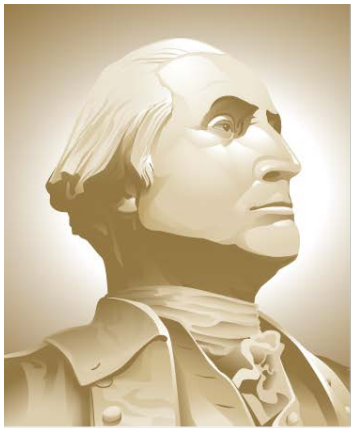
VTRA 2015 US -230 Case and VTRA 2015 Base Case Comparison



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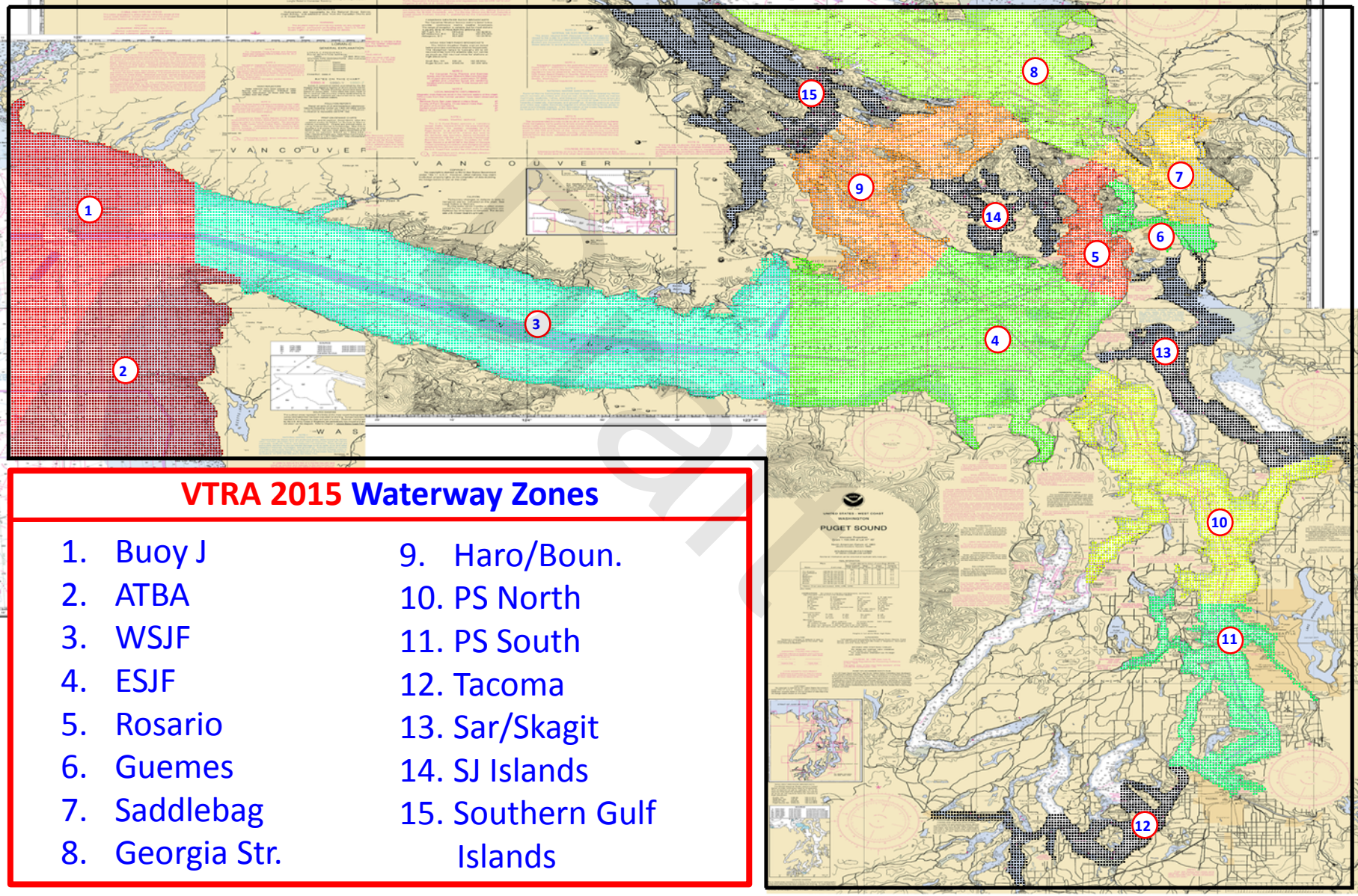
Jason R.W. Merrick (VCU) and J. Rene van Dorp (GW)

