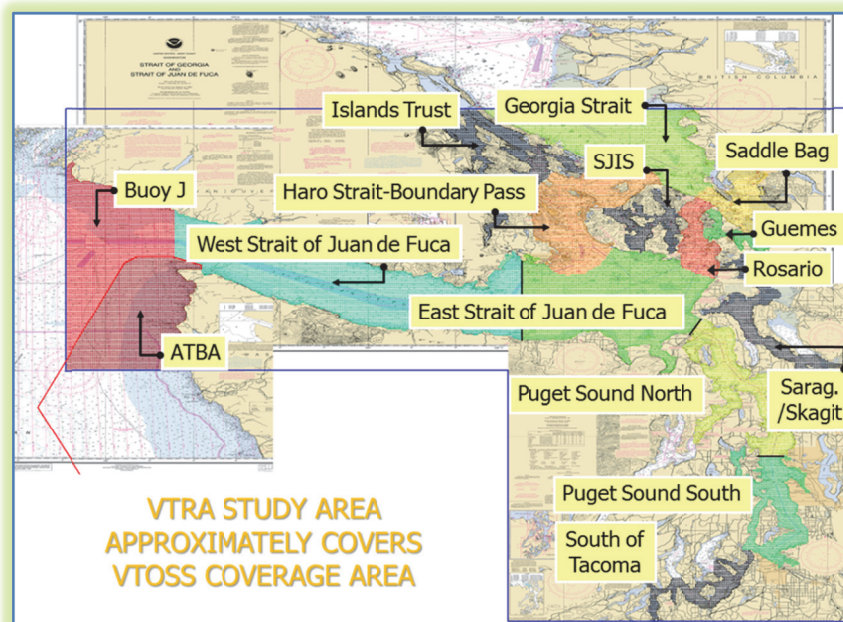*Final Report*

Vessel Traffic Risk Assessment (VTRA):

Updating the 2005 VTRA GW/VCU MTS Simulation Model from VTOSS 2005 to VTOSS 2010 data

April 2013

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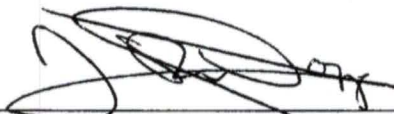jrmerric@vcu.edu

Prepared for:

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Final Report

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April 2013

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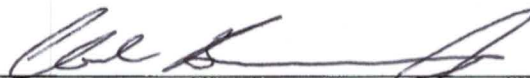
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PREFACE

This report is submitted by Johan Rene van Dorp (GW) and Jason R.W. Merrick (VCU). The content of the report describes the update of a Vessel Traffic Risk Assessment (VTRA) Maritime Transportation System (MTS) simulation model developed from using 2005 Vessel Traffic Operational Support System (VTOSS) data to using 2010 VTOSS data. Henceforth this project shall be named the VTRA update. The VTRA update commenced in August 2012 and spanned eight months. The VTRA study area includes: (1) portions of the Washington outer coast, (2) the Strait of Juan de Fuca and (3) the approaches to and passages through the San Juan Islands, Puget Sound and Haro-Strait/Boundary Pass. The project was funded by a grant from the Environmental Protection Agency (EPA) to the Makah Tribe. This report is has been reviewed and approved by the Makah.

From the outset of this project the support from the United States Coast Guard (USCG) District 13, including Sector Puget Sound, and the Puget Sound Harbor Safety Committee (PSHSC) have been unwavering. In particular, Mark Ashley's (USCG) and John Veentjer's (Chair of the PSHSC) support have been instrumental in providing the necessary data for the VTRA update. The PSHSC unselfishly extended their hospitality to allow GW/VCU to present their progress over the course of this project during their meetings every two months starting in October 2012. The PSHSC provided GW/VCU a public platform to obtain feedback from and access to the maritime community during the VTRA update. A PSHSC steering committee served as an advisory group during this update and will continue to serve as a steering committee in a follow-on project funded by the Puget Sound Partnership (PSP) using the VTRA update as its starting point.

