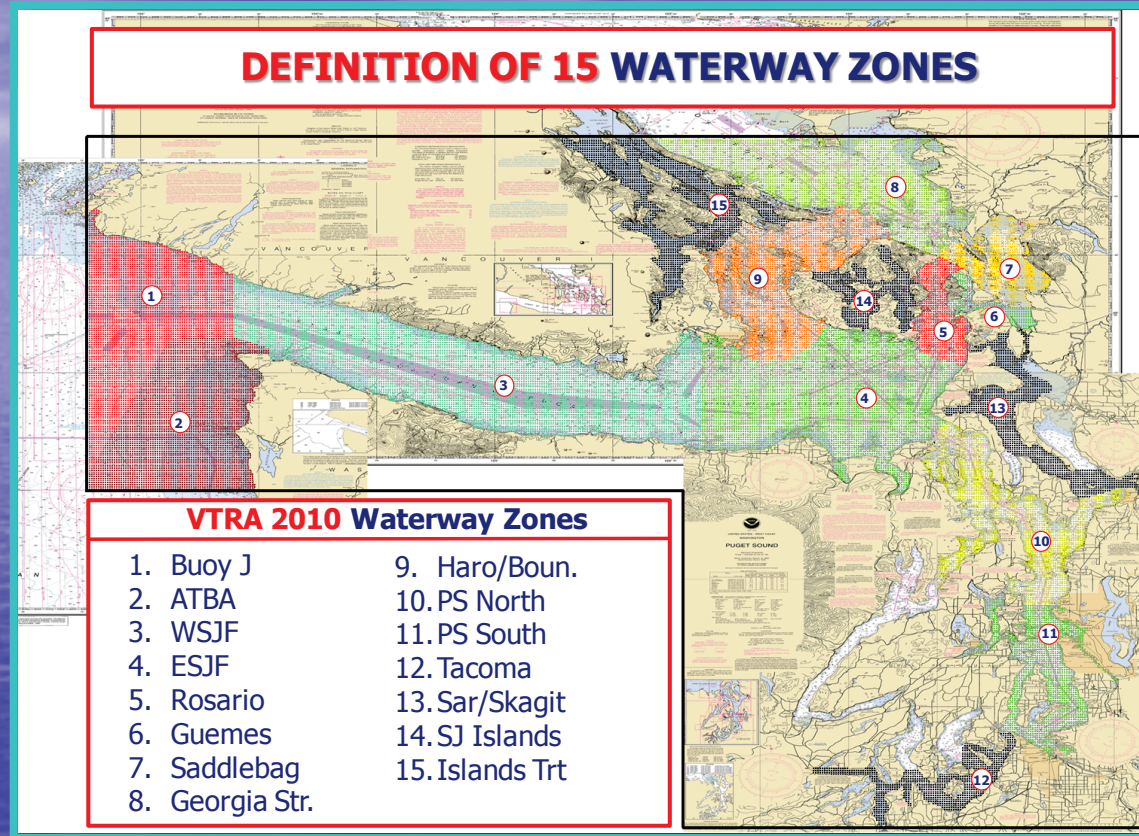


VTRA 2010 – SYNOPSIS OF RMM SCENARIO COMPARISON APPLIED TO CASE T: GW – KM - DP



GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

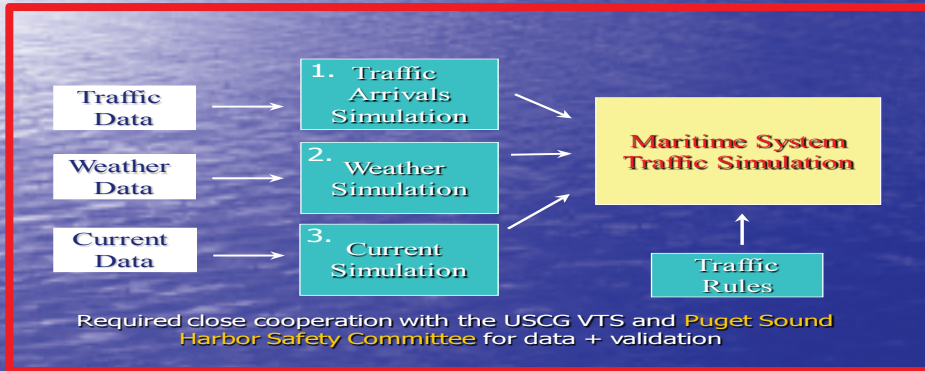
FOCUS VESSELS TRAVEL THROUGH VTRA STUDY AREA

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



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	<-----X----->	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

Step 1 Damage calculation

A SR 259 Collision Scenario

struck ship -velocity -displacement -hull type

collision -location -angle

striking ship -velocity -displacement -bow angle

Perpendicular Kinetic Energy

Tangential Kinetic Energy

103

IMPORTANT:

THE OPERATIVE WORD IN PRESENTING THESE ANALYSIS RESULTS IS THE USE OF THE WORD

POTENTIAL

TO INDICATE THAT THESE ANALYSIS RESULTS DO NOT FOLLOW FROM AN HISTORICAL DATA ANALYSIS, BUT THROUGH THE USE OF AN ANALYSIS TOOL THAT EVALUATES SUCH **POTENTIAL**.

THE 2010 YEAR IS CONSIDERED **THE BASE CASE YEAR** AND A BASE CASE YEAR POTENTIAL IS EVALUATED.

NEXT, **WHAT-IF SCENARIOS** ARE DEVELOPED FROM THE BASE CASE BY ADDING ADDITIONAL HYPOTHETICAL TRAFFIC AND A WHAT-IF POTENTIAL IS EVALUATED AND COMPARED **RELATIVE TO THE BASE CASE** TO INFORM **RISK MANAGEMENT**.

**WHAT-IF SCENARIOS = BASE CASE 2010
TRAFFIC WITH FOLLOWING
WHAT-IF FOCUS VESSELS**

Q: GW - 487

487 Gateway Bulk Carriers + Bunkering Barges

R: KM - 348

348 Trans mountain Pipeline Expansion (Kinder Morgan) Tankers + Bunkering Barges

S: DP - 415

348 Delta Port Bulk Carriers + Bunkering Barges
67 Delta Port Container Ships+ Bunkering Barges

T: GW – KM - DP

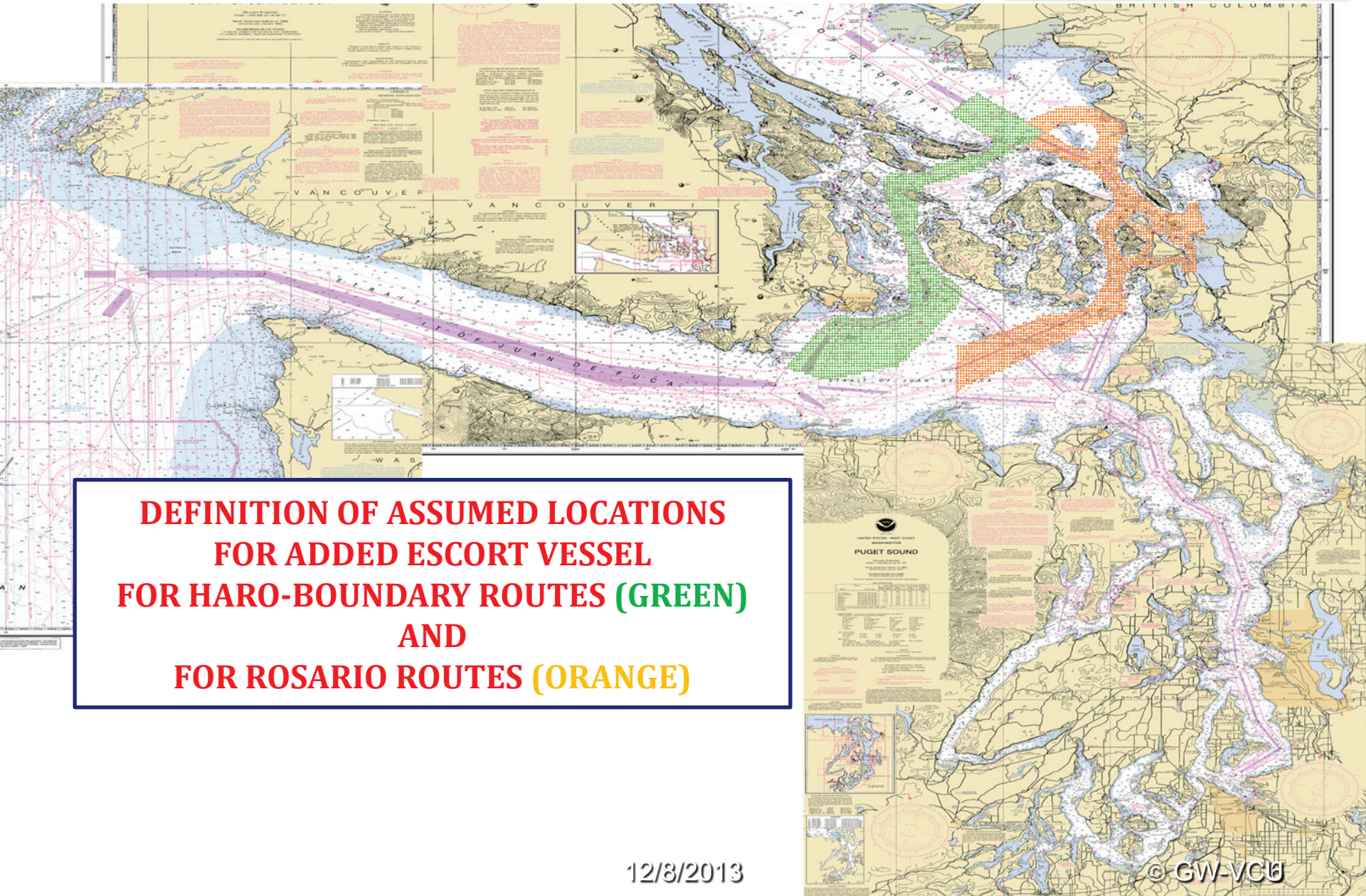
Combination of GW – 487, KM – 348 and DP-415
What-If Scenarios

RISK MITIGATION MEASURES (RMM) SCENARIOS CONSIDERED IN THIS PRESENTATION

T: GW – KM – DP & 6 RMM

1. VTRA 2010 Base Case and Max Speed Container Vessels @ 17 knots.
2. VTRA 2010 Base Case and Human Error Inciden On Oil Barges reduced by 50%.
3. No Bunkering for Gateway Vessels
4. ATB Vessels obey Rosario one-way regime
5. + 1 Escort for Laden Tank Focus Vessels (except Oil Barges) and Cape size Bulk Carriers on Rosario Routes (see next page)
6. + 1 Escort for All Focus Vessels on Haro-Boundary Pass Routes (see next page)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010



12/8/2013

RISK MITIGATION MEASURES (RMM) SCENARIOS CONSIDERED IN THIS PRESENTATION

T: GW – KM – DP & OW ATB

VTRA 2010 Base Case and ATB's obey One Way Rosario Regime

T: GW – KM – DP & EC

+ 1 Escort for Cape size Bulk Carriers on Rosario Routes
and Haro Routes (see previous page)

T: GW – KM – DP & EH

+ 1 Escort for All Focus Vessels on Haro-Boundary
Pass Routes (see previous page)

T: GW – KM – DP & ER

+ 1 Escort for Laden Tank Focus Vessels (except Oil Barges)
and Cape size Bulk Carriers on Rosario Routes (see previous page)

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

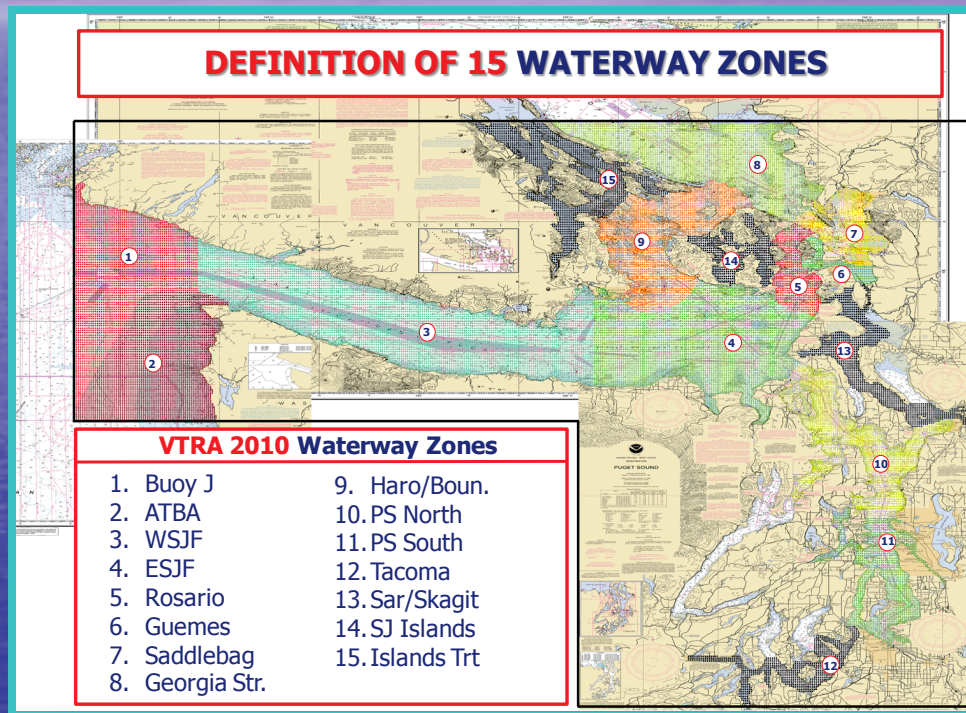
Disclaimer: No information is available on volume of oil or type of oil on board a vessel and we have to rely on overarching assumptions regarding movement of amount and type of oil as focus vessels move through the study area.

