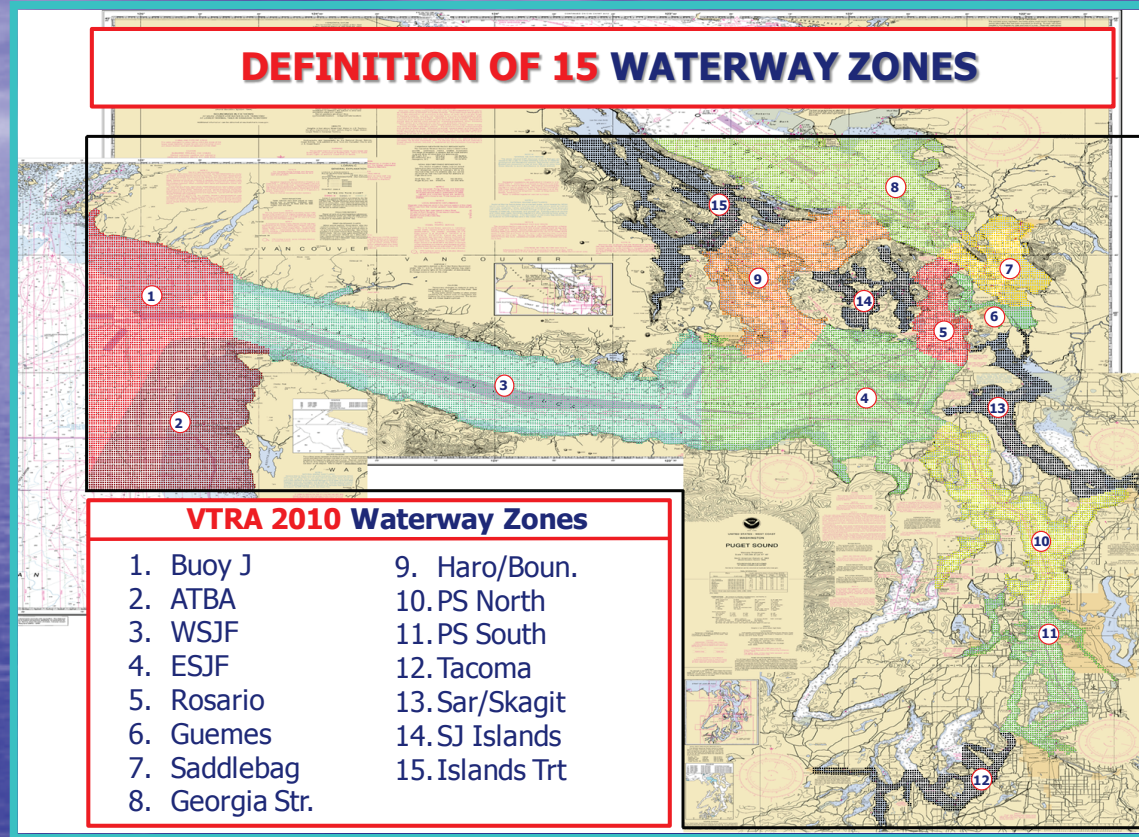


VTRA 2010 – SYNOPSIS OF LOW SCENARIO COMPARISONS APPLIED TO CASE T: GW - KM - DP



GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

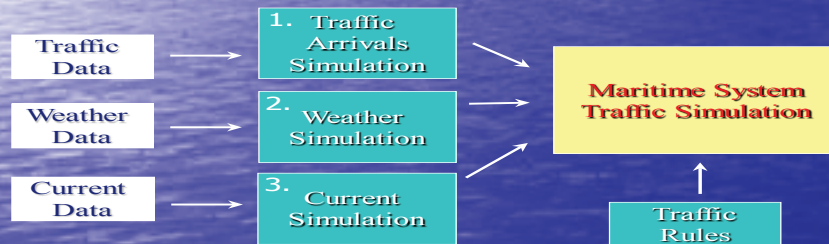
FOCUS VESSELS TRAVEL THROUGH VTRA STUDY AREA

Focus Vessels: Tanker, ATB, Chem. Carrier, Oil Barge, Bulk Carrier, Container Vessel and Other Cargo Vessels

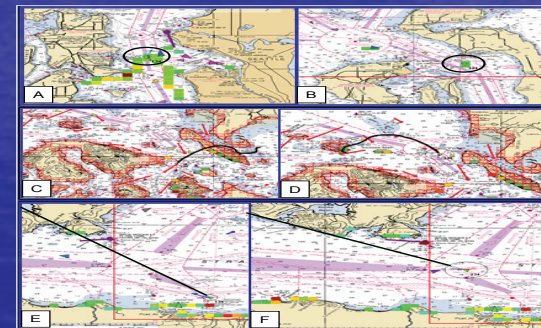
We developed a vessel traffic movement modeled largely based on VTOSS 2010 data validated using AIS 2010 data. We consider the 2010 traffic model a base case year and denote it scenario **P – BASE CASE**.

We add vessel traffic to 2010 traffic model to mimic what-if scenarios and we compare them to the base case year.

SNAPSHOTS OF KEY VTRA MODEL COMPONENTS



Required close cooperation with the USCG VTS and Puget Sound Harbor Safety Committee for data + validation



Generating Accident Scenarios:

Counting Collision Accident Scenario's

Counting Drift Grounding Accident Scenario's

Counting Powered Grounding Accident Scenario's

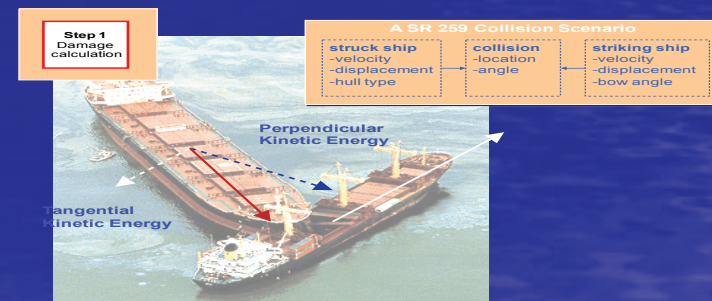
77

Conduct Expert Judgment Elicitations via Questionnaires

Q30		
Situation 1	TANKER DESCRIPTION	Situation 2
Straits of Juan de Fuca East	Location	
Inbound	Direction	
Laden	Cargo	
1 Escort	Escorts	
Untethered	Tethering	
	INTERACTING VESSEL	
Shallow Draft Pass. Vessel	Vessel Type	
Crossing the Bow	Traffic Scenario	
Less than 1 mile	Traffic Proximity	
	WATERWAY CONDITIONS	
More than 0.5 mile Visibility	Visibility	Less than 0.5 mile Visibility
Along Vessel	Wind Direction	
Less than 10 knots	Wind Speed	
Almost Slack	Current	
Along Vessel - Opposite Direction	Current Direction	
More? :	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	: More?
Situation 1 is worse		Situation 2 is worse

Example of potential experts: USCG VTS Operators, Puget Sound Pilots, Tanker Captains and First Mates, Tug Captains and First Mates, etc.

89



103

T – GW – KM – DP & LOW TANKERS

VTRA 2010 CASE T TRAFFIC WITH

LOW TANKER CASE – LEFT COLUMN

TANKER CALL NUMBER HIGH-LOW ANALYSIS FROM 1998-2012

	LOW - YEAR: - #	2010	HIGH - YEAR: + #
CHERRY POINT	193 - 1998 : -136	329	398 - 2007 : +69
ANACORTES	184 - 1998 : -58	242	319 - 2007 : +77
FERNDAL	118 - 1998 : 3	115	111 - 2007 : -+4
Total Change Tank FV	-191		+150

T – GW – KM – DP & LOW TAN. AND C. FV

VTRA 2010 CASE T TRAFFIC WITH LOW TANKERS AND

LOW CARGO FOCUS VESSELS – LEFT COLUMN

BULK TRANSIT NUMBER HIGH-LOW ANALYSIS FROM 2008-2012

	LOW - YEAR: - #	2010	HIGH - YEAR: + #
Bouy J - Georgia Strait	1095 - 2009 : -63	1159	1268 - 2011 : +109
Bouy J - Puget Sound	344 - 2009 : 22	322	325 - 2011 : +3
Puget Sound - Georgia Strait	0 - 2009 : +0	0	0 - 2011 : +0
Total Change Bulk FV	-41		+112

CONTAINER TRANSIT NUMBER HIGH-LOW ANALYSIS FROM 2008-2012

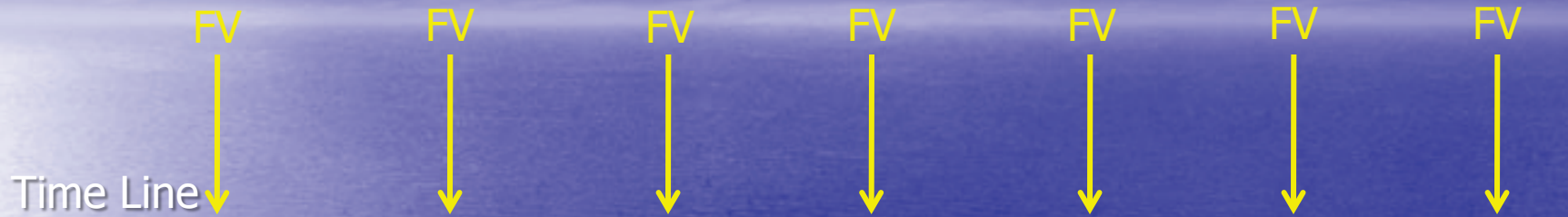
	LOW - YEAR: - #	2010	HIGH - YEAR: + #
Bouy J - Georgia Strait	223 - 2009 : -85	308	332 - 2011 : +25
Bouy J - Puget Sound	812 - 2009 : +46	766	807 - 2011 : +41
Puget Sound - Georgia Strait	274 - 2009 : +52	222	258 - 2011 : +36
Total Change Container FV	+13		+102

OTHER CARGO TRANSIT NUMBER HIGH-LOW ANALYSIS FROM 2008-2012

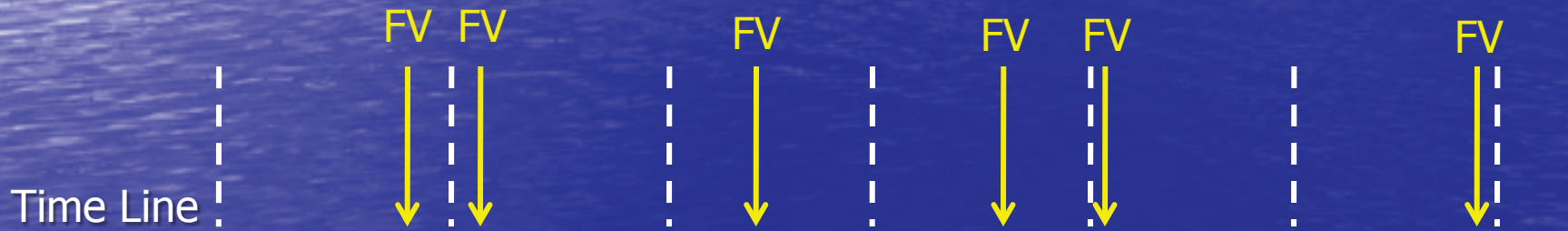
	LOW - YEAR: - #	2010	HIGH - YEAR: + #
Bouy J - Georgia Strait	336 - 2009 : -50	386	421 - 2011 : +36
Bouy J - Puget Sound	280 - 2009 : +28	252	255 - 2011 : +3
Puget Sound - Georgia Strait	246 - 2009 : +20	226	260 - 2011 : +34
Total Change Other Cargo FV	-2		+73

T – GW – KM – DP & + VAR

VTRA 2010 CASE T TRAFFIC WITH ADDED VARIABLE WHAT-IF FV



Case T: Equidistant arrivals of What-If Focus Vessels



**Case T & + Var : Random Arrivals of What-If Focus Vessels
within Equidistant Time arrivals**

EXPOSURE DEFINITIONS

VESSEL TIME EXPOSURE:

TOTAL AMOUNT OF ANNUAL TIME A FOCUS VESSEL IS MOVING THROUGH THE VTRA STUDY AREA

FUEL OIL TIME EXPOSURE:

TOTAL AMOUNT OF ANNUAL TIME A CUBIC METER OF FOCUS VESSEL FUEL OIL IS MOVING THROUGH THE VTRA STUDY AREA

CARGO OIL TIME EXPOSURE:

TOTAL AMOUNT OF ANNUAL TIME A CUBIC METER OF FOCUS VESSEL CARGO (CRUDE + PRODUCT) OIL IS MOVING THROUGH THE VTRA STUDY AREA

FOCUS VESSELS MOVE OIL: Crude, Product and Fuel

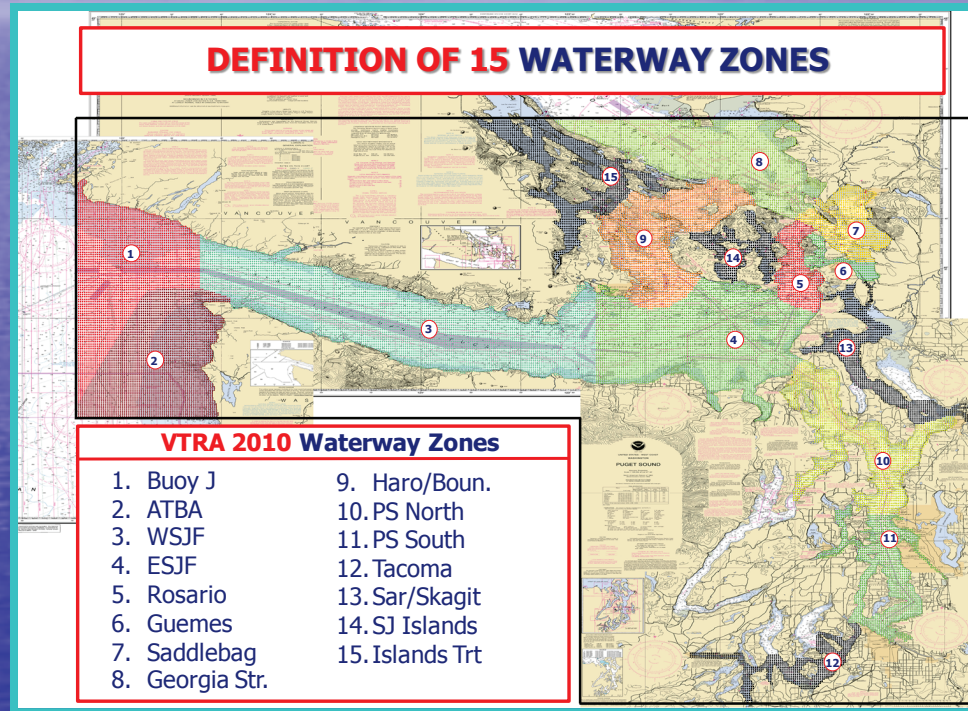
Disclaimer: No information is available on volume of oil or type of oil on board a vessel and we have to rely on overarching assumptions regarding movement of amount and type of oil as focus vessels move through the study area.

- Assumption 1 : Tankers are classified as crude or product carriers by name
- Assumption 2 : Chemical carriers transport product.
- Assumption 3 : Oil barges are assumed to transport product.
- Assumption 4 : All Focus Vessels fuel tanks are 50% full
- Assumption 5 : US bound crude tankers are assumed fully laden as they arrive in study area, drop of equal amounts at their stops and leave empty.
- Assumption 6 : Canadian bound crude tankers are assumed empty as they arrive and fully laden as they depart.
- Assumption 7 : Product Tankers and ATB's are assumed fully laden as they depart study area, empty as they arrive.
- Assumption 8 : Chemical carriers are assumed fully laden as they arrive in the study area, empty when they leave the study area.
- Assumption 9 : When ATB's go back and forth between two destinations within the study area they are assumed 50% full
- Assumption 10: Oil barges are assumed fully laden as they travel through study area.
- Assumption 11: Tank Focus Vessels not covered by 1-10 are assumed fully laden.

