CHAPTER 7

VTRA 2010 FINAL REPORT

Preventing Oil Spills from Large Ships and Barges In Northern Puget Sound & Strait of Juan de Fuca

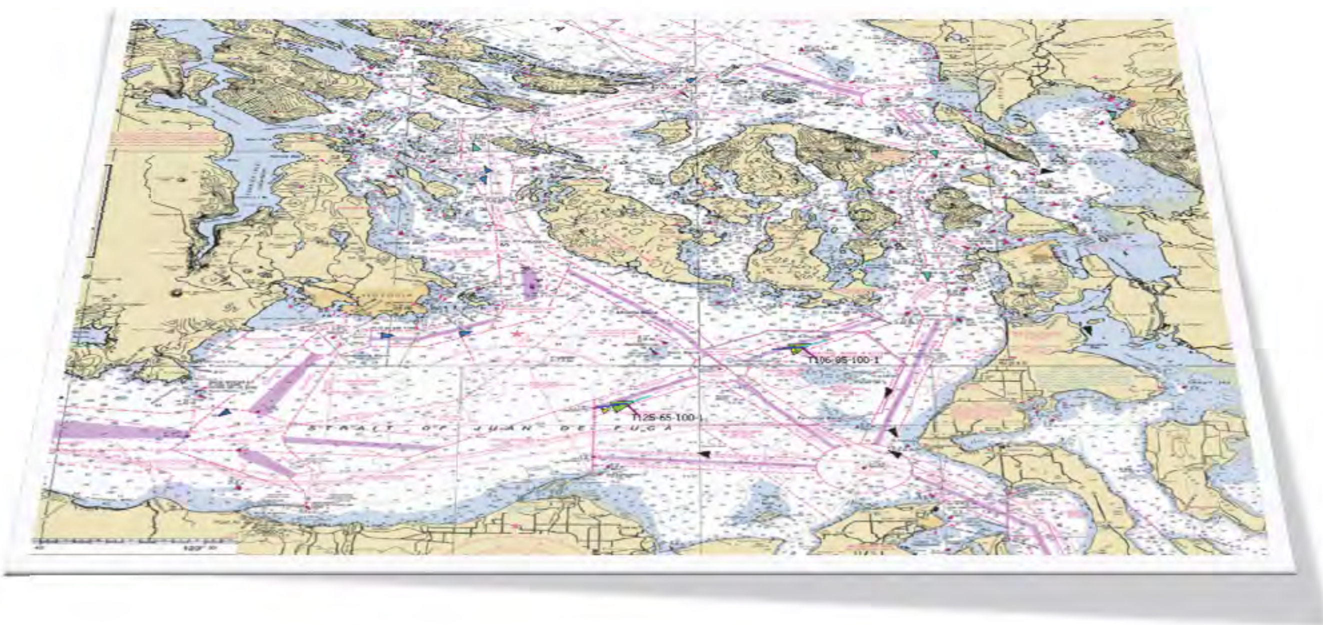

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Table Contents

7. WHAT-IF SCENARIOS

This study does not attempt to predict the future of vessel traffic in the study area. Such predictions are often made based on observable trends in the traffic levels or projections of potential economic changes and their possible impacts on traffic levels. As we have seen in the last decade, predicting global economic changes is difficult and unpredictable Economic changes can lead to unforeseen changes in traffic levels and reversals in previously observed trends. This means predictions can prove to be inaccurate, particularly in the medium to long term.

Modeling the What-If Scenarios

In this study, the Steering Committee chose to model only the traffic level impacts of planned expansion and construction projects that were in advanced stages of a permitting process. Each planned project forms a What-If scenario and What-If vessels are added to the simulation of the 2010 Base Case year. Four What-If scenarios were modeled in the study (see Table 11).

Table 11. Descriptors and short descriptions of Base Case and four What-If Scenarios

	WHAT IF SCENARIO ANALYSIS
P - Base Case	Modeled Base Case 2010 year informed by VTOSS 2010 data amongst other sources.
Q - GW - 487	Gateway expansion scenario with 487 additional bulk carriers and bunkering support
R - KM - 348	Transmountain pipeline expansion with additional 348 tankers and bunkering support
S - DP - 415	Delta Port Expansion with additional 348 bulk carriers and 67 container vessels
T - GW - KM - DP	Combined expnasion scenario of above three expansion scenarios

The next step in modeling the What-If scenarios is to determine the routes that the additional vessels will take in the simulation. Routes were chosen from the VTOSS 2010 data for vessels that actually transited the system to each location. The only change to an actual route that was made was for the Gateway routes as the bulk terminal is not yet in operation, so routes that went close to the planned terminal were chosen and modified to the correct location. Figure 66, Figure 67, and Figure 68 show the What-If vessel routes for the Gateway case, the Trans-Mountain Pipeline Expansion case, and the Delta Port case respectively.

Adding this number of additional vessels will also lead to additional bunkering operations in the study area. The Steering Committee determined that 47% of Gateway vessels would bunker on the inbound transit and as a first analysis the bunkering would take place at the Vendovi anchorage. The bunkering tug would transit from Seattle to Vendovi anchorage laden and then return to Seattle.

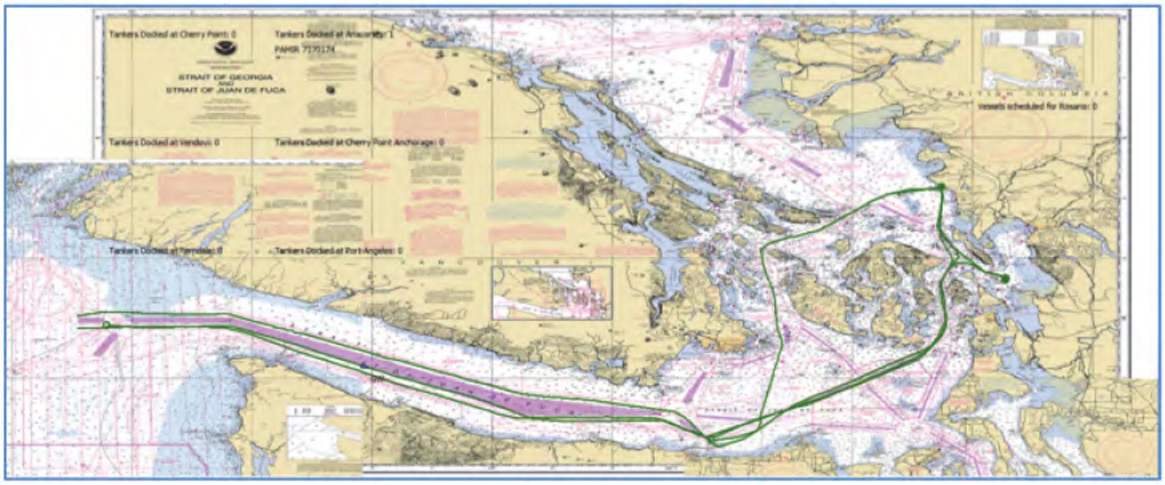

Figure 66. The routes used for the What-If vessels in the Gateway case.

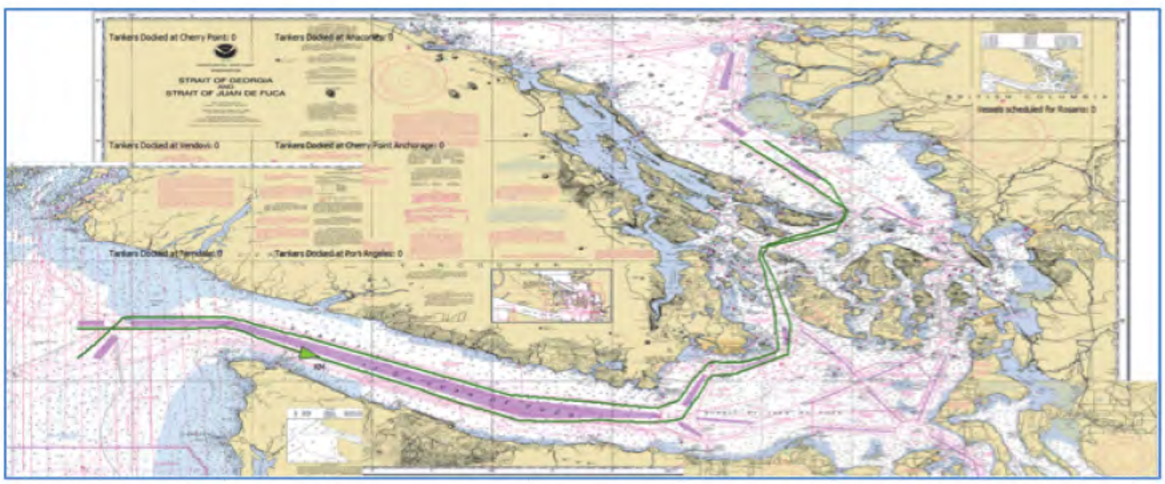

Figure 67.The routes used for the What-If vessels in the Trans-Mountain Pipeline Expansion case.

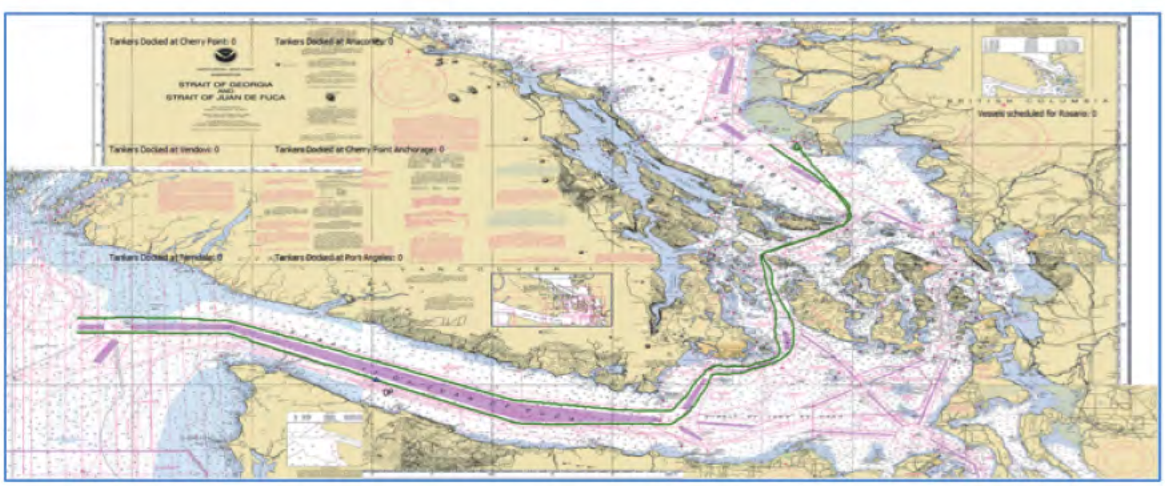

Figure 68.The routes used for the What-If vessels in the Delta Port case.

The Steering Committee decided that bunkering for the Trans-Mountain pipeline expansion scenario and the combination of proposed changes at Delta Port would take place out of the study area, but would require additional bunkering supply transits, 34 for the Delta Port bulk carriers, 6 for the Delta Port container vessels, and 21 for the Trans-Mountain pipeline expansion oil tankers annually. As a first analysis, these bunkering supply transits are modeled as transiting from the Cherry Point area and out of the study area to the north. Figure 69 shows the bunkering tug routes used for the what-if scenarios.