This effort utilizes the extensive technical work already completed by the George Washington (GW) University and Virginia Commonwealth University (VCU) under previously funded projects. Specifically, the Prince William Sound Risk Assessment (1996), The Washington State Ferry Risk Assessment (1998), The San Francisco Bay Exposure Assessment (2004) and the 2005 Vessel Traffic Risk Assessment (VTRA). GW/VCU's VTRA analysis tool evaluates the duration that vessels travel through the VTRA study area by vessel type (referred to as exposure hereafter) and the accident frequency and oil losses from a pre-defined class of focus vessels. The inclusion of a time on the water element in the evaluation of exposure sets the GW/VCU methodology apart from count based approaches that focus on, for example, number of vessel transits, visits or calls. The GW/VCU VTRA analysis methodology has been well documented and peer-reviewed in the academic literature and continuously improved over the course of these projects. A reference list is provided at the end of this document.

EXECUTIVE SUMMARY

While the Pacific Northwest enjoys a relatively safe marine transportation system (MTS), the potential impact of a catastrophic spill on the region's environment, economy and quality of life continues to be a major concern. The effects of a significant spill would likely be devastating on the long-term restoration and productivity of this region including the US-Canadian boundary waters of the Washington outer coast, the Strait of Juan de Fuca and the approaches to and passages through the San Juan Islands, Puget Sound and Haro-Strait/Boundary Pass. Recent developments have significantly elevated this level of concern given the number of commercial projects being proposed for northern Puget Sound and southern British Columbia over the next decade. Moreover, these proposed commercial projects, while adding many hundreds of deep draft ship transits, potentially increase significantly the amount of oil being transported throughout the area. The unique presence of Washington State Treaty tribes serving as resource trustees in this marine environment elevate the need for collaboratively developed protective measures.

The purpose of this project is to update to 2005 VTRA model using the 2010 VTOSS dataset to more closely approximate the present-day patterns in commercial traffic for future use of the GW/VCU VTRA analysis model regarding what potential actions be taken to mitigate potential increases in oil spill risk from large commercial vessel oil spills in the VTRA study area. In addition, this update will allow for a 2005 – 2010 VTRA model comparison in terms of changes in overall traffic in the VTRA study area.

The maritime traffic in this particular geographic area has been extensively studied by a variety of efforts in the past. One of the more recent being the VTRA conducted by GW/VCU from 2006-2008 (2005 VTRA hereafter) and funded by BP to inform a US Army Corp of Engineers' Environmental Impact Statement (EIS) regarding BP's dock expansion at Cherry Point. The primary data source for modeling commercial traffic participating in the Vessel Traffic Service (VTS) in the 2005 VTRA model was VTOSS 2005 data. Smaller vessel traffic not participating in these three VTS providers, but also modeled in the 2005 VTRA using a variety of data sources, include: state, tribal and Canadian fisheries, USCG permitted regatta events and whale watching activities.

A prime advantage of the VTOSS data is that it provides a single US-Canadian cross boundary data source of larger commercial vessel movements in the VTRA study area recorded by the three VTS providers: Seattle (US), Tofino (Canada) and Victoria (Canada). No doubt, current safety levels experienced in this MTS are to a great extent the benefit of the joint external vigilance risk management role the US and Canadian Coast guards play.

The 2005 VTRA model replicates vessel movement throughout the VTRA study area. The GW/VCU MTS VTRA methodology has been well documented and peer-reviewed in the

academic literature. A summary of the methodology is provided in this document with references to peer-reviewed publications and technical reports dispersed throughout this summary. It is particularly well suited to evaluate potential future risk increases as a result of planned commercial projects alluded to above, as well as to test risk mitigation measures to counter such increases prior to implementing them. To more closely approximate the present-day patterns in commercial traffic for future scenario analysis, the 2005 VTRA model is updated with the 2010 VTOSS dataset. The 2010 year is the last full year of traffic data recorded by VTOSS. Subsequent years are recorded using a different system.

Not only does the VTRA updated model represent an unprecedented level of detail in the depiction of maritime traffic, but more importantly this update has been validated using a an independently collected data source. Specifically, the model update was validated using 2010 Automatic Independent Surveillance (AIS) crossing line count data provided by the Marine Exchange Puget Sound (MXPS).