VTRA 2010 – SYNOPSIS OF 3D SCENARIO COMPARISON

VESSEL TIME EXPOSURE

By What-if Focus Vessels and Base Case Focus Vessels



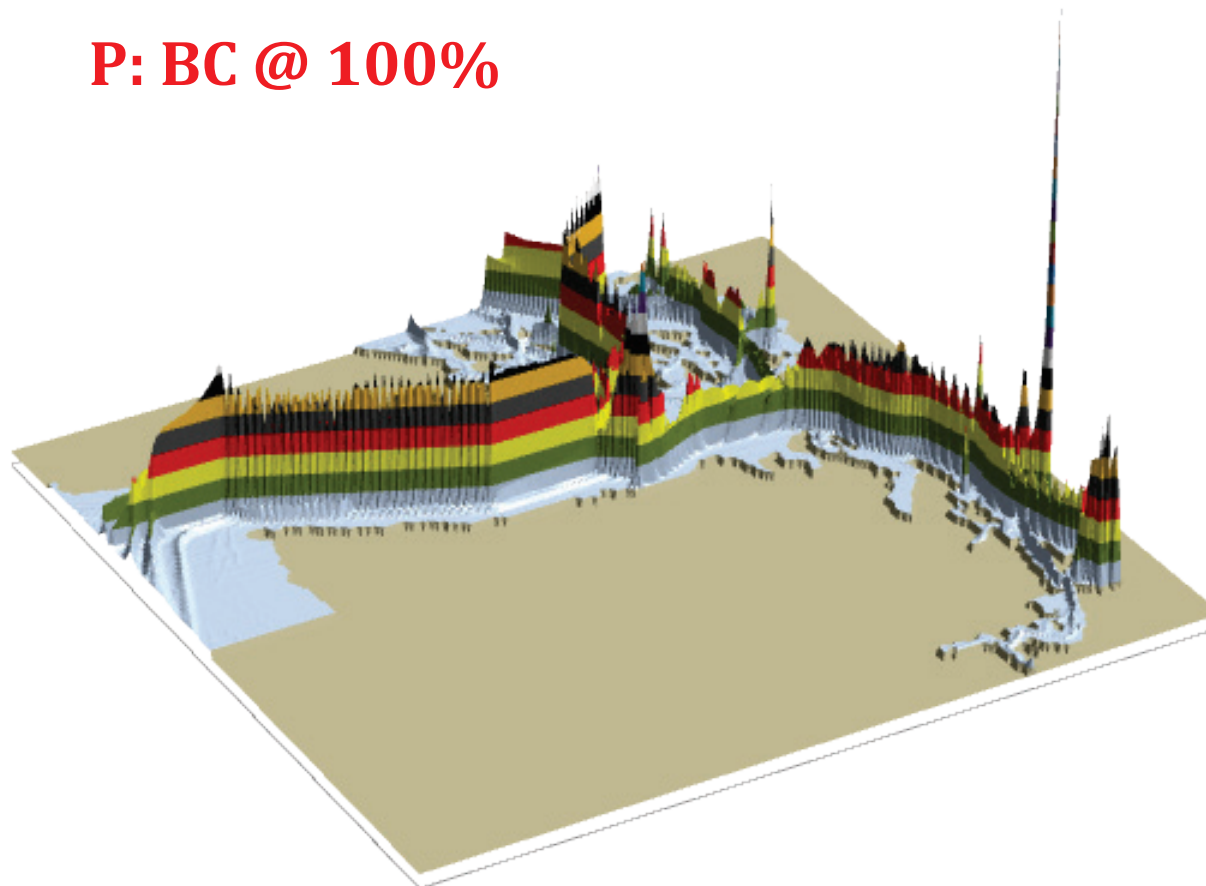
GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

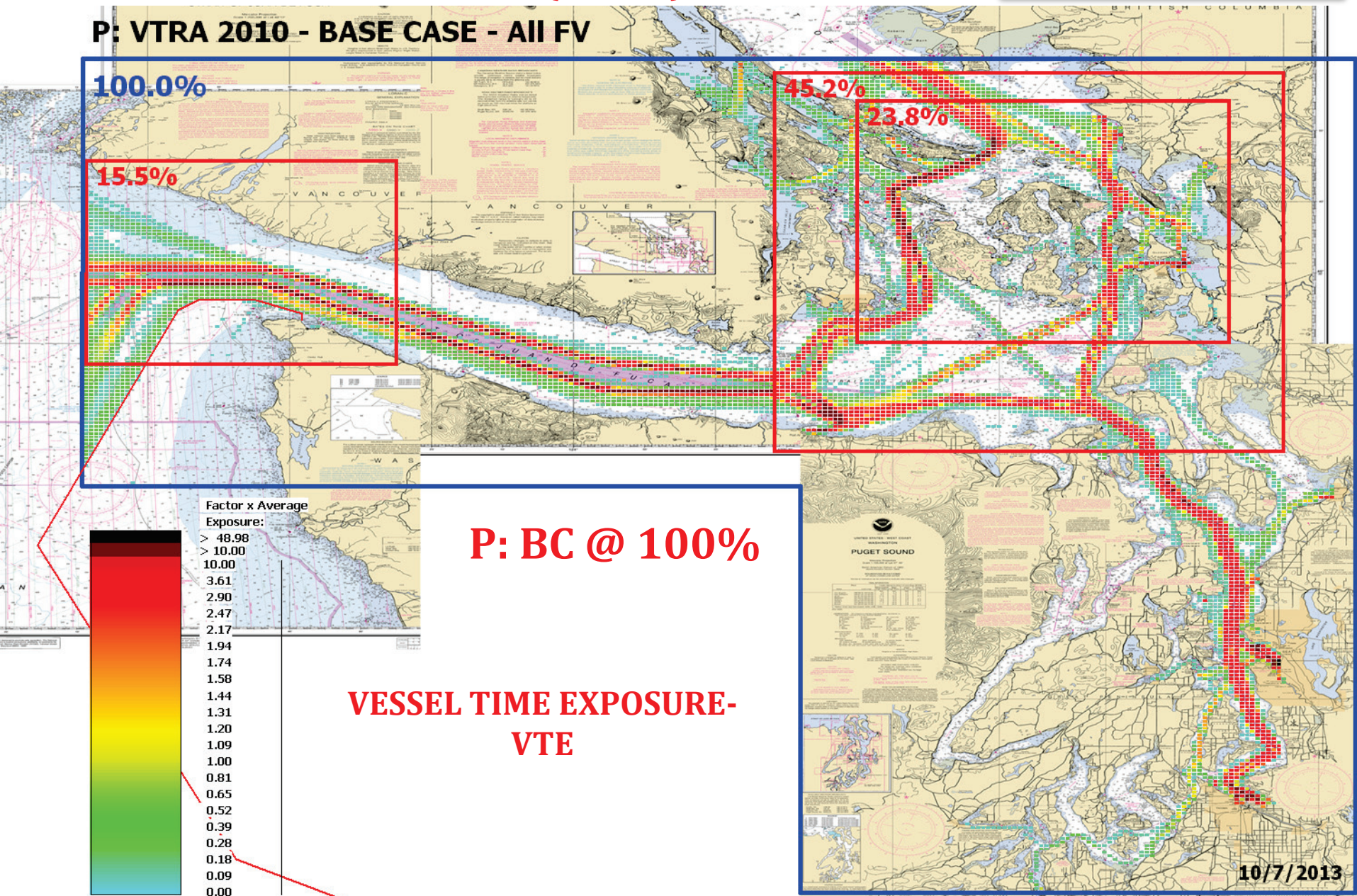
P: Base Case 3D Risk Profile All FV - Vessel Time Exposure: 100% of Base Case VTE

P: BC @ 100%



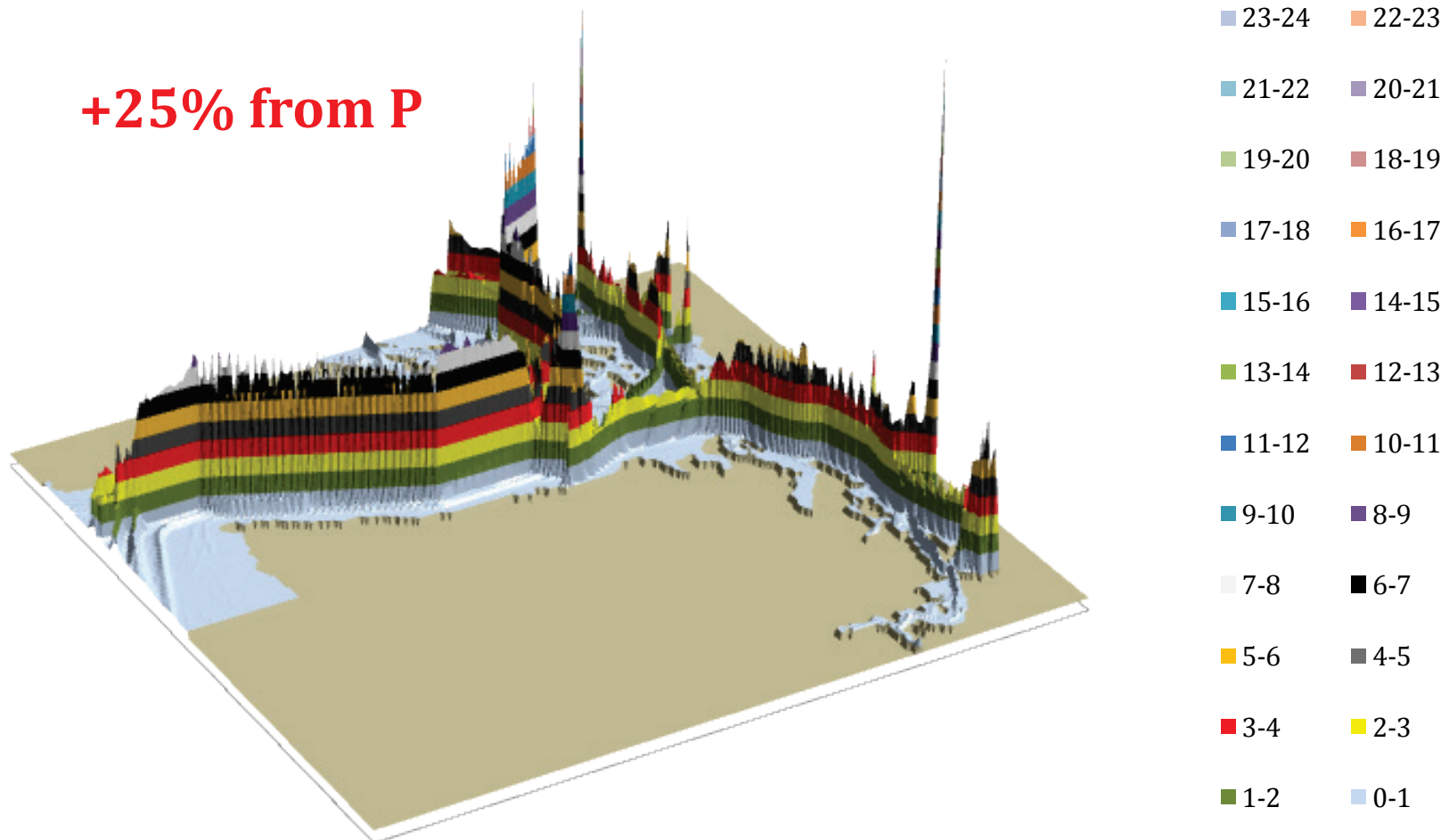
VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

P: VTRA 2010 - BASE CASE - All FV



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

T: GW - KM - DP 3D Risk Profile
All FV - Vessel Time Exposure: 125% of Base Case VTE



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

T: VTRA 2010 - GW 487- KM 348 - DP Cont. 67 and Bulk 348 - All FV

124.7%

19.9%

59.2%

33.5%

+25% from P

**VESSEL TIME EXPOSURE-
VTE**

Factor x Average
Exposure:

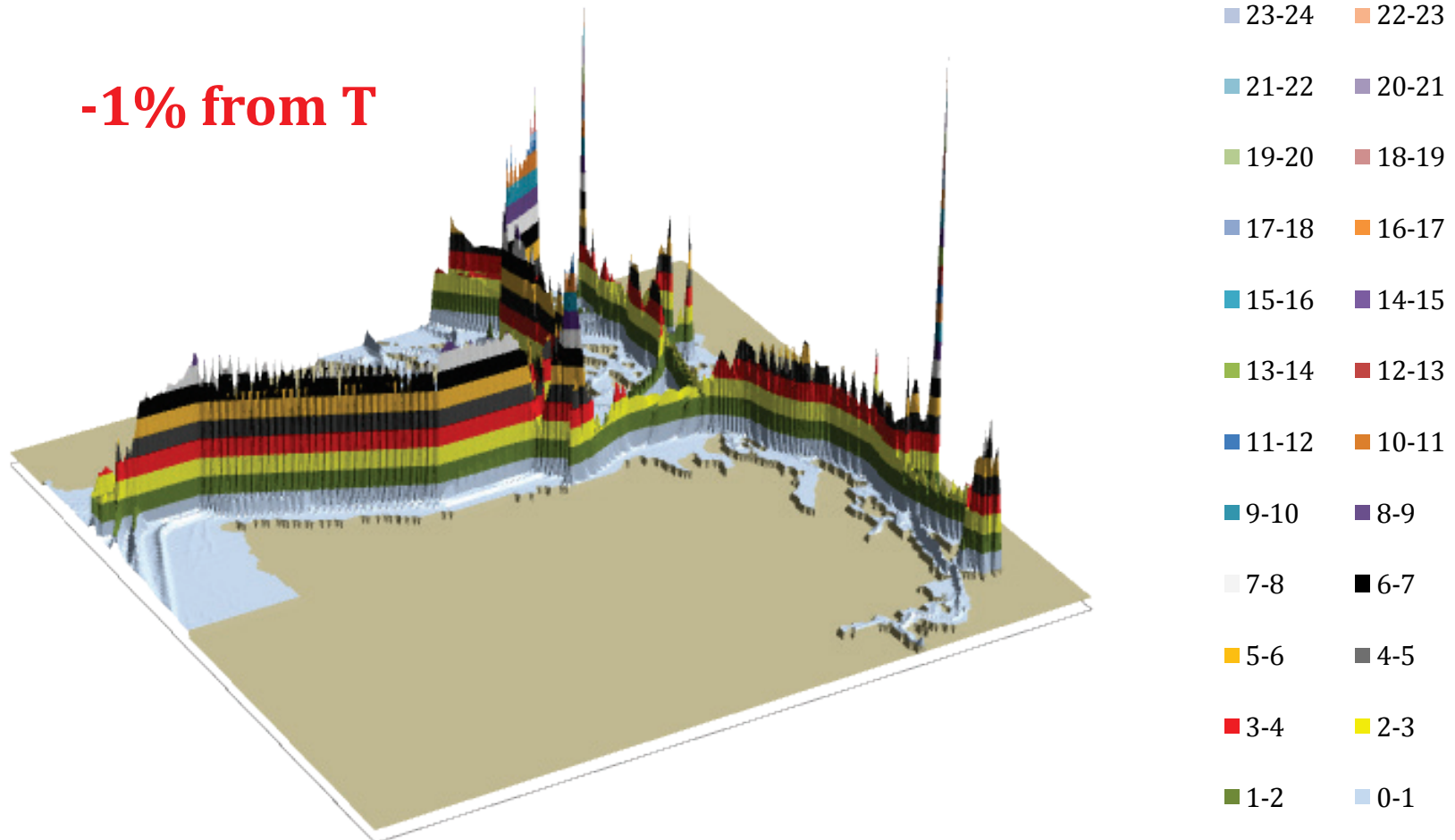
> 48.98
> 10.00
10.00
3.61
2.90
2.47
2.17
1.94
1.74
1.58
1.44
1.31
1.20
1.09
1.00
0.81
0.65
0.52
0.39
0.28
0.18
0.09
0.00

11/16/2013

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

T : GW - KM - DP & +VAR FV 3D Risk Profile
All FV - Vessel Time Exposure: 124% of Base Case VTE

-1% from T



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

T: GW 487 - KM 348 - DP 415 & ADDED VARIABILITY WHAT-IF ARRIVALS - All FV

124.0%

19.8%

58.7%

33.3%

-1% from T

VESSEL TIME EXPOSURE-
VTE

Factor x Average
Exposure:

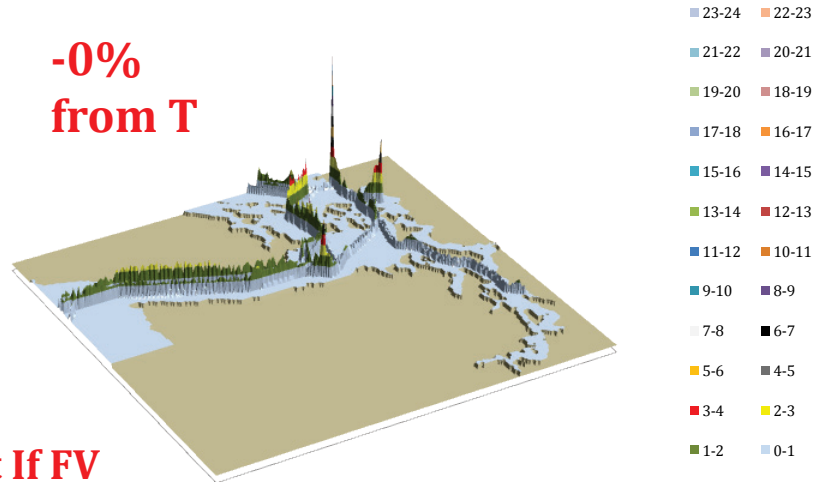
> 48.98
> 10.00
10.00
3.61
2.90
2.47
2.17
1.94
1.74
1.58
1.44
1.31
1.20
1.09
1.00
0.81
0.65
0.52
0.39
0.28
0.18
0.09
0.00

12/21/2013

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

T : GW - KM - DP & Low Tan 3D Risk Profile
What-If FV - Vessel Time Exp.: 24% of Base Case VTE

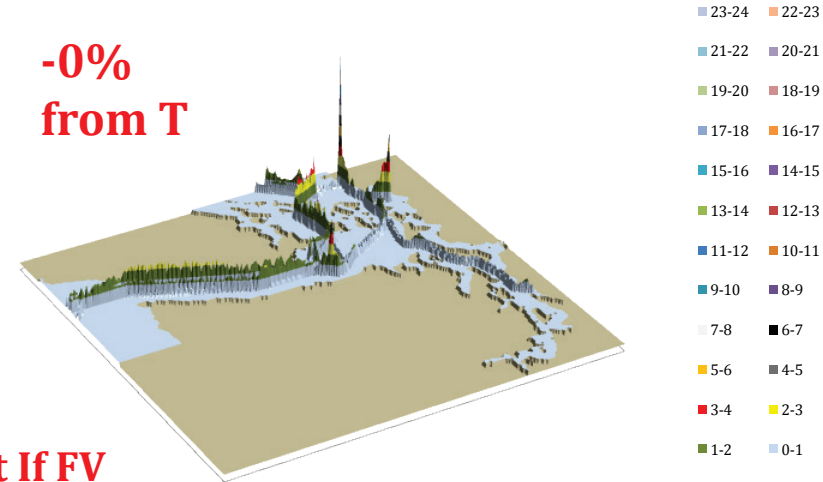
**-0%
from T**



What If FV

T : GW - KM - DP & Low Tan + CFV 3D Risk Profile
What-If FV - Vessel Time Exp.: 24% of Base Case VTE