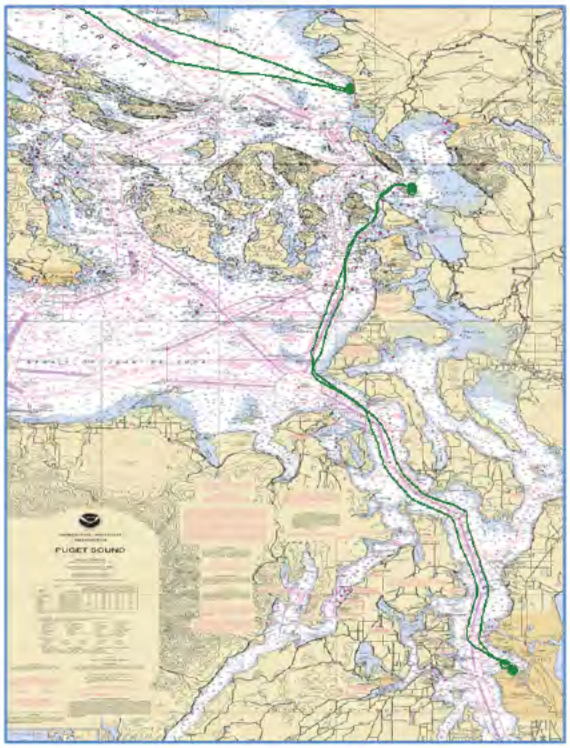

Figure 69.The tug routes used for additional bunkering in the What-If scenarios.

The final decision concerning modeling What-If scenarios relates to the arrival patterns of the additional vessels. While knowing the count of the number of vessels of each type calling at a given dock or port is informative, to simulate the vessels over time one must know the time between one such vessel arriving in the system and the next. The variability in these inter-arrival times changes from destination to destination and from vessel type to vessel type. The variability in inter-arrival times for each of the projects in the What-If scenarios will not be known until the projects have been underway for a period of time. In modeling, if the specifics of a situation are unknown and there is no data upon which to base modeling decisions, the simplest assumption is preferable. In this case, the simplest assumption is to assume that the inter-arrival times are all equal and that the vessels arrive at a constant rate. This assumption can be changed in later analysis, but it is a reasonable approach to start modeling the What-If scenarios.

Summary of System-Wide What-If Scenarios Results

Adding What-If vessels to the 2010 Base Case can have multiple effects, both direct and indirect effects:

1. What-If vessels directly increase the vessel exposure time and the oil exposure time. This means the What-If vessel will add to the collision and grounding exposure. With additional exposure the What-If vessels can have a triggering incident and so add to the POTENTIAL collision and grounding frequencies.
2. While a What-If vessel interacts with another vessel, the other vessel also may have a triggering incident and so there is another source of increase in the POTENTIAL collision and grounding frequencies. This source of increase is attributed to the vessel having the triggering incident, but would not be there without adding the What-If vessel to the simulation. This can still be considered a direct effect.
3. When the What-If vessel passes through the one-way zone at Rosario Strait and the exclusion zone at Boundary Pass, this can cause delays or slow down other vessels that are part of the original 2010 Base Case. This changes the 2010 Base Case vessel's transit through the system and can either increase or decrease their exposure and hence collision and grounding POTENTIAL. As an example, Figure 70 shows two screenshots that occurred within a simulated hour of one another in a What-If simulation. The figure shows one northbound (left) and one southbound (right) tanker interacting with a fleet of fishing vessels returning to port at the end of the day. If the tankers transits had occurred two hours earlier (as occurred in the Base Case 2010 simulation) then the interactions would not have occurred. These interactions occurred because of a change in the timing of tankers and led to an increased exposure and so an increased POTENTIAL for collision that is not caused directly by a What-If vessel and thus ought be considered an indirect effect.

Figure 71 shows three graphs. Each shows the percentage change in a given simulation output metric from the 2010 Base Case results. The change is shown for each What-If scenario and for completeness the 2010 Base Case is shown as a 0% change from itself. The change is shown as a bar graph, but the actual percentage change is also shown in text. The left panel graph in Figure 71 shows the change in vessel time exposure, the middle graph shows the change in POTENTIAL collision frequency, and the right panel graph shows the change in POTENTIAL grounding frequency. One can observe in Figure 71 that the changes in both POTENTIAL collision frequency and POTENTIAL grounding frequency are driven by the changes in exposure time. The changes in POTENTIAL collision frequency are larger than the changes in POTENTIAL grounding frequency.

Figure 72 shows a similar set of graphs as Figure 73, but this time showing the changes in fuel oil time exposure in the left panel graph, POTENTIAL collision fuel oil loss in the middle graph, and POTENTIAL grounding fuel oil loss in the right panel graph. The exposure changes for fuel oil are not exactly the same as vessel time exposure changes in value (as different vessel types carry different amounts of fuel), the overall pattern across the What-If scenarios, however, is the same and the ensuing changes in POTENTIAL collision and grounding fuel loss display a similar pattern.

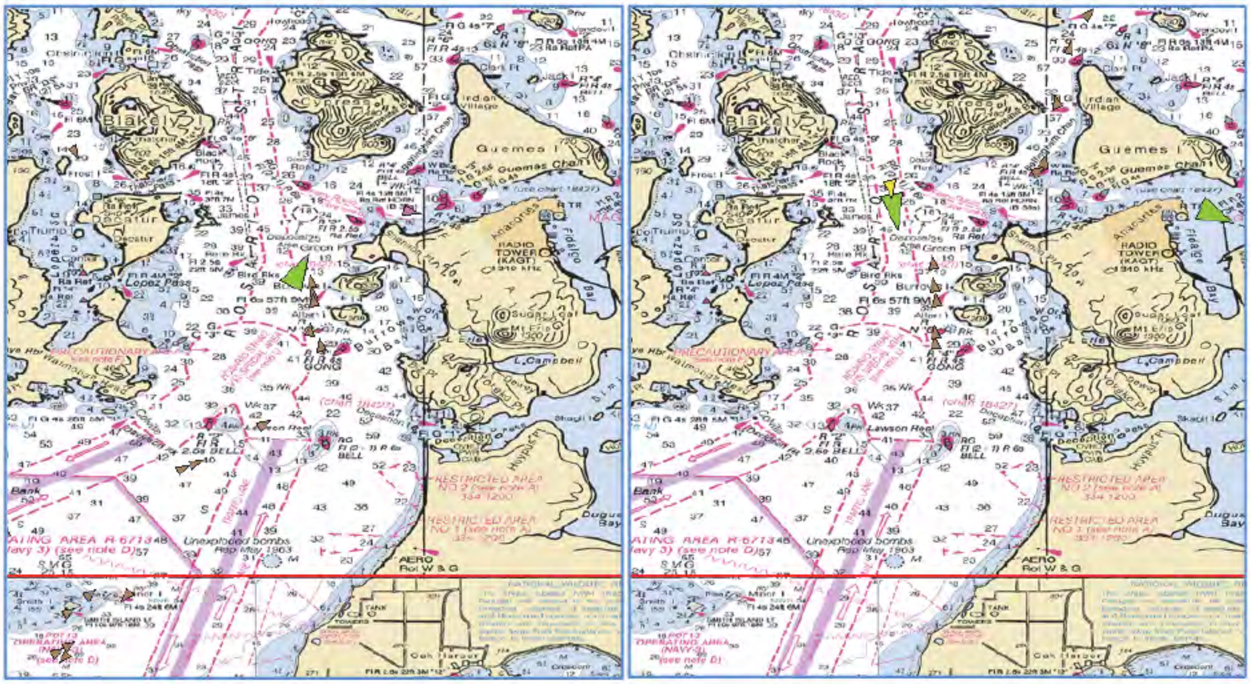

Figure 70. An indirect effect of a What-If scenario – the change in timing of the tanker transits causes two tankers (green triangles) to interact with a fishing fleet (gray triangles) returning to port at the day's end.

Figure 73 shows a similar set of graphs as Figure 71 and Figure 72, but this time showing the changes in cargo oil time exposure in the left panel graph, POTENTIAL collision cargo oil loss in the middle graph, and POTENTIAL grounding cargo oil loss in the right graph. The patterns in exposure changes shown in Figure 73 are not the same as in Figure 71 and Figure 72 as the bulk carriers and container vessels in Gateway and Delta Port What-If scenarios do not carry cargo oil. Thus, the Trans Mountain Pipeline Expansion project leads to the greatest increases in cargo oil time exposure. This leads to the higher increases in POTENTIAL collision cargo oil loss and POTENTIAL grounding cargo oil loss.

However, there is another interesting result as the change in POTENTIAL collision cargo oil loss for the Gateway scenario is not proportional to the change in cargo oil time exposure. The additional What-If bulk carriers in the Gateway scenario do not carry cargo oil. There is only a modest increase in POTENTIAL collision frequency for the Gateway scenario in Figure 71, so this result must be caused by a change in the mix of vessels interacting with Base Case tank vessels that do carry cargo oil. One would expect that this result is driven by increased interactions between Base Case tank vessels and Gateway bulk carriers. However, the result is not so simple.

There is a change in mix of interactions in the Gateway What-If Scenario with multiple types of vessels around the Rosario Strait one-way zone, including other oil tankers, ferries, fishing vessel and barges etc. This is the indirect effect discussed at the beginning of this section where the What-If vessels passing through the one-way zone at Rosario Strait, causes a delay or slowdown of other vessels that are part of the original 2010 Base Case, and leads to a change in the vessel mix interacting with tank focus vessels. This is an interesting result and could not be found without building a detailed simulation model of the system to capture such indirect effects.

Moreover, a worthwhile consideration is whether the changes caused by the combined What-If scenario is just the sum of the changes caused by each of the three separate What-If scenarios or whether there is an interaction between the scenarios being operational simultaneously. The changes in the POTENTIAL collision frequency (Figure 71, green bordered panel) from the three separate What-If scenarios add up to 13% + 9% + 10% = 32%. The change from the combined What-If scenario is only 21%. Thus the dynamics of the system here are changed in a way that reduces collision risk. On the other hand (Figure 72, green bordered panel), the POTENTIAL fuel losses of collisions are additive for the three What-If scenarios. However, the changes in the POTENTIAL collision cargo oil loss (Figure 73, green bordered panel) from the three separate What-If scenarios add up to 37% + 44% - 2% = 79%. The change for the combined What-If scenario is 97%. Thus the mix of vessels from the three What-If Scenarios involved in interactions with Base Case 2010 vessels must lead to more POTENTIAL oil losses. The most plausible cause for this effect is the combination of containers and bulk carriers using Haro-Strait to transit to Delta Port and the additional tankers using Haro-Strait to transit to Vancouver.

The changes in the POTENTIAL grounding frequency from the three separate What-If scenarios add up to 11% + 3% + 3% = 16%. The change from the combined What-If scenario is 17%. These are close, and it would appear that grounding frequency changes are about additive. On the other hand, the changes in the POTENTIAL grounding cargo oil loss from the three separate What-If scenarios add up to 0% + 50% + 0% = 50%. The change in POTENTIAL oil loss from the combined What-If scenario is 73%. So again we have an increase beyond the sum of the three individual What-If scenarios, which likely means that the vessels involved in the additional grounding potential are tank vessels.