The value of such an independent validating data source is illustrated in Figure 1. Figure 1 compares east bound and west bound crossing line counts at the entrance of the Strait of Juan de Fuca generated by the GW/VCU model updated with VTOSS 2010 data to those recorded by AIS in 2010. Observe from Figure 1 there is strong agreement in the number of cargo, tanker and passenger vessel entering and leaving the West Strait of Juan de Fuca.
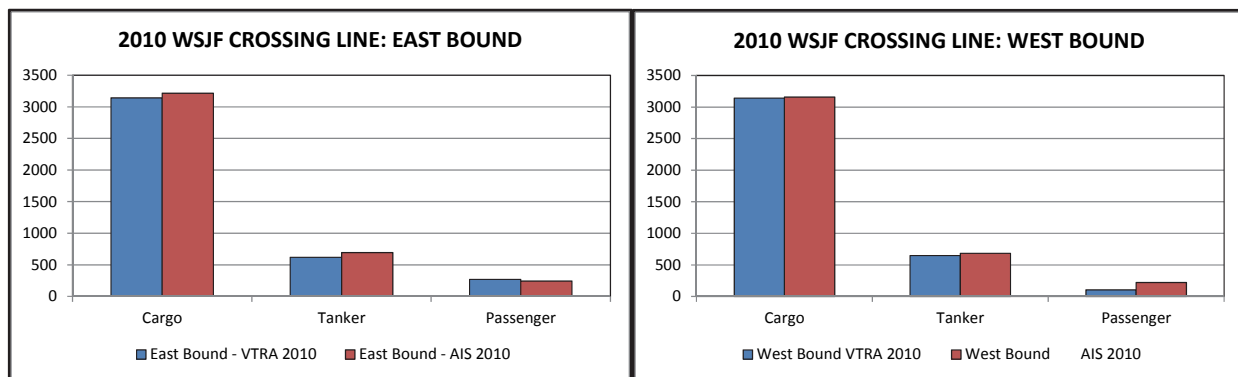
Figure 1. Comparison of AIS 2010 and VTOSS 2010 crossing line counts for cargo, tanker and passenger vessels for the West Strait of Juan de Fuca crossing line depicted in Figure 32B.

The updating of the 2005 VTRA model to 2010 VTOSS data described herein followed the collaborative analysis approach[1] involving coordination with Puget Sound stakeholders through the Puget Sound Harbor Safety Committee:

"In collaborative analysis, the groups involved in a policy debate work together to assemble and direct a joint research team, which then studies the technical aspects of the policy issue in question. Representative from all the participating groups are given the ability to monitor and adjust the research throughout its evolution. Collaborative analysis aims to overcome suspicions of distorted communication giving each group in the debate the means to assure

*that other groups are not manipulating the analysis. The ultimate goal is to generate **a single body of knowledge** that will be accepted by all the groups in the debate as a valid basis for policy negotiations and agreements. – George J. Busenberg, 1999."*

The validated 2010 VTRA update, combined with its unprecedented level of detail, and developed using this collaborative analysis approach, is particularly well suited to serve as such a single body of knowledge. The VTRA update provides a starting point for future vessel risk studies conducted in the area to inform federal agencies, tribes, local governments, industry and non-profit groups in Washington State and British Columbia on potential risk management options. A common starting point amongst these studies may further facilitate achieving consensus risk management decisions regarding vessel operations in the study area. One future vessel traffic risk study is currently funded by the Puget Sound Partnership through another Environment Protection Agency (EPA) grant award. This study has committed to using the VTRA update combined with the collaborative analysis approach that is integral to the GW/VCU VTRA methodology.

In addition to updating to VTOSS 2010 data, an overall traffic density comparison analysis is presented comparing the 2005 and 2010 VTOSS datasets by tankers, cargo, passenger, service, tug-tow and fishing vessels. However, caution should be exercised when interpreting such a comparison due to modeling enhancements included in the VTRA update. For example, a vessel's individual route has been retained in the VTRA update, whereas in the 2005 VTRA representative vessel routes were constructed by vessel type. The lack of an AIS 2005 validation data source for the 2005 VTRA only adds to that caution. Hence, Figure 2only shows for the VTRA update by vessel type (including non-participating VTS traffic) the overall distribution of the total time vessels move through the VTRA study area.

In light of planned future commercial projects in the VTRA study area, and with an eye towards larger potential oil spills, we further restrict ourselves in the executive summary to describing a combined 2010 cargo, tanker and tug-tow vessel traffic profile. This subset of traffic totals 41.4% of the traffic depicted in Figure 2. This 41.4% breaks down as follows: tug-tows (47.5%), cargo (44.8%) and tankers (7.7%).

