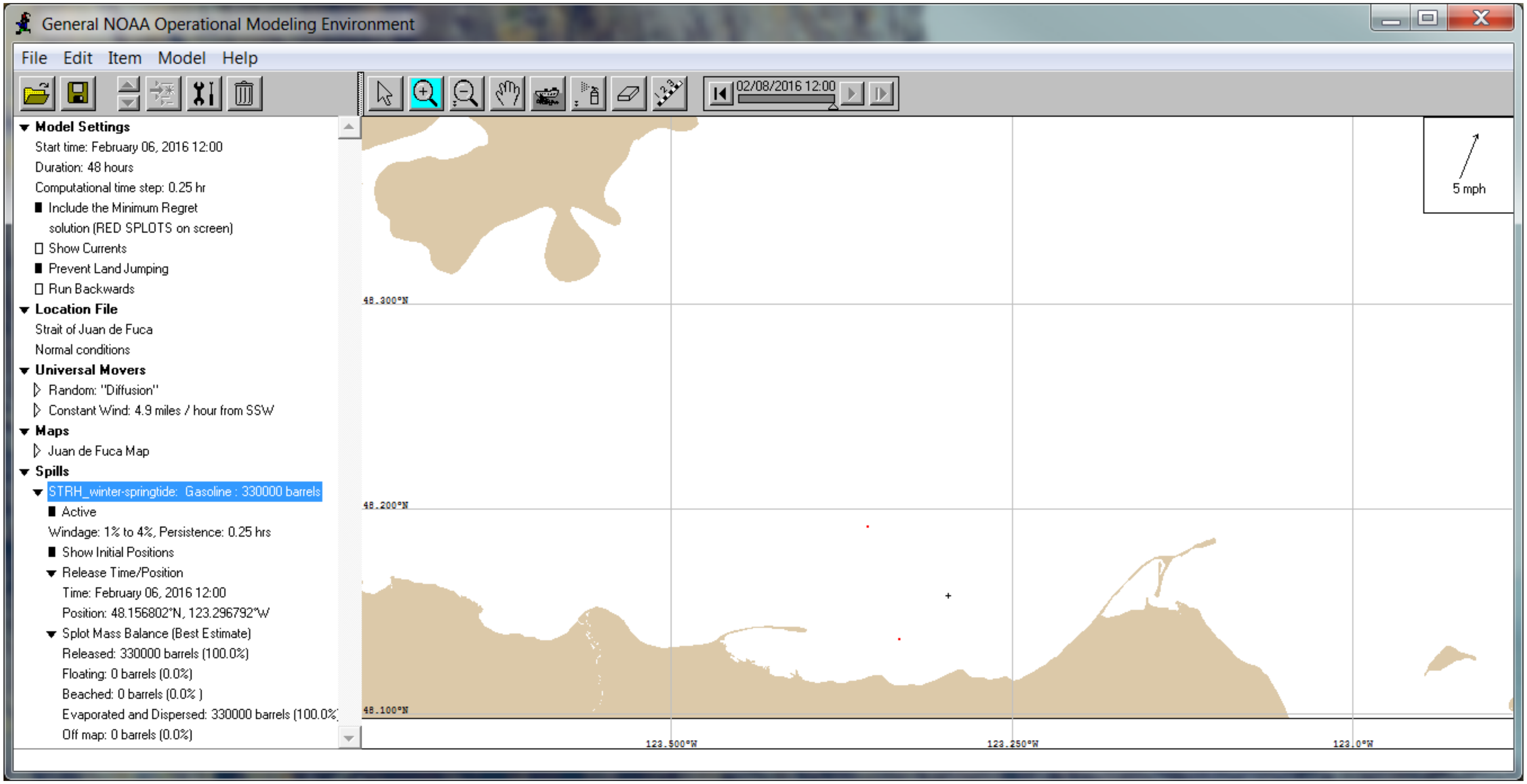

Figure G-9 (i). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ spring tide scenario: Hour 48.

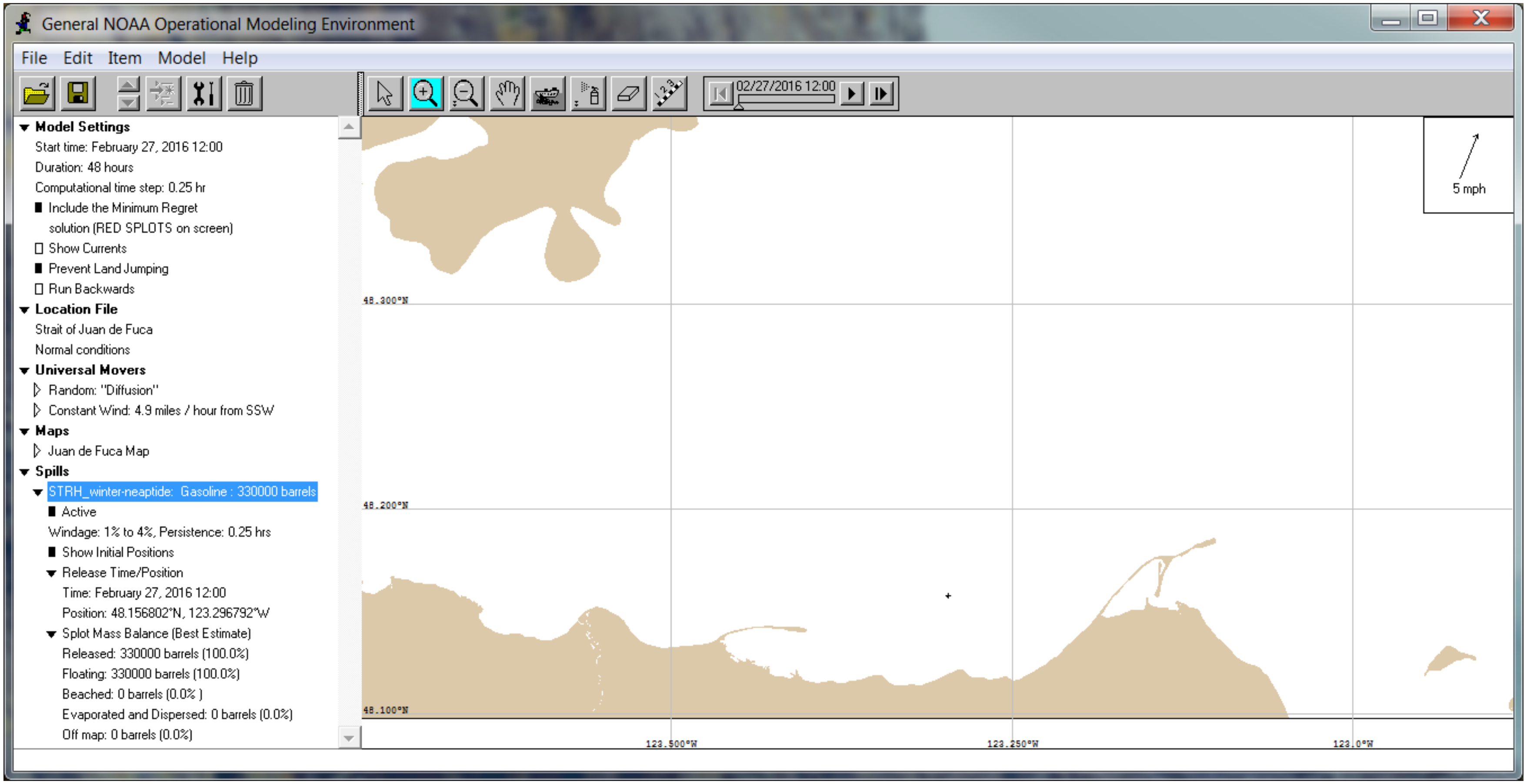

Figure G-10 (a). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ neap tide scenario: Hour 0.

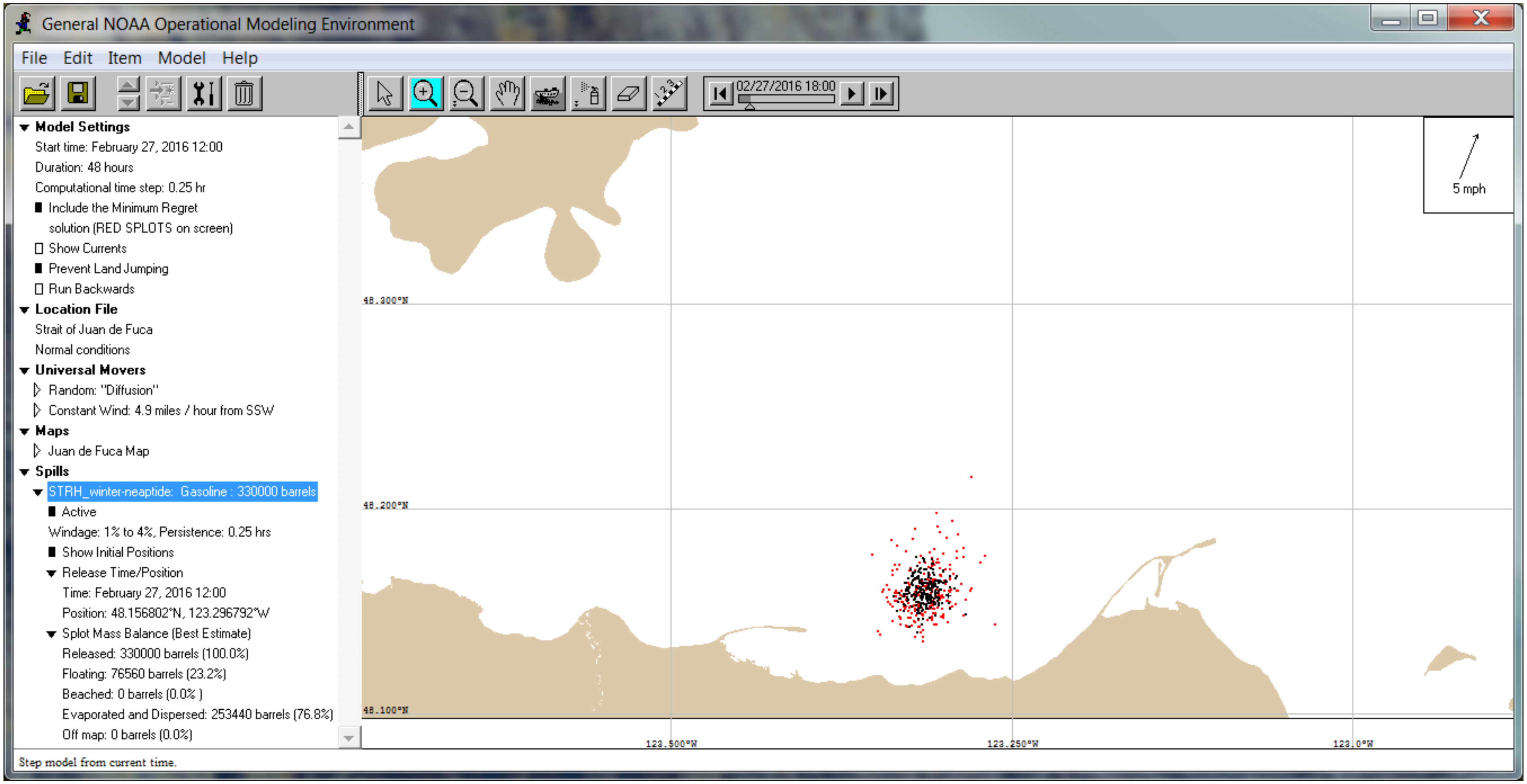

Figure G-10 (b). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ neap tide scenario: Hour 6.

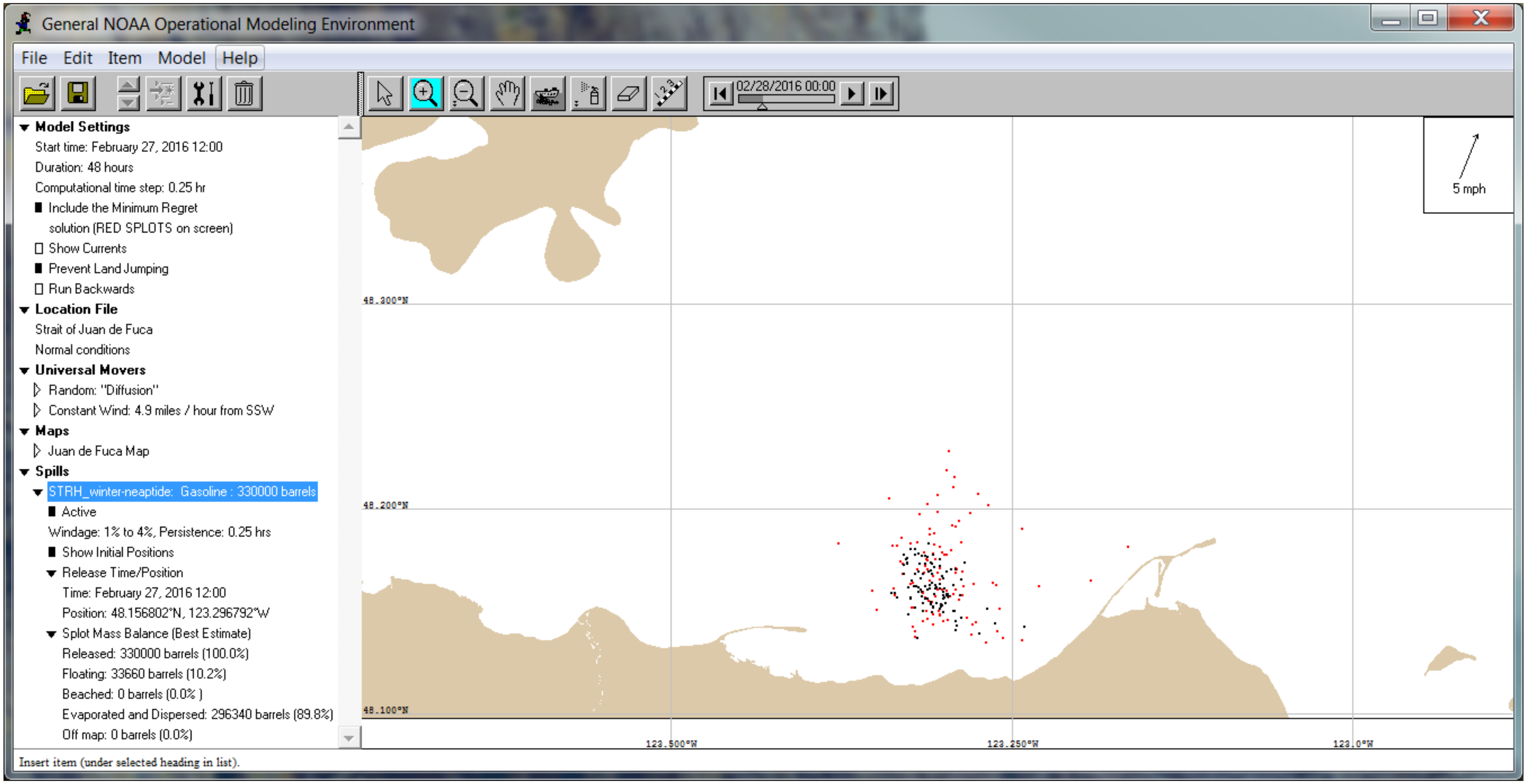

Figure G-10 (c). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ neap tide scenario: Hour 12.

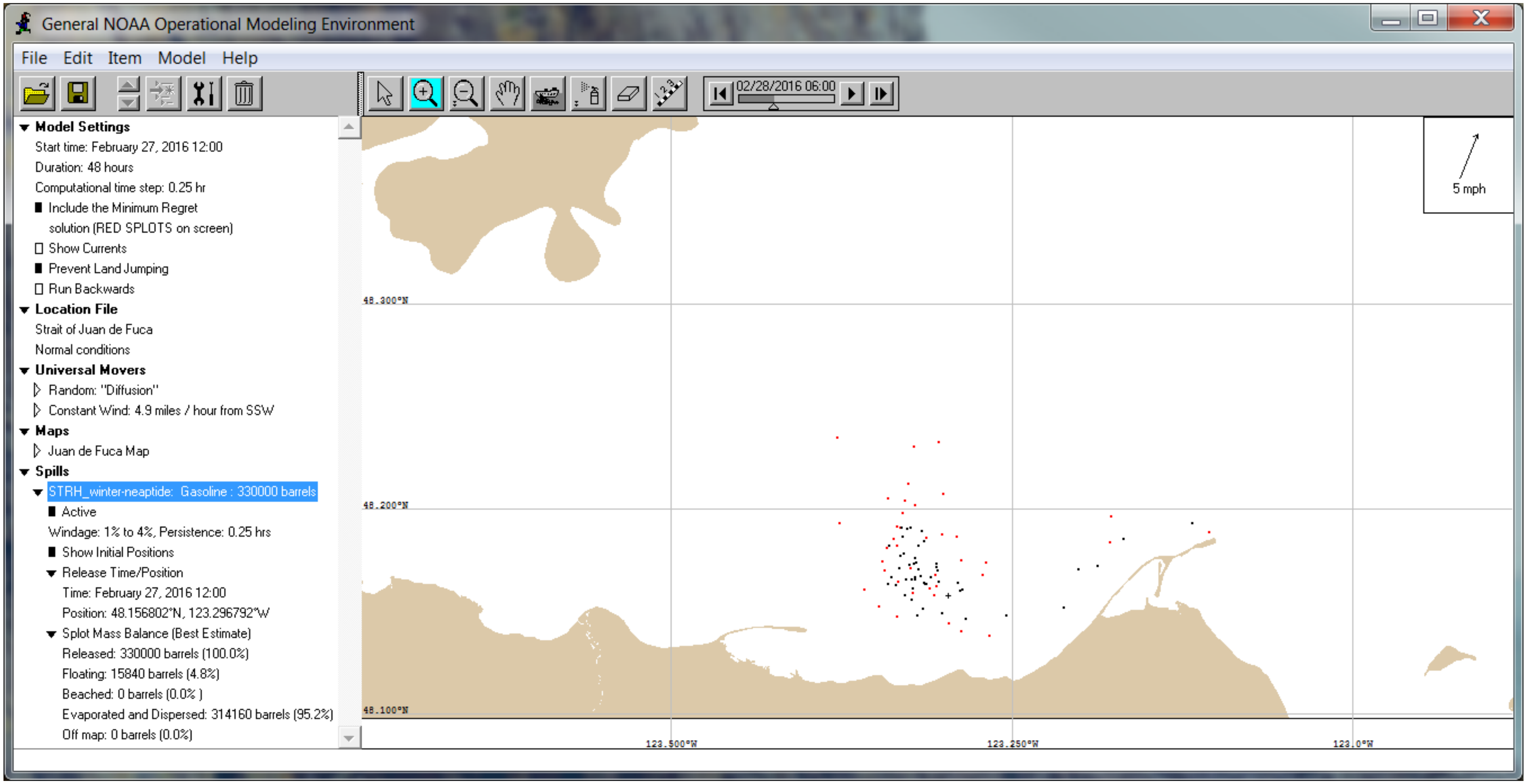

Figure G-10 (d). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ neap tide scenario: Hour 18.

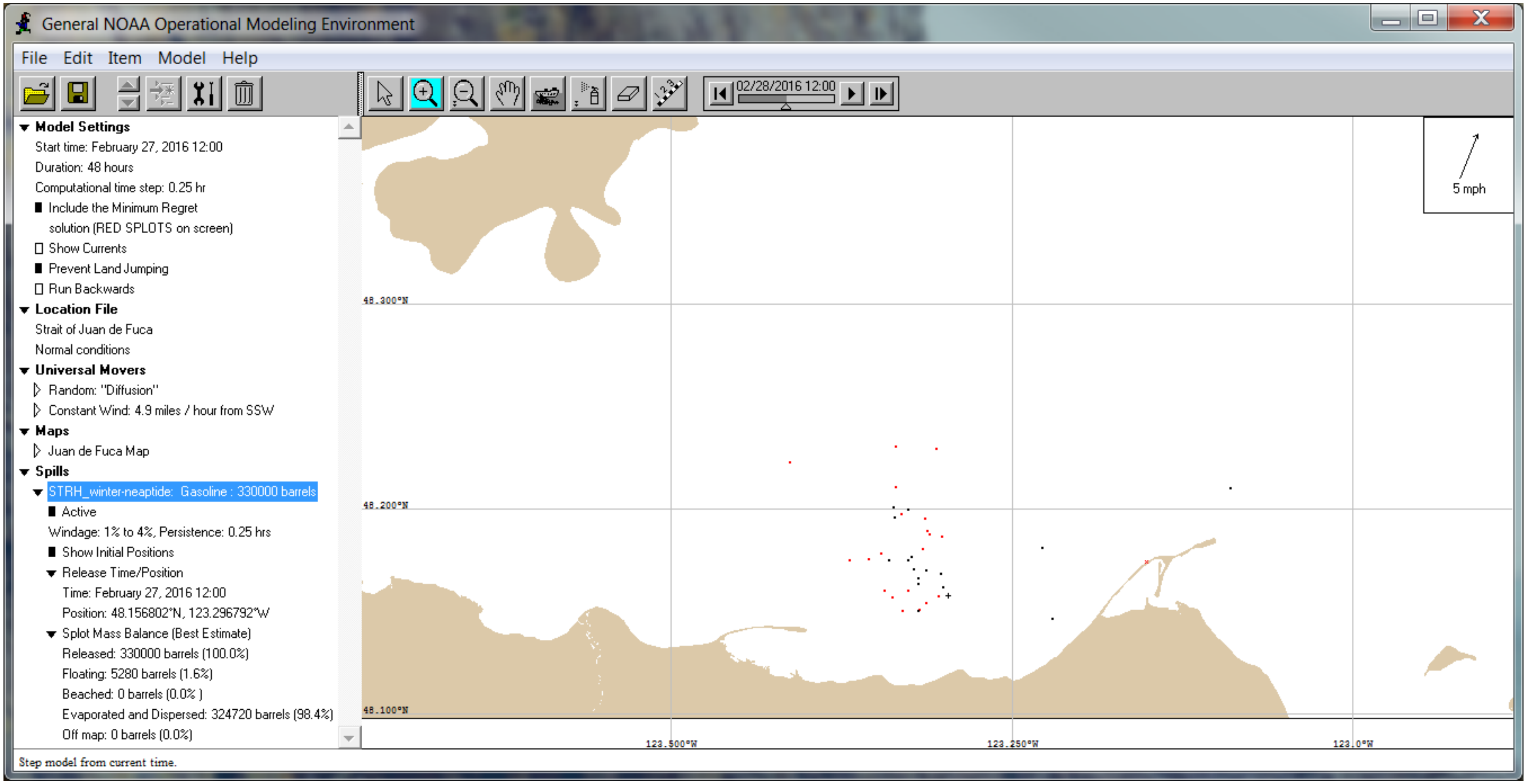

Figure G-10 (e). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ neap tide scenario: Hour 24.

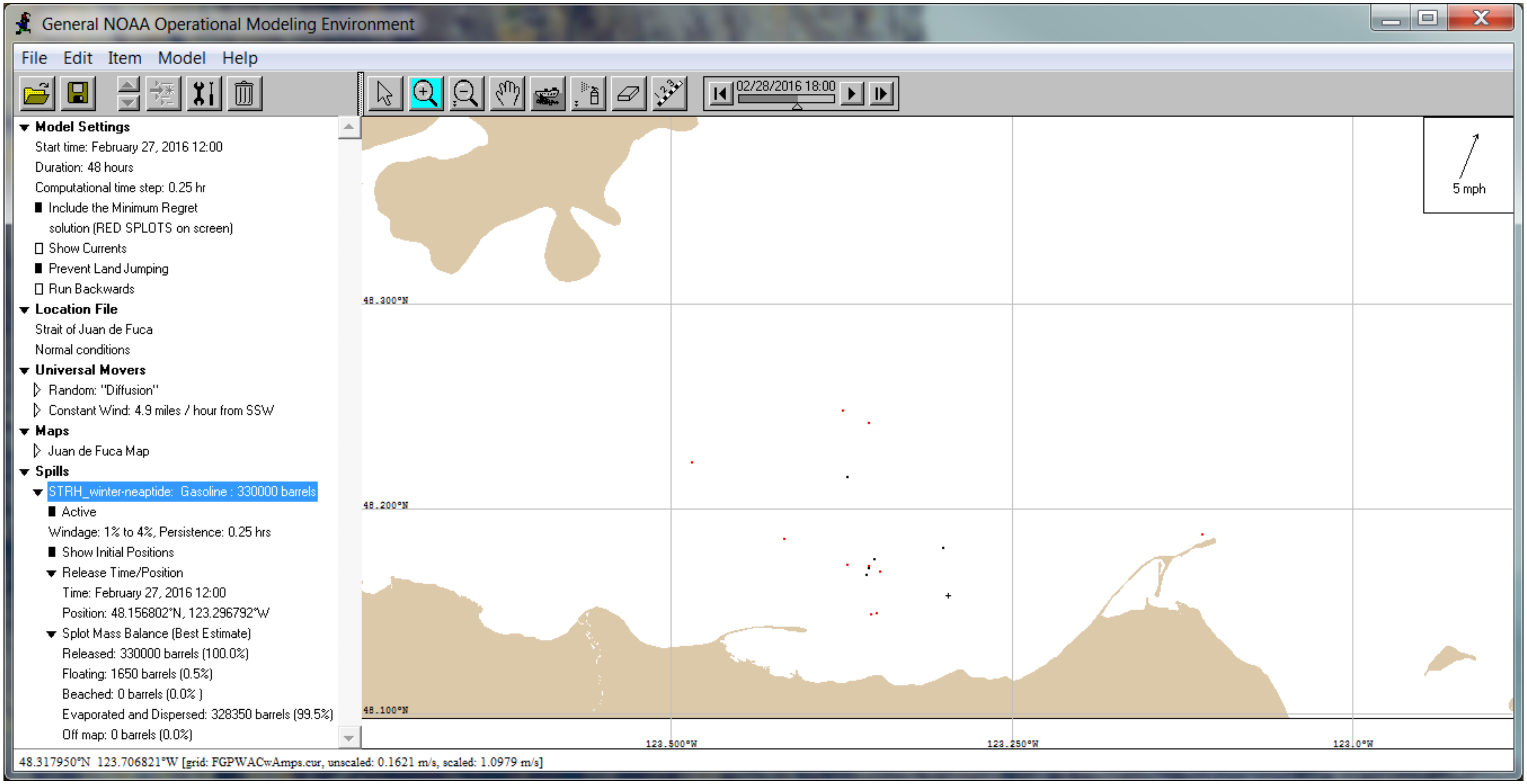

Figure G-10 (f). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ neap tide scenario: Hour 30.

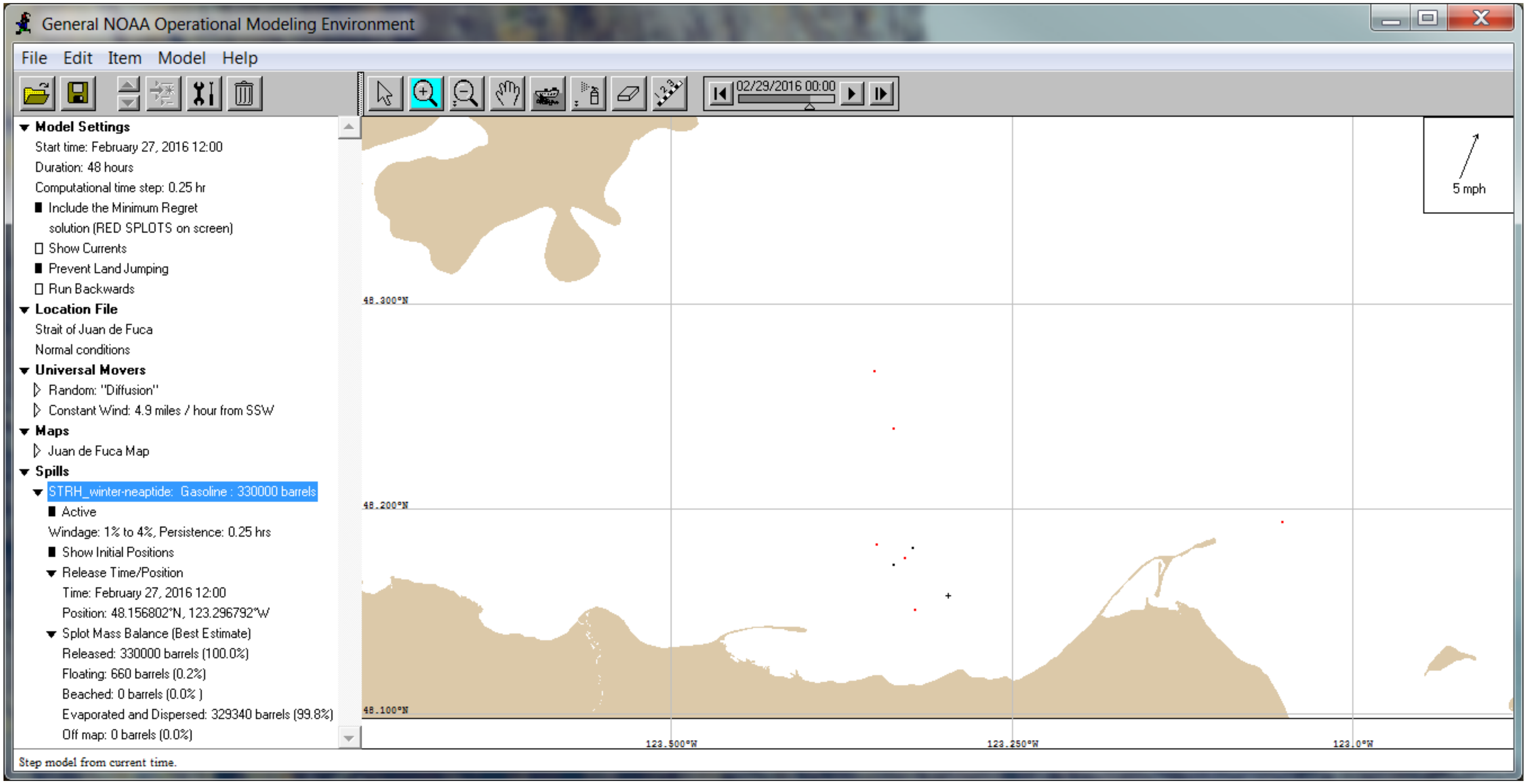

Figure G-10 (g). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ neap tide scenario: Hour 36.