- 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



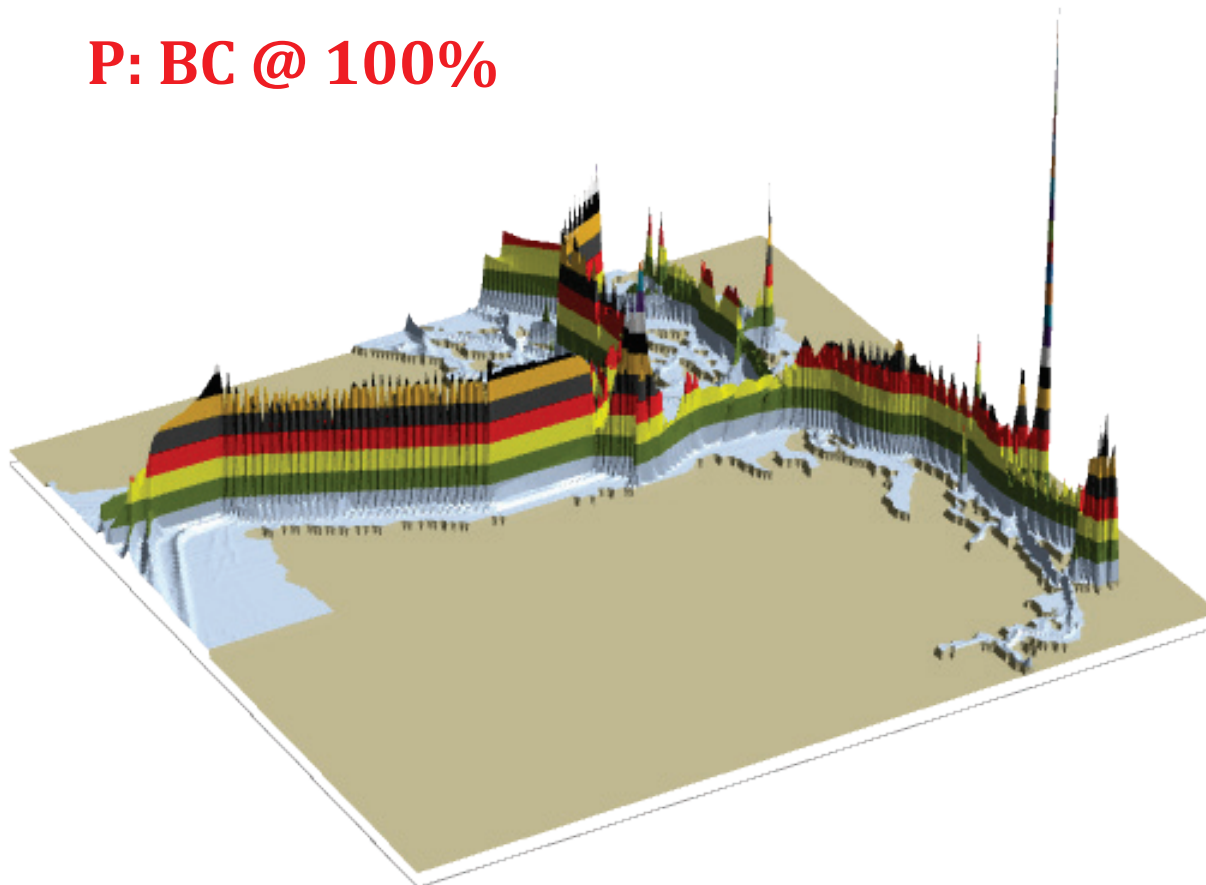
GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

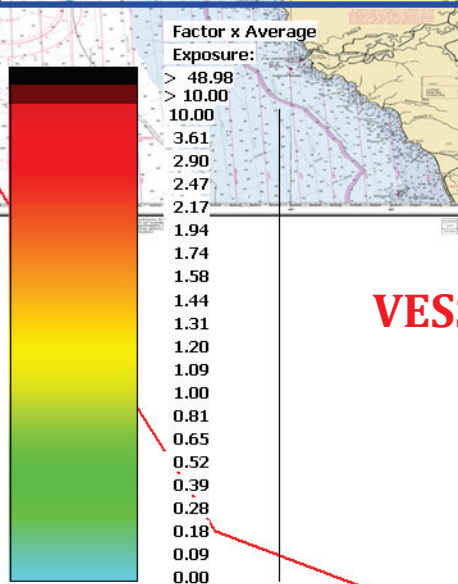
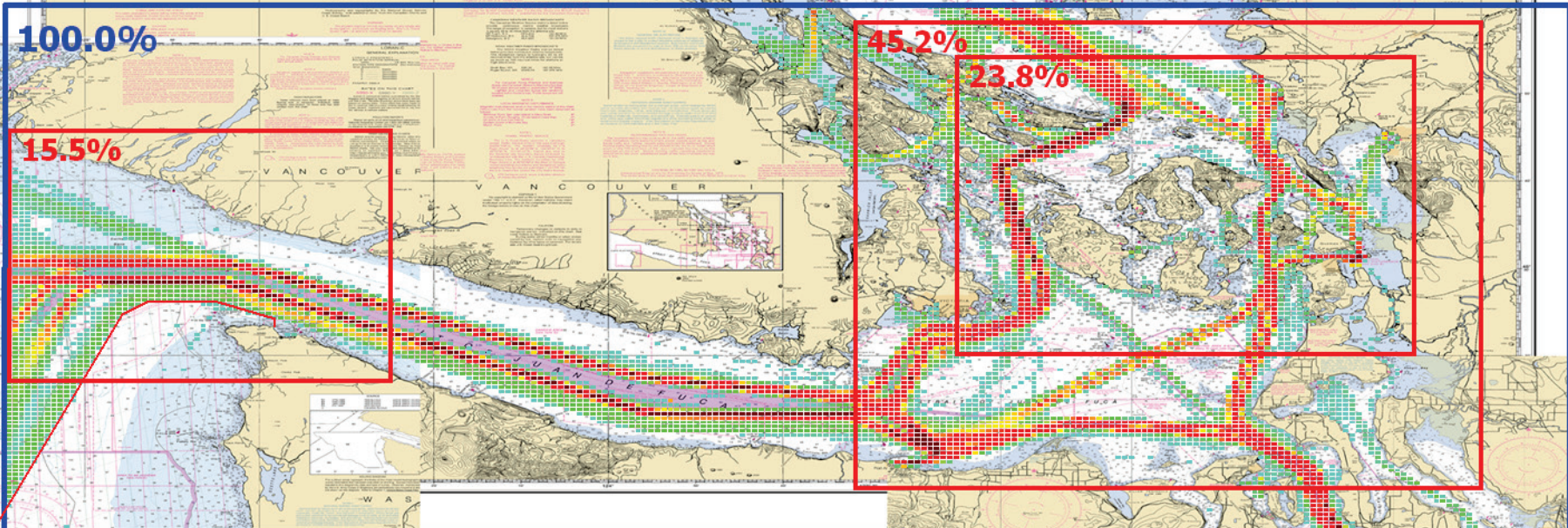
P: Base Case 3D Risk Profile All FV - Vessel Time Exposure: 100% of Base Case VTE

P: BC @ 100%



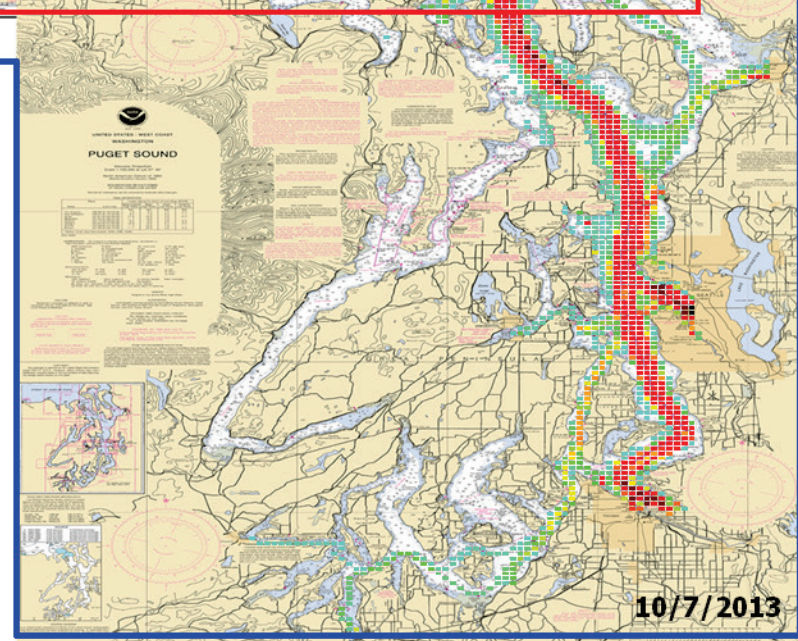
VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

P: VTRA 2010 - BASE CASE - All FV



P: BC @ 100%

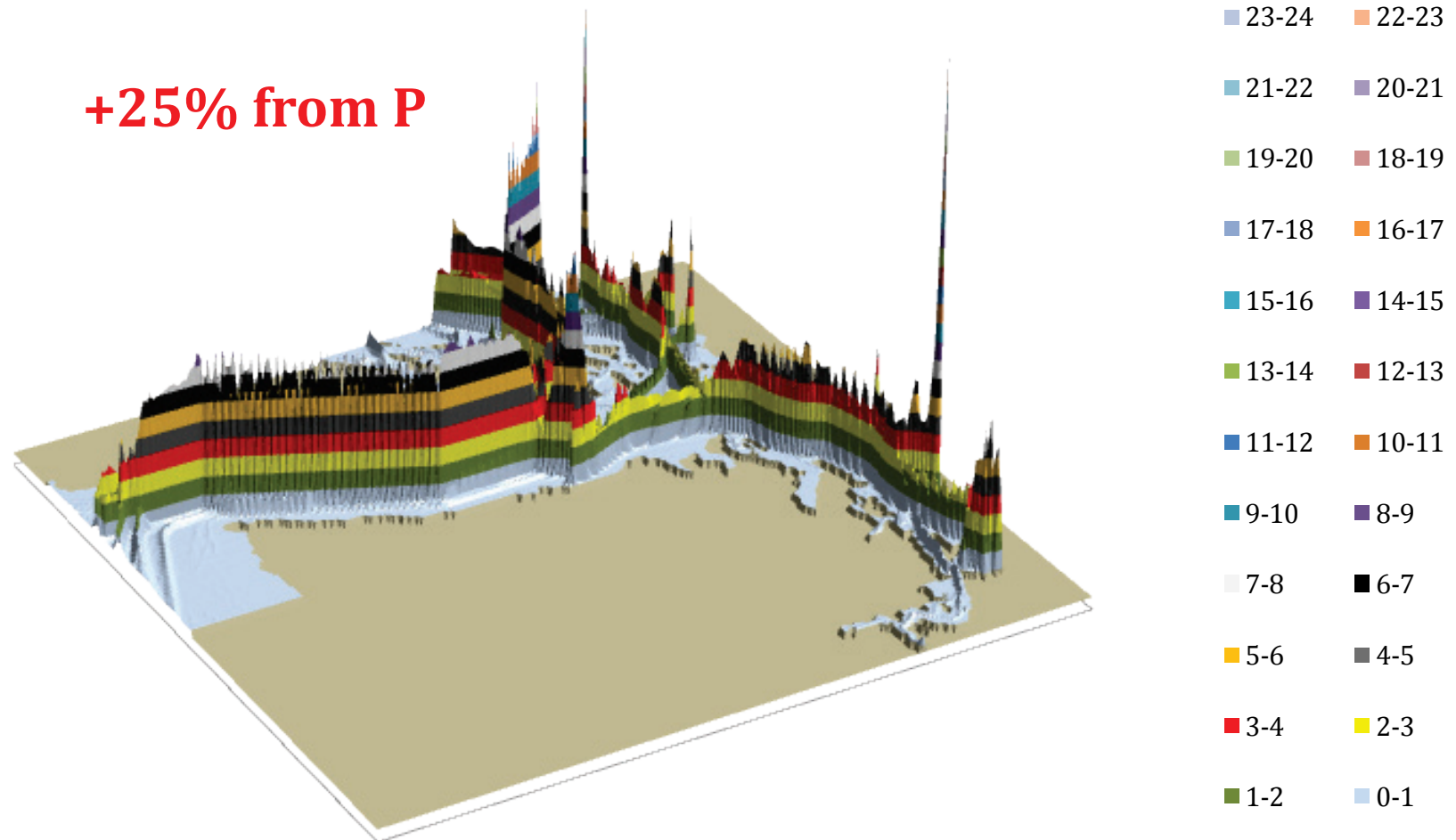
**VESSEL TIME EXPOSURE-
VTE**



10/7/2013

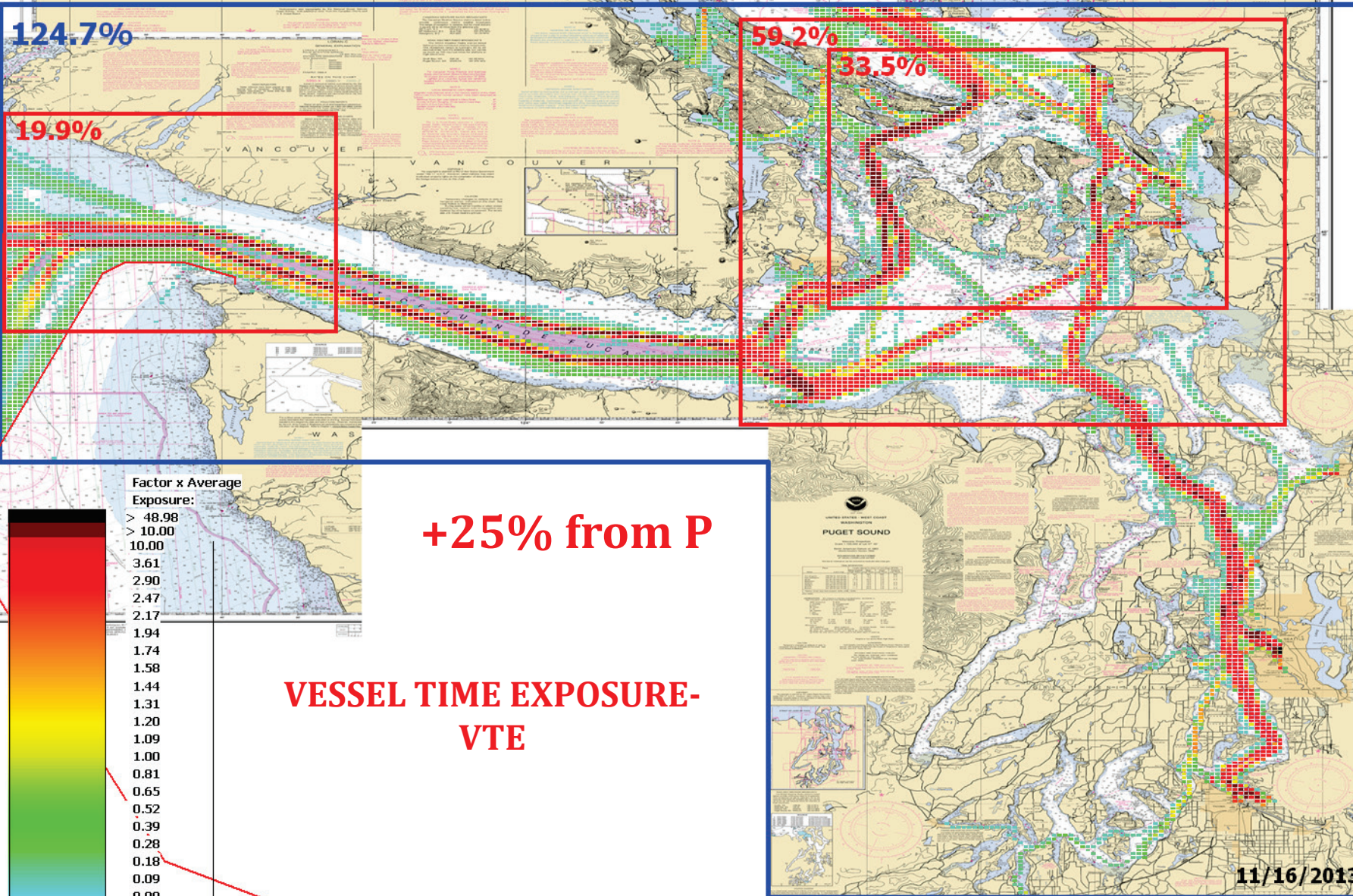
VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