Table 1 shows the distribution of the durations that cargo, tanker, and tug-tow traffic move across the 15 waterway locations of the study area (depicted on the cover page). Specifically, the fourth column in Table 1 lists the annual number of days that cargo, tanker or tug-tow vessels move within a particular waterway location. Dividing the annual number of days by 365 provides the average number of such vessels moving in a waterway location at an arbitrary point in time (the fifth column in Table 1). If one divides the number of days such vessels move in a particular waterway location by the total number of days these vessels move in the overall study area, one obtains the location's percentage of

exposure (the sixth column in Table 1). Finally, by dividing the percentage of exposure by the relative size of a waterway location (the third column in Table 1) one obtains a waterway location's density factor (the last column of Table 1).
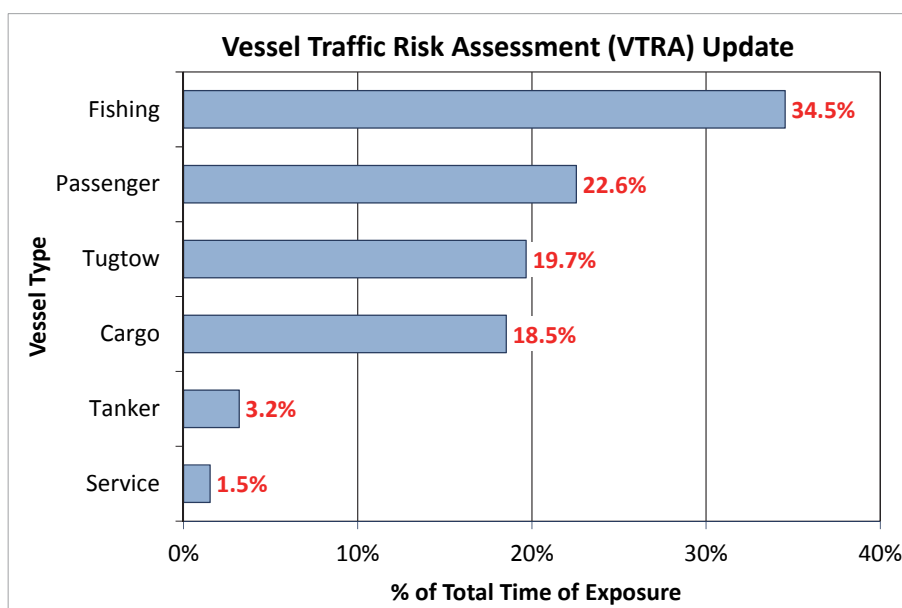
Vessel Traffic Risk Assessment (VTRA) Update

Vessel Type	% of Total Time of Exposure
Fishing	34.5%
Passenger	22.6%
Tugtow	19.7%
Cargo	18.5%
Tanker	3.2%
Service	1.5%

Figure 2. Percentage of time a vessel is moving in the VTRA system by master type in the VTRA Update

Table 1. Detailed exposure analysis of cargo, tanker and tug-tow vessels by the fifteen waterway locations on the cover by the GW/VCU VTRA model updated with VTOSS 2010 data.

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
LOCATION	**# Grid Cells**	**% Area**	**# Days Vessel is Moving per year**	**Average # of Vessels**	**% of Total Time of Exposure**	**Density Factor (DF)**
WSJF	2857	19.6%	2683.7	7.4	23.2%	1.18
PS North	983	6.8%	1896.7	5.2	16.4%	2.43
ESJF	2049	14.1%	1538.9	4.2	13.3%	0.94
Georgia Str.	1424	9.8%	1168.3	3.2	10.1%	1.03
Haro/Boun.	1066	7.3%	1145.1	3.1	9.9%	1.35
PS South	619	4.3%	1090.9	3.0	9.4%	2.22
Bouy J	1478	10.2%	701.5	1.9	6.1%	0.60
Rosario	307	2.1%	481.2	1.3	4.2%	1.97
Islands Trt	696	4.8%	324.0	0.9	2.8%	0.59
Tac. South	326	2.2%	166.7	0.5	1.4%	0.64
Saddlebag	375	2.6%	156.0	0.4	1.3%	0.52
Sar./Skagit	459	3.2%	80.8	0.2	0.7%	0.22
Guemes	127	0.9%	68.4	0.2	0.6%	0.68
ATBA	1520	10.5%	45.9	0.1	0.4%	0.04
SJ Islands	259	1.8%	15.6	0.0	0.1%	0.08
Total	**13246**	**100.0%**	**11563.8**	**31.7**	**100.0%**	**1.0**