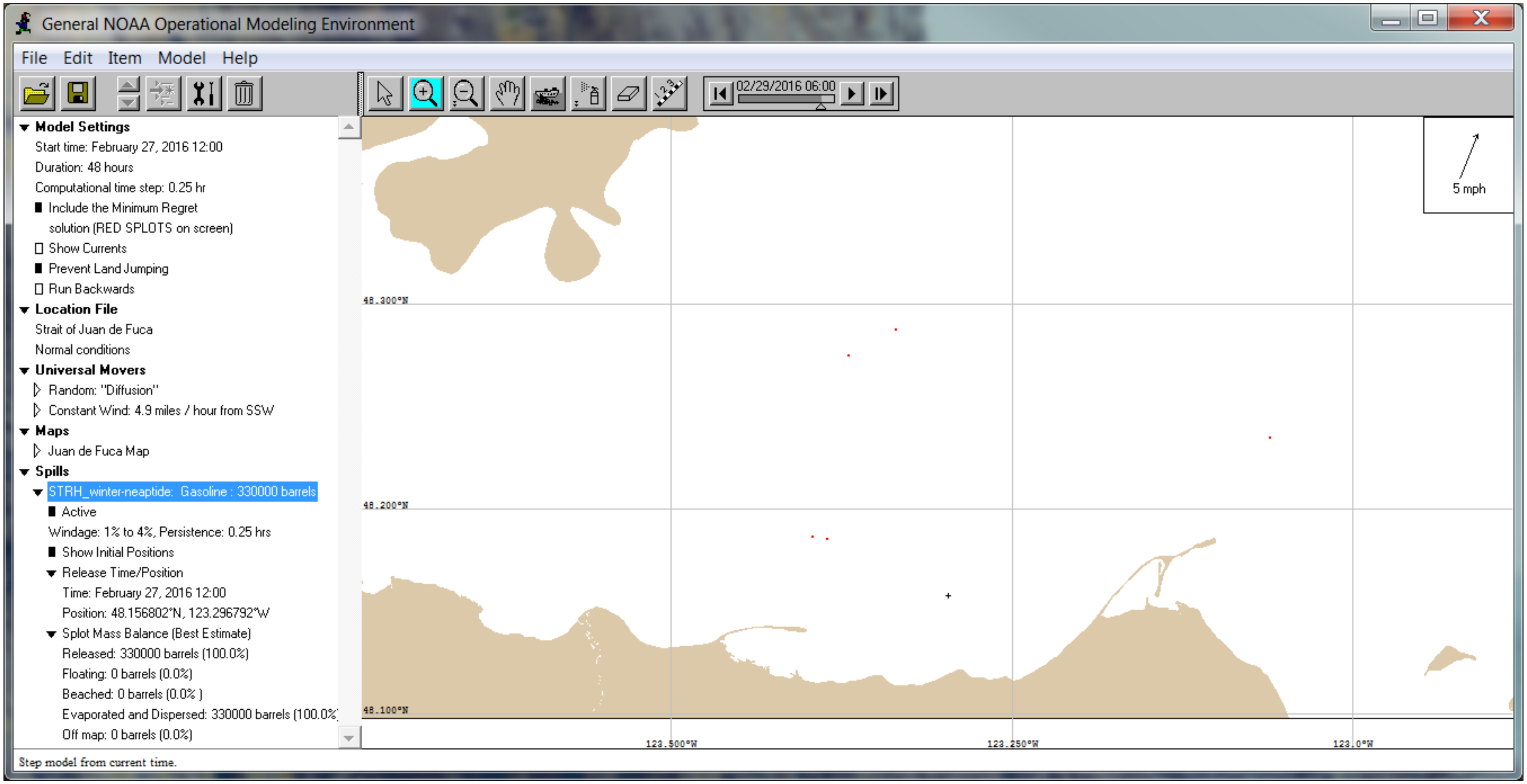

Figure G-10 (h). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ neap tide scenario: Hour 42.

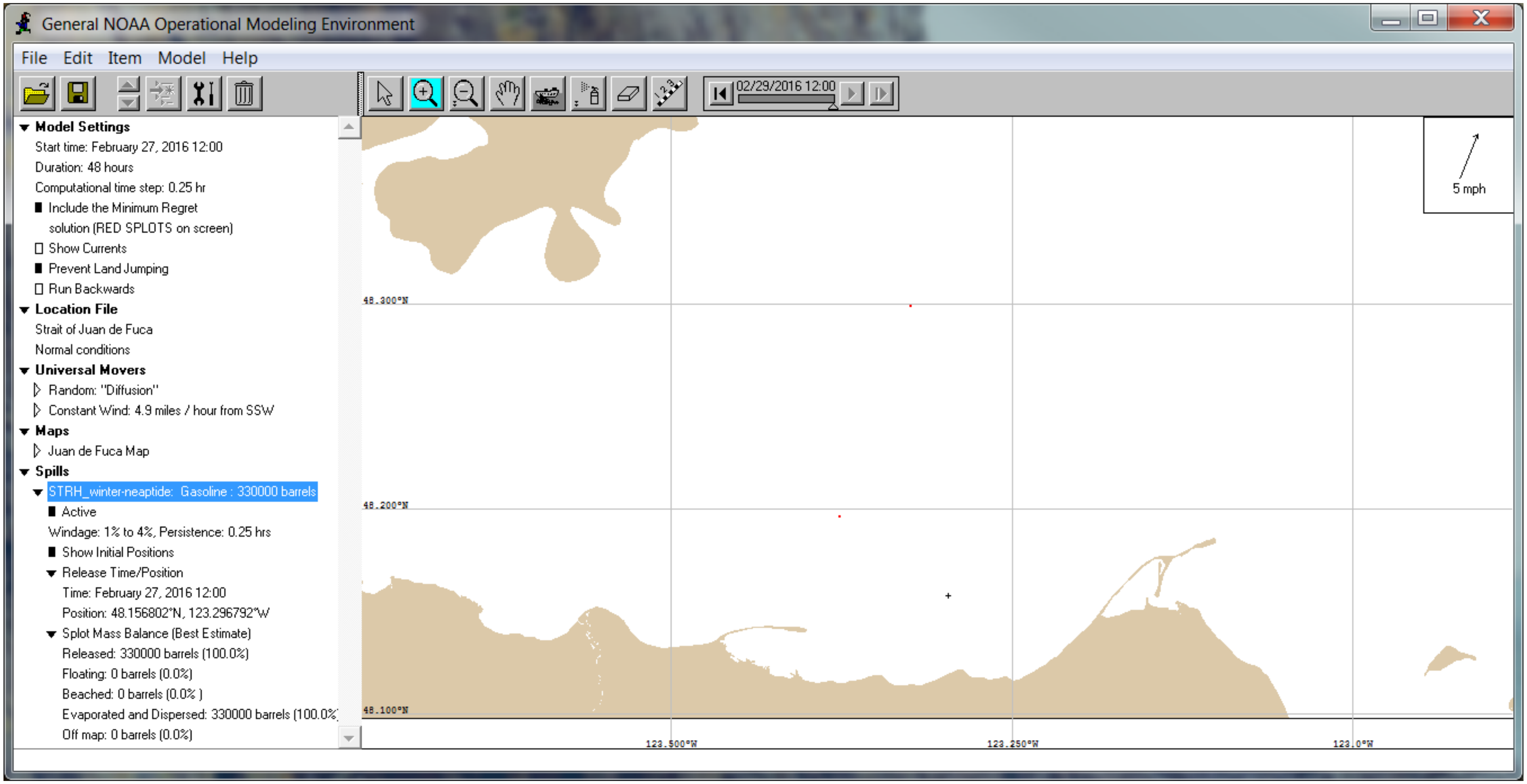

Figure G-10 (i). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, winter@ neap tide scenario: Hour 48.

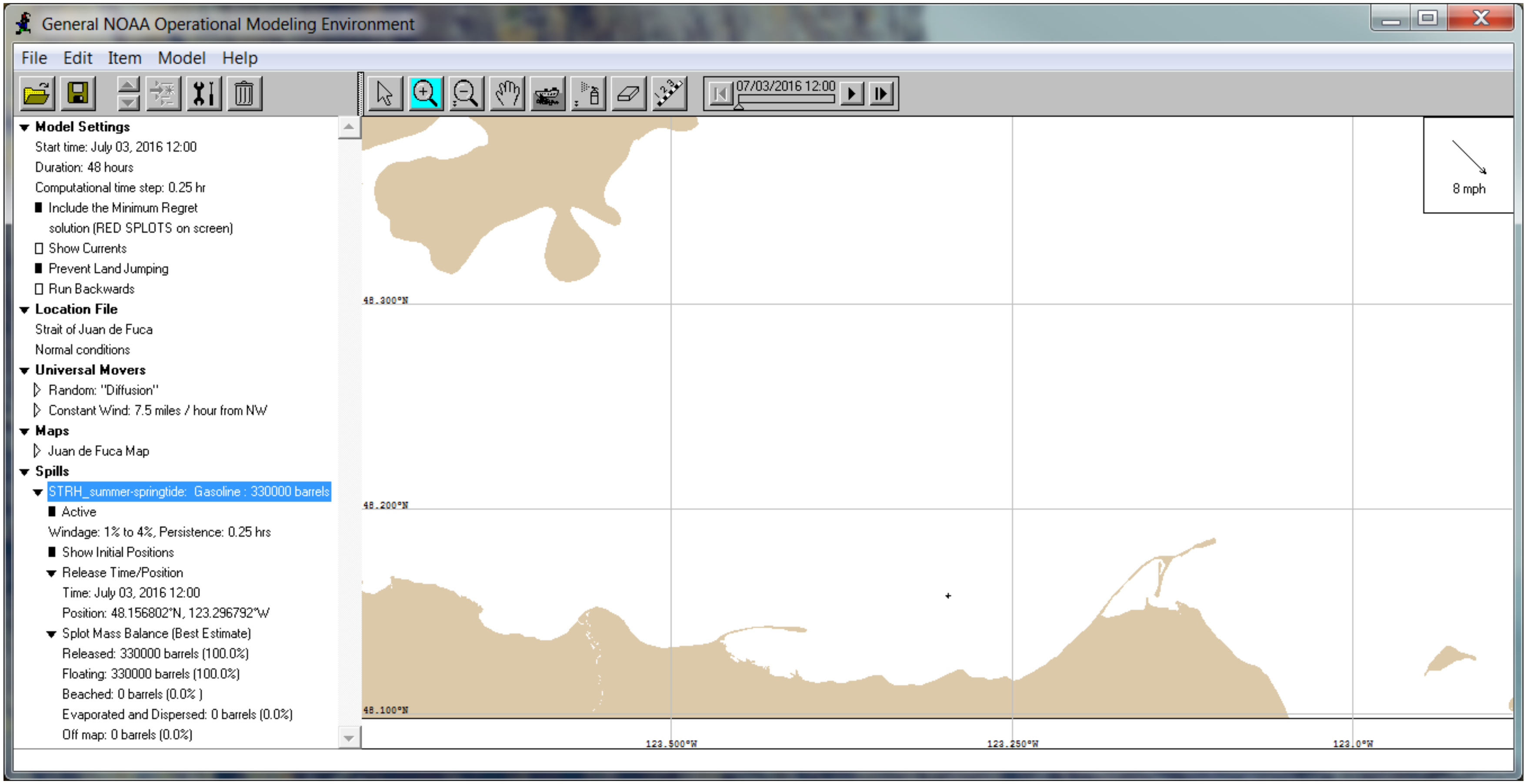

Figure G-11 (a). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ spring tide scenario: Hour 0.

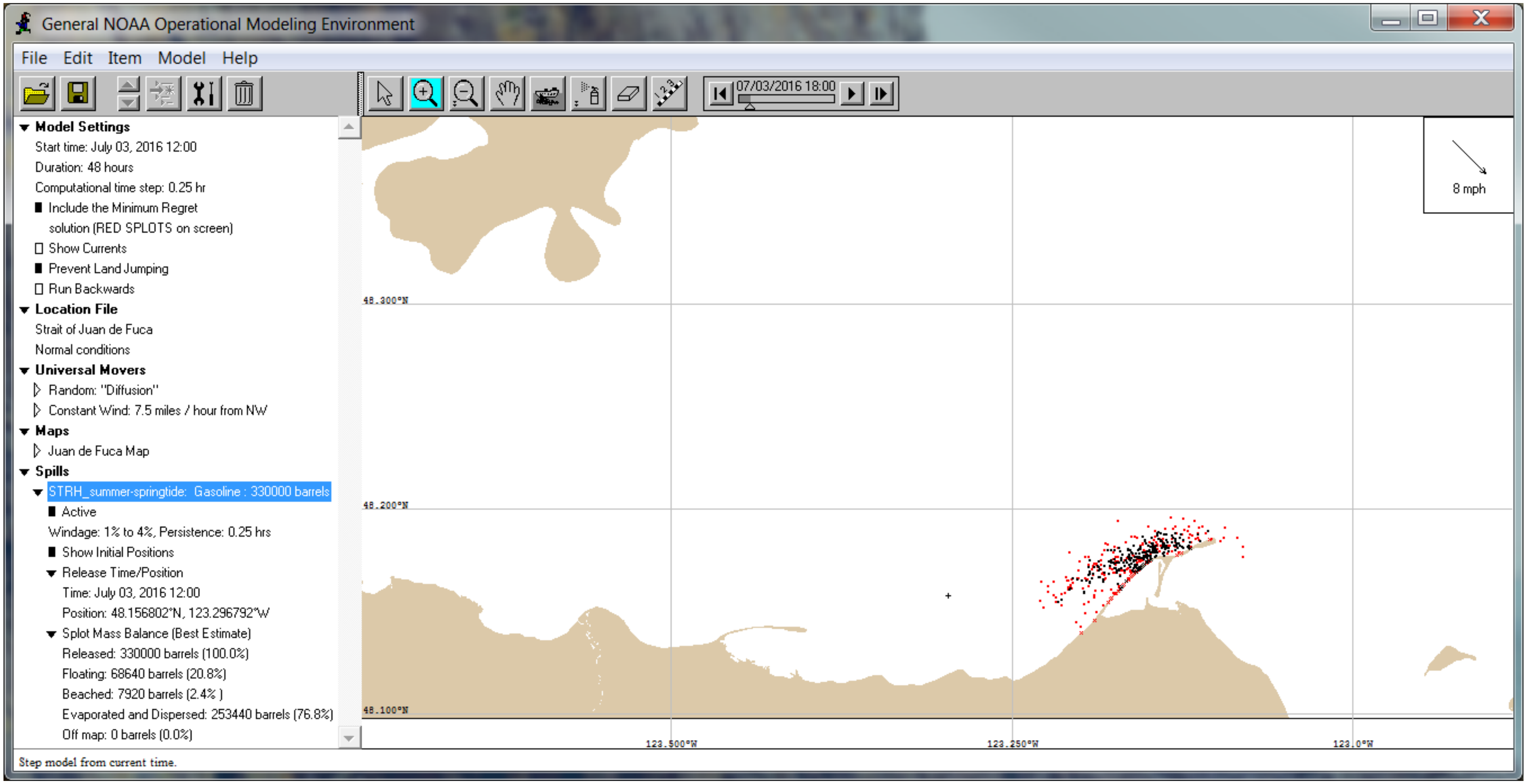

Figure G-11 (b). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ spring tide scenario: Hour 6.

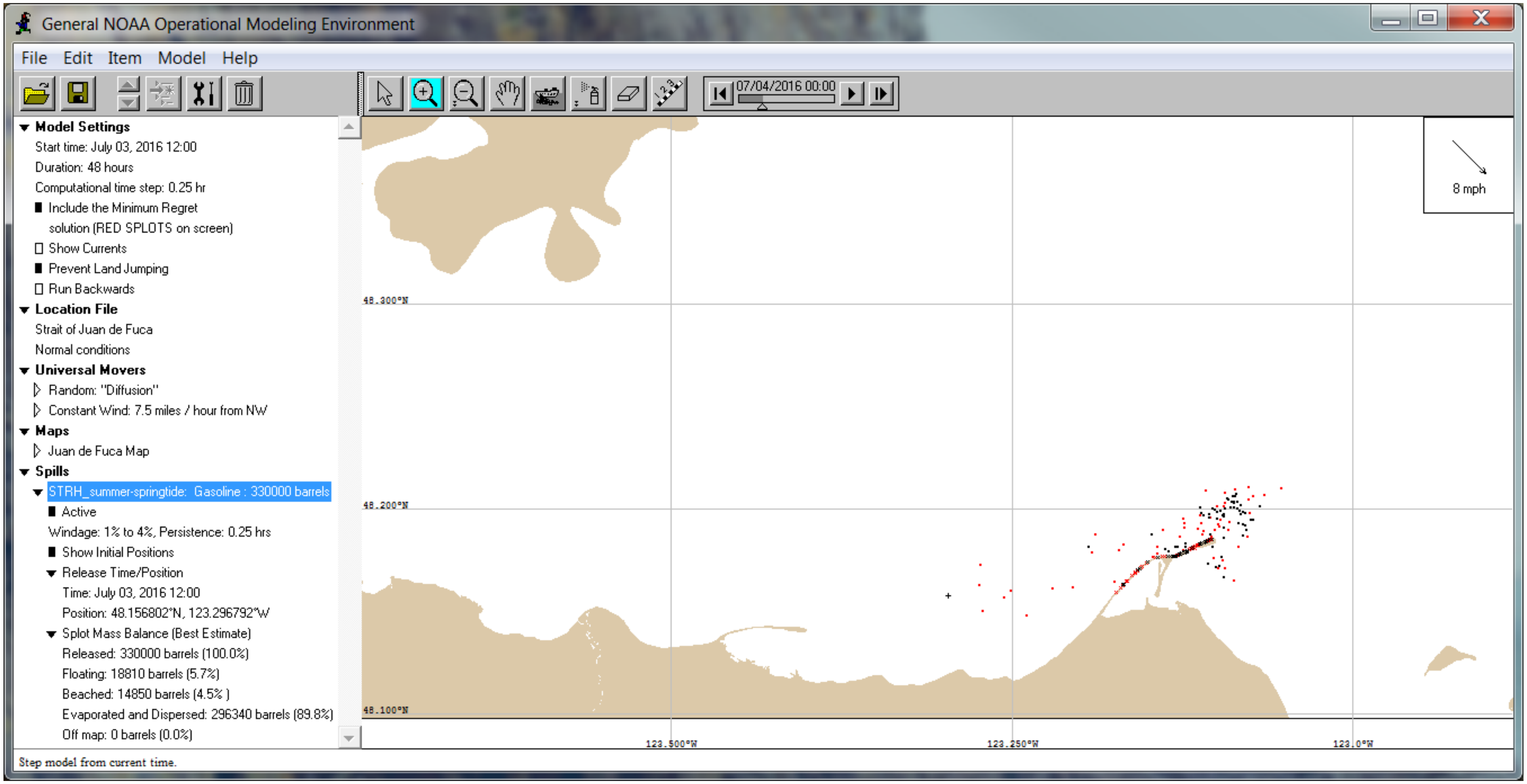

Figure G-11 (c). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ spring tide scenario: Hour 12.

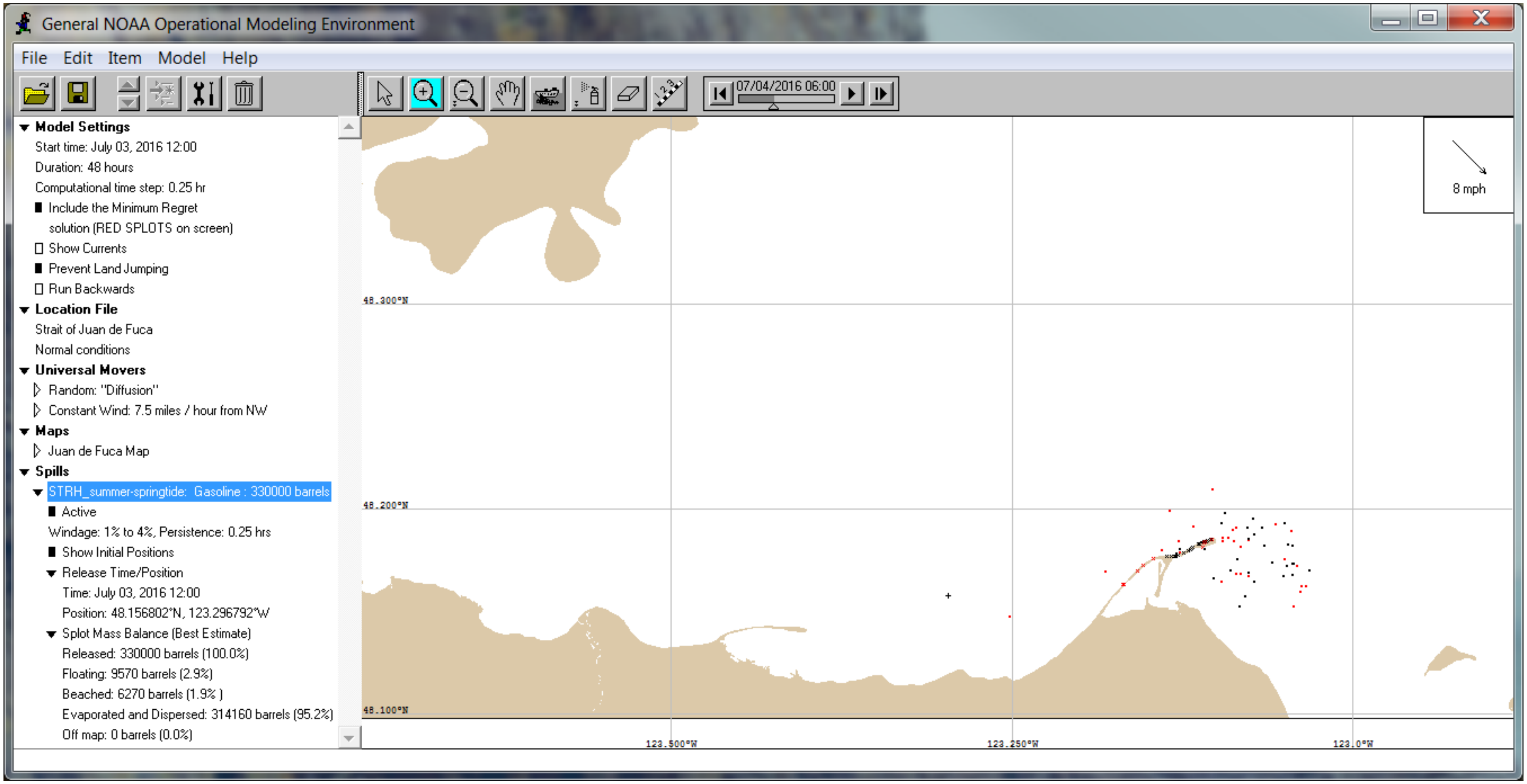

Figure G-11 (d). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ spring tide scenario: Hour 18.

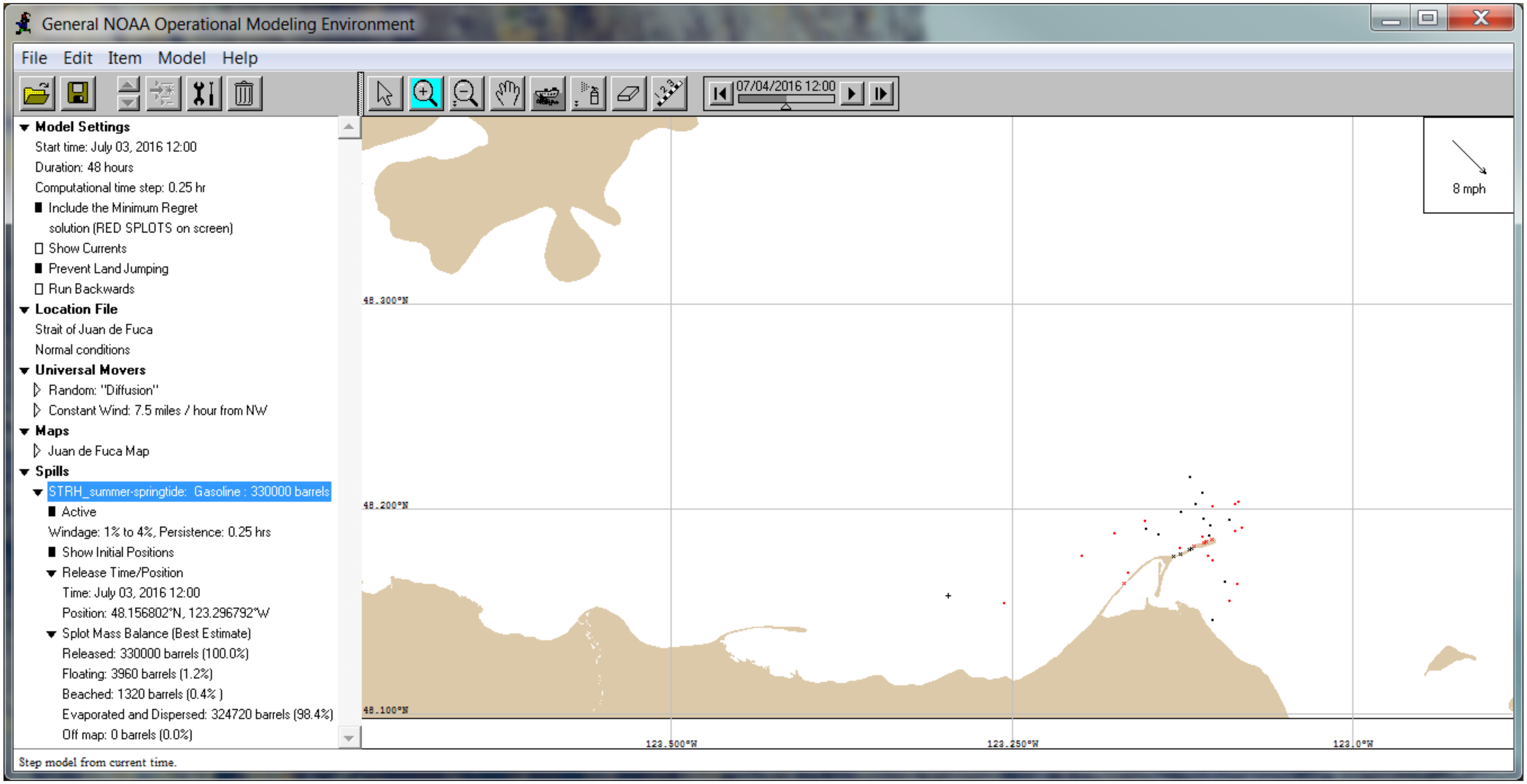

Figure G-11 (e). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ spring tide scenario: Hour 24.

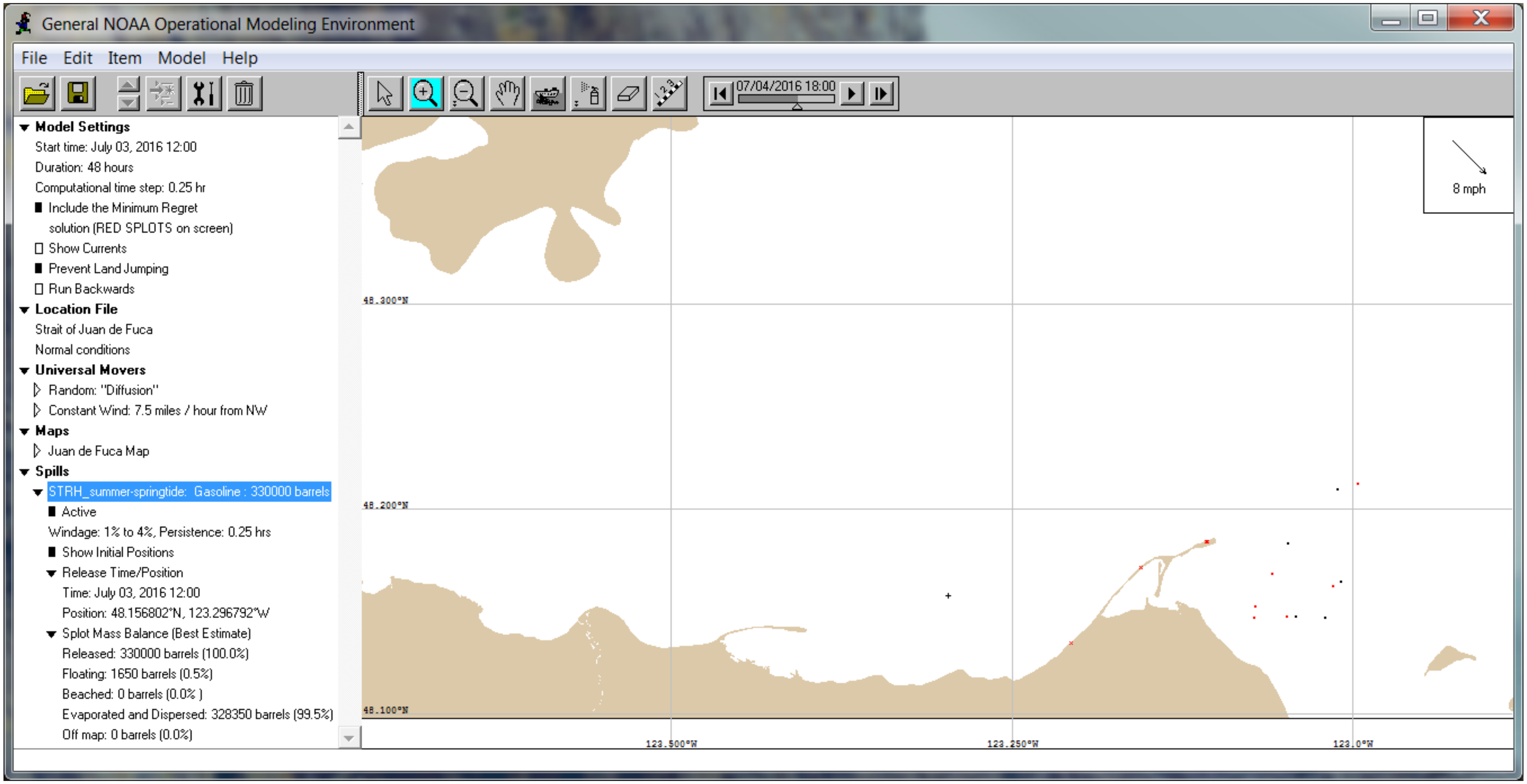

Figure G-11 (f). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ spring tide scenario: Hour 30.

