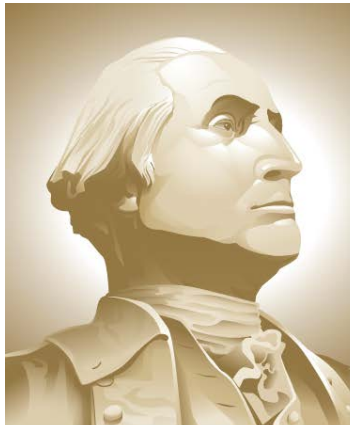


VTRA 2015 Base Case Construction and Comparison to VTRA 2015 Calibration Case



**THE GEORGE
WASHINGTON
UNIVERSITY**

WASHINGTON, DC

VCU

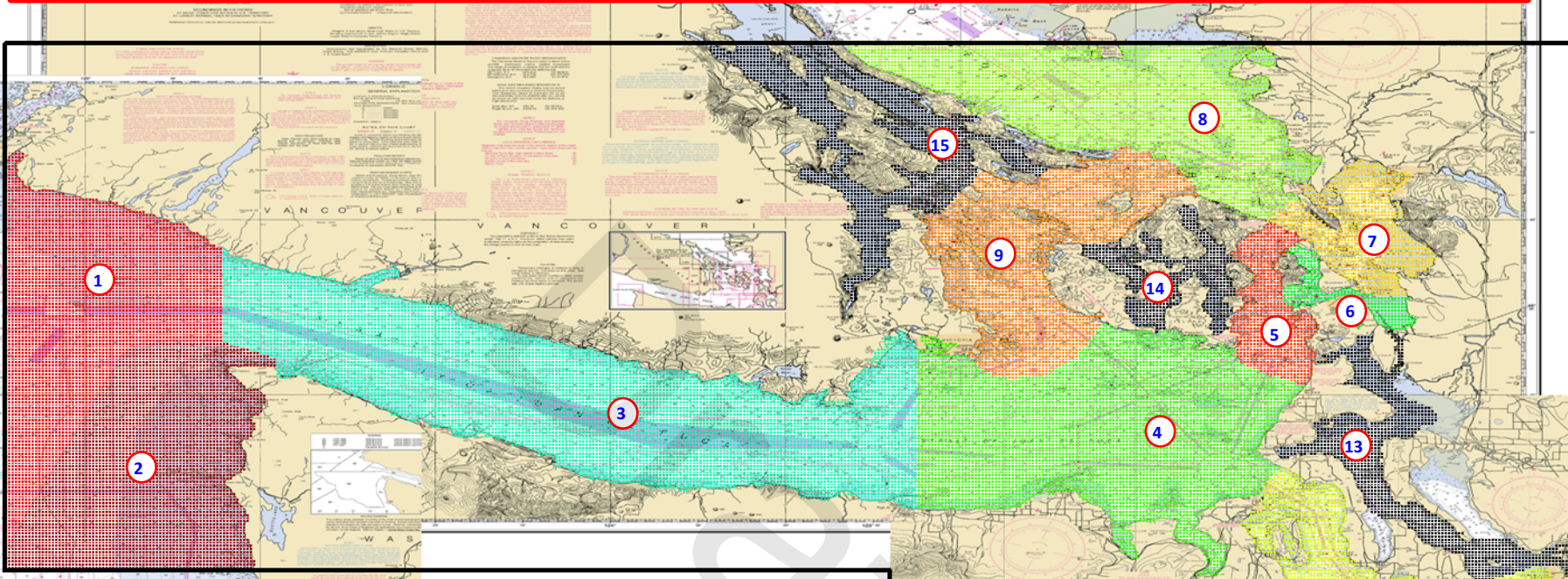
Jason R.W. Merrick (VCU) and J. Rene van Dorp (GW)

July, 2016

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

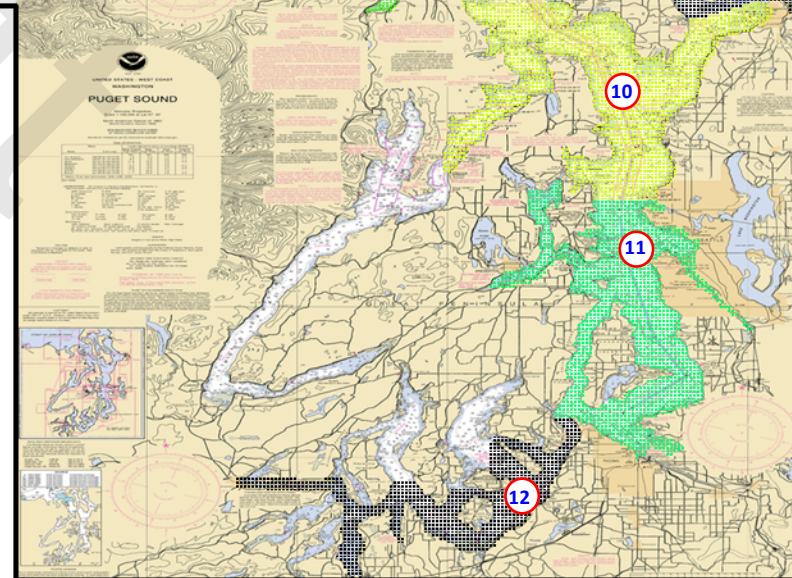


DEFINITION OF 15 WATERWAY ZONES



VTRA 2015 Waterway Zones

- | | |
|-----------------|---------------------------|
| 1. Buoy J | 9. Haro/Boun. |
| 2. ATBA | 10. PS North |
| 3. WSJF | 11. PS South |
| 4. ESJF | 12. Tacoma |
| 5. Rosario | 13. Sar/Skagit |
| 6. Guemes | 14. SJ Islands |
| 7. Saddlebag | 15. Southern Gulf Islands |
| 8. Georgia Str. | |



VESSEL TRAFFIC RISK ASSESSMENT (VTRA 2015)

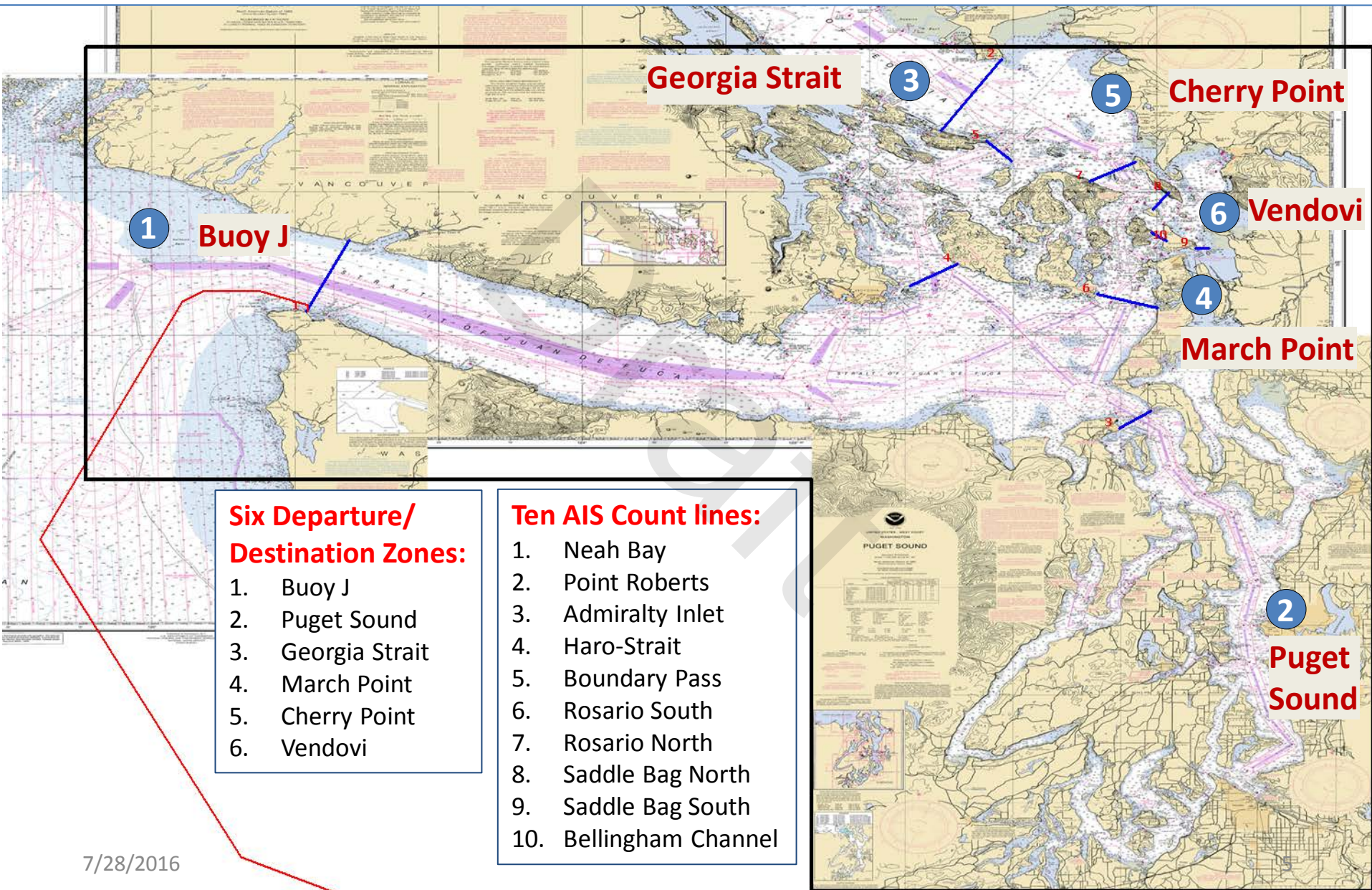
BASE CASE CONSTRUCTION INFORMED BY
AIS 2010 - 2015 TRAFFIC STREAM ANALYSIS

Jason R.W. Merrick (VCU) and J. Rene van Dorp (GW)

July, 2016



VESSEL TRAFFIC RISK ASSESSMENT (VTRA 2015)



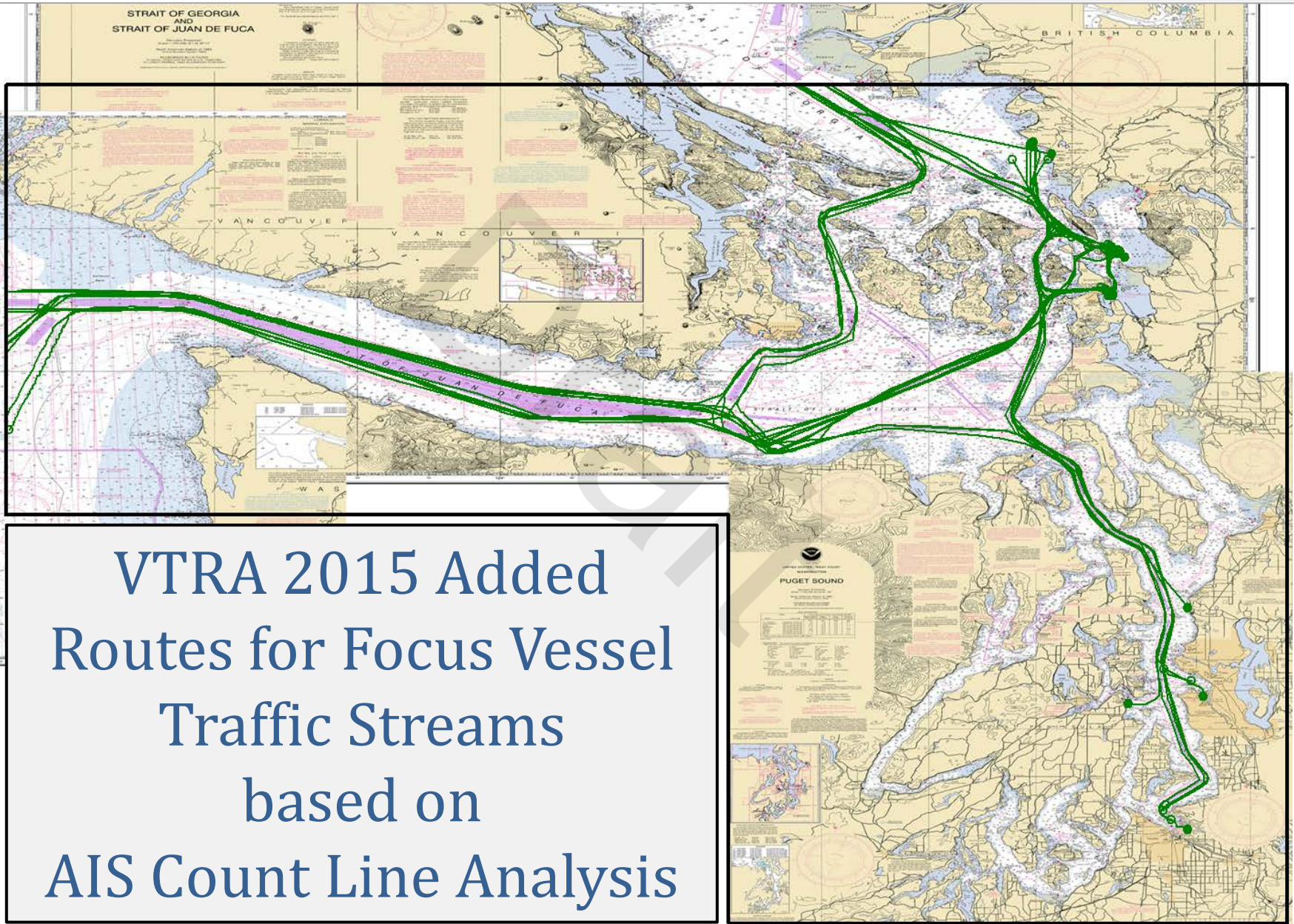
Six Departure/ Destination Zones:

1. Buoy J
2. Puget Sound
3. Georgia Strait
4. March Point
5. Cherry Point
6. Vendovi

Ten AIS Count lines:

1. Neah Bay
2. Point Roberts
3. Admiralty Inlet
4. Haro-Strait
5. Boundary Pass
6. Rosario South
7. Rosario North
8. Saddle Bag North
9. Saddle Bag South
10. Bellingham Channel

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



VTRA 2015 Added
Routes for Focus Vessel
Traffic Streams
based on
AIS Count Line Analysis

Georgia Strait

3

Point Roberts Crossing Line

VTRA 2015 Waterway Schematic + AIS Crossing Lines

5

Cherry Point

6

Vendovi

Neah Bay Crossing Line

Haro Crossing Lines

Rosario Crossing Lines

Bellingham Channel Crossing Line

Saddle Bag Crossing Lines

4

March Point

Admiralty Inlet Crossing Line

1

Buoy J

AVERAGE VESSEL COUNT ERROR		
ATB	Cargo	Tanker
5	99	12

Per Year

2

Puget Sound

VESSEL TRAFFIC RISK ASSESSMENT (VTRA 2015)



6 Departure Zones/Destination Zone

1: Buoy J Zone 3: Georgia Strait Zone 5: Cherry Point Zone
2: Puget Sound South Zone 4: March Point Zone 6: Vendovi Zone

Traffic Stream Variable Definitions:

$x_{ij} \equiv$ # of vessels traveling from Departure Zone i to Destination Zone j

$x_{ijH} \equiv$ # of vessels traveling from Dep. Zone i to Dest. Zone j **through Haro - Strait**

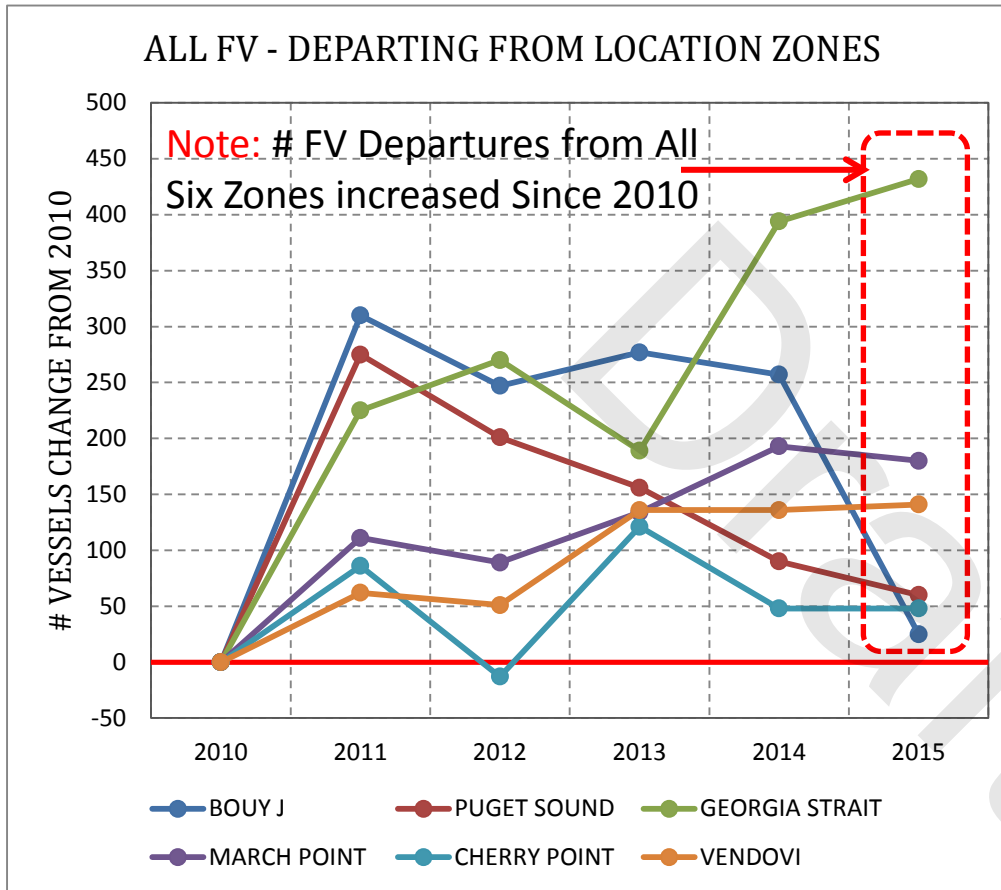
$x_{ijR} \equiv$ # of vessels traveling from Dep. Zone i to Dest. Zone j **through Rosario**

$x_{ijS} \equiv$ # of vessels traveling from Dep. Zone i to Dest. Zone j **through Saddle Bag**

$x_{ijB} \equiv$ # of vessels traveling from Dep. Zone i to Dest. Zone j **through Belling. Channel**

VESSEL TRAFFIC RISK ASSESSMENT (VTRA 2015)

- Summary Traffic Stream Analysis



FROM	2010	2011	2012	2013	2014	2015
BOUY J	0	310	247	277	257	25
PUGET SOUND	0	275	201	156	90	60
GEORGIA STRAIT	0	225	270	189	394	432
MARCH POINT	0	111	89	134	193	180
CHERRY POINT	0	86	-13	121	48	48
VENDOVI	0	62	51	136	136	141