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



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

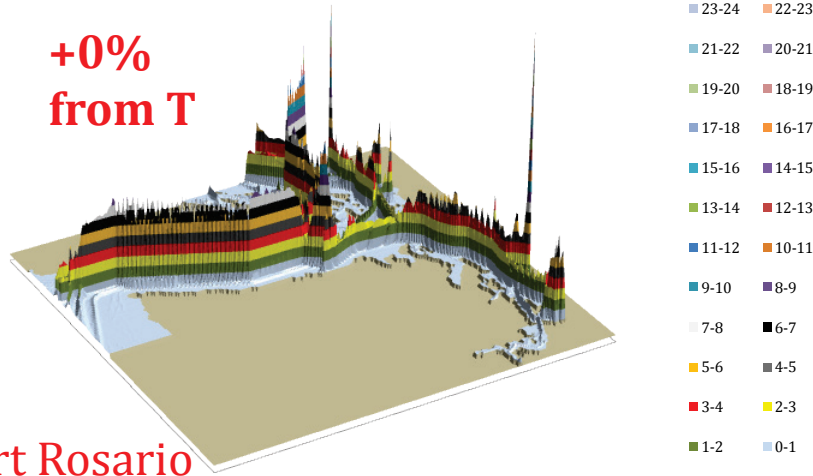
T: VTRA 2010 - GW 487- KM 348 - DP Cont. 67 and Bulk 348 - All FV



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

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

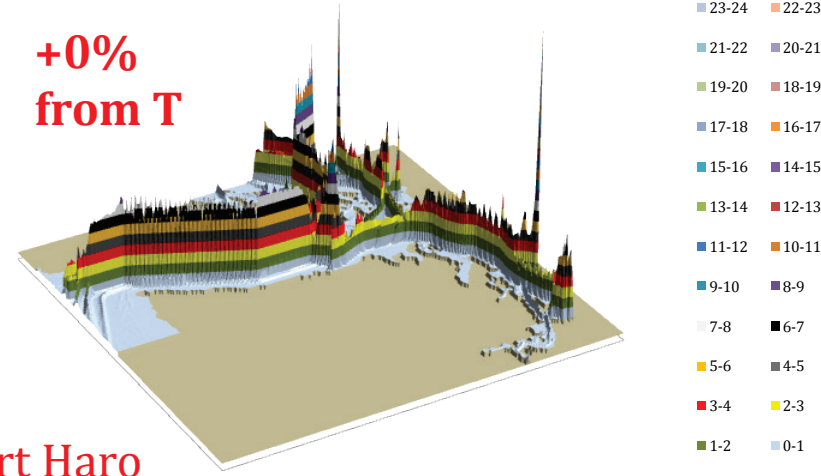
**+0%
from T**



Escort Rosario

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

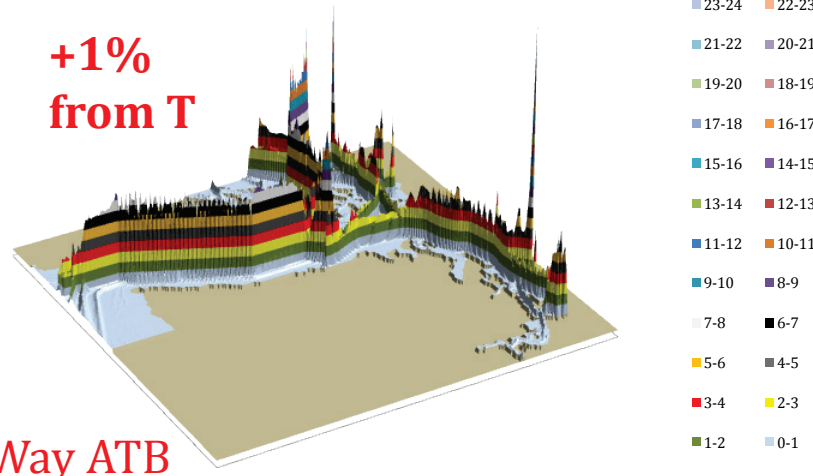
**+0%
from T**



Escort Haro

T: GW - KM - DP & OW ATB 3D Risk Profile
All FV - Vessel Time Exposure: 126% of Base Case VTE

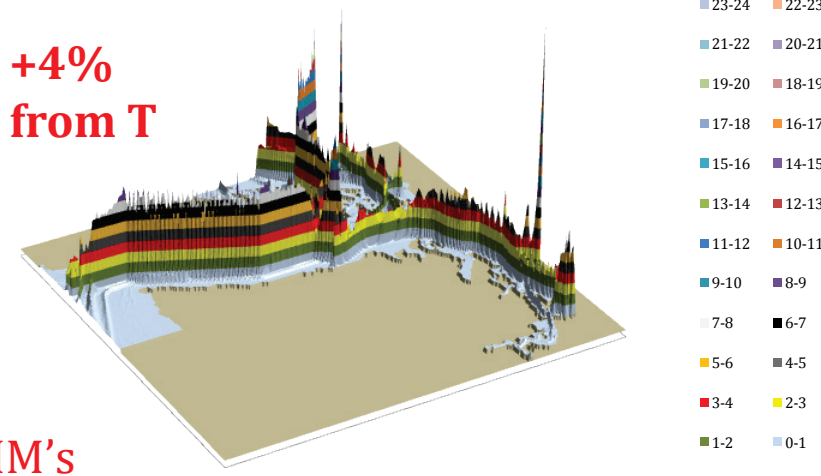
**+1%
from T**



One Way ATB

T: GW - KM - DP & 6 RMM 3D Risk Profile
All FV - Vessel Time Exposure: 128% of Base Case VTE

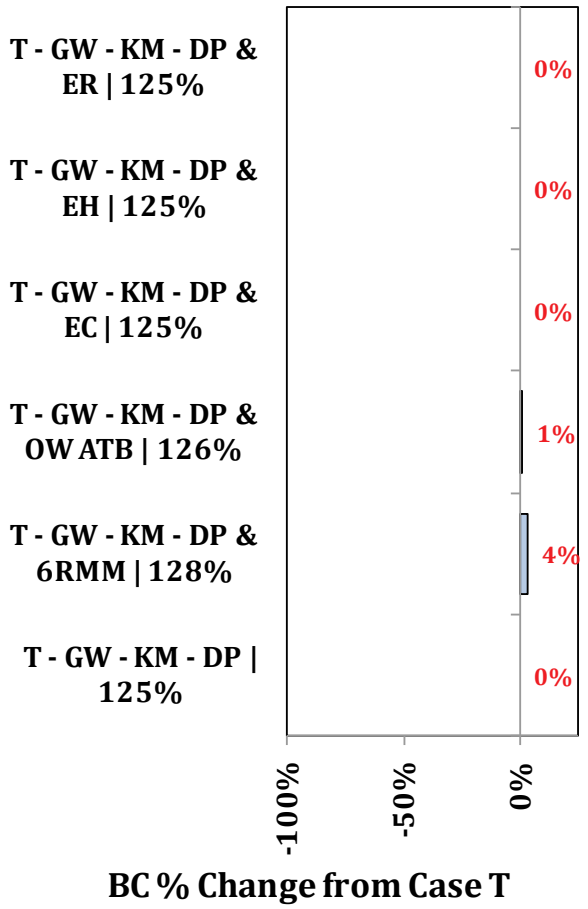
**+4%
from T**



6 RMM's

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

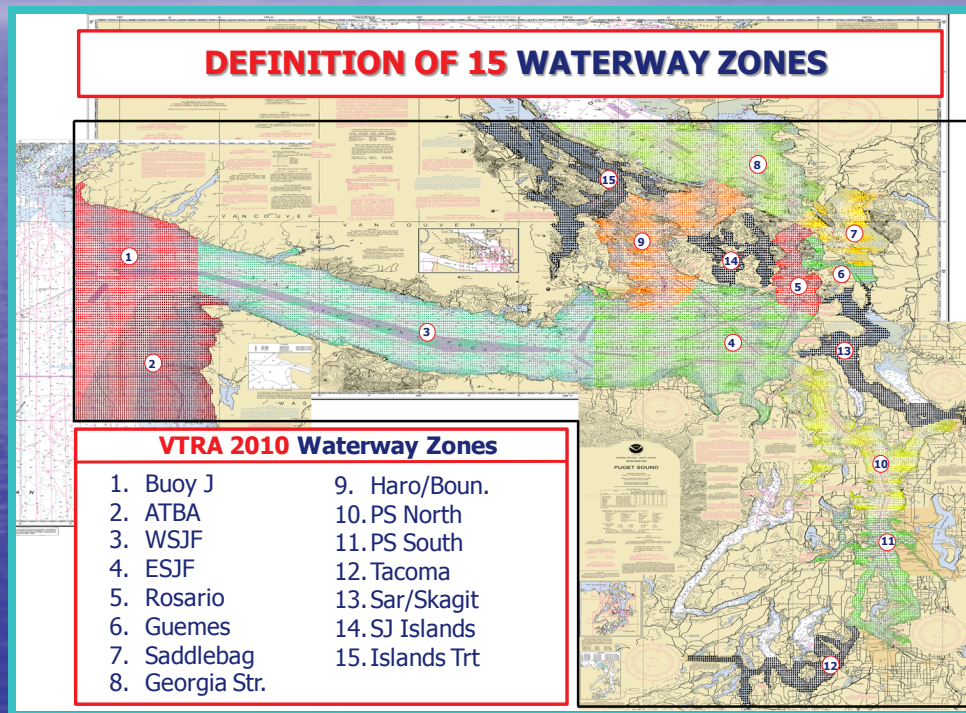
Annual Vessel Time Exposure (WI + BC Vessels)



VTRA 2010 – SYNOPSIS OF 3D SCENARIO COMPARISON

POTENTIAL ACCIDENT FREQUENCY

By What-if Focus Vessels and Base Case Focus Vessels



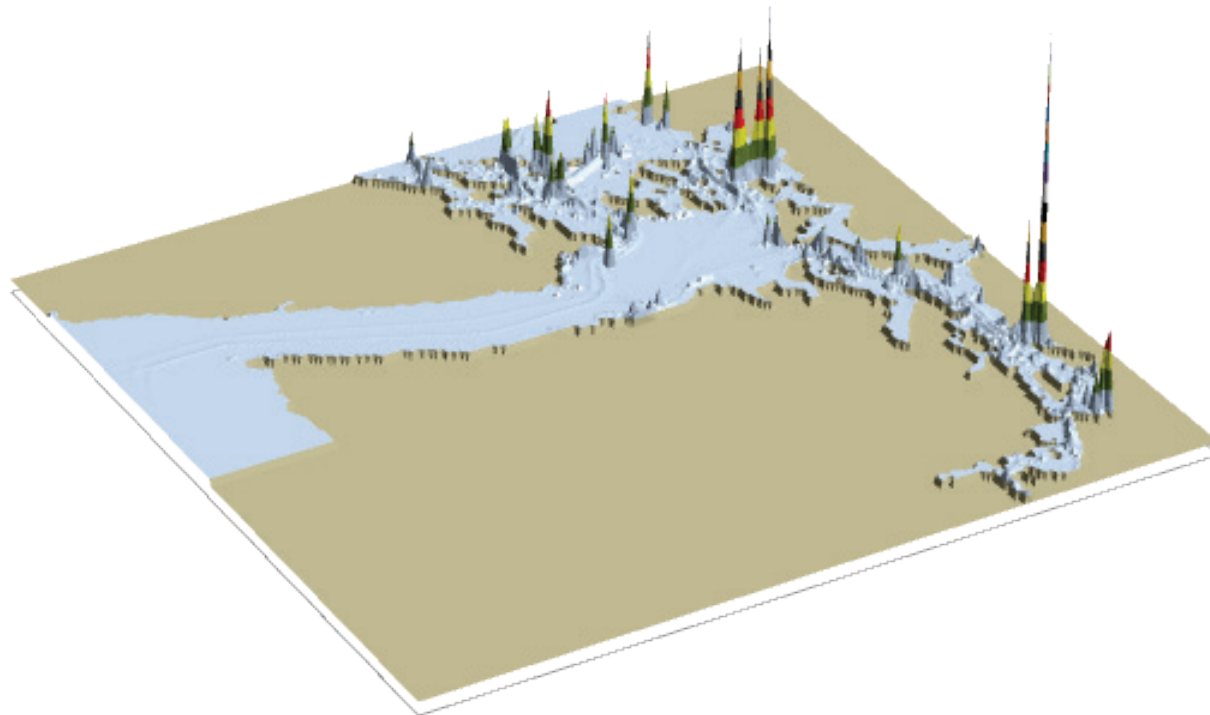
GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

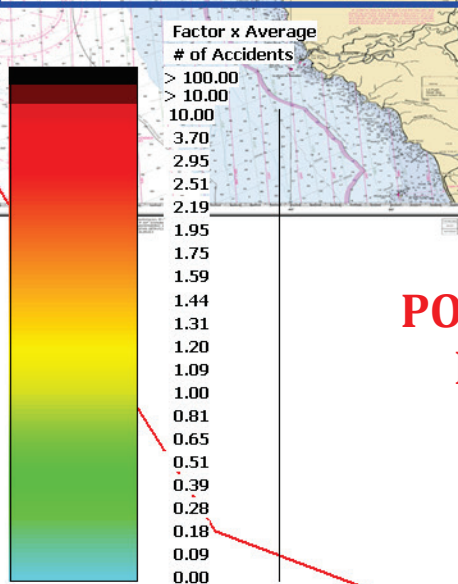
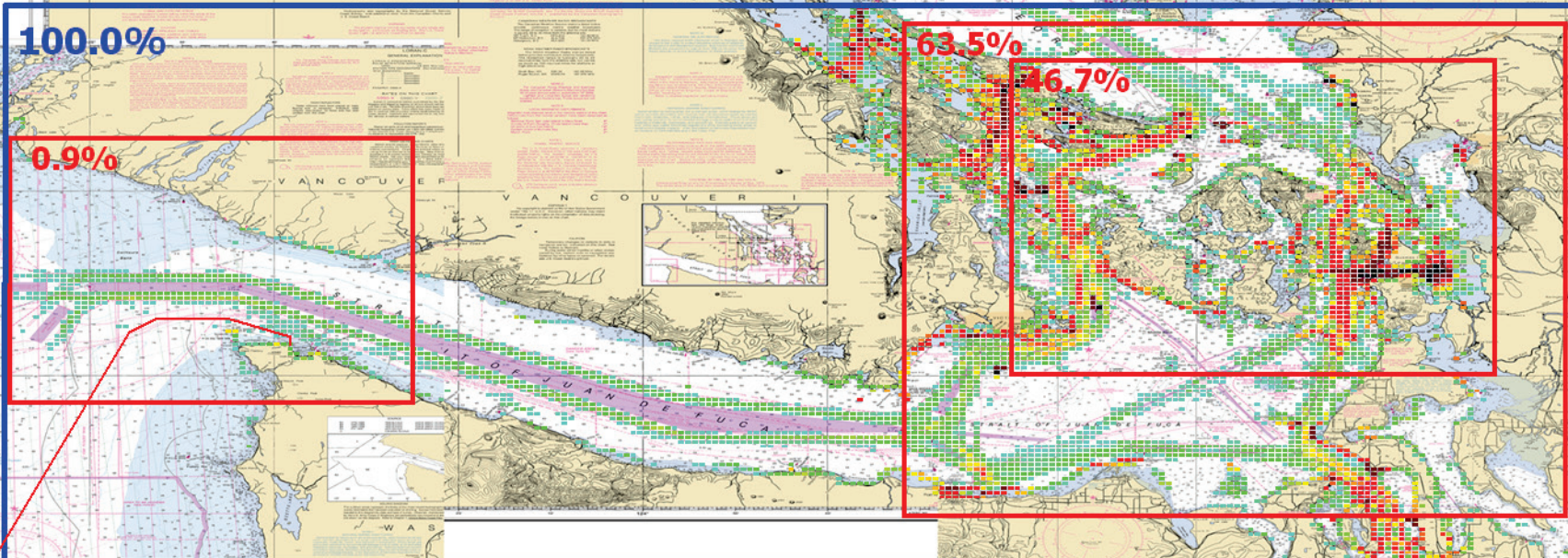
P: Base Case 3D Risk Profile All FV - Pot.Grou+Coll.Acc.Freq.: 100% of Base Case PCF