In Figure 3 and Figure 4 waterway locations are ranked by their exposure and density factor evaluated in Table 1, respectively.
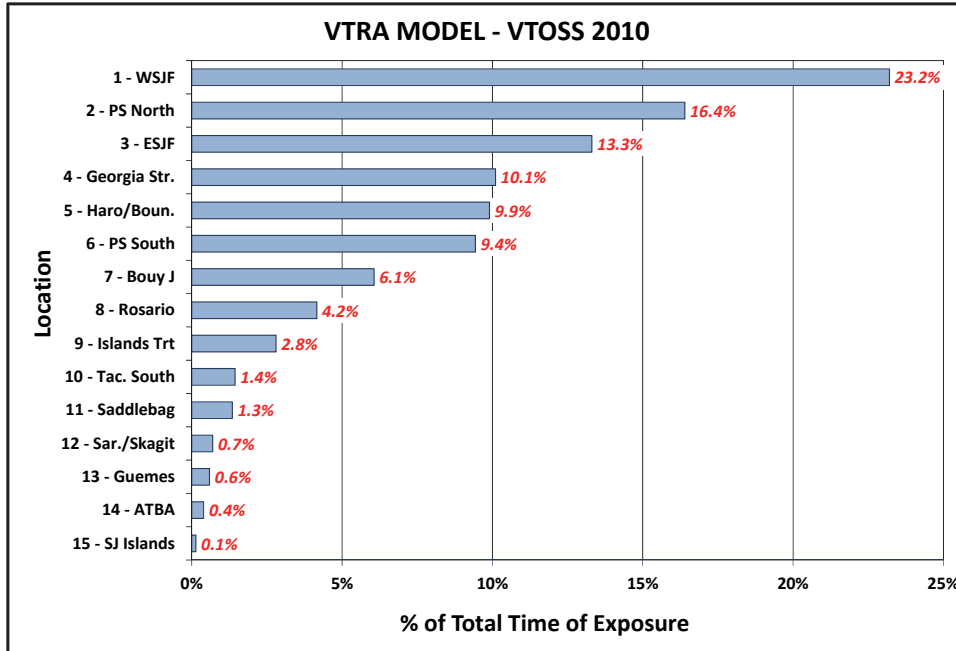

Figure 3. Waterway locations ranked by percentage of total time of exposure to cargo, tanker or tug-tow vessels as evaluated by the GW/VCU VTRA model updated using VTOSS 2010 data (see Table 1).
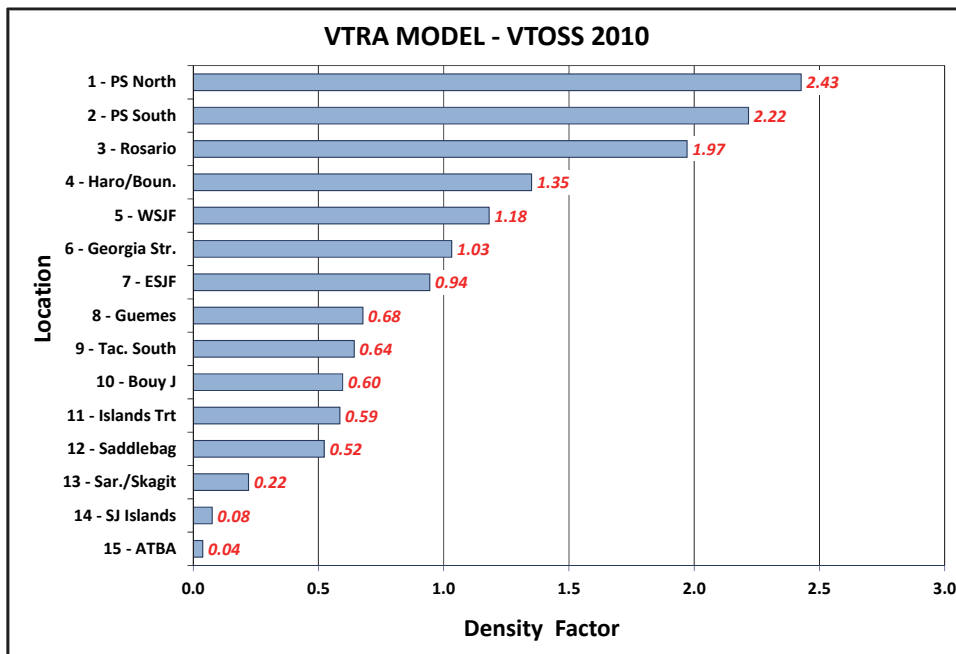

Figure 4. Waterway locations ranked by density factor restricted to cargo, tanker or tug-tow vessels as evaluated by the GW/VCU VTRA model updated using VTOSS 2010 data (Table 1).