From Zone	Variable	2010	2011	2012	2013	2014	2015
Buoy J	x12	0	101	42	14	-72	-136
	x13	0	104	127	75	191	110
	x14	0	17	42	21	53	17
	x15r	0	15	6	41	14	-8
	x15h	0	43	-8	38	-20	-21
	x16B	0	9	13	43	49	34
	x16S	0	20	26	47	41	30
Puget Sound	x21	0	147	124	95	22	-98
	x23h	0	105	99	85	130	165
	x23r	0	8	7	-6	-6	25
	x24	0	7	-4	-3	-13	-4
	x25	0	8	-11	2	-10	-8
	x26B	0	-16	-13	-2	-10	0
	x26S	0	19	2	-14	-21	-18
Georgia Strait	x31	0	76	86	18	136	91
	x32h	0	122	108	91	127	124
	x32r	0	3	22	17	8	39
	x34S	0	19	8	30	27	44
	X34R	0	-1	23	10	53	56
	x35	0	2	17	1	14	38
	x36	0	2	7	22	27	40
March Point	x41	0	23	44	22	49	17
	x42	0	14	3	12	-2	3
	x43S	0	8	1	9	21	37
	x43R	0	7	24	9	45	61
	x45S	0	20	5	25	27	28
	x45R	0	6	-12	23	-1	-11
	x46S	0	20	14	4	23	17
x46R	0	11	10	32	32	30	
Cherry Point	x51h	0	10	-38	20	-20	-10
	x51r	0	32	8	47	26	-6
	x52	0	19	5	10	9	10
	x53	0	6	33	2	14	22
	x54S	0	20	-1	17	1	14
	x54R	0	14	-6	26	19	4
	x56	0	-12	-11	0	-2	11
Vendovi	x61B	0	8	-1	10	9	5
	x61R	0	16	24	37	33	22
	x62B	0	-2	-1	1	2	11
	x62R	0	2	4	0	-3	2
	x63	0	-1	0	20	18	32
	x64S	0	34	18	24	29	24
	x64R	0	-1	8	15	25	29
x65	0	-2	-6	28	22	17	

Modeled ATB Traffic Stream Changes Departing from Zones 1, 2 or 3

Georgia Strait

3

X_{32R} X_{34R}

Point Roberts Crossing Line

5 Cherry Point

Bellingham Channel Crossing Line

6 Vendovi

Saddle Bag Crossing Lines

4 March Point

Admiralty Inlet Crossing Line

2 Puget Sound

Neah Bay Crossing Line

Haro Crossing Lines

Rosario Crossing Lines

+8

+8

+15

+14

+16

+25

+12

+6

+21

+7

+5

X_{15R}

X_{16S}

X_{16B}

X_{14}

X_{12}

1

Buoy J

AVERAGE VESSEL COUNT ERROR		
ATB	Cargo	Tanker
5	99	12

+6

X_{21}

X_{25}

X_{26B} X_{24}

7/28/2016

Per Year – Only Traffic Stream Changes above Average Count Error are modeled

Modeled ATB Traffic Stream Changes Departing from Zones 4 or 5

Georgia Strait

3

Point Roberts Crossing Line

5 Cherry Point

Bellingham Channel Crossing Line

6 Vendovi

Saddle Bag Crossing Lines

4 March Point

Admiralty Inlet Crossing Line

2 Puget Sound

Neah Bay Crossing Line

+8 +20

+11

+22

X_{51R}

X₅₂

X_{54R}

X_{54S}

X₅₆

+8

+12

+9

X_{46S}

X_{45S}

X_{43S}

X_{46R}

X_{45R}

X_{43R}

X₄₂

X₄₁

+22 +11

+7

+20

+10

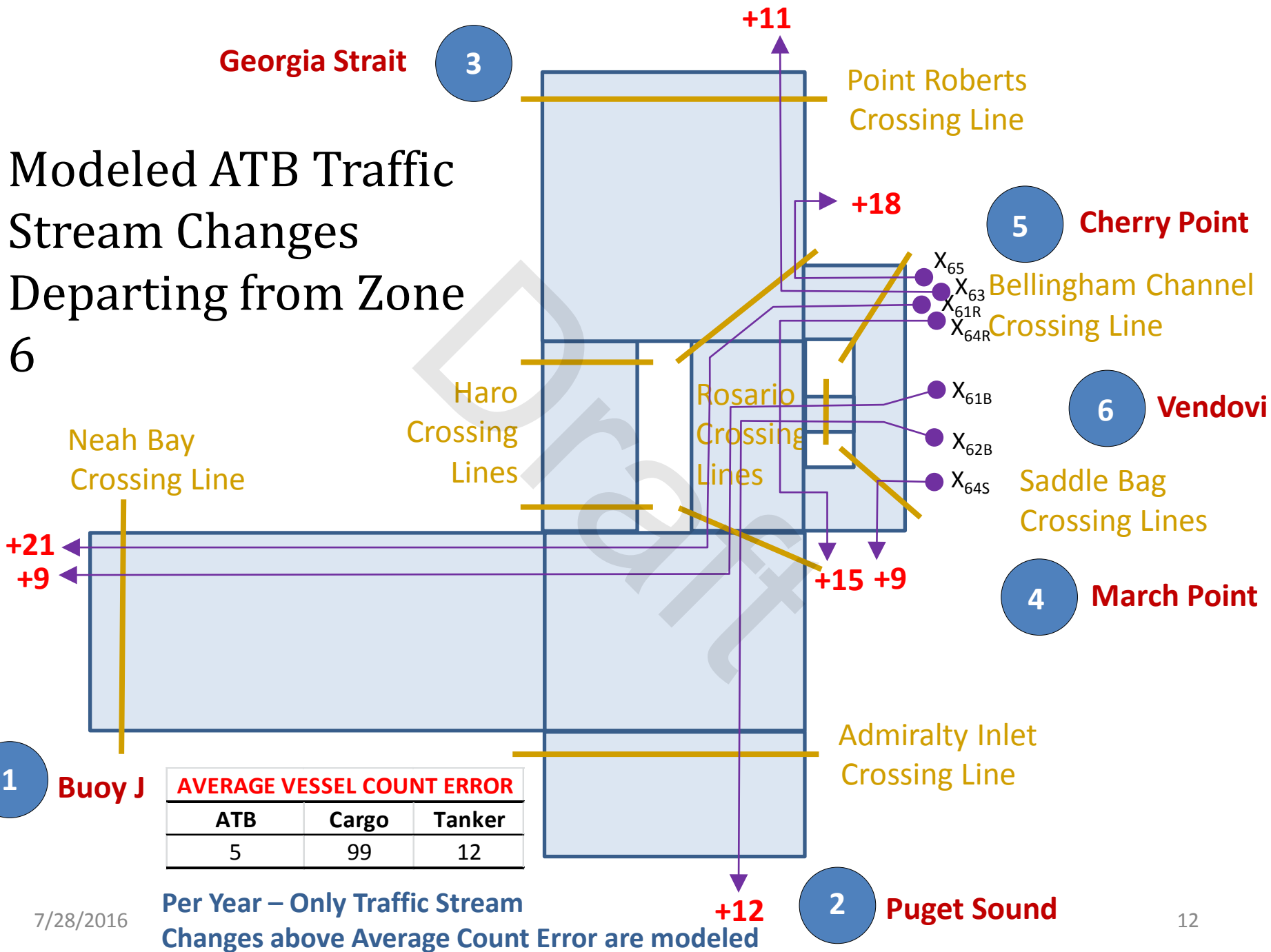
+6

1 Buoy J

AVERAGE VESSEL COUNT ERROR		
ATB	Cargo	Tanker
5	99	12

Per Year – Only Traffic Stream Changes above Average Count Error are modeled

Modeled ATB Traffic Stream Changes Departing from Zone 6



Modeled Tank FV (Excl. ATB's) Traffic Stream Changes Departing from Zones 1 through 6

Georgia Strait

3

X_{31} -22 X_{35}

Point Roberts
Crossing Line

5 Cherry Point

Bellingham Channel
Crossing Line

6 Vendovi

Saddle Bag
Crossing Lines

4 March Point

2 Puget Sound

Neah Bay
Crossing Line

Haro
Crossing
Lines

Rosario
Crossing
Lines

Admiralty Inlet
Crossing Line

X_{13}
 X_{15R}
 X_{16S}
 X_{12}

-21

-19

X_{51R}
+16
-19
-13

+16
+19

+15

X_{45R}
 X_{46R}

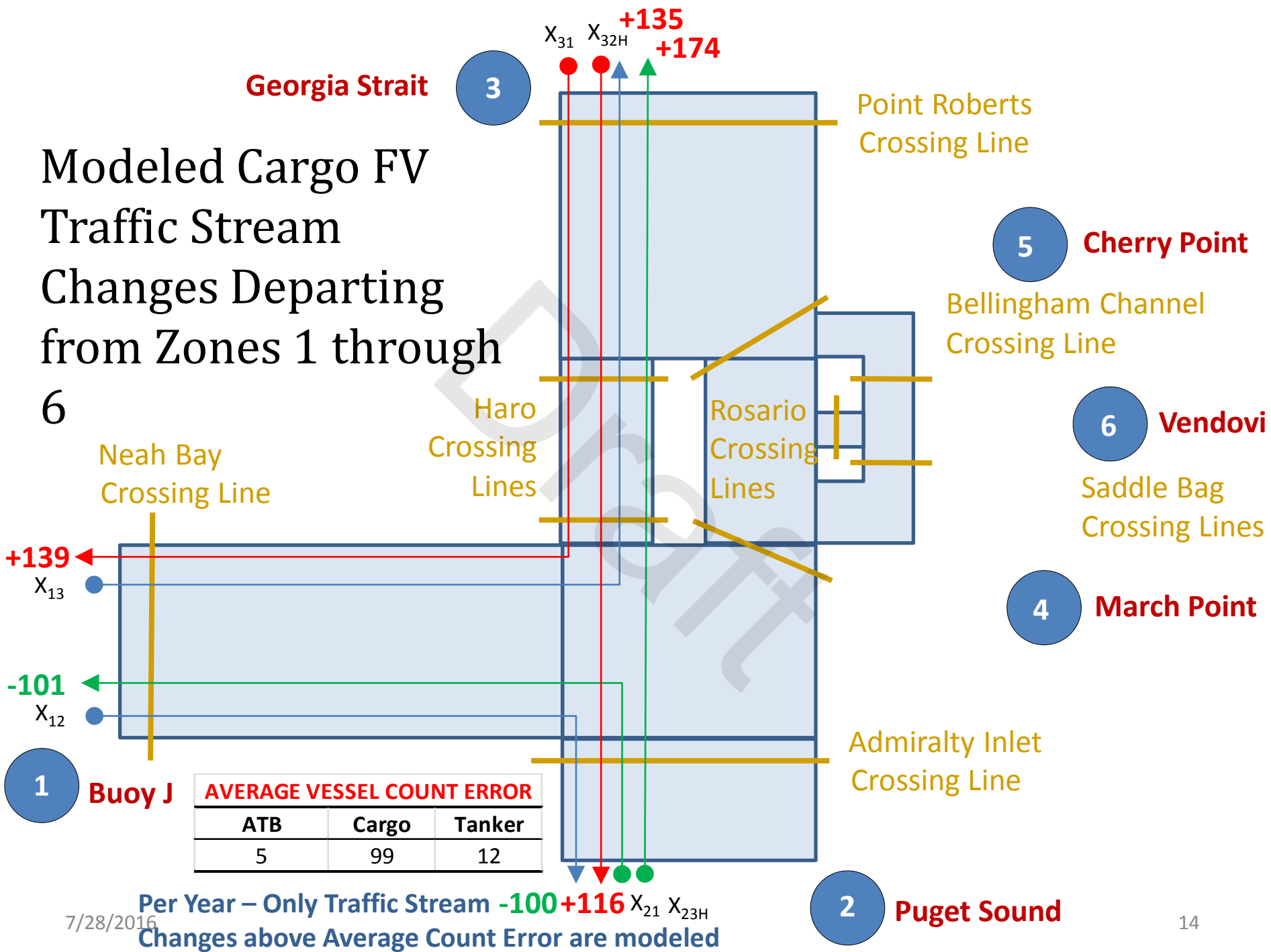
-31

1 Buoy J

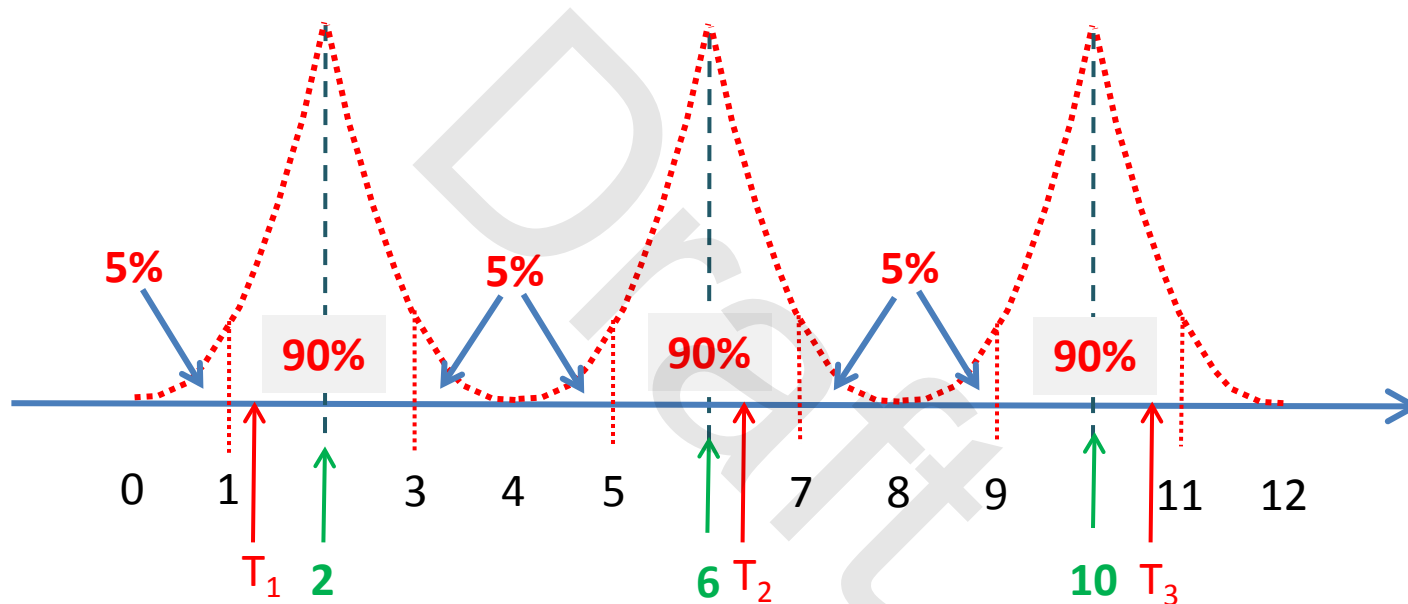
AVERAGE VESSEL COUNT ERROR		
ATB	Cargo	Tanker
5	99	12

Per Year – Only Traffic Stream
Changes above Average Count Error are modeled

Modeled Cargo FV Traffic Stream Changes Departing from Zones 1 through 6



VTRA 2015 – Traffic Stream What If FV Scheduled Random Arrival Pattern Model



VTRA 2010 Equidistant Fixed Arrival Pattern (one every 4 days)

VTRA 2015 Random Arrival Pattern (3 Random Times in 12 days)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA 2015)

Vessel Time Exposure (VTE)
VTRA 2015 Base Case Comparison
to VTRA 2015 Calibration Case

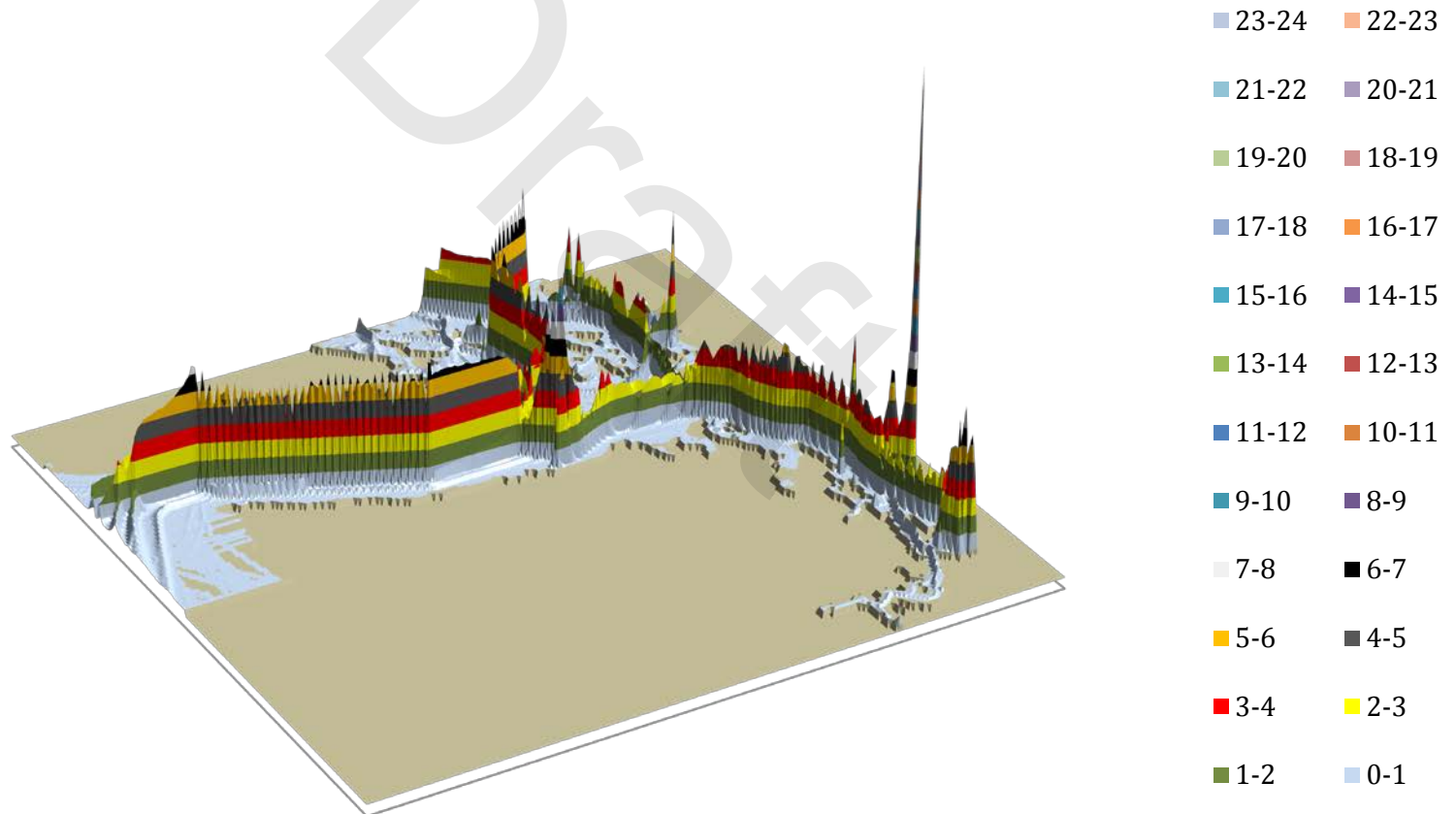
Jason R.W. Merrick (VCU) and J. Rene van Dorp (GW)