P: BC @ 100%



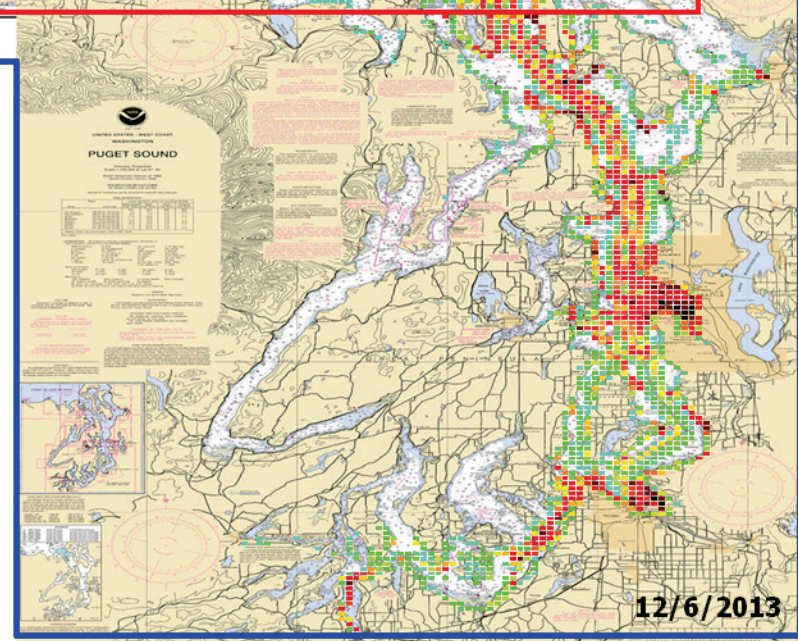
VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

P: VTRA 2010 - BASE CASE - ALL FV



P: BC @ 100%

POTENTIAL ACCIDENT FREQUENCY - PAF

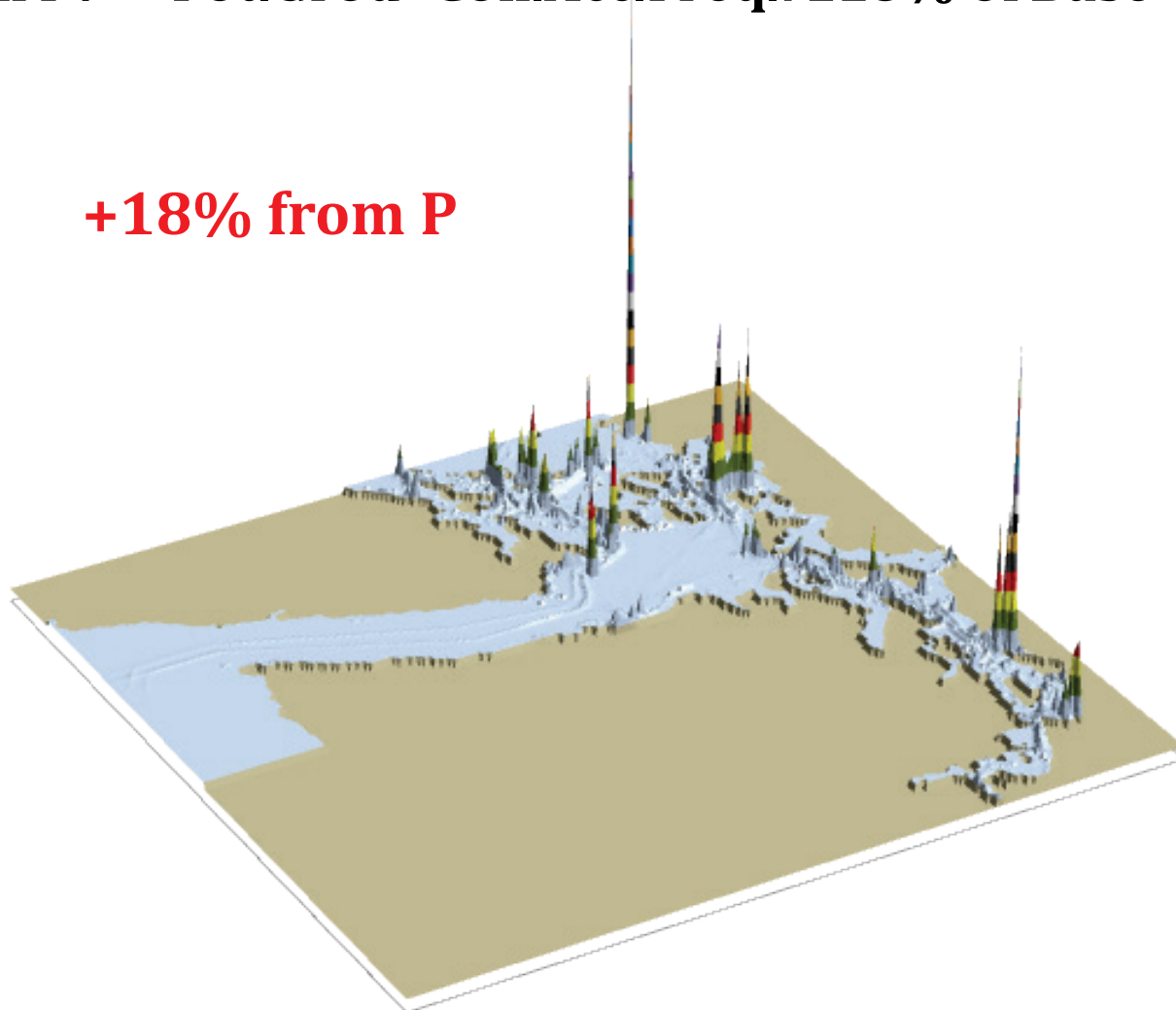


12/6/2013

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

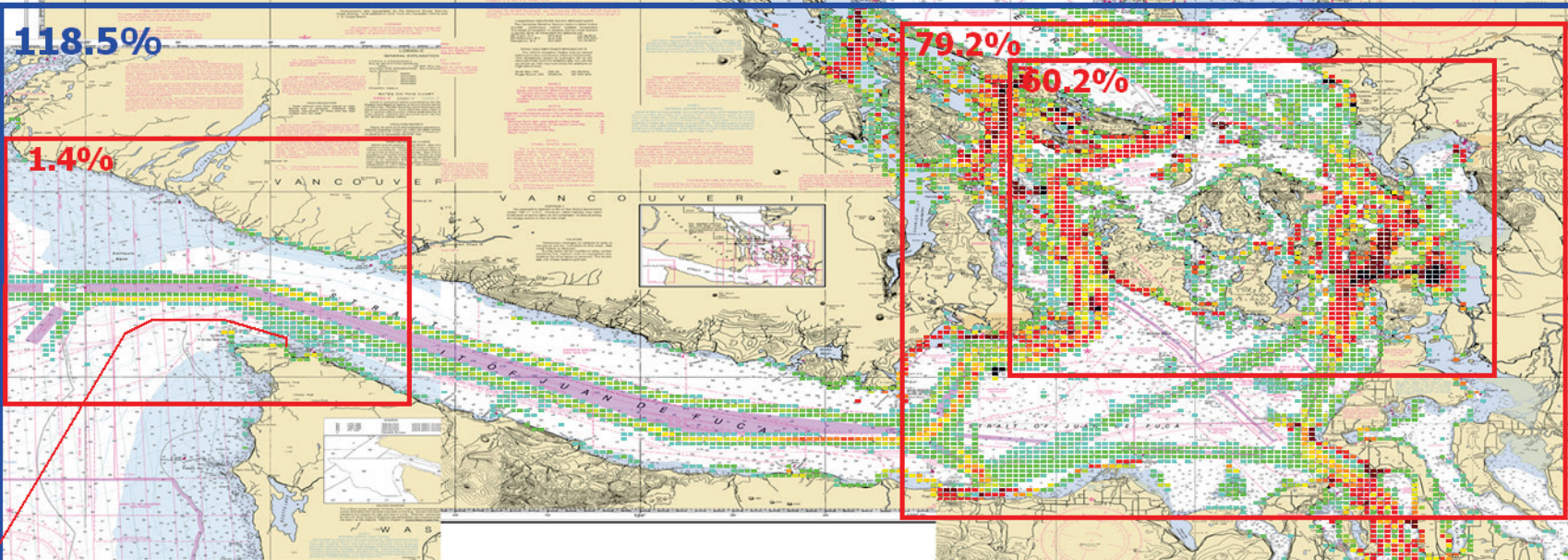
T: VTRA 2010 - GW 487- KM 348 - DP Cont. 67 and Bulk 348 - ALL FV

118.5%

1.4%

79.2%

50.2%



Factor x Average
of Accidents

- > 100.00
- > 10.00
- 10.00
- 3.70
- 2.95
- 2.51
- 2.19
- 1.95
- 1.75
- 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

+18% from P

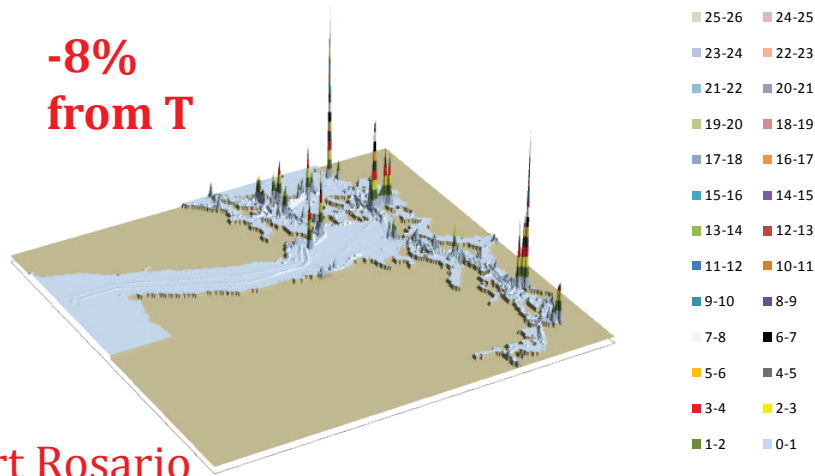
POTENTIAL ACCIDENT FREQUENCY - PAF

12/6/2013

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

T: GW - KM - DP & ER 3D Risk Profile
All FV - Pot.Grou+Coll.Acc.Freq.: 111% of Base Case PCF

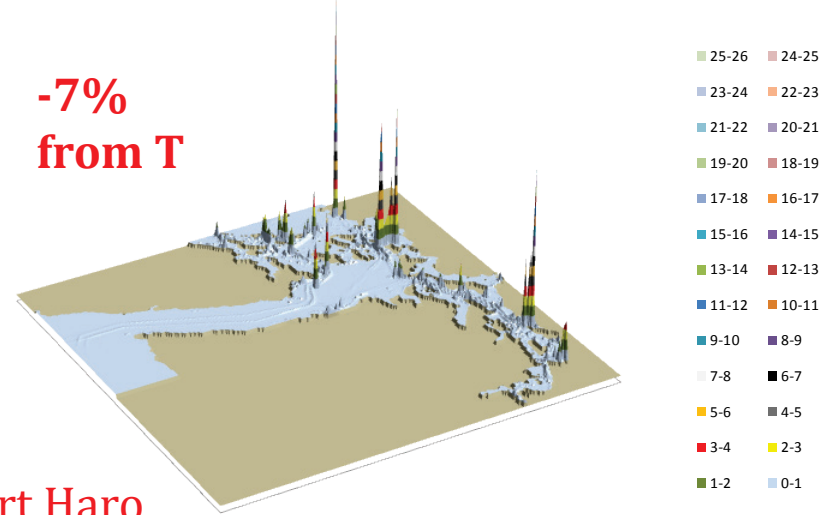
**-8%
from T**



Escort Rosario

T: GW - KM - DP & EH 3D Risk Profile
All FV - Pot.Grou+Coll.Acc.Freq.: 111% of Base Case PCF

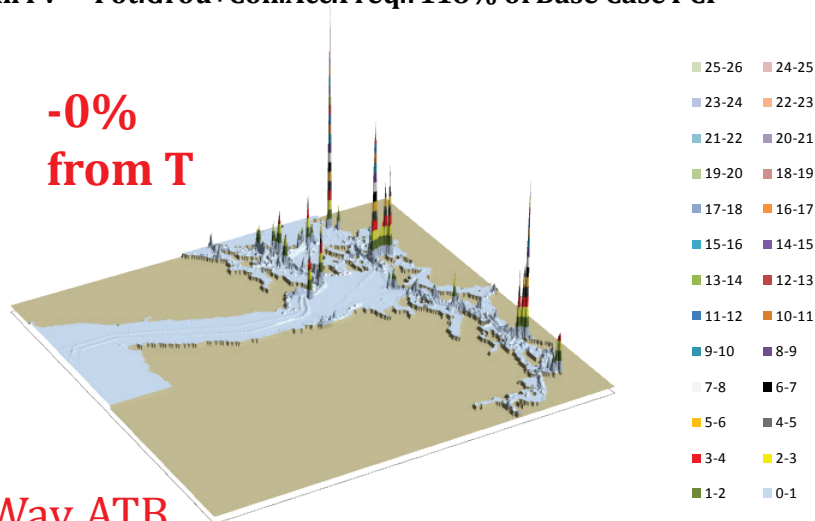
**-7%
from T**



Escort Haro

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

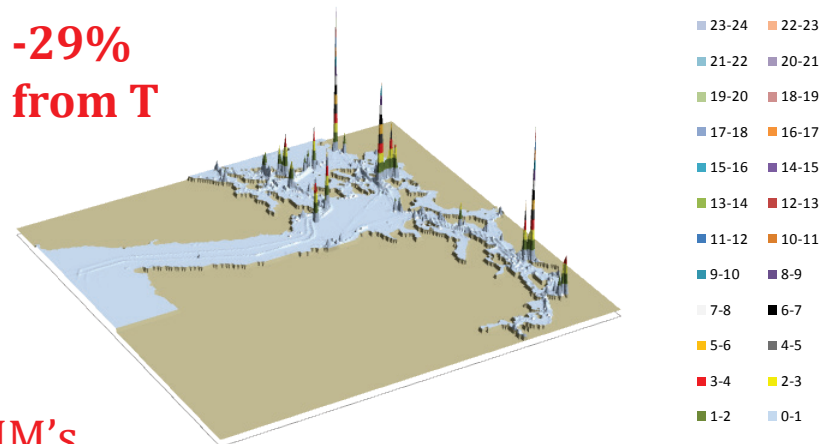
**-0%
from T**



One Way ATB

T: GW - KM - DP & 6 RMM 3D Risk Profile
All FV - Pot.Grou+Coll.Acc.Freq.: 89% of Base Case PCF