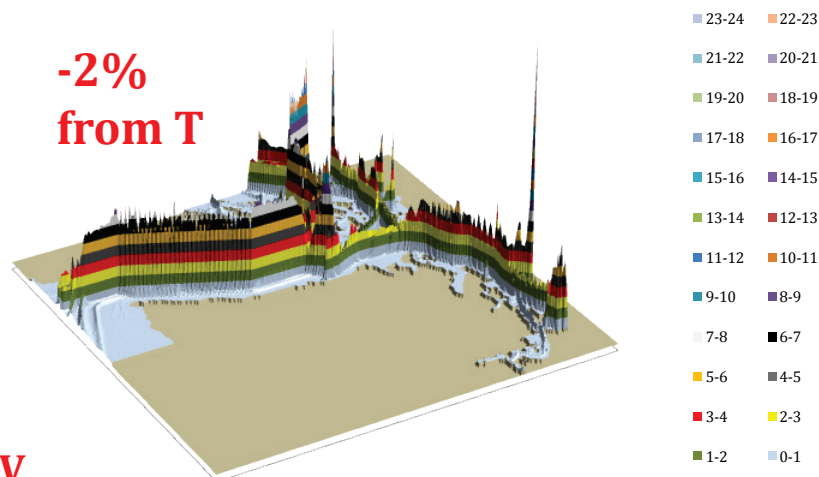
**-0%
from T**



What If FV

T : GW - KM - DP & Low Tan 3D Risk Profile
All FV - Vessel Time Exposure: 123% of Base Case VTE

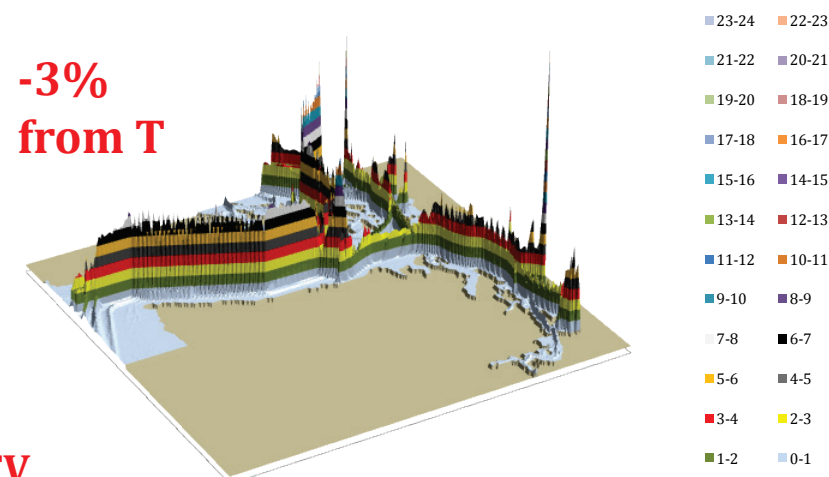
**-2%
from T**



All FV

T : GW - KM - DP & Low Tan + CFV 3D Risk Profile
All FV - Vessel Time Exposure: 121% of Base Case VTE

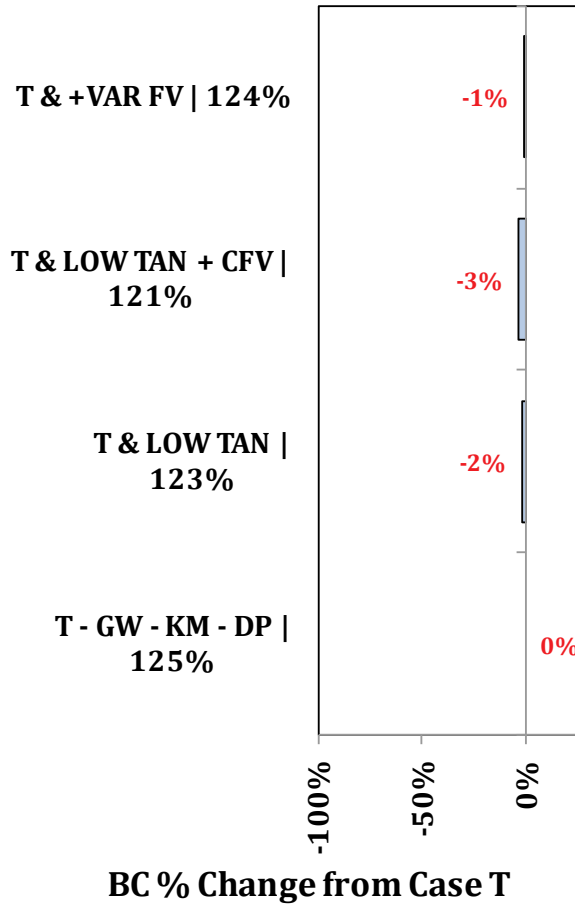
**-3%
from T**



All FV

VTRA 2010 : VESSEL TIME EXPOSURE, POT. ACC. FREQ POT. OIL. LOSS COMPARISON ALL FOCUS VESSELS

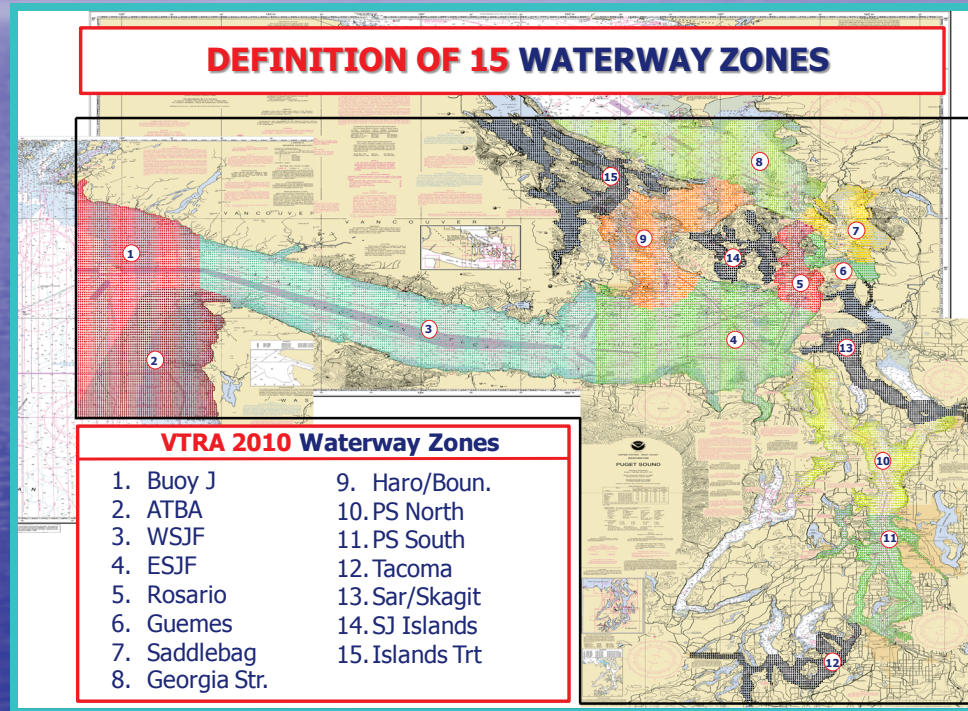
Annual Vessel Time Exposure (WI + BC Vessels)



VTRA 2010 – SYNOPSIS OF 3D SCENARIO COMPARISON

POTENTIAL ACCIDENT FREQUENCY

By What-if Focus Vessels and Base Case Focus Vessels



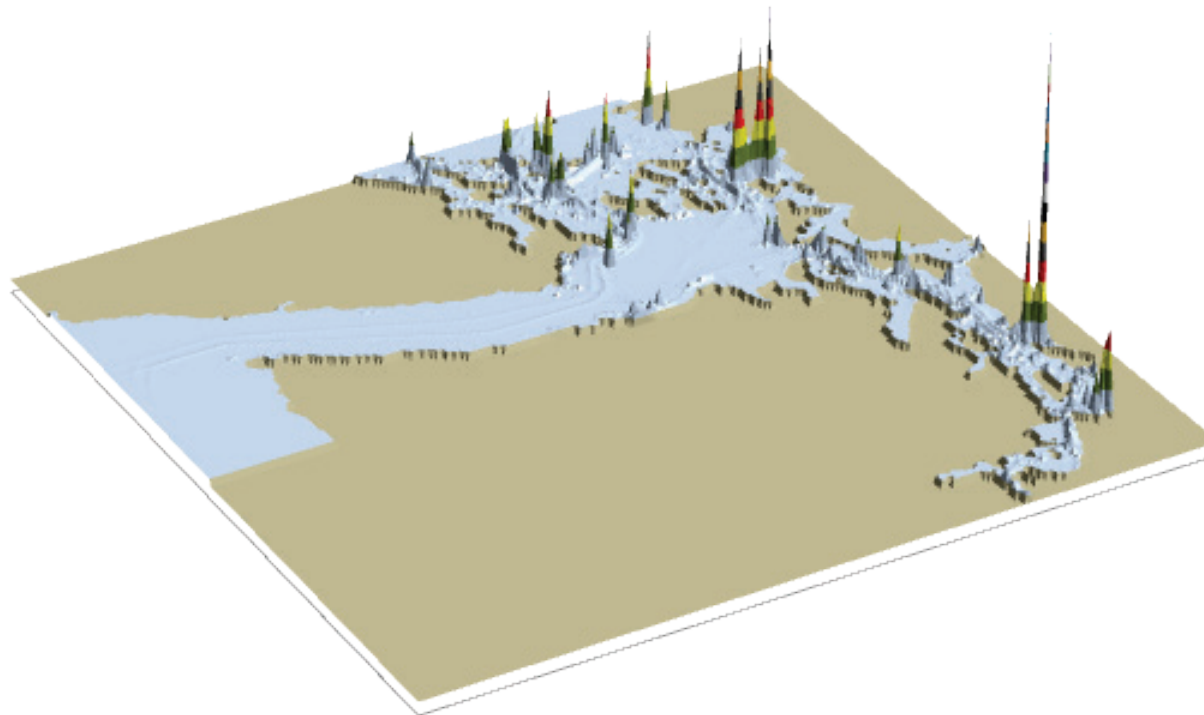
GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

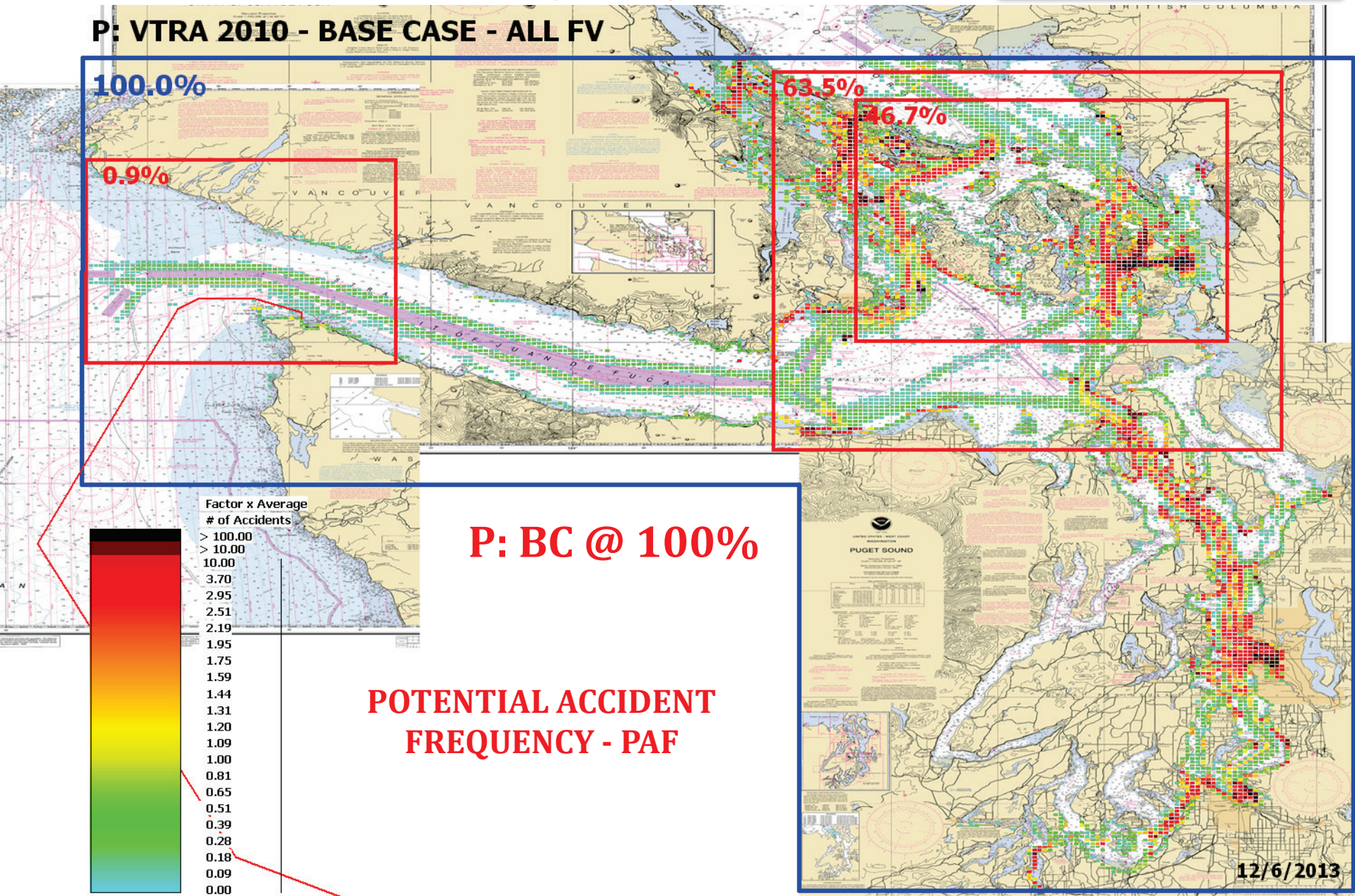
P: Base Case 3D Risk Profile All FV - Pot.Grou+Coll.Acc.Freq.: 100% of Base Case PCF