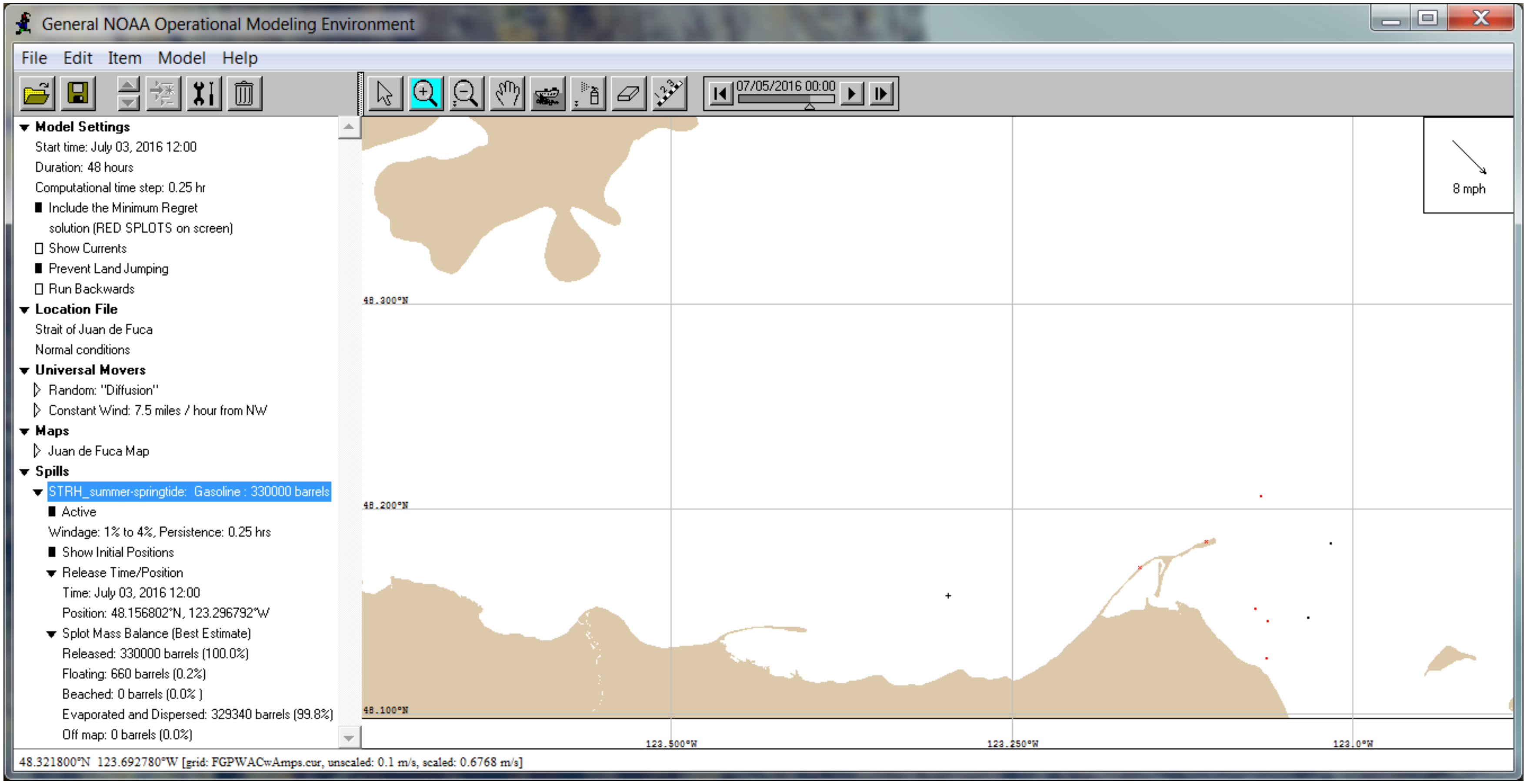

Figure G-11 (g). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ spring tide scenario: Hour 36.

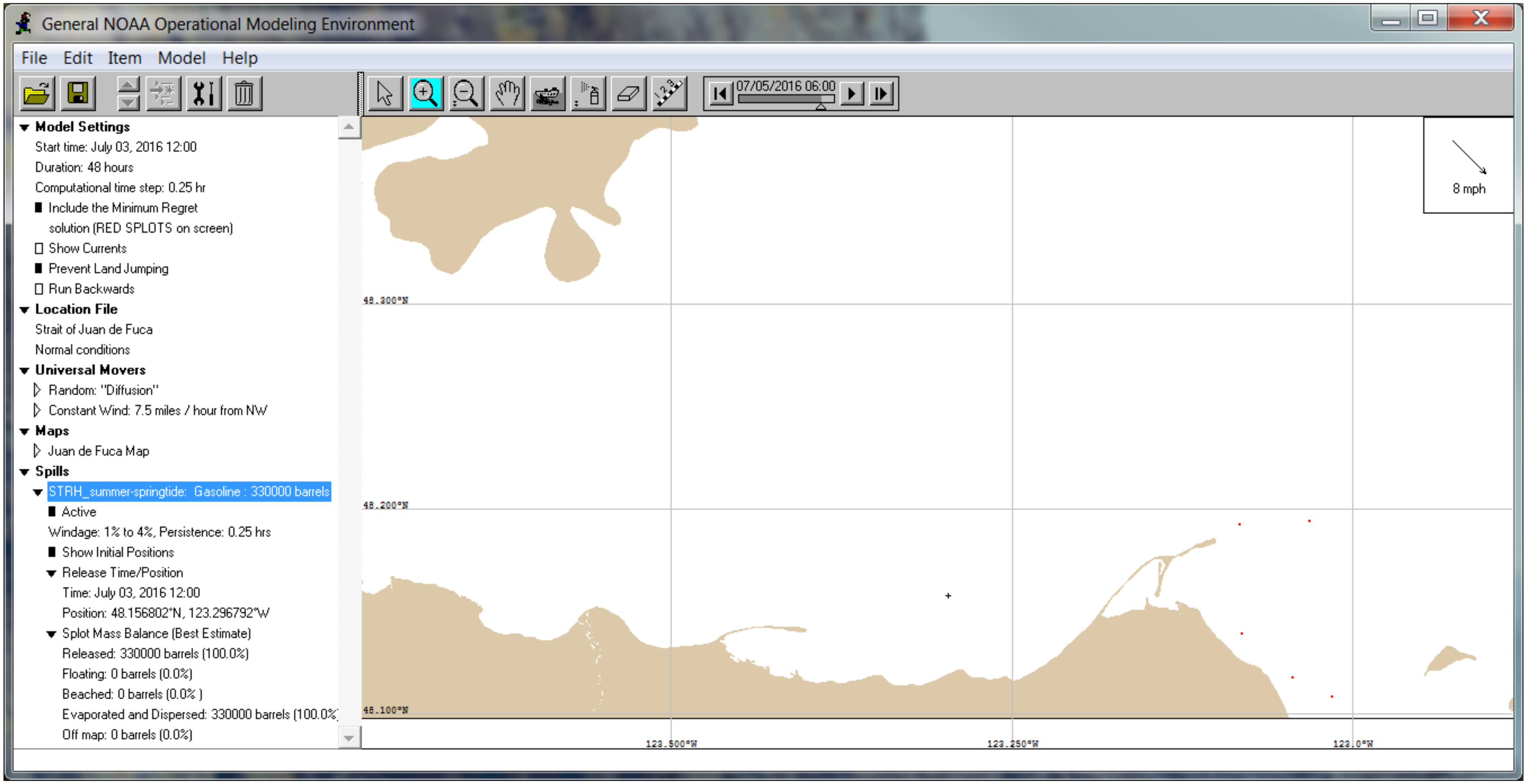

Figure G-11 (h). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ spring tide scenario: Hour 42.

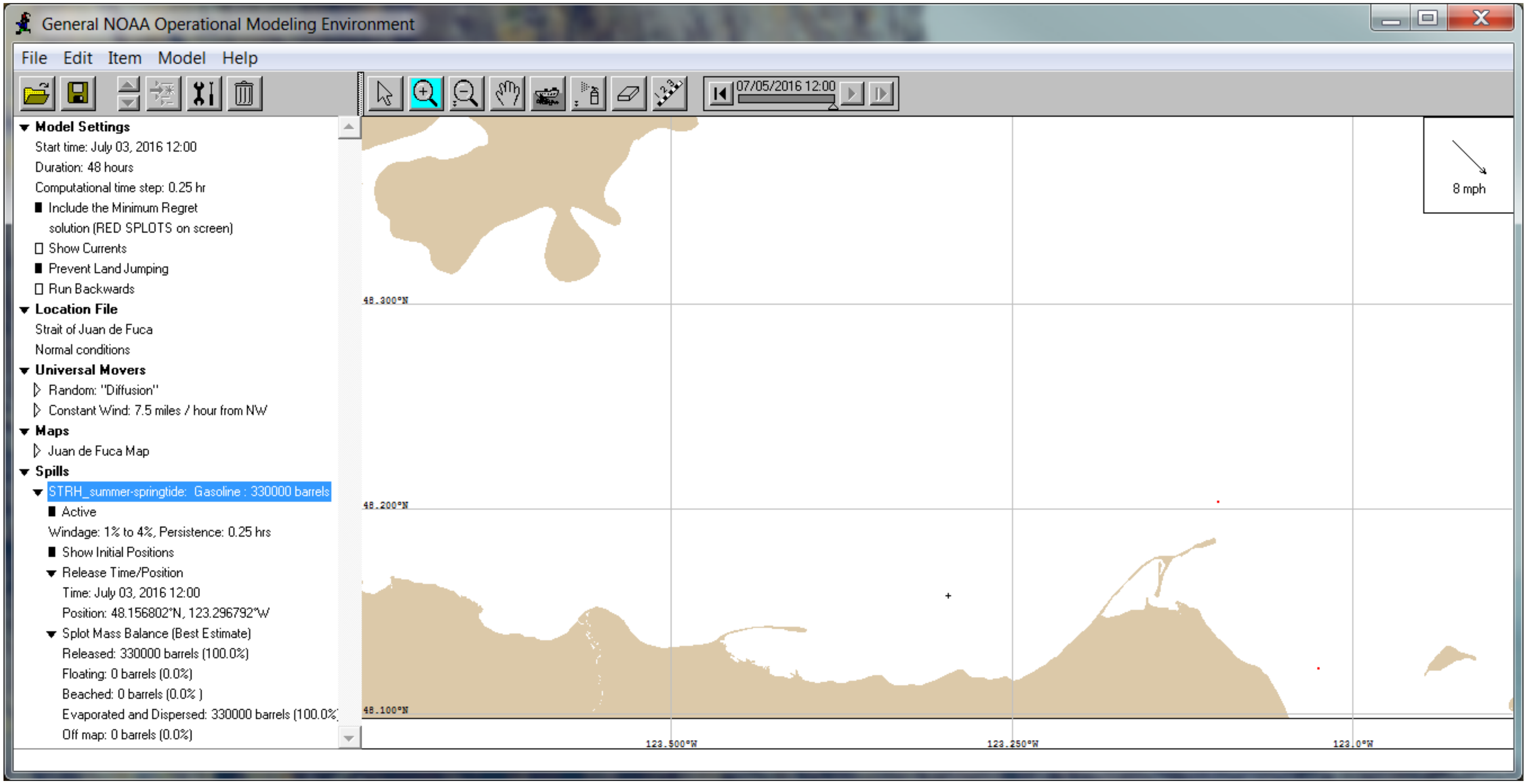

Figure G-11 (i). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ spring tide scenario: Hour 48.

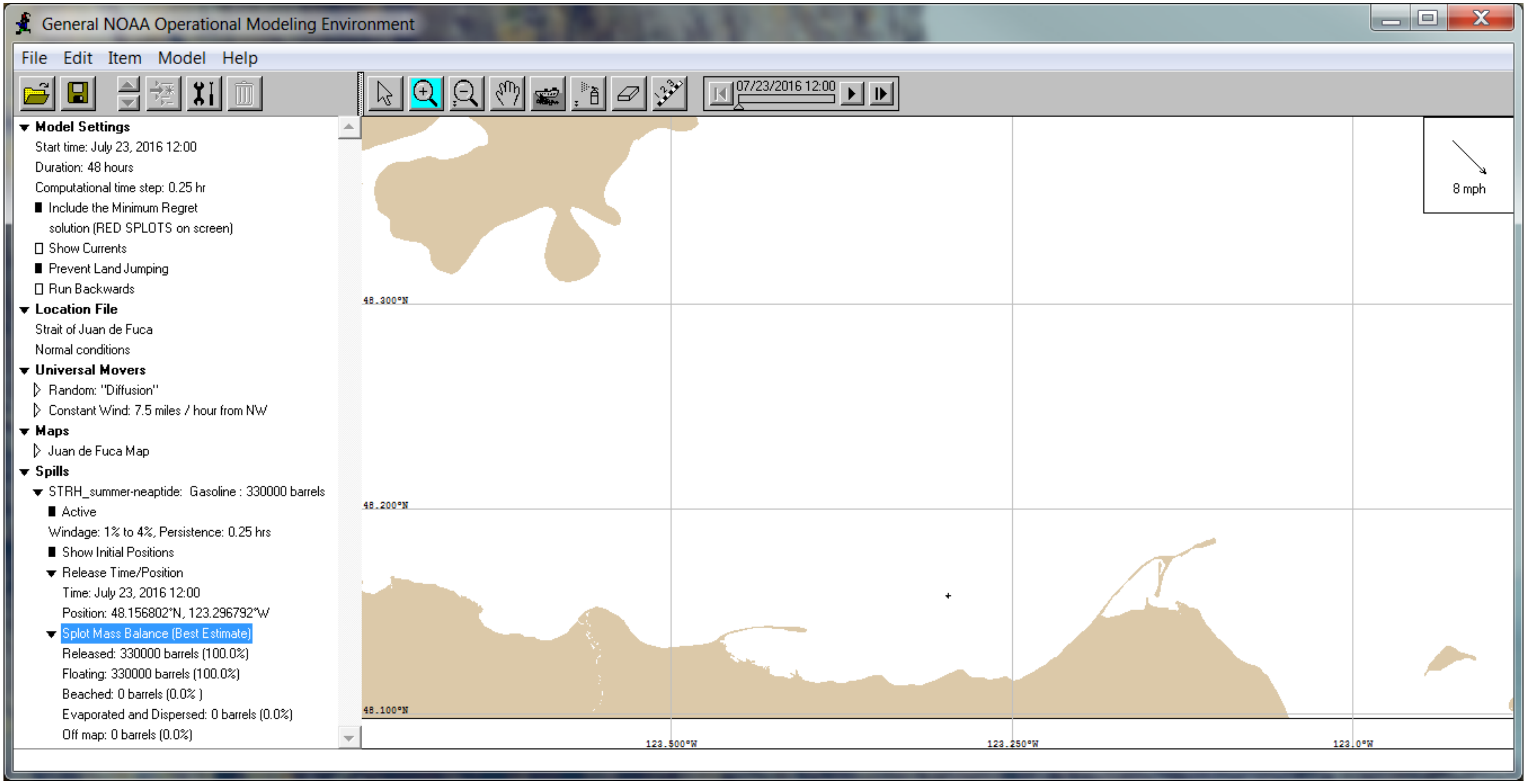

Figure G-12 (a). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ neap tide scenario: Hour 0.

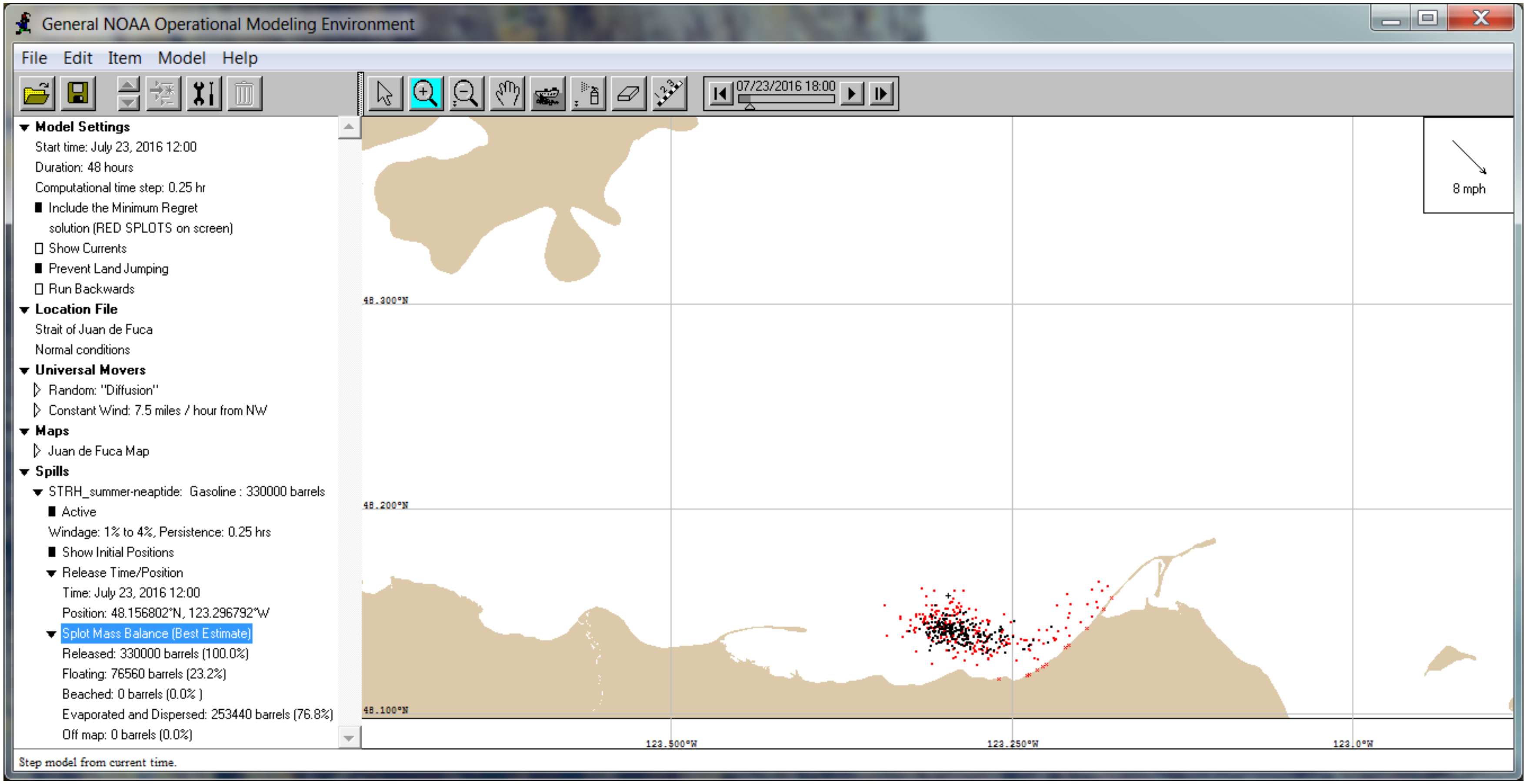

Figure G-12 (b). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ neap tide scenario: Hour 6.

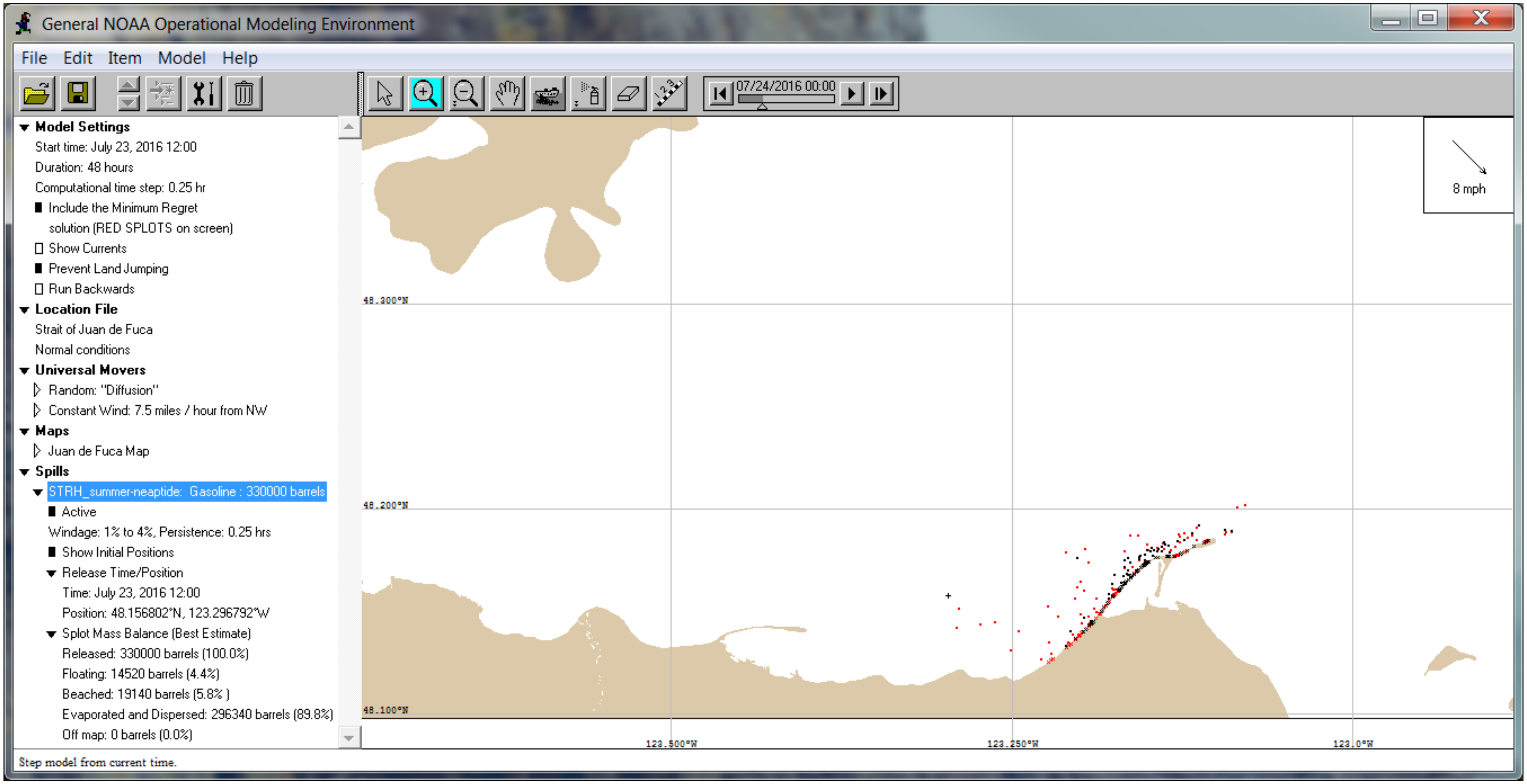

Figure G-12 (c). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ neap tide scenario: Hour 12.

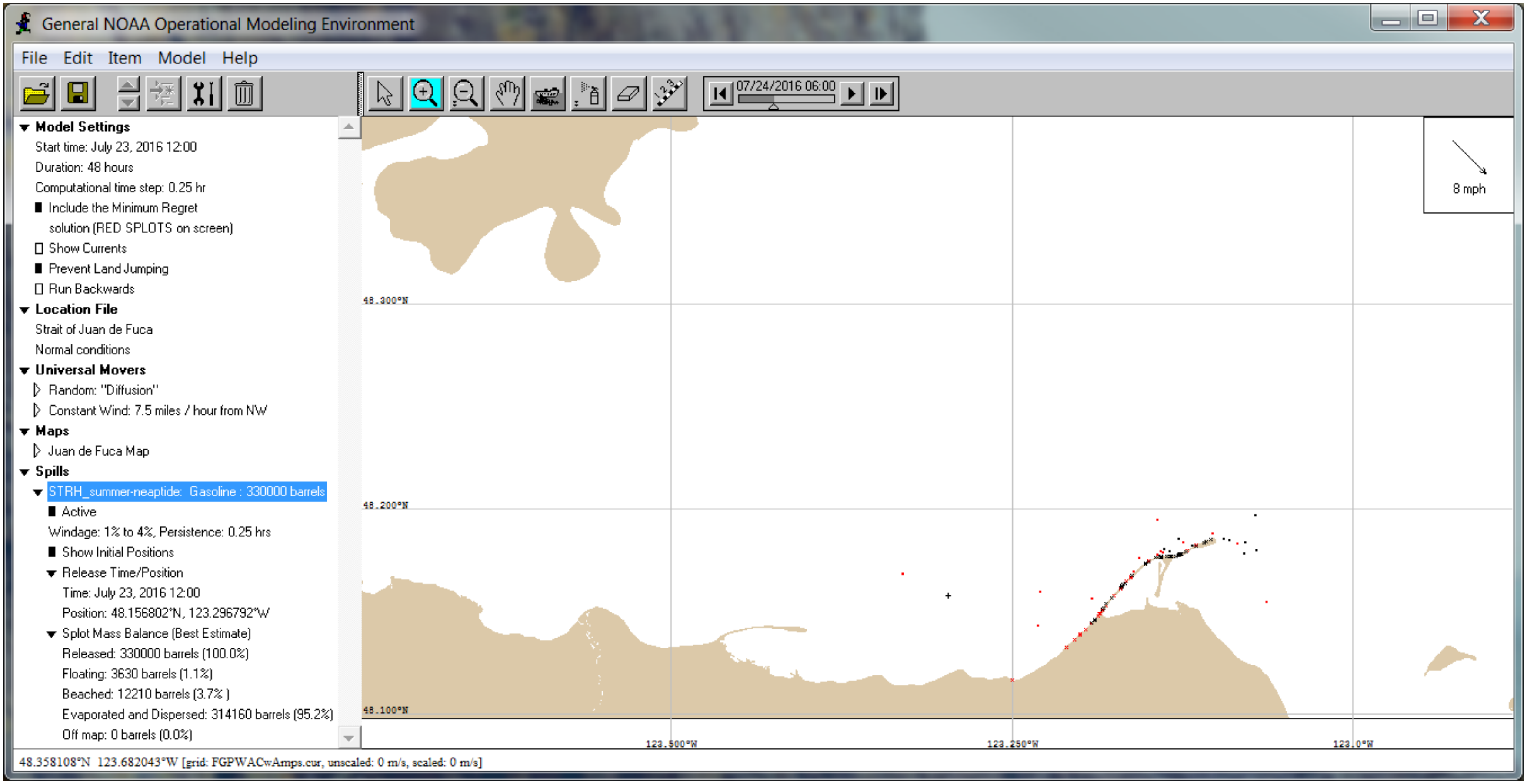

Figure G-12 (d). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ neap tide scenario: Hour 18.

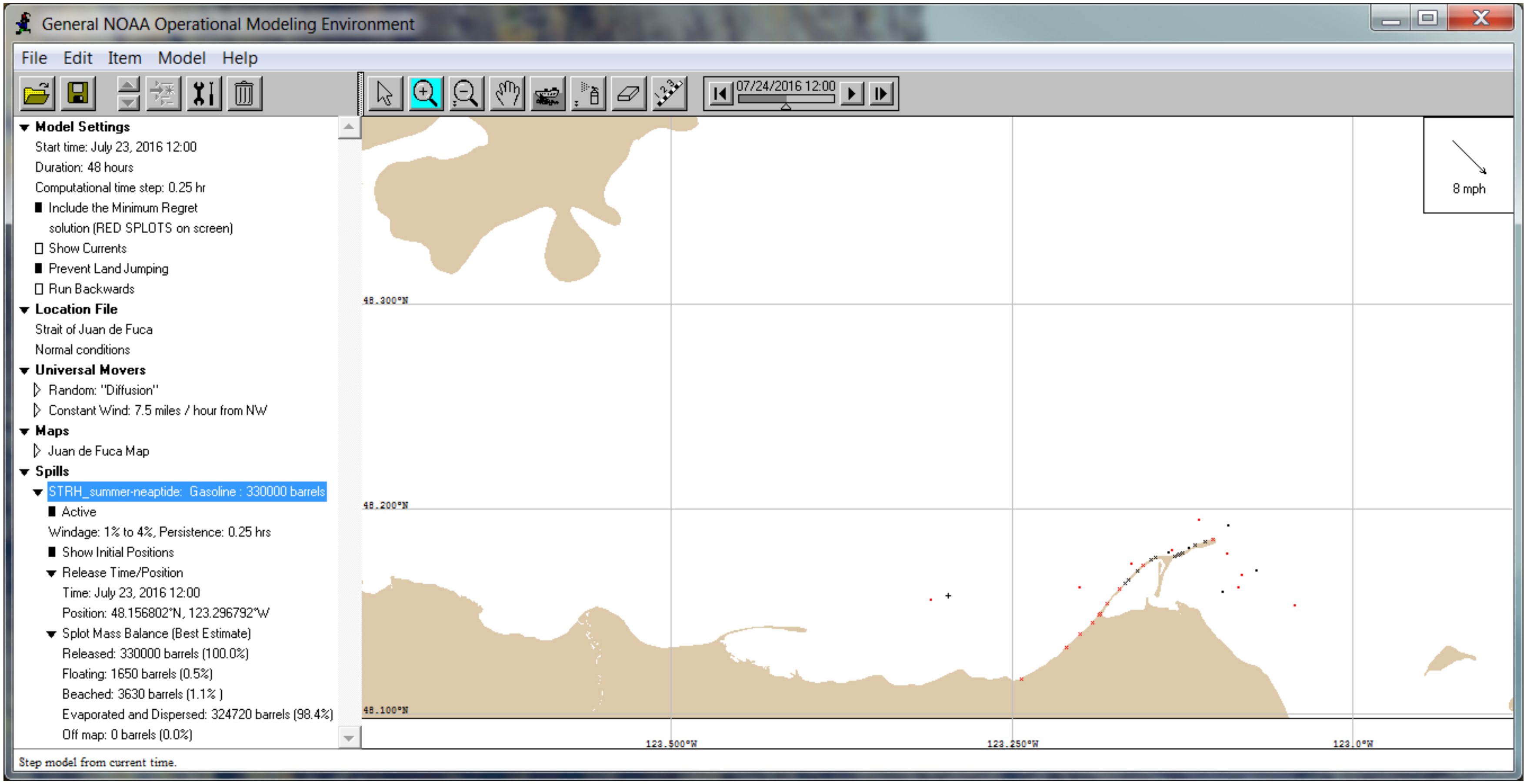

Figure G-12 (e). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ neap tide scenario: Hour 24.

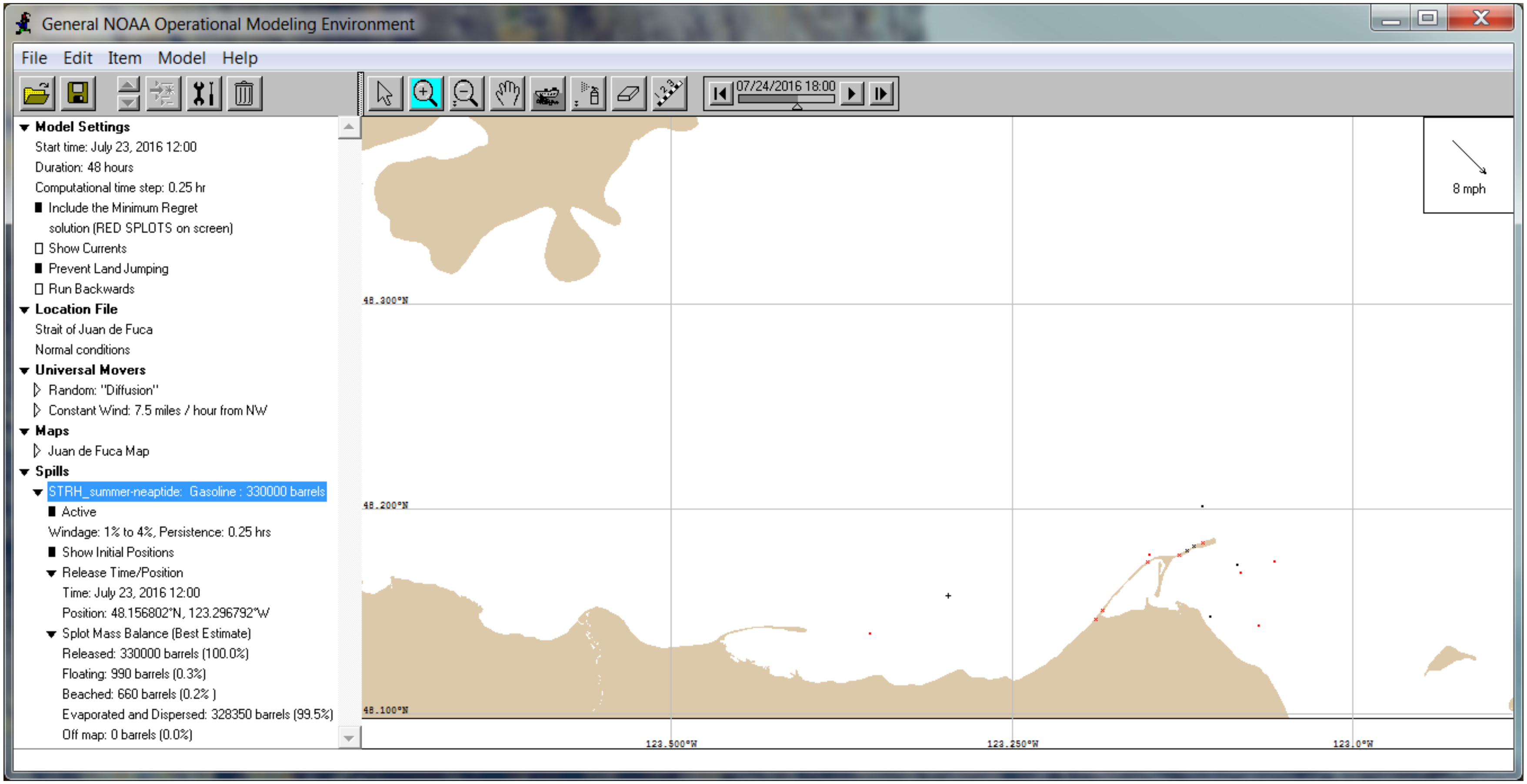

Figure G-12 (f). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ neap tide scenario: Hour 30.