Finally, Figure 74 combines the results from Figure 71, Figure 72 and Figure 73 and presents the percent changes in vessel time exposure, potential accident frequency and potential accident oil loss from the base case. Again, for completeness the base case is included as 0% as a reference point in Figure 74. Observe from Figure 74 that while the vessel time exposure percentages from the three separate What-If scenarios added equate to the vessel time exposure percentage of the combined case, one observes this is not the case for accident frequencies combined and oil losses combined. Most notably, the combined case has a potential oil loss increase of 68%, whereas the

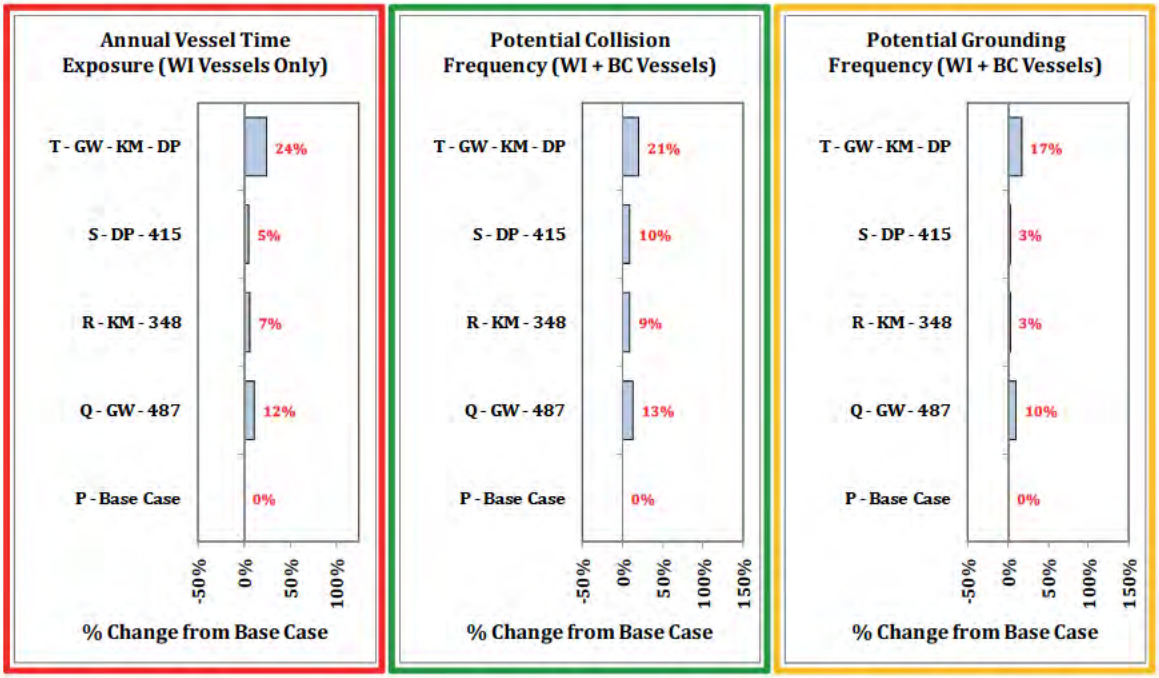

Figure 71. An overview comparison of the changes from the 2010 base case for each What-If scenario in terms of vessel time of exposure, POTENTIAL collision frequency, and POTENTIAL grounding frequency.

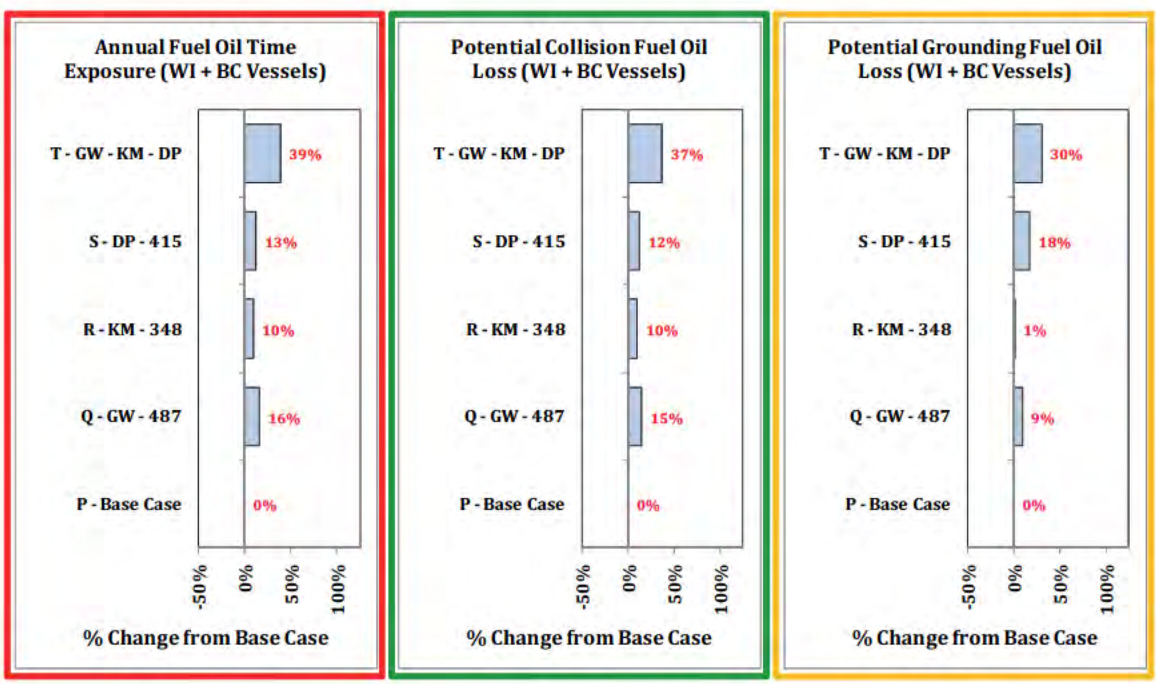

Figure 72. An overview comparison of the changes from the 2010 base case for each What-If scenario in terms of fuel oil movement exposure, POTENTIAL collision fuel oil loss, and POTENTIAL grounding fuel oil loss.

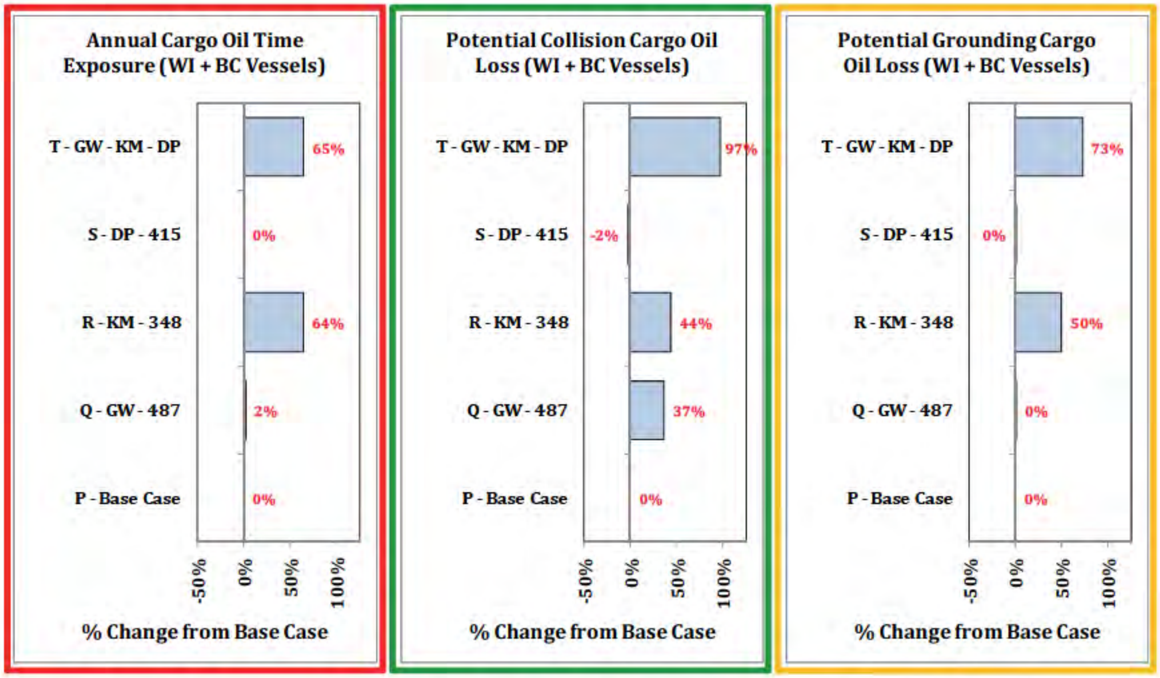

Figure 73. An overview comparison of the changes from the 2010 base case for each What-If scenario in terms of cargo oil movement exposure, POTENTIAL collision cargo oil loss, and POTENTIAL grounding cargo oil loss.

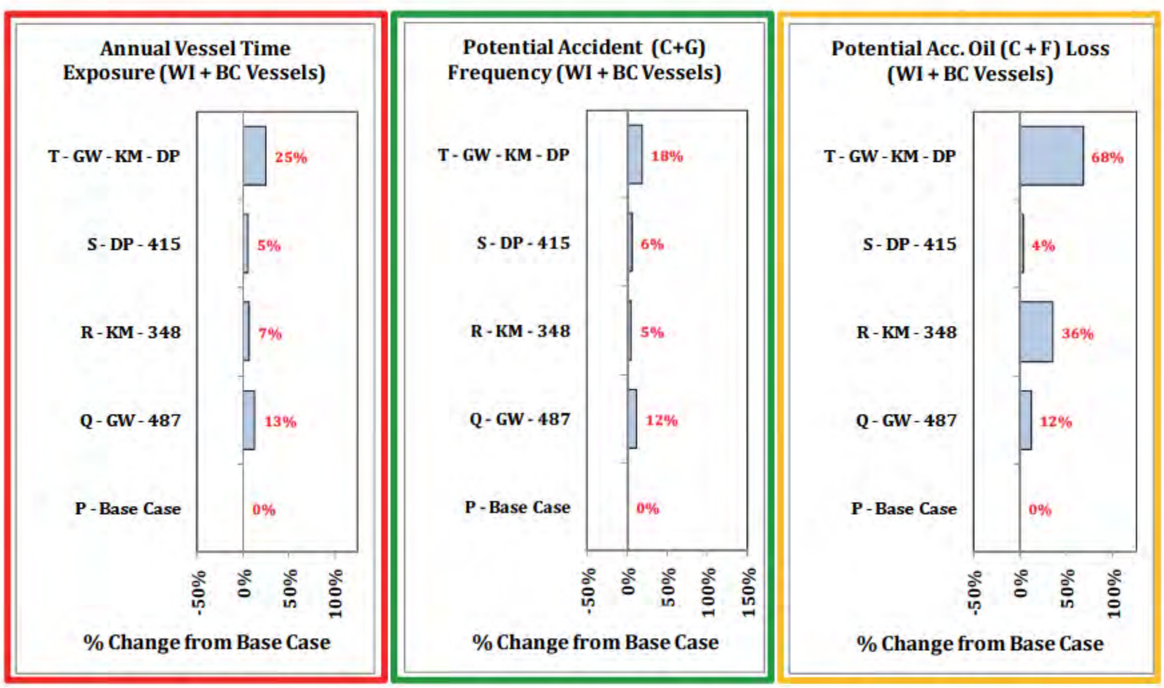

Figure 74. An overview comparison of the changes from the 2010 base case for each What-If scenario in terms of vessel time exposure, POTENTIAL accident frequency, and POTENTIAL accident oil loss.

three separate What-If scenarios combined gives 4%+36%+12% = 52%. Hence, besides an additive effect of combining the three What-If scenarios an additional multiplier effect becomes apparent when all are assumed operational. Again such a multiplier effect could not be found without building a detailed simulation model of the system to capture additional interaction effects when simultaneously running traffic from the three What-If scenarios.