P: BC @ 100%



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

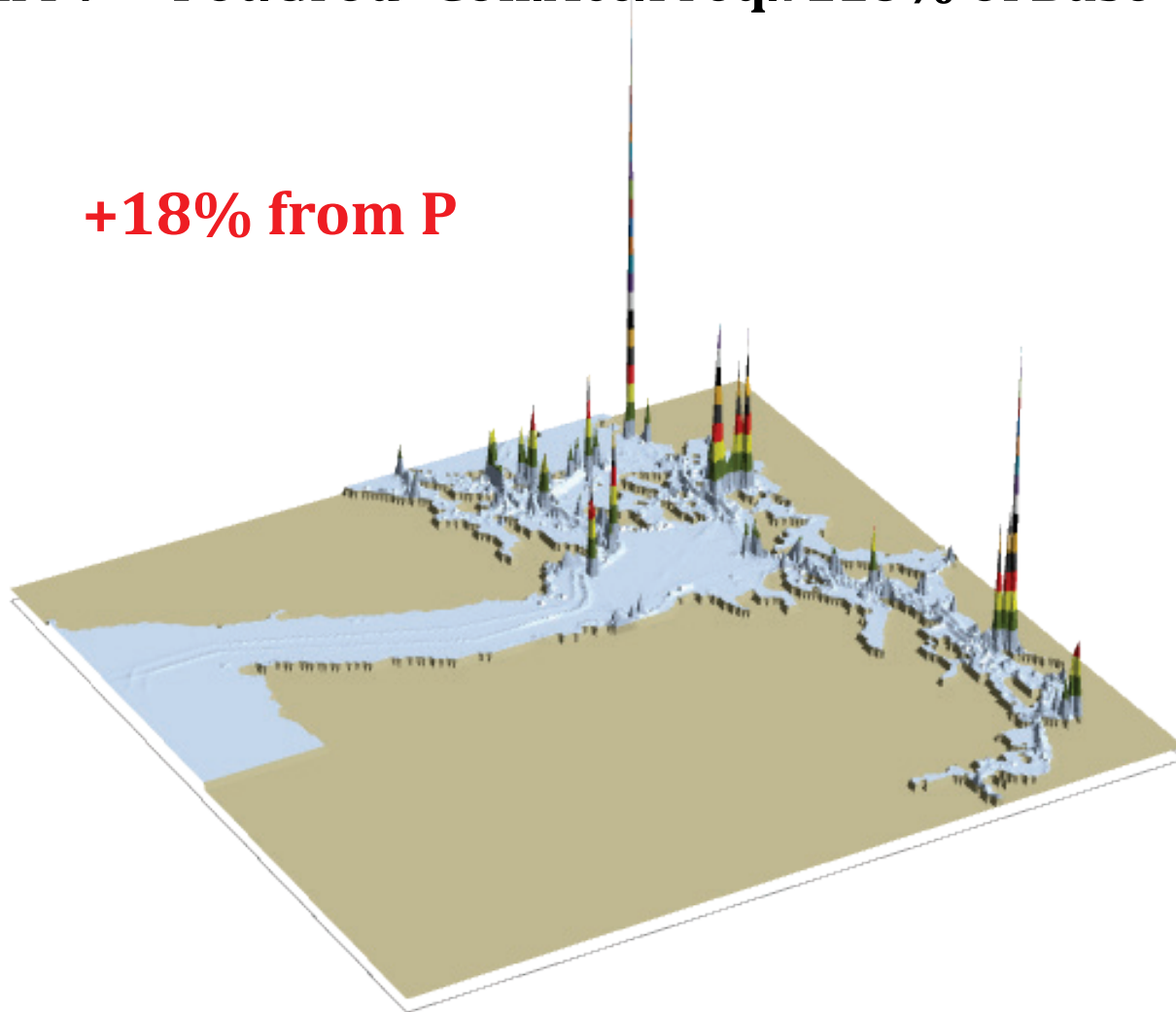
P: VTRA 2010 - BASE CASE - ALL FV



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

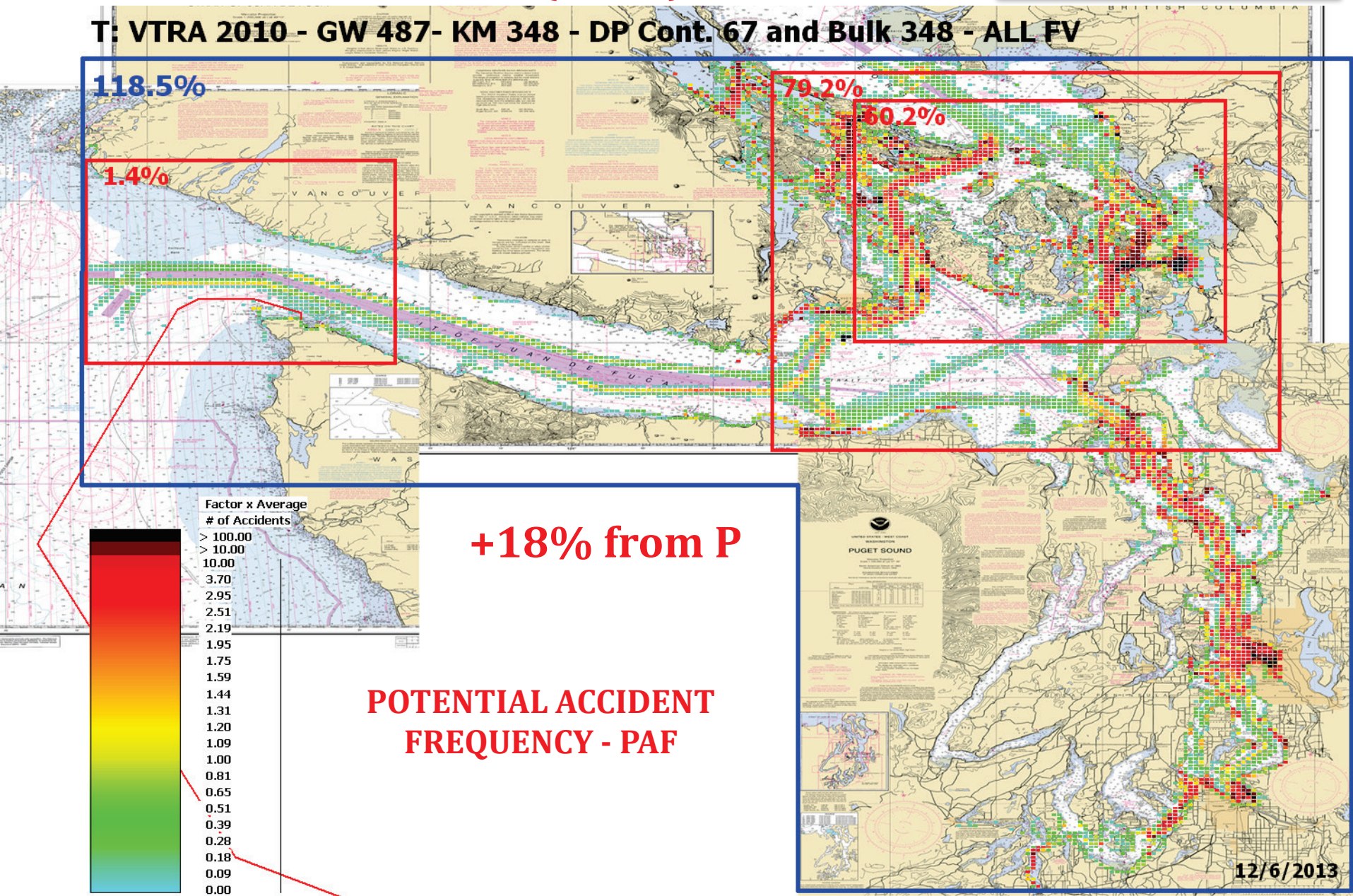
T: GW - KM - DP 3D Risk Profile
All FV - Pot.Grou+Coll.Acc.Freq.: 118% of Base Case PCF

+18% from P



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

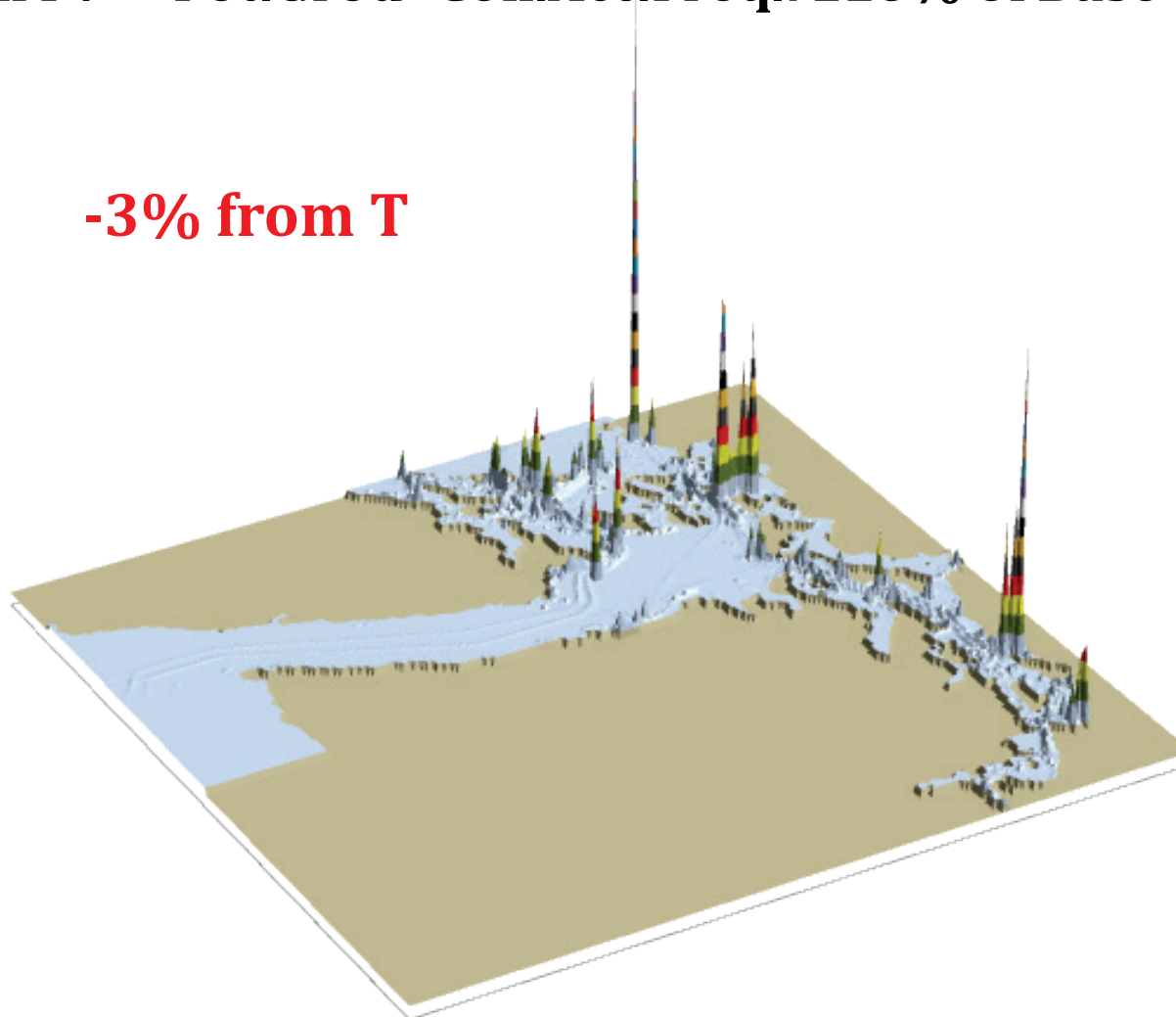
T: VTRA 2010 - GW 487- KM 348 - DP Cont. 67 and Bulk 348 - ALL FV



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

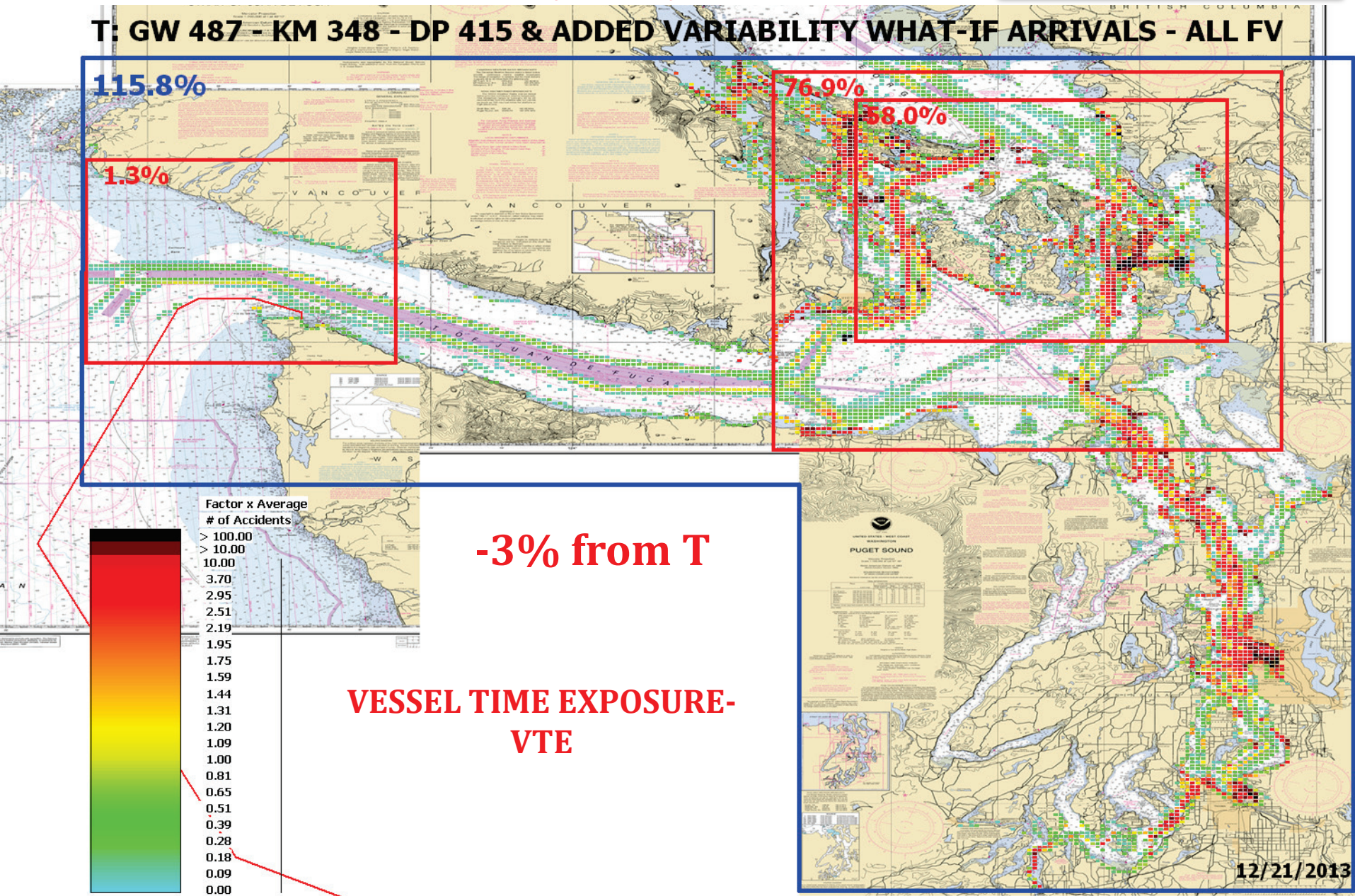
T : GW - KM - DP & +VAR FV 3D Risk Profile
All FV - Pot.Grou+Coll.Acc.Freq.: 116% of Base Case PCF

-3% from T



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

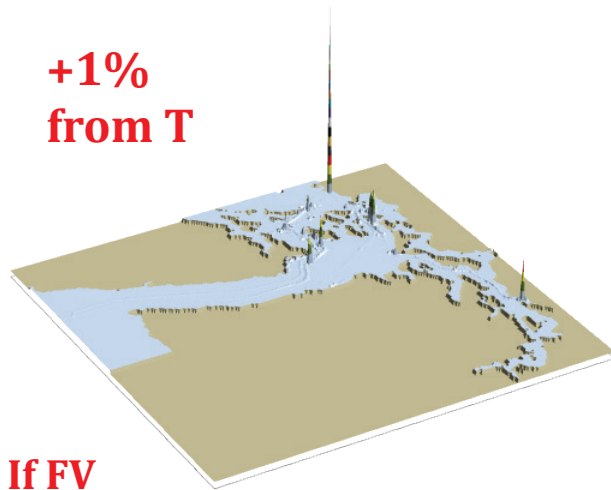
T: GW 487 - KM 348 - DP 415 & ADDED VARIABILITY WHAT-IF ARRIVALS - ALL FV



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

T : GW - KM - DP & Low Tan 3D Risk Profile
What If FV - Pot.Gr+Co.Acc.Freq.: 20% of Base Case PCF

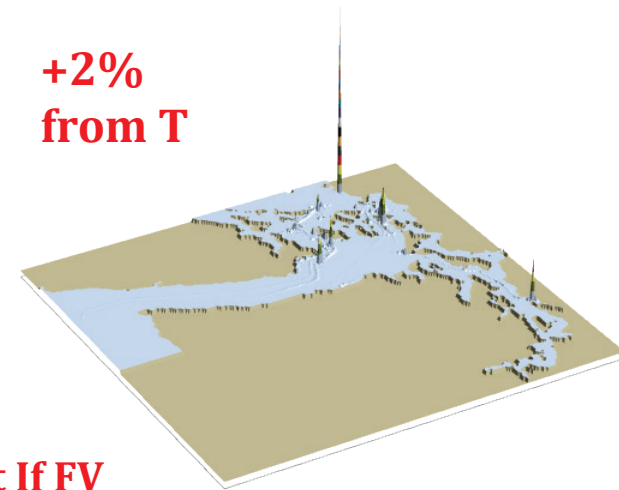
**+1%
from T**



What If FV

T : GW - KM - DP & Low Tan + CFV 3D Risk Profile
What If FV - Pot.Gr+Co.Acc.Freq.: 20% of Base Case PCF

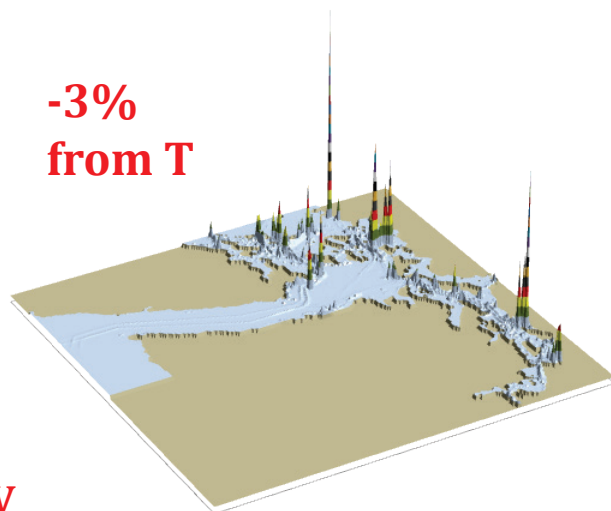
**+2%
from T**



What If FV

T : GW - KM - DP & Low Tan 3D Risk Profile
All FV - Pot.Grou+Coll.Acc.Freq.: 116% of Base Case PCF

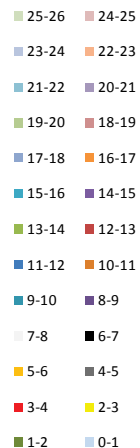
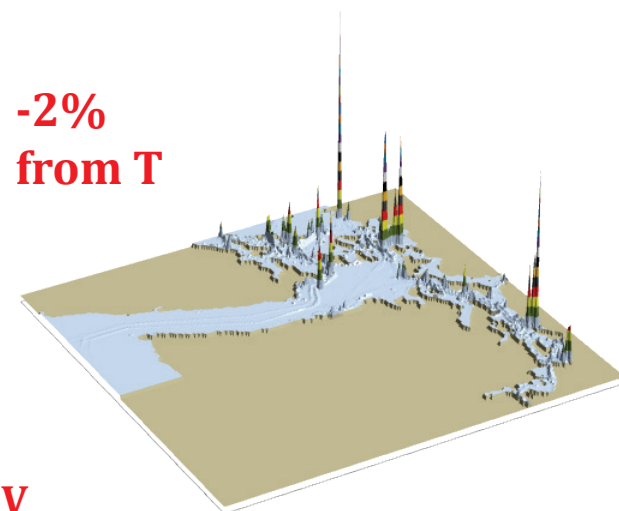
**-3%
from T**



All FV

T : GW - KM - DP & Low Tan + CFV 3D Risk Profile
All FV - Pot.Grou+Coll.Acc.Freq.: 116% of Base Case PCF