August 9th – 10th, 2016

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

DEFINITION OF 15 WATERWAY ZONES



VTRA 2015 Waterway Zones

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

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

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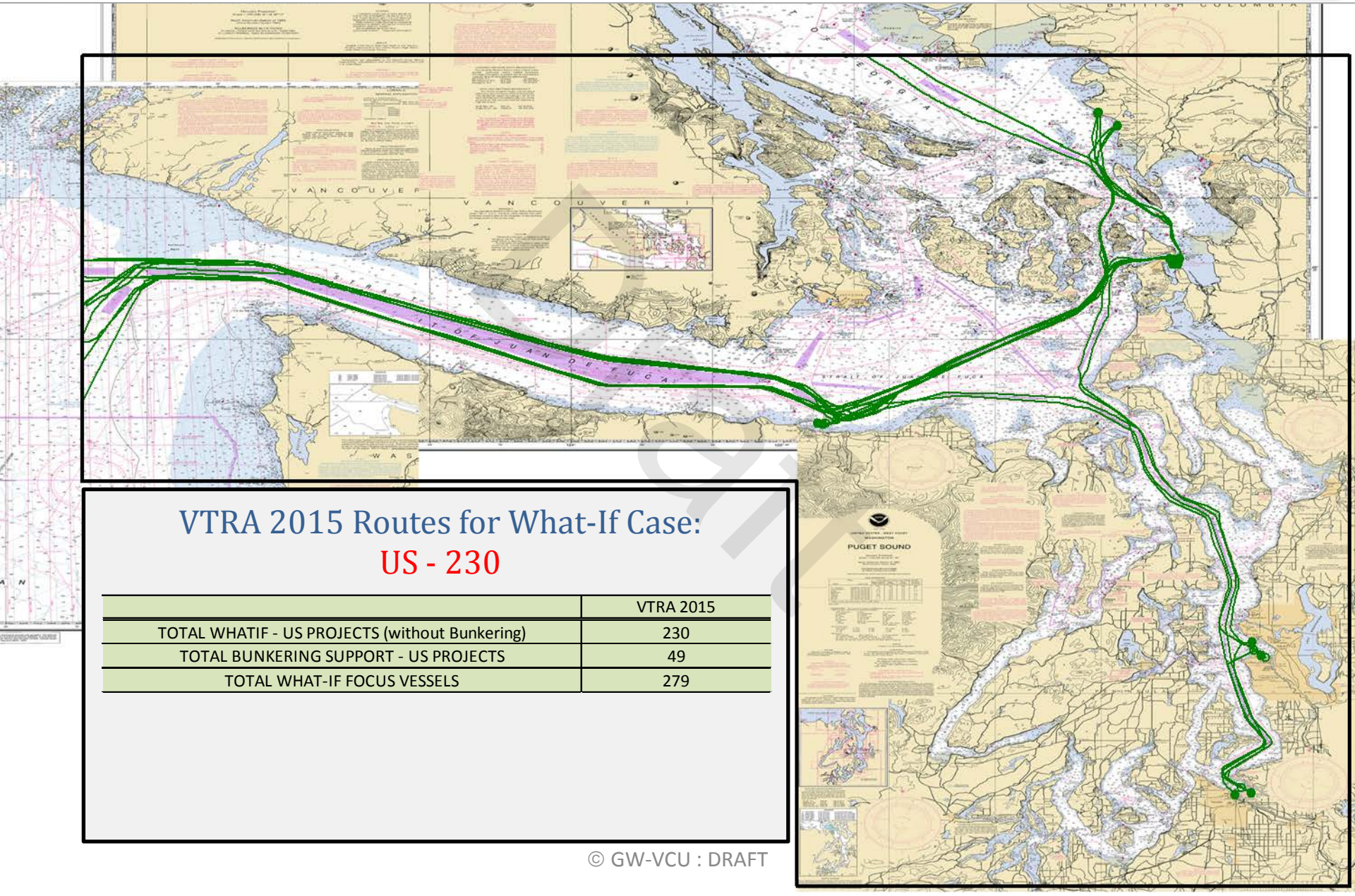
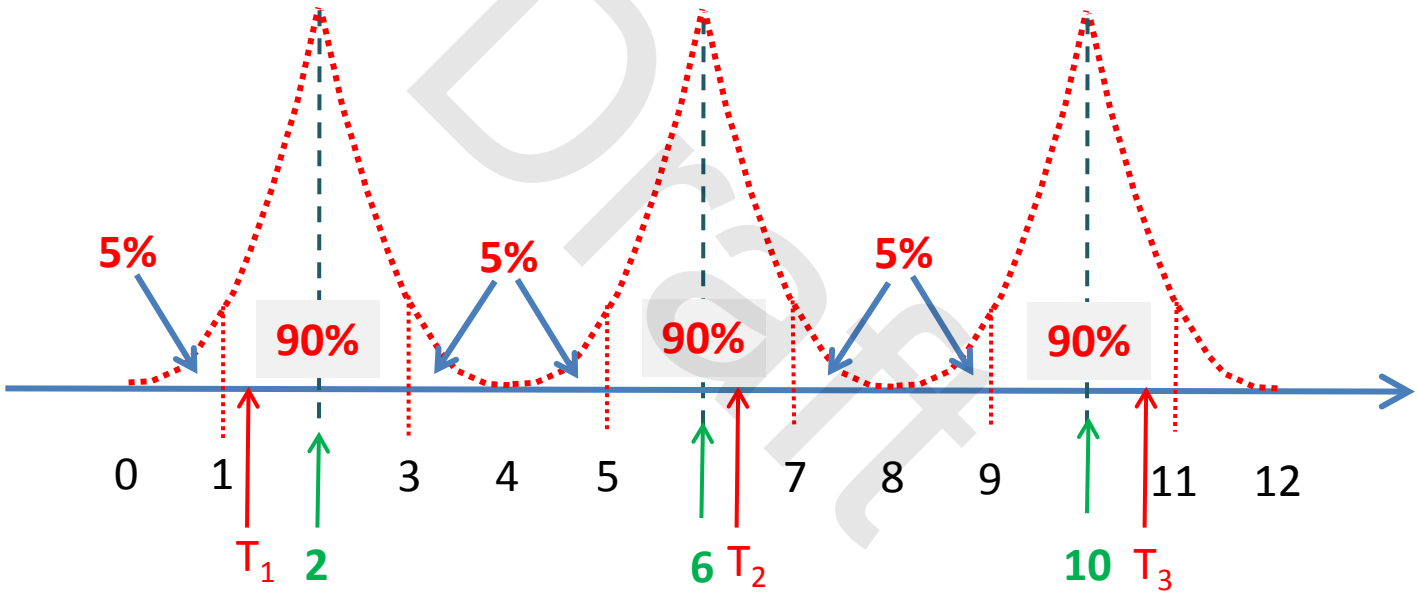


VTRA 2015 Routes for What-If Case:
US - 230

	VTRA 2015
TOTAL WHATIF - US PROJECTS (without Bunkering)	230
TOTAL BUNKERING SUPPORT - US PROJECTS	49
TOTAL WHAT-IF FOCUS VESSELS	279

VTRA 2015 – What If FV
Scheduled Random Arrival Pattern Model
(See Example Graph below)



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

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

By Waterway Zone Risk Comparison

Oil Spill Size Category:

ALL SPILL SIZES

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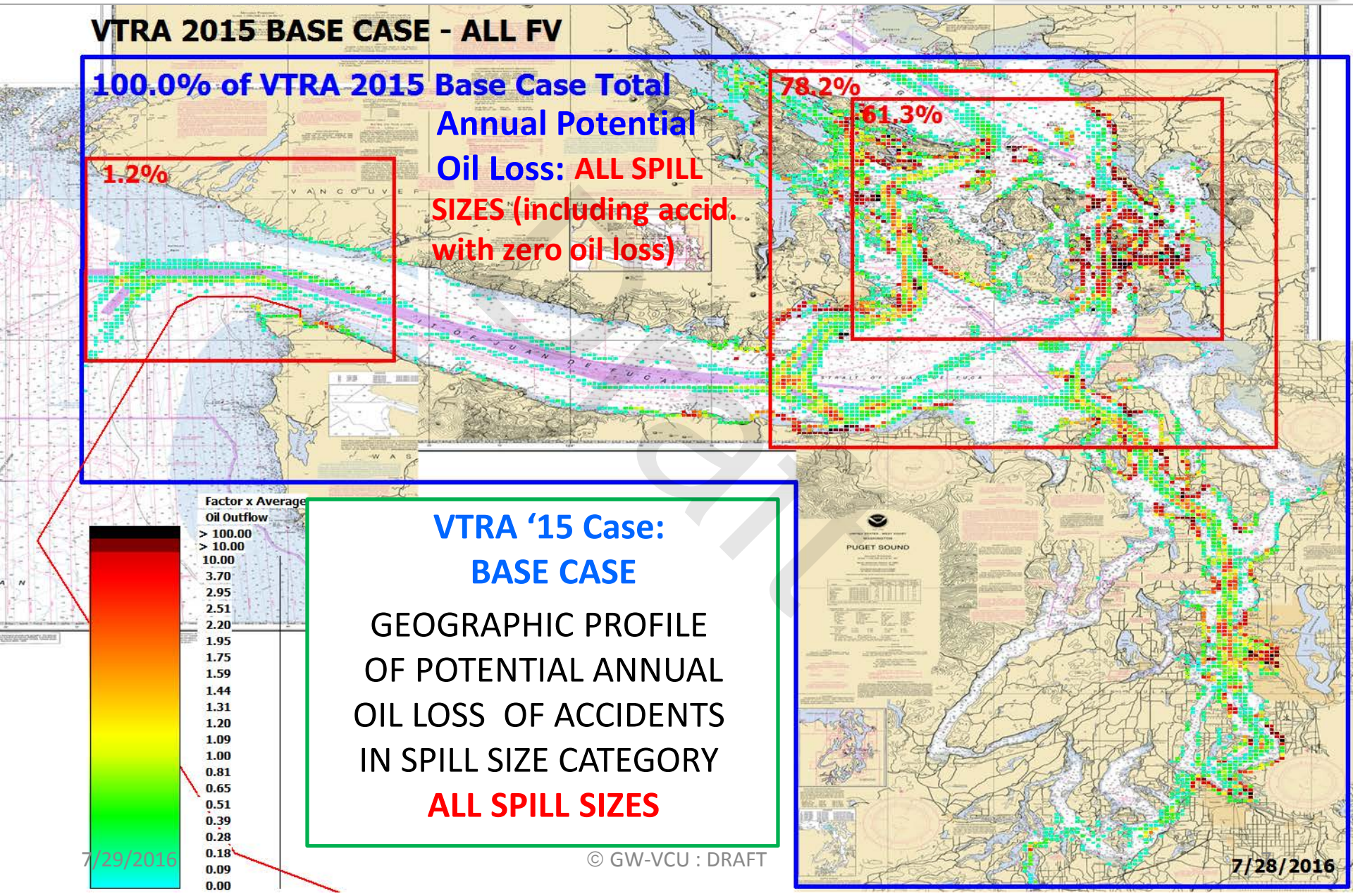

VTRA '15 Case:
BASE CASE

GEOGRAPHIC PROFILE
OF POTENTIAL ANNUAL