July, 2016



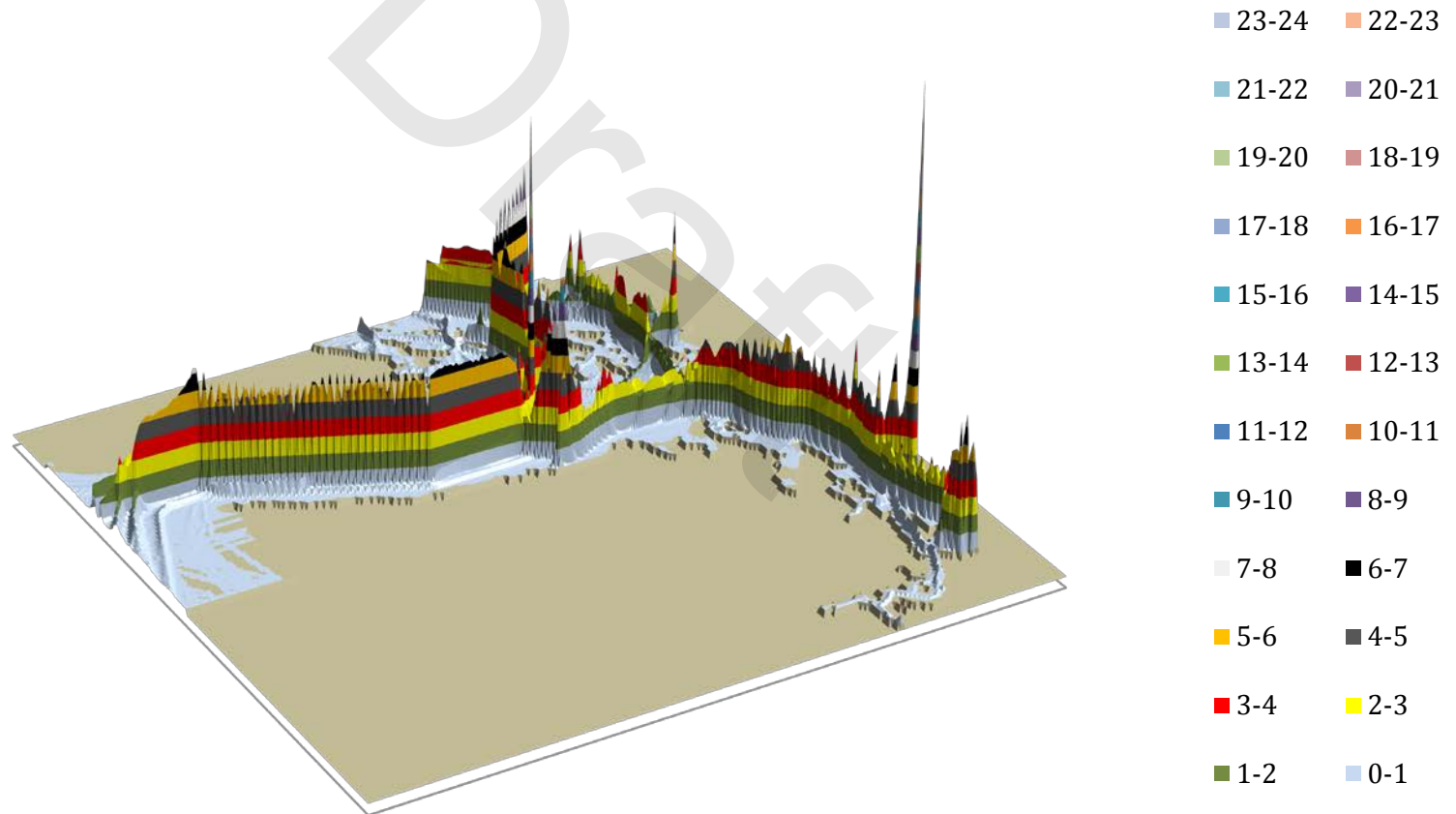
VTRA '15 Cal. Case Vessel Time Exposure (VTE)

VTRA '15: Cal. Case 3D Risk Profile
All FV - Vessel Time Exposure: 100% of Cal. Case VTE



VTRA '15 Base Case Vessel Time Exposure (VTE)

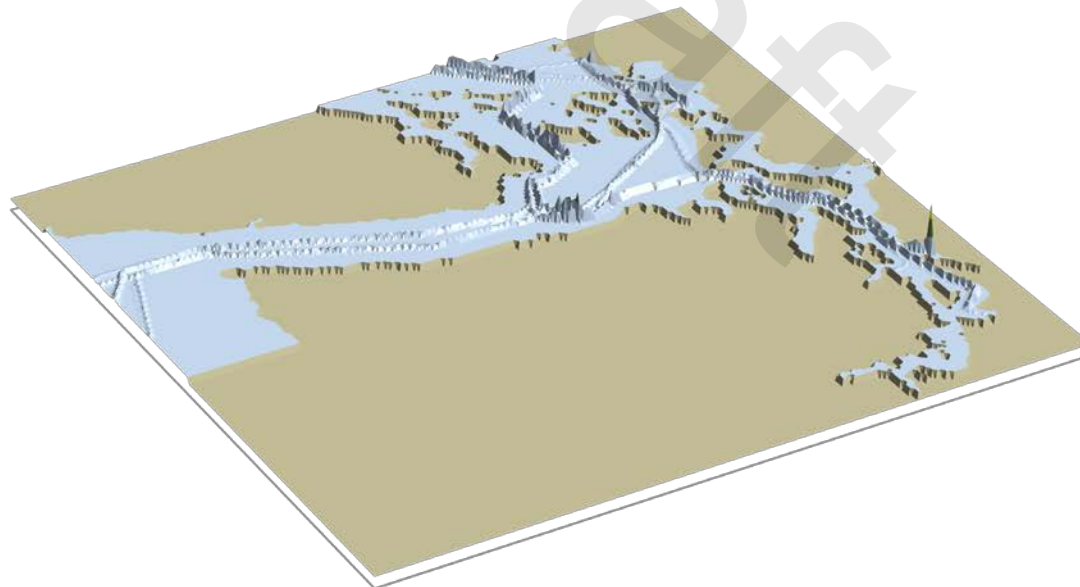
VTRA '15: Base Case 3D Risk Profile
All FV - Vessel Time Exposure: 104% of Cal. Case VTE



Added VTRA '15 Base Case What-If FV VTE

VTRA '15: Base Case 3D Risk Profile
Added '15 FV - Vessel Time Exp.: 7% of Cal. Case VTE

↑
Conclusion: 7% - 4% = 3%
Reduction in VTRA 2015 Cal.
VTE was Modeled as well.



- | | |
|---------|---------|
| ■ 23-24 | ■ 22-23 |
| ■ 21-22 | ■ 20-21 |
| ■ 19-20 | ■ 18-19 |
| ■ 17-18 | ■ 16-17 |
| ■ 15-16 | ■ 14-15 |
| ■ 13-14 | ■ 12-13 |
| ■ 11-12 | ■ 10-11 |
| ■ 9-10 | ■ 8-9 |
| ■ 7-8 | ■ 6-7 |
| ■ 5-6 | ■ 4-5 |
| ■ 3-4 | ■ 2-3 |
| ■ 1-2 | ■ 0-1 |

VESSEL TRAFFIC RISK ASSESSMENT (VTRA 2015)

Oil Time Exposure (OTE)
VTRA 2015 Base Case Comparison
to VTRA 2015 Calibration Case

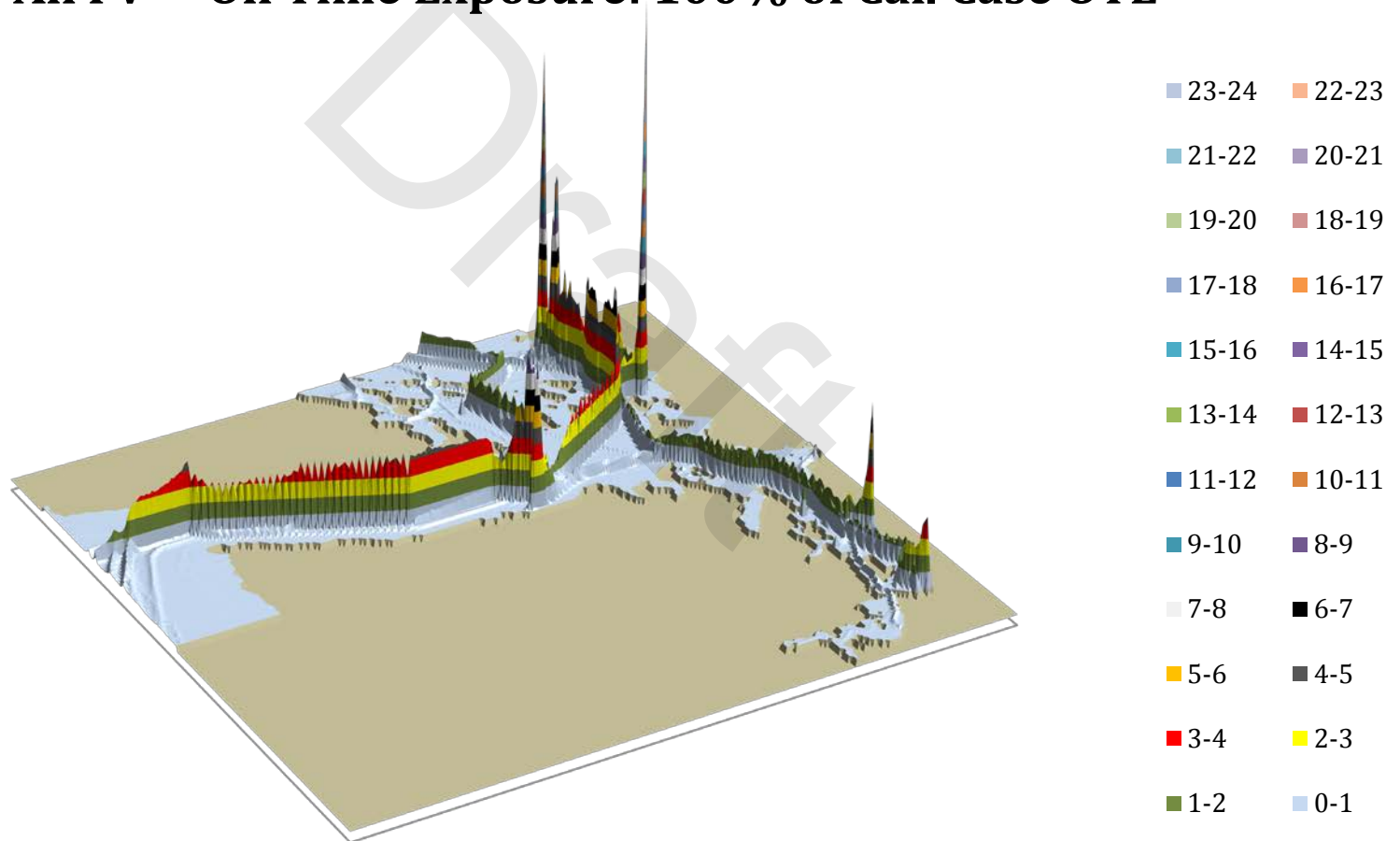
Jason R.W. Merrick (VCU) and J. Rene van Dorp (GW)

July, 2016



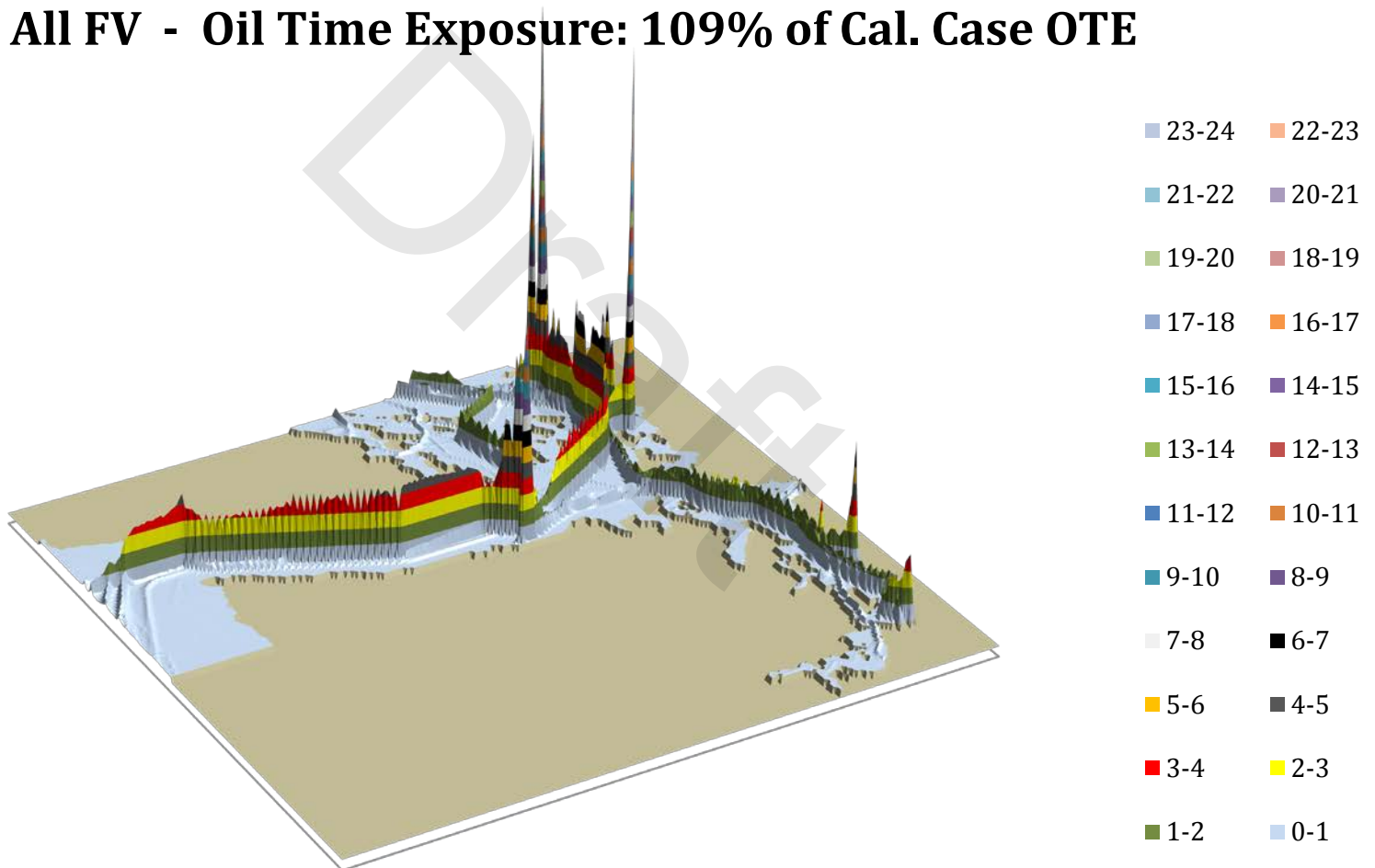
VTRA '15 Cal. Case Oil Time Exposure (OTE)

VTRA '15: Cal. Case 3D Risk Profile
All FV - Oil Time Exposure: 100% of Cal. Case OTE



VTRA '15 Base Case Oil Time Exposure (OTE)

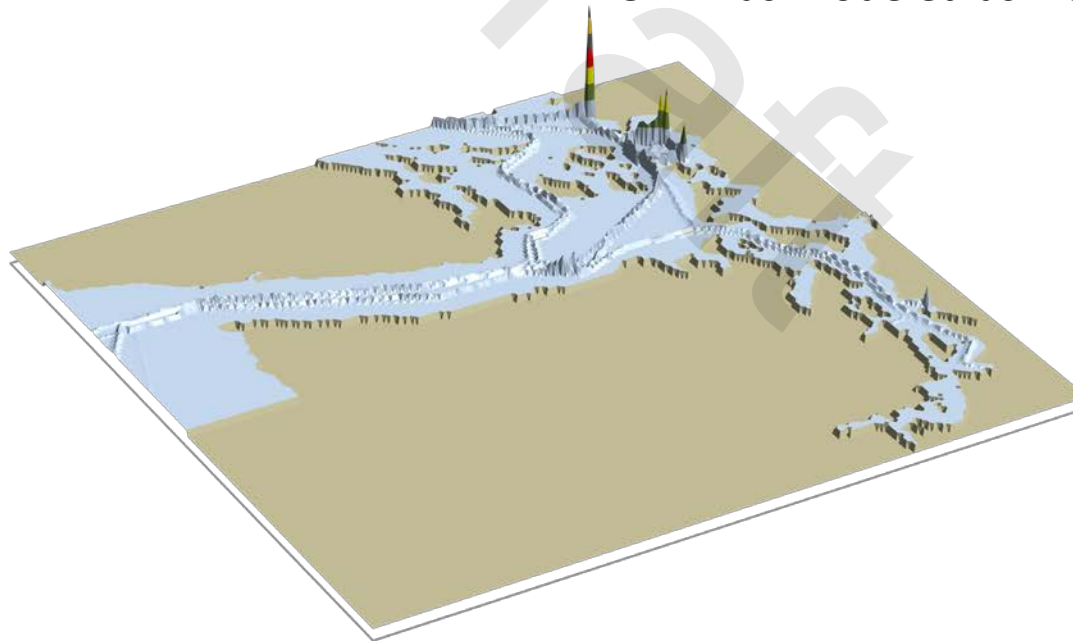
VTRA '15: Base Case 3D Risk Profile
All FV - Oil Time Exposure: 109% of Cal. Case OTE



Added VTRA '15 Base Case What-If FV OTE

VTRA '15: Base Case 3D Risk Profile
Added '15 FV - Oil Time Exposure: 11% of Cal. Case OTE

↑
Conclusion: 11% - 9% = 2%
Reduction in VTRA 2015 Cal.
OTE was Modeled as well.