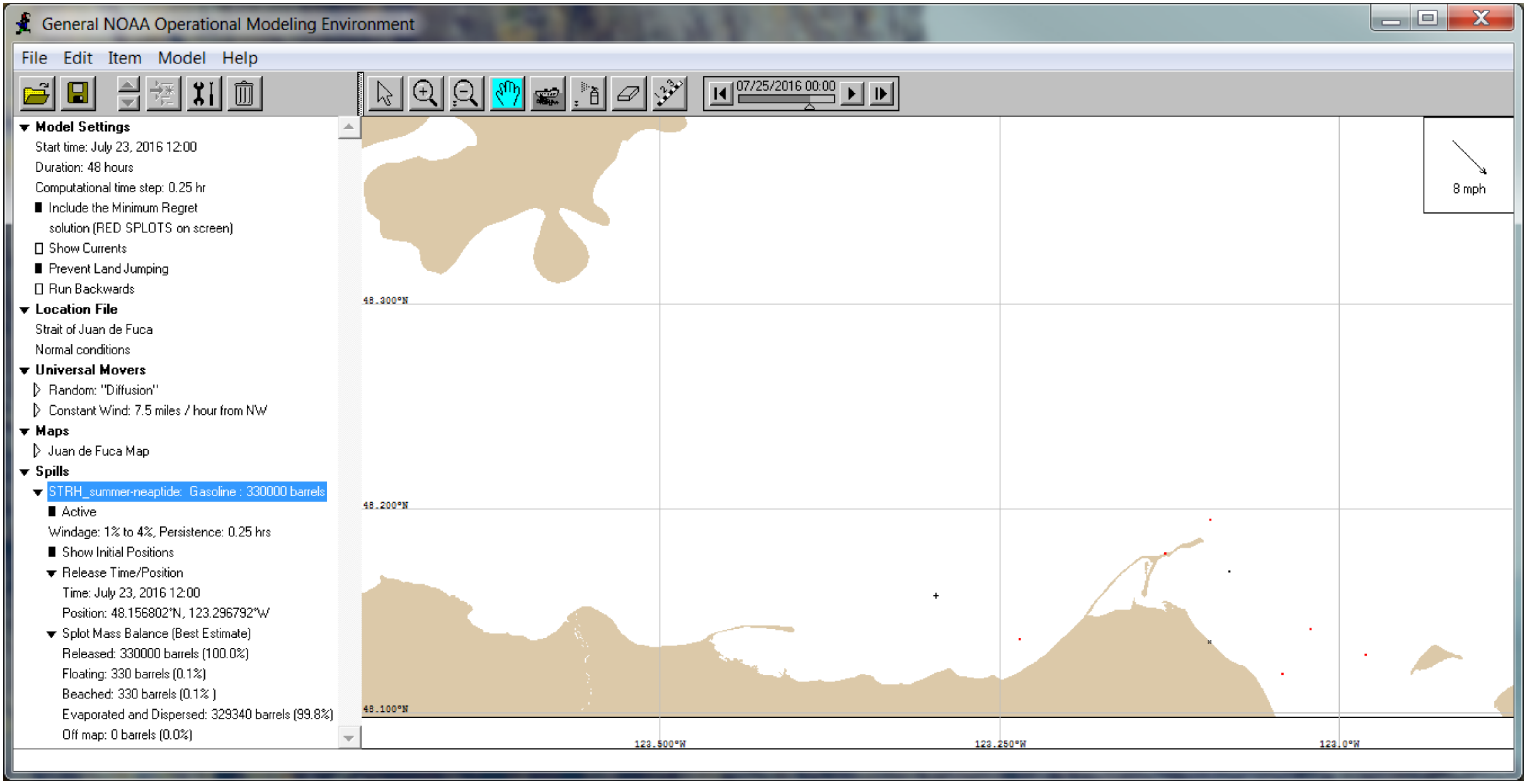

Figure G-12 (g). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ neap tide scenario: Hour 36.

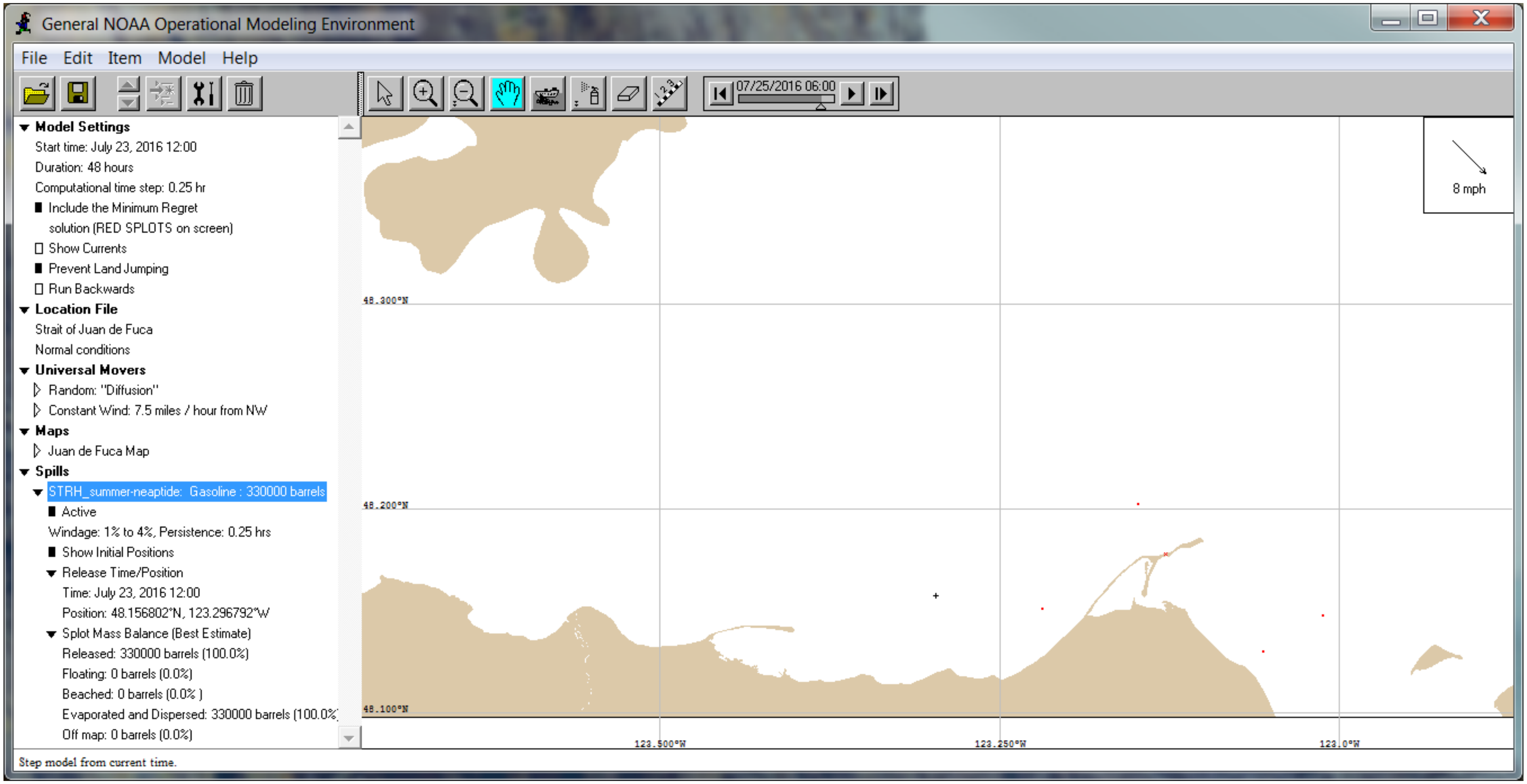

Figure G-12 (h). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ neap tide scenario: Hour 42.

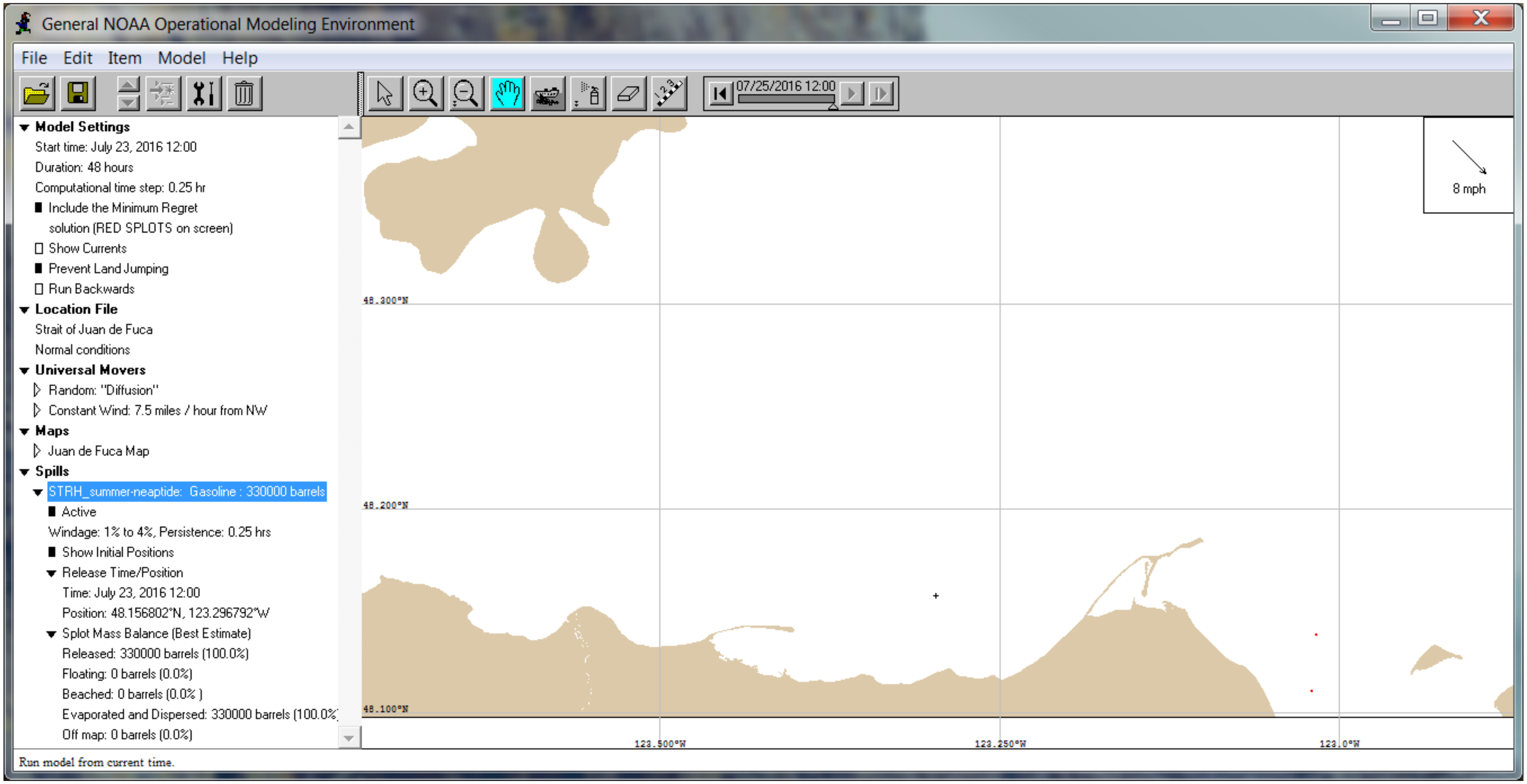

Figure G-12 (i). GNOME Model Output, Port Angeles (STR-H), 330,000 bbls, summer@ neap tide scenario: Hour 48.

Table G-5. List of Figures for Vessel Transit Scenario near Rosario Strait (SJI-O)
GNOME Modeling of Gasoline Trajectories Individual Run Results

Figure #	Season	Tidal Influence	Wind Speed (mph) /Wind Direction	Volume bbl	Date/Time	Hour into model run
Figure G-13 (a)	Winter	Spring	12.0/SE	330,000	06-Feb-16 12:00	0
Figure G-13 (b)					06-Feb-16 18:00	6
Figure G-13 (c)					07-Feb-16 00:00	12
Figure G-13 (d)					07-Feb-16 06:00	18
Figure G-13 (e)					07-Feb-16 12:00	24
Figure G-13 (f)					07-Feb-16 18:00	30
Figure G-13 (g)					08-Feb-16 00:00	36
Figure G-13 (h)					08-Feb-16 06:00	42
Figure G-13 (i)					08-Feb-16 12:00	48
Figure G-14 (a)	Winter	Neap	12.0/SE	330,000	27-Feb-16 12:00	0
Figure G-14 (b)					27-Feb-16 18:00	6
Figure G-14 (c)					28-Feb-16 00:00	12
Figure G-14 (d)					28-Feb-16 06:00	18
Figure G-14 (e)					28-Feb-16 12:00	24
Figure G-14 (f)					28-Feb-16 18:00	30
Figure G-14 (g)					29-Feb-16 00:00	36
Figure G-14 (h)					29-Feb-16 06:00	42
Figure G-14 (i)					29-Feb-16 12:00	48
Figure G-15 (a)	Summer	Spring	10.4/WSW	330,000	03-Jul-16 12:00	0
Figure G-15 (b)					03-Jul -16 18:00	6
Figure G-15 (c)					04-Jul -16 00:00	12
Figure G-15 (d)					04-Jul -16 06:00	18
Figure G-15 (e)					04-Jul -16 12:00	24
Figure G-15 (f)					04-Jul -16 18:00	30
Figure G-15 (g)					05-Jul -16 00:00	36
Figure G-15 (h)					05-Jul -16 06:00	42
Figure G-15 (i)					05-Jul -16 12:00	48
Figure G-16 (a)	Summer	Neap	10.4/WSW	330,000	24-Jul-16 12:00	0
Figure G-16 (b)					24-Jul -16 18:00	6
Figure G-16 (c)					25-Jul -16 00:00	12
Figure G-16 (d)					25-Jul -16 06:00	18
Figure G-16 (e)					25-Jul -16 12:00	24
Figure G-16 (f)					25-Jul -16 18:00	30
Figure G-16 (g)					26-Jul -16 00:00	36
Figure G-16 (h)					26-Jul -16 06:00	42
Figure G-16 (i)					26-Jul -16 12:00	48

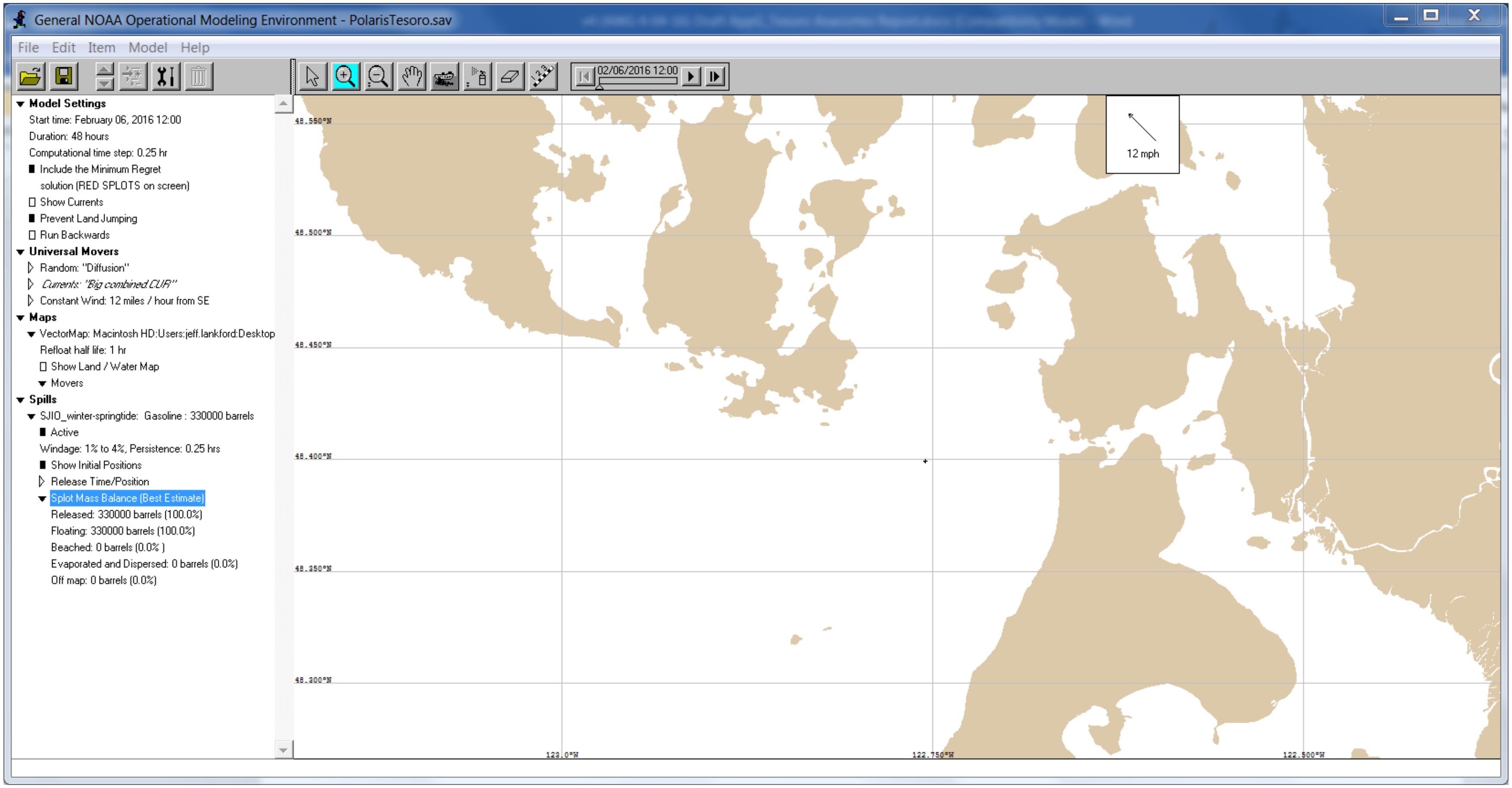

Figure G-13 (a). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter@ spring tide scenario: Hour 0.

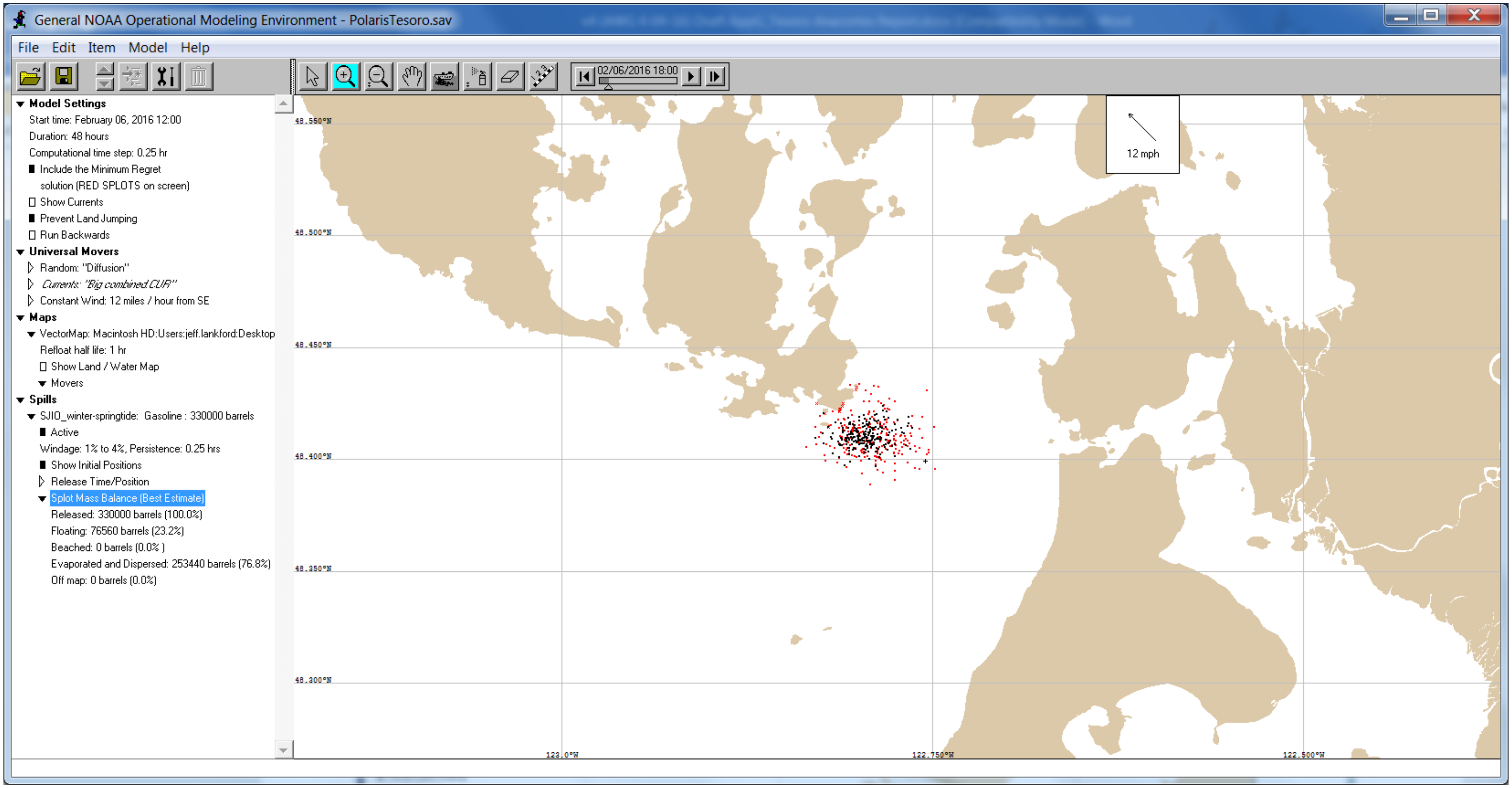

Figure G-13 (b). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter@ spring tide scenario: Hour 6.

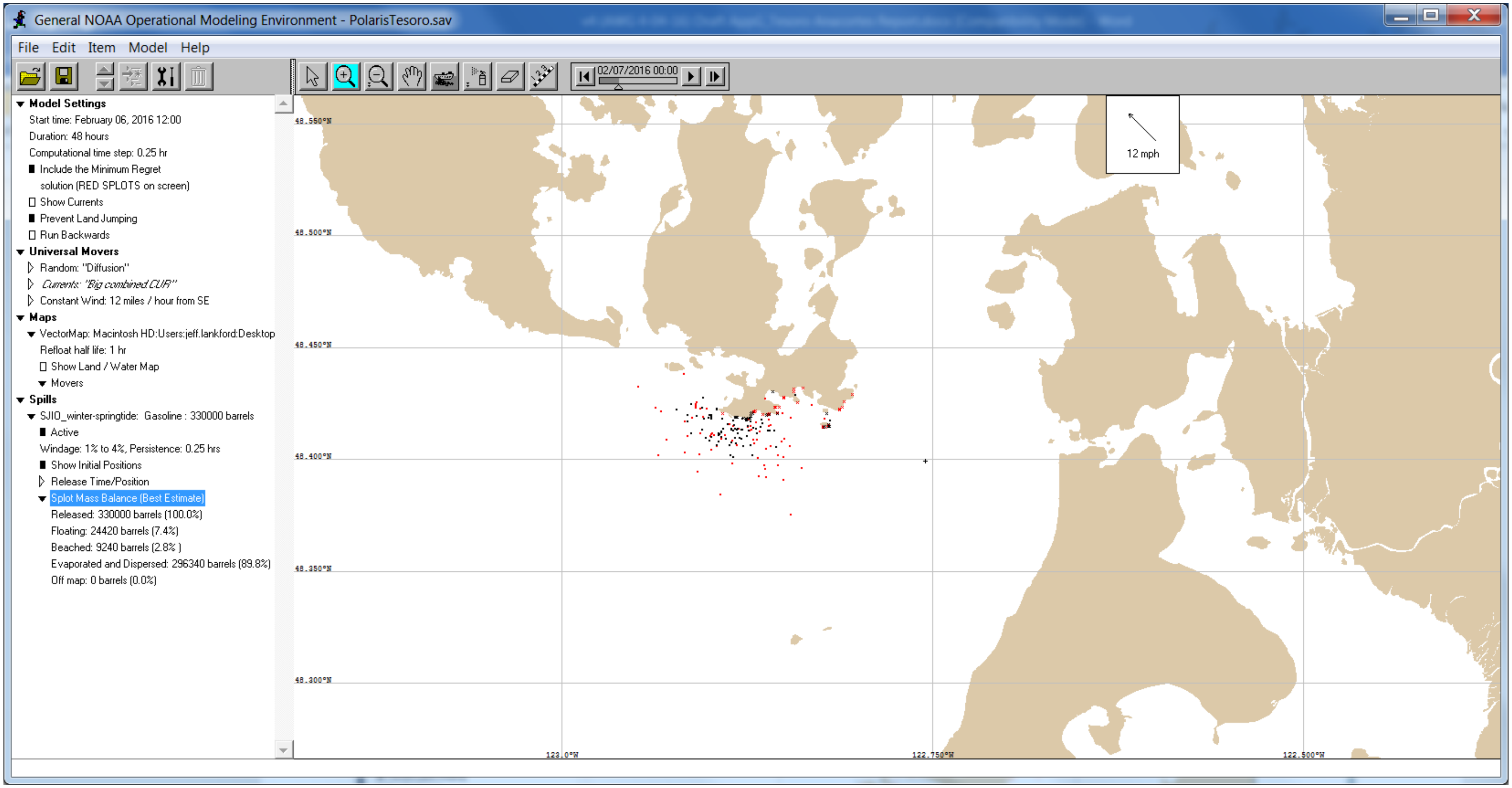

Figure G-13 (c). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter@ spring tide scenario: Hour 12.

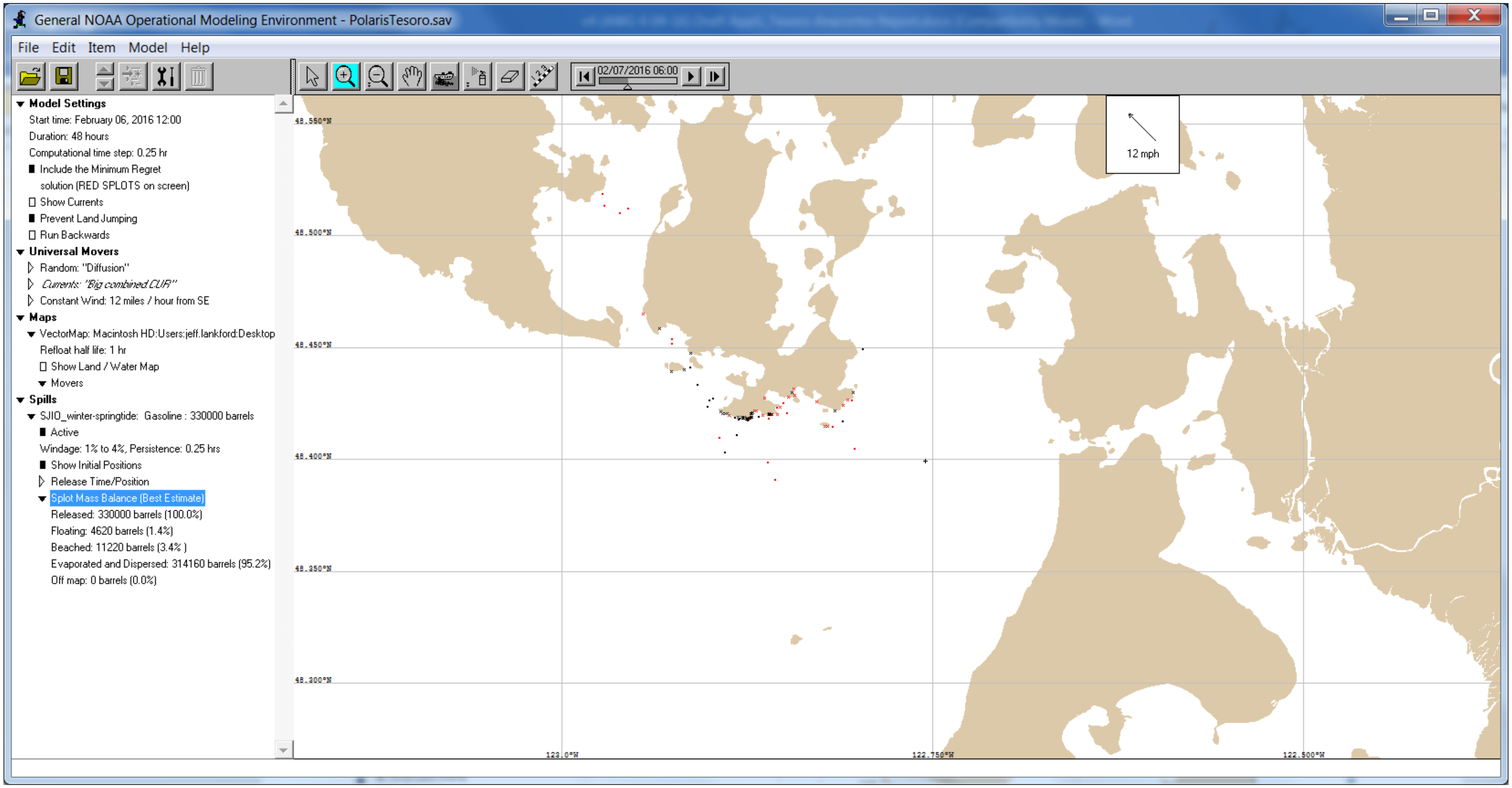

Figure G-13 (d). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter@ spring tide scenario: Hour 18.