By waterway zone analysis results of What-If scenarios

Figure 80 through Figure 87 capture in geographic graphical detail the changes in POTENTIAL accident frequency and POTENTIAL oil outflow. These geographic profiles are presented in a 2D format and in a 3D format. Increases in risk in the 2D format are observed though a darkening of color when adding traffic, whereas changes in the 3D format are observed through the addition of peaks when adding traffic. One ought to exercise caution in drawing conclusions from these 3D profiles as at times a more concentrated high peak with a small base may contribute less to overall system risk than a smaller peak with larger wide base. To further interpret/observe/evaluate changes in risk we therefore aggregate the detailed information from the 2D and 3D geographic profiles by the 15 waterway zones outlined in Figure 1. The by waterway zone analysis results are summarized in the graphic format depicted in Figure 75 (which is the same as Figure 8 in the executive summary).

In turn, the combined changes of the 15 waterway zones yield the overall system-wide changes discussed previously in Figure 71 through Figure 74. Hence, the by waterway zone analysis is an information layer between the detailed visual explicit geographic risk profiles and a single system-wide risk number that described the percentage change in risk for the system as a whole. Both the by waterway zone analyses and system-wide analyses, however, use the geographic profile analyses as their input. The geographic profiles provide for a detailed nuanced visual evaluation of that single system-wide risk number and capture the complex changes in the distribution of system risk geographically when adding What-If traffic to the VTRA 2010 baseline scenario. The by waterway zone analyses depicted in Figure 76 through Figure 79 capture these complex changes locally. Below we firstly provide a detailed explanation of the by waterway zone analysis output format.

Explanation format of by Waterway Zone analysis results

Firstly consider the titles of the figure legend in Figure 75. The base case serves as the benchmark for the relative comparisons in Figure 75 and the base case system-wide POTENTIAL oil losses are set at 100%. In the combined What-If scenario (T) this increases by (+68%) and hence the total POTENTIAL oil loss evaluated for Case T equals 100% + 68% = 168%. Thus all percentages in Figure 75 are evaluated in terms of base case percentages. Hence, we have a system-wide increase by a relative multiplicative overall factor 1.68 in POTENTIAL oil outflow. Said differently, the POTENTIAL oil losses of the base case (100%) are multiplied by a factor 1.68 in case of Scenario T.

The blue bars in Figure 75 represent the percentage waterway zone contribution to POTENTIAL oil losses in the 2010 Base Case. The waterway zones are ranked in Figure 75 by the blue bar percentages. Hence, the largest percentage contribution of 17% to the Base Case (P) total POTENTIAL oil loss is observed for the Guemes waterway zone, the second largest 14.9% for the Rosario waterway zone, etc. If we sum all base case waterway zone percentages we arrive at 100%, that is:

17.0+14.9+13.4+10.0+10.0+9.8+9.8+4.8+4.8+3.9+0.6+0.4+0.2+ 0.2+0.1 = 100%.

The red bars in Figure 75 represent the percentage waterway zone contribution to POTENTIAL oil losses in the combined What-If scenario (T) in base case percentages. Hence, the Guemes waterway zone contributes 22.3% to the total 168% POTENTIAL oil outflow in Case T, the Rosario waterway zone contributes 15.5%, etc. If we sum all Case T waterway zone percentages we arrive at 168%, that is:

22.3+15.5+12.6+10.0+10.3+23.8+46.7+9.8+6.5+7.1+2.5+0.4+0.2+ 0.2+0.3 = 168%.

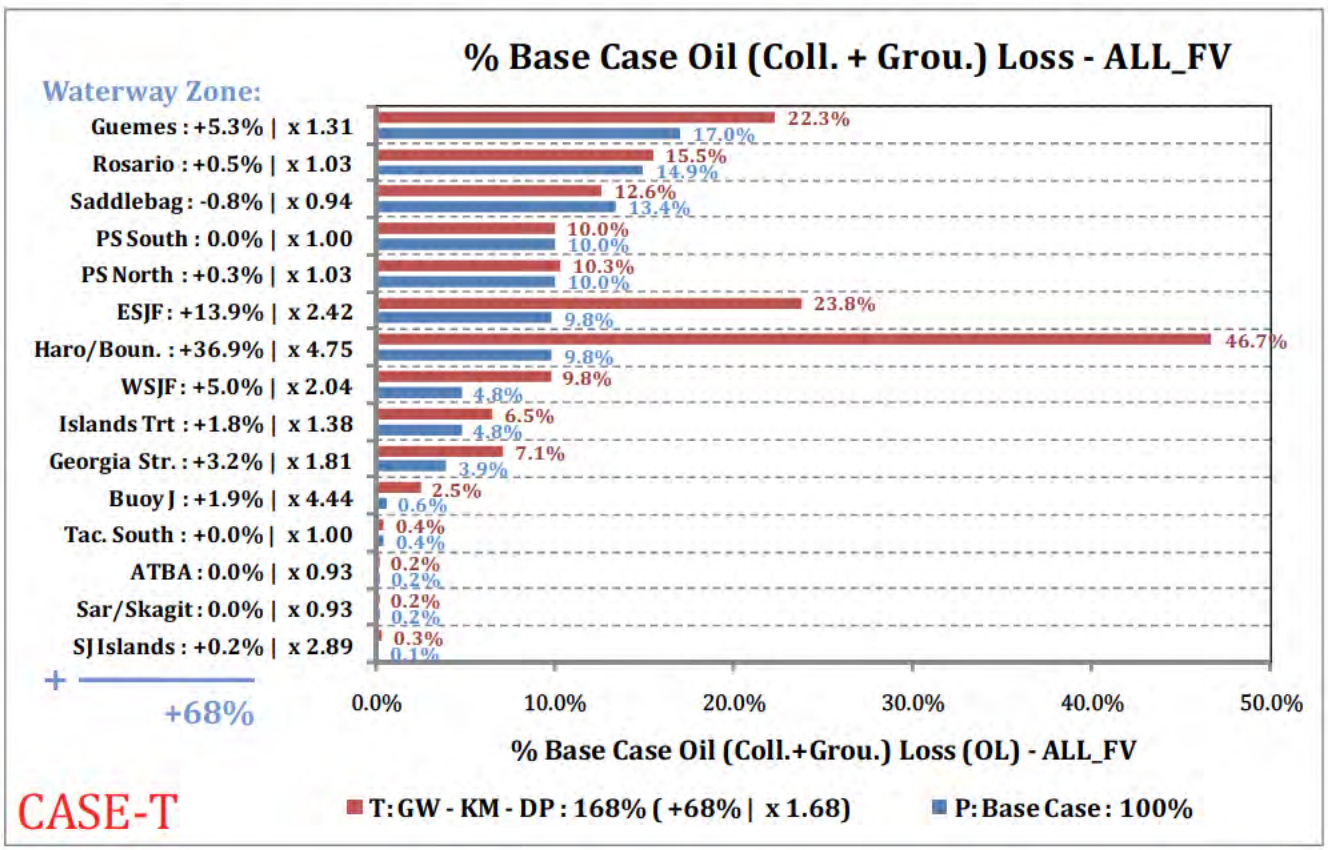

Figure 75. Relative comparison of POTENTIAL oil outflow by waterway zone. Blue bars show the percentage by waterway zone for the base case 2010 year, red bars show the percentage for Case T in terms of base case percentages. Absolute differences by waterway zone and relative multipliers by waterway zone are provided in the y-axis labels.

Observe from Figure 75 that the Guemes waterway zone is not the largest contributor to system-wide POTENTIAL oil losses anymore in Case T. Instead the Haro-Strait/Boundary pass waterway zone is now the largest contributor, East-Strait of Juan de Fuca the second largest, etc.

Concentrating now on the y-axis labels, the absolute percentage changes are indicated to left. To the right a relative multiplicative factor is evaluated by waterway zone. For example, we have for the Guemes waterway zone:

$$22.3\%-17.0\% = +5.3\% \text{ and } 22.3\%/17.3\% = \times 1.31.$$

In other words, going from the Base Case (P) to the Combined What-If Scenario (T), the Guemes waterway zone experiences a +5.3% absolute increase in terms of system-wide base case percentage of POTENTIAL oil loss. This translates, going from Base Case (P) to the Combined What-If Scenario (T), into a multiplication for the Guemes waterway zone Base Case POTENTIAL oil loss by a relative multiplicative waterway zone factor 1.31. Similarly, we have for the Haro-Strait/Boundary Pass waterway zone:

$$46.7\%-9.8\% = +36.9\% \text{ and } 46.7\%/9.8\% = \times 4.75.$$

In other words, going from the base case (P) to the Combined What-If scenario (T) the Haro-Strait/Boundary Pass waterway zone experiences a +36.9% absolute increase measured in terms of system-wide base case percentage of POTENTIAL oil loss. This means that going from base case (P) to the Combined What-If Scenario (T), the base case POTENTIAL oil loss in the Haro-Strait/Boundary Pass waterway zone is multiplied by a relative waterway zone factor ×4.75, etc.

By comparing the relative waterway zone factors one concludes which waterway zone experiences a larger share of the overall POTENTIAL oil loss increases normalized by waterway zone. For example, the Haro-Strait/Boundary Pass waterway zone (×4.75) comes first, second the Buoy J waterway zone (×4.44), third the San Juan Islands waterway zone (×2.89), fourth the East Strait of Juan de Fuca waterway zone (×2.42), etc. Waterway zones with a relative waterway zone factor larger than the relative system-wide factor (×1.68) experience. relatively speaking, a larger than system-wide effect of the What-If Scenario expansion and waterway zones with a relative waterway zone factor less than the relative system-wide factor (×1.68) experience, relative speaking, a smaller than system-wide effect of the What-If scenario expansion.

Finally, if we add the absolute percentage increases by waterway zone we arrive at the system-wide absolute percentage increase, i.e.:

$$5.3+0.5-0.8+0.0+0.3+13.9+36.9+5.0+1.8+3.2+1.9+0.0+0.0+ 0.0+0.2 = +68\%.$$

Thus, 8 out of the 15 waterway zones experience little to no effect in terms of POTENTIAL oil loss when all three expansion scenarios are operational. No doubt, such localized information helps in the design of a risk mitigation measures portfolio that aims to reduce these POTENTIAL increases.

Below we shall summarize by waterway zone results for the four different What-If Scenarios. We strongly encourage readers however to consult geographic profiles Figure 80 through Figure 87 to help further interpret the by waterway zone summary results in POTENTIAL accident frequency and POTENTIAL oil loss.

Gateway Terminal waterway zone results

The left panel of Figure 76 compares waterway zone accident frequency POTENTIAL in the base case against the Gateway What-If Scenario. Similarly the right panel compares a waterway zone's oil outflow POTENTIAL. The largest absolute increase in POTENTIAL accident frequency (+3.4%) is observed in the Georgia Strait waterway zone, which is predominantly an increase in POTENTIAL allision frequency which does not translate into additional potential oil outflow (see the right panel of Figure 76). This also constitutes the largest relative waterway zone increase of a factor 1.83 in POTENTIAL accident frequency.