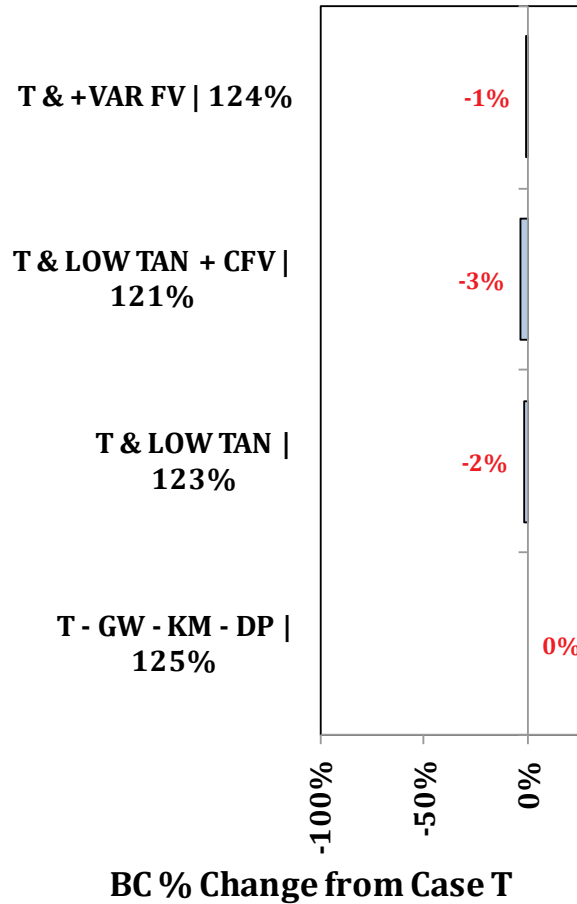
**-2%
from T**



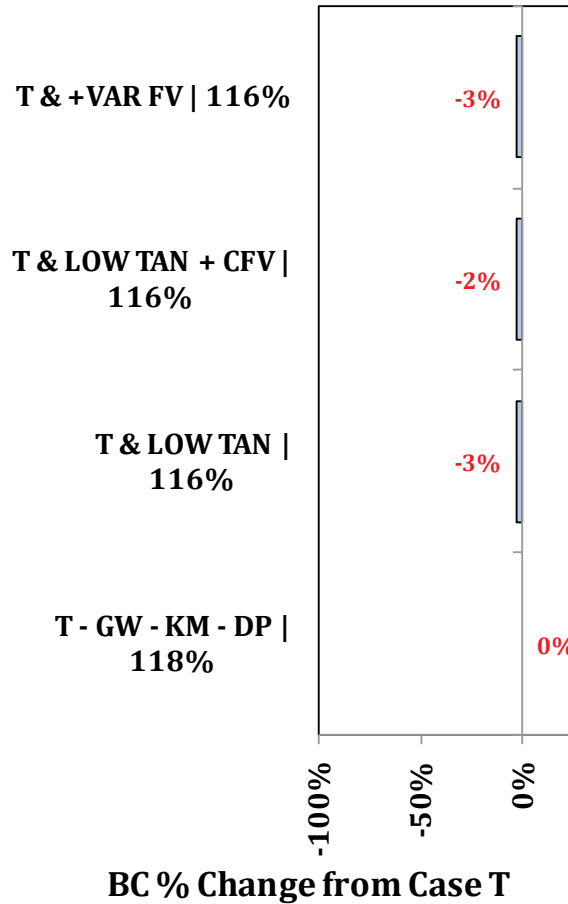
All FV

VTRA 2010 : VESSEL TIME EXPOSURE, POT. ACC. FREQ POT. OIL. LOSS COMPARISON ALL FOCUS VESSELS

**Annual Vessel Time
Exposure (WI + BC Vessels)**



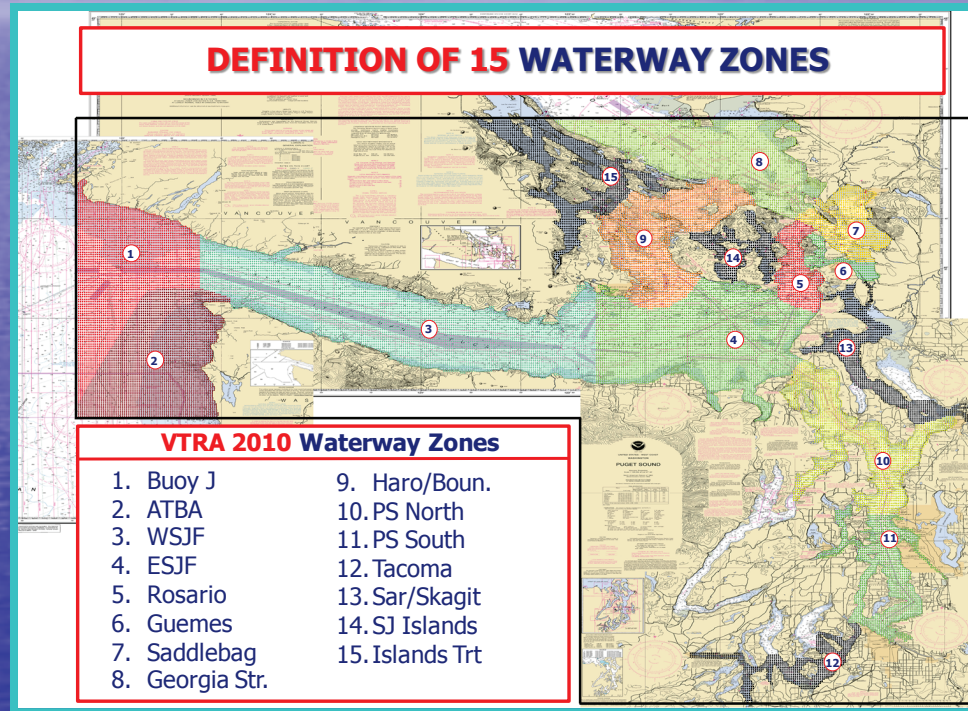
**Potential Accident (C+G)
Frequency (WI + BC Vessels)**



VTRA 2010 – SYNOPSIS OF 3D SCENARIO COMPARISON

POTENTIAL OIL LOSS

By What-if Focus Vessels and Base Case Focus Vessels



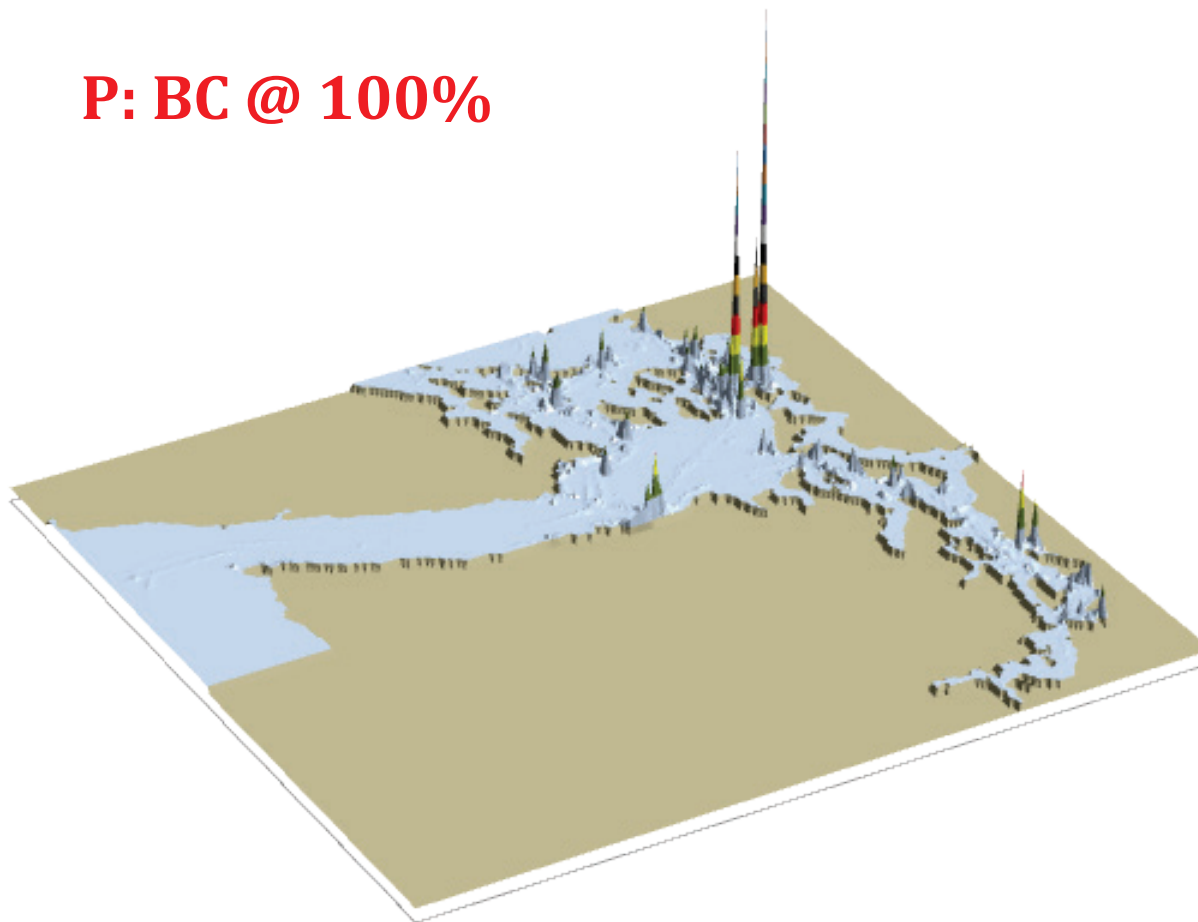
GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

P: Base Case 3D Risk Profile All FV - Pot. Grou+Coll.Oil Loss: 100% of Base Case PCO

P: BC @ 100%



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

P: VTRA 2010 - BASE CASE - ALL FV

100.0%

1.3%

79.9%

62.6%

P: BC @ 100%

**POTENTIAL ACCIDENT
OIL LOSS - POL**

Factor x Average
Oil Outflow

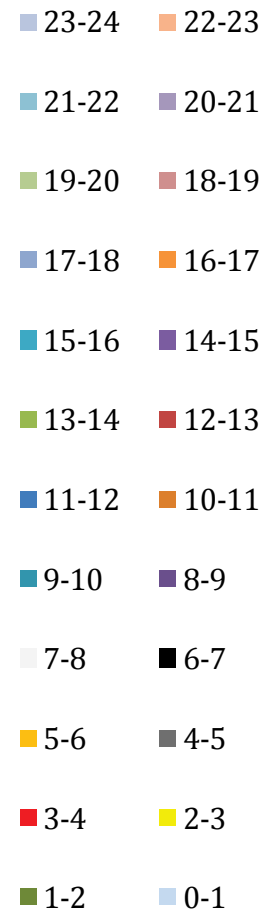
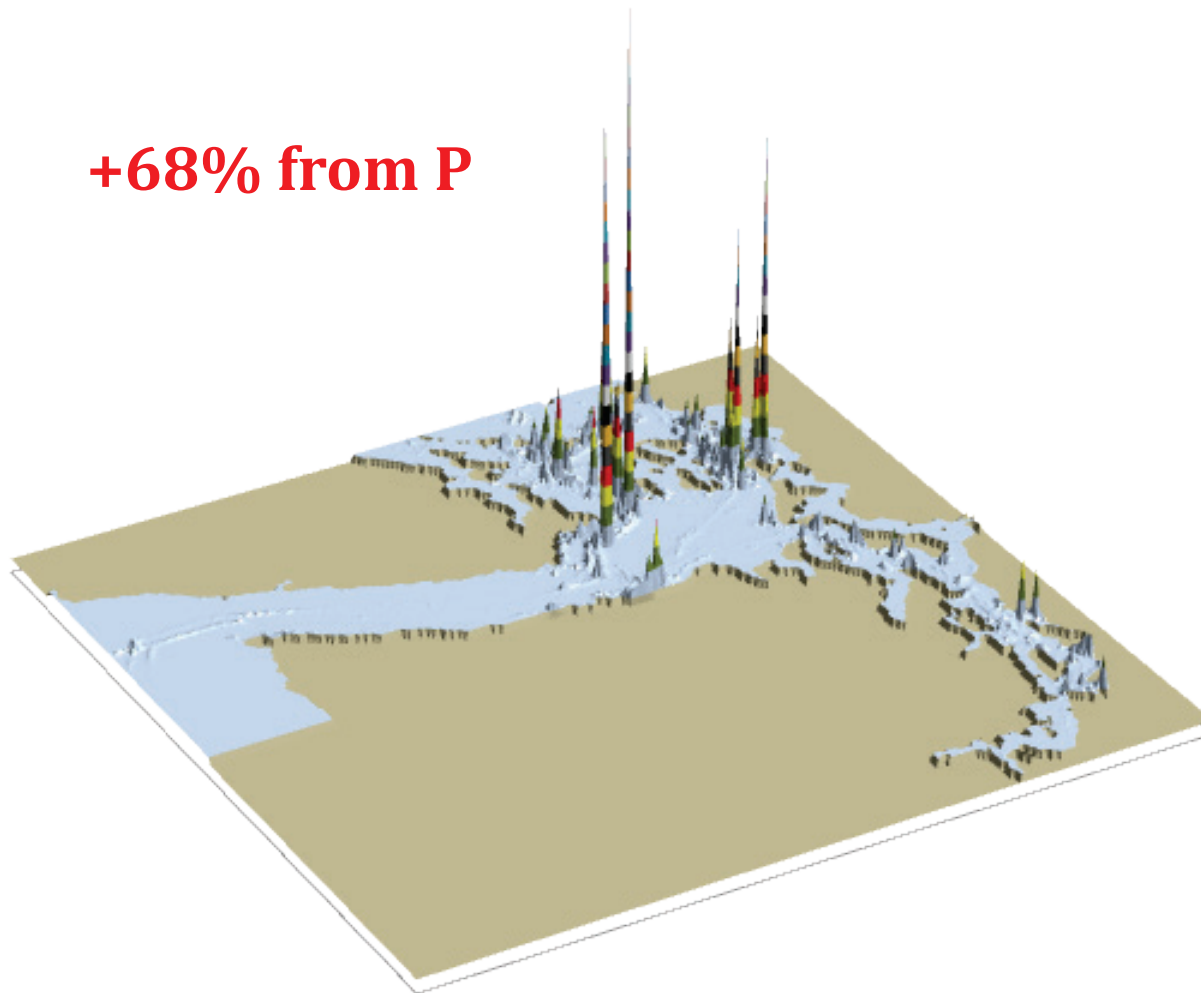
> 100.00
> 10.00
10.00
3.70
2.95
2.51
2.20
1.95
1.76
1.59
1.44
1.31
1.20
1.09
1.00
0.81
0.65
0.51
0.39
0.28
0.18
0.09
0.00

12/6/2013

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

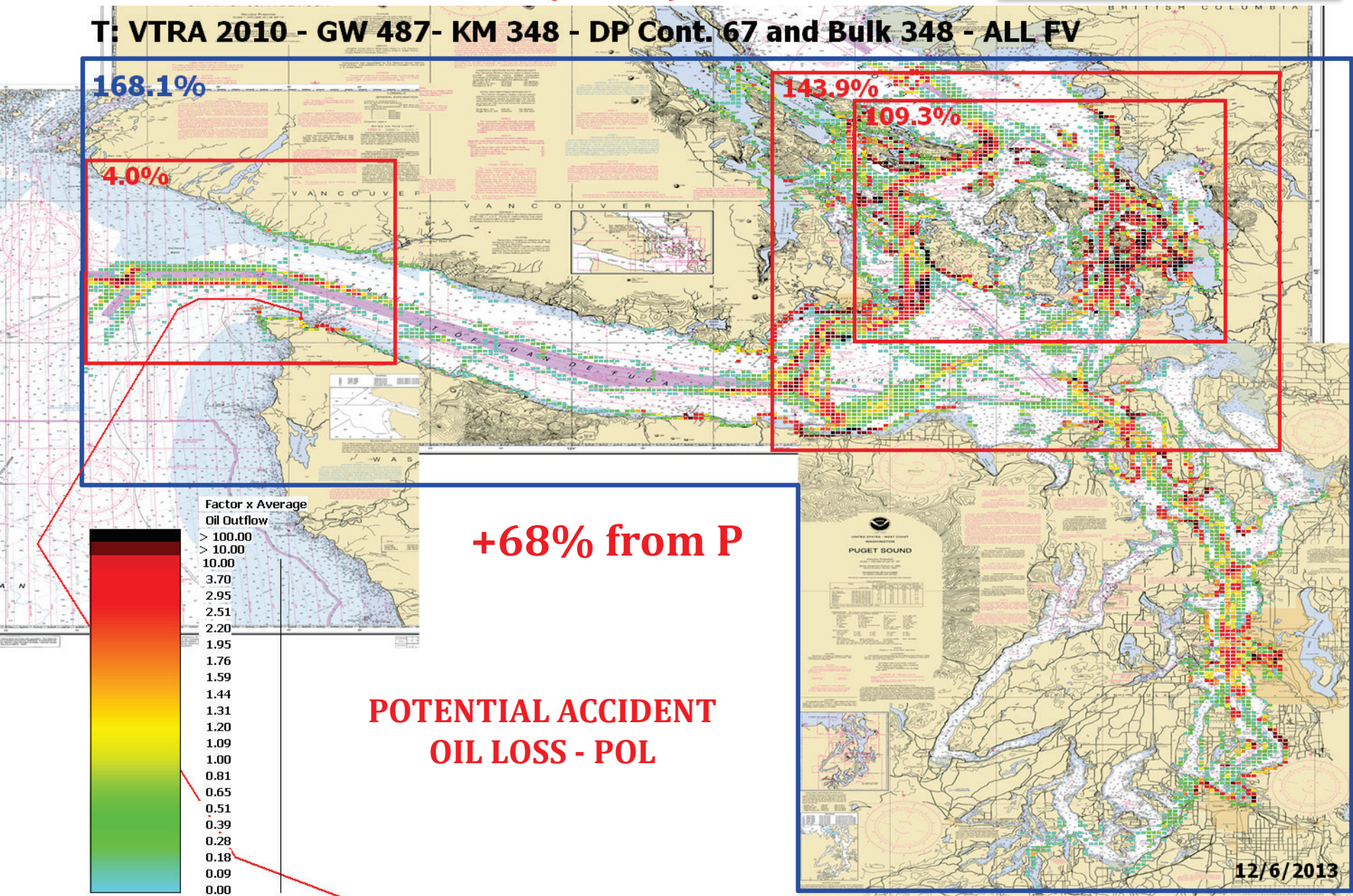
T: GW - KM - DP 3D Risk Profile
All FV - Pot. Grou+Coll.Oil Loss: 168% of Base Case PCO