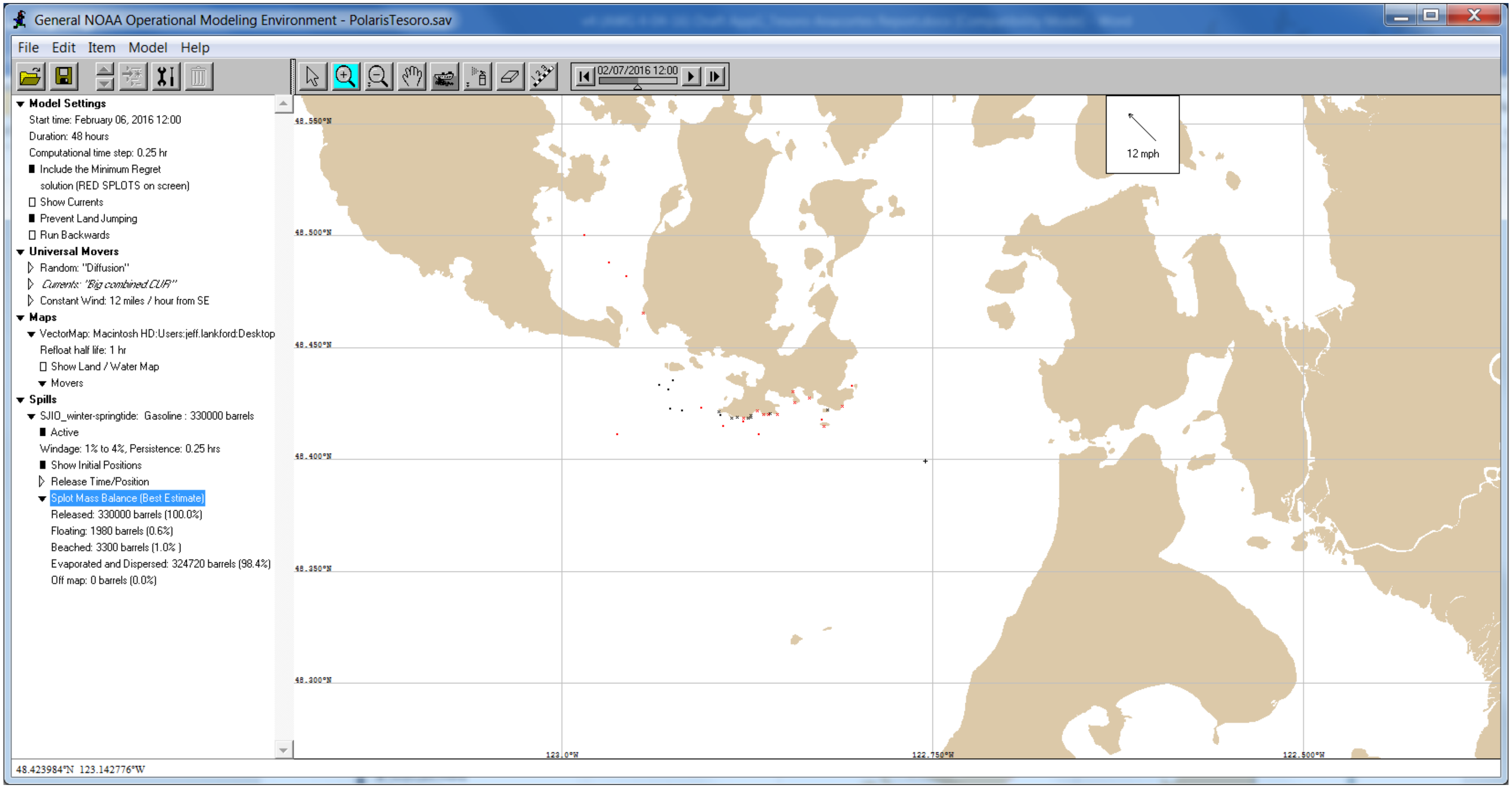

Figure G-13 (e). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter@ spring tide scenario: Hour 24.

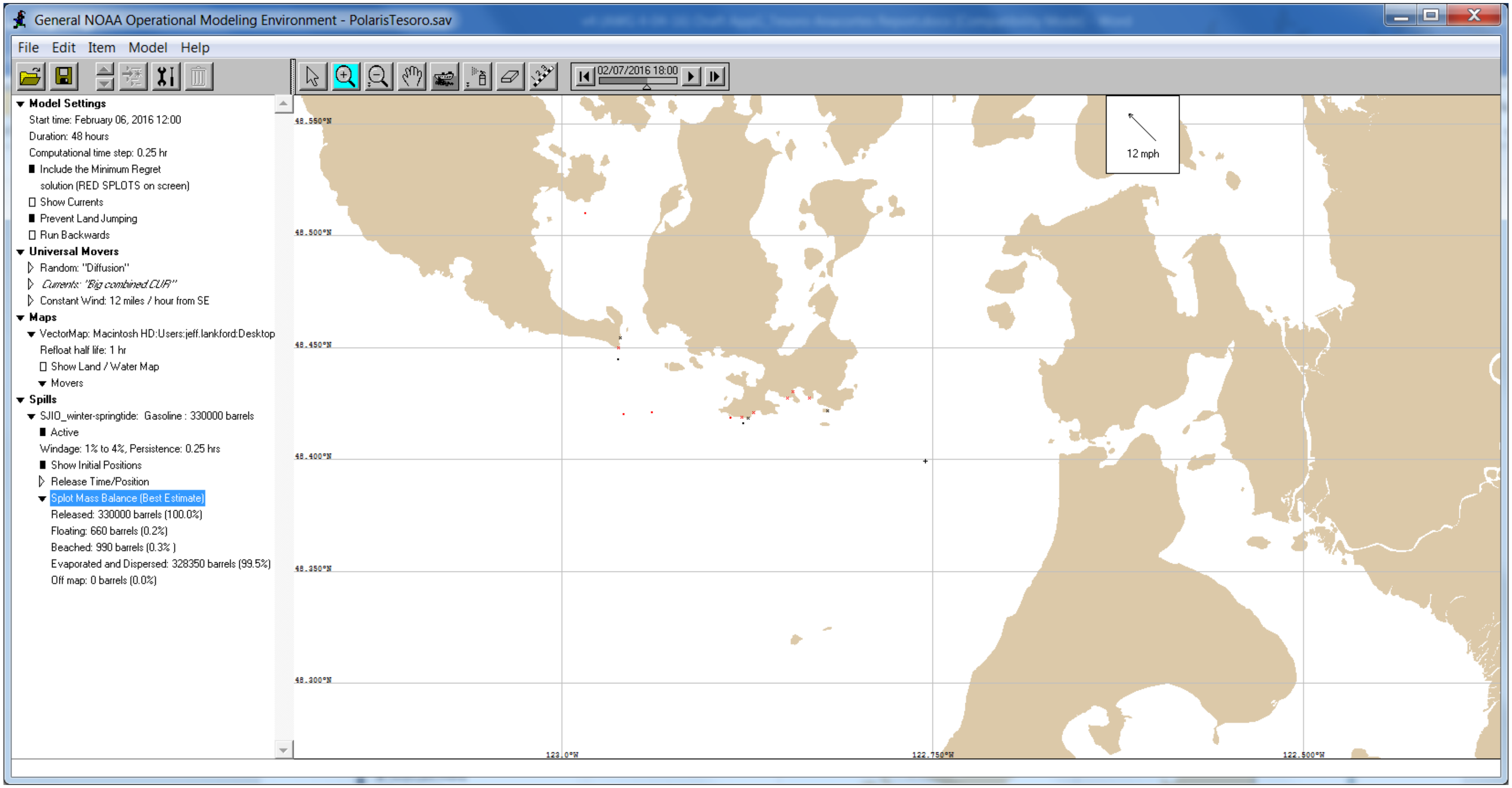

Figure G-13 (f). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter@ spring tide scenario: Hour 30.

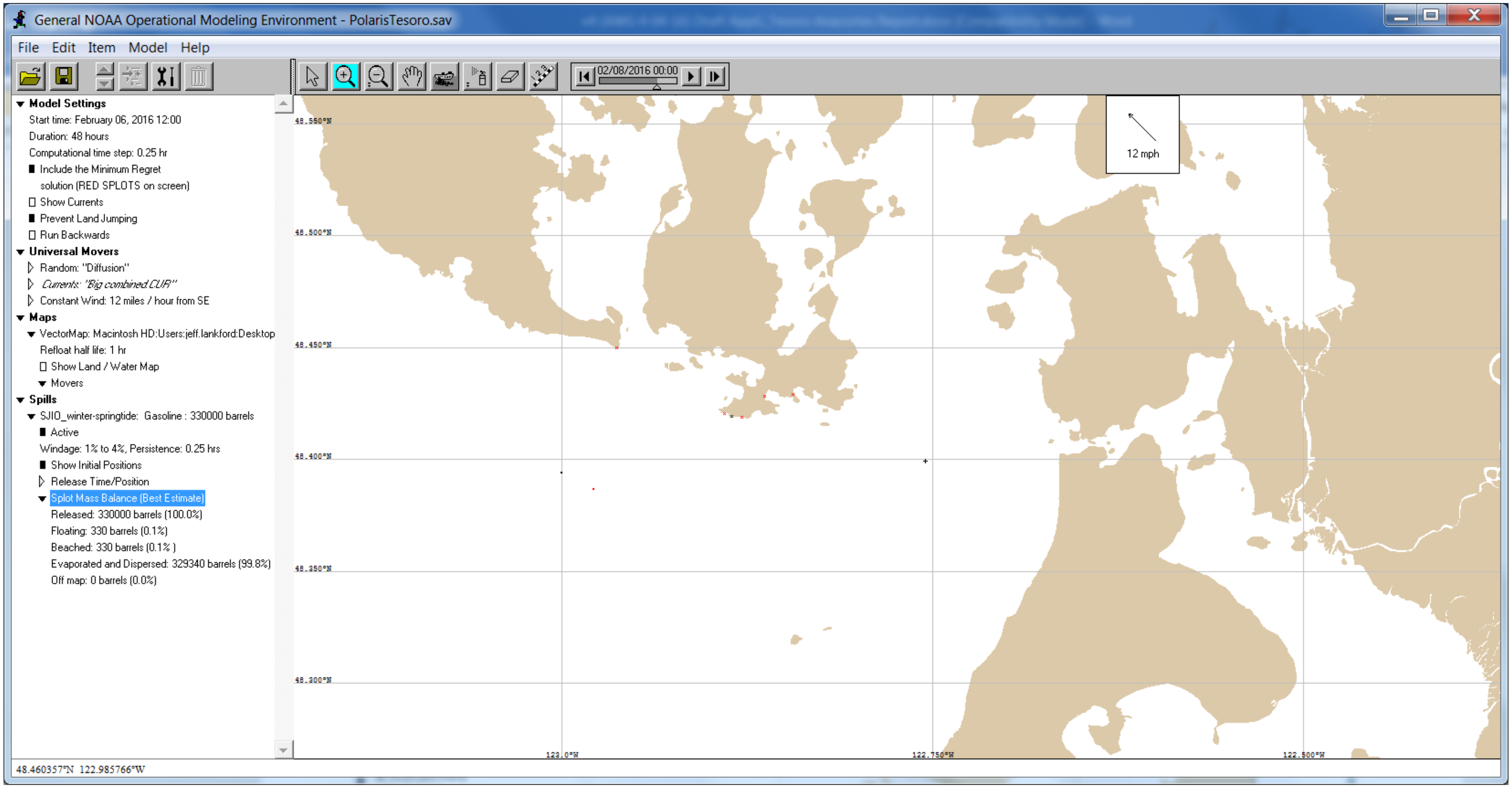

Figure G-13 (g). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter@ spring tide scenario: Hour 36.

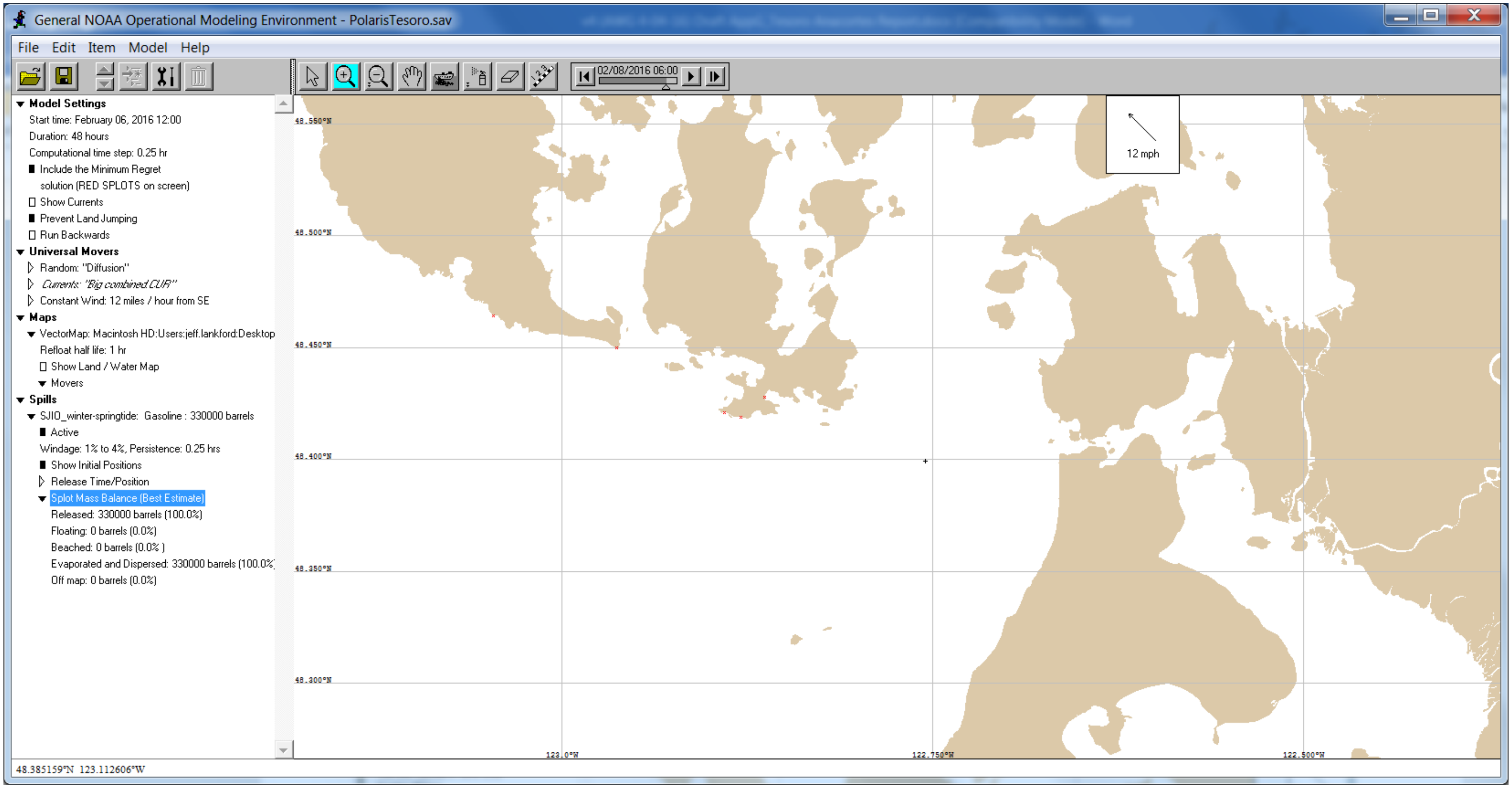

Figure G-13 (h). GNOME Model Output, Rosario Strait (SJI-O330, 000 bbls, winter@ spring tide scenario: Hour 42.

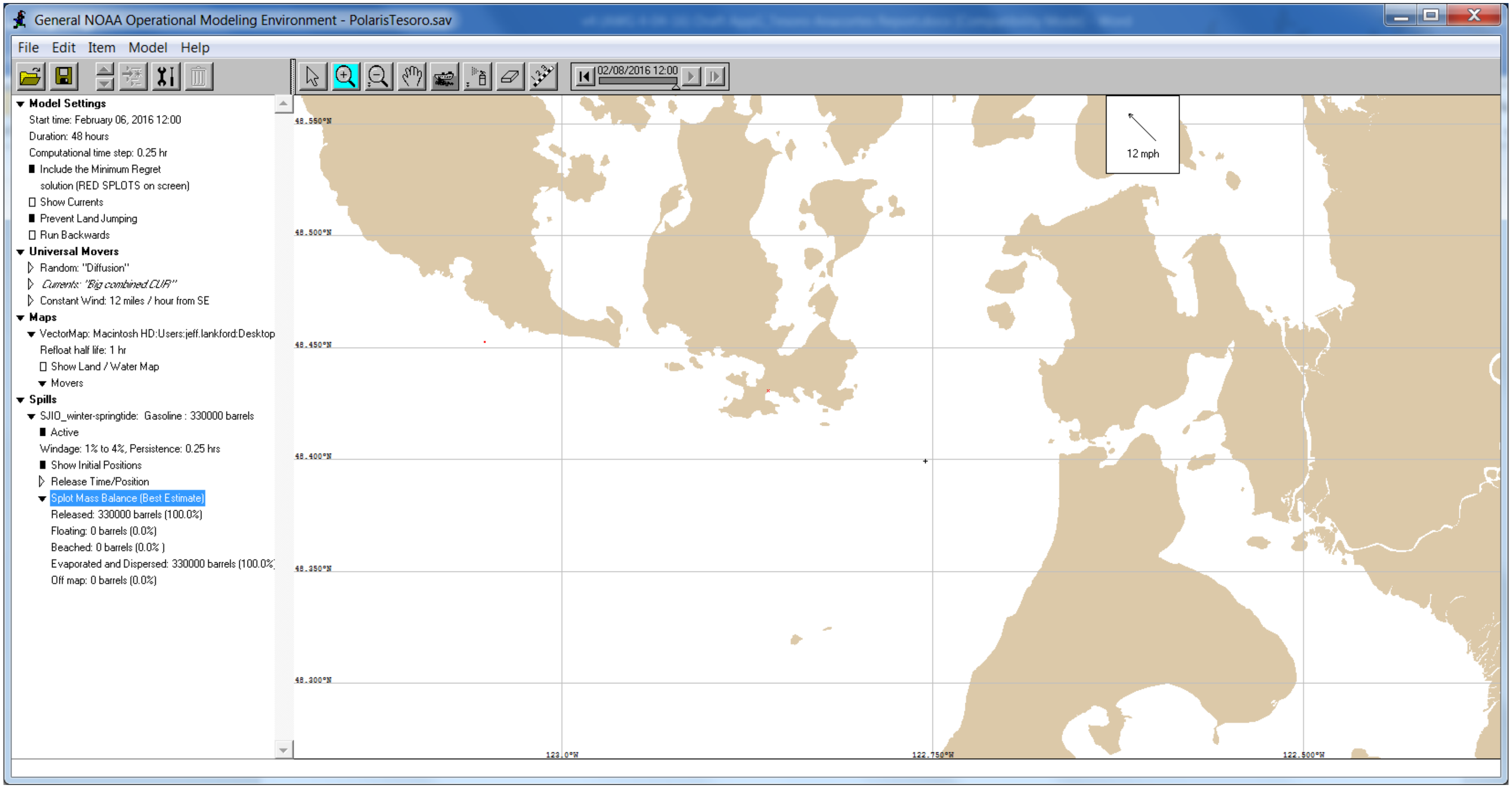

Figure G-13 (i). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter@ spring tide scenario: Hour 48.

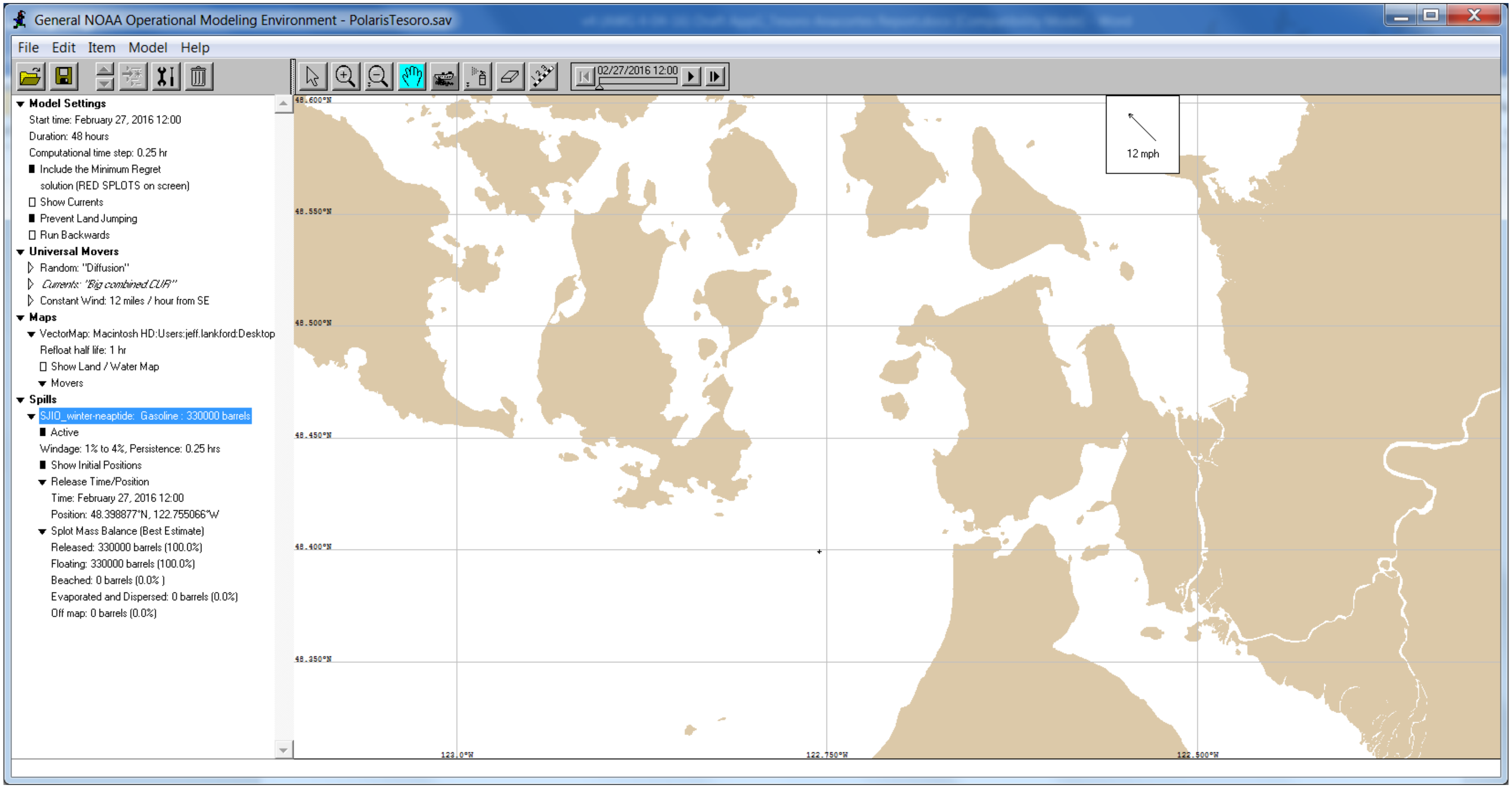

Figure G-14 (a). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter@ neap tide scenario: Hour 0.

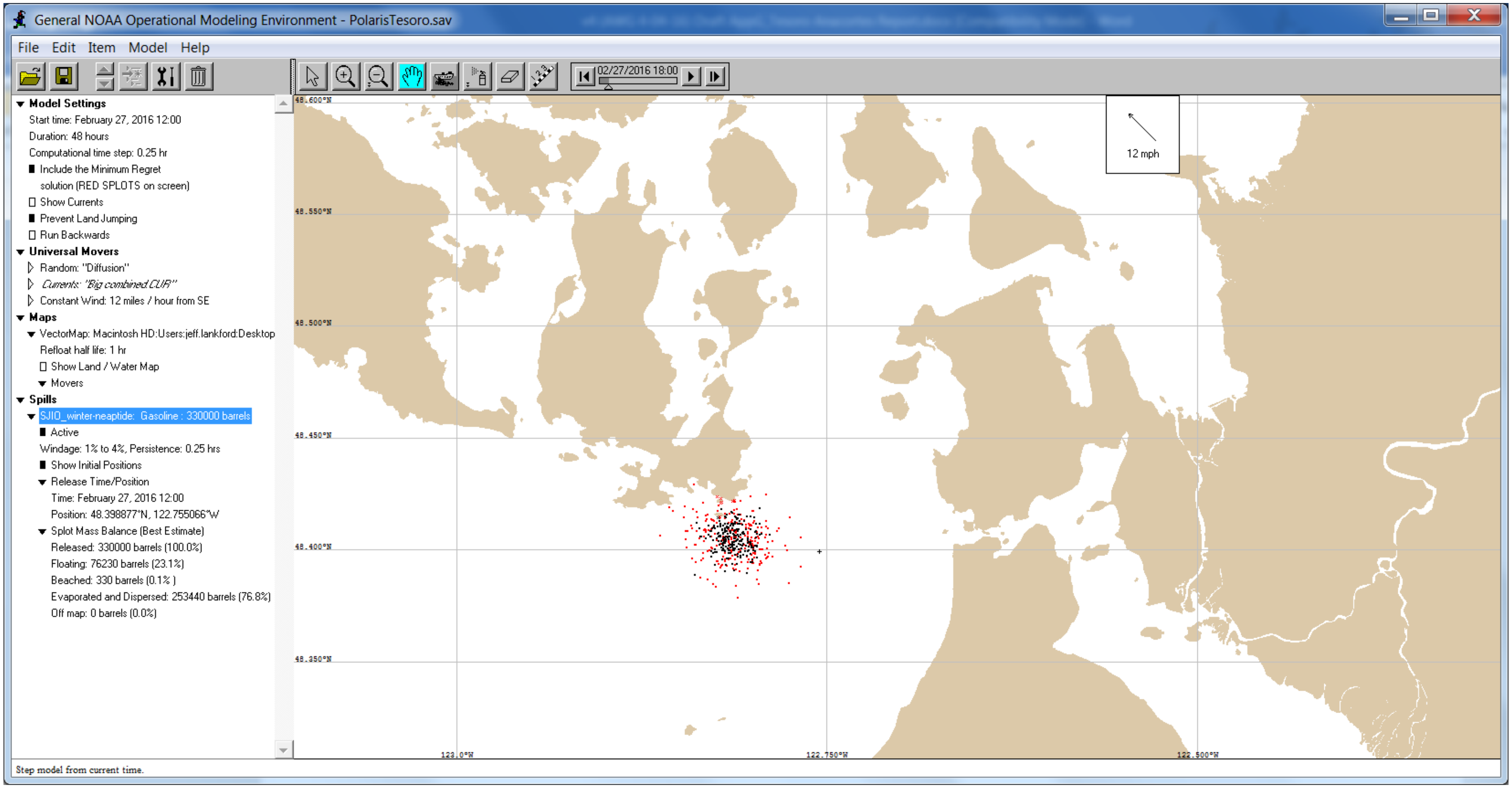

Figure G-14 (b). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter @ neap tide scenario: Hour 6.

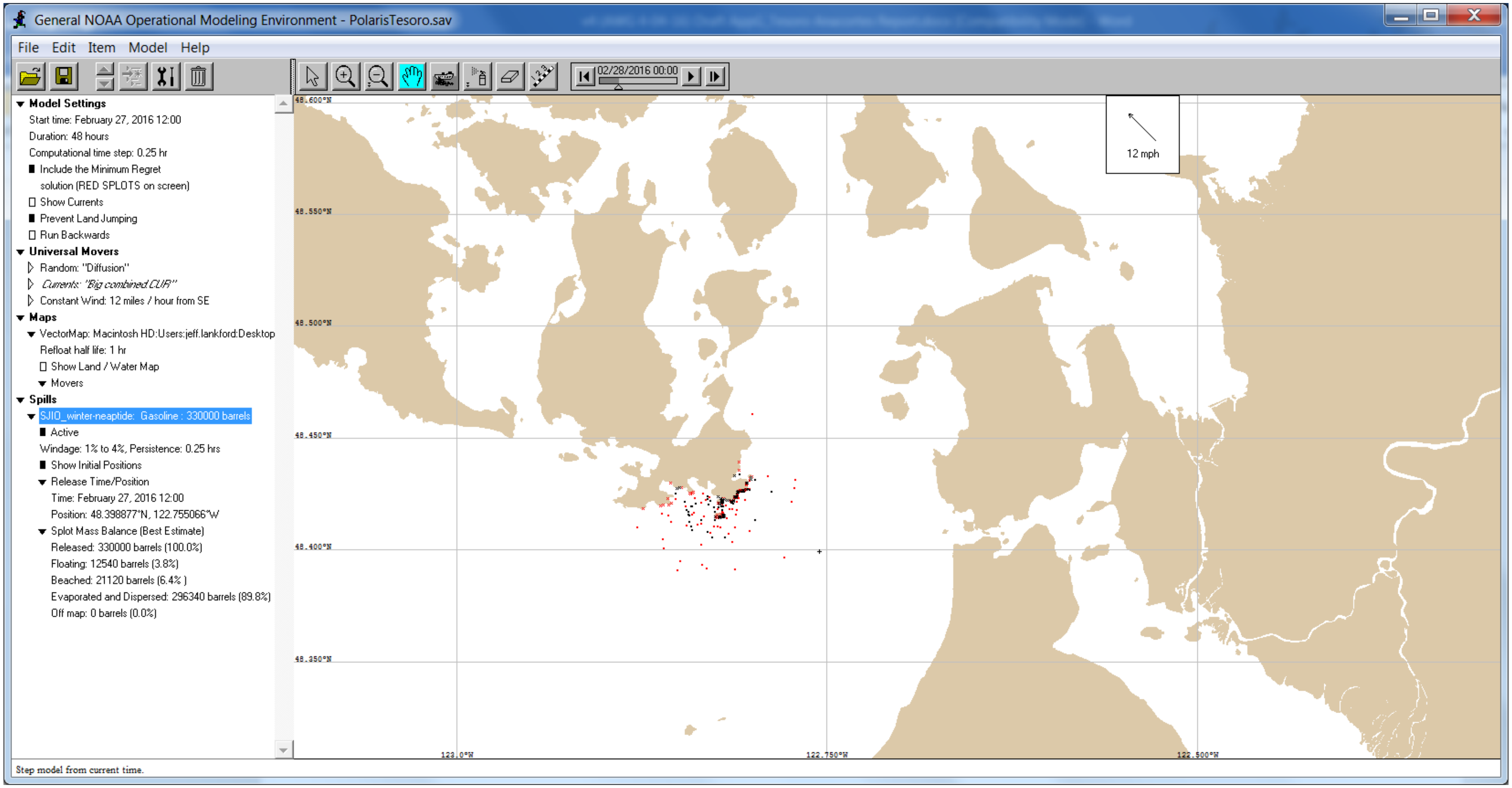

Figure G-14 (c). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter @ neap tide scenario: Hour 12.