From the right panel in Figure 76 one observes the largest absolute increase in POTENTIAL oil outflow (8.1%) in the Guemes waterway zone. Further analysis showed this to be a result of added interactions between oil barges and tank focus vessels in the Gateway What-If Scenario. Hence, this is an indirect effect/unintended consequence of adding Gateway traffic to the one-way Rosario zone, which overall changes the dynamic of the Base Case 2010 traffic behavior here in an adverse manner. Here too this constitutes the largest relative waterway zone increase of a factor of 1.48. Although the Buoy J waterway zone only contributes 0.6% to the overall total base case outflow POTENTIAL, it does experience the second largest relative waterway zone factor increase of 1.41.

Trans Mountain Pipeline waterway zone results

The left panel of Figure 77 compares waterway zone accident frequency potential in the base case against the Trans Mountain Pipeline What-If Scenario. Similarly the right panel compares a waterway zone's oil outflow potential. The largest absolute increase in POTENTIAL accident frequency (+1.6%) is observed in the Island Trust waterway zone defined on the title page. The largest relative waterway zone increase of a factor 1.21 in POTENTIAL accident frequency, however, is observed in the Buoy J waterway zone.

From the right panel in Figure 77 one observes the largest absolute POTENTIAL increase in oil outflow (+17.3%) in the Haro-Strait/Boundary pass waterway zone. Here, however this constitutes the largest relative waterway zone increase of a factor of 2.76. Notably, the East Strait of Juan de Fuca experiences an absolute increase in POTENTIAL oil outflow of 10.6% and a relative waterway zone increase factor of 2.08. Although the Buoy J waterway zone only contributes 0.6% to the overall total base case outflow POTENTIAL, it does experience the second largest relative waterway zone factor increase of 2.32.

It is important to realize here that base case oil loss is evaluated in the VTRA 2010 with respect to all focus vessels, i.e. bulk carriers, container vessels, other cargo vessels, chemical carriers, atb's, oil barges and tankers. If absolute increases and relative waterway zone increase factors would have been evaluated with respect to base case oil losses from tankers alone, relative waterway zone increase factors would be higher as one divides by a smaller amount of POTENTIAL oil loss (i.e. that of tankers alone, excluding the combined POTENTIAL oil loss from the other focus vessels).

Delta Port geographic waterway zone results

The left panel of Figure 78 compares waterway zone accident frequency POTENTIAL in the base case against the Delta Port What-If Scenario. Similarly the right panel compares a waterway zone's oil outflow POTENTIAL. The largest absolute increase in POTENTIAL accident frequency (+2.4%) is observed in the Guemes waterway zone, which, given that the Delta Port What-If focus vessels travel through Haro-Strait/Boundary Pass, has to be an indirect effect. The largest relative waterway zone increase factor 1.18 is observed in the Saddlebag waterway zone, which too is an indirect effect. Haro-Strait/Boundary Pass experiences an absolute effect increase of 1.7% and a relative waterway zone increase factor of 1.14. The latter can be considered direct effects of the Delta Port What-If Scenario.

From the right panel in Figure 78 one observes the largest absolute increase in POTENTIAL oil outflow (+3.8%) in the Haro-Strait/Boundary Pass waterway zone. Here too this constitutes the largest relative waterway zone increase of a factor of 1.38. Although the Buoy J waterway zone only contributes 0.6% to the overall total base case outflow POTENTIAL, it does experience the second largest relative waterway zone factor increase of 1.34.

Combined What-If scenario waterway zone results

The left panel of Figure 79 compares waterway zone accident frequency POTENTIAL in the base case against the Combined What-If Scenario (T). Similarly the right panel compares a waterway zone's oil outflow POTENTIAL. The largest absolute increase in POTENTIAL accident frequency (+4.4%) is observed in the Haro-Strait/Boundary Pas waterway zone. The largest relative waterway zone increase factor 1.89 is observed in the Georgia Strait waterway zone. Although the Buoy J waterway zone only contributes 0.4% to the overall total base case outflow POTENTIAL, it does experience the second largest relative waterway zone factor increase of 1.61 in POTENTIAL accident frequency.

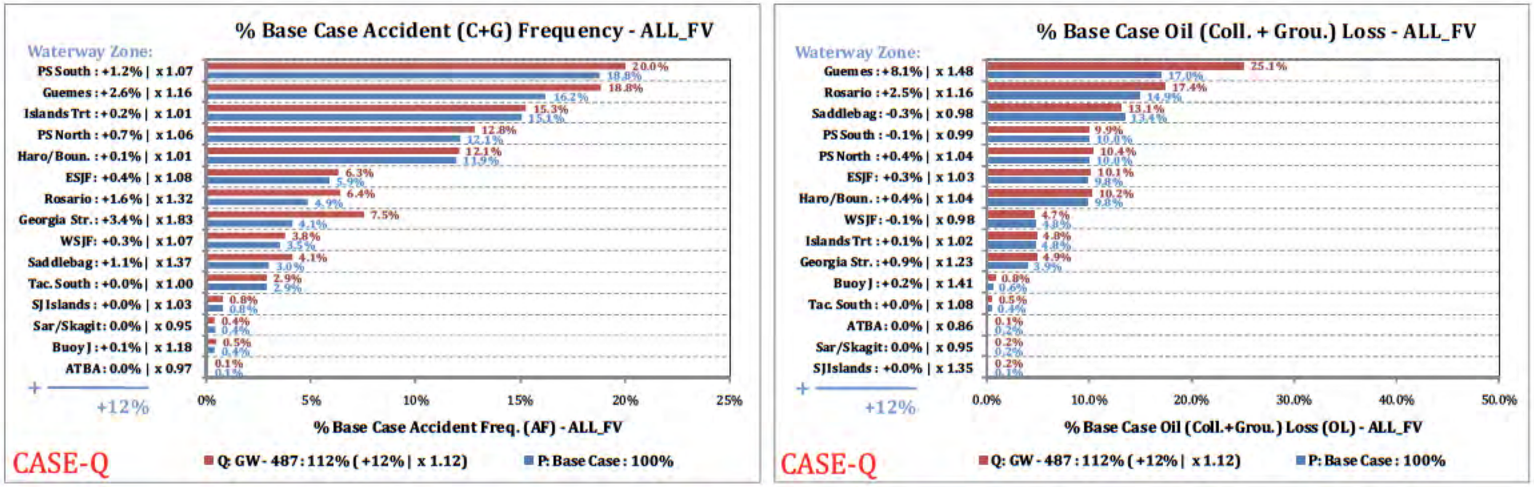

Figure 76. By waterway zone comparison of POTENTIAL accident frequency and POTENTIAL oil outflow of Case Q with Case P. For a detail explanation of output format see Page 97.

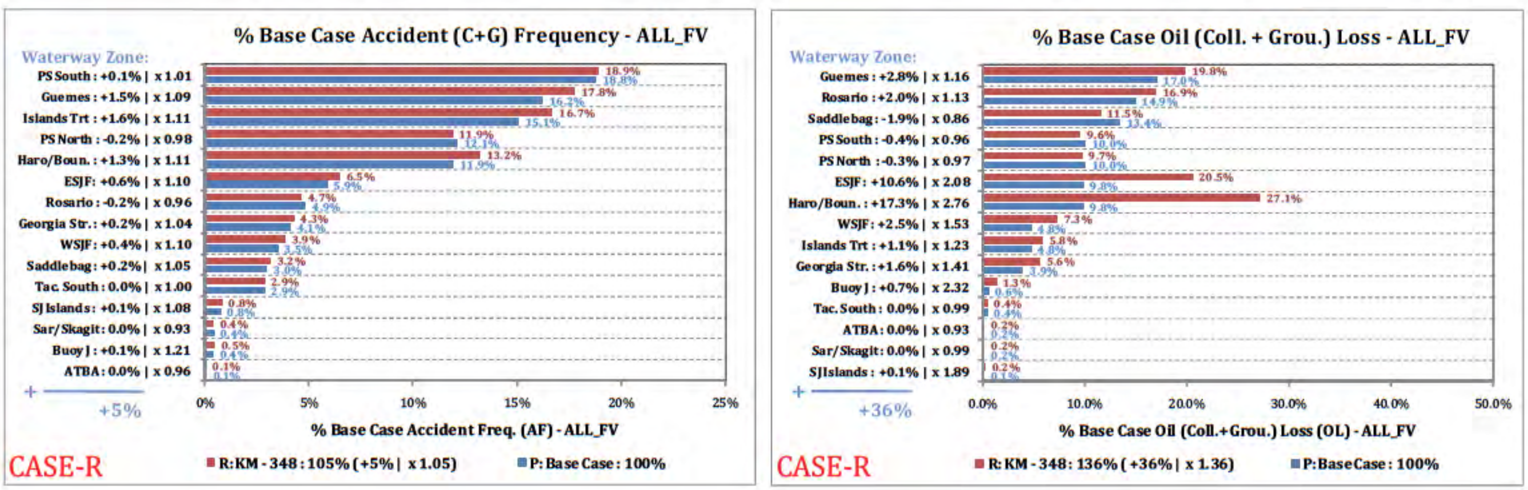

Figure 77. By waterway zone comparison of POTENTIAL accident frequency and POTENTIAL oil outflow of Case R with Case P. For a detail explanation of output format see Page 97.

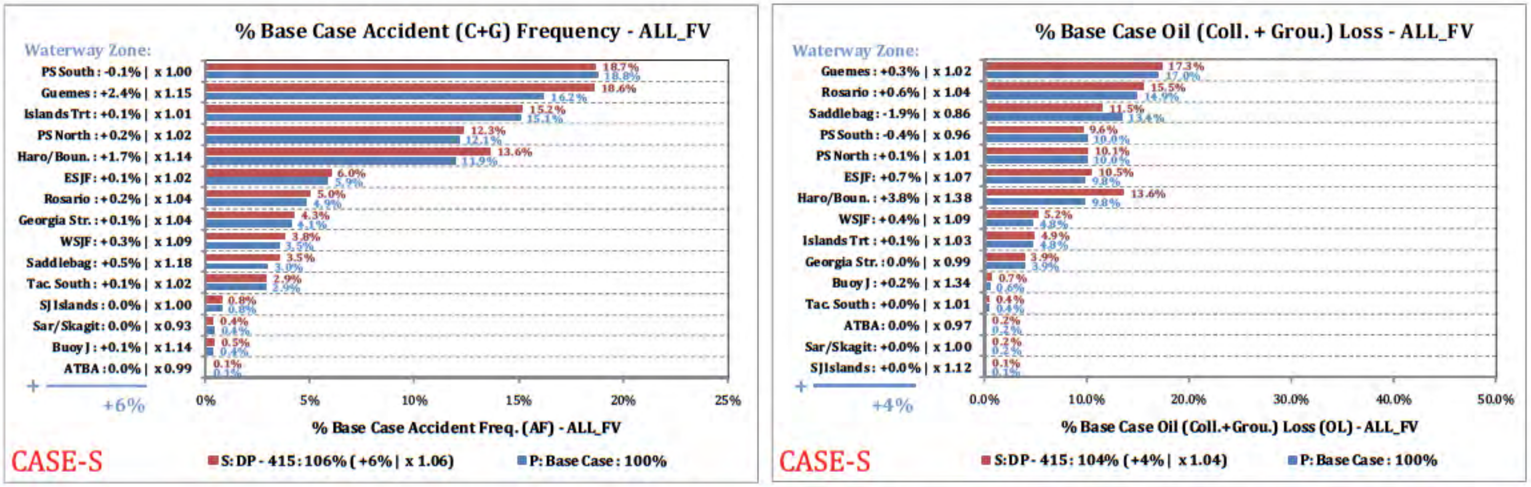

Figure 78. By waterway zone comparison of POTENTIAL accident frequency and POTENTIAL oil Outflow of Case S with Case P. For a detail explanation of output format see Page 97.