Figure 3 shows that the West Strait of Juan de Fuca (WSJF) ranks first in terms of exposure. However, when accounting for its size, the WSJF ranks fifth in terms of density factor (see, Figure 4). Similar conclusions can be drawn for the other 14 waterway locations.

The analysis in Table 1 and presentations in Figure 3 and Figure 4 serve as a reminder that "the world is not average". To further emphasize this observation, Figure 5 plots the times series (plotted every 15 minutes}of the number of cargo, tanker and tug-tow vessels moving in the VTRA study area as evaluated by the VTRA update. From the left panel one observes that number of cargo and tanker vessels combined moving in the VTRA study area ranges from zero to 33. From the right panel one observes that the number of tug-tow vessels also ranges from zero to 33. Recall, that on average the total number of cargo, tanker and tug-tow vessels <u>combined</u> at any point in time values approximately 31.7(as evaluated in the last row of Table 1).
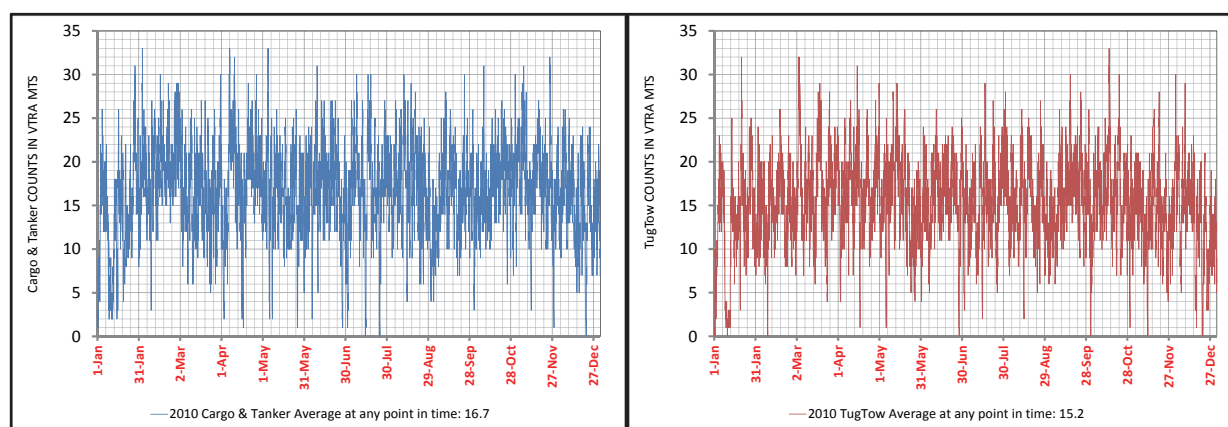
Figure 5. Time series of number of cargo, tanker and tug-tow vessels moving in the VTRA study area evaluated using the VTRA update. Left Panel: Cargo and tanker counts combined; Right Panel: Tug-tow counts.

Finally, Figure 6 below presents a geographic profile of exposure of cargo, tanker or tug-tow vessels moving in the VTRA study area, which is a unique output format of the GW/VCU VTRA model. About one quarter of cargo, tanker or tug-tow exposure (25%) occurs within the smaller red rectangle in Figure 6. About one half of this exposure (46%) occurs in the larger red rectangle. Thus about 54% of the remaining exposure is accounted for by the area outside the larger red rectangle within the VTRA study area. More importantly, through the use of its color scale, Figure 6 provides a refined visual representation of exposure by location.

The color scale provides a relative comparison of (1) the amount of time a vessel is moving within a particular grid cell with (2) the average amount of time a vessel is moving within any grid cell in the VTRA study area. While the waterway locations listed in Table 1 differ in size, grid cells in Figure 6 are all 0.25 square nautical miles in size. The color yellow represents the average amount of time a cargo, tanker or tug-tow vessel grid cell is moving