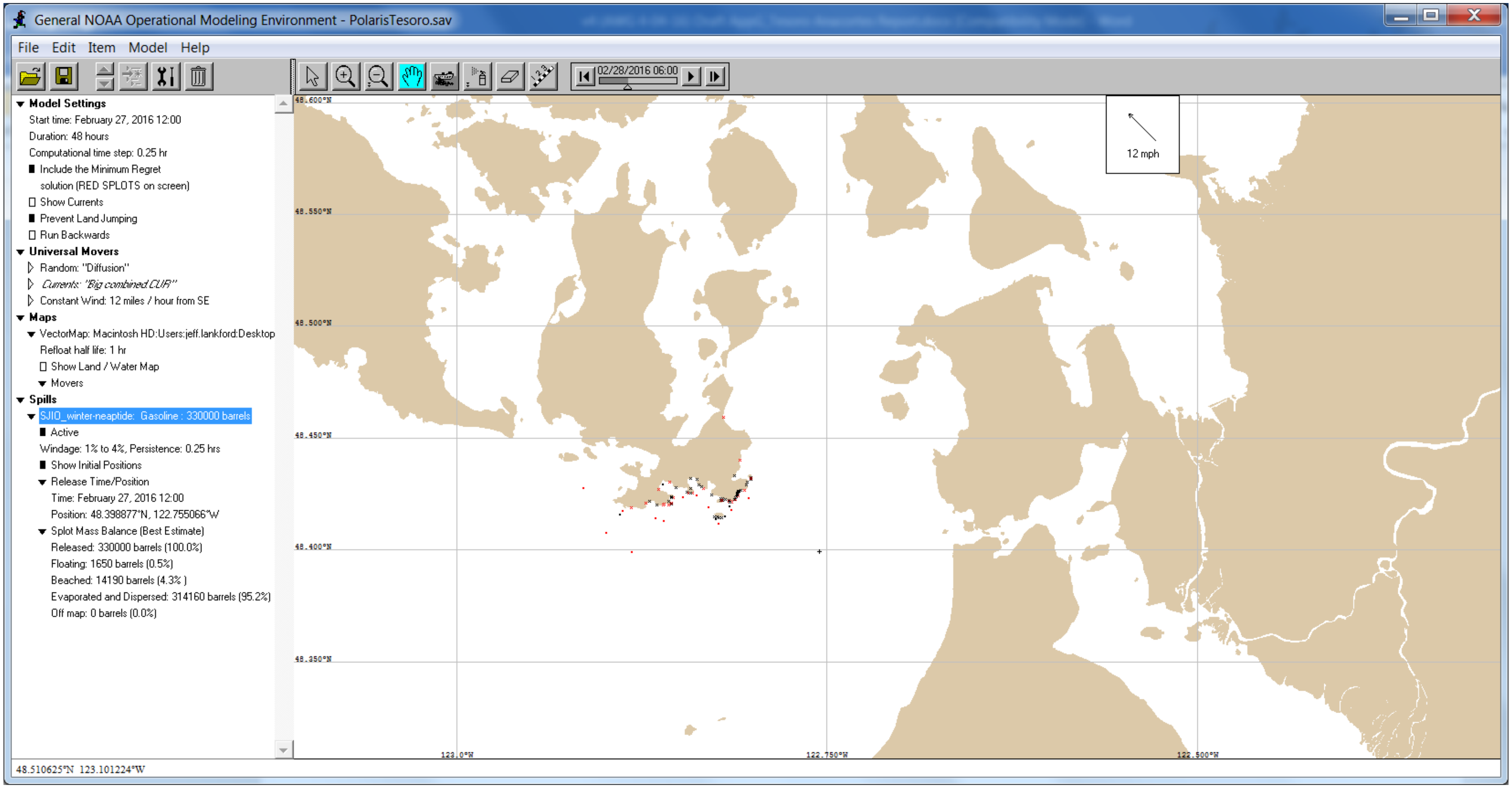

Figure G-14 (d). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter @ neap tide scenario: Hour 18.

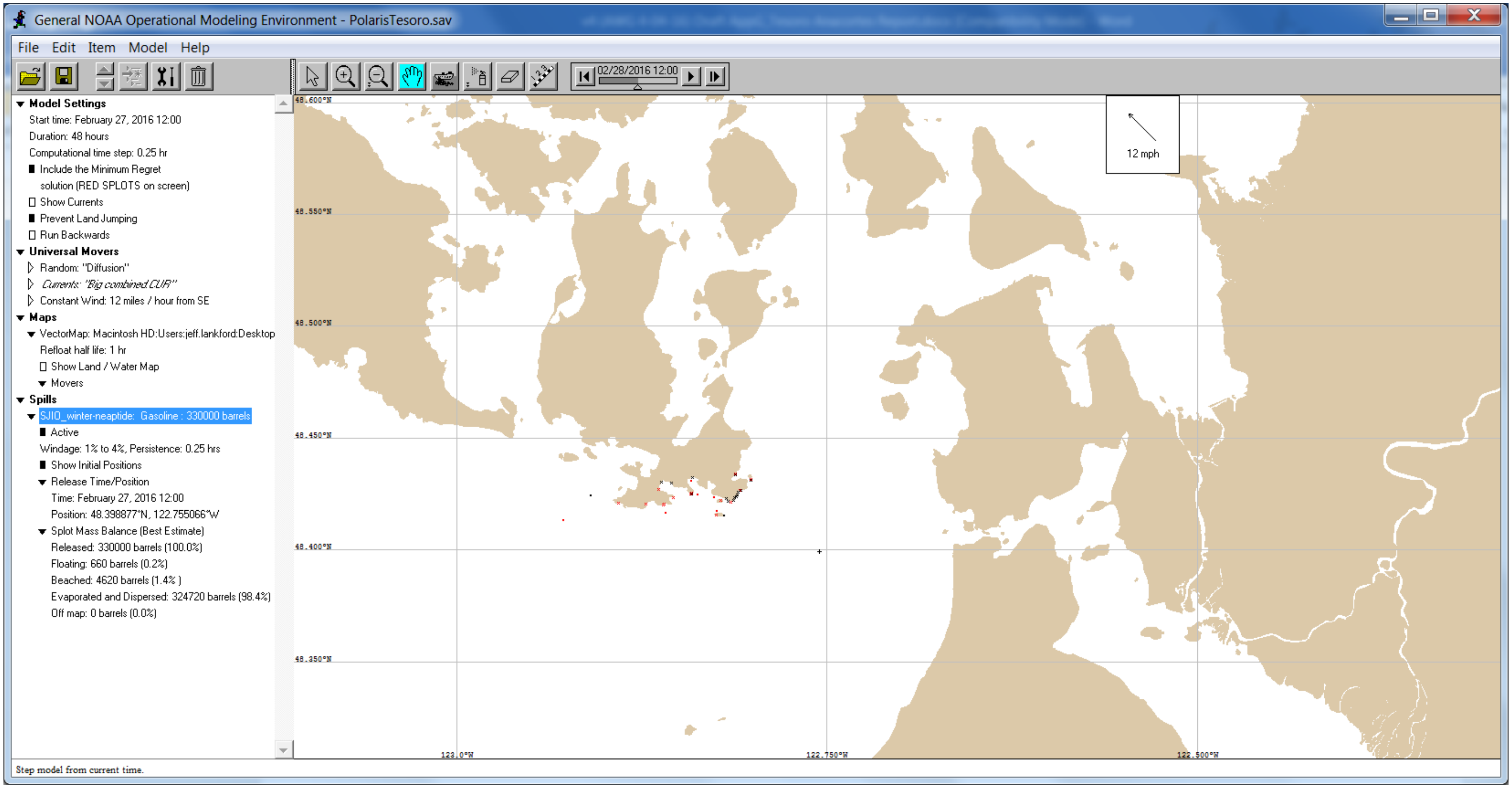

Figure G-14 (e). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter @ neap tide scenario: Hour 24.

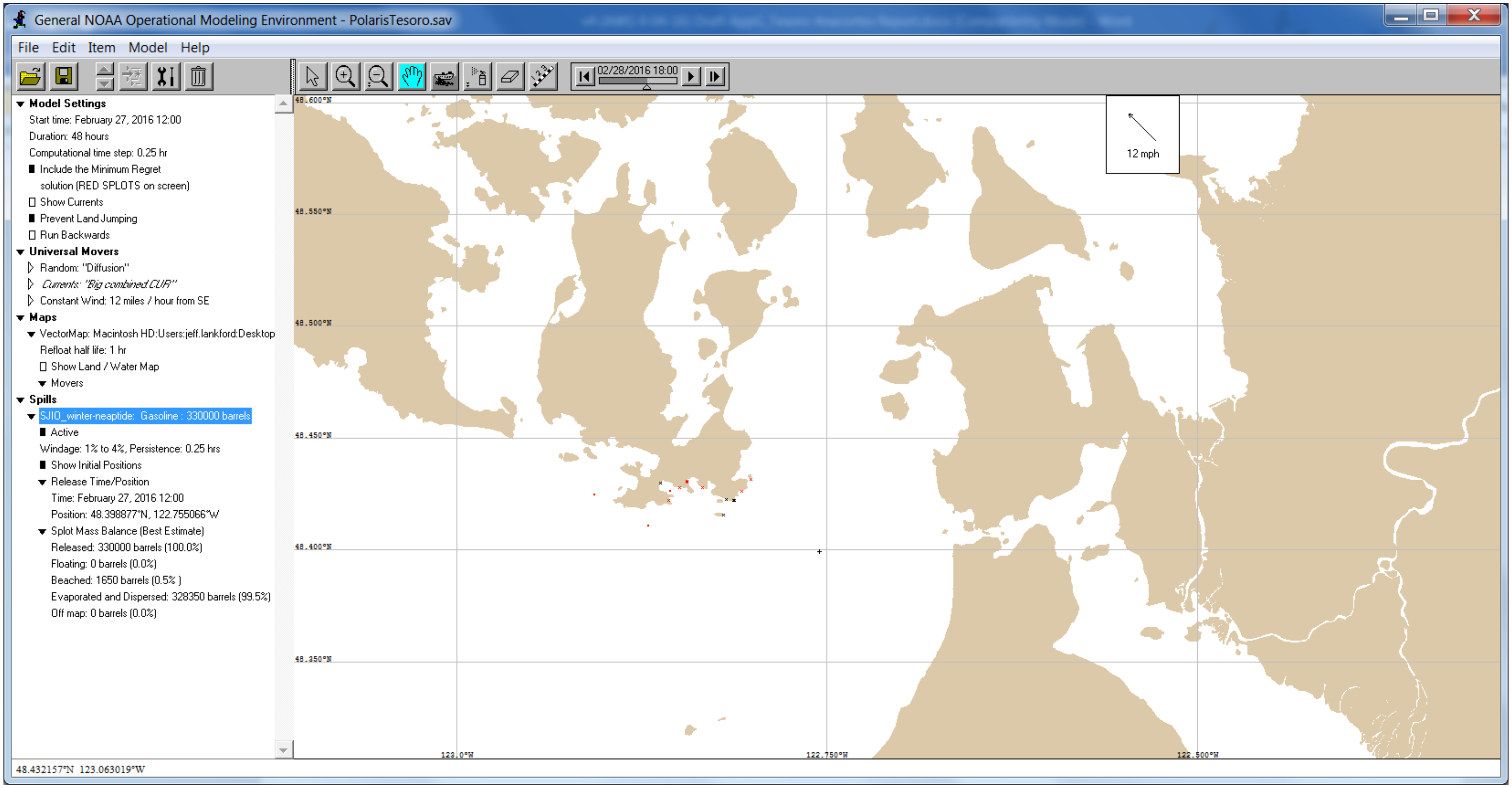

Figure G-14 (f). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter @ neap tide scenario: Hour 30.

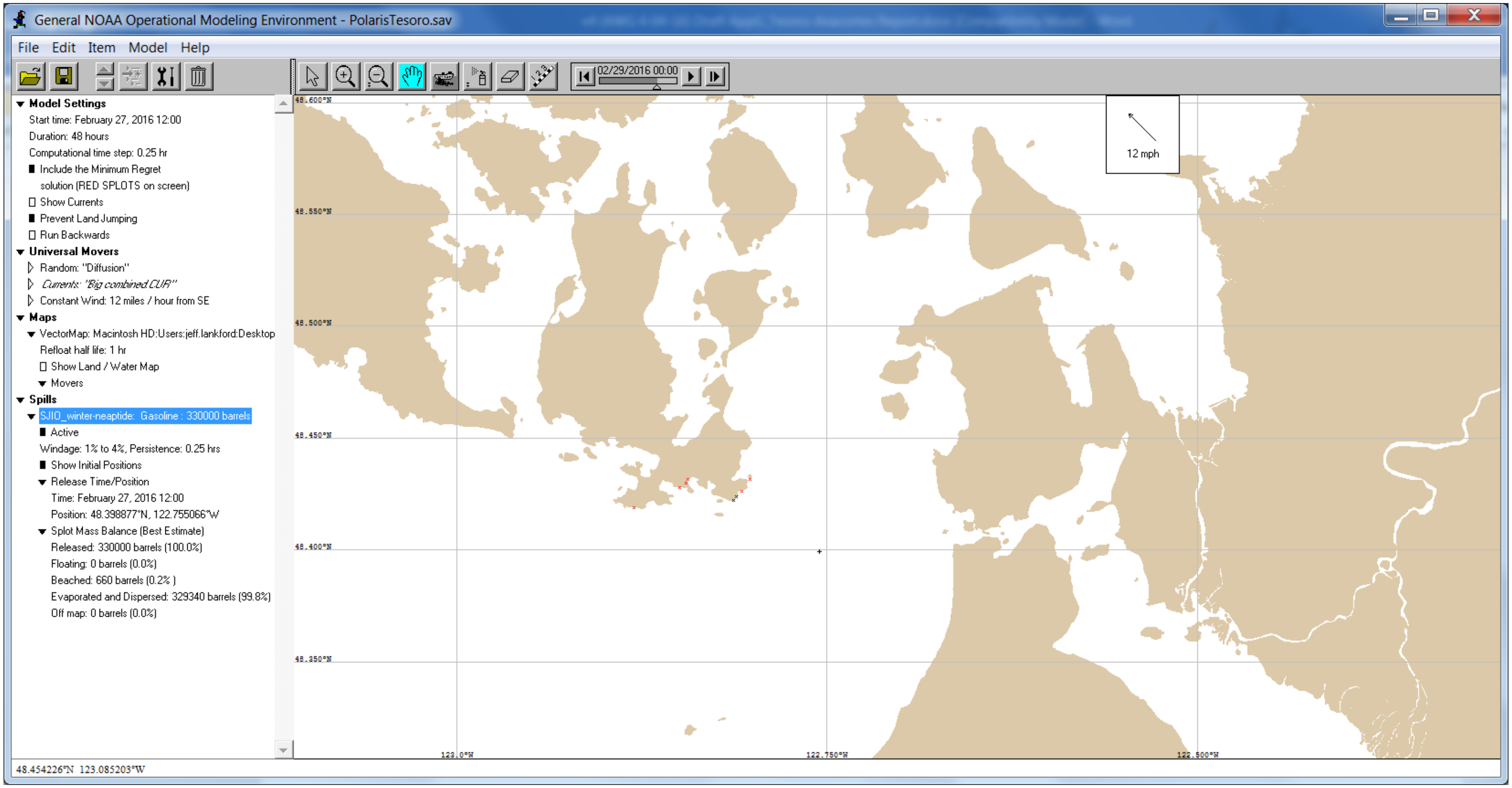

Figure G-14 (g). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter @ neap tide scenario: Hour 36.

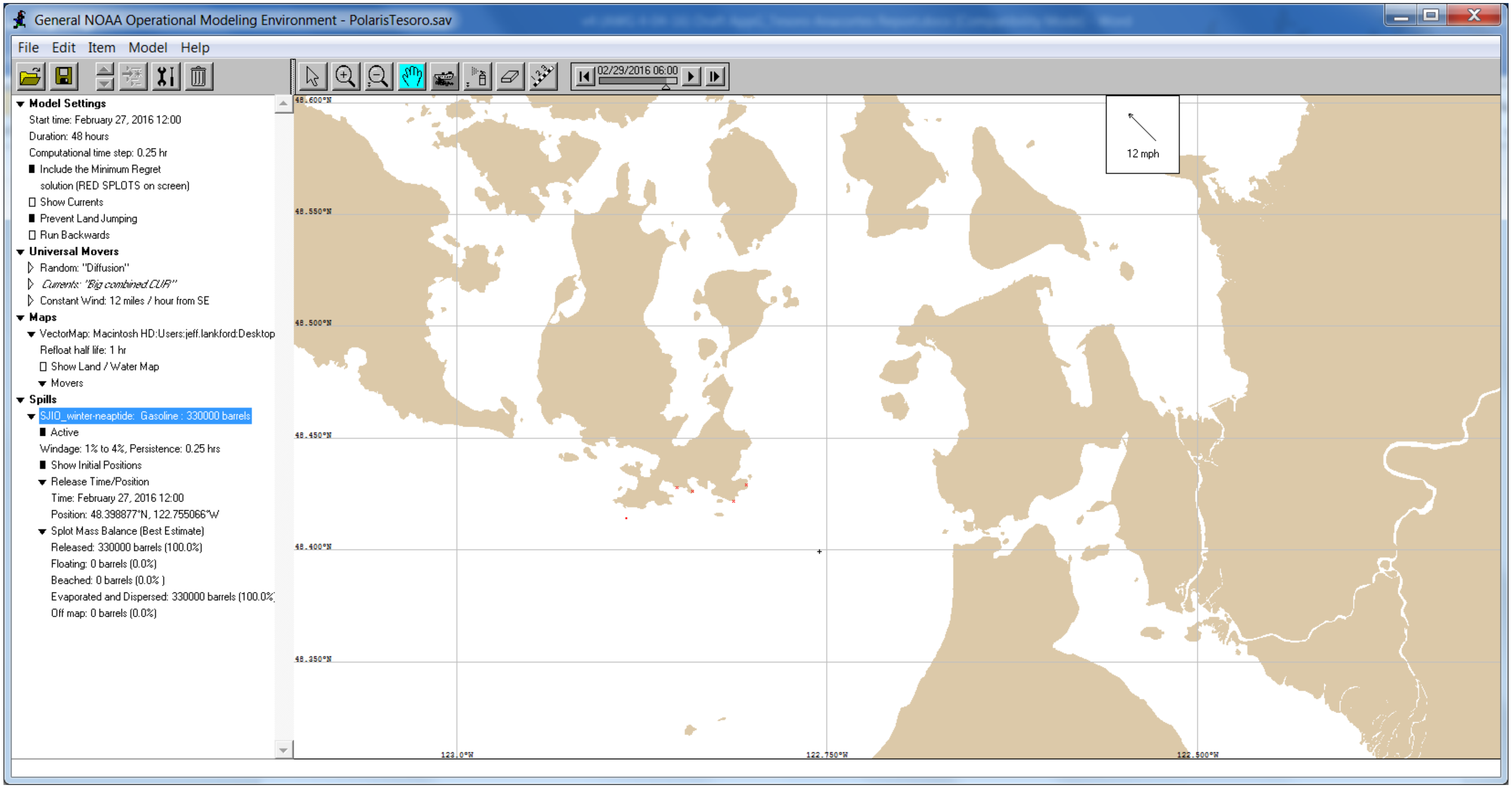

Figure G-14 (h). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter @ neap tide scenario: Hour 42.

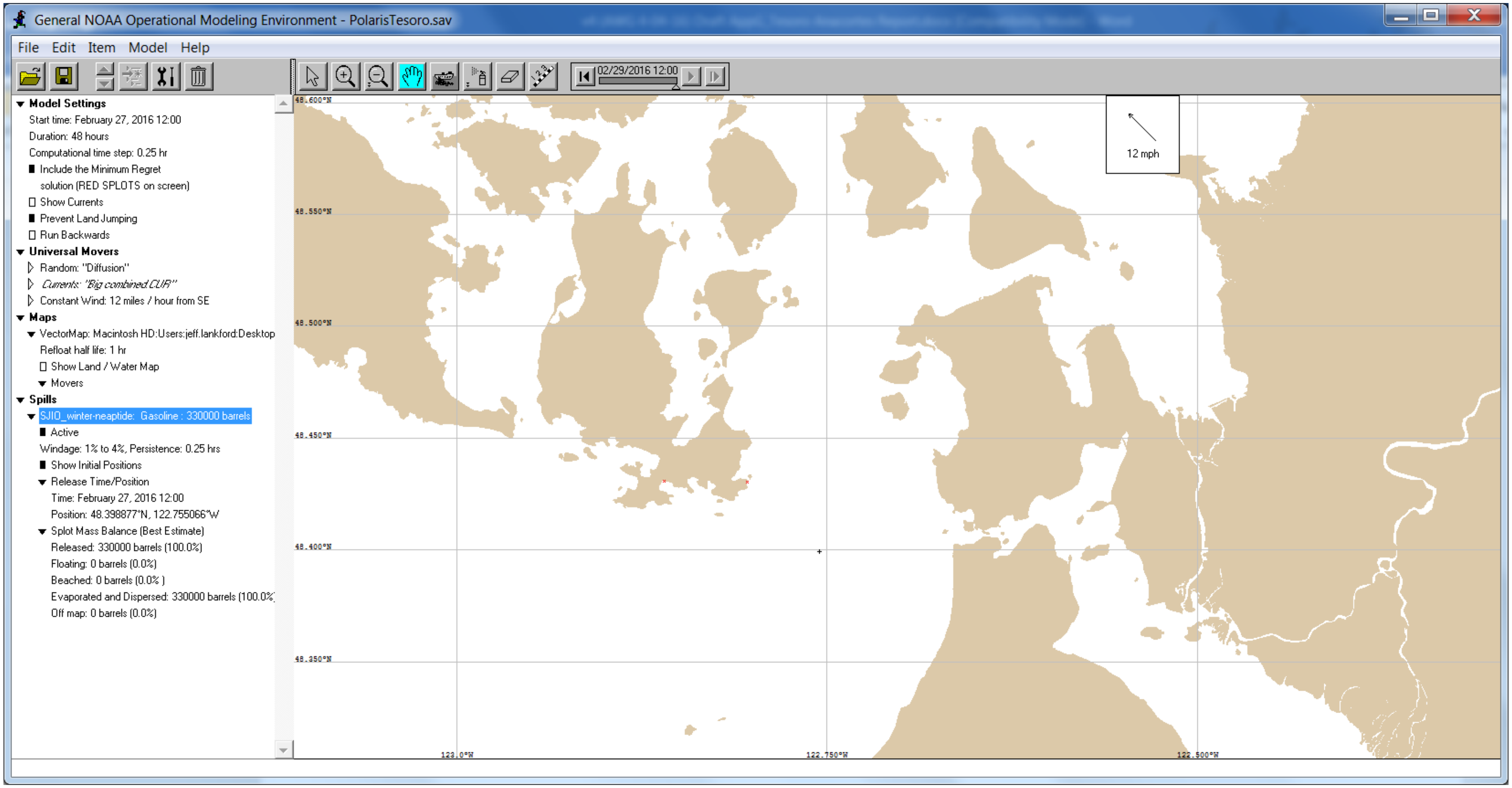

Figure G-14 (i). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, winter @ neap tide scenario: Hour 48.

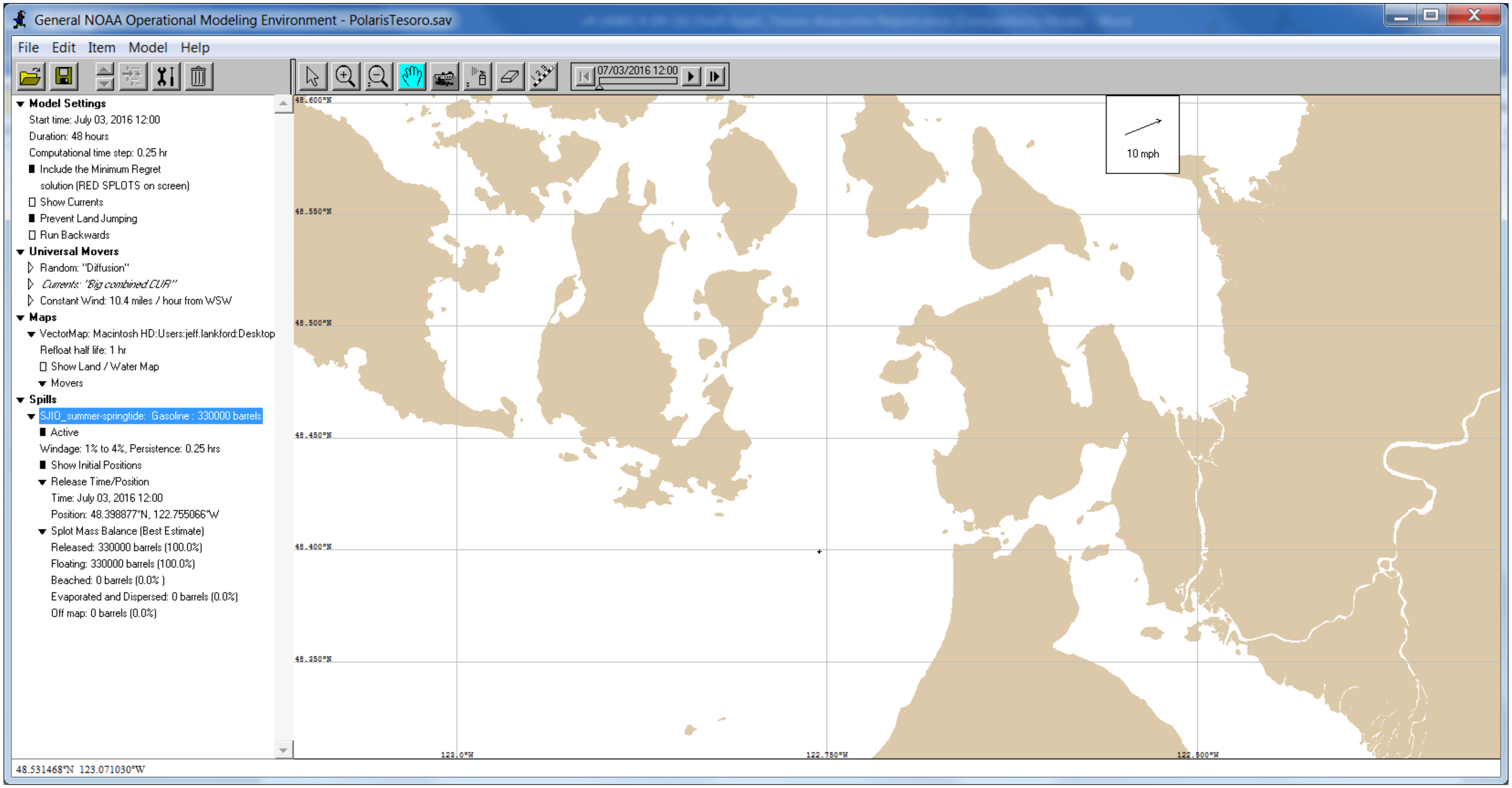

Figure G-15 (a). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ spring tide scenario: Hour 0.

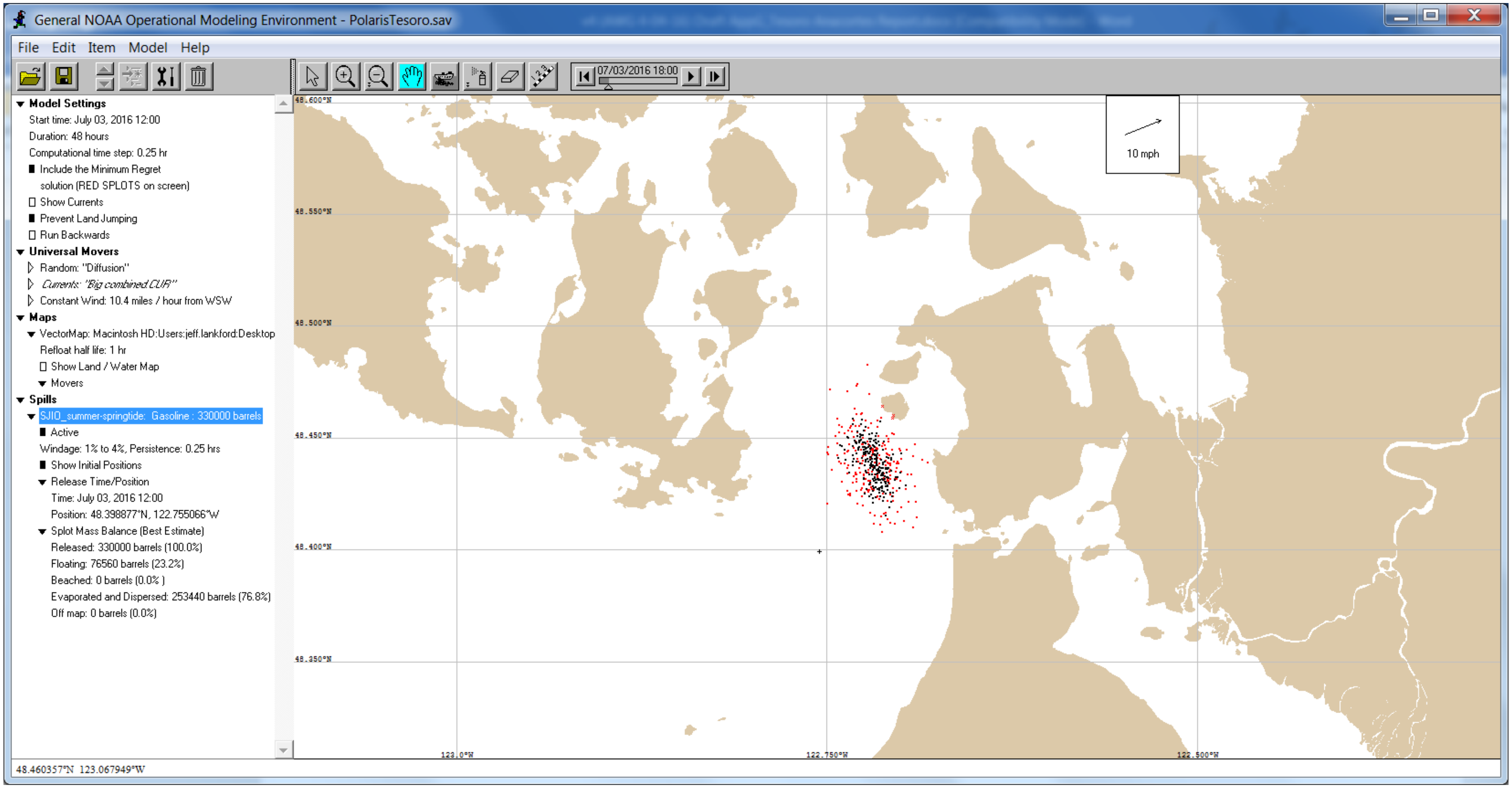

Figure G-15 (b). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ spring tide scenario: Hour 6.