OIL LOSS OF ACCIDENTS
IN SPILL SIZE CATEGORY
ALL SPILL SIZES

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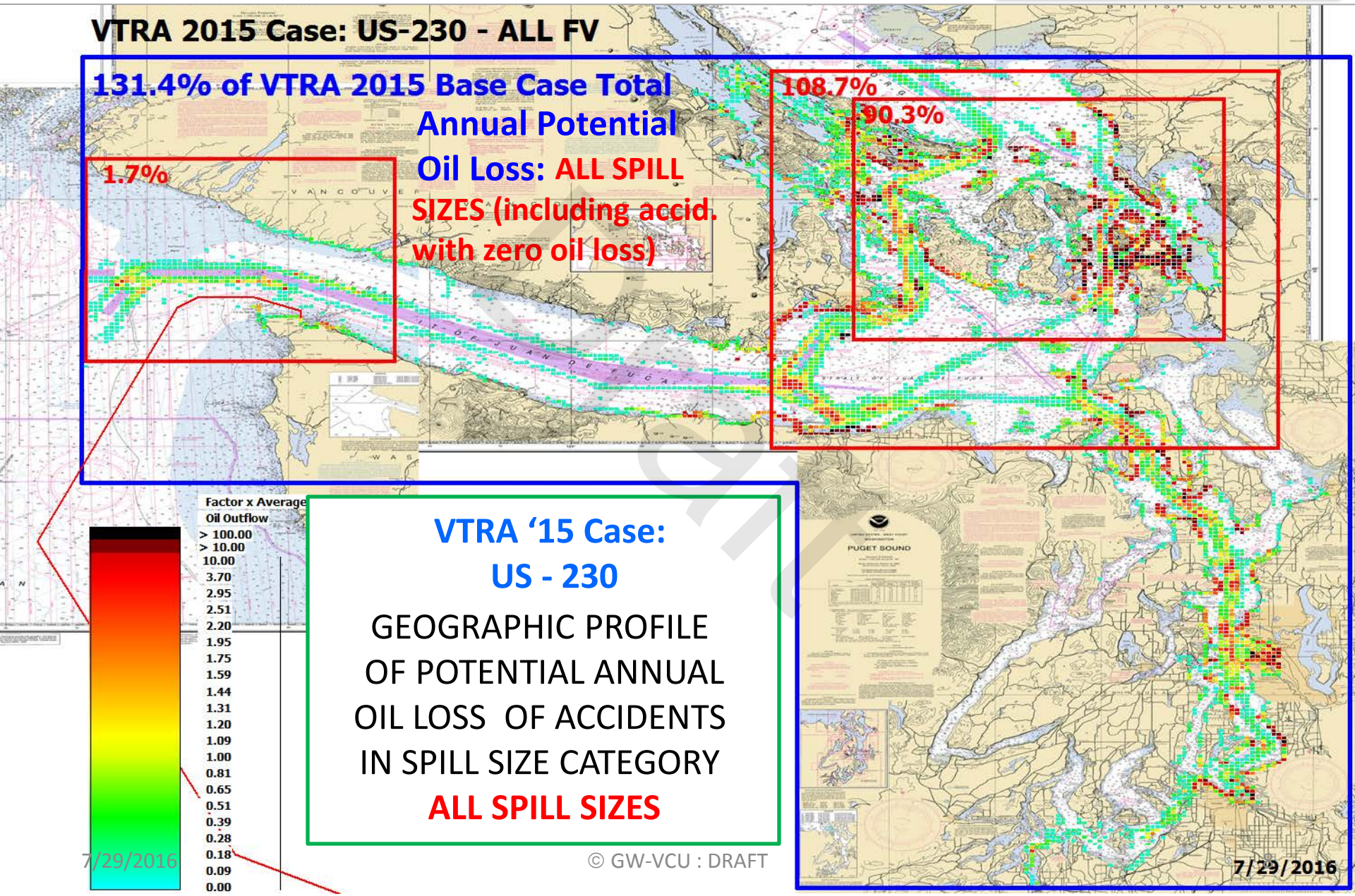
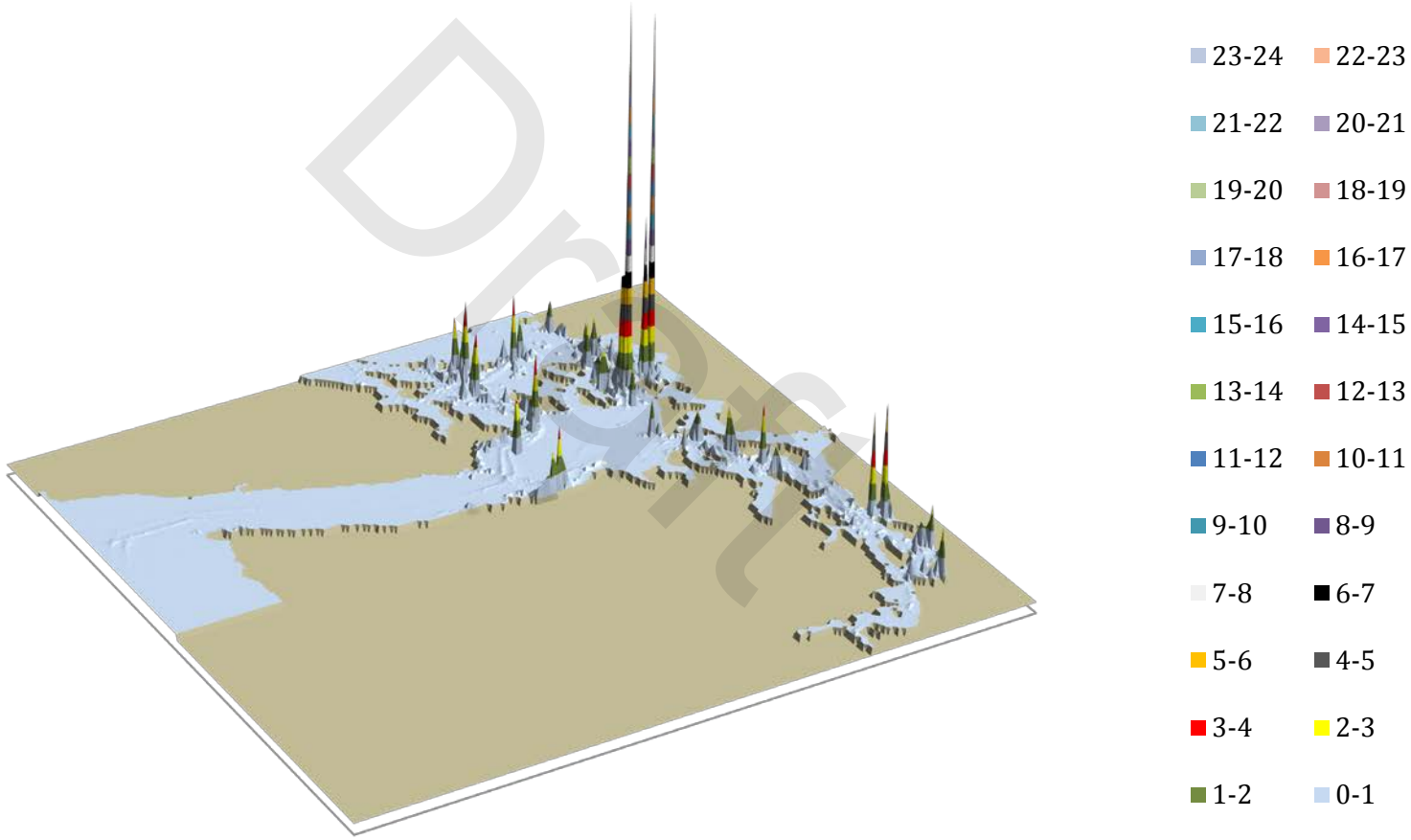