By Waterway Zone Risk Comparison

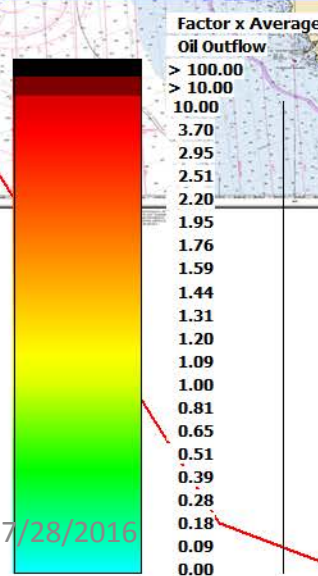
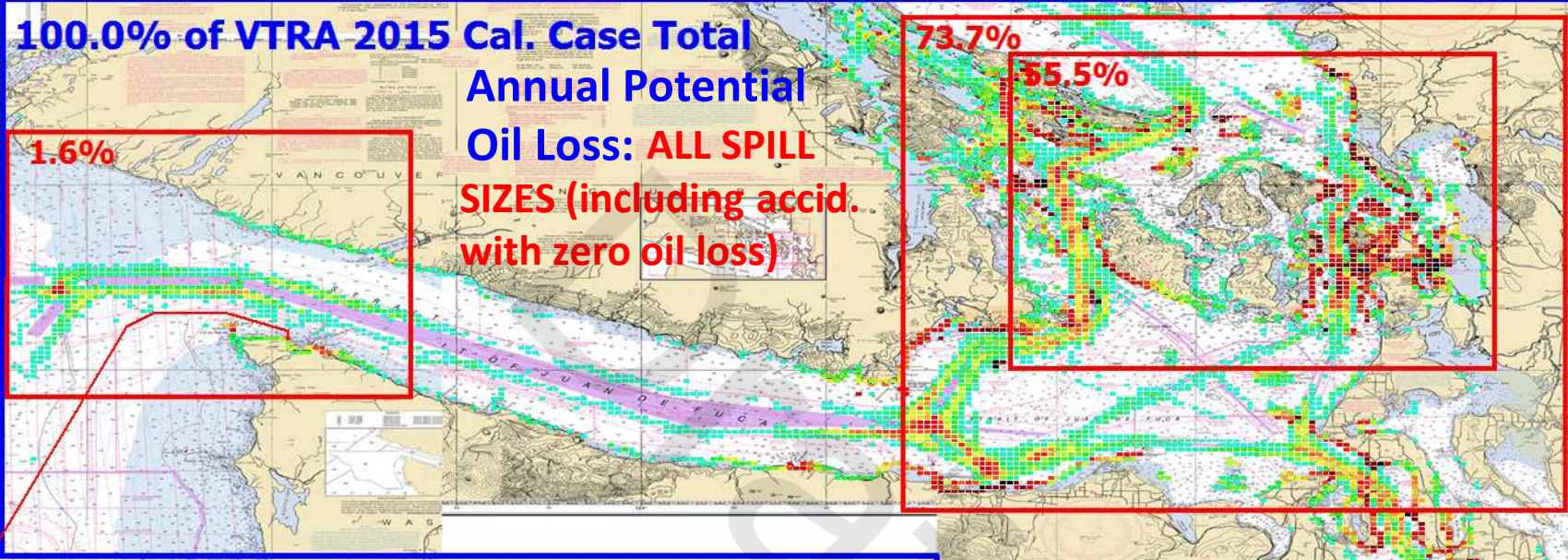
Oil Spill Size Category:

ALL SPILL SIZES

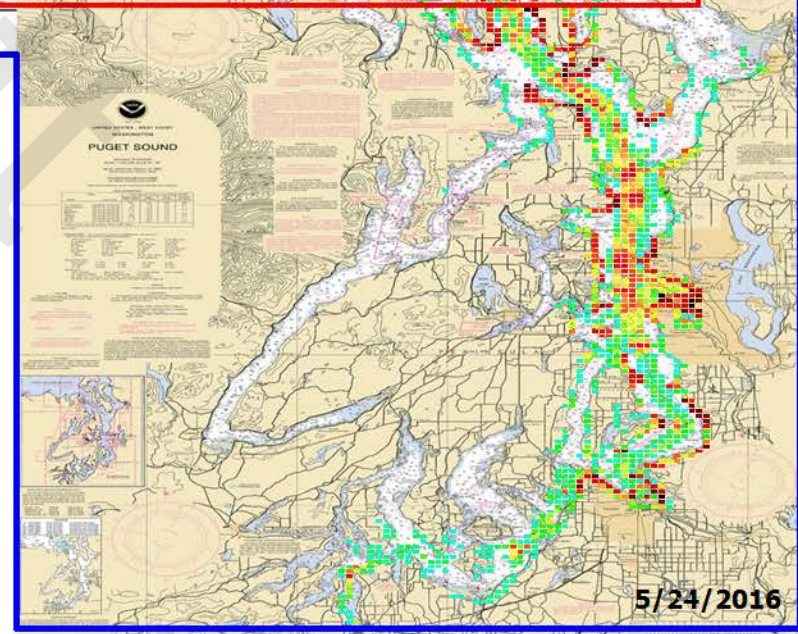
VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



VTRA 2015 CALIBRATION CASE - ALL FV



VTRA '15: Cal. Case
GEOGRAPHIC PROFILE
OF POTENTIAL ANNUAL
OIL LOSS OF ACCIDENTS
IN SPILL SIZE CATEGORY
ALL SPILL SIZES



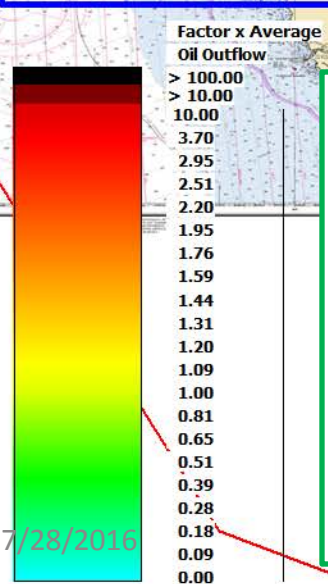
VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

VTRA 2015 BASE CASE - ALL FV

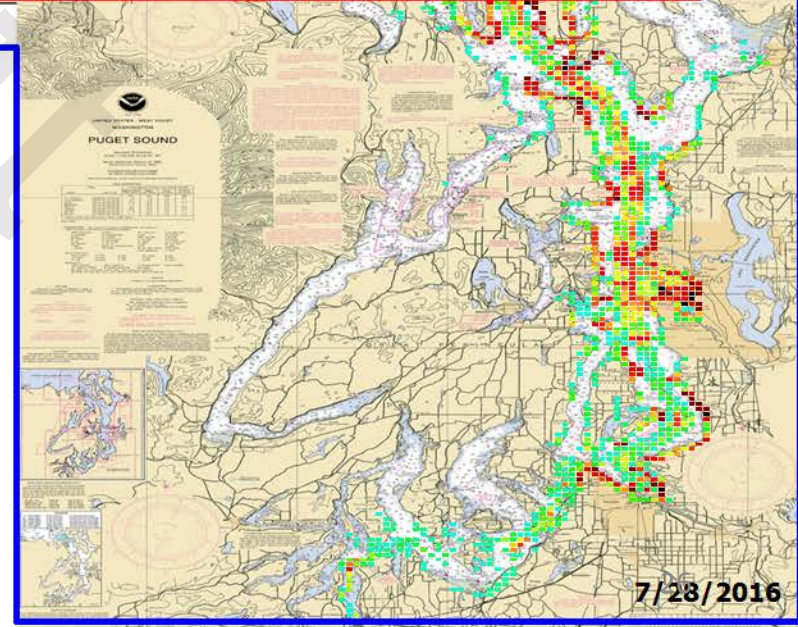
120.2% of VTRA 2015 Cal. Case Total Annual Potential Oil Loss: ALL SPILL SIZES (including accid. with zero oil loss)

93.9%
73.6%

1.5%



VTRA '15 Base Case
GEOGRAPHIC PROFILE
OF POTENTIAL ANNUAL
OIL LOSS OF ACCIDENTS
IN SPILL SIZE CATEGORY
ALL SPILL SIZES



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

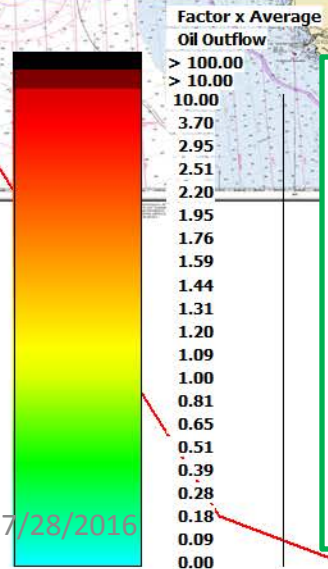
VTRA 2015 BASE CASE - Added 2015 FV

27.3% of VTRA 2015 Cal. Case Total Annual Potential Oil Loss: ALL SPILL SIZES (including accid. with zero oil loss)

0.1%

23.9%

20.9%

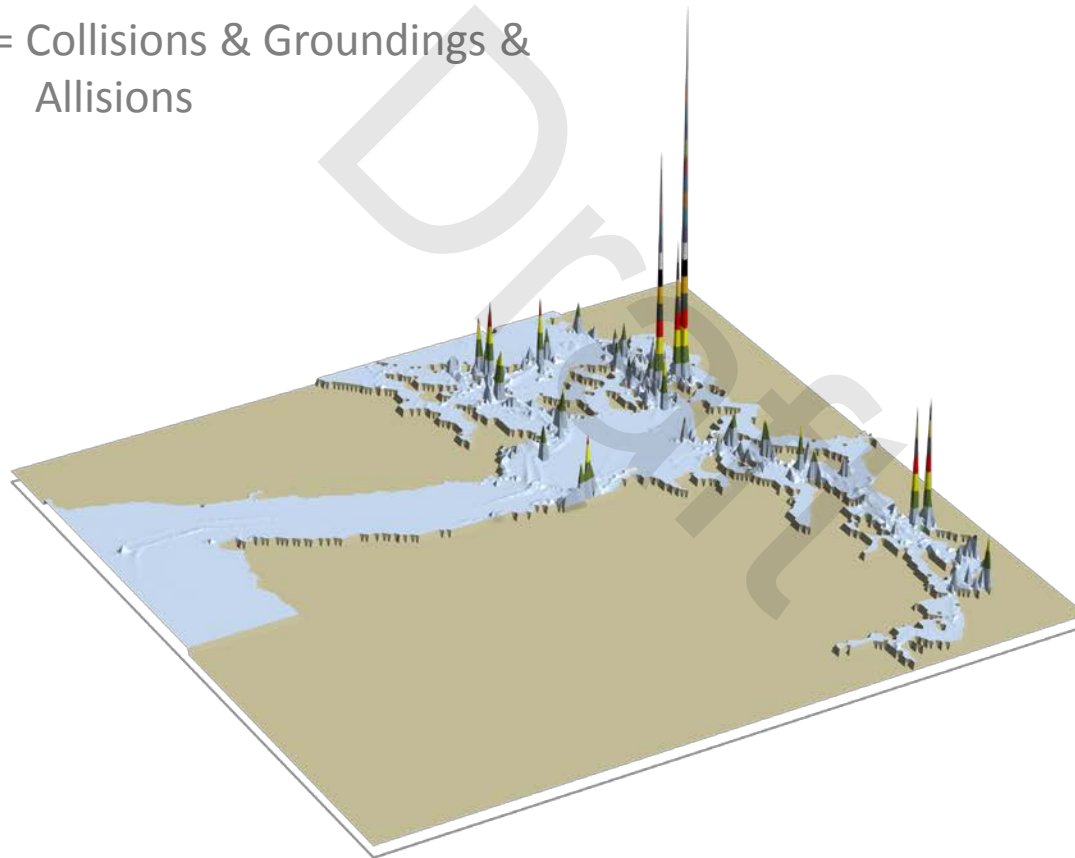


VTRA '15 Base Case
GEOGRAPHIC PROFILE OF POTENTIAL ANNUAL OIL LOSS OF ACCIDENTS IN SPILL SIZE CATEGORY
ALL SPILL SIZES OF ADDED TRAFFIC STREAMS

Conclusion:
27.3% - 20.2% = 7.1%
Reduction in Pot. Oil Loss due to other OTE decreases

VTRA '15: Cal. Case 3D Risk Profile All FV - Pot.C+G+A.Oil Loss: 100% of Cal. Case POL

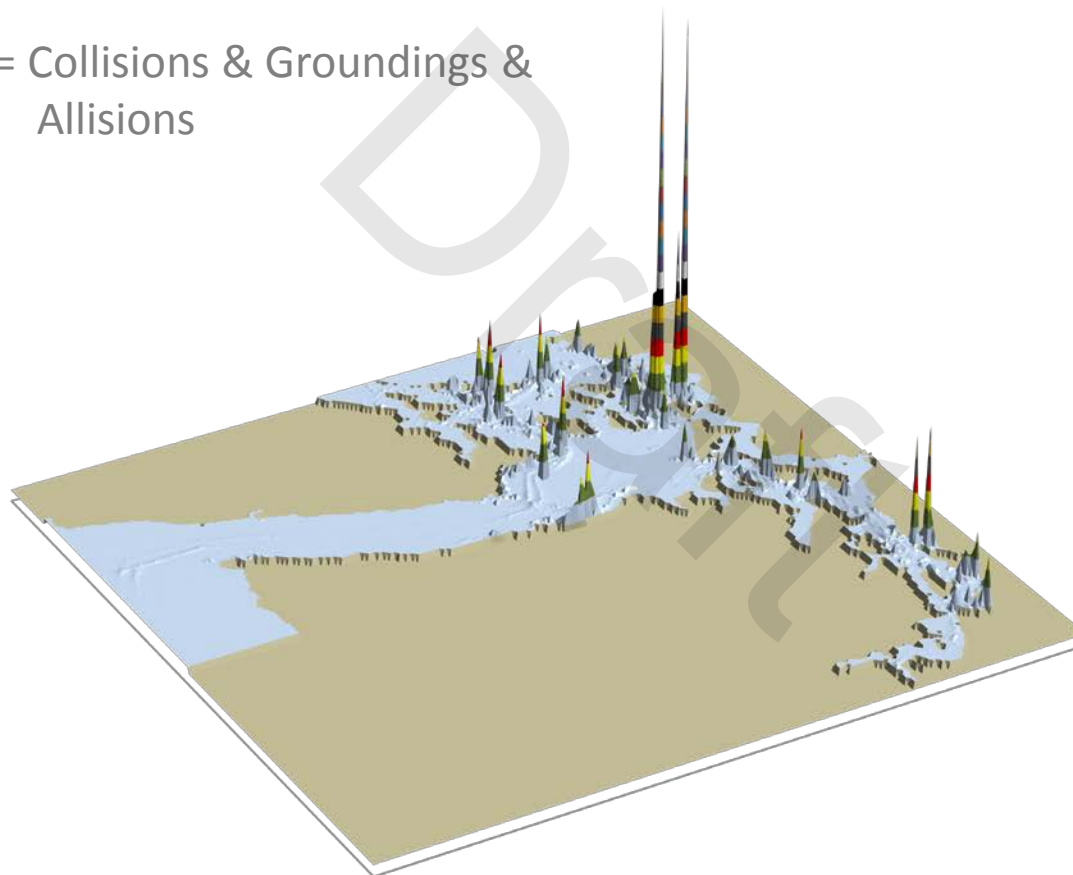
C+G+A = Collisions & Groundings &
Allisions



- | | |
|---------|---------|
| ■ 23-24 | ■ 22-23 |
| ■ 21-22 | ■ 20-21 |
| ■ 19-20 | ■ 18-19 |
| ■ 17-18 | ■ 16-17 |
| ■ 15-16 | ■ 14-15 |
| ■ 13-14 | ■ 12-13 |
| ■ 11-12 | ■ 10-11 |
| ■ 9-10 | ■ 8-9 |
| ■ 7-8 | ■ 6-7 |
| ■ 5-6 | ■ 4-5 |
| ■ 3-4 | ■ 2-3 |
| ■ 1-2 | ■ 0-1 |

VTRA '15: Base Case 3D Risk Profile All FV - Pot.C+G+A.Oil Loss: 120% of Cal. Case POL

C+G+A = Collisions & Groundings &
Allisions

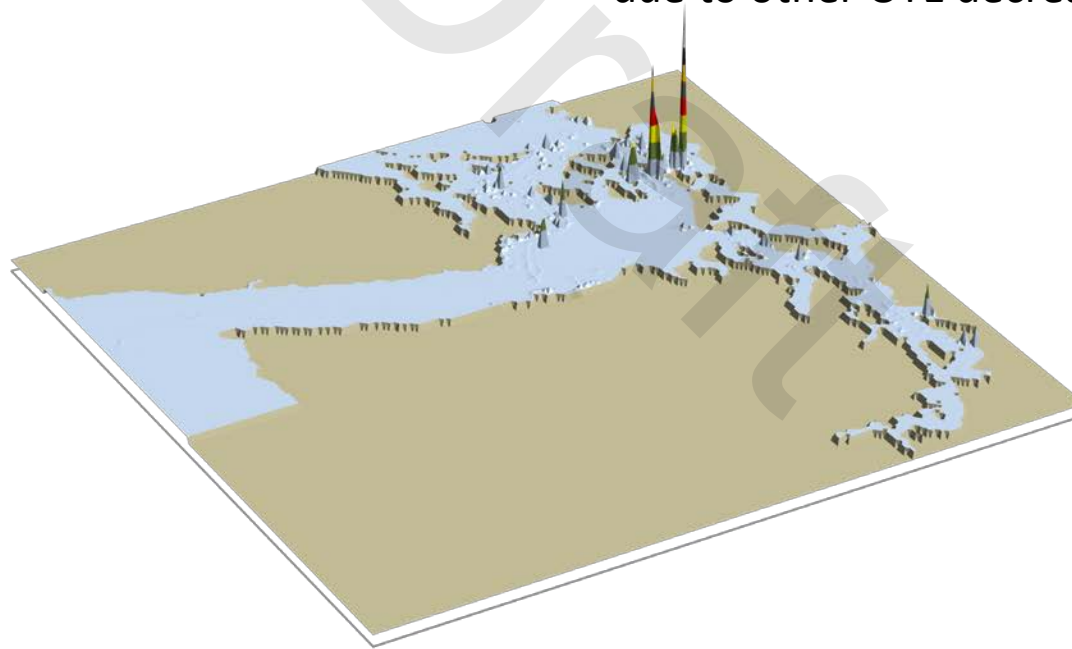


- | | |
|---------|---------|
| ■ 23-24 | ■ 22-23 |
| ■ 21-22 | ■ 20-21 |
| ■ 19-20 | ■ 18-19 |
| ■ 17-18 | ■ 16-17 |
| ■ 15-16 | ■ 14-15 |
| ■ 13-14 | ■ 12-13 |
| ■ 11-12 | ■ 10-11 |
| ■ 9-10 | ■ 8-9 |
| ■ 7-8 | ■ 6-7 |
| ■ 5-6 | ■ 4-5 |
| ■ 3-4 | ■ 2-3 |
| ■ 1-2 | ■ 0-1 |

VTRA '15: Base Case 3D Risk Profile Added '15 FV - Pot.C+G+A.Oil Loss: 27% of Cal. Case POL

C+G+A = Collisions & Groundings & Allisions

Conclusion: 27%- 20% = 7%
Reduction in Pot. Oil Loss
due to other OTE decreases

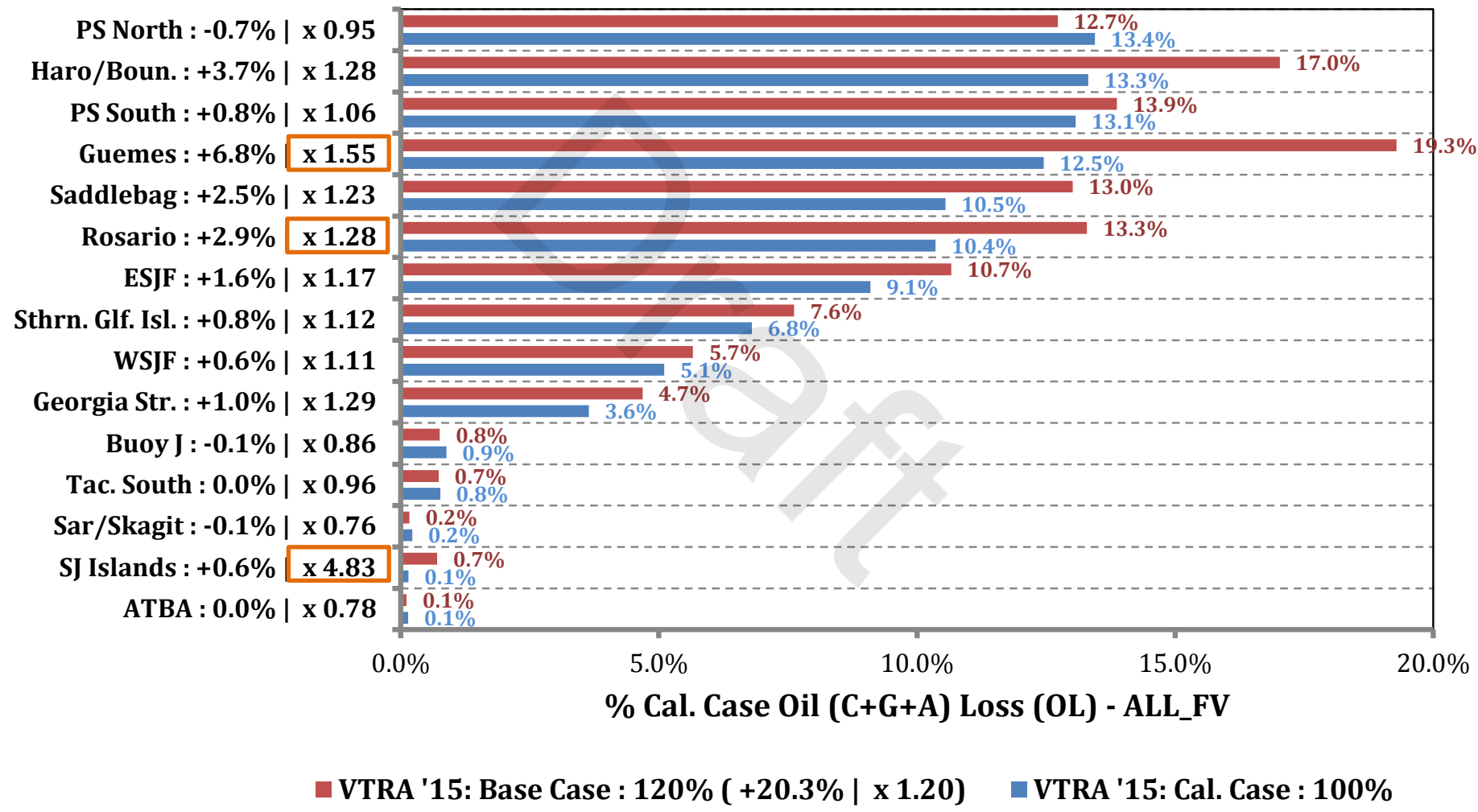


- | | |
|---------|---------|
| ■ 23-24 | ■ 22-23 |
| ■ 21-22 | ■ 20-21 |
| ■ 19-20 | ■ 18-19 |
| ■ 17-18 | ■ 16-17 |
| ■ 15-16 | ■ 14-15 |
| ■ 13-14 | ■ 12-13 |
| ■ 11-12 | ■ 10-11 |
| ■ 9-10 | ■ 8-9 |
| ■ 7-8 | ■ 6-7 |
| ■ 5-6 | ■ 4-5 |
| ■ 3-4 | ■ 2-3 |
| ■ 1-2 | ■ 0-1 |