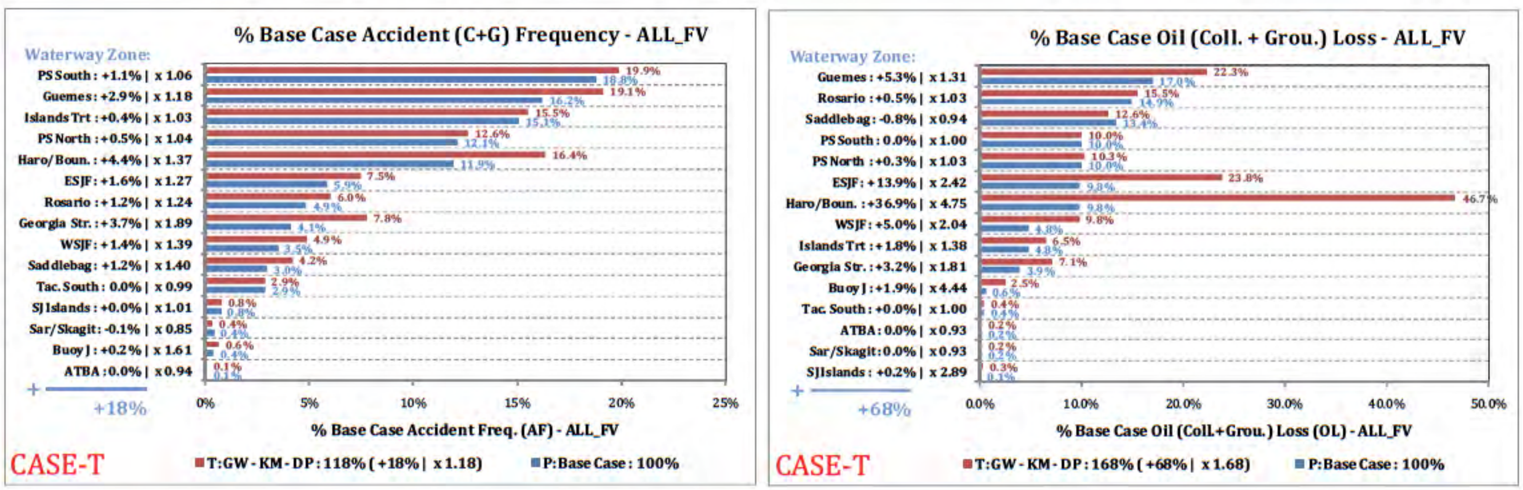

Figure 79. By waterway zone comparison of POTENTIAL accident frequency and POTENTIAL oil outflow of Case T with Case P. For a detailed explanation of output format see Page 97.

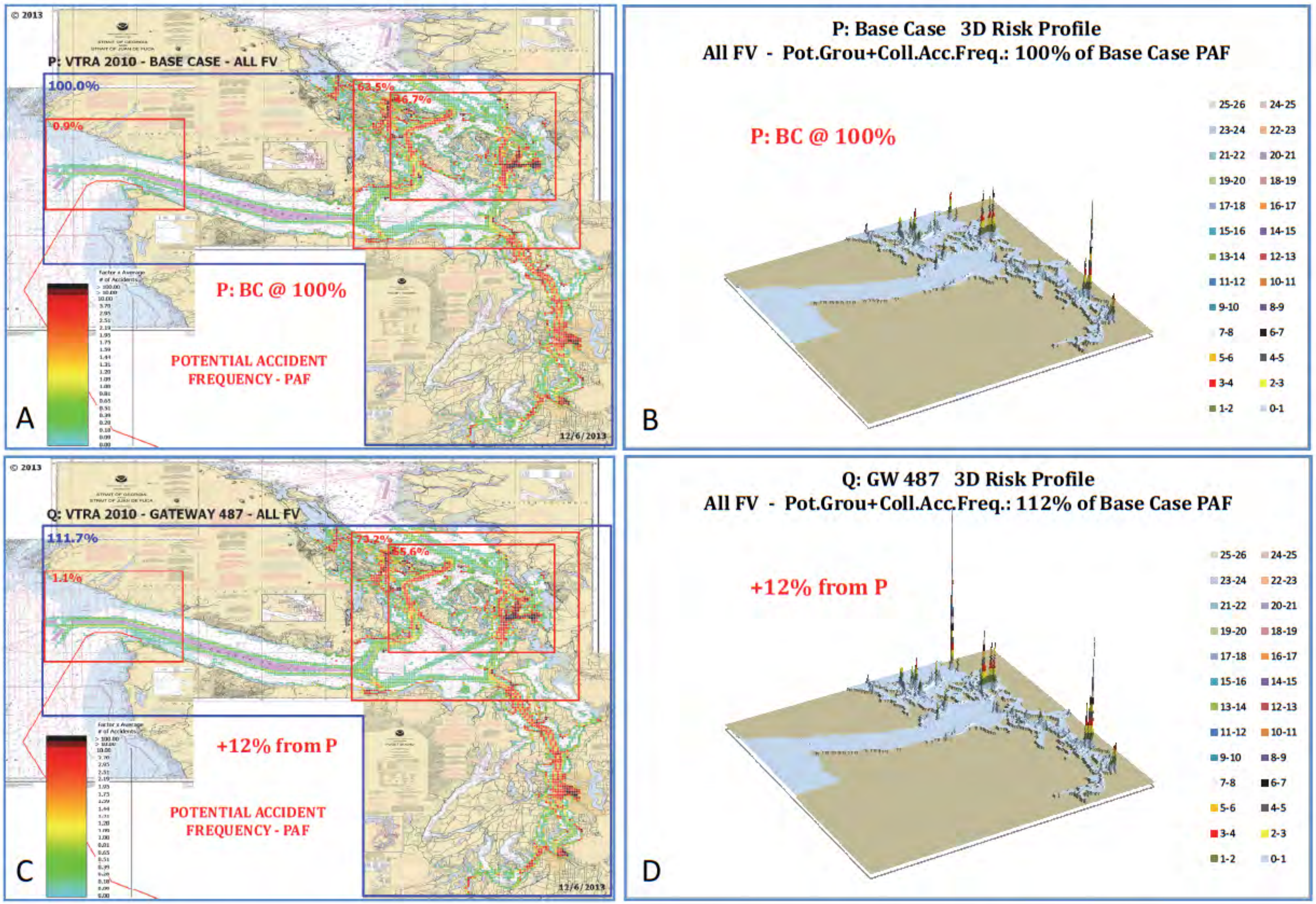

Figure 80.POTENTIAL accident frequency geographic profile comparison between Case P and Case Q.

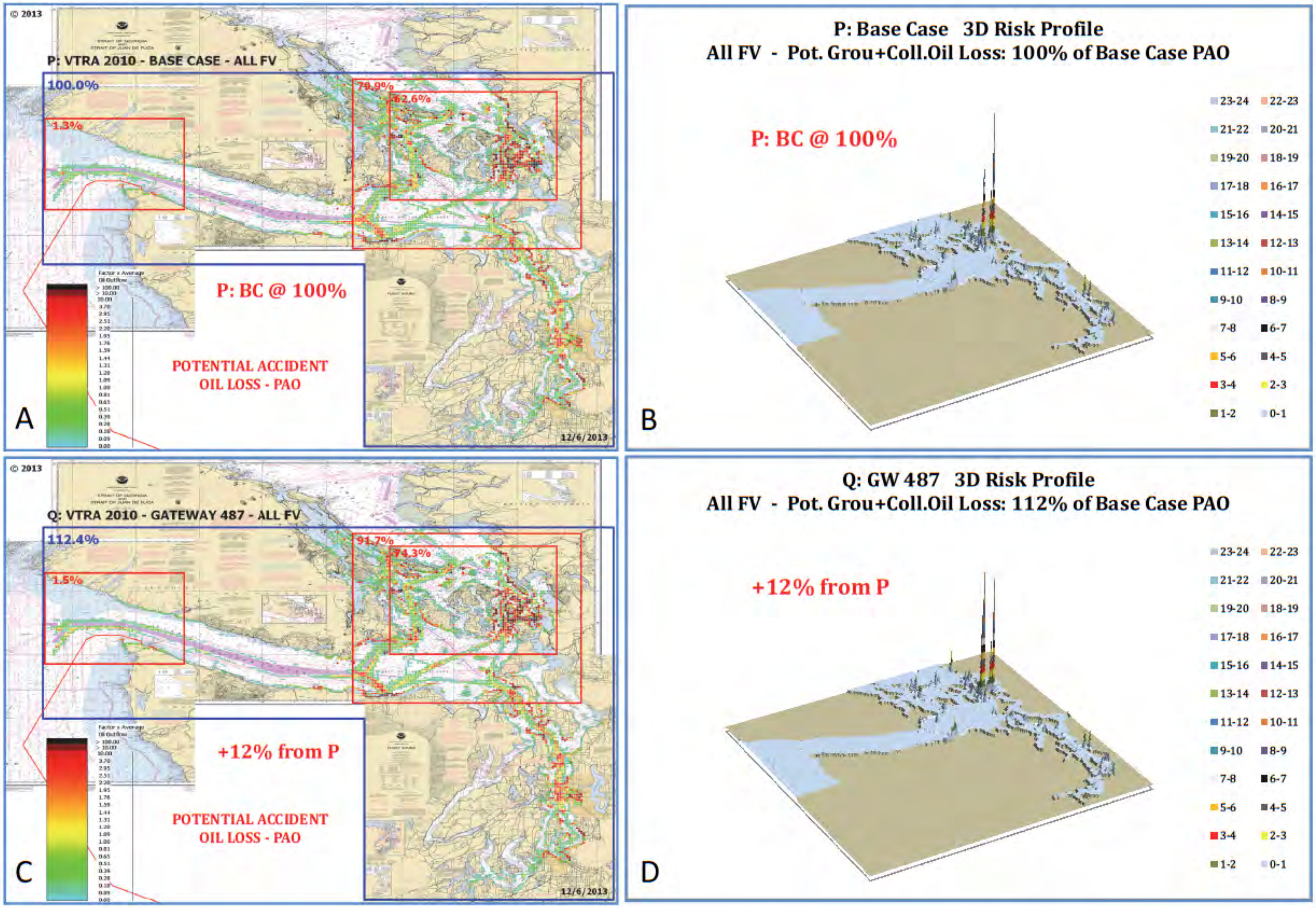

Figure 81.POTENTIAL oil outflow geographic profile comparison between Case P and Case Q.