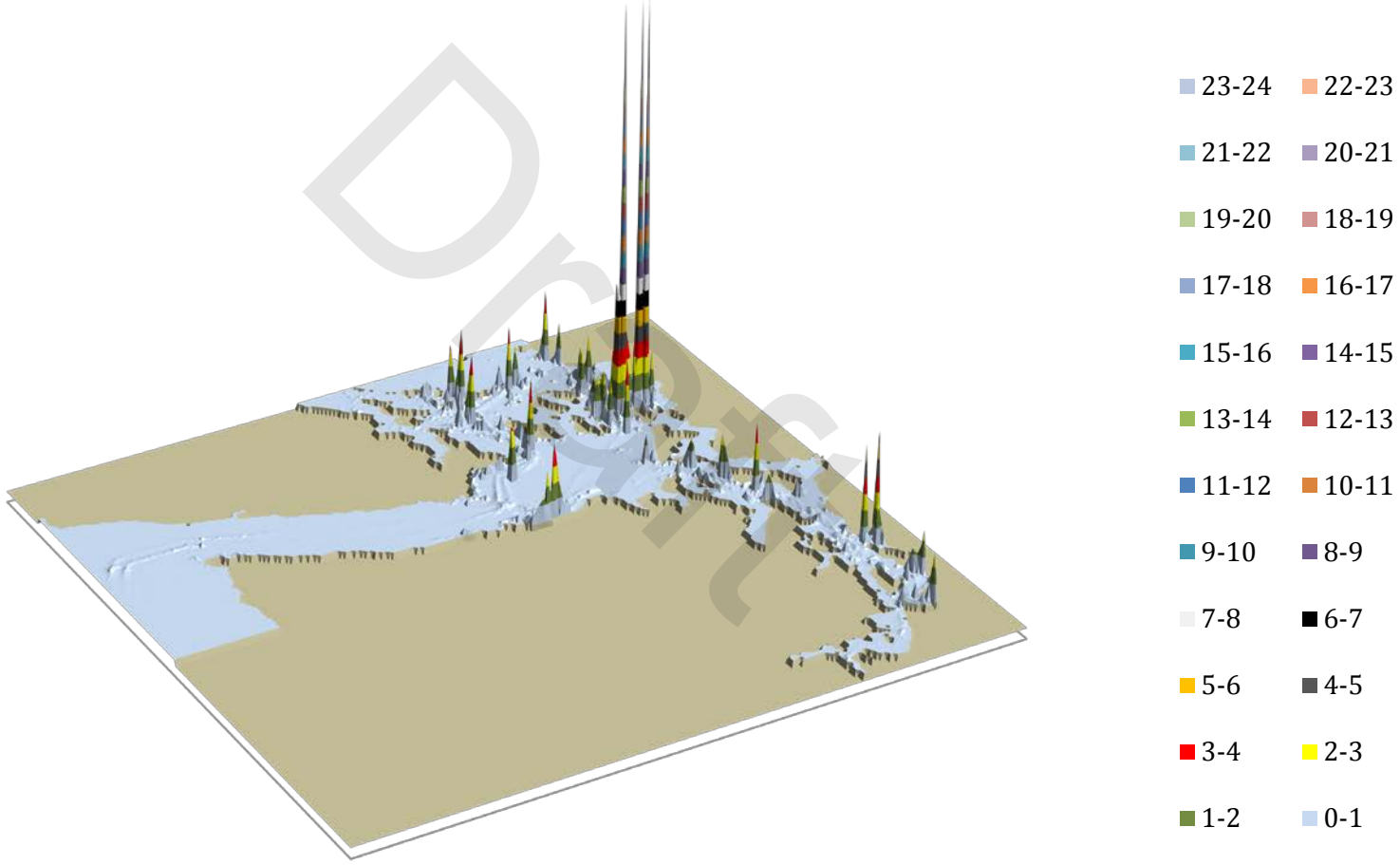
VTRA '15 Case:
US - 230

GEOGRAPHIC PROFILE
OF POTENTIAL ANNUAL
OIL LOSS OF ACCIDENTS
IN SPILL SIZE CATEGORY
ALL SPILL SIZES

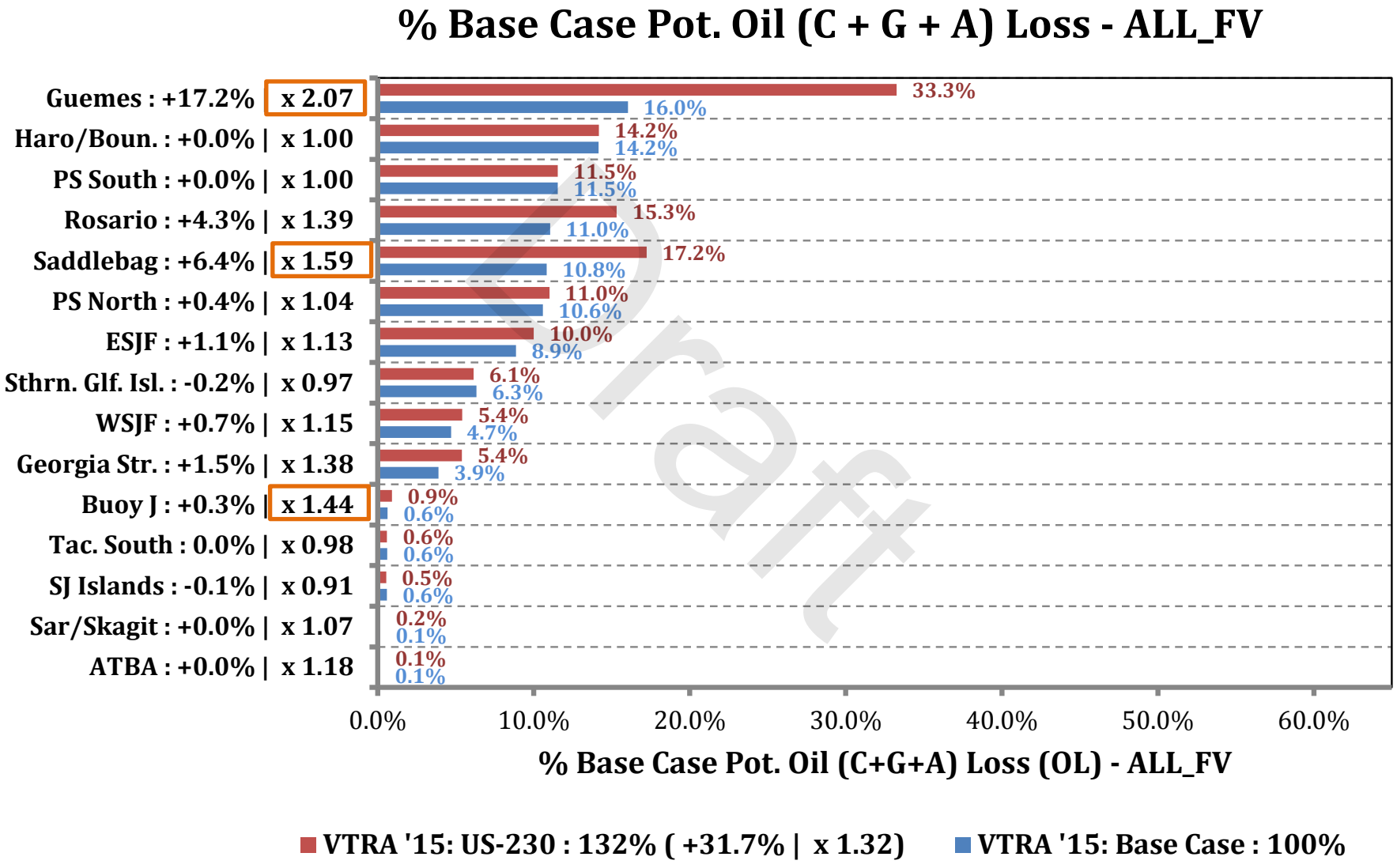
VTRA '15: Base Case 3D Risk Profile All FV - Pot.C+G+A.Oil Loss: 100% of Base Case POL