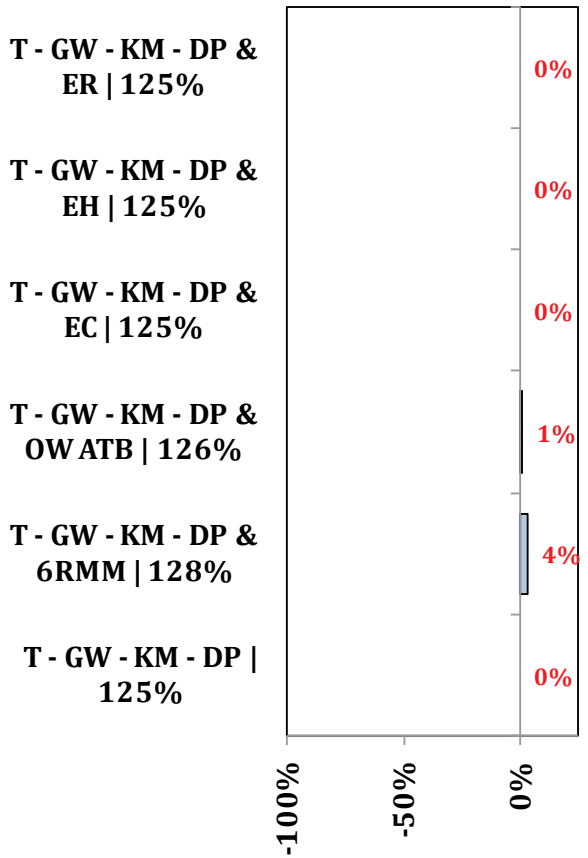
**-29%
from T**



6 RMM's

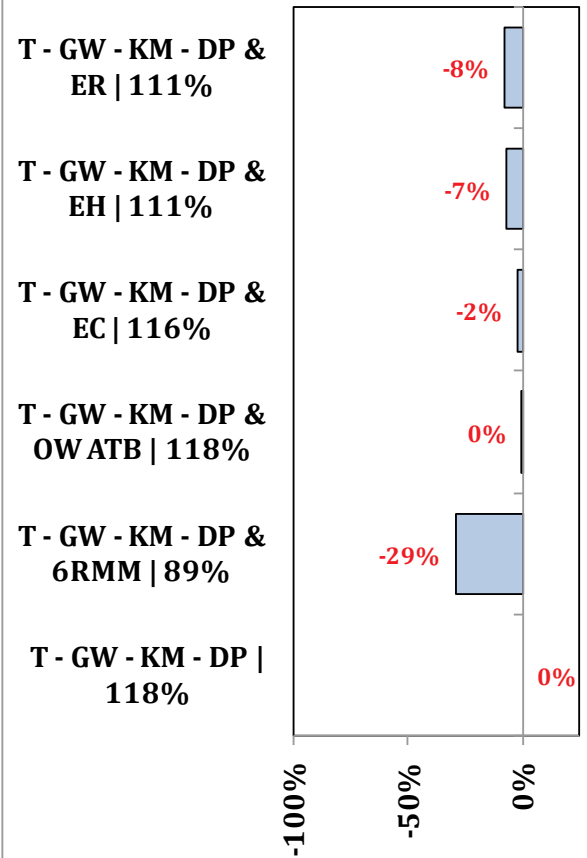
VTRA 2010 : VESSEL TIME EXPOSURE, POT. ACC. FREQ POT. OIL. LOSS COMPARISON ALL FOCUS VESSELS

Annual Vessel Time Exposure (WI + BC Vessels)