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



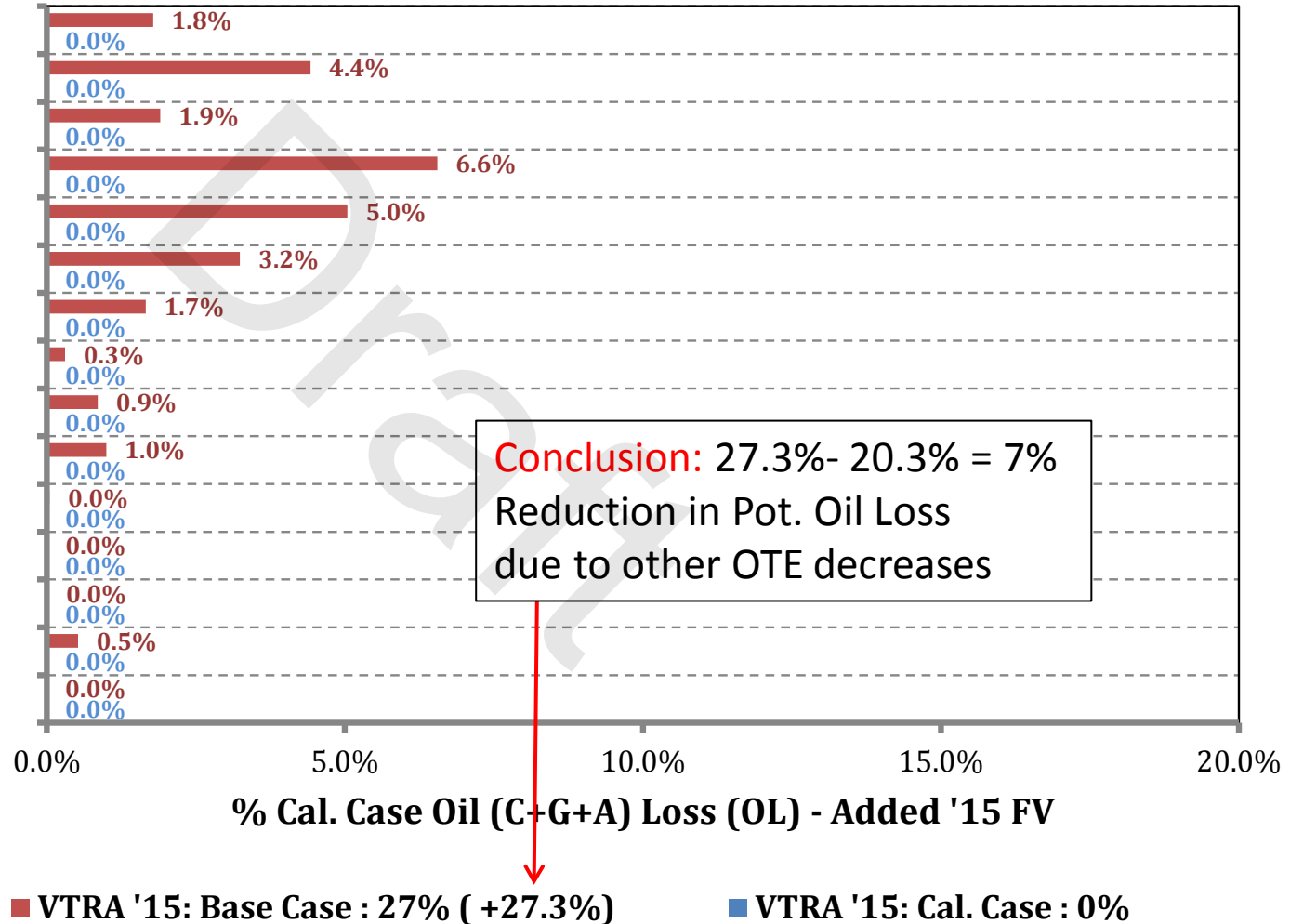
% Cal. Case Oil (C + G + A) Loss - ALL_FV



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

% Cal. Case Oil (C + G + A) Loss - Added '15 FV

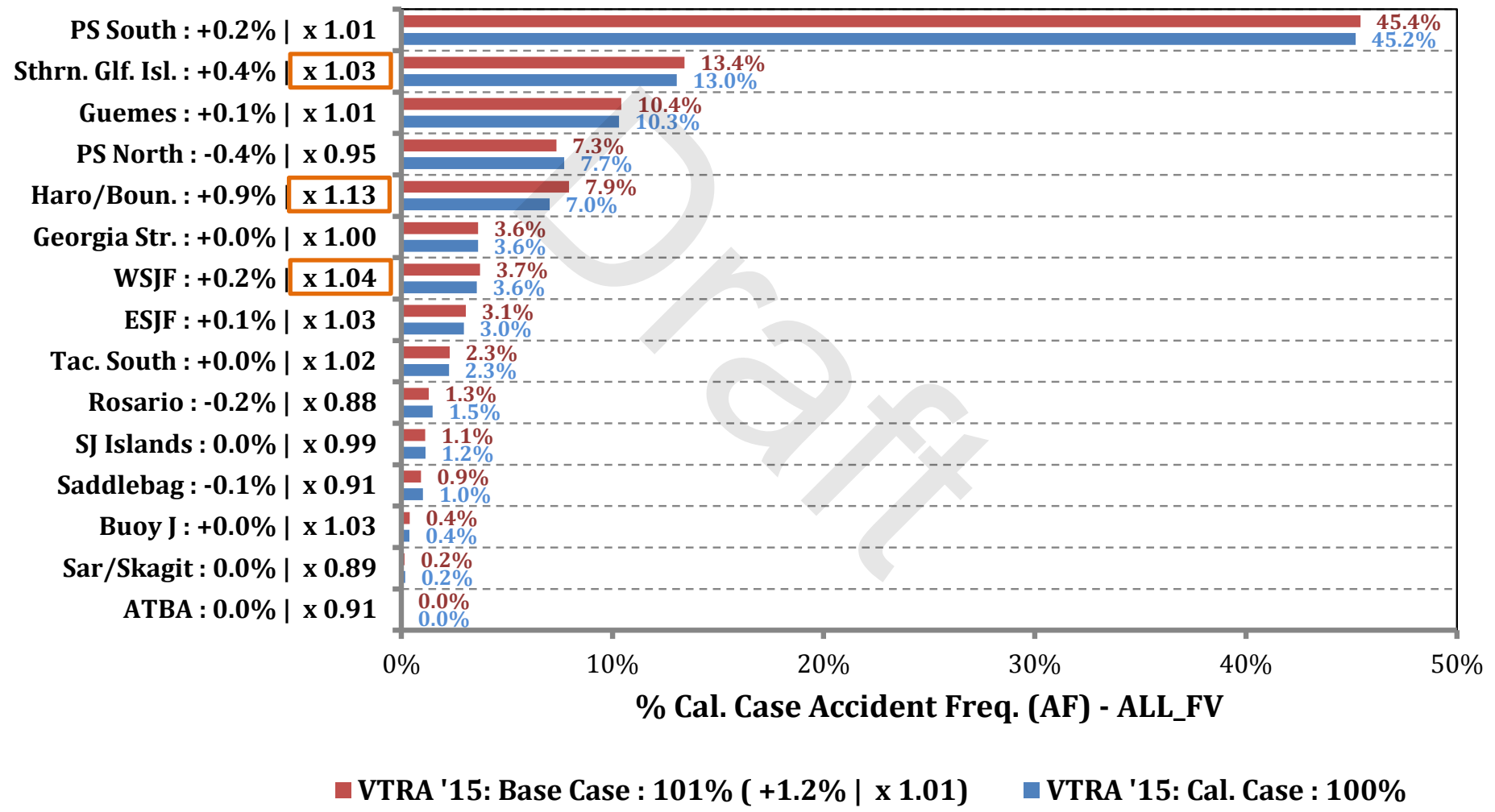
- PS North : +1.8%
- Haro/Boun. : **+4.4%**
- PS South : +1.9%
- Guemes : **+6.6%**
- Saddlebag : **+5.0%**
- Rosario : +3.2%
- ESJF : +1.7%
- Sthrn. Glf. Isl. : +0.3%
- WSJF : +0.9%
- Georgia Str. : +1.0%
- Buoy J : +0.0%
- Tac. South : +0.0%
- Sar/Skagit : +0.0%
- SJ Islands : +0.5%
- ATBA : +0.0%



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



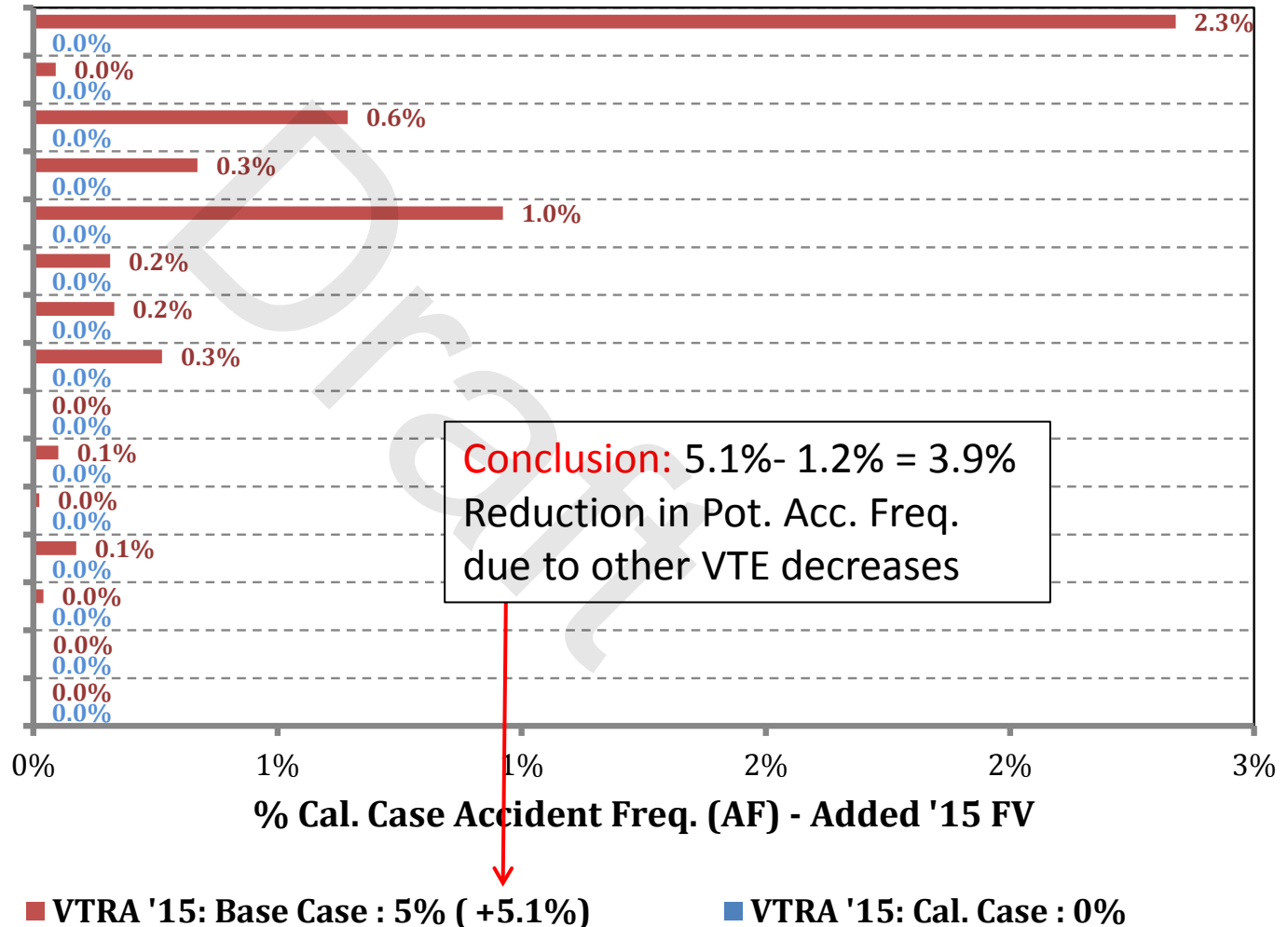
% Cal. Case Accident (C+G+A) Frequency - ALL_FV



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

% Cal. Case Accident (C+G+A) Frequency - Added '15 FV

PS South :	+2.3%
Sthrn. Glf. Isl. :	+0.0%
Guemes :	+0.6%
PS North :	+0.3%
Haro/Boun. :	+1.0%
Georgia Str. :	+0.2%
WSJF :	+0.2%
ESJF :	+0.3%
Tac. South :	+0.0%
Rosario :	+0.1%
SJ Islands :	+0.0%
Saddlebag :	+0.1%
Buoy J :	+0.0%
Sar/Skagit :	+0.0%
ATBA :	+0.0%



By Waterway Zone Risk Comparison

Oil Spill Size Category:
2500 m³ or more

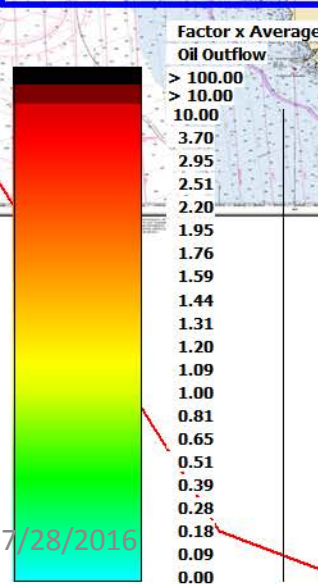
VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

VTRA 2015 CALIBRATION CASE - ALL FV

39.8% of VTRA 2015 Cal. Case Total Annual Potential Oil Loss:
SPILL SIZES LARGER THAN 2,500 m³

33.9%
27.2%

1.0%



VTRA '15: Cal. Case
GEOGRAPHIC PROFILE OF POTENTIAL ANNUAL OIL LOSS OF ACCIDENTS WITH SPILL SIZE 2,500 m³ or more

≈ 0.47% Probability of Spill Occurrence in 10 years

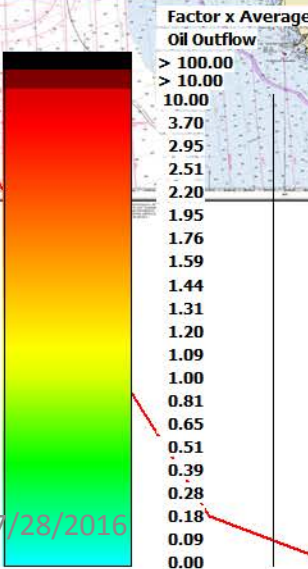
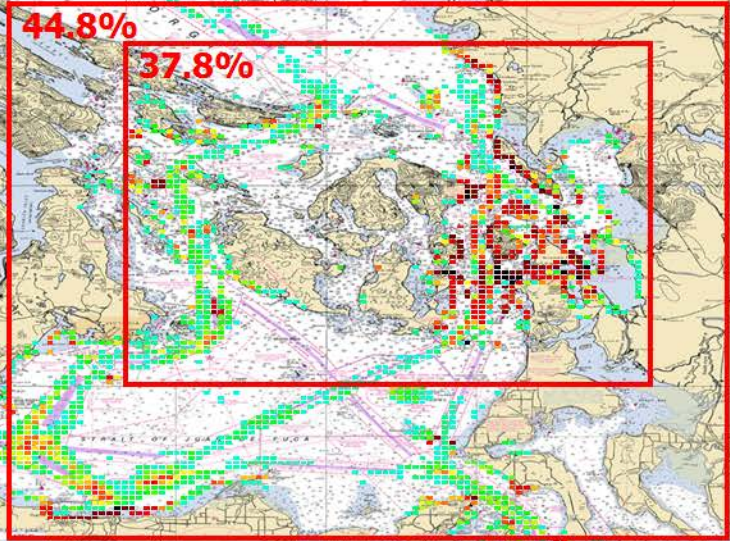
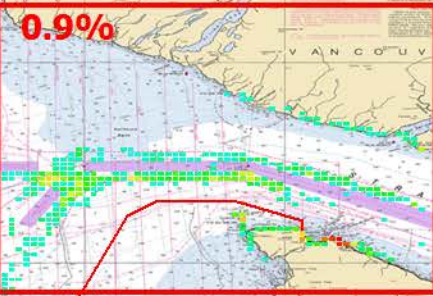
Average of ≈ 5,746 m³ Per Potential Spill (≈ 4,942 Metric. Tons)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

VTRA 2015 BASE CASE - ALL FV

50.5% of VTRA 2015 Cal. Case Total Annual Potential Oil Loss:

SPILL SIZES LARGER THAN 2,500 m³



VTRA '15 Base Case GEOGRAPHIC PROFILE OF POTENTIAL ANNUAL OIL LOSS OF ACCIDENTS WITH SPILL SIZE 2,500 m³ or more

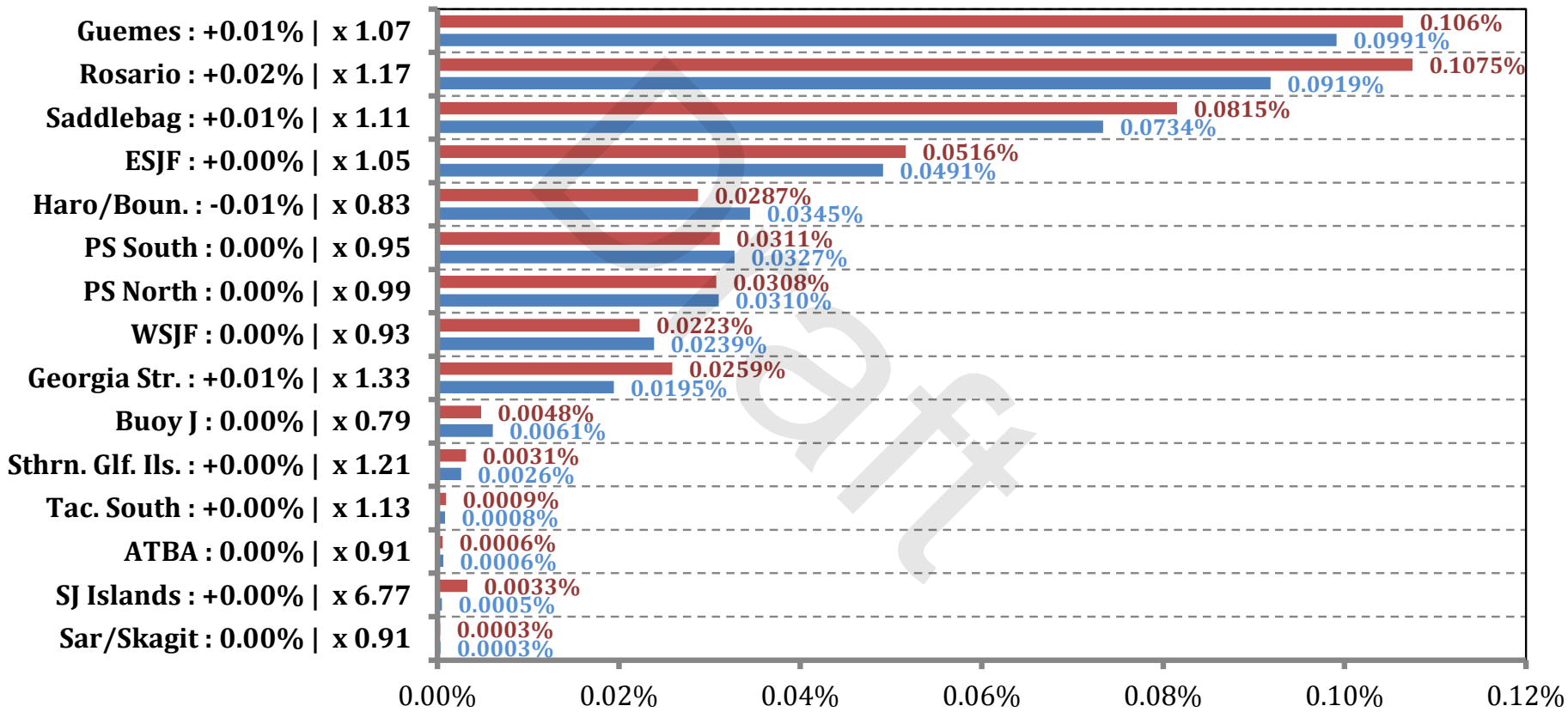
≈ 0.50% Probability of Spill Occurrence in 10 years

Average of ≈ 6,798 m³ Per Potential Spill (≈ 5,846 Metric Tons)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



Prob. Estimate At Least One Accident in 10 Years - ALL_FV - Oil Spill Size Category: 2500 cubic meters or more



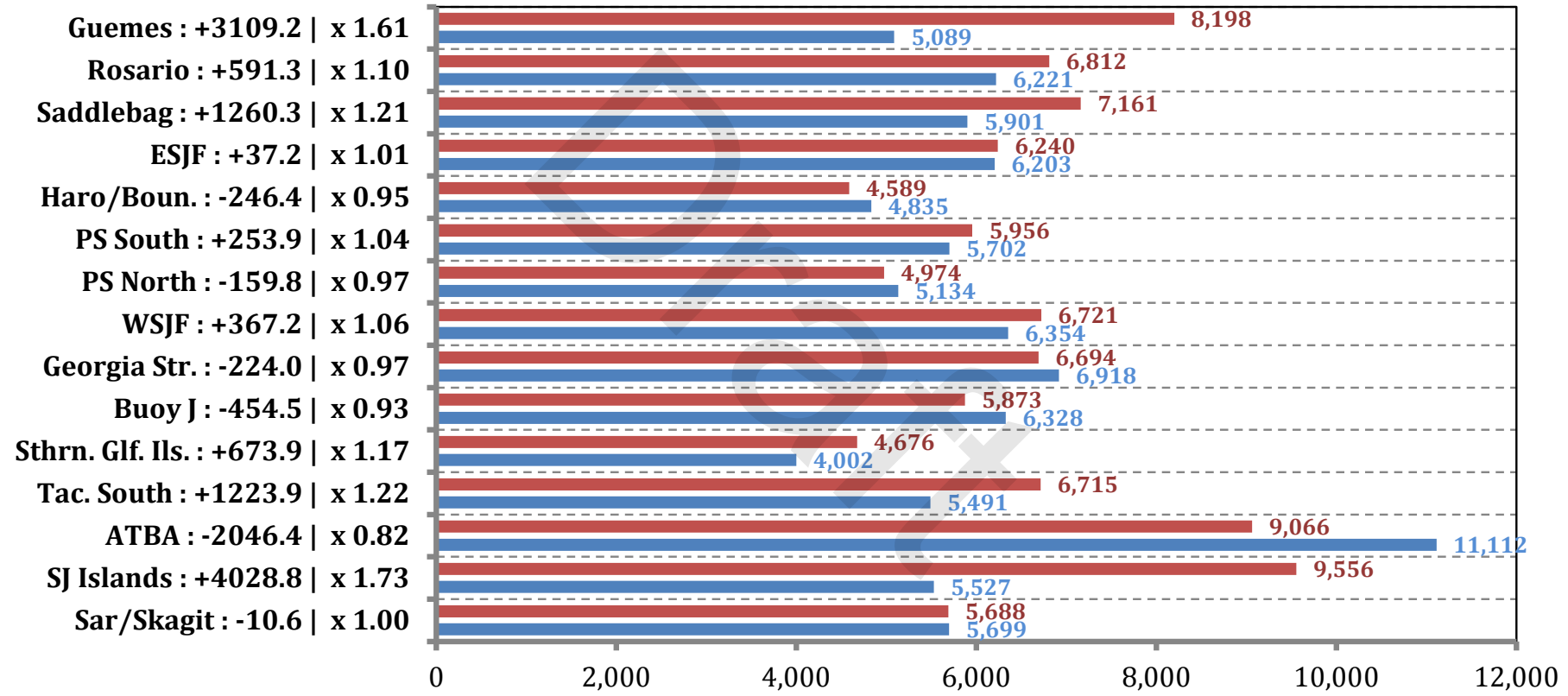
Prob. Estimate At Least One Accident in 10 Years

■ VTRA '15: Base Case : 0.50% (+0.03% | x 1.07) ■ VTRA '15: Cal. Case : 0.47%

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



Potential Spill Size (m3) per Accident - ALL_FV - Oil Spill Size Category: 2500 cubic meters or more



Potential Spill Size (m3) per Accident

■ VTRA '15: Base Case : 6798 m3 (+1052.4 | x 1.18) ■ VTRA '15: Cal. Case : 5746 m3

By Waterway Zone Risk Comparison

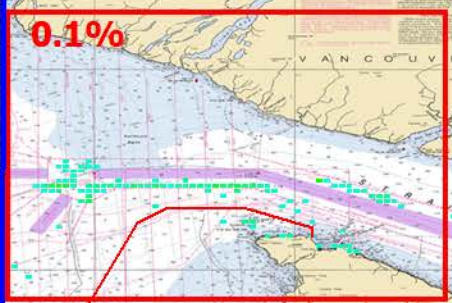
Oil Spill Size Category:

1000 m³ - 2500 m³

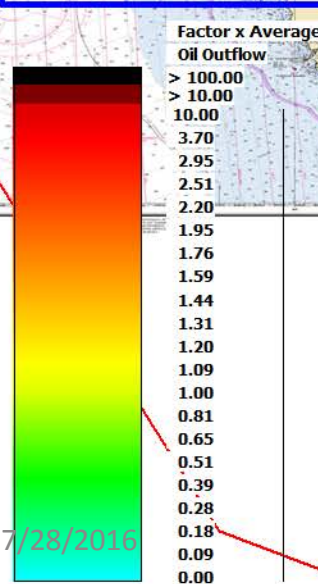
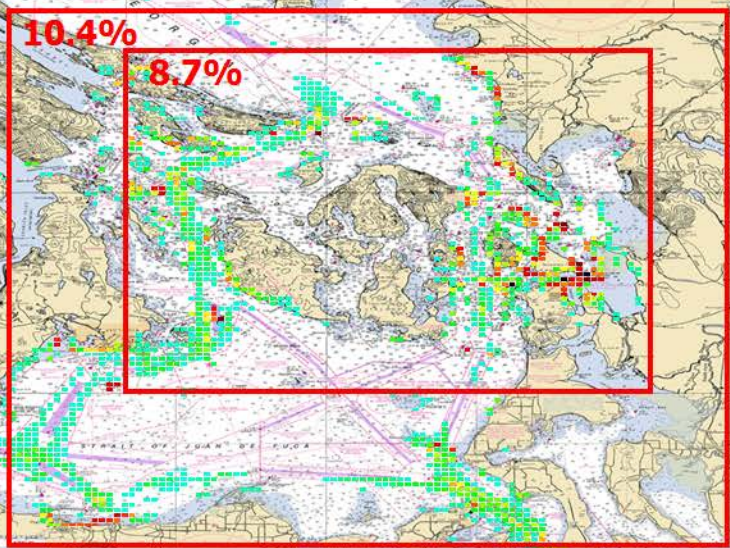
VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

VTRA 2015 CALIBRATION CASE - ALL FV

12.2% of VTRA 2015 Cal. Case Total Annual Potential Oil Loss:



Oil Loss:
SPILL SIZES BETWEEN
1,000 m³ - 2,500 m³



VTRA '15: Cal. Case
GEOGRAPHIC PROFILE
OF POTENTIAL
ANNUAL OIL LOSS
OF ACCIDENTS
WITH SPILL SIZE BETWEEN
1,000 m³ - 2,500 m³

≈ 0.50% Probability of Spill Occurrence in 10 years

Average of ≈ 1,628 m³ Per Potential Spill (≈ 1,400 Metric Tons)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

VTRA 2015 BASE CASE - ALL FV

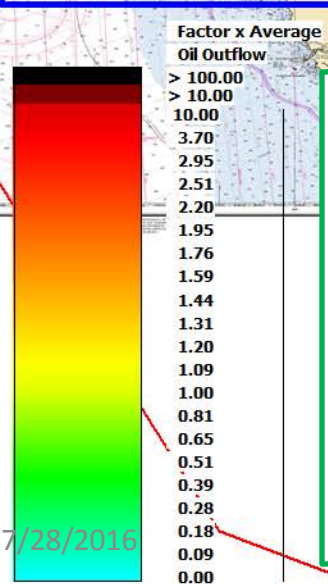
14.7% of VTRA 2015 Cal. Case Total Annual Potential Oil Loss:

0.1%

SPILL SIZES BETWEEN 1,000 m³ - 2,500 m³

12.8%

10.9%



VTRA '15 Base Case
GEOGRAPHIC PROFILE OF POTENTIAL ANNUAL OIL LOSS OF ACCIDENTS WITH SPILL SIZE **BETWEEN 1,000 m³ - 2,500 m³**

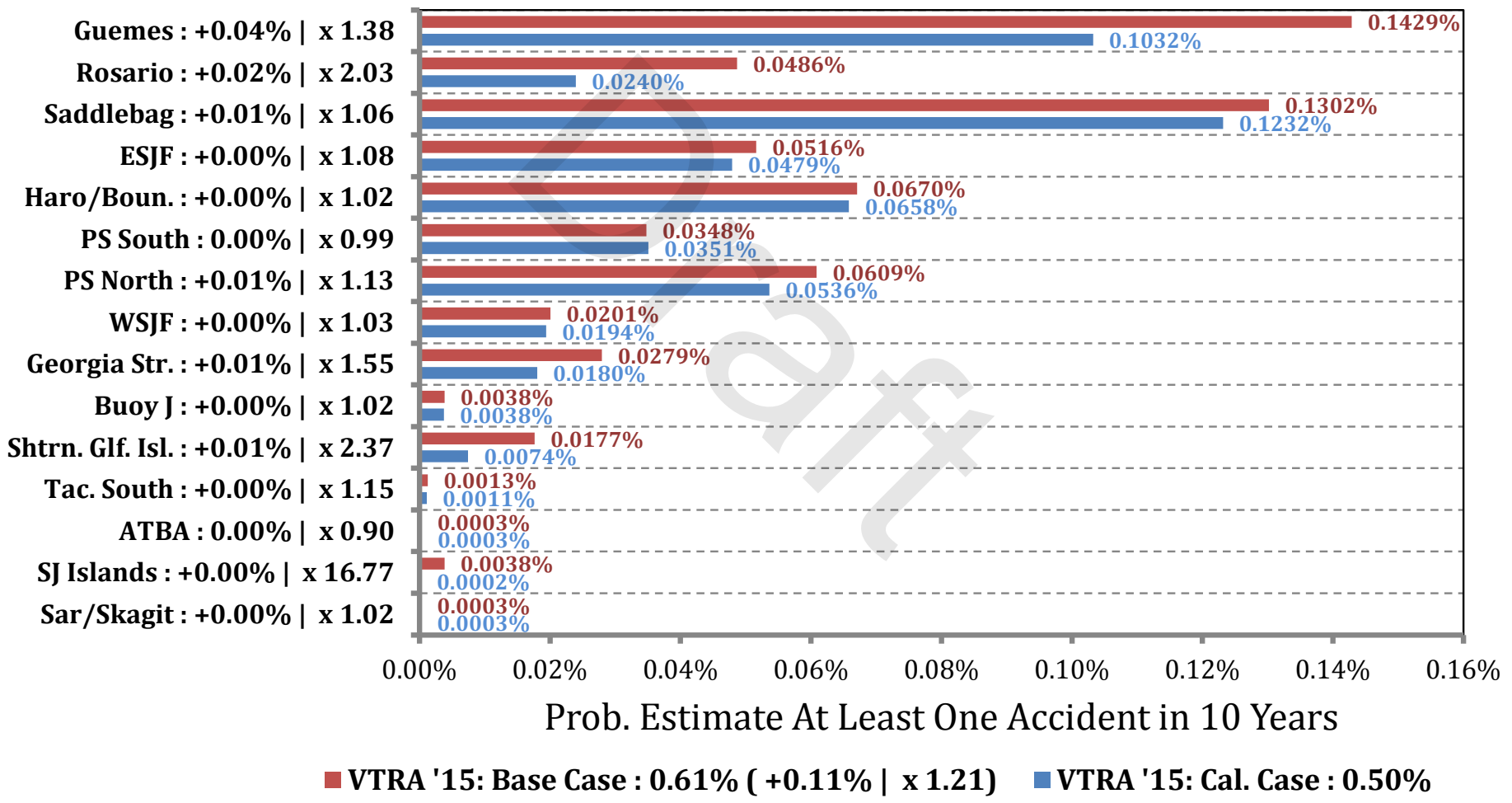
≈ 0.61% Probability of Spill Occurrence in 10 years

Average of ≈ 1,619 m³ Per Potential Spill (≈ 1,392 Metric Tons)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



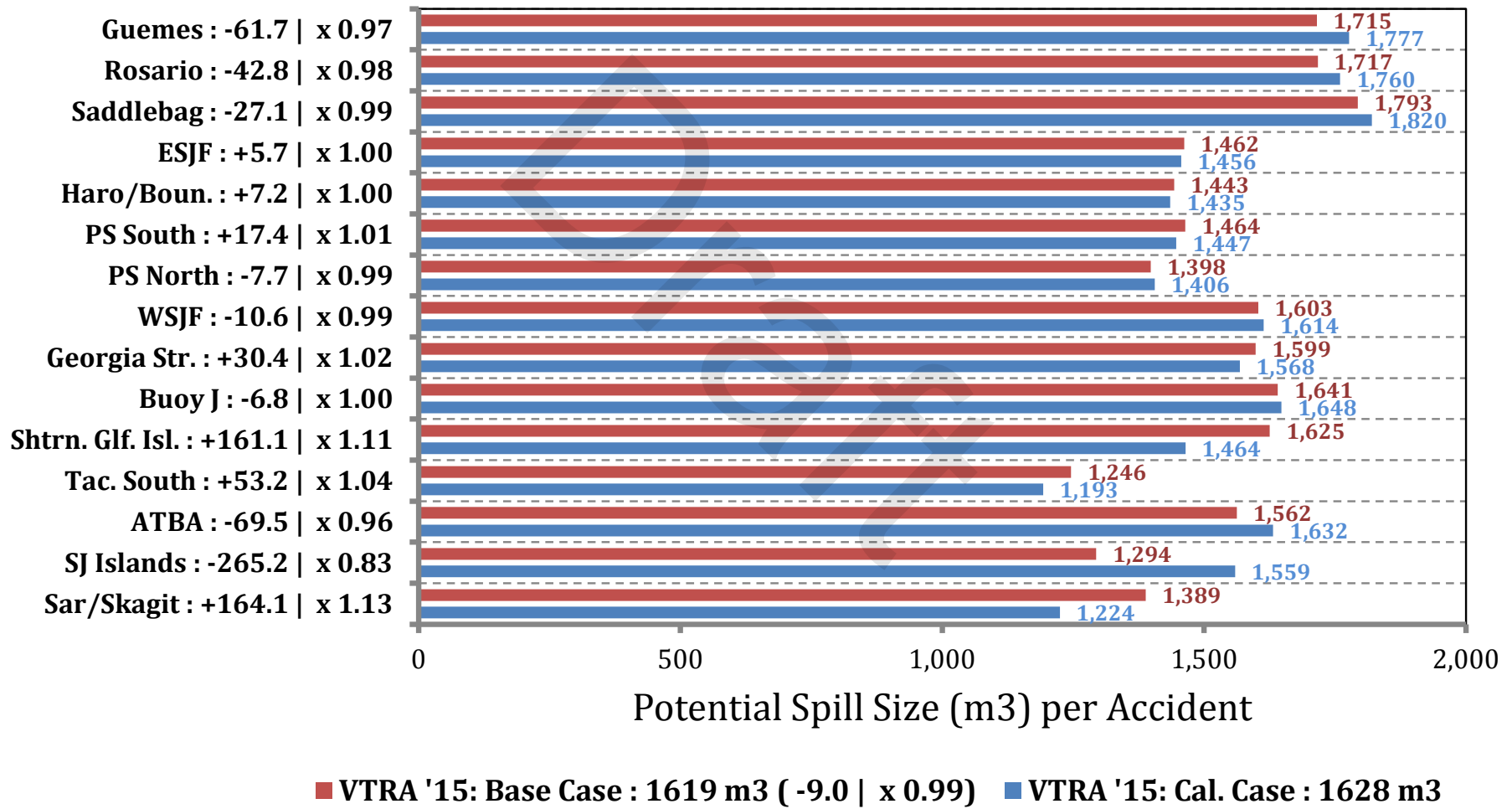
Prob. Estimate At Least One Accident in 10 Years - ALL_FV - Oil Spill Size Category: 1000 - 2500 m3



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



Potential Spill Size (m³) per Accident - ALL_FV - Oil Spill Size Category: 1000 - 2500 m³



By Waterway Zone Risk Comparison

Oil Spill Size Category:

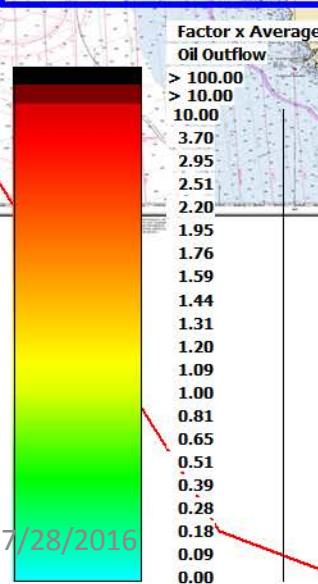
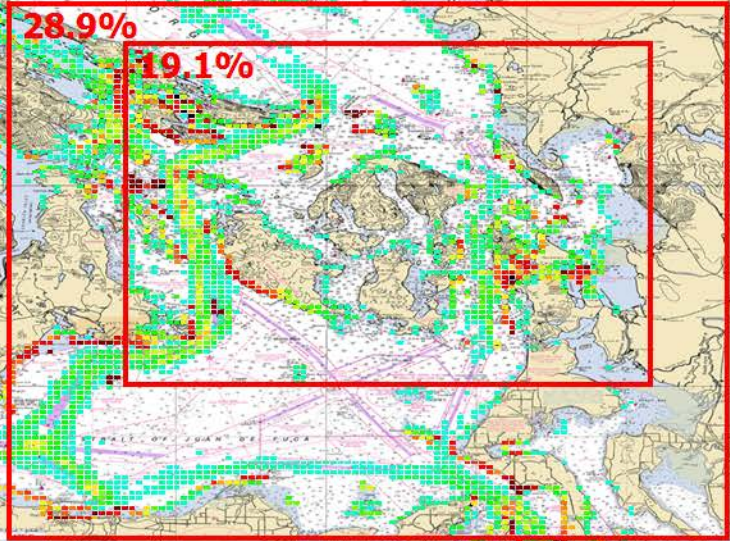
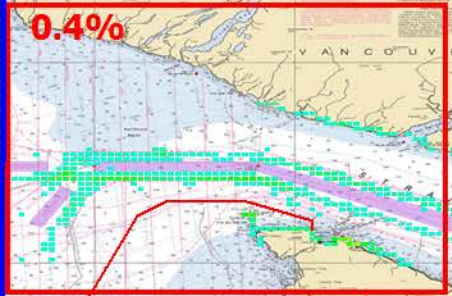
$1 \text{ m}^3 - 1000 \text{ m}^3$

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

VTRA 2015 CALIBRATION CASE - ALL FV

47.4% of VTRA 2015 Cal. Case Total Annual Potential Oil Loss:

Oil Loss: SPILL SIZES BETWEEN 1 m³ - 1,000 m³



VTRA '15: Cal. Case
GEOGRAPHIC PROFILE OF ANNUAL POTENTIAL OIL LOSS OF ACCIDENTS WITH SPILL SIZE **BETWEEN 1 m³ - 1000 m³**

≈ 53.2% Probability of Spill Occurrence in 10 years

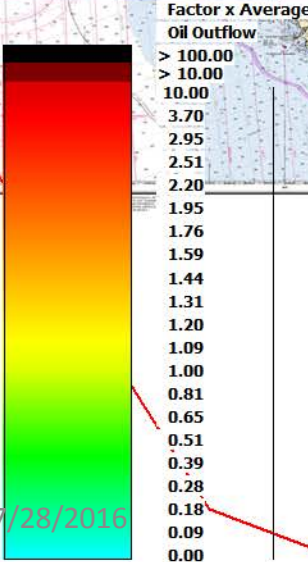
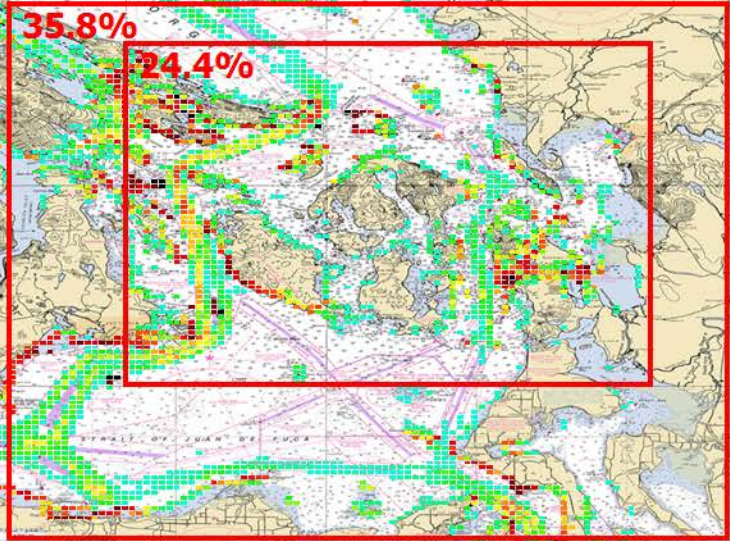
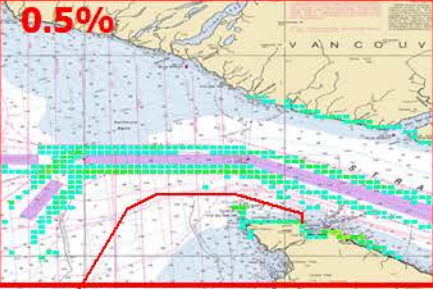
Average of ≈ 42 m³ Per Potential Spill (≈ 265 barrels)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

VTRA 2015 BASE CASE - ALL FV

54.4% of VTRA 2015 Cal. Case Total Annual Potential Oil Loss:

Oil Loss: SPILL SIZES BETWEEN 1 m³ - 1,000 m³



VTRA '15 Base GEOGRAPHIC PROFILE OF ANNUAL POTENTIAL OIL LOSS OF ACCIDENTS WITH SPILL SIZE BETWEEN 1 m³ - 1000 m³

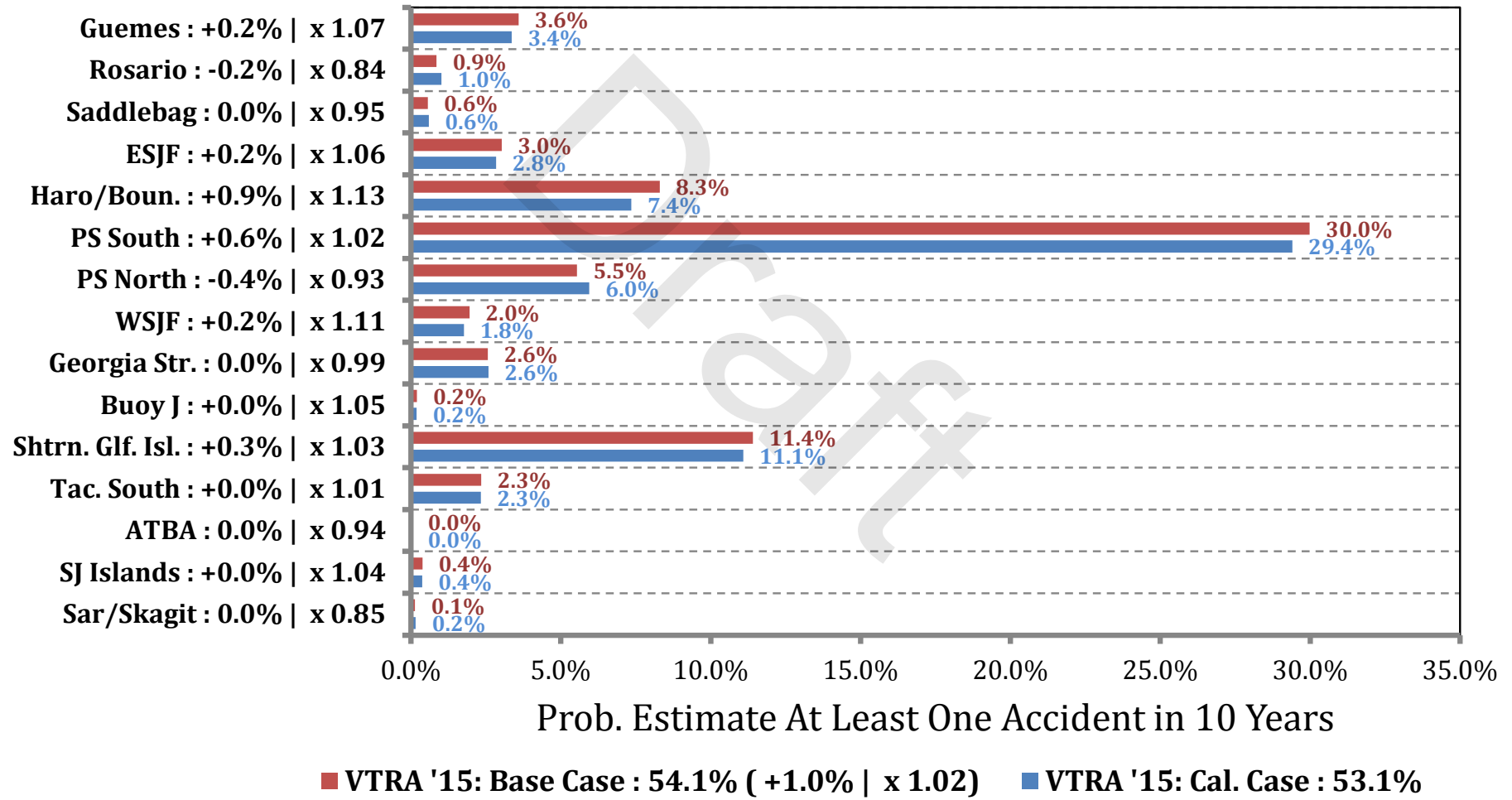
≈ 54.2% Probability of Spill Occurrence in 10 years

Average of ≈ 46.9 m³ Per Potential Spill (≈ 295 Barrels)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

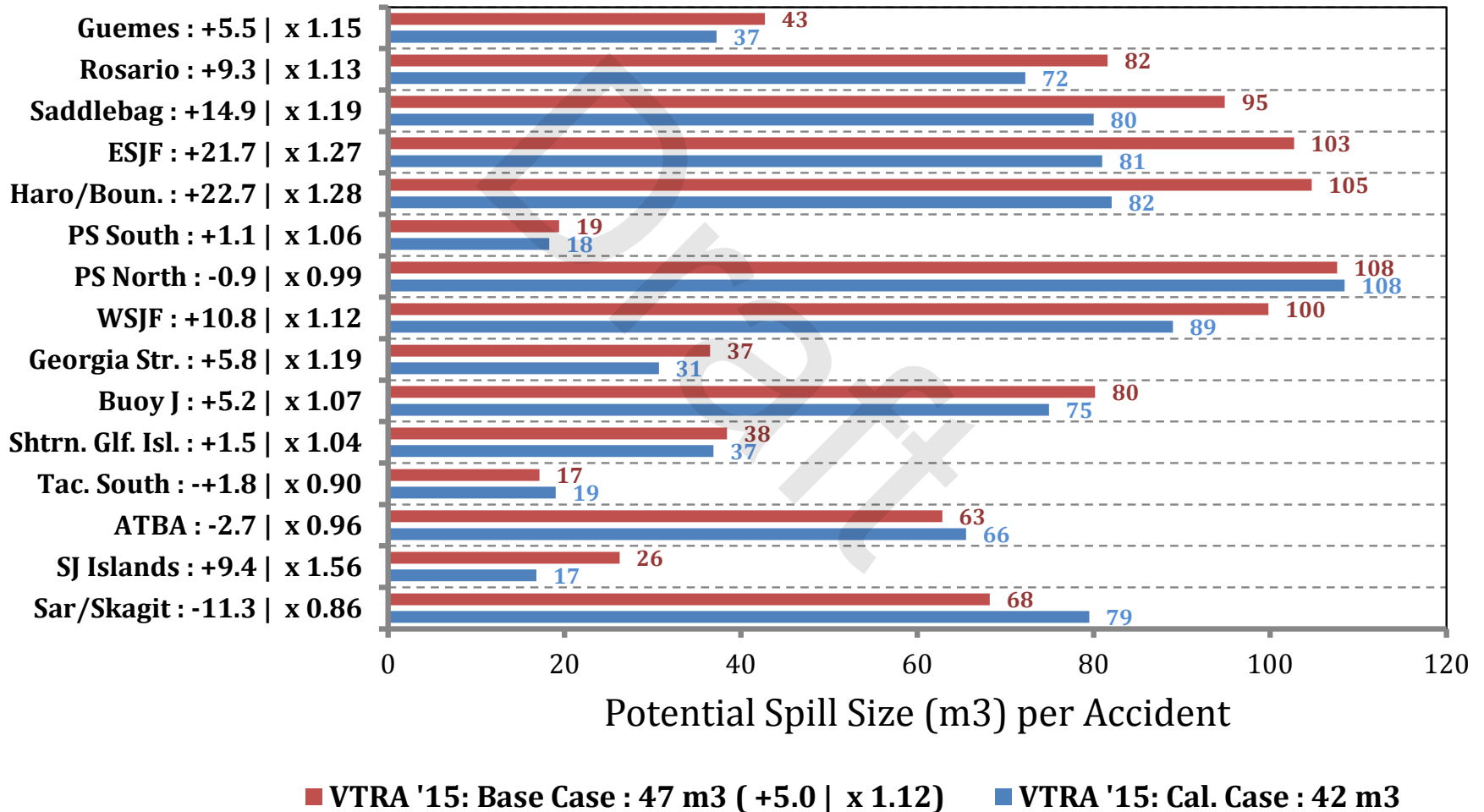


Prob. Estimate At Least One Accident in 10 Years - ALL_FV - Oil Spill Size Category: 1 - 1000 m3



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

Potential Spill Size (m³) per Accident - ALL_FV - Oil Spill Size Category: 1 - 1000 m³



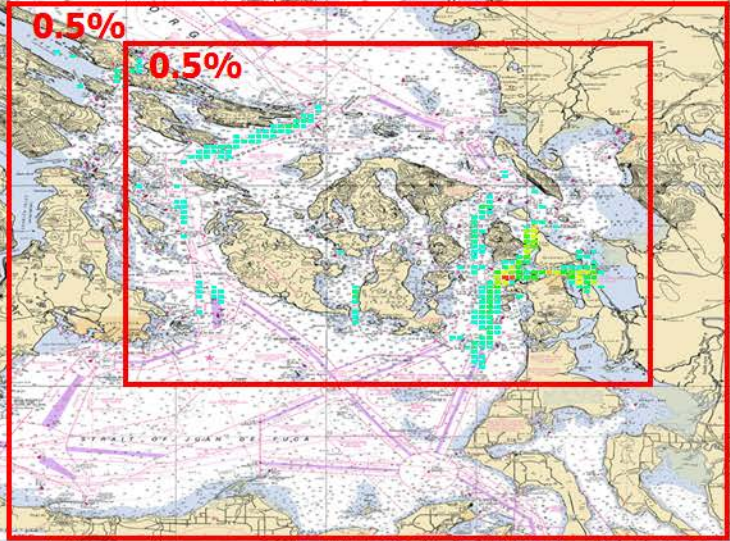
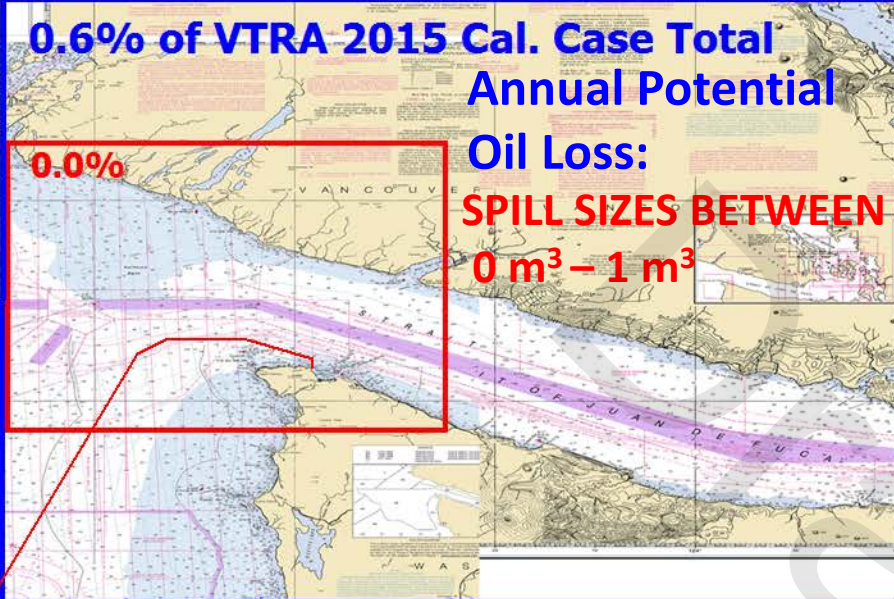
By Waterway Zone Risk Comparison

Oil Spill Size Category:

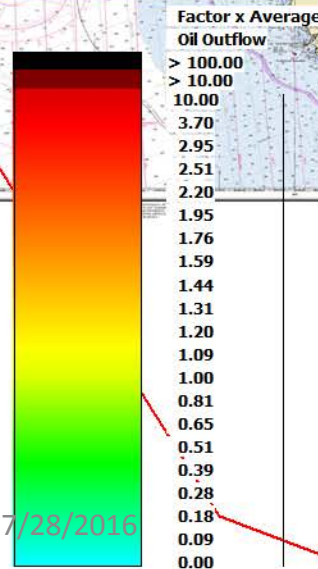
$0 \text{ m}^3 - 1 \text{ m}^3$

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

VTRA 2015 CALIBRATION CASE - ALL FV



0.6% of VTRA 2015 Cal. Case Total Annual Potential Oil Loss:
SPILL SIZES BETWEEN
 $0 \text{ m}^3 - 1 \text{ m}^3$



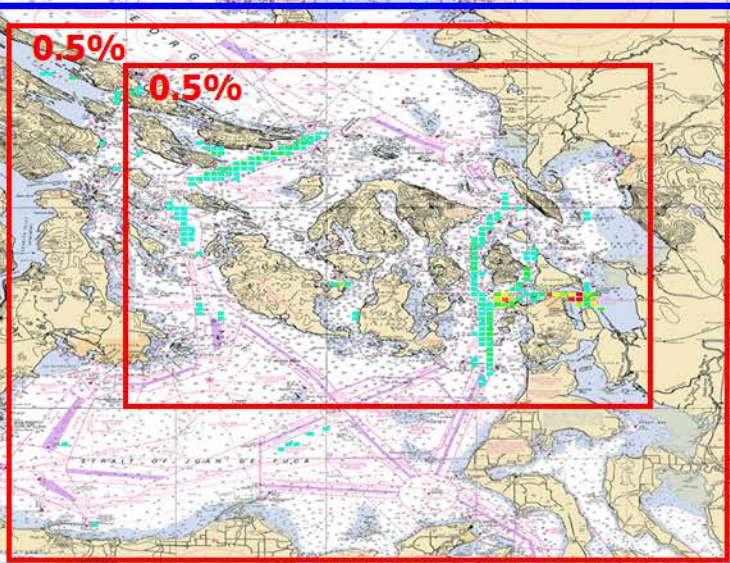
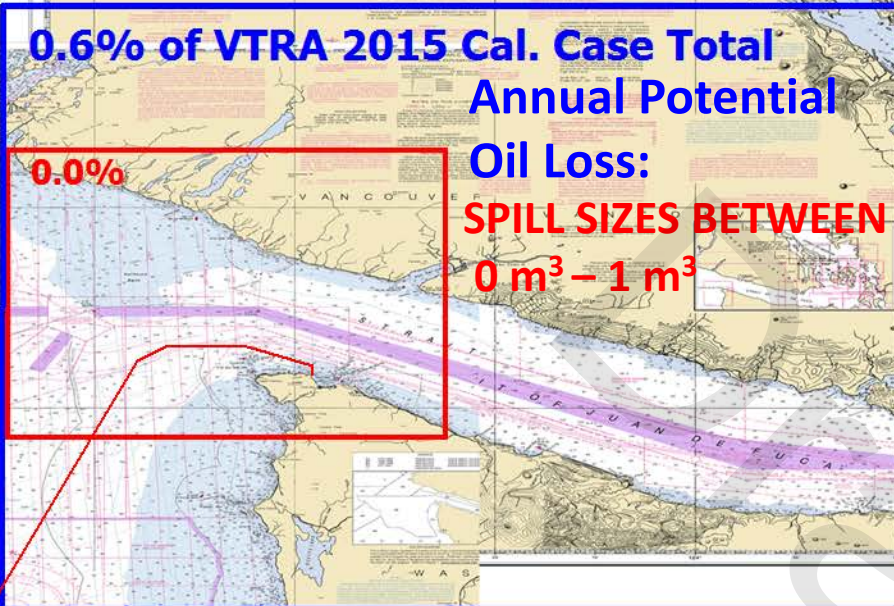
VTRA '15: Cal. Case
 GEOGRAPHIC PROFILE
 OF ANNUAL
 POTENTIAL OIL LOSS
 OF ACCIDENTS
 WITH SPILL SIZE
BETWEEN $0 \text{ m}^3 - 1 \text{ m}^3$