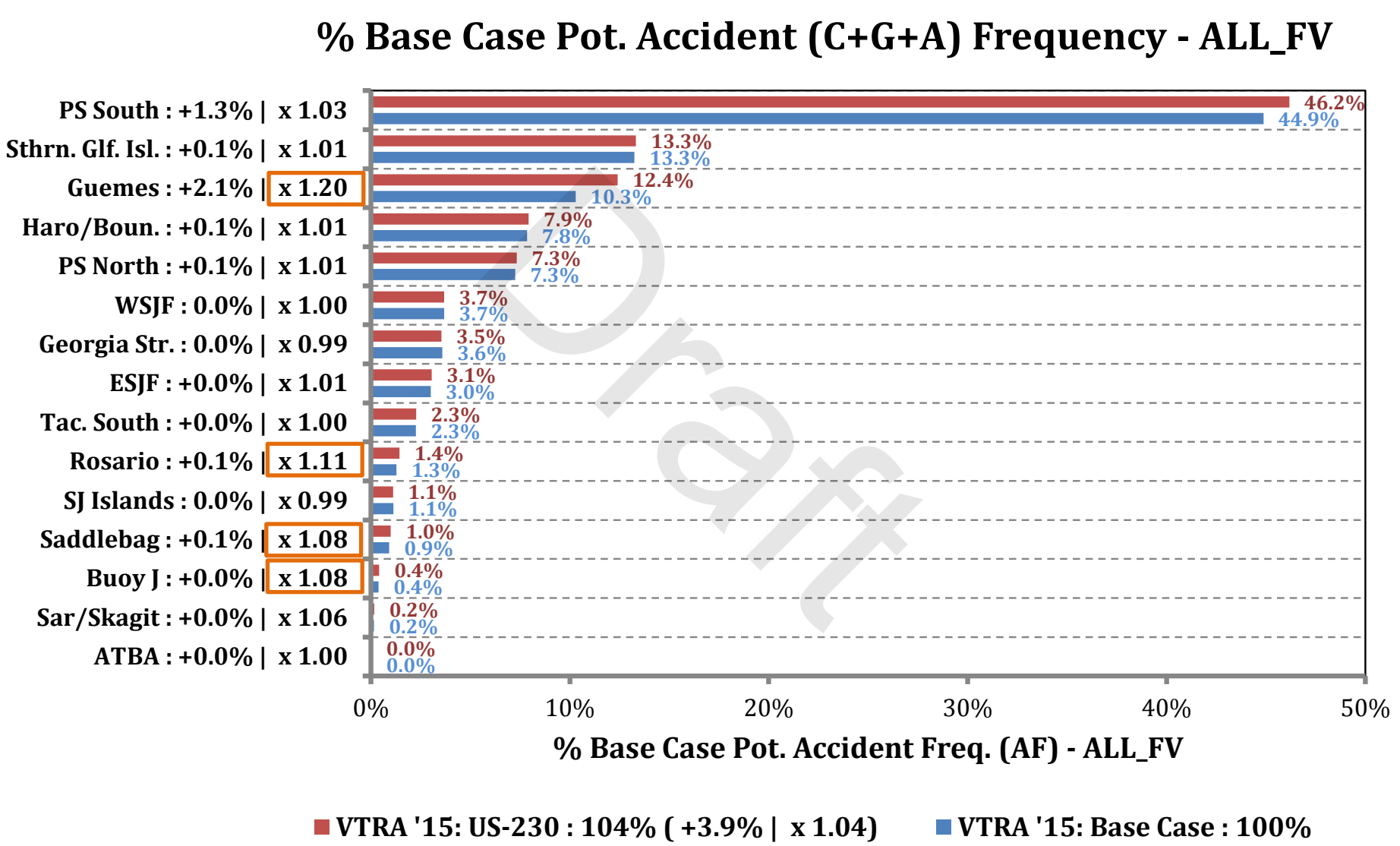
VTRA '15: US-230 3D Risk Profile All FV - Pot.C+G+A.Oil Loss: 132% of Base Case POL



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



By Waterway Zone Risk Comparison

Oil Spill Size Category:

2500 m^3 or more

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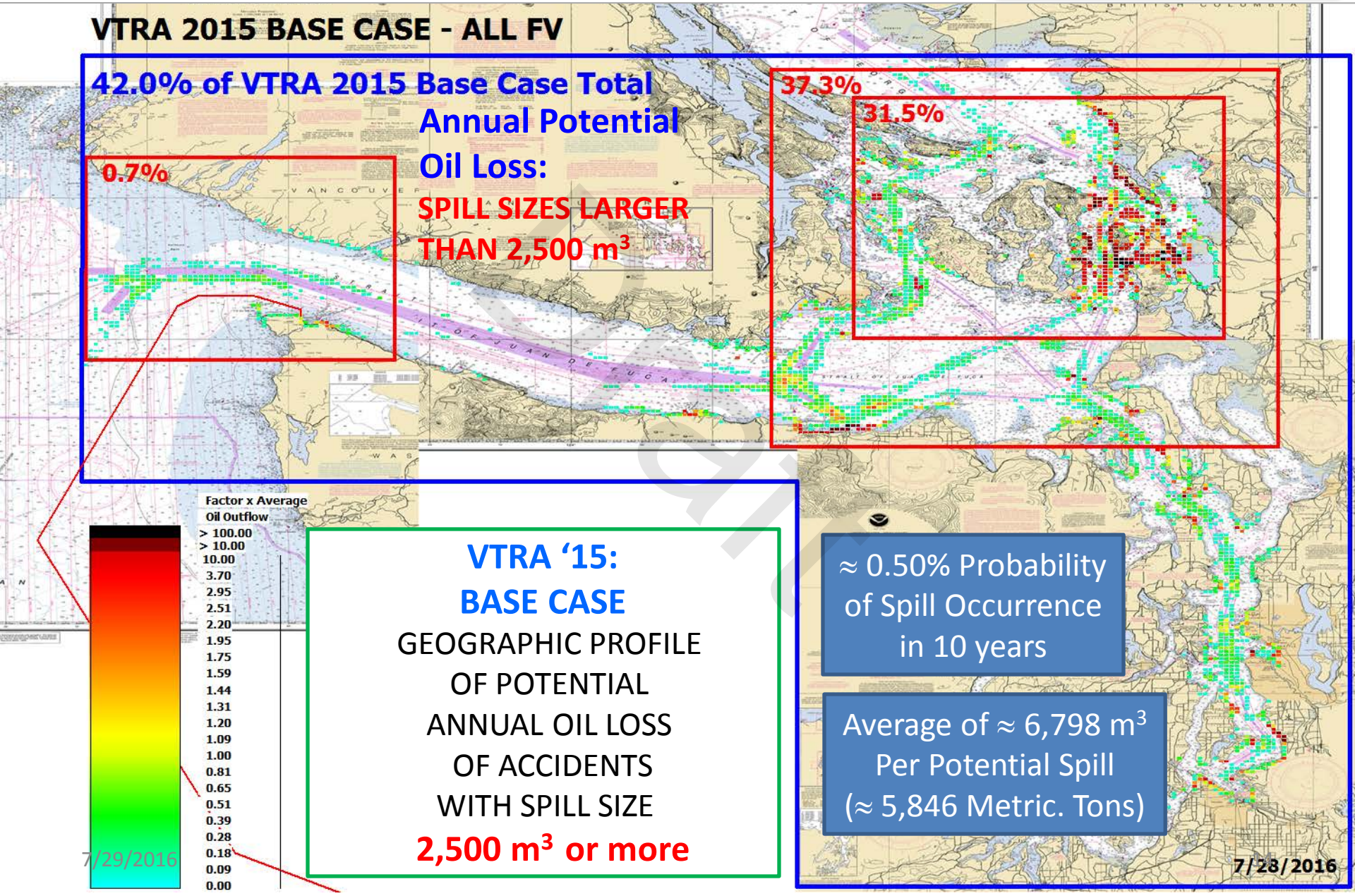