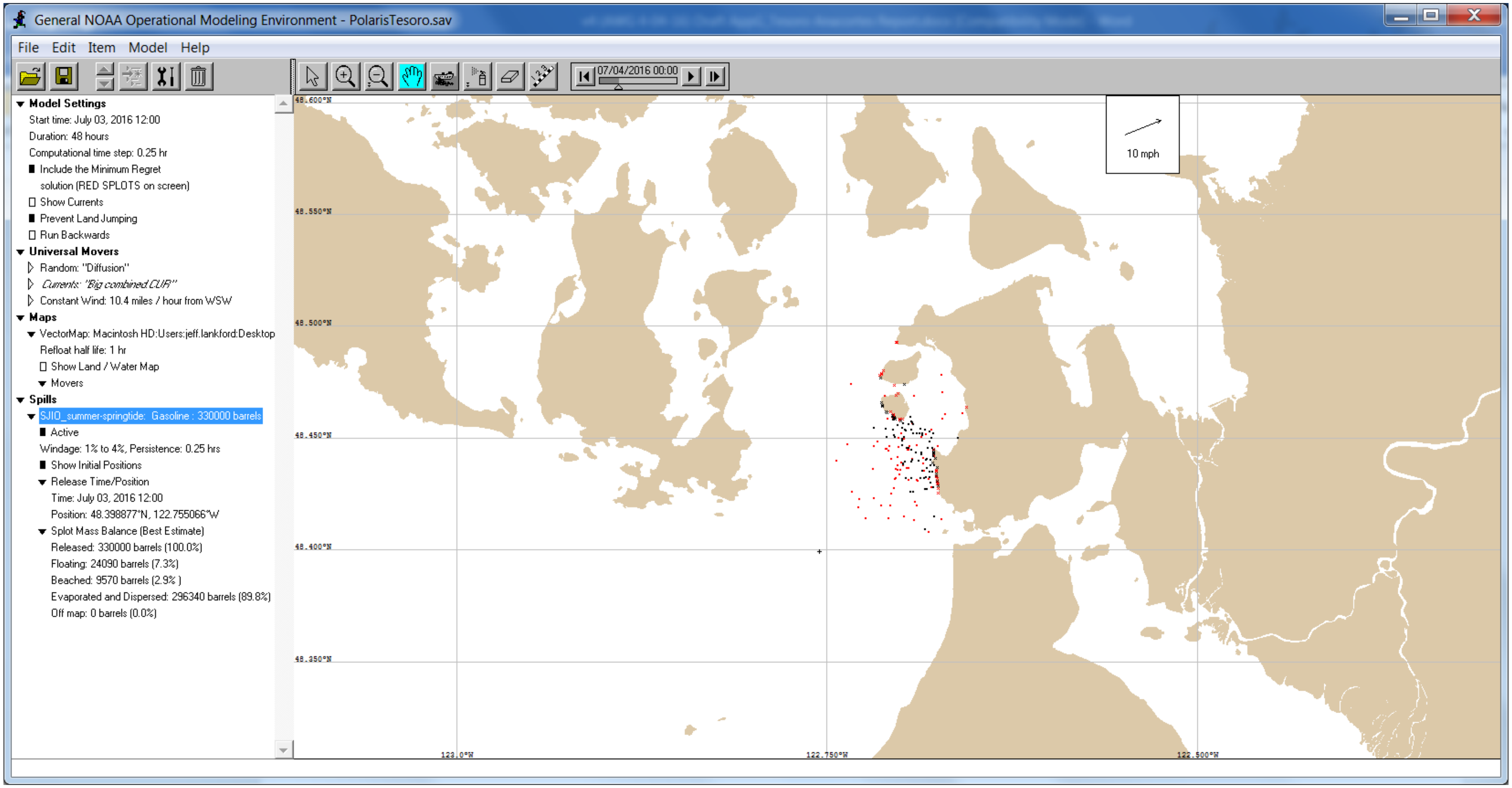

Figure G-15 (c). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ spring tide scenario: Hour 12.

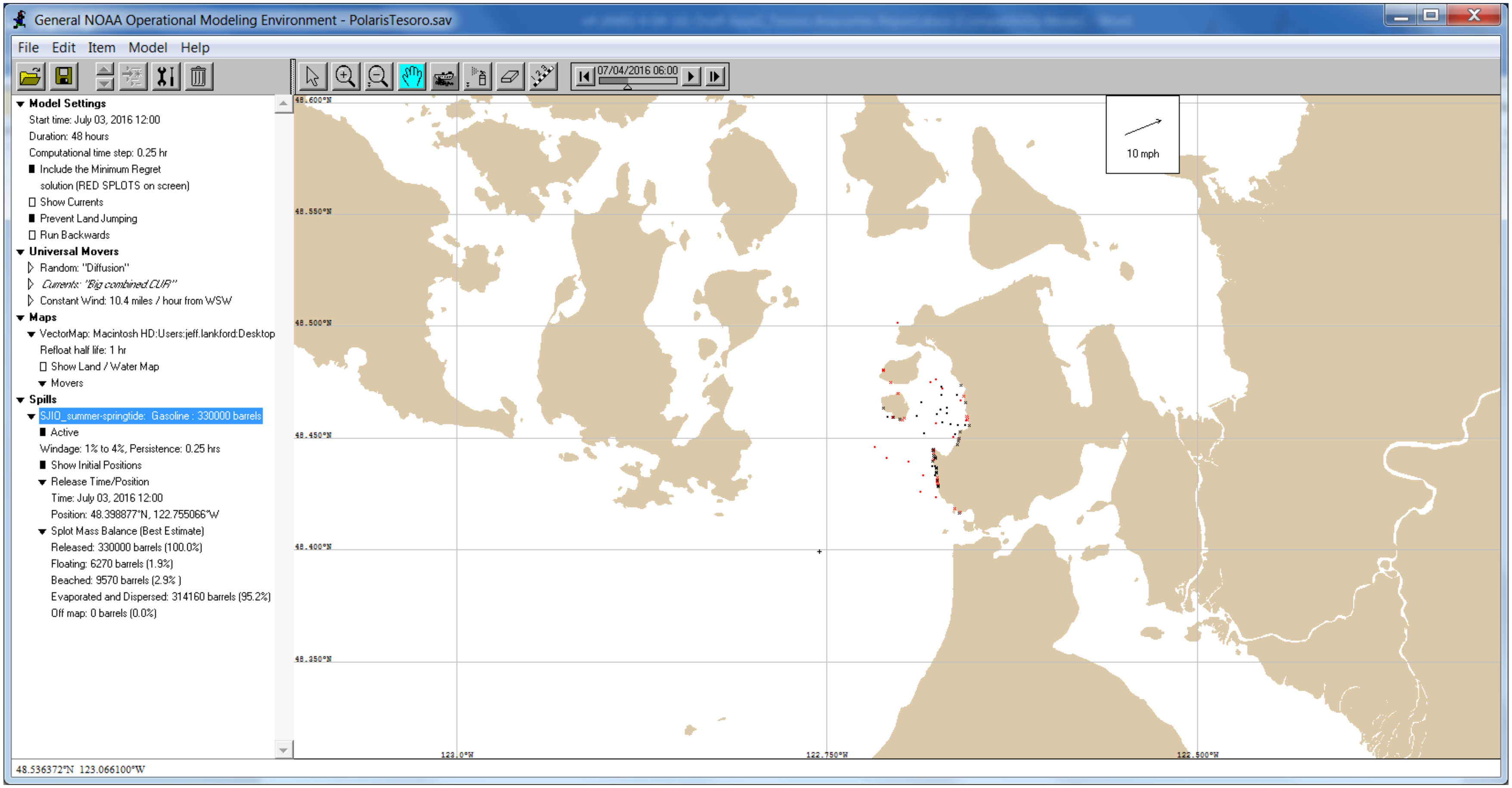

Figure G-15 (d). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ spring tide scenario: Hour 18.

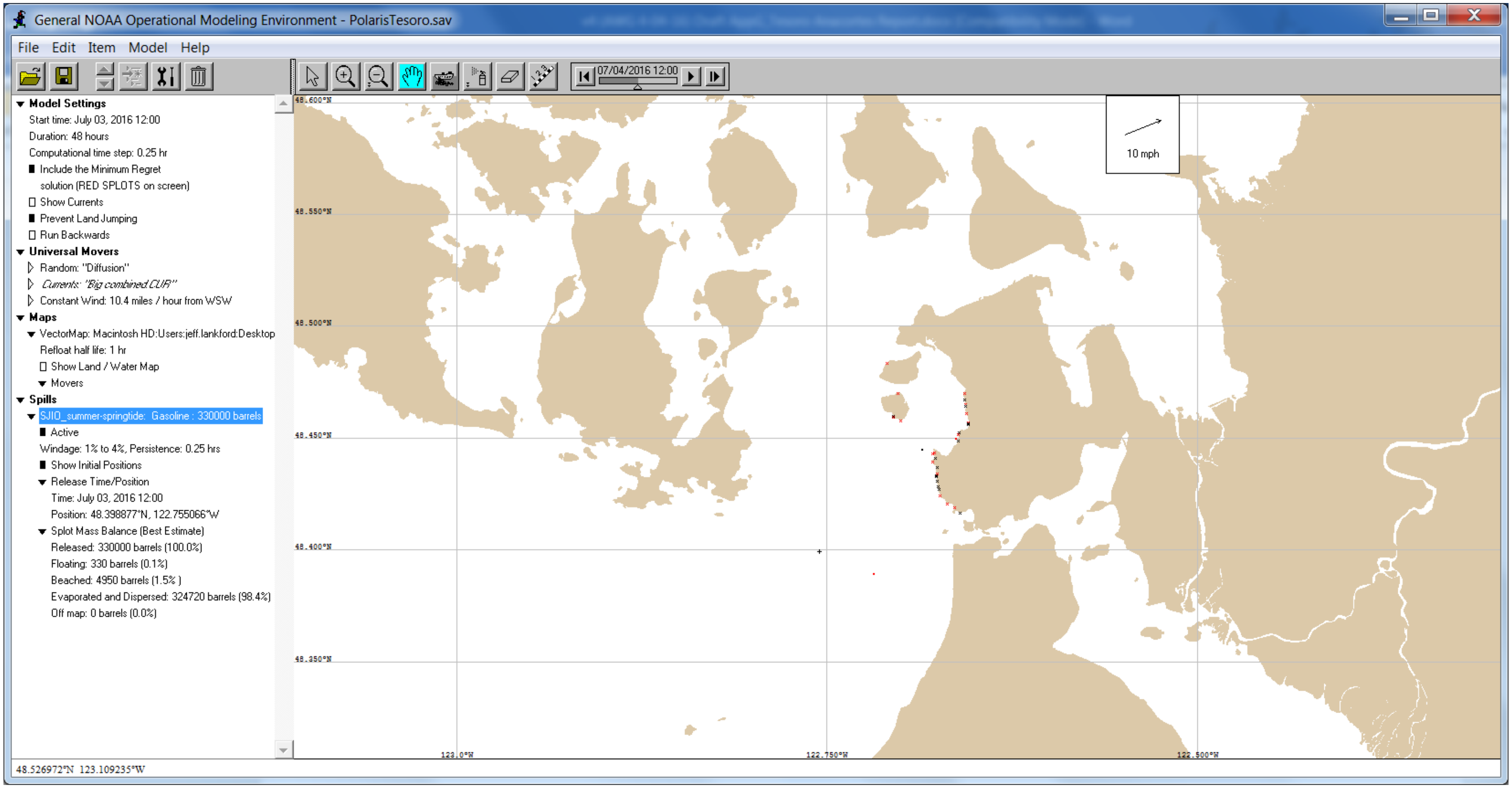

Figure G-15 (e). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ spring tide scenario: Hour 24.

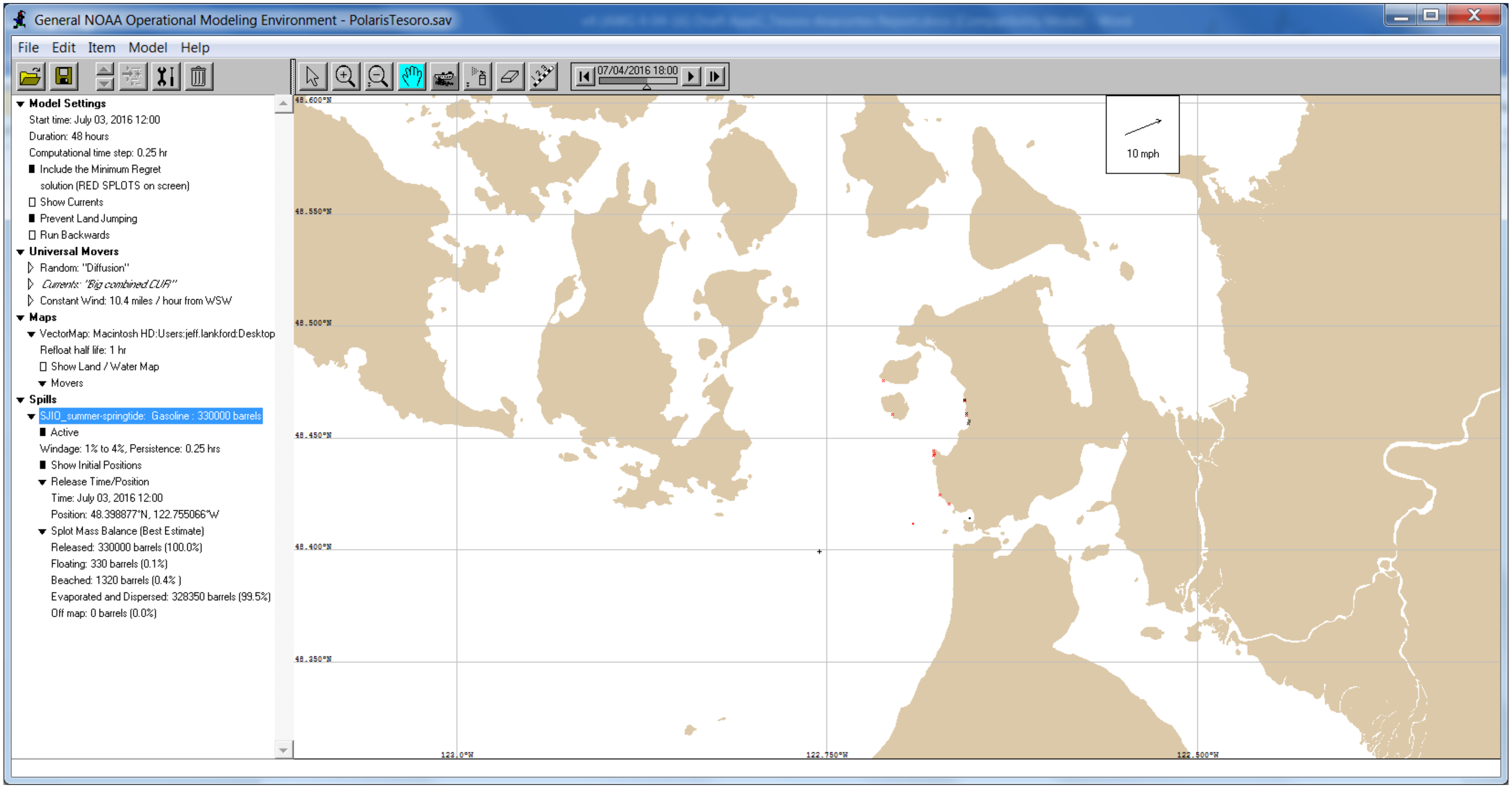

Figure G-15 (f). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ spring tide scenario: Hour 30.

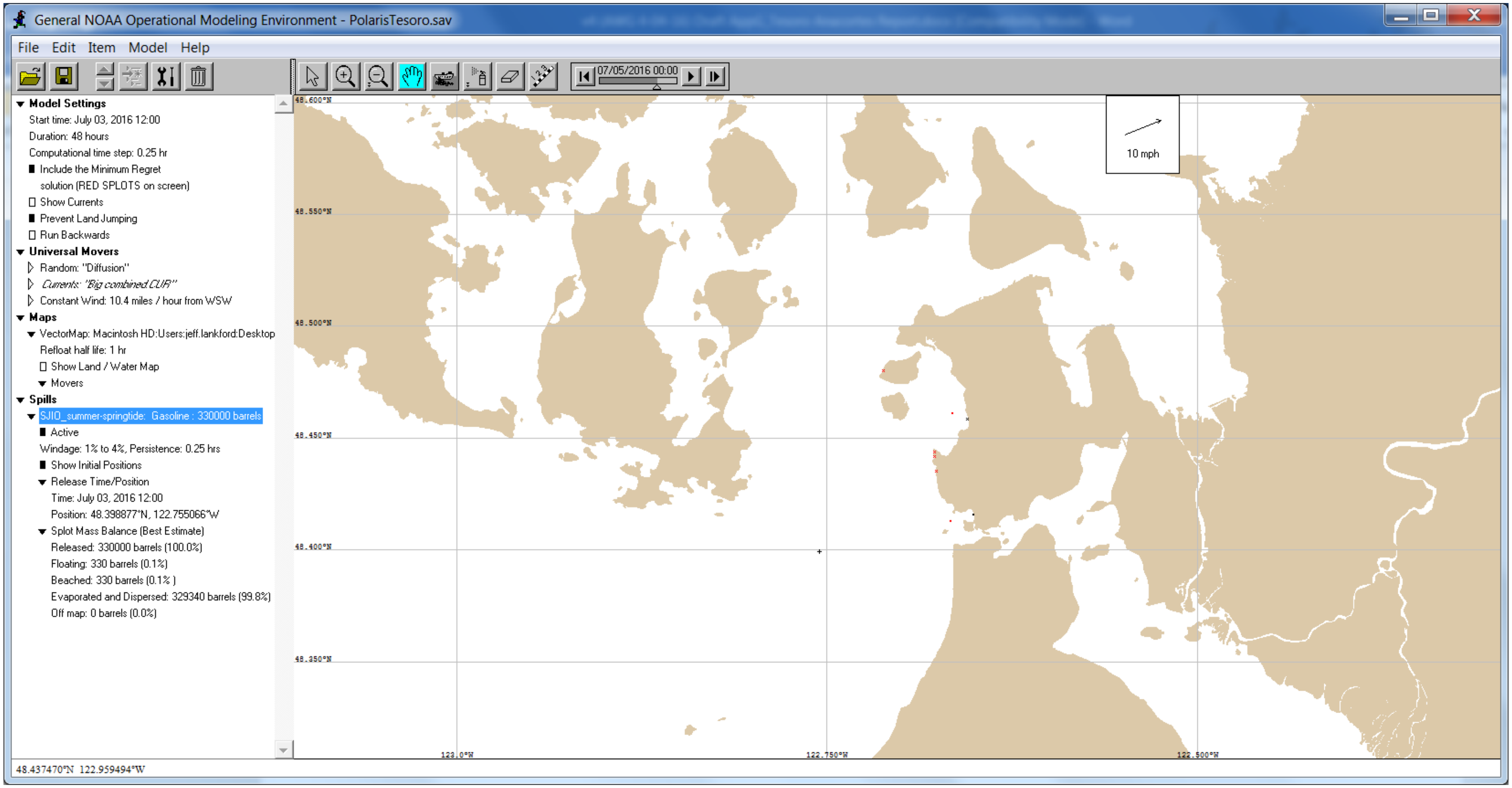

Figure G-15 (g). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ spring tide scenario: Hour 36.

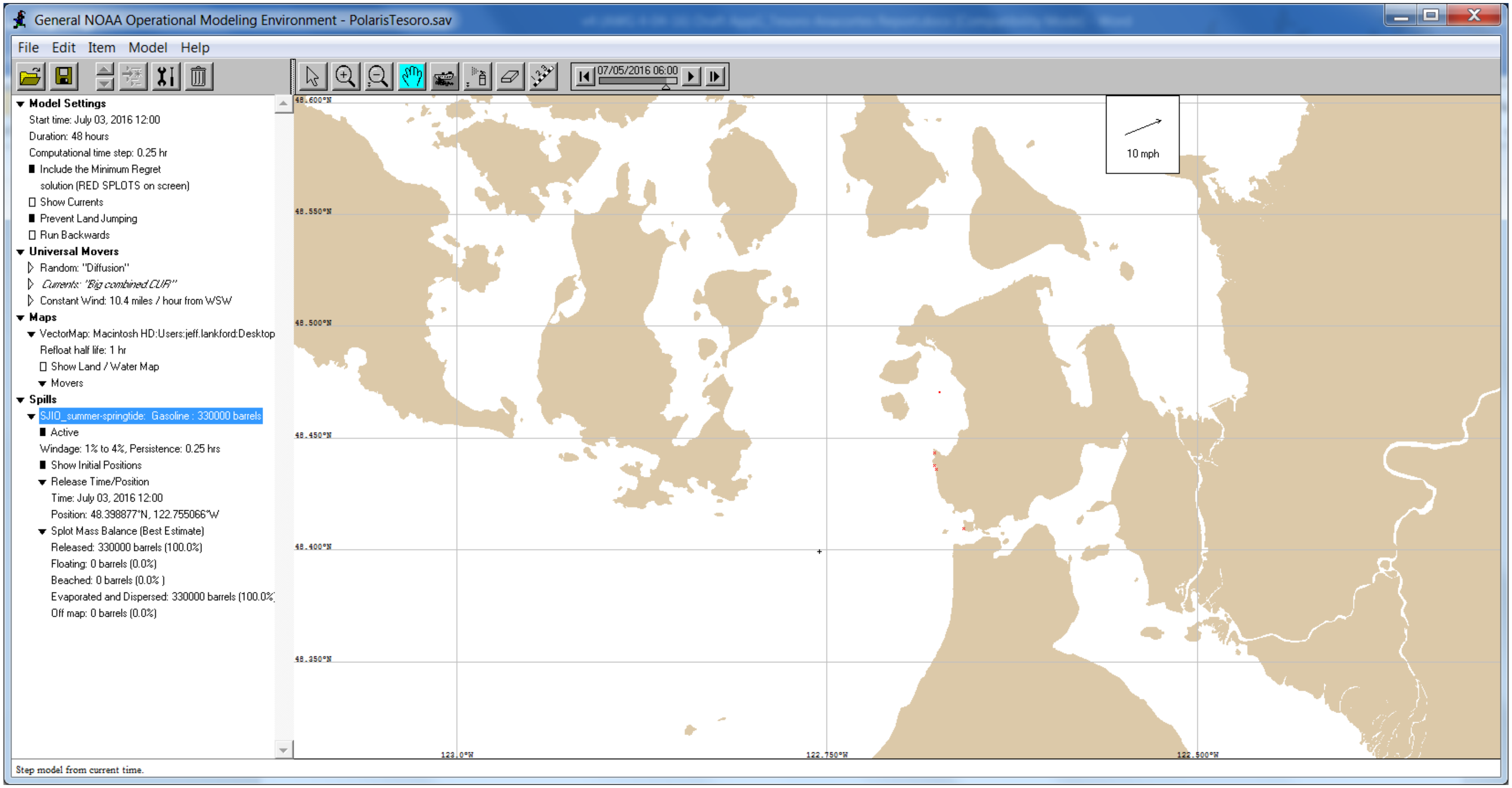

Figure G-15 (h). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ spring tide scenario: Hour 42.

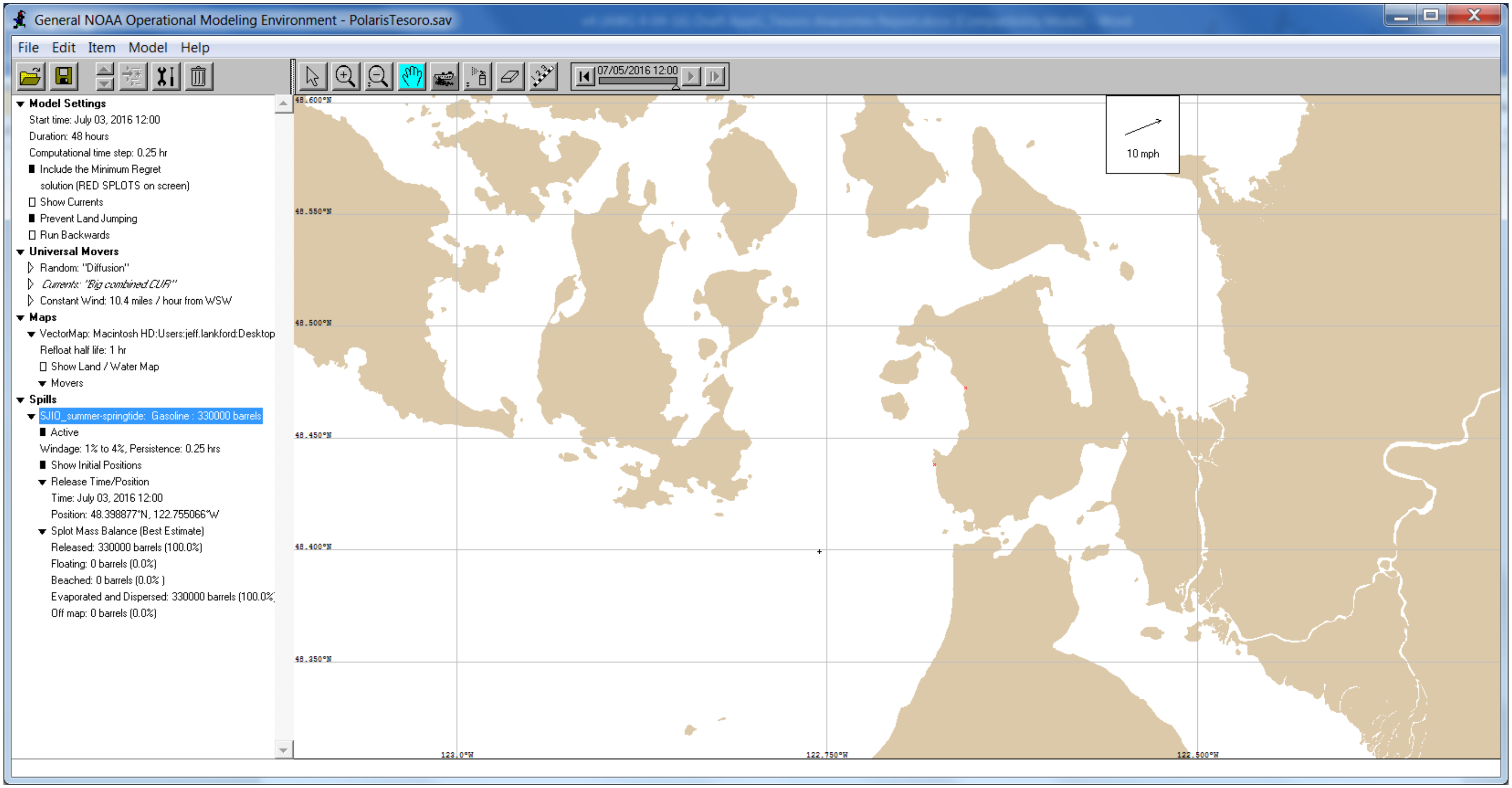

Figure G-15 (i). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ spring tide scenario: Hour 48.

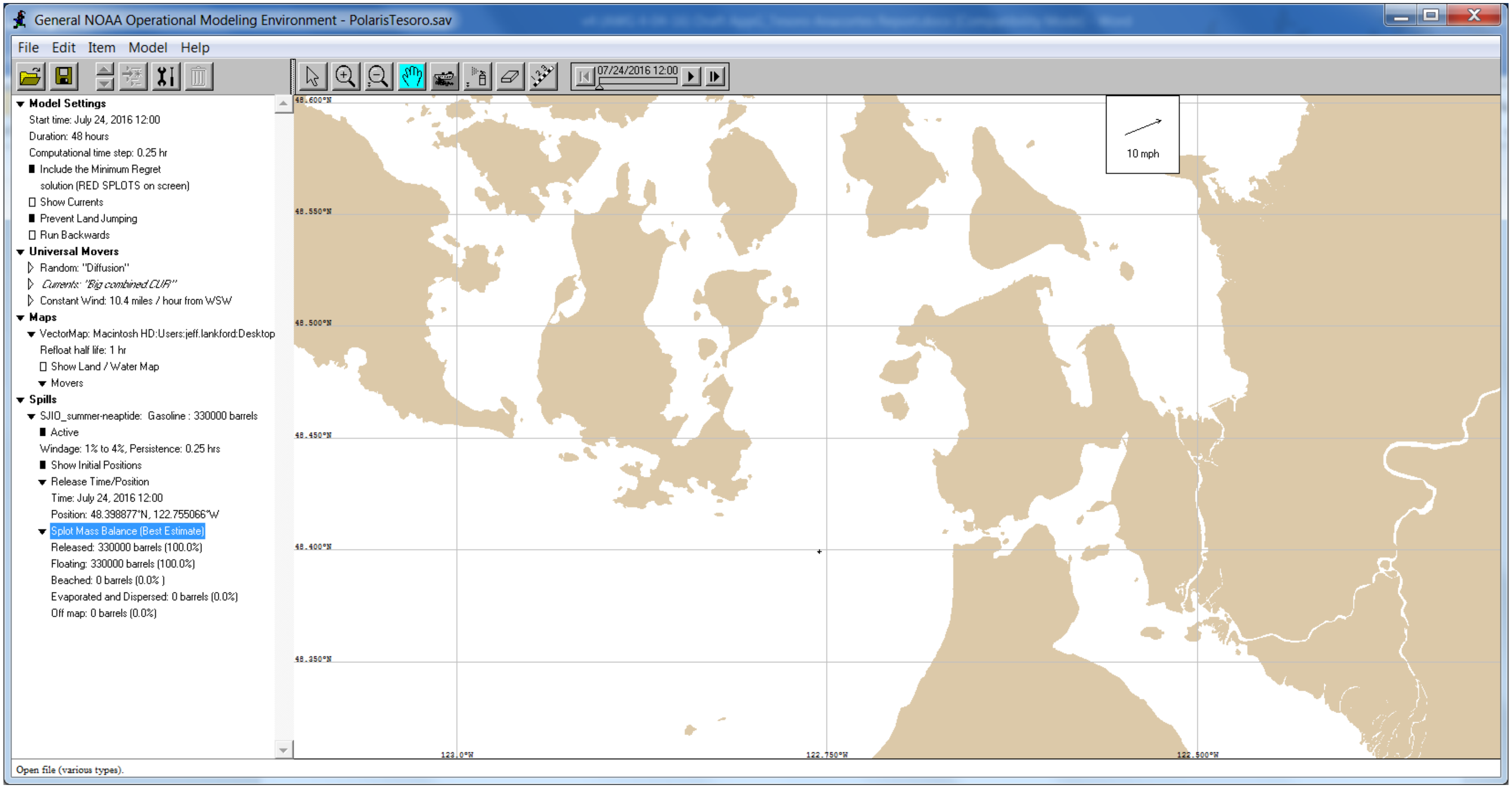

Figure G-16 (a). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ neap tide scenario: Hour 0.