BC % Change from Case T

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



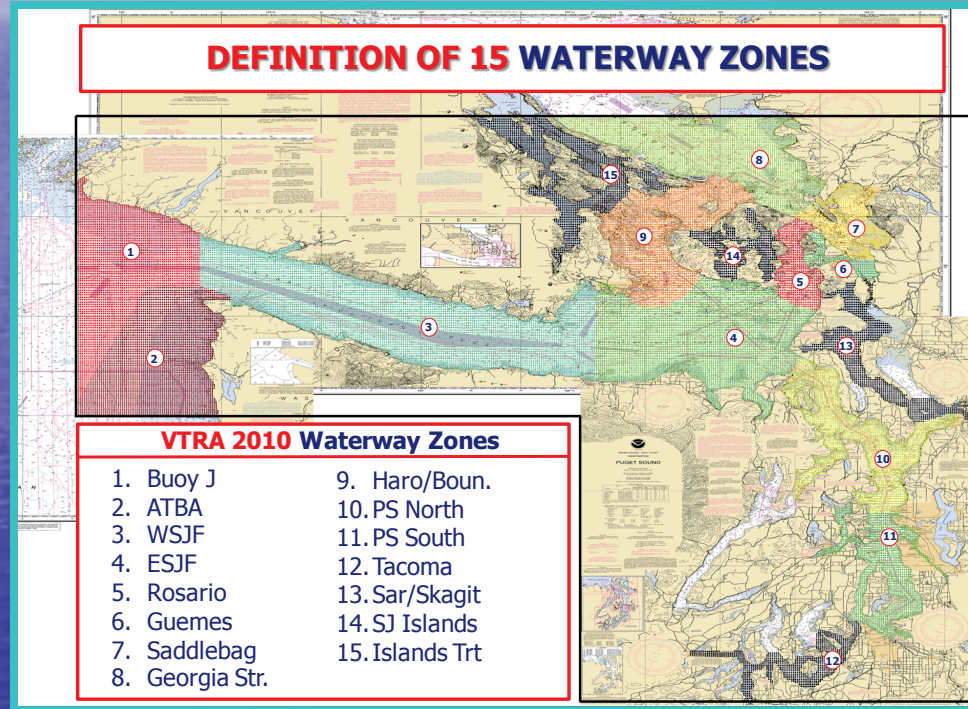
BC % Change from Case T



VTRA 2010 – SYNOPSIS OF 3D SCENARIO COMPARISON

POTENTIAL OIL LOSS

By What-if Focus Vessels and Base Case Focus Vessels



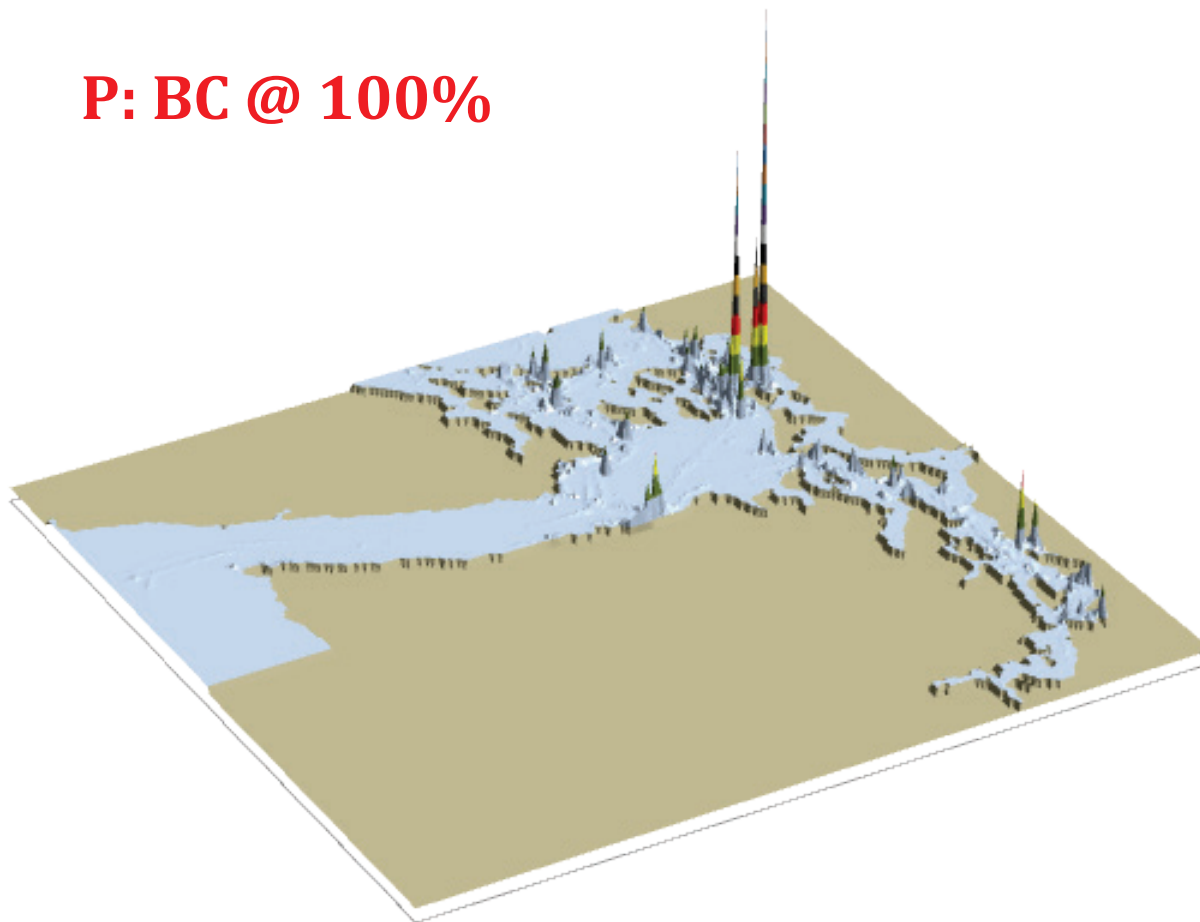
GWU Personnel: Dr. J. Rene van Dorp

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

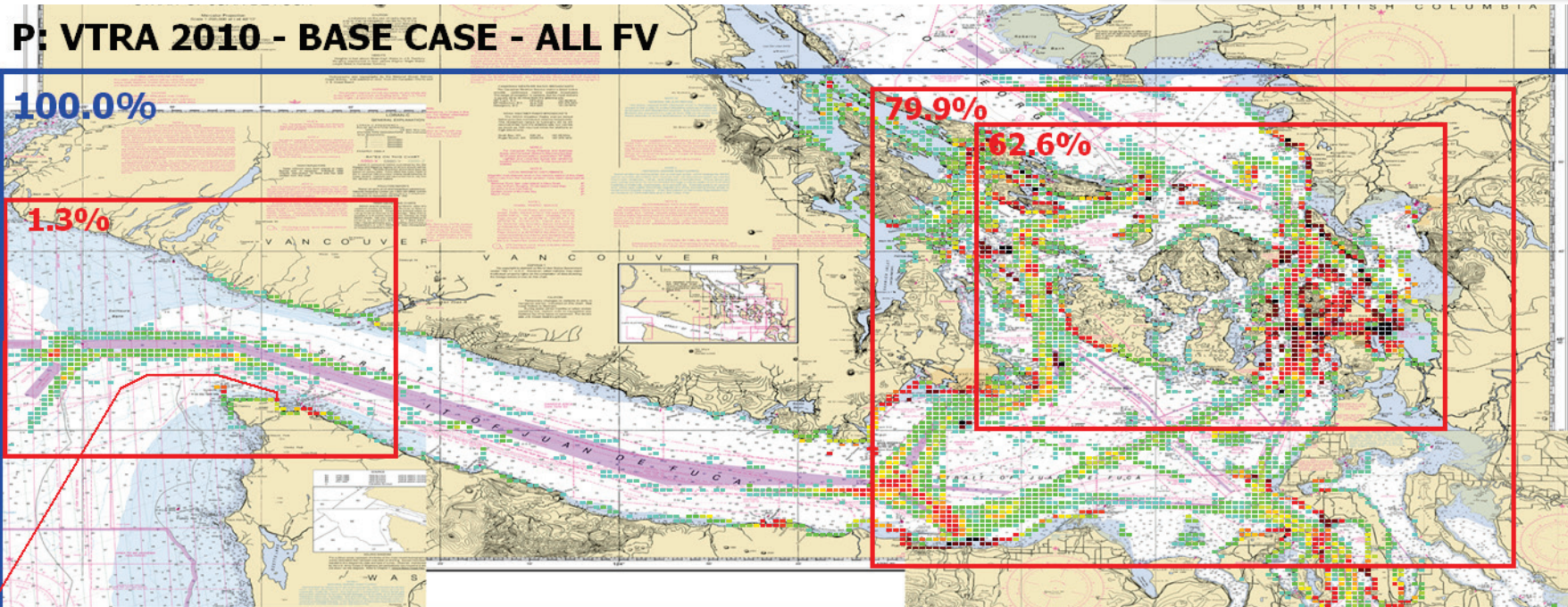
P: VTRA 2010 - BASE CASE - ALL FV

100.0%

1.3%

79.9%

62.6%

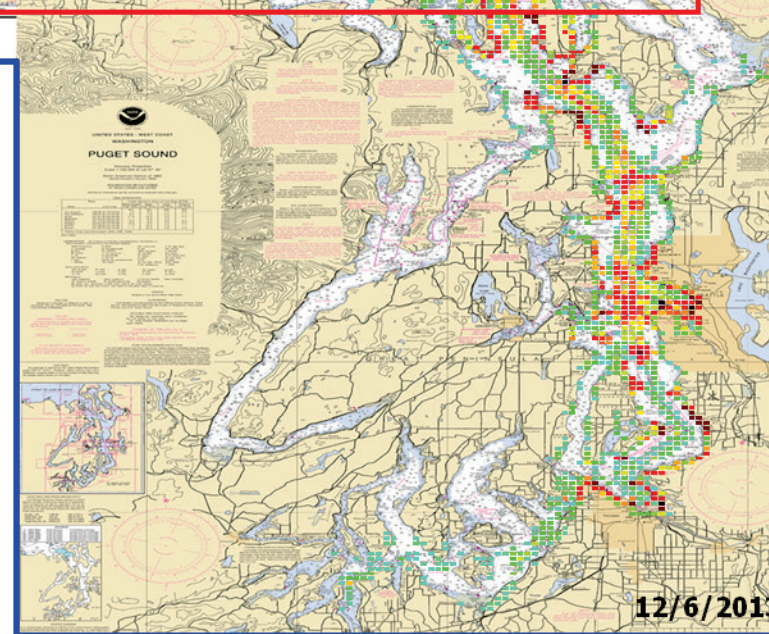


Factor x Average
Oil Outflow

- > 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

P: BC @ 100%

**POTENTIAL ACCIDENT
OIL LOSS - POL**

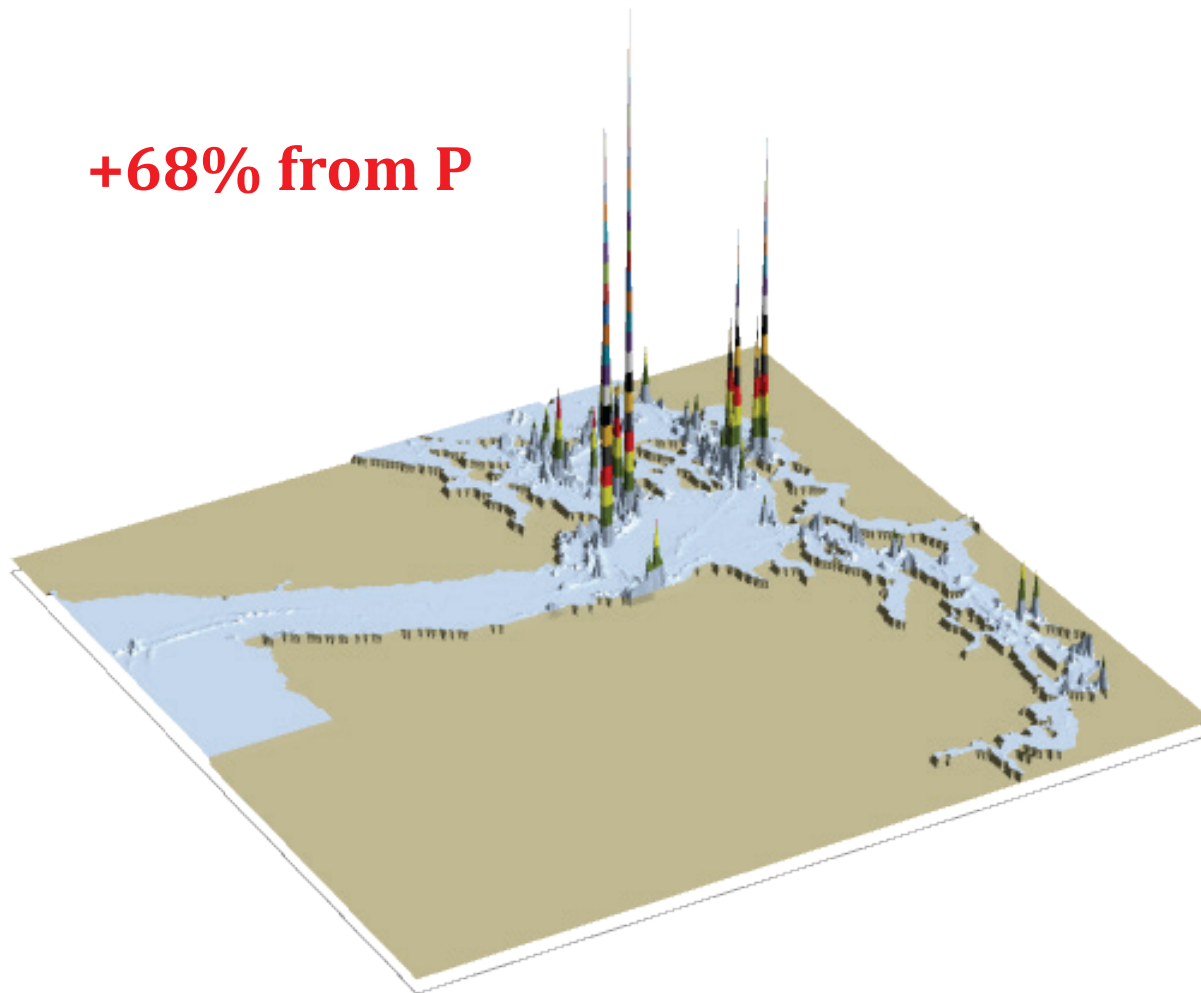


12/6/2013

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

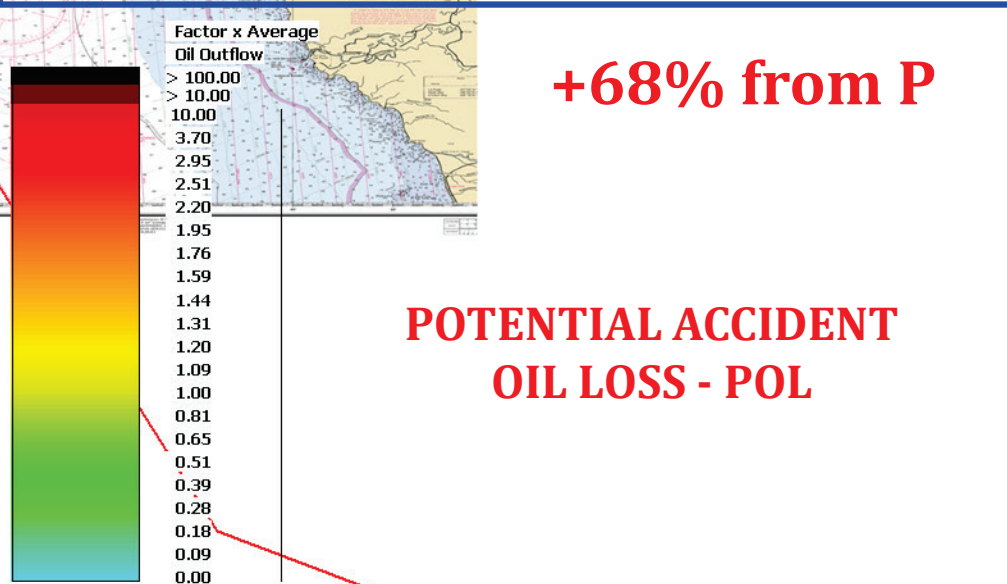
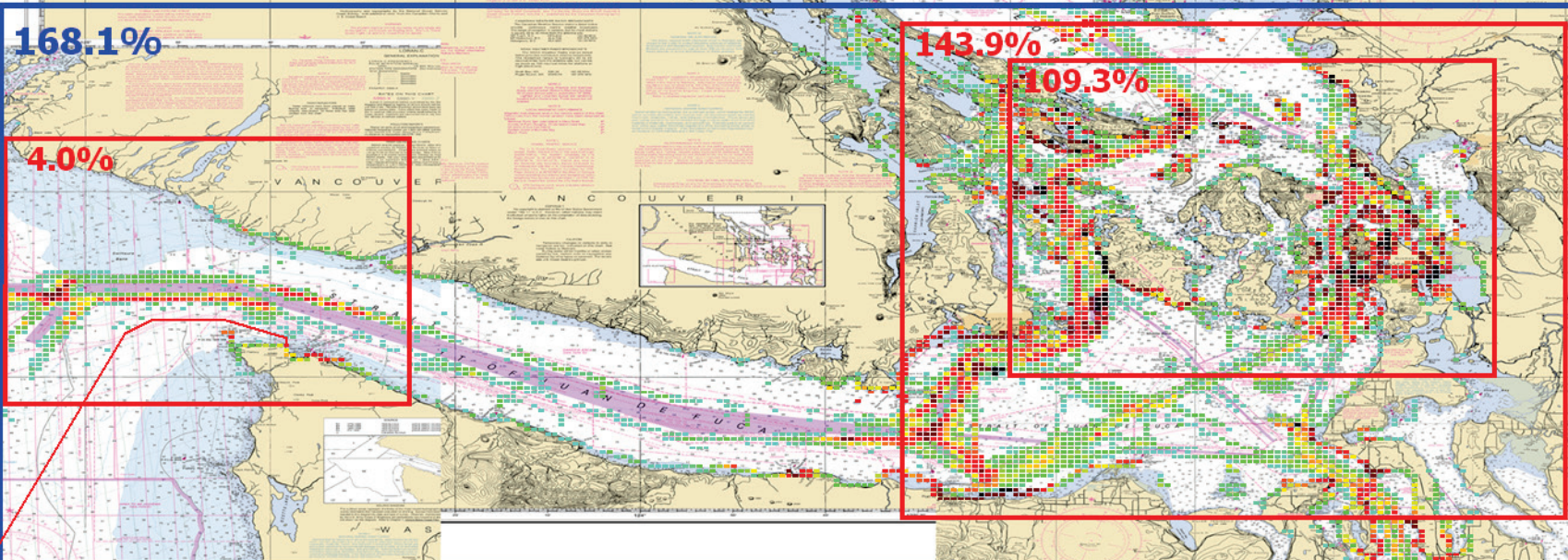
T: GW - KM - DP 3D Risk Profile All FV - Pot. Grou+Coll.Oil Loss: 168% of Base Case PCO

+68% from P



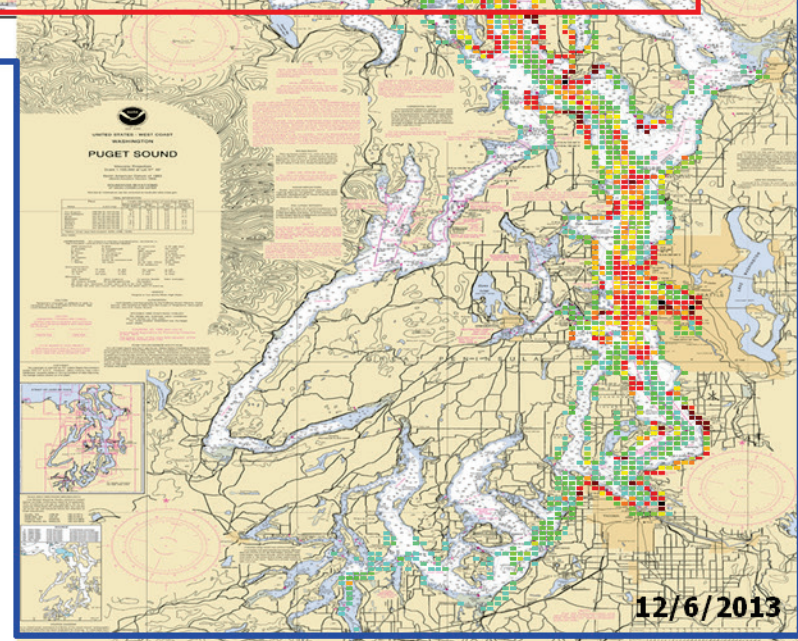
VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

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



+68% from P

POTENTIAL ACCIDENT OIL LOSS - POL

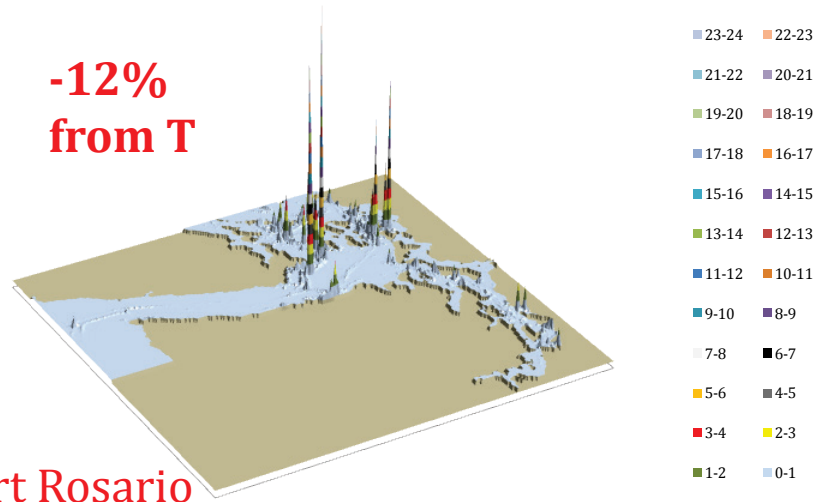


12/6/2013

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

T: GW - KM - DP & ER 3D Risk Profile
All FV - Pot. Grou+Coll.Oil Loss: 156% of Base Case PCO

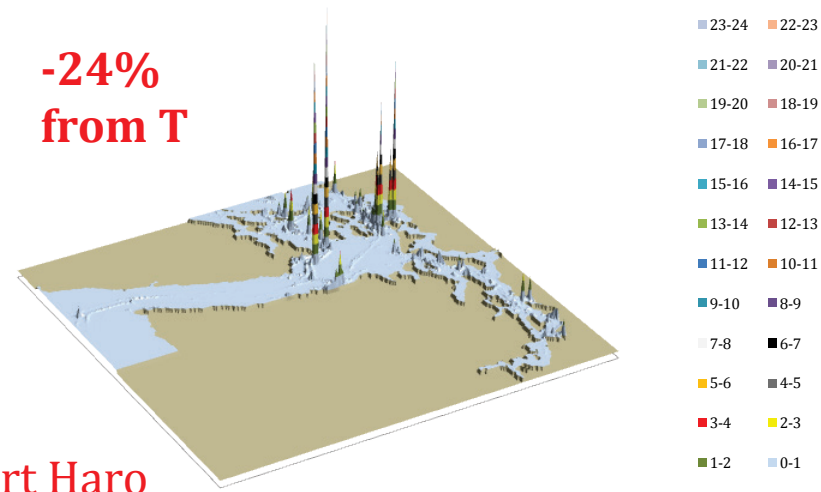
**-12%
from T**



Escort Rosario

T: GW - KM - DP & EH 3D Risk Profile
All FV - Pot. Grou+Coll.Oil Loss: 144% of Base Case PCO

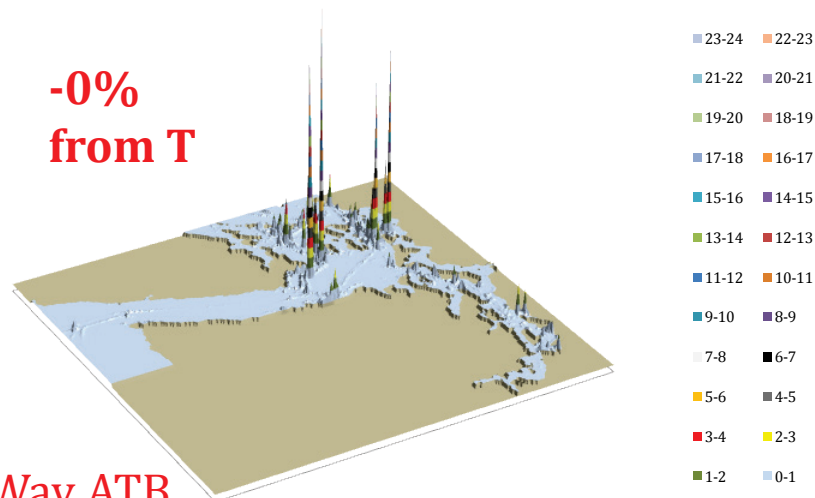
**-24%
from T**



Escort Haro

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

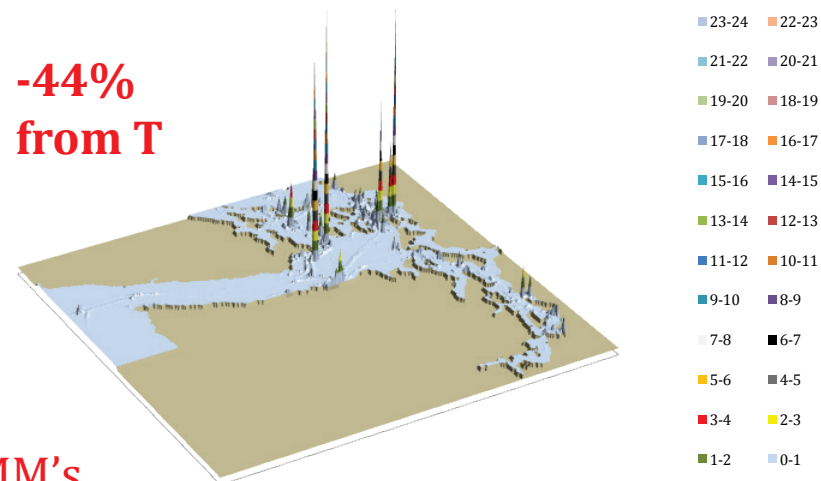
**-0%
from T**



One Way ATB

T: GW - KM - DP & 6 RMM 3D Risk Profile
All FV - Pot. Grou+Coll.Oil Loss: 124% of Base Case PCO