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

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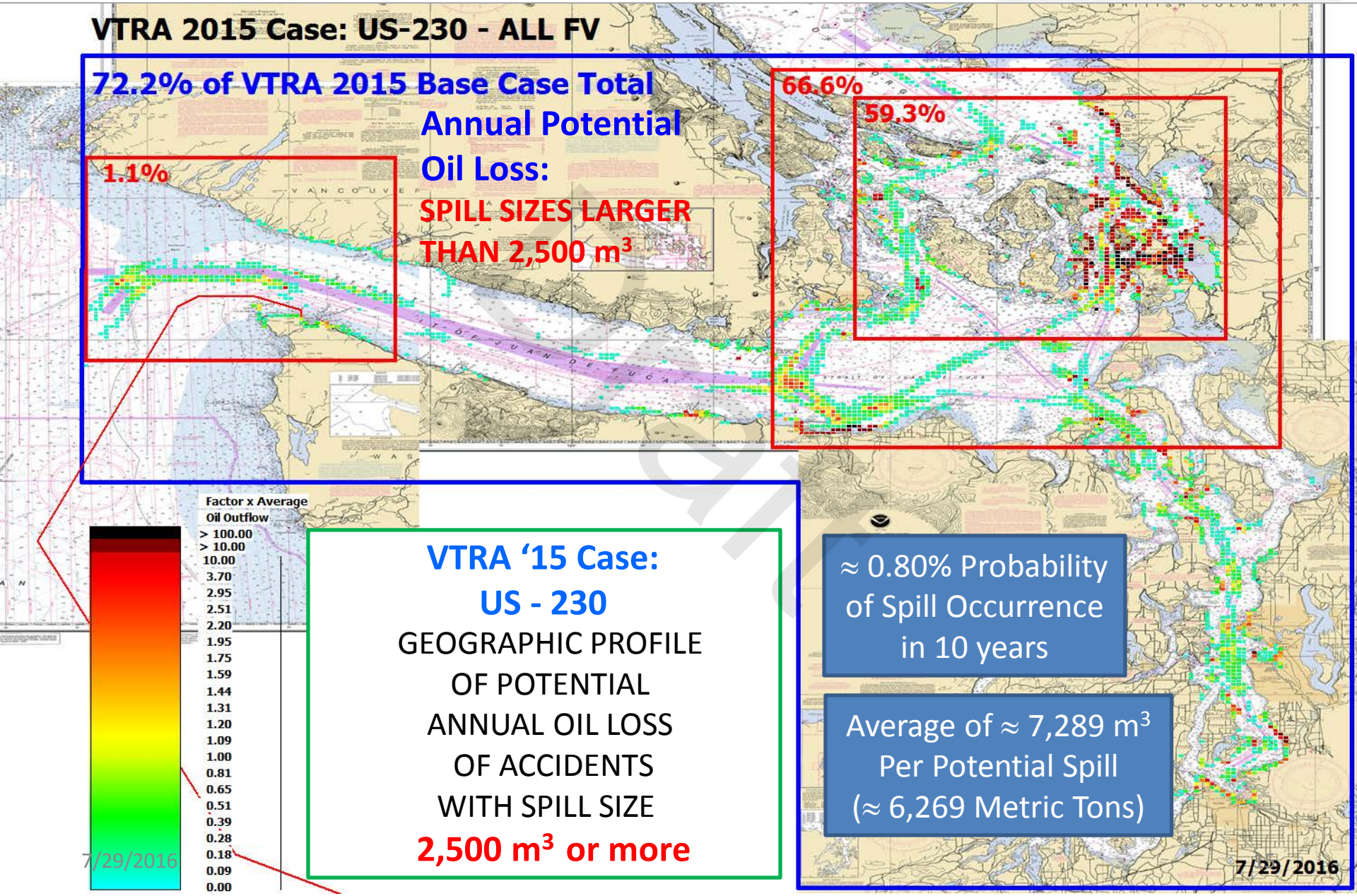
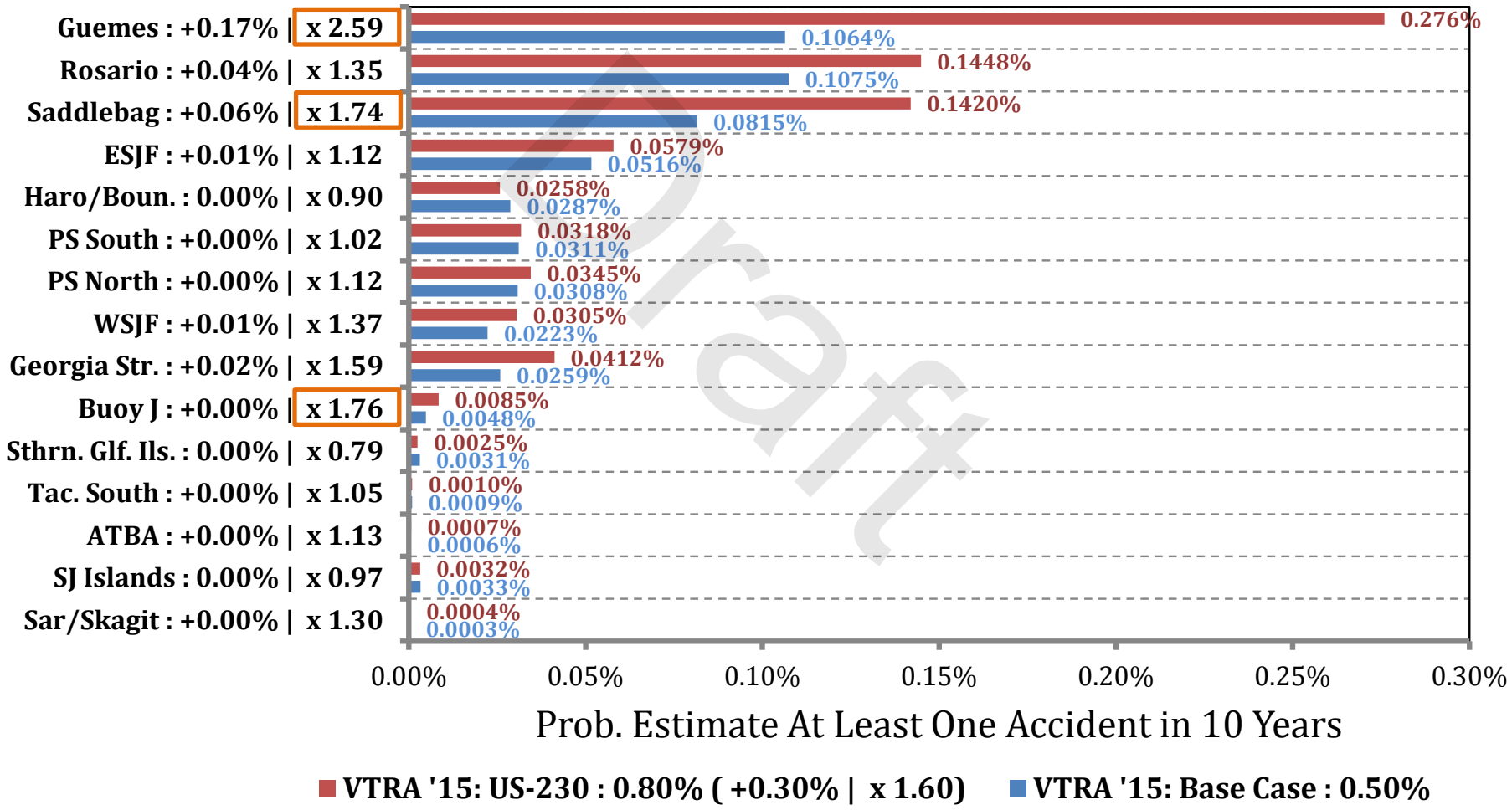
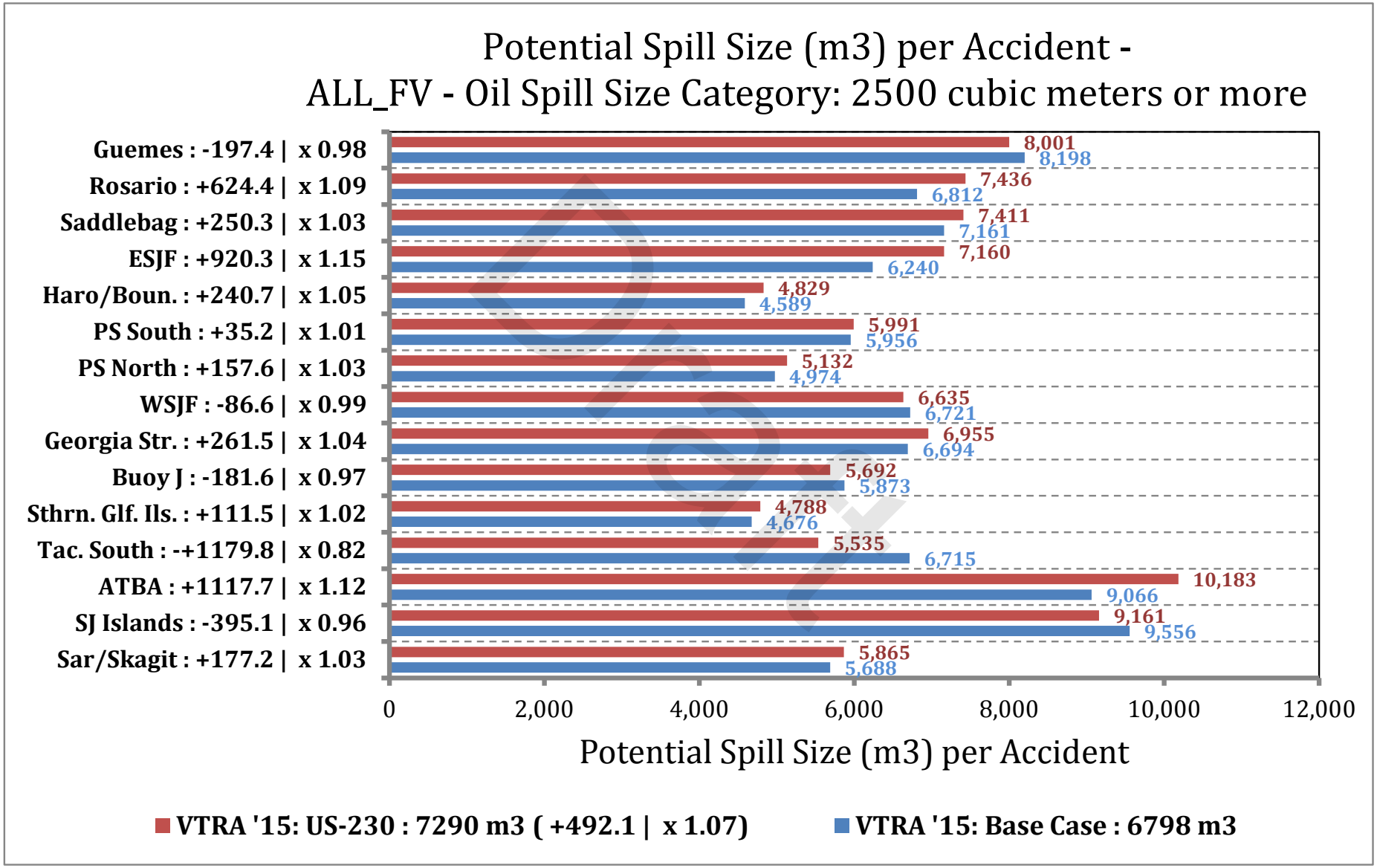