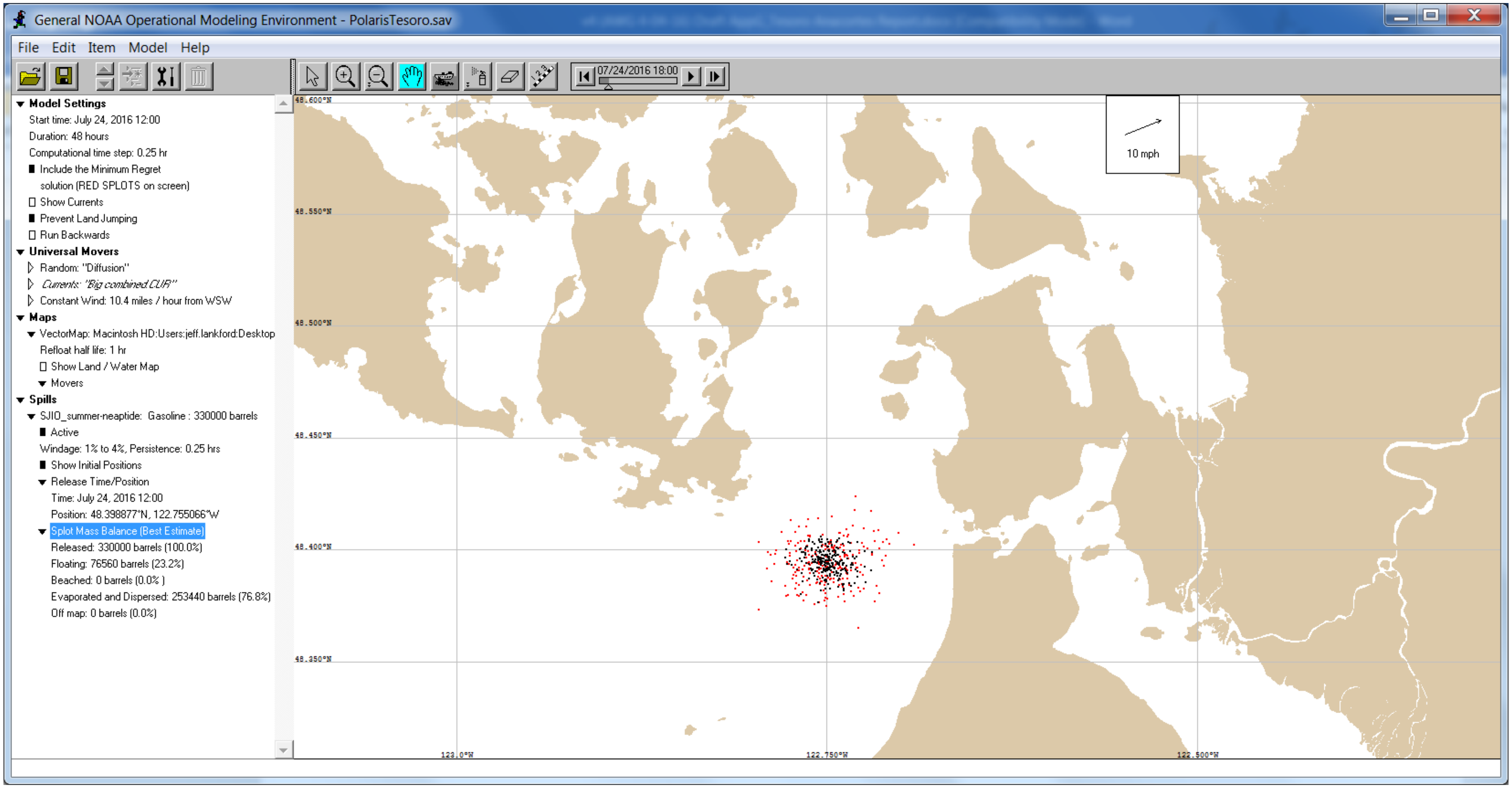

Figure G-16 (b). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ neap tide scenario: Hour 6.

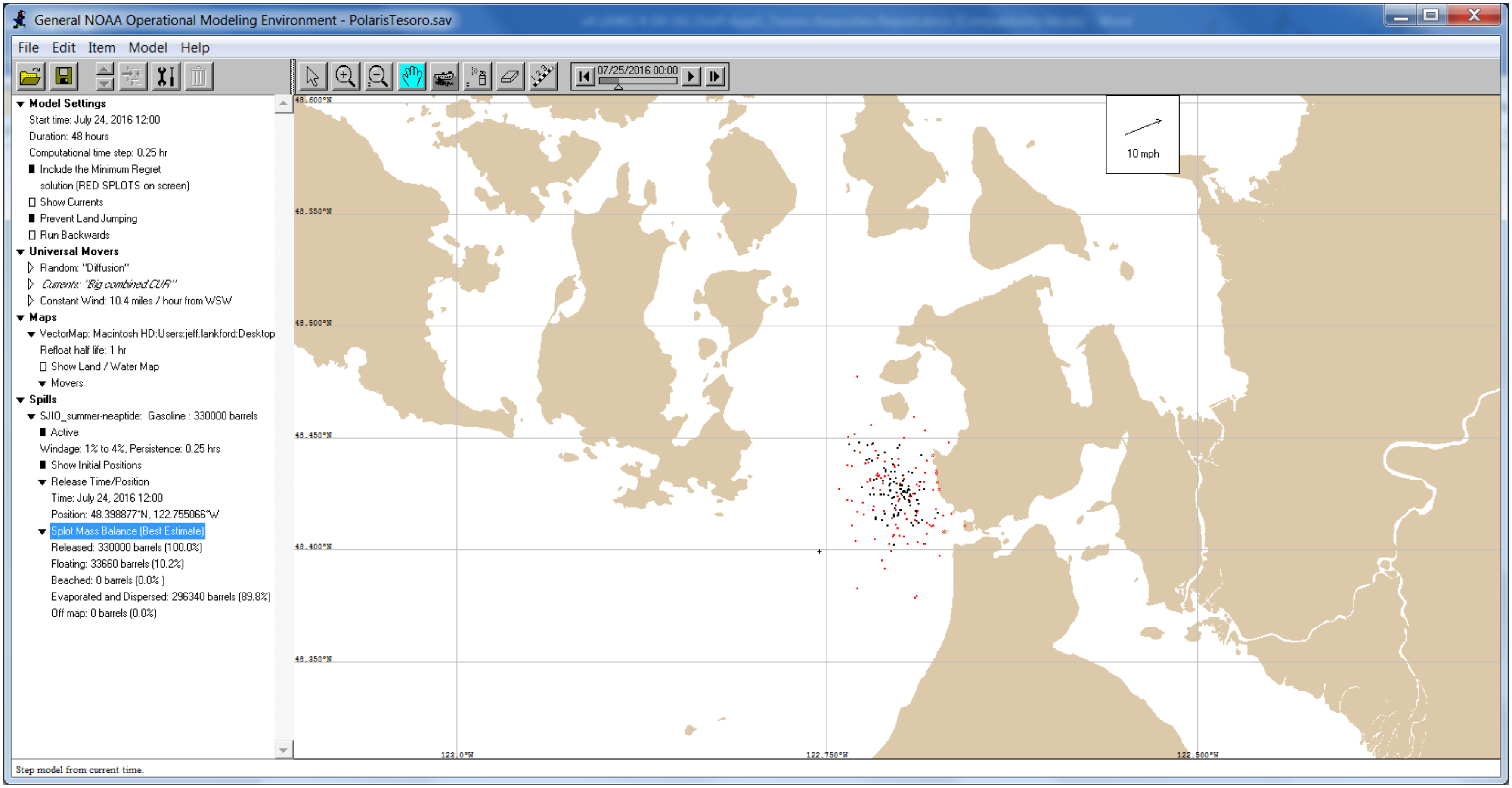

Figure G-16 (c). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ neap tide scenario: Hour 12.

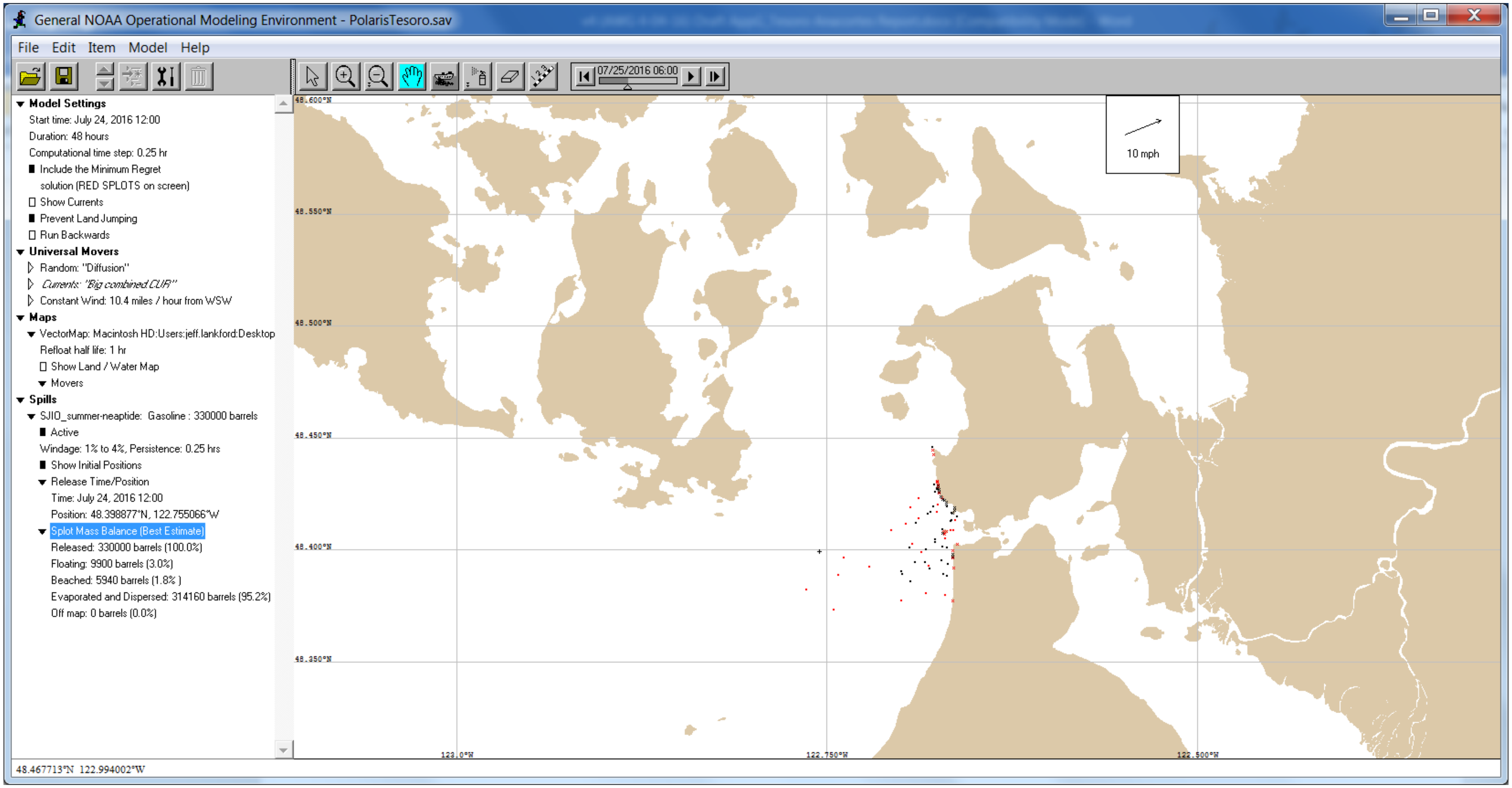

Figure G-16 (d). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ neap tide scenario: Hour 18.

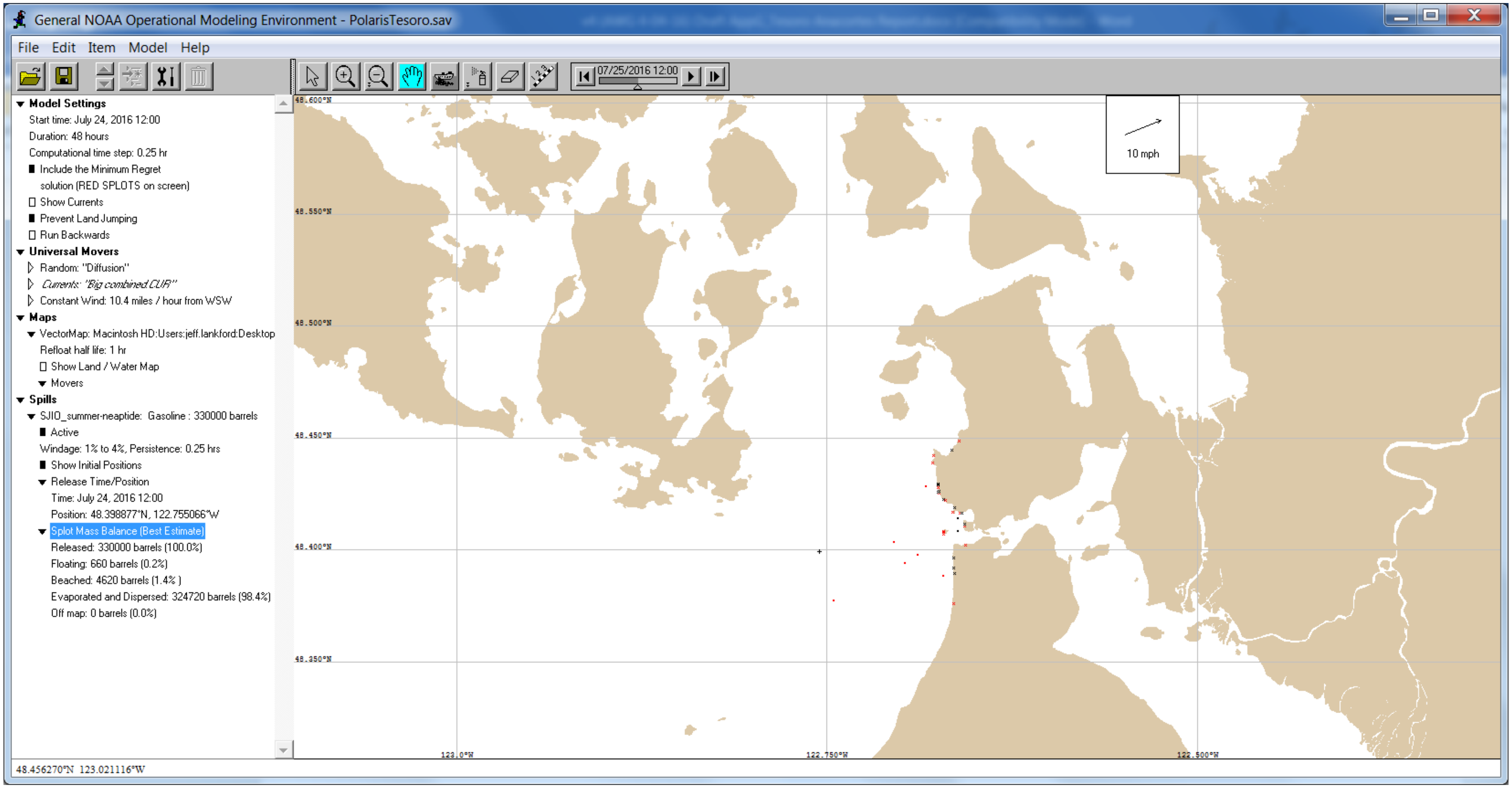

Figure G-16 (e). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ neap tide scenario: Hour 24.

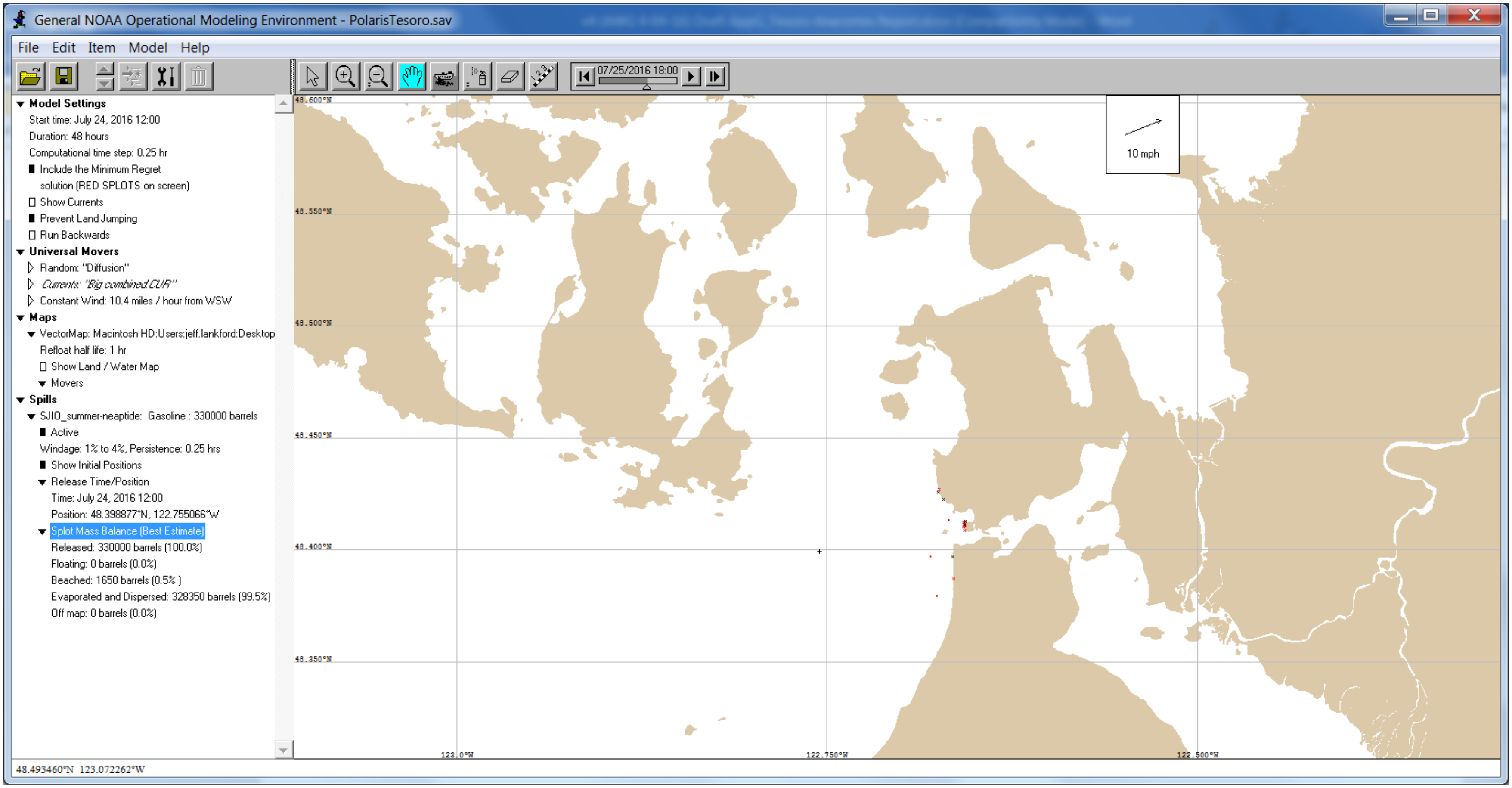

Figure G-16 (f). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ neap tide scenario: Hour 30.

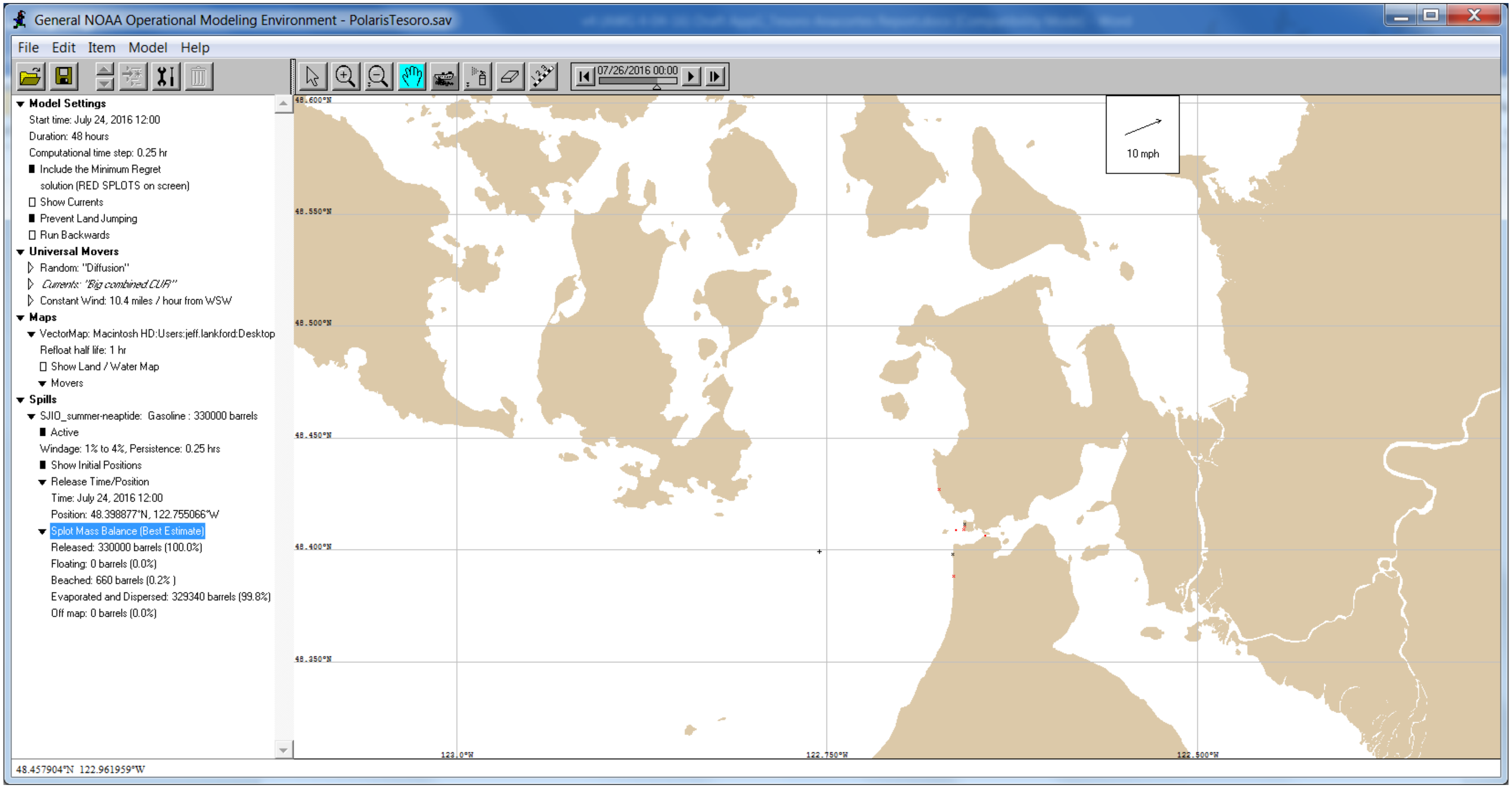

Figure G-16 (g). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ neap tide scenario: Hour 36.

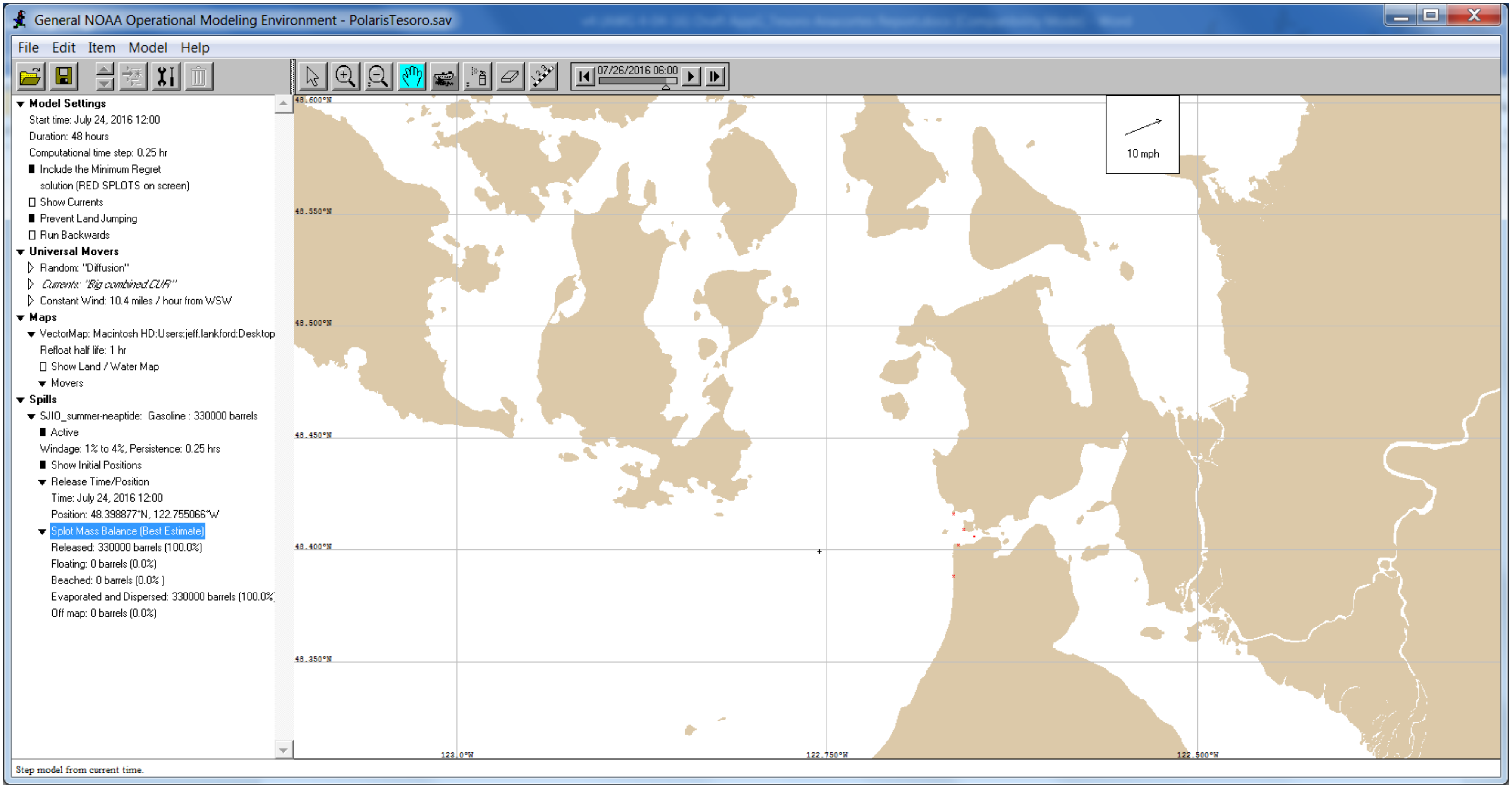

Figure G-16 (h). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ neap tide scenario: Hour 42.

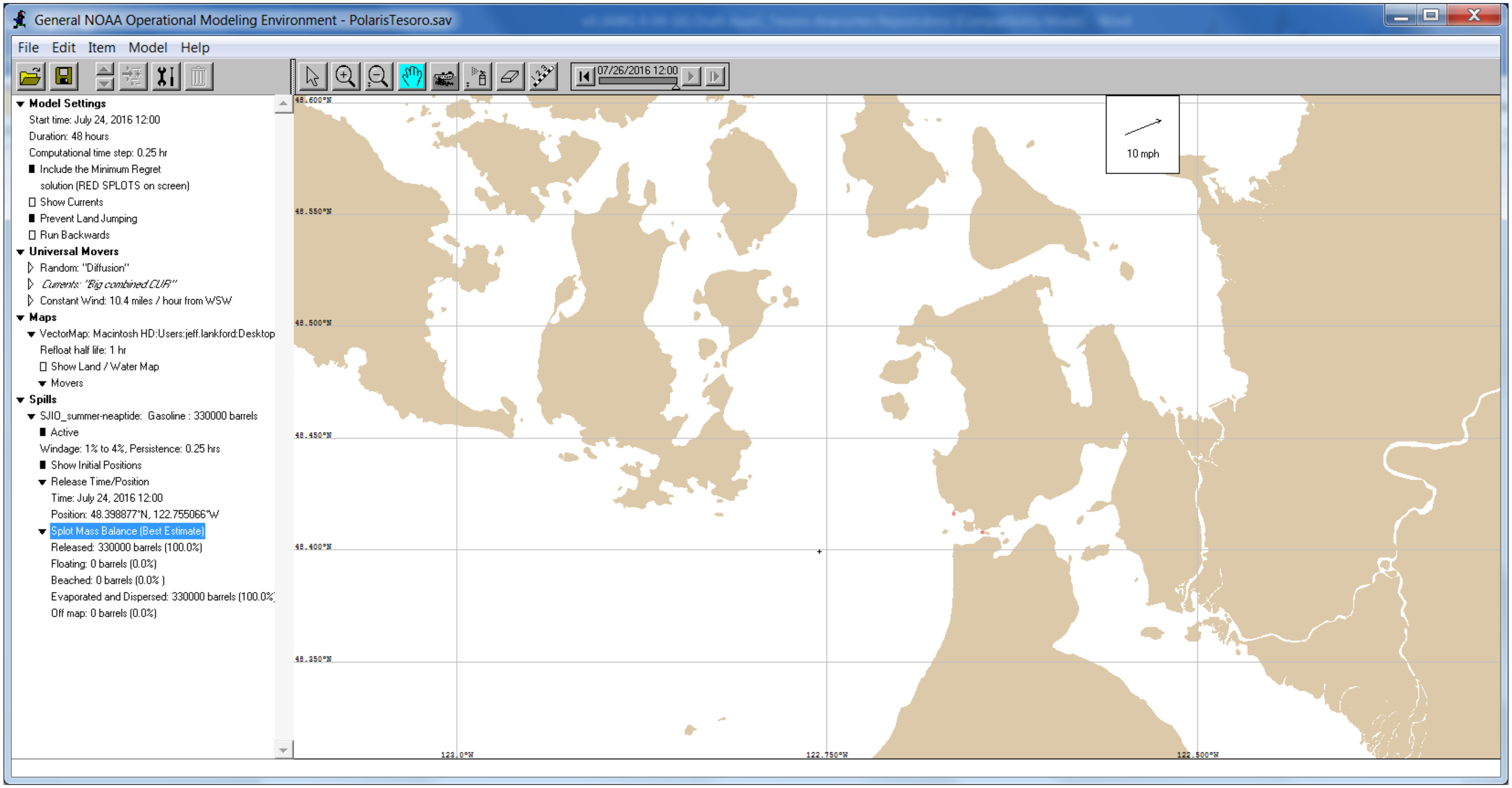

Figure G-16 (i). GNOME Model Output, Rosario Strait (SJI-O), 330,000 bbls, summer @ neap tide scenario: Hour 48.

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