within a grid cell and is assigned the factor 1.0 depicted to the right of the color legend. Those grid cells with an exposure less than average are assigned a color below the yellow color and those that are above average get a color assigned above the yellow color. To the right of each color on the color legend it is indicated by what approximate factor the exposure in the particular grid cell differs from the observed average across all grid cells. Overall the grid cell exposure factors range in Figure 6 from zero to over 42. Stationary vessels, either at anchor or at the dock, are not reflected in this exposure profile.
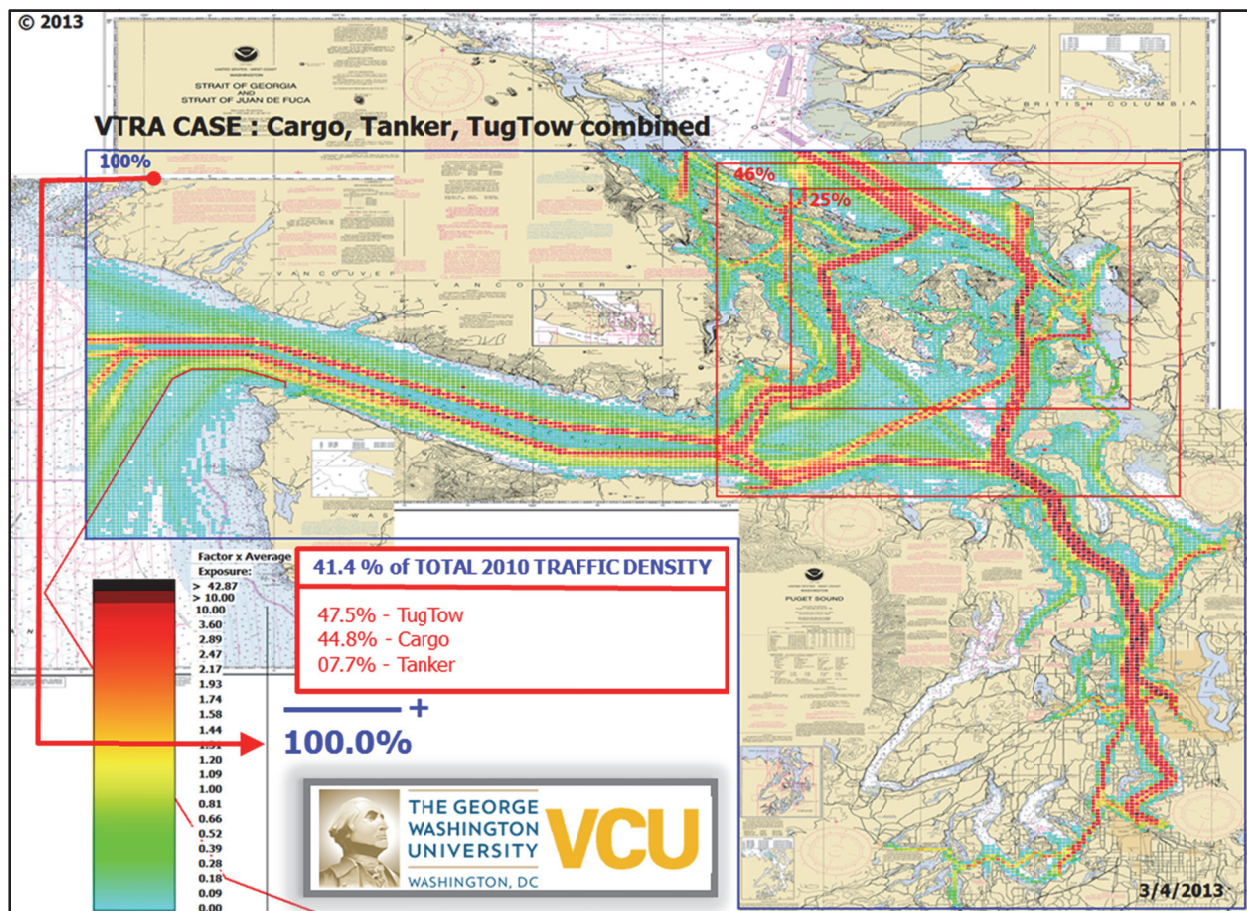
Figure 6. Geographic profile of time of exposure to tug-tow, cargo or tank vessels moving in the VTRA study area as evaluated by the updated GW/VCU VTRA model using VTOSS 2010 data.

Similar geographic profiles can be generated by vessel type using the VTRA update model. An additional accident analysis layer allows for the generation of geographic profiles in terms of accident frequency. Overlaying an oil outflow analysis model over the accident frequency profile allows for the generation of a geographic profile of potential oil loss. Development of these profiles will be the focus of the PSP grant utilizing the comprehensive and validated traffic picture presented herein as a starting point.