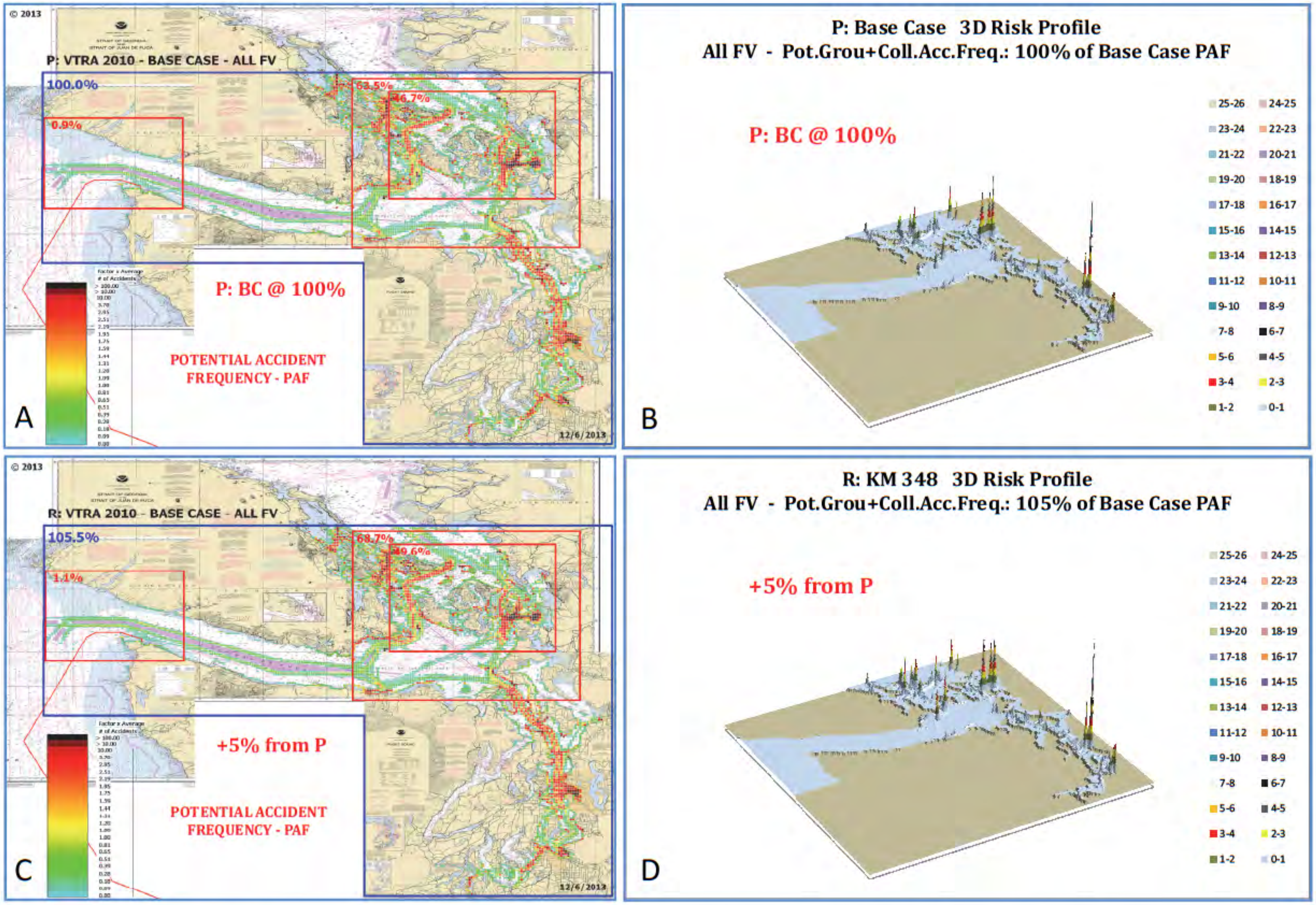

Figure 82.POTENTIAL accident frequency geographic profile comparison between Case P and Case R.

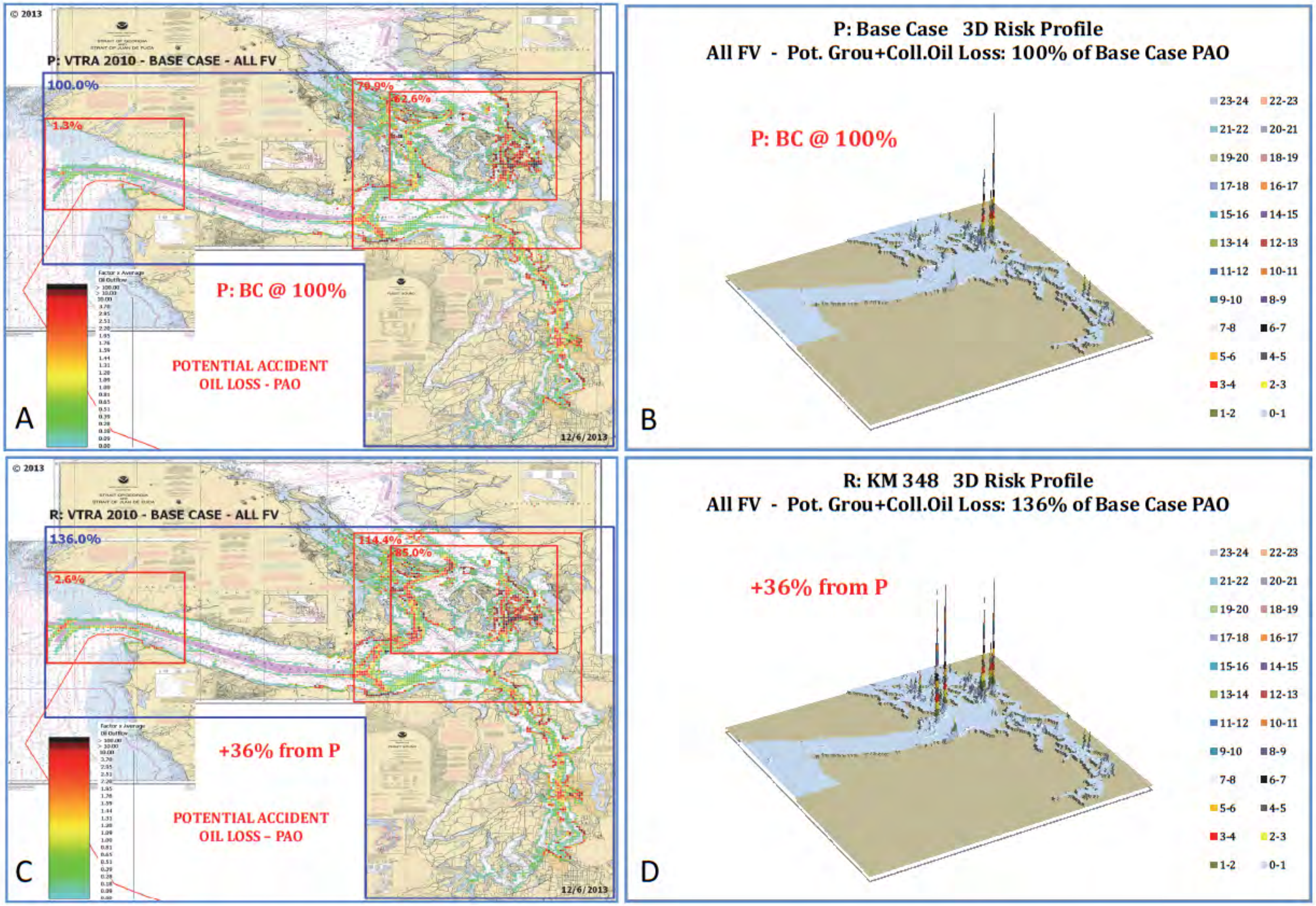

Figure 83.POTENTIAL oil outflow geographic profile comparison between Case P and Case R.

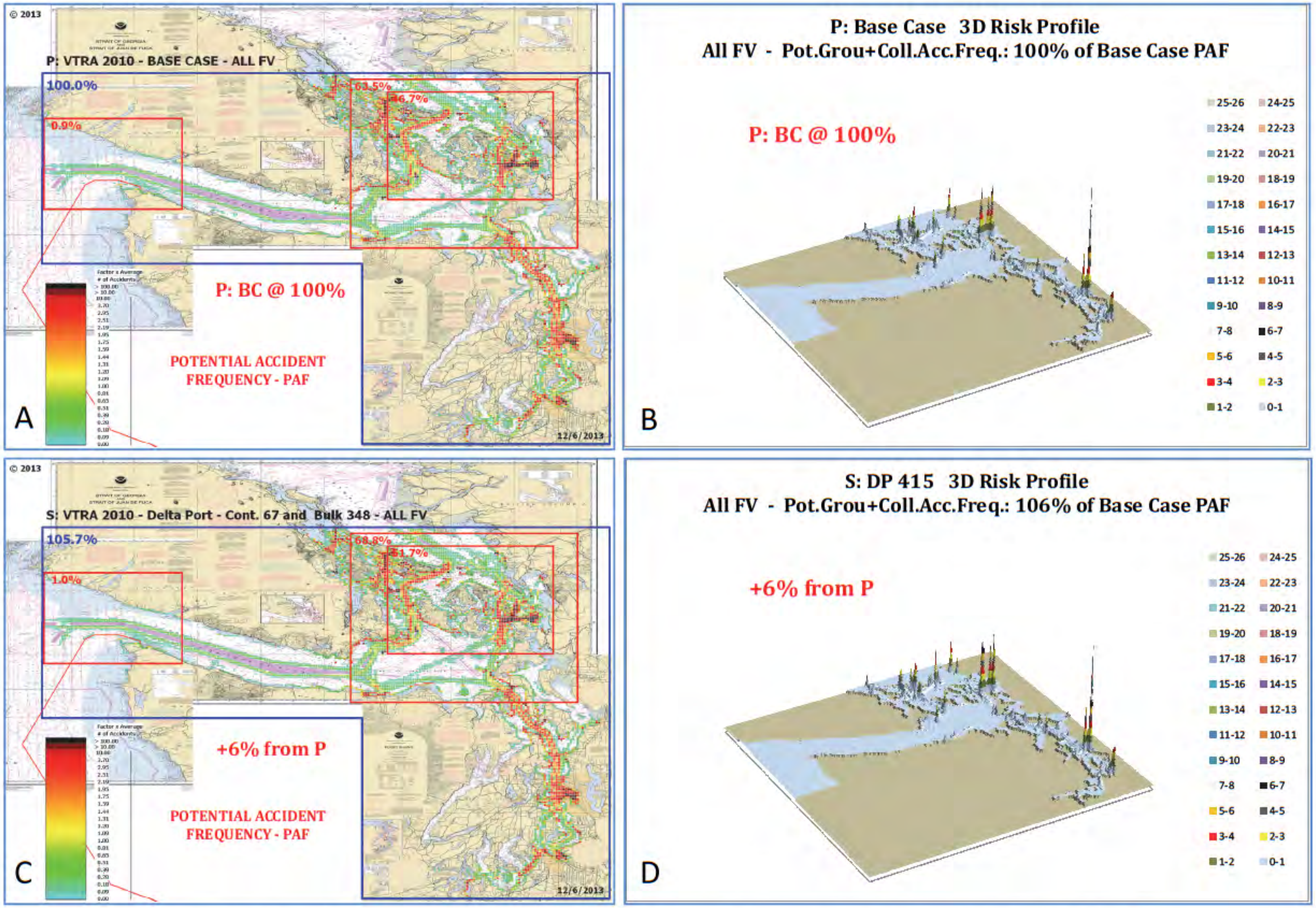

Figure 84.POTENTIAL accident frequency geographic profile comparison between Case P and Case S.