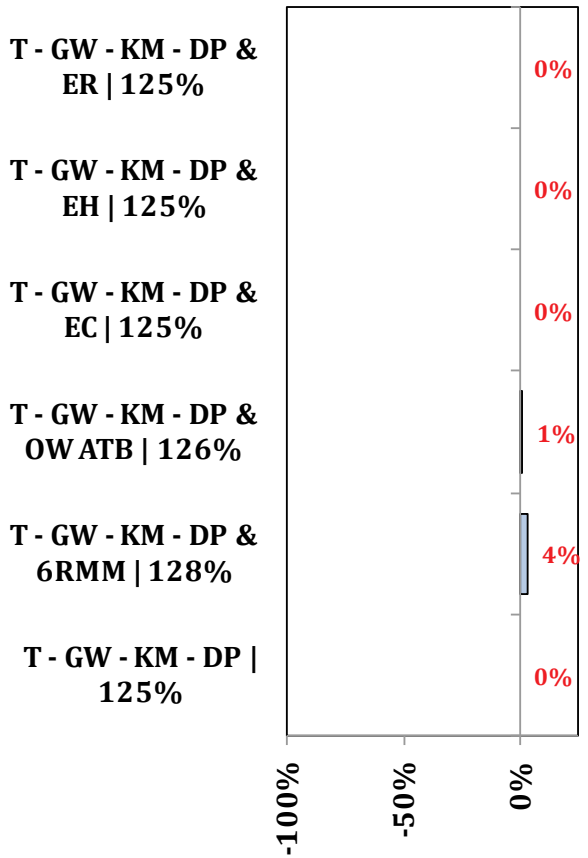
**-44%
from T**



6 RMM's

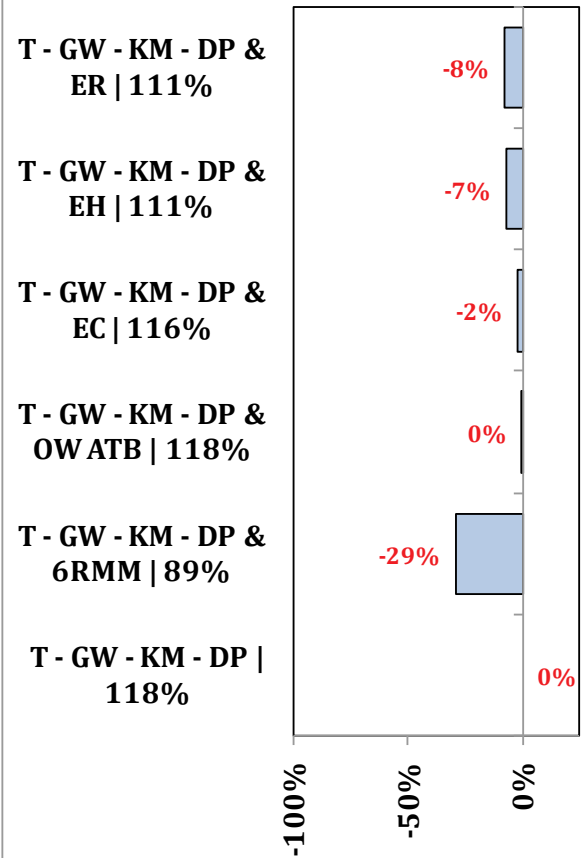
VTRA 2010 : VESSEL TIME EXPOSURE, POT. ACC. FREQ POT. OIL. LOSS COMPARISON ALL FOCUS VESSELS

Annual Vessel Time Exposure (WI + BC Vessels)



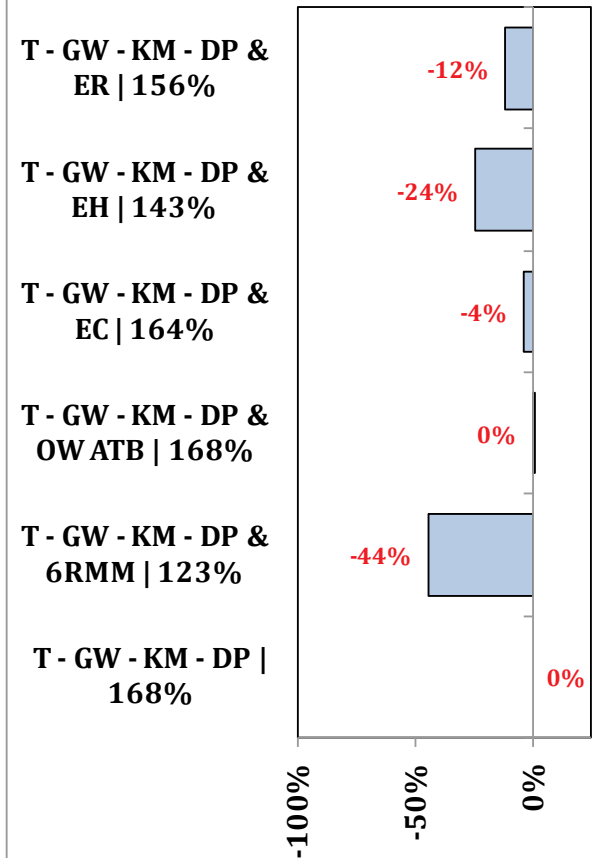
BC % Change from Case T

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



BC % Change from Case T

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

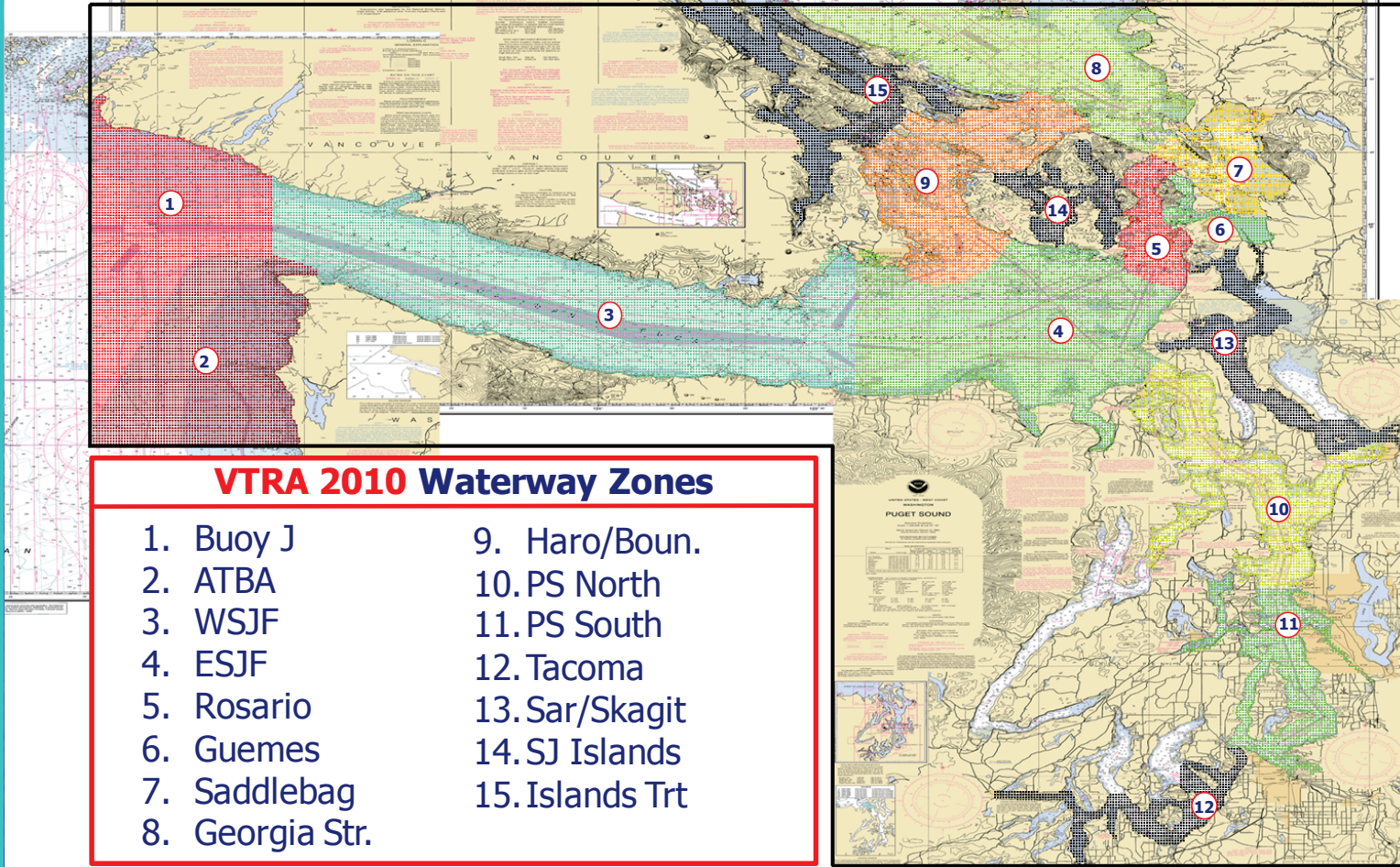


BC % Change from Case T



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

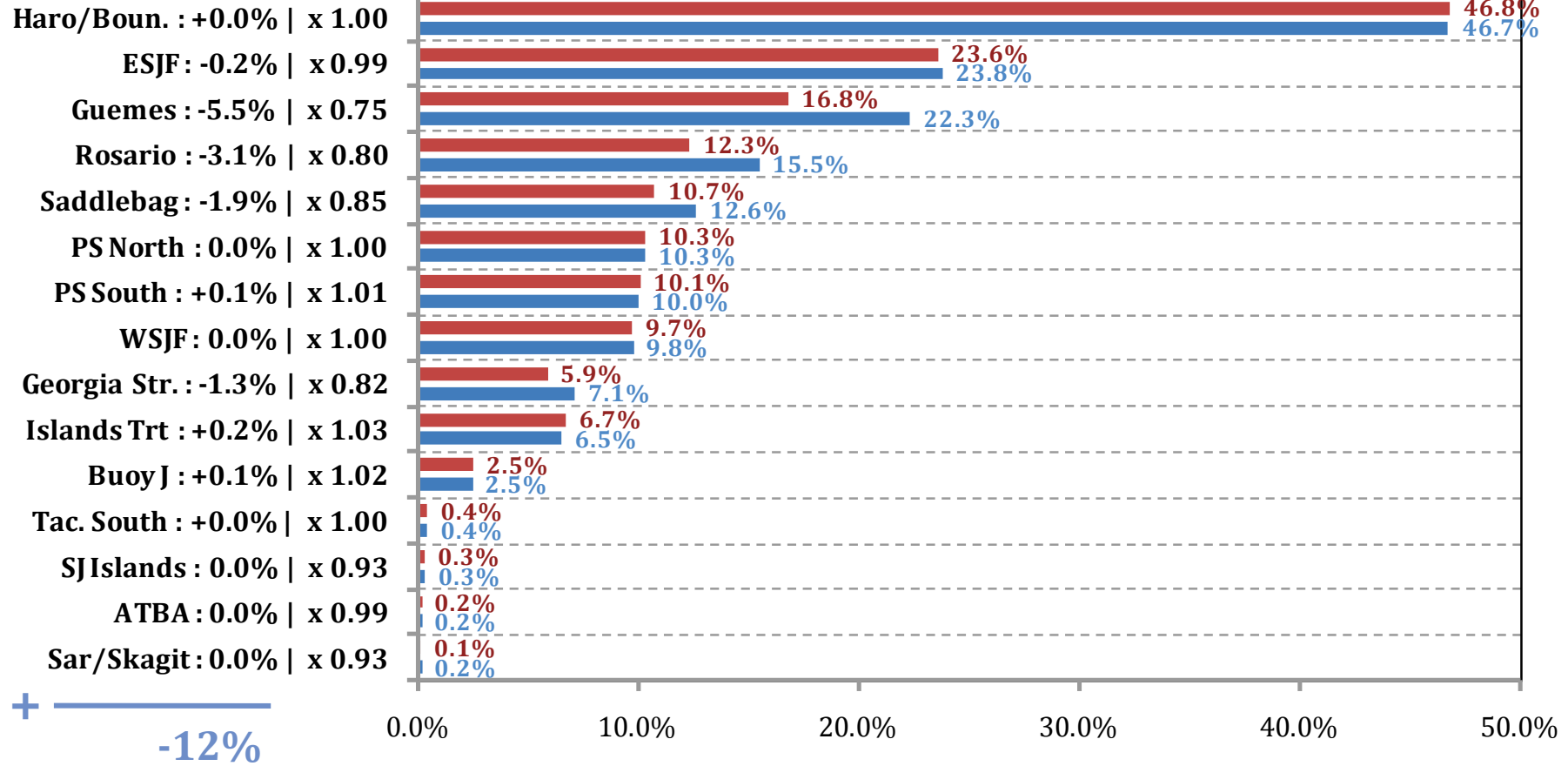
DEFINITION OF 15 WATERWAY ZONES



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

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

Waterway Zone:



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

■ T:GW - KM - DP & ER : 156% (-11.7% | x 0.93) ■ T:GW - KM - DP : 168%

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

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

Waterway Zone:

Haro/Boun. : -18.5% | x 0.60

ESJF: -2.2% | x 0.91

Guemes : +1.1% | x 1.05

Rosario : -0.5% | x 0.97

Saddlebag: -0.4% | x 0.97

PS North : +0.0% | x 1.00

PS South : 0.0% | x 1.00

WSJF: -1.4% | x 0.86

Georgia Str. : -0.9% | x 0.87

Islands Trt : -1.6% | x 0.76

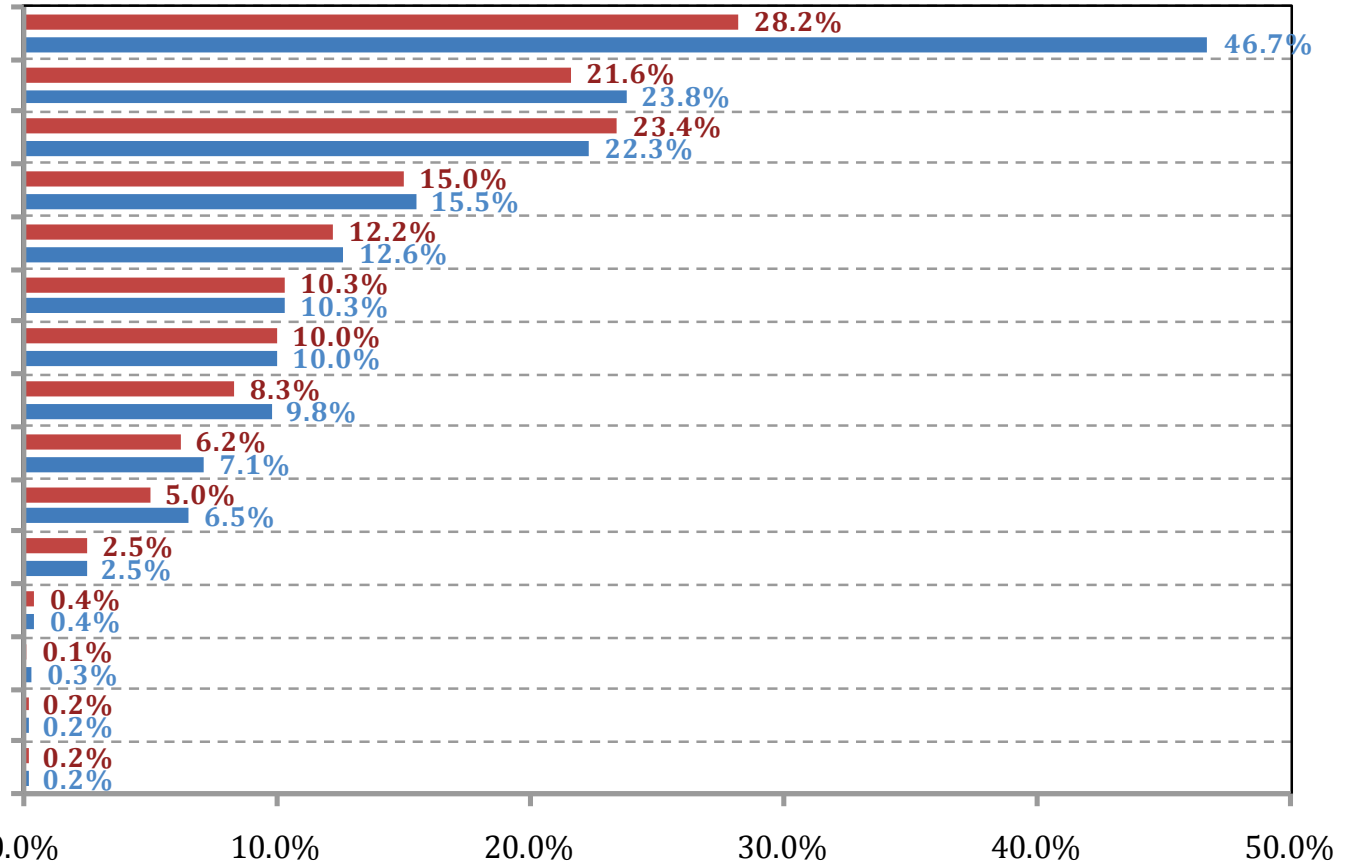
Buoy J : +0.1% | x 1.02

Tac. South : 0.0% | x 1.00

SJIslands : -0.2% | x 0.41

ATBA : 0.0% | x 0.99

Sar/Skagit : 0.0% | x 0.99



+ -24%

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

■ T:GW - KM - DP & EH: 144% (-24.5% | x 0.85) ■ T:GW - KM - DP : 168%

T & EH

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

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

Waterway Zone:

Haro/Boun. : -2.6% | x 0.94

ESJF: -0.3% | x 0.99

Guemes : +1.1% | x 1.05

Rosario : -0.8% | x 0.95

Saddlebag: -0.6% | x 0.96

PS North : 0.0% | x 1.00

PS South : +0.0% | x 1.00

WSJF: -0.1% | x 0.99

Georgia Str. : -0.9% | x 0.88

Islands Trt : +0.1% | x 1.01

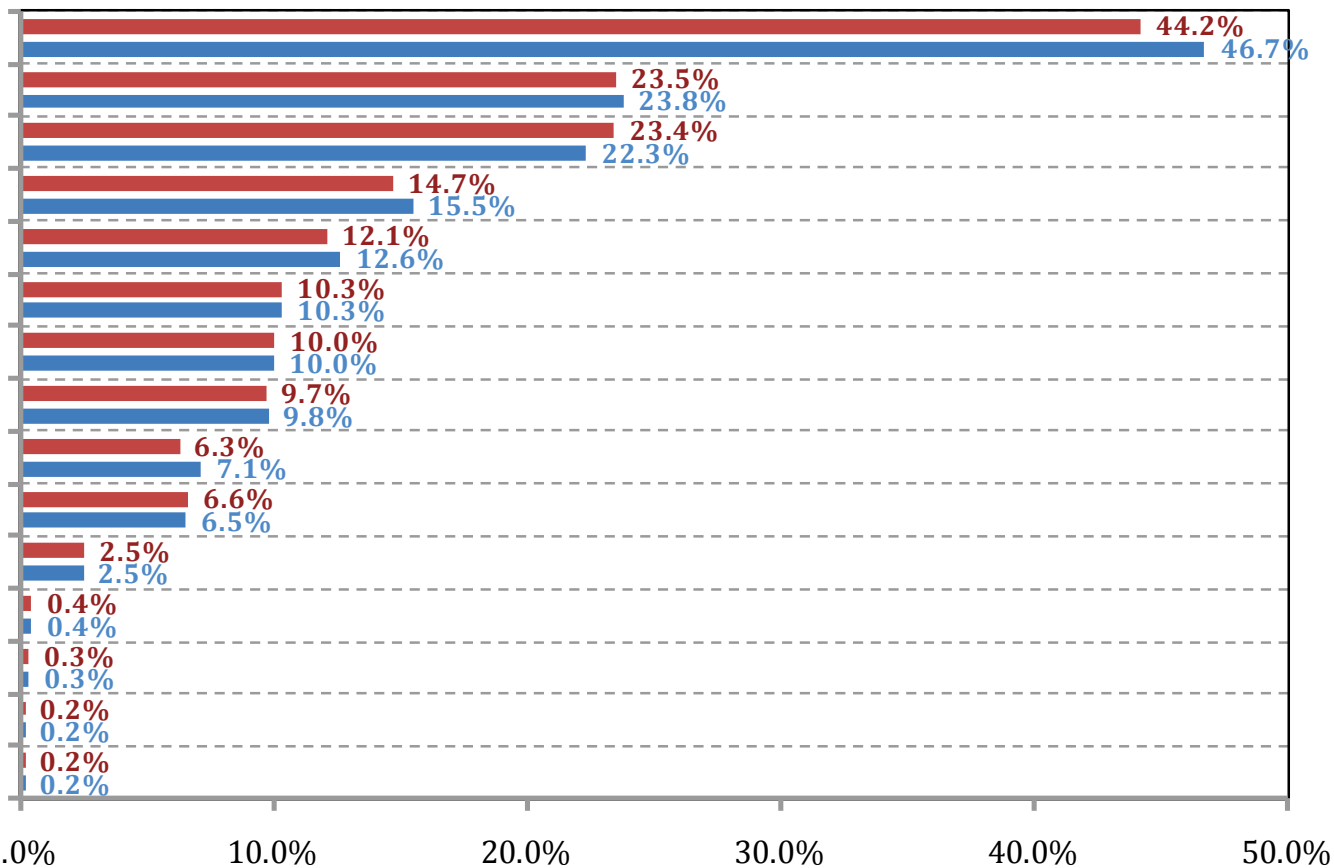
Buoy J : +0.1% | x 1.02

Tac. South : +0.0% | x 1.00

SJIslands : 0.0% | x 0.97

ATBA : 0.0% | x 0.99

Sar/Skagit : +0.0% | x 1.00



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

■ T:GW - KM - DP & EC : 164% (-3.9% | x 0.98)

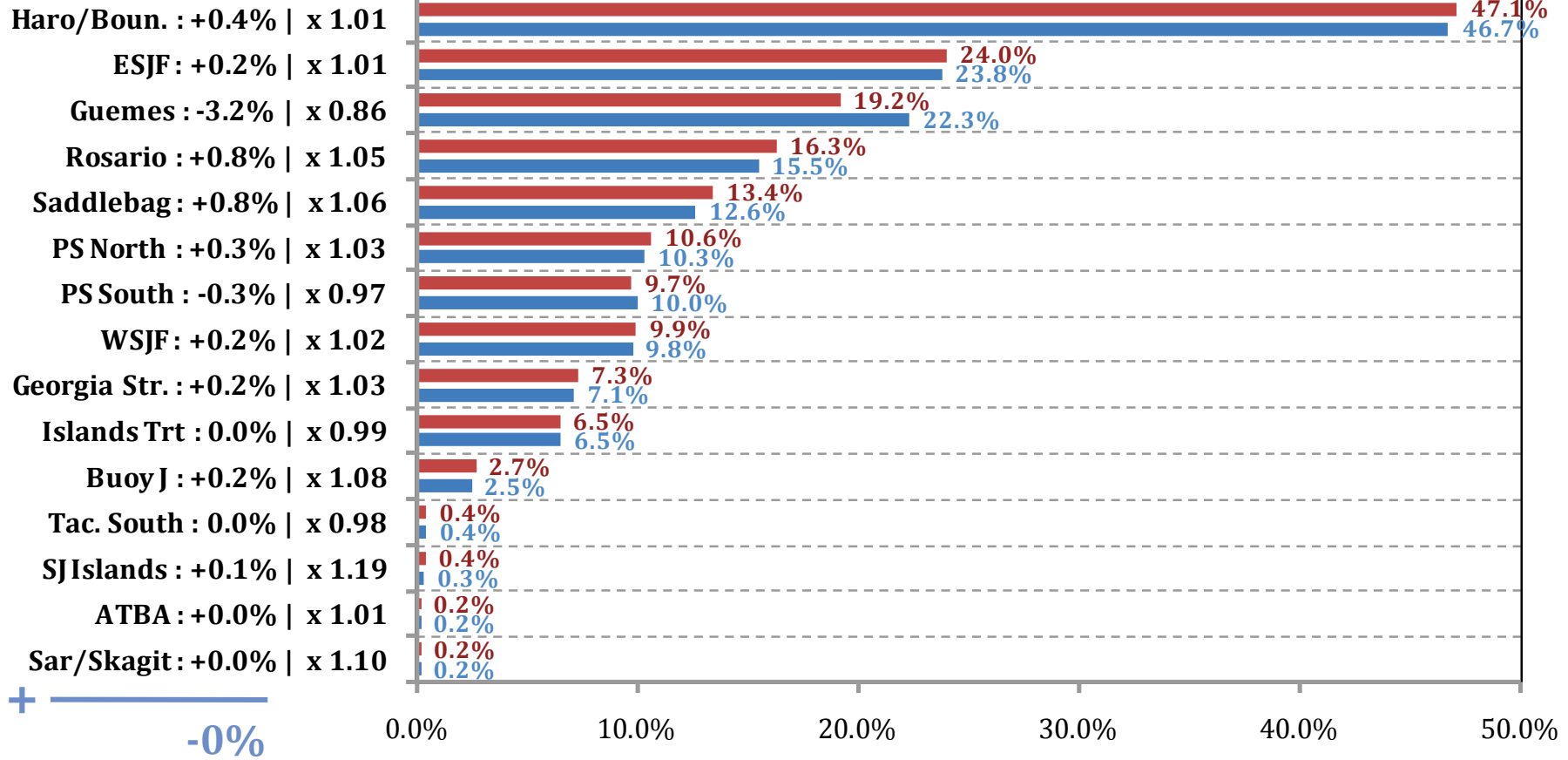
■ T:GW - KM - DP : 168%

T & EC

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

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

Waterway Zone:



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

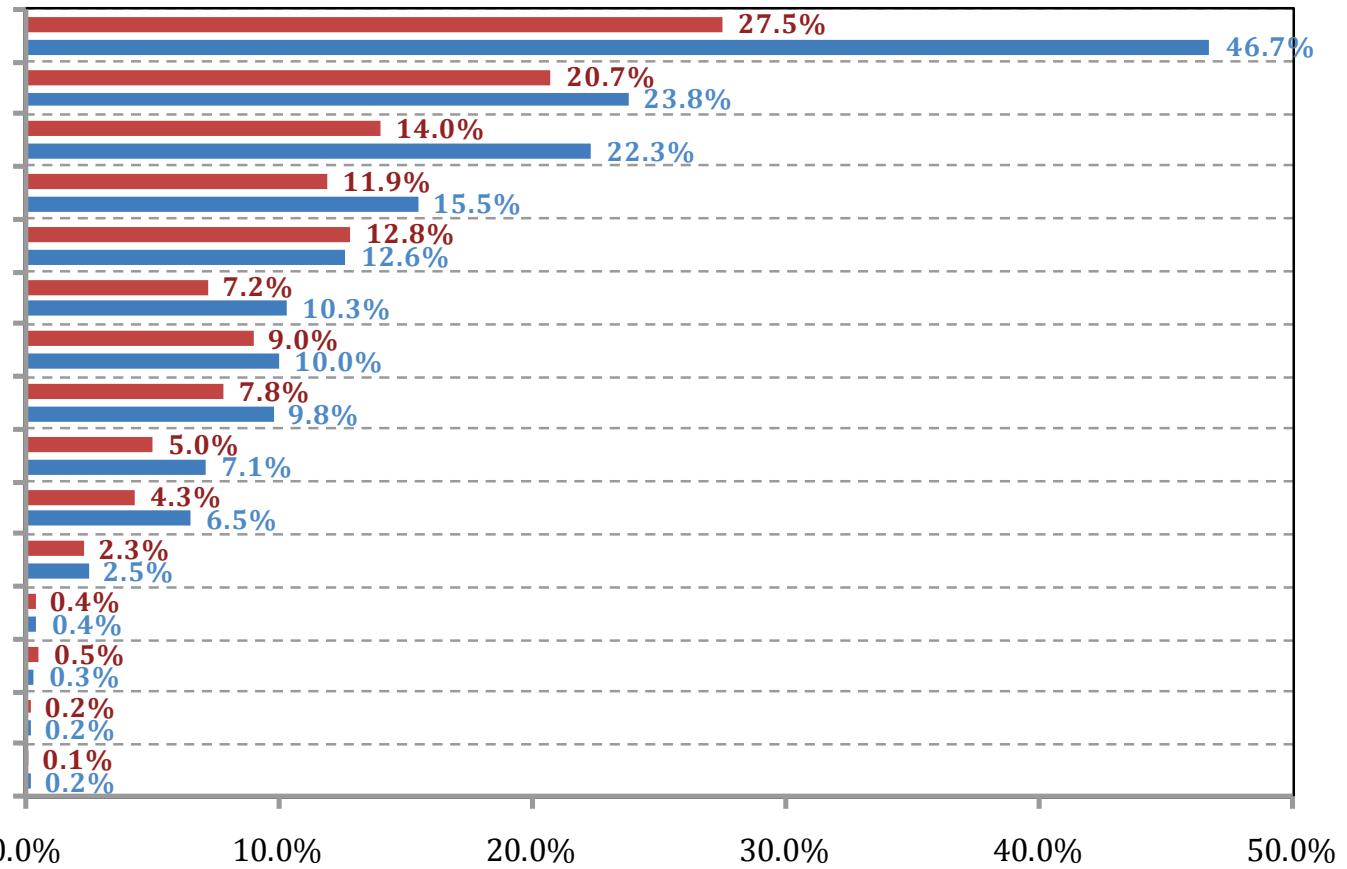
T & OW ATB ■ T:GW - KM - DP & OW ATB: 168% (-0.3% | x 1.00) ■ T:GW - KM - DP: 168%

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

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

Waterway Zone:

Haro/Boun. : -19.3% | x 0.59
 ESJF : -3.0% | x 0.87
 Guemes : -8.3% | x 0.63
 Rosario : -3.6% | x 0.77
 Saddlebag : +0.2% | x 1.01
 PS North : -3.1% | x 0.70
 PS South : -1.0% | x 0.90
 WSJF : -1.9% | x 0.80
 Georgia Str. : -2.1% | x 0.71
 Islands Trt : -2.2% | x 0.67
 Buoy J : -0.2% | x 0.93
 Tac. South : -0.1% | x 0.81
 SJIslands : +0.2% | x 1.56
 ATBA : 0.0% | x 0.97
 Sar/Skagit : -0.1% | x 0.46



+ **-44%**

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

T & 6RMM

■ T:GW - KM - DP & 6 RMM: 124% (-44.5% | x 0.74) ■ T:GW - KM - DP: 168%