+68% from P



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

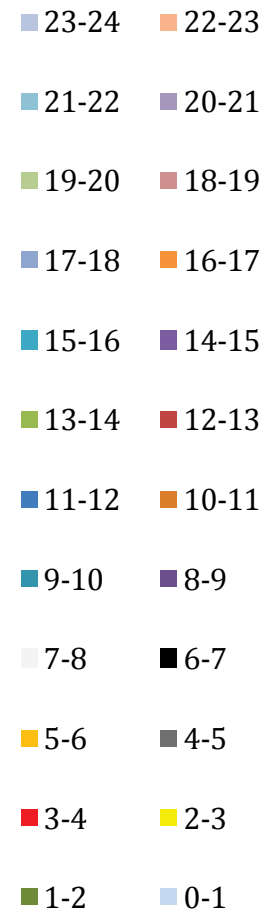
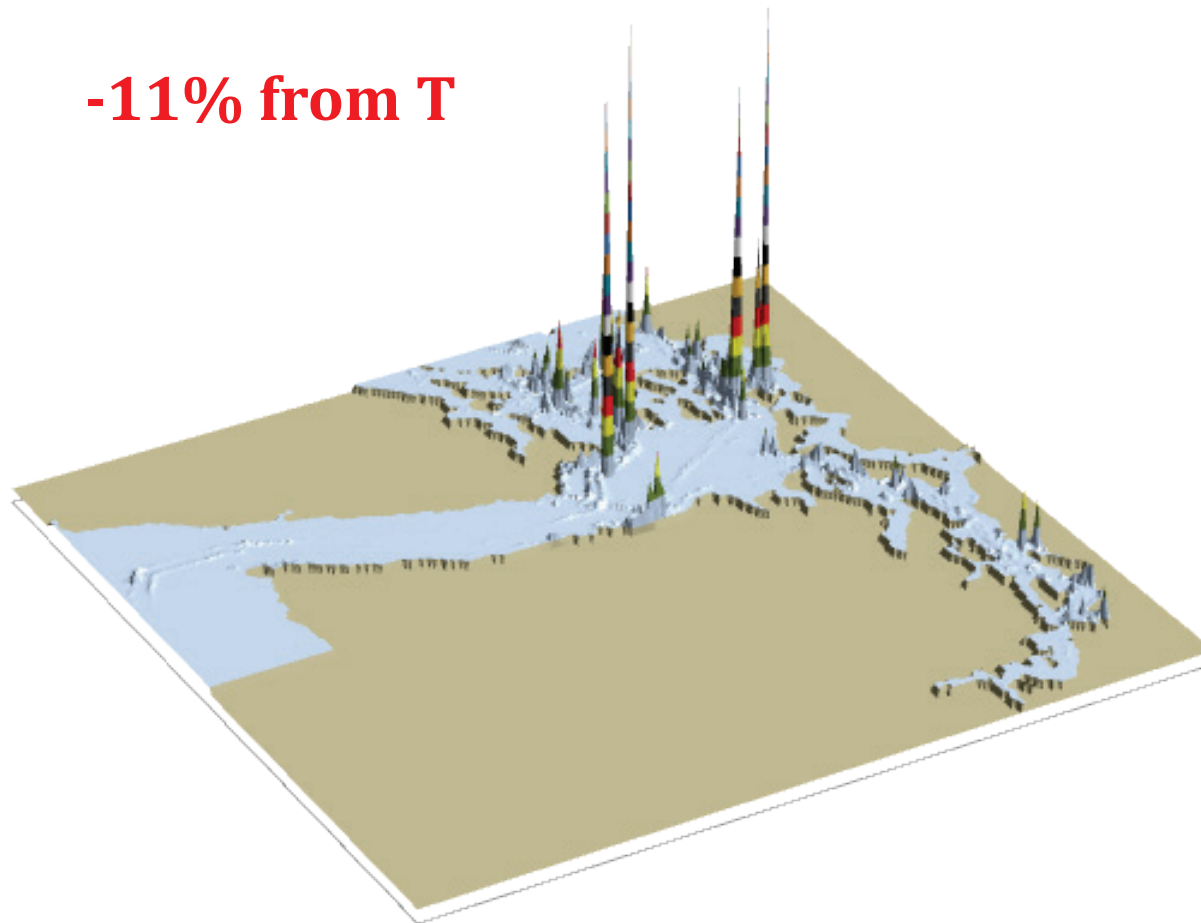
T: VTRA 2010 - GW 487- KM 348 - DP Cont. 67 and Bulk 348 - ALL FV



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

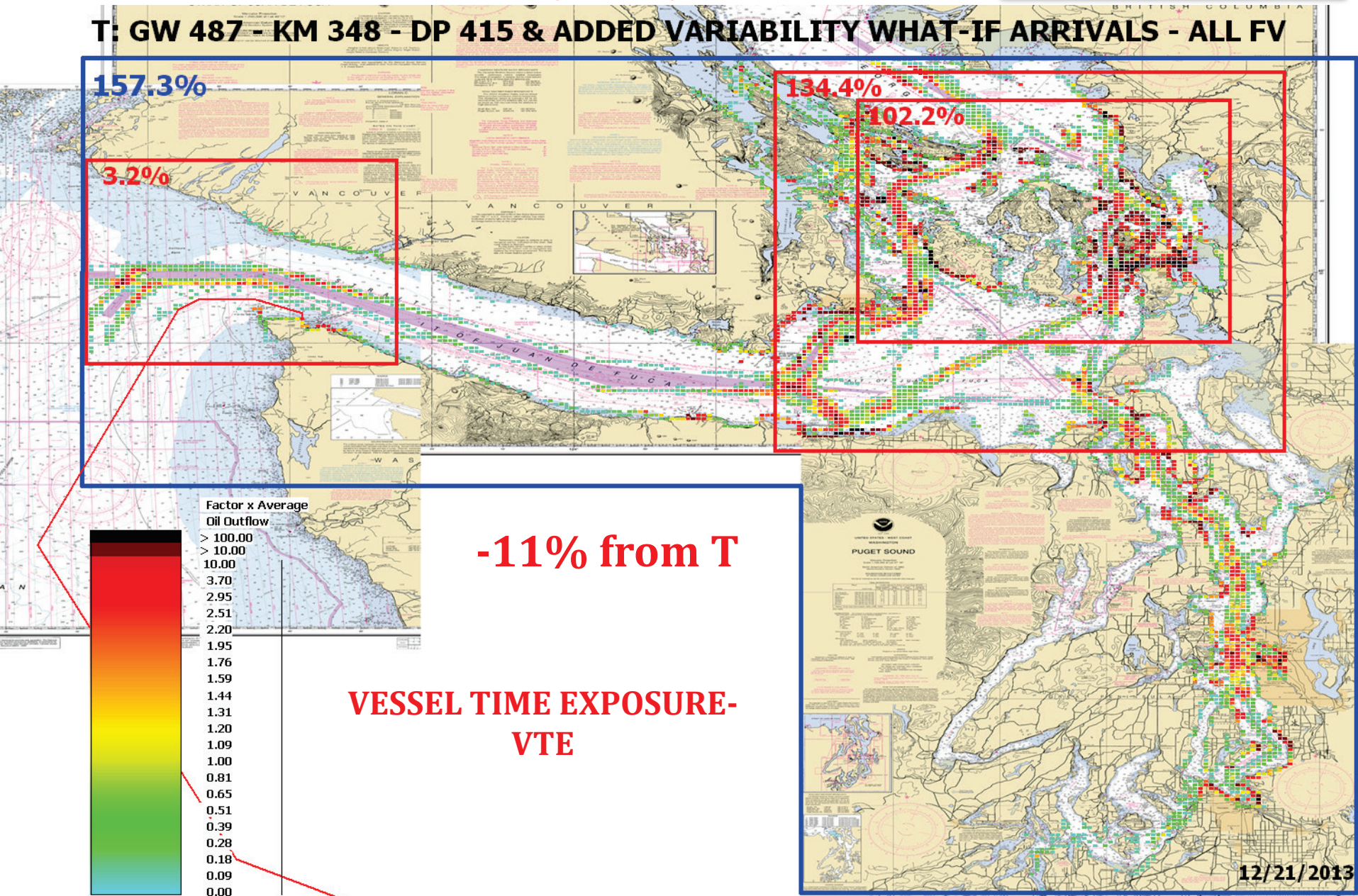
T : GW - KM - DP & +VAR FV 3D Risk Profile
All FV - Pot. Grou+Coll.Oil Loss: 157% of Base Case PCO

-11% from T



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

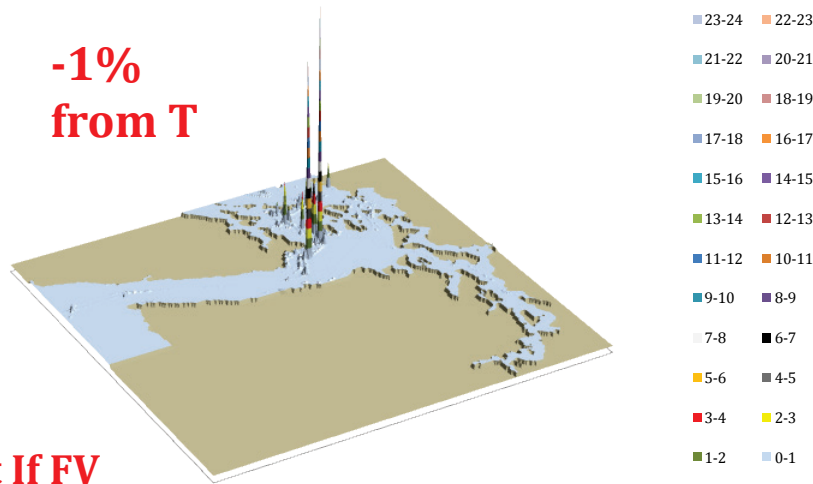
T: GW 487 - KM 348 - DP 415 & ADDED VARIABILITY WHAT-IF ARRIVALS - ALL FV



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

T : GW - KM - DP & Low Tan 3D Risk Profile
What If FV - Pot. Gr+Co.Oil Loss: 61% of Base Case PCO

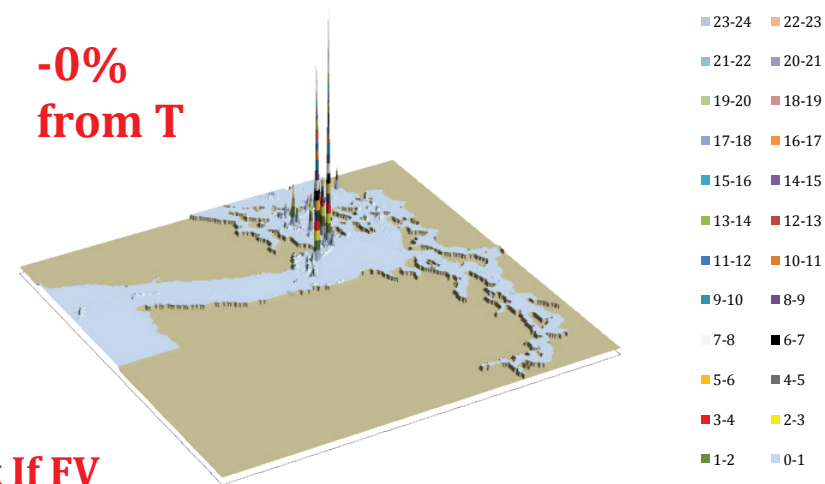
**-1%
from T**



What If FV

T : GW - KM - DP & Low Tan + CFV 3D Risk Profile
What If FV - Pot. Gr+Co.Oil Loss: 61% of Base Case PCO

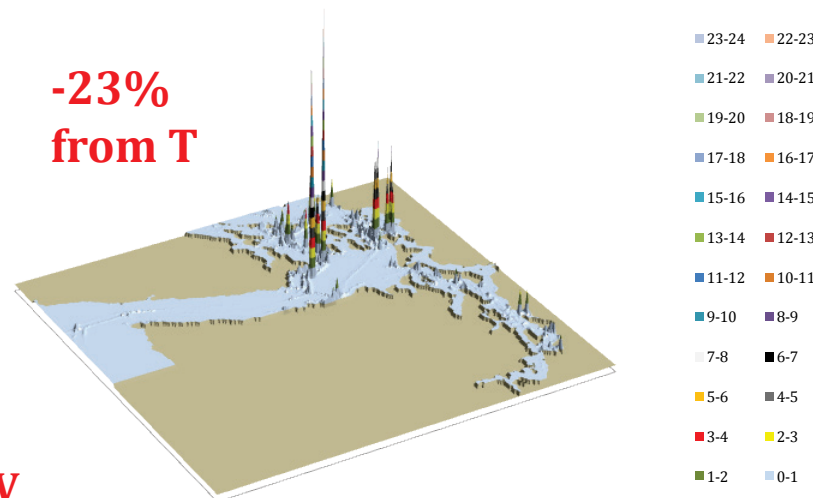
**-0%
from T**



What If FV

T : GW - KM - DP & Low Tan 3D Risk Profile
All FV - Pot. Grou+Coll.Oil Loss: 145% of Base Case PCO

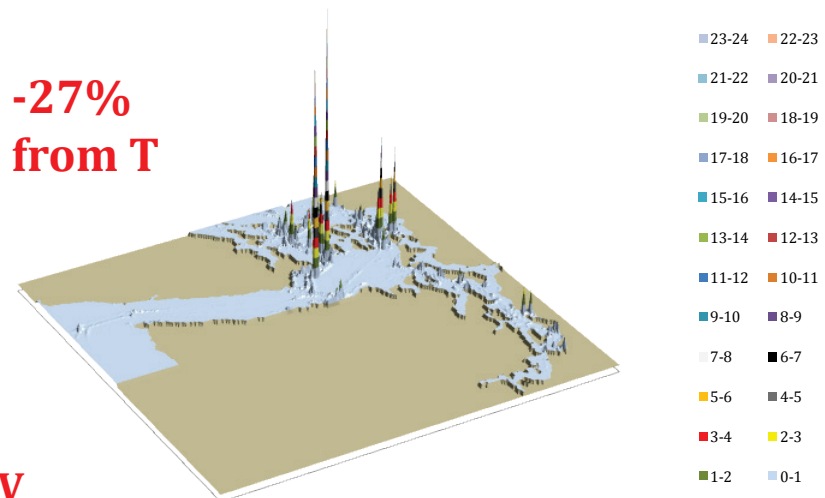
**-23%
from T**



All FV

T : GW - KM - DP & Low Tan + CFV 3D Risk Profile
All FV - Pot. Grou+Coll.Oil Loss: 141% of Base Case PCO