A detailed consideration of traffic levels is particularly important as one moves forward to considering risk and potential changes in risk from the commercial projects being proposed for the northern Puget Sound and southern British Columbia over the next decade. To put it simply, keeping everything else the same, when traffic increases risk increases, unless mitigated. Further, there is no guarantee that risk increases due to traffic increases can be fully mitigated.

This begs the question then, when faced with perhaps inevitable traffic increases how can one manage risk increases that cannot be fully mitigated? One approach could be to evenly distribute future risk across the affected area, i.e. to allow for risk increases in locations that currently have low risk levels compared to those that are already higher. On the other hand, should one aim for an equitable distribution of future risk allowing for each location to have a similar relative percentage increase in risk?

The challenge of risk management is for it to be location specific, taking into consideration the type and location of traffic and how it changes as a result of proposed traffic increases. One must realize that risk does not necessarily disappear when mitigated locally, but has tendency to migrate. Such risk migrations are preferably avoided, but may be inevitable. Needless to say, risk mitigation at one location ought not result in an increase in risk elsewhere that is larger.

These are important questions for the PSP project using the VTRA update as a starting point. In our opinion, they can only be answered utilizing the collaborative analysis approach (see, [1]), to which the PSP has committed. No doubt these questions are equally important in other ongoing studies considering the potential risk of traffic increases as a result of future planned commercial projects. We hope that other studies can benefit from the validated and vetted analysis of the VTOSS 2010 dataset performed in this project and presented in this report. Summarizing, we advocate a collaborative systems approach towards risk management, not one that is just locally targeted missing potential side effects or points of view.

In light of the observations in this VTRA update dispersed throughout this report, while considering a longer-term view of risk management in the VTRA study area, we close with the observation that there is a serious need for an electronic data source that is cross-boundary (US and Canadian waters) where the vessel type is consistently defined and verified. VTOSS and AIS are such cross-boundary electronic data sources and could serve this purpose. Moreover, with the same eye towards risk management analysis it would be equally beneficial if such datasets records capture cargo or at a minimum cargo levels (laden, unladen, 50% laden, etc.). In particular, we would like to call out the need for recording at a greater consistency the cargo type and levels of tug-tow barges.

However without VTOSS and AIS currently possessing such a common and consistently recorded vessel identifier, vessel type, cargo type and cargo level classifications, VTOSS and AIS unfortunately still require some vetting at the individual vessel level. In this study, we have performed vetting at the individual vessel level by vessel master type (see Table 3).

We hope that other studies can benefit from the validated and vetted analysis of the VTOSS 2010 dataset performed in this project and presented in this report.

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Appendix: Glossary and List of Acronyms

- Allision–The collision of a vessel with its intended docking berth.
- ATB – Articulated Tug Barge
- Ecology – The Washington Department of Ecology's Spill Prevention, Preparedness and Response Program which is the primary state organization with authority and accountability for managing oil and hazardous material spill risk state-wide. Ecology is assisting PSP in conducting the VTRA with its expertise and experience.
- EPA – Environmental Protection Agency.
- MTS – Maritime Transportation System.
- FV – Focus Vessel.
- ITB – Integrated Tug Barge.
- IV – Interacting Vessel.
- MXPS – Marine Exchange Puget Sound.
- NGO – Non-Governmental Organization.
- NPO – Non-Persistent Oil
- Study Area – The Washington waters of Puget Sound east of Cape Flattery, north of Admiralty Inlet and west of Deception Pass, and their approaches.
- GW – George Washington University is the prime subgrant awardee.
- VCU – Virginia Commonwealth University is a sub-awardee to GW.
- GW/VCU – The technical team composed of GW and VCU.
- PO – Persistent Oil.
- PSP – The Puget Sound Partnership is the Washington state agency responsible for developing a Puget Sound Action Agenda, convening a Cross Partnership Oil Spill Work Group and for coordinating work to restore and protect Puget Sound.
- PSHSC – The Puget Sound Harbor Safety Committee.
- PSP Advisory Group – A steering committee of stakeholders advising the Puget Sound Partnership and GW/VCU over the course of this study.
- QAPP – Quality Assurance Project Plan
- USCG – US Coast Guard Sector Seattle, District 13.
- VTOSS – Vessel Traffic Operational Support System
- VTRA – Vessel Traffic Risk Assessment
- VTS – Vessel Traffic Service is the real-time marine traffic monitoring system used by the USCG, similar to air traffic control for aircraft.