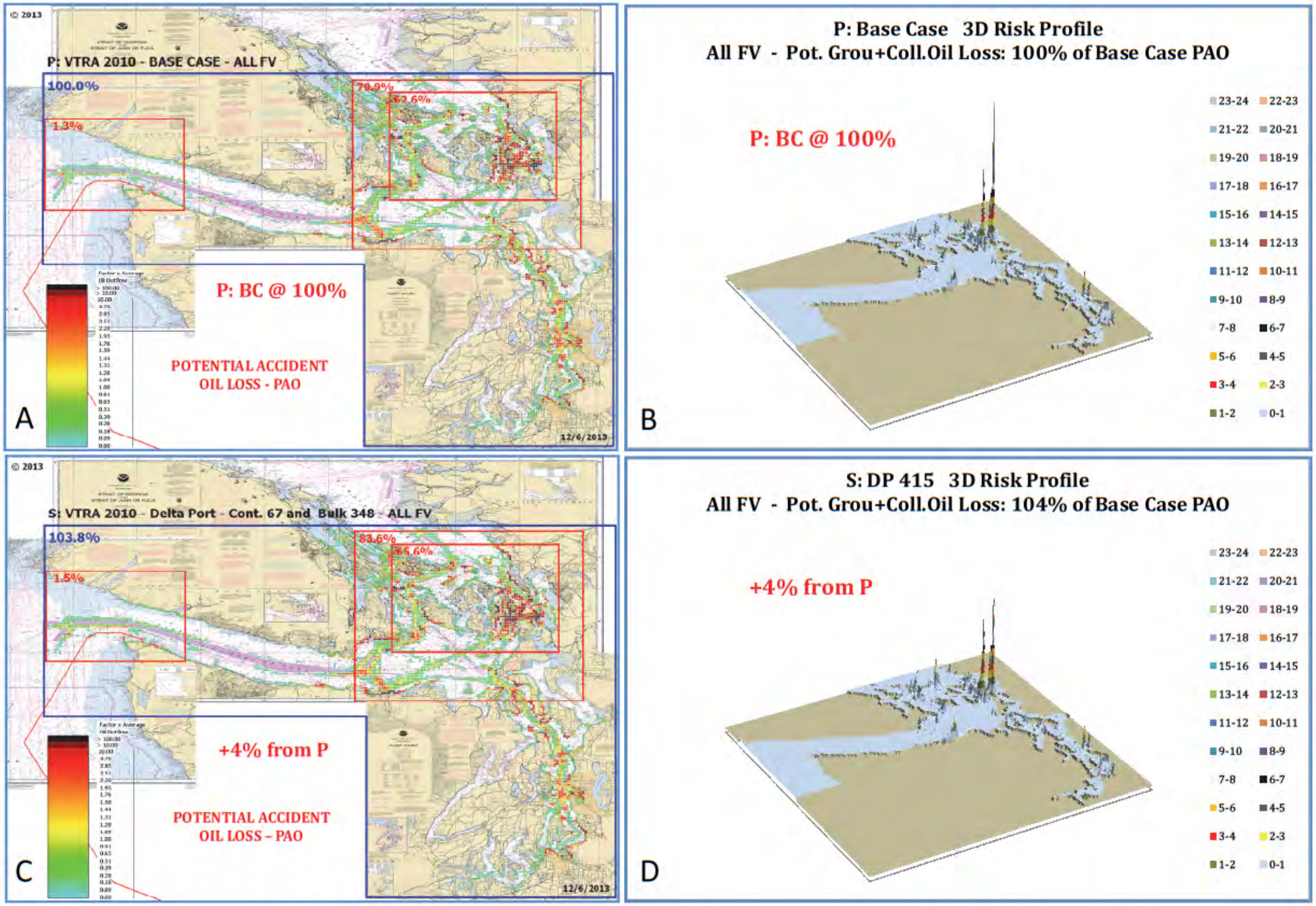

Figure 85.POTENTIAL oil outflow geographic profile comparison between Case P and Case S.

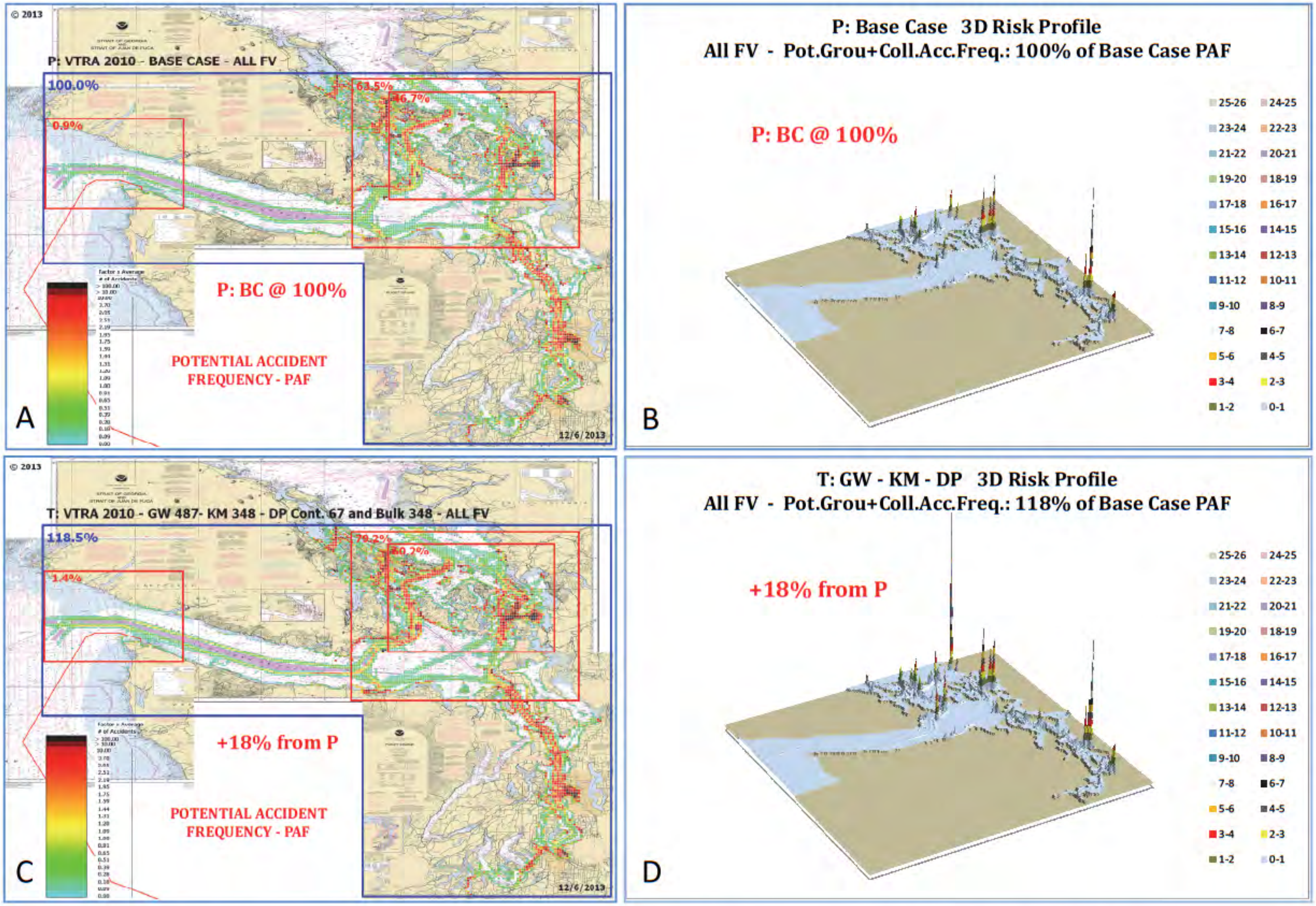

Figure 86.POTENTIAL accident frequency geographic profile comparison between Case P and Case T.

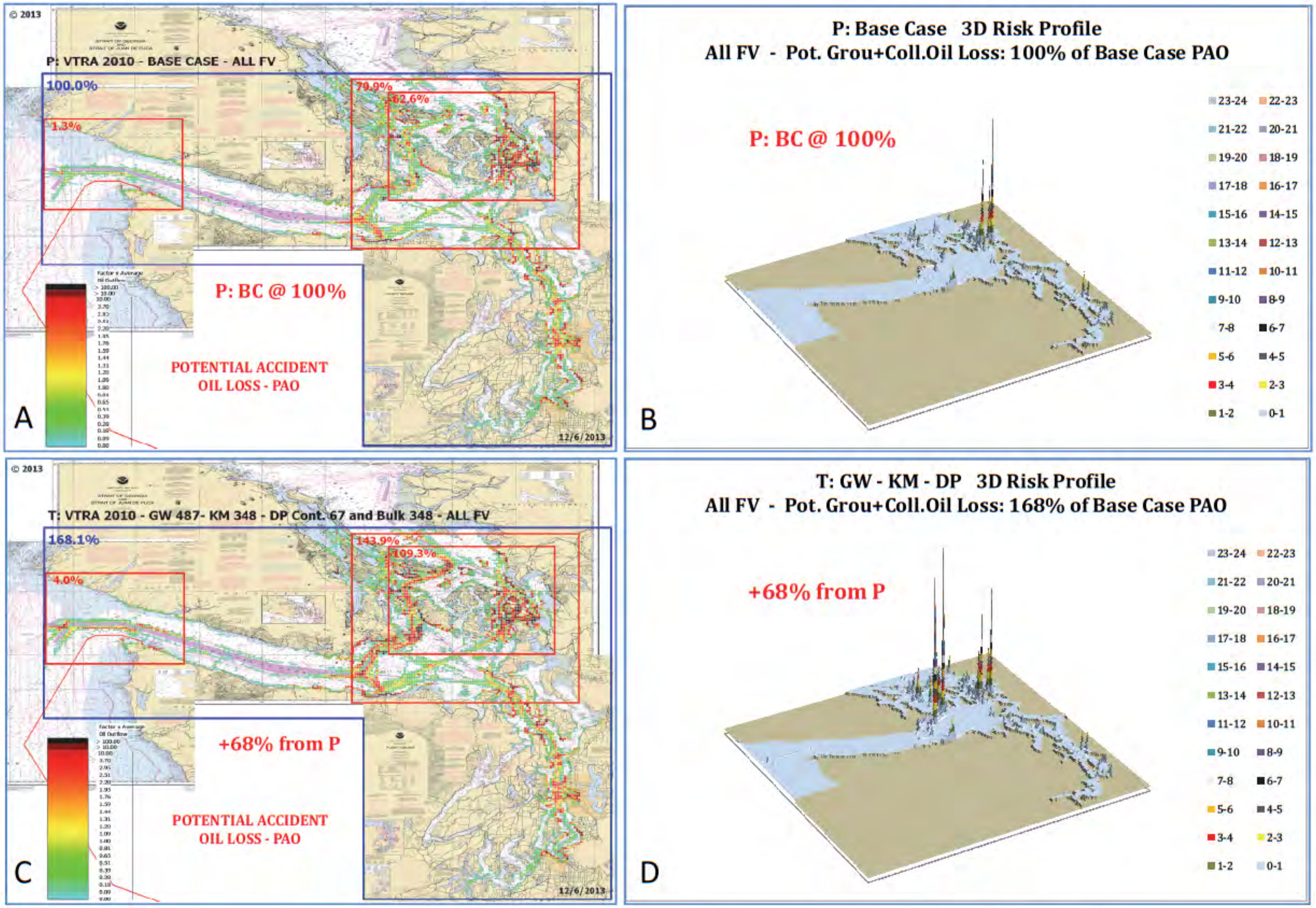

Figure 87.POTENTIAL oil outflow geographic profile comparison between Case P and Case T

From the right panel in Figure 79 one observes the largest absolute increase in POTENTIAL oil outflow (+36.9%) in the Haro-Strait/Boundary Pass waterway zone. Here this constitutes the largest relative waterway zone increase of a factor of 4.75. Once more, although the Buoy J waterway zone only contributes 0.6% to the overall total base case outflow POTENTIAL, it does experience the second largest relative waterway zone factor increase of 4.44.