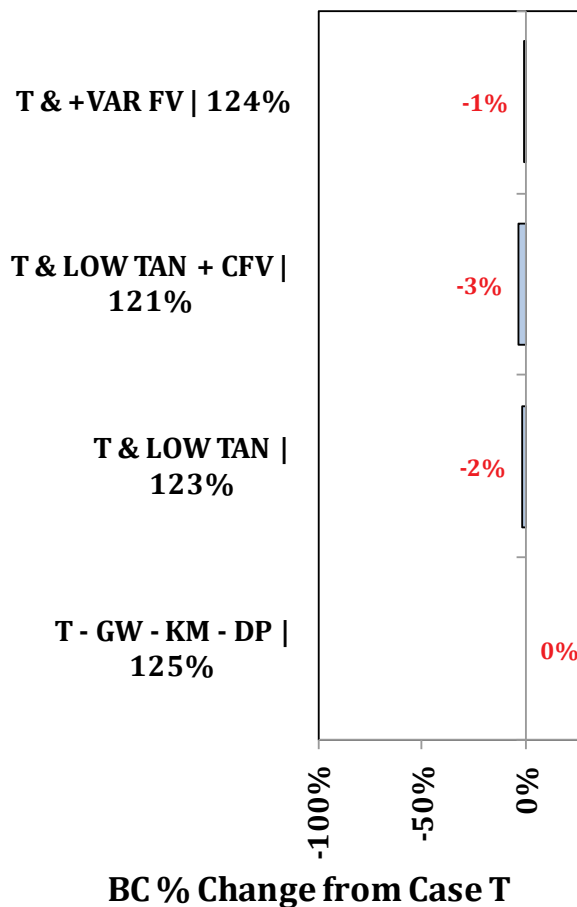
**-27%
from T**



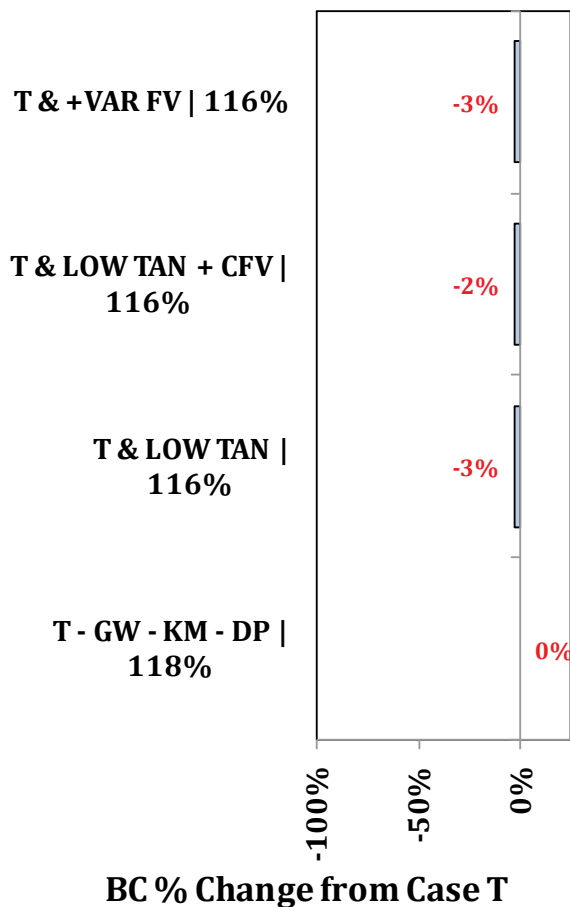
All FV

VTRA 2010 : VESSEL TIME EXPOSURE, POT. ACC. FREQ POT. OIL. LOSS COMPARISON ALL FOCUS VESSELS

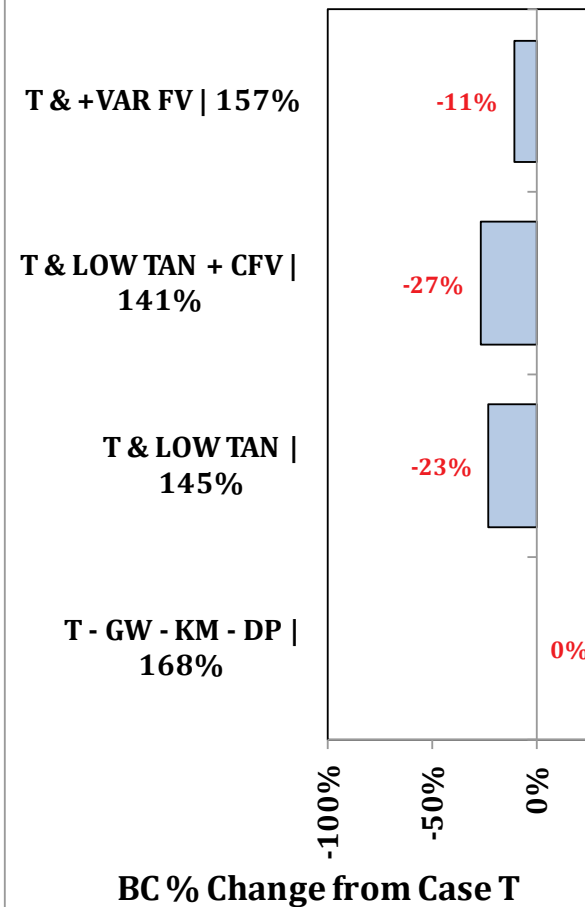
**Annual Vessel Time
Exposure (WI + BC Vessels)**



**Potential Accident (C+G)
Frequency (WI + BC Vessels)**



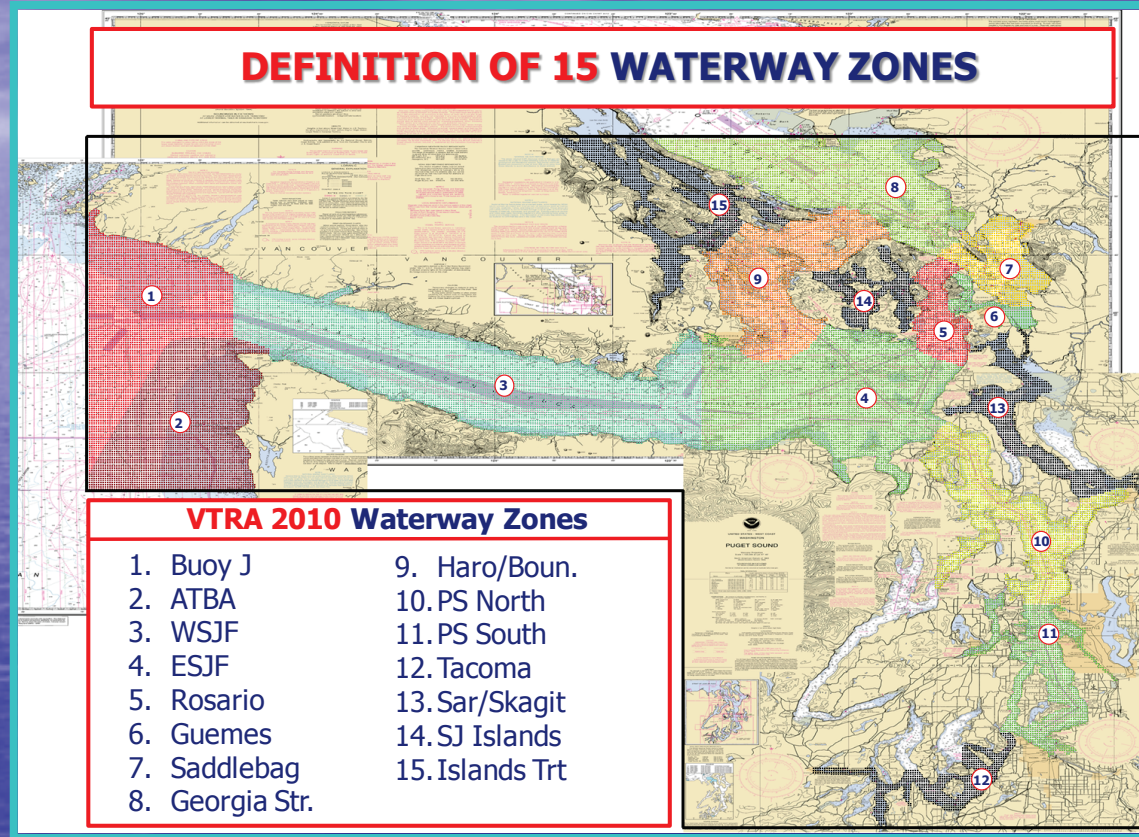
**Potential Acc. Oil (C + F) Loss
(WI + BC Vessels)**



THE GEORGE
WASHINGTON
UNIVERSITY
WASHINGTON, DC

VCU

VTRA 2010 – SYNOPSIS OF WHAT-IF COMPARISON: POTENTIAL ACCIDENT FREQUENCY BY WATERWAY ZONE



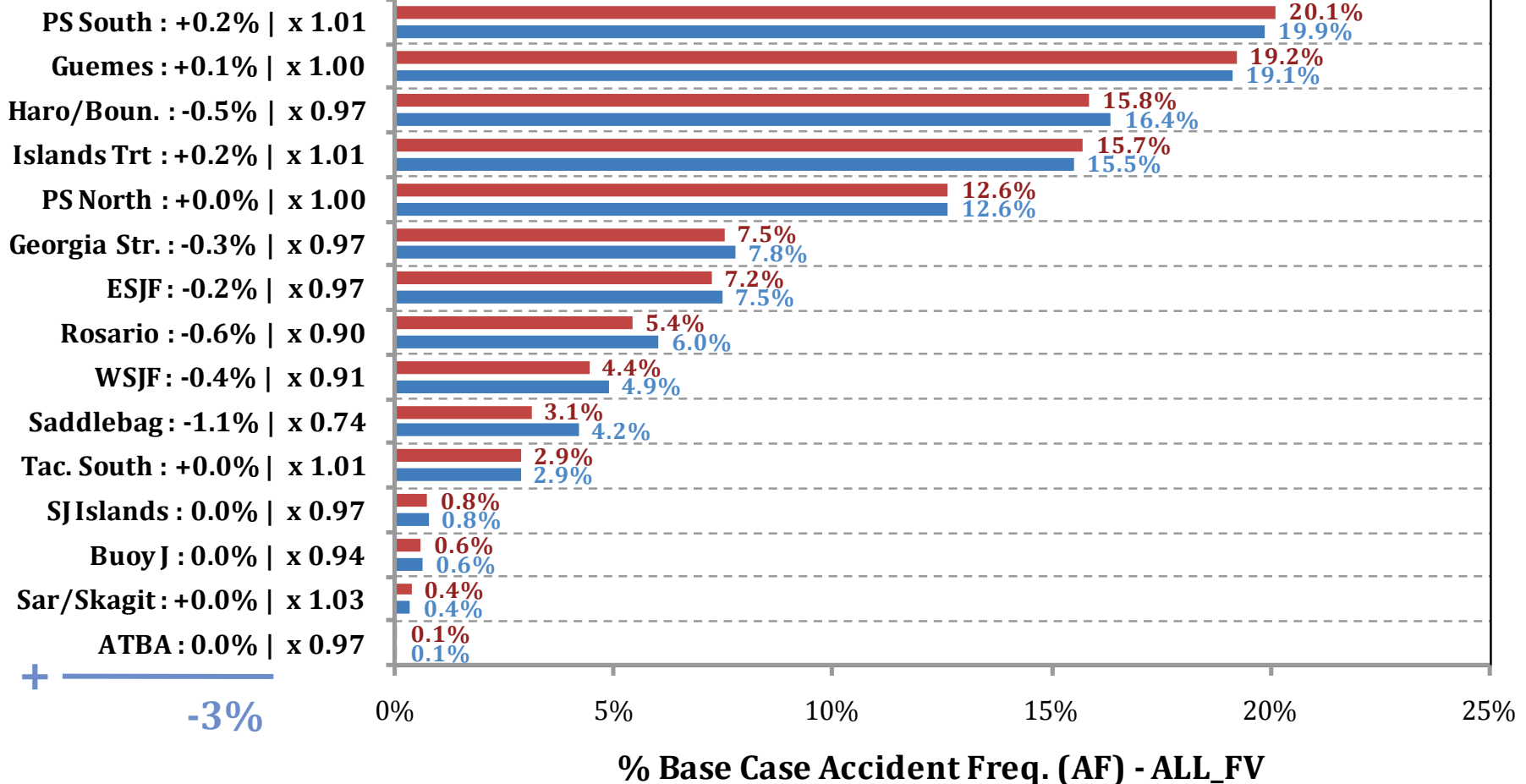
GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

% Base Case Accident (C+G) Frequency - ALL_FV

Waterway Zone:



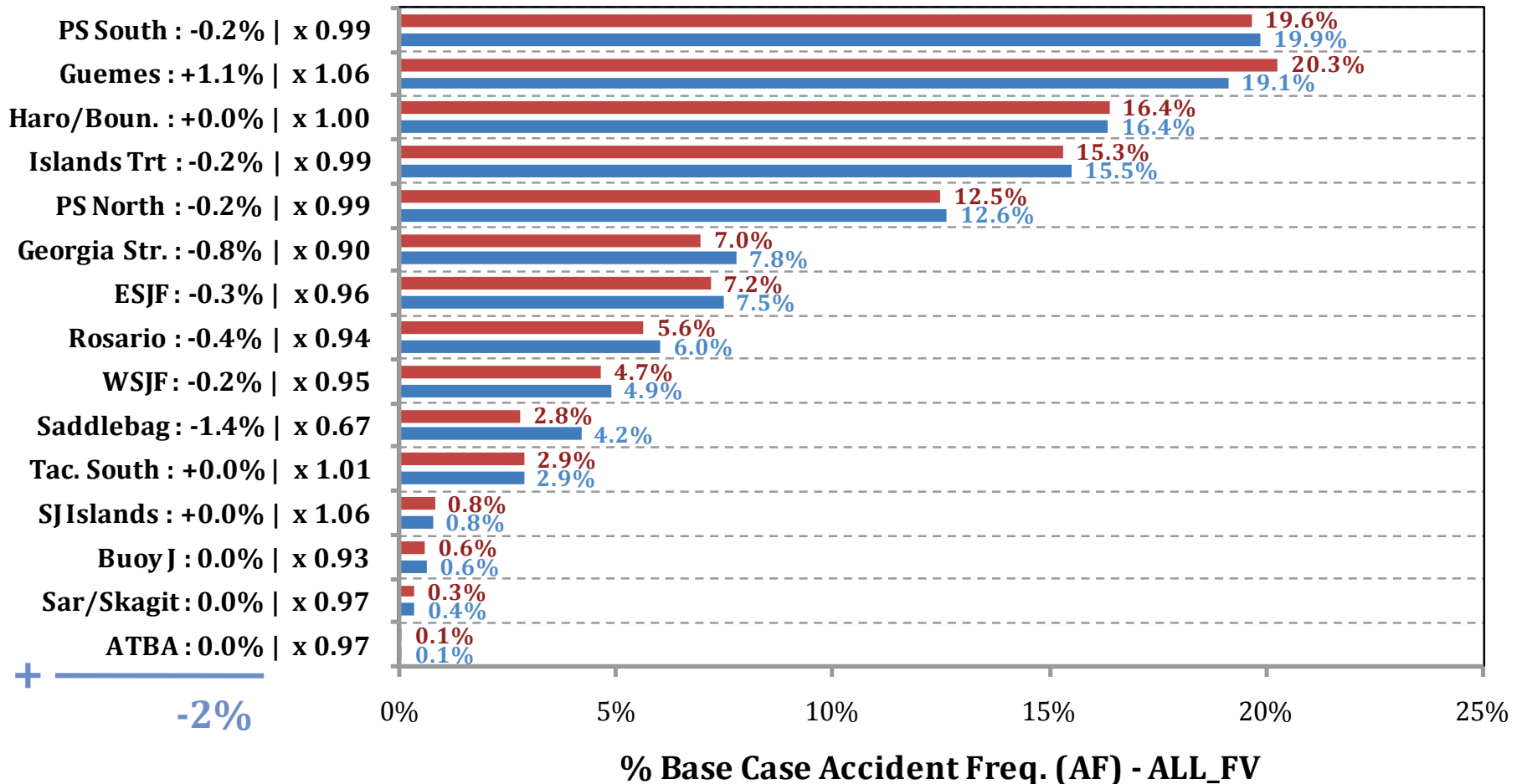
T & + VAR

■ T:GW-KM-DP&+VARFV : 116% (-3% | x 0.98) ■ T:GW-KM-DP : 118%

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

% Base Case Accident (C+G) Frequency - ALL_FV

Waterway Zone:



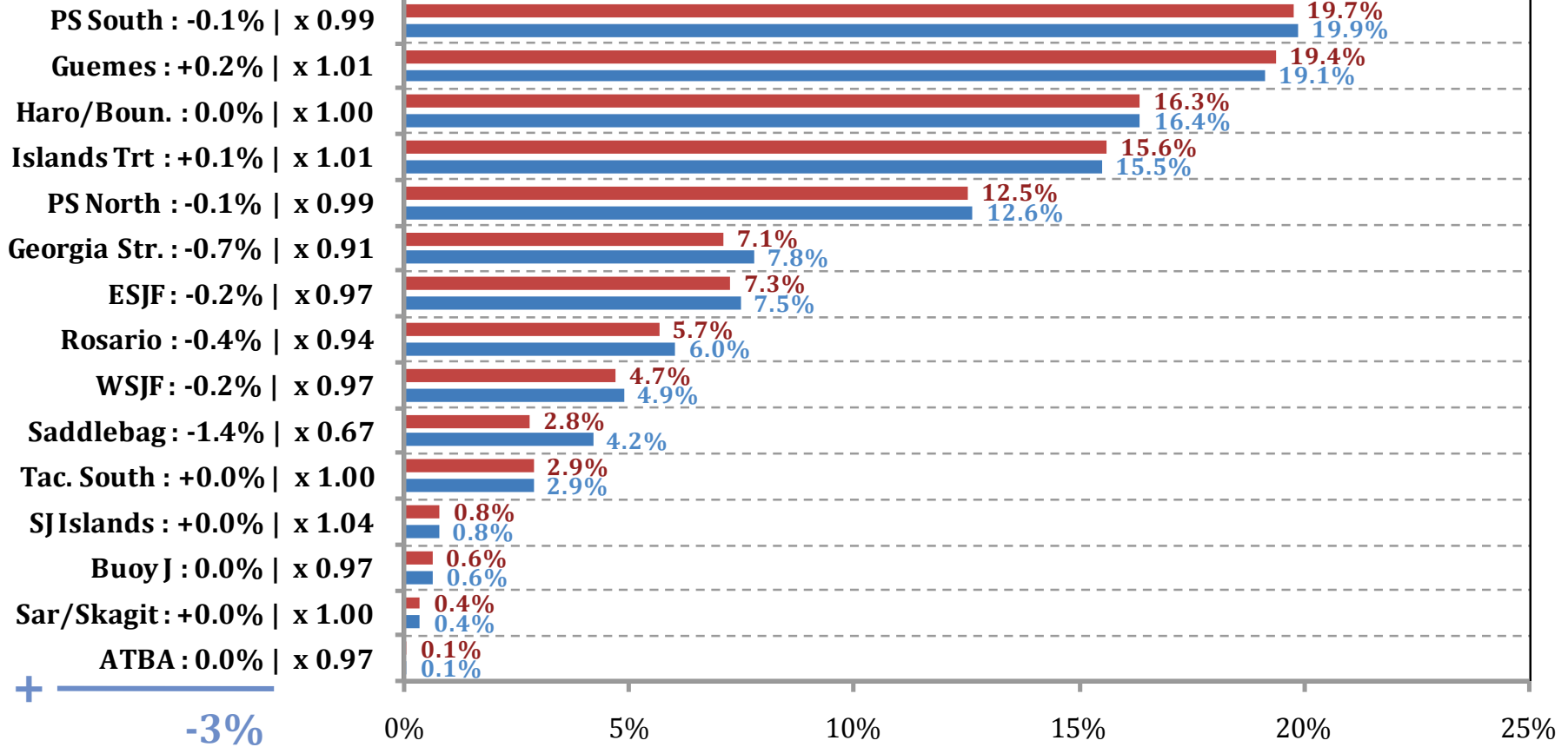
T & LTC

■ T: GW - KM - DP & Low Tan + CFV : 116% (-2% | x 0.98) ■ T: GW - KM - DP : 118%

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

% Base Case Accident (C+G) Frequency - ALL_FV

Waterway Zone:

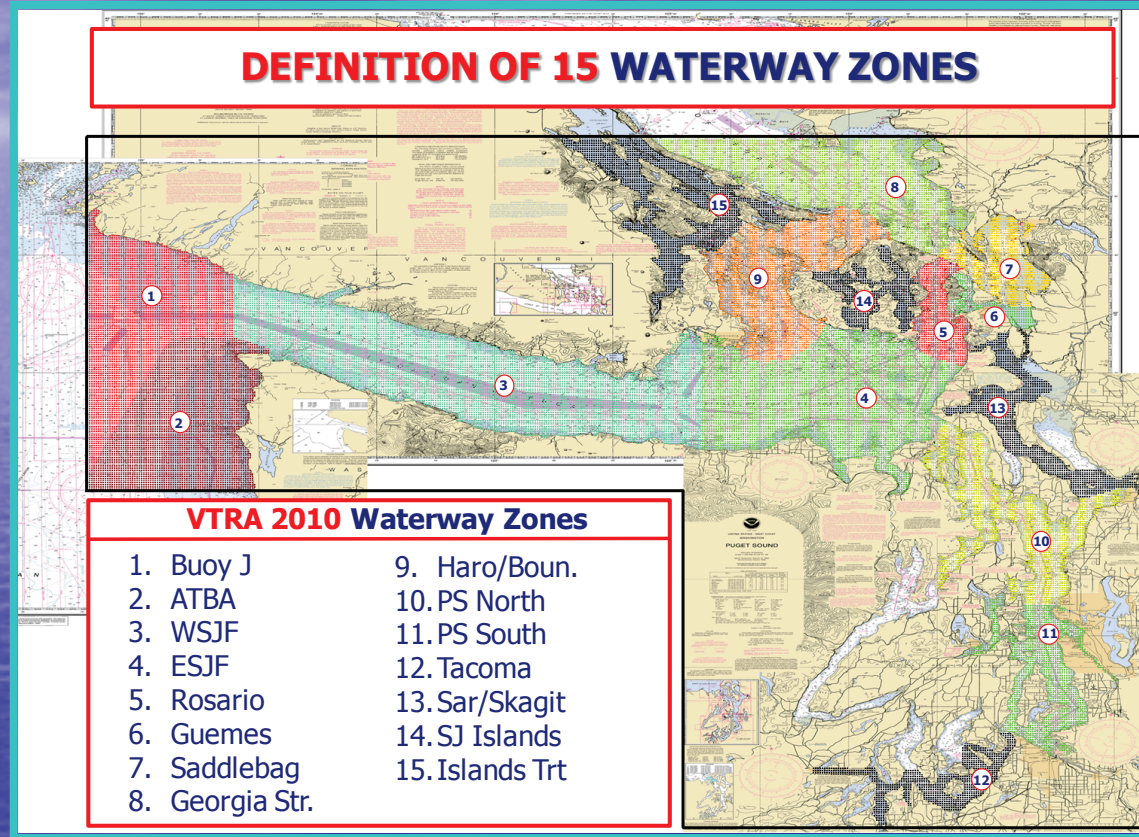


% Base Case Accident Freq. (AF) - ALL_FV

■ T: GW - KM - DP & Low Tan : 116% (-3% | x 0.98) ■ T: GW - KM - DP : 118%

T & LT

VTRA 2010 – SYNOPSIS OF WHAT-IF COMPARISON: POTENTIAL OIL LOSS BY WATERWAY ZONE



GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

% Base Case Oil (Coll. + Grou.) Loss - ALL_FV

Waterway Zone:

Haro/Boun. : -8.2% | x 0.82

ESJF : -2.0% | x 0.92

Guemes : +0.5% | x 1.02

Rosario : +0.1% | x 1.00

Saddlebag : +1.3% | x 1.10

PS North : +0.2% | x 1.02

PS South : -0.2% | x 0.98

WSJF : -1.5% | x 0.85

Georgia Str. : -0.2% | x 0.97

Islands Trt : +0.0% | x 1.00

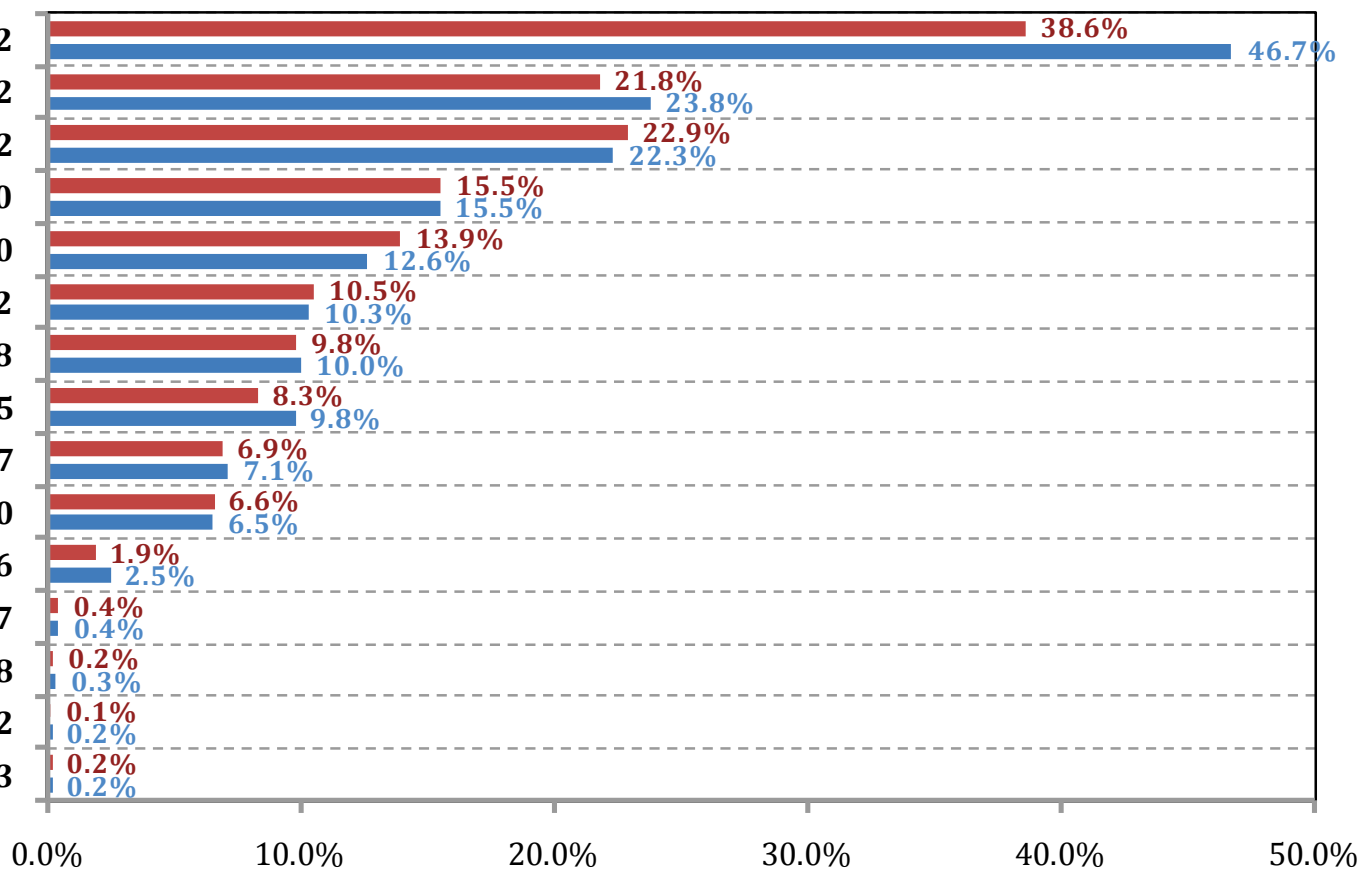
Buoy J : -0.6% | x 0.76

Tac. South : 0.0% | x 0.97

SJ Islands : -0.1% | x 0.68

ATBA : 0.0% | x 0.92

Sar/Skagit : +0.0% | x 1.03



% Base Case Oil (Coll.+Grou.) Loss (OL) - ALL_FV

T & +VAR

■ T: GW - KM - DP & +VARFV : 157% (-11% | x 0.94) ■ T: GW - KM - DP : 168%

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

% Base Case Oil (Coll. + Grou.) Loss - ALL_FV

Waterway Zone:

Haro/Boun. : -0.8% | x 0.98

ESJF : -3.0% | x 0.88

Guemes : -8.9% | x 0.60

Rosario : -4.2% | x 0.73

Saddlebag : -4.9% | x 0.61

PS North : -0.9% | x 0.92

PS South : -1.3% | x 0.87

WSJF : -0.7% | x 0.93

Georgia Str. : -1.6% | x 0.78

Islands Trt : -0.2% | x 0.97

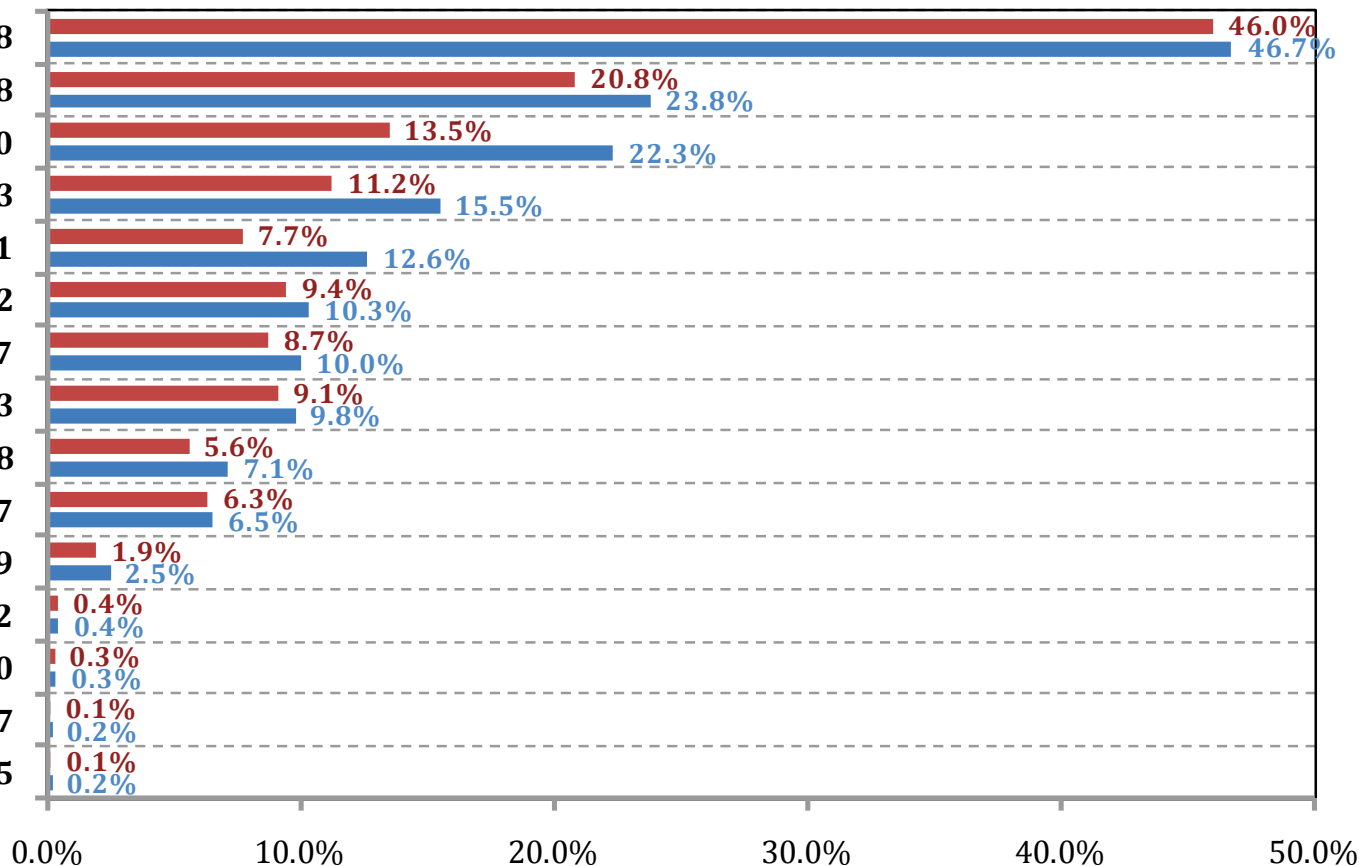
Buoy J : -0.5% | x 0.79

Tac. South : 0.0% | x 0.92

SJ Islands : -0.1% | x 0.80

ATBA : 0.0% | x 0.77

Sar/Skagit : 0.0% | x 0.95



+ -27%

% Base Case Oil (Coll.+Grou.) Loss (OL) - ALL_FV

T & LTC

■ T: GW - KM - DP & Low Tan + CFV : 141% (-27% | x 0.84) ■ T: GW - KM - DP : 168%

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

% Base Case Oil (Coll. + Grou.) Loss - ALL_FV

Waterway Zone:

Haro/Boun. : -0.8% | x 0.98

ESJF : -3.0% | x 0.88

Guemes : -6.8% | x 0.69

Rosario : -2.9% | x 0.81

Saddlebag : -4.7% | x 0.63

PS North : -0.7% | x 0.93

PS South : -1.1% | x 0.89

WSJF : -0.7% | x 0.93

Georgia Str. : -1.4% | x 0.80

Islands Trt : -0.1% | x 0.99

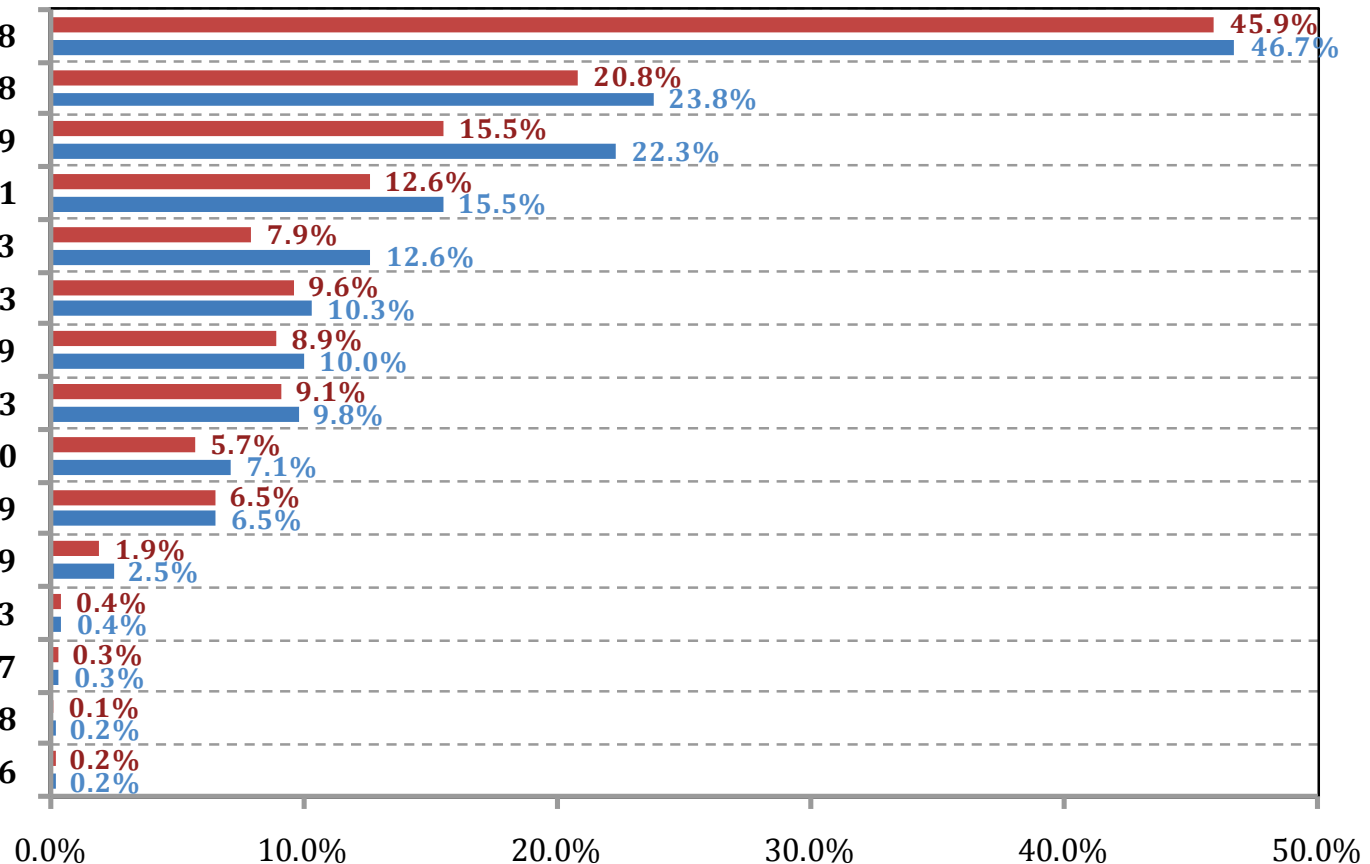
Buoy J : -0.5% | x 0.79

Tac. South : 0.0% | x 0.93

SJ Islands : -0.1% | x 0.77

ATBA : 0.0% | x 0.78

Sar/Skagit : 0.0% | x 0.96



+ -23%

% Base Case Oil (Coll.+Grou.) Loss (OL) - ALL_FV

T & LT

■ T: GW - KM - DP & Low Tan: 145% (-23% | x 0.86) ■ T: GW - KM - DP: 168%