≈ 100% Probability
 of Spill Occurrence
 in 10 years

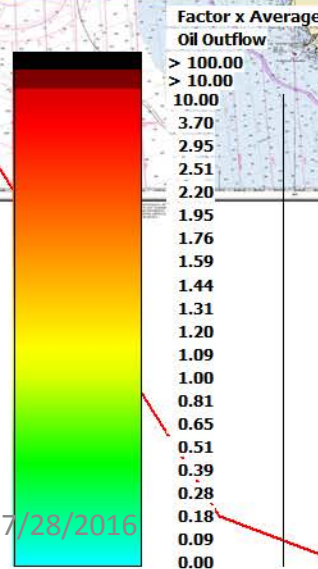
Average of ≈ 0.01 m^3
 Per Potential Spill
 (≈ 2.4 gallons)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

VTRA 2015 BASE CASE - ALL FV



0.6% of VTRA 2015 Cal. Case Total Annual Potential Oil Loss:
SPILL SIZES BETWEEN
 $0\text{ m}^3 - 1\text{ m}^3$



VTRA '15: Base Case
GEOGRAPHIC PROFILE
OF ANNUAL
POTENTIAL OIL LOSS
OF ACCIDENTS
WITH SPILL SIZE
BETWEEN $0\text{ m}^3 - 1\text{ m}^3$

≈ 100% Probability of Spill Occurrence in 10 years

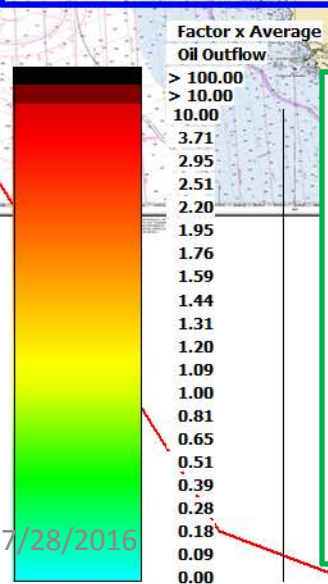
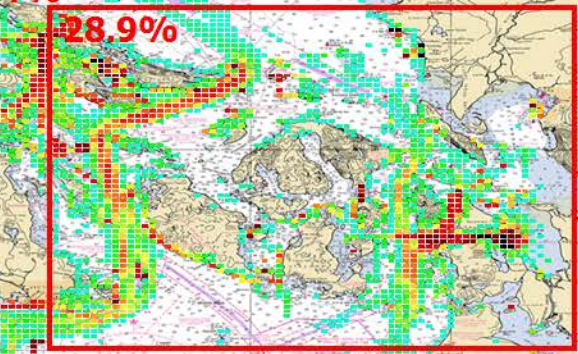
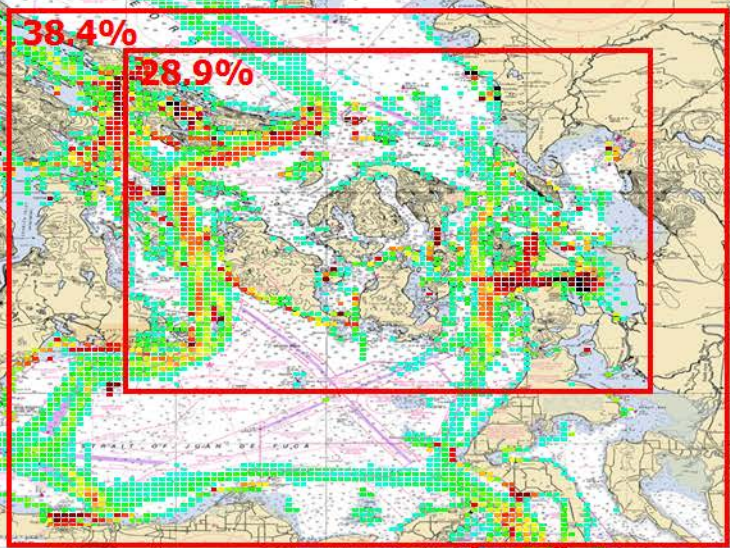
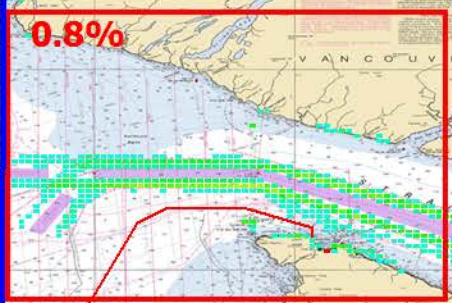
Average of ≈ 0.01 m^3 Per Potential Spill (= 2.3 gallons)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

VTRA 2015 CALIBRATION CASE - ALL FV

98.2% of VTRA 2015 Cal. Case Total Potential Annual # Accidents:

SPILL SIZES BETWEEN $0\text{ m}^3 - 1\text{ m}^3$



VTRA '15: Cal. Case
GEOGRAPHIC PROFILE
OF ANNUAL
POTENTIAL OIL LOSS
OF ACCIDENTS
WITH SPILL SIZE
BETWEEN $0\text{ m}^3 - 1\text{ m}^3$

≈ 100% Probability
of Spill Occurrence
in 10 years

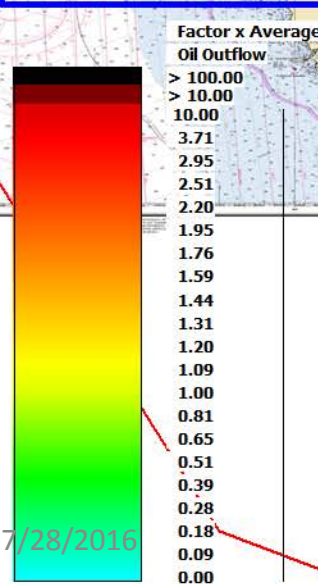
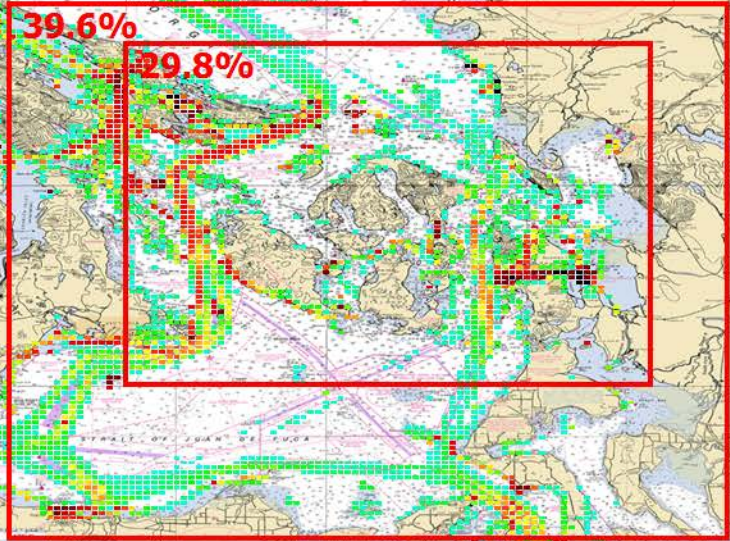
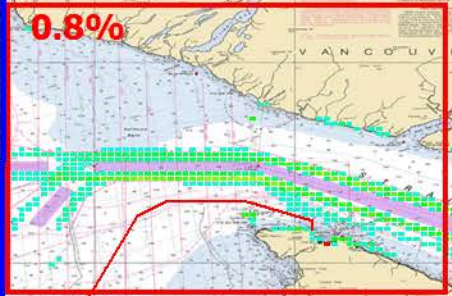
Average of ≈ 0.01 m^3
Per Potential Spill
(≈ 2.4 gallons)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

VTRA 2015 BASE CASE - ALL FV

99.4% of VTRA 2015 Cal. Case Total Potential Annual # Accidents:

SPILL SIZES BETWEEN $0\text{ m}^3 - 1\text{ m}^3$



VTRA '15: Base Case
GEOGRAPHIC PROFILE
OF ANNUAL
POTENTIAL OIL LOSS
OF ACCIDENTS
WITH SPILL SIZE
BETWEEN $0\text{ m}^3 - 1\text{ m}^3$

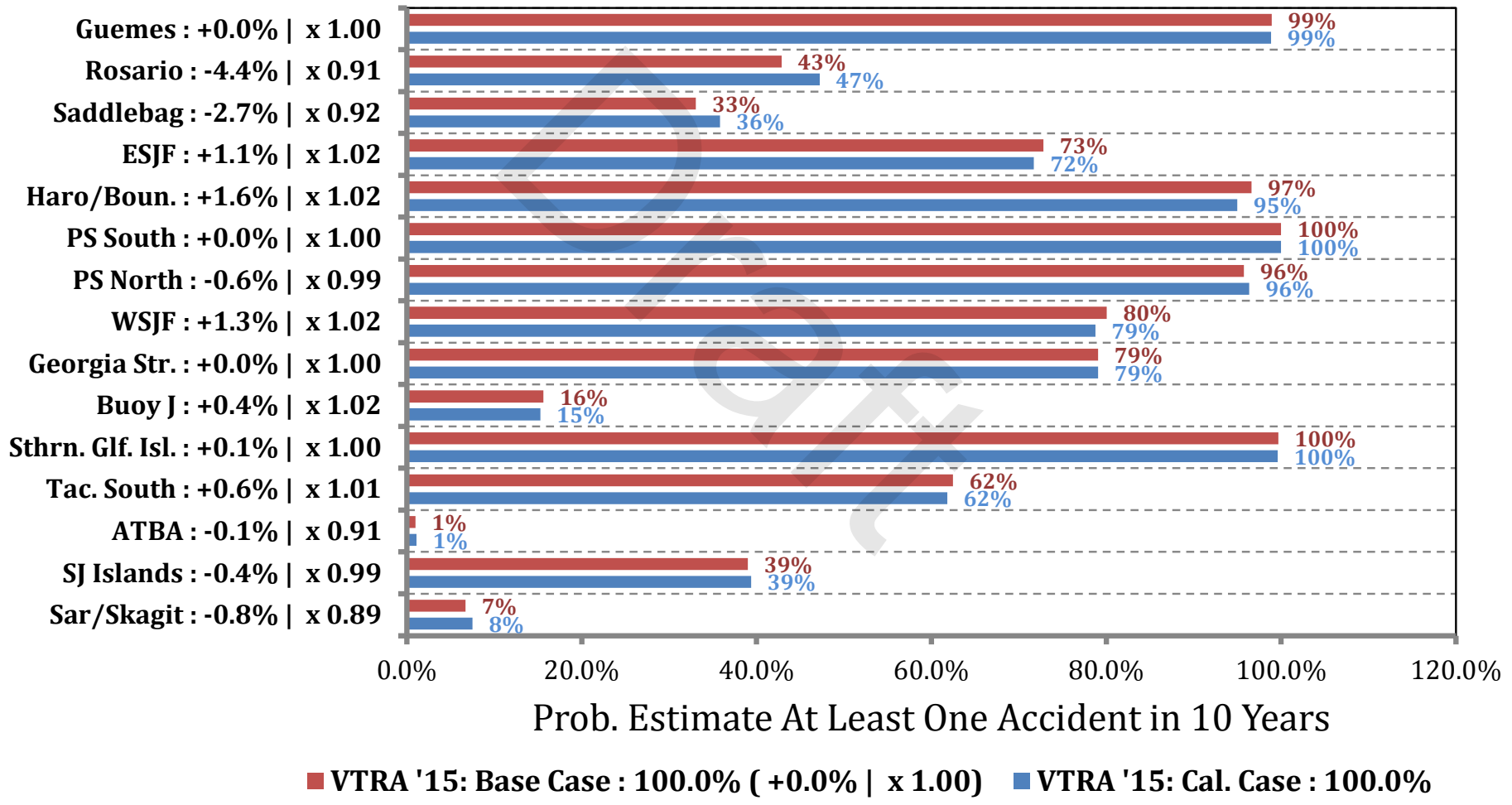
≈ 100% Probability
of Spill Occurrence
in 10 years

Average of ≈ 0.01 m^3
Per Potential Spill
(= 2.3 gallons)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

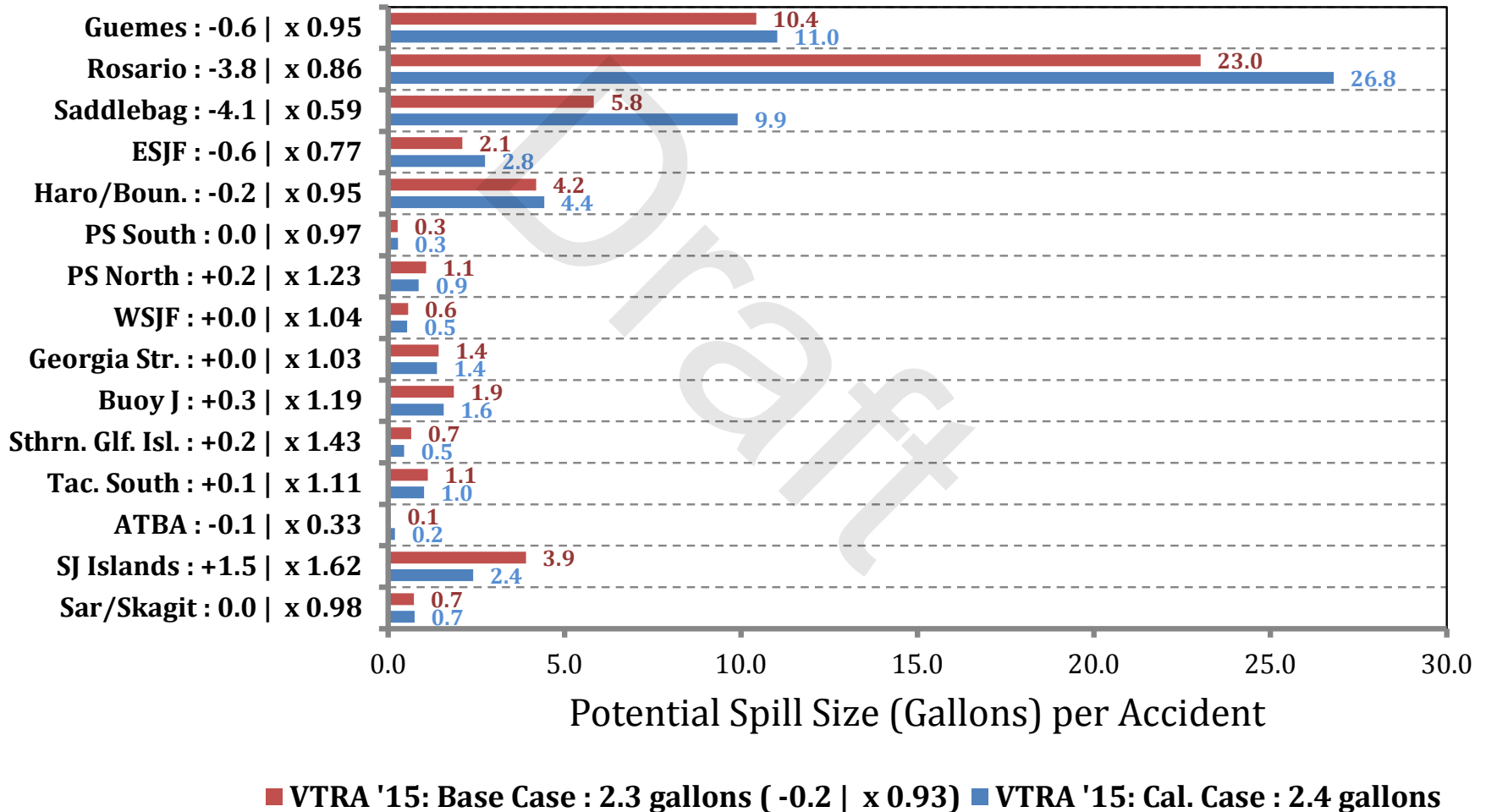


Prob. Estimate At Least One Accident in 10 Years - ALL_FV - Oil Spill Size Category: 0 - 264 Gallons



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

Potential Spill Size (Gallons) per Accident - ALL_FV - Oil Spill Size Category: 0 - 264 Gallons



Summary Risk Comparison

Oil Spill Size Category:
All Spill Sizes

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



Summary Risk Comparison

		OIL_2500_MORE	OIL_1000_2500	OIL_1_1000	OIL_0_1	TOTAL_OIL
VTRA '15 CAL. CASE	Base Case % Potential Annual Oil Loss	39.8%	12.2%	47.4%	0.6%	100.0%
	Base Case % Potential Annual Accident Frequency	0.01%	0.01%	1.7%	98.2%	100.0%
	Average potential spill size per accident (in m ³)	5,745	1,627	42.0	0.01	1.5
	Probability of at least one accident in 1 year by spill size	0.05%	0.05%	7.3%	98.7%	98.8%
	Probability of at least one accident in 10 year by spill size	0.47%	0.50%	53.2%	100.0%	100.0%
	Probability of at least one accident in 25 years by spill size	1.16%	1.25%	85.0%	100.0%	100.0%
		OIL_2500_MORE	OIL_1000_2500	OIL_1_1000	OIL_0_1	TOTAL_OIL
VTRA '15 BASE CASE	Base Case % Potential Annual Oil Loss	50.5% (+10.64% x1.27)	14.7% (+2.54% x1.21)	54.4% (+7.05% x1.15)	0.6% (-0.03% x0.94)	120.2% (+20.2% x1.20)
	Base Case % Potential Annual Accident Frequency	0.01% (+0.00% x1.07)	0.01% (+0.00% x1.21)	1.8% (+0.05% x1.03)	99.4% (+1.11% x1.01)	101.2% (+1.2% x1.01)
	Average potential spill size per accident (in m ³)	6798 (+1053 x1.18)	1619 (-9 x0.99)	46.9 (+4.9 x1.12)	0.01 (0.00 x0.93)	1.8 (+0.3 x1.19)
	Probability of at least one accident in 1 year by spill size	0.05% (+0.00% x1.07)	0.06% (+0.01% x1.21)	7.5% (+0.20% x1.03)	98.7% (+0.06% x1.00)	98.8% (+0.06% x1.00)
	Probability of at least one accident in 10 year by spill size	0.50% (+0.03% x1.07)	0.61% (+0.11% x1.21)	54.2% (+0.99% x1.02)	100.0% (0.00% x1.00)	100.0% (0.00% x1.00)
	Probability of at least one accident in 25 years by spill size	1.24% (+0.08% x1.07)	1.52% (+0.27% x1.21)	85.8% (+0.78% x1.01)	100.0% (0.00% x1.00)	100.0% (0.00% x1.00)