Prob. Estimate At Least One Accident in 10 Years -
ALL_FV - Oil Spill Size Category: 2500 cubic meters or more
Guemes : +0.17% | x 2.59
Rosario : +0.04% | x 1.35
Saddlebag : +0.06% | x 1.74
ESJF : +0.01% | x 1.12
Haro/Boun. : 0.00% | x 0.90
PS South : +0.00% | x 1.02
PS North : +0.00% | x 1.12
WSJF : +0.01% | x 1.37
Georgia Str. : +0.02% | x 1.59
Buoy J : +0.00% | x 1.76
Sthrn. Glf. Ils. : 0.00% | x 0.79
Tac. South : +0.00% | x 1.05
ATBA : +0.00% | x 1.13
SJ Islands : 0.00% | x 0.97
Sar/Skagit : +0.00% | x 1.30
0.276%
0.1064%
0.1448%
0.1075%
0.1420%
0.0815%
0.0579%
0.0516%
0.0258%
0.0287%
0.0318%
0.0311%
0.0345%
0.0308%
0.0305%
0.0223%
0.0412%
0.0259%
0.0085%
0.0048%
0.0025%
0.0031%
0.0010%
0.0009%
0.0007%
0.0006%
0.0032%
0.0033%
0.0004%
0.0003%
0.00%
0.05%
0.10%
0.15%
0.20%
0.25%
0.30%
Prob. Estimate At Least One Accident in 10 Years
VTRA '15: US-230 : 0.80% (+0.30% | x 1.60)
VTRA '15: Base Case : 0.50%

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



By Waterway Zone Risk Comparison

Oil Spill Size Category:

1000 m^3 - 2500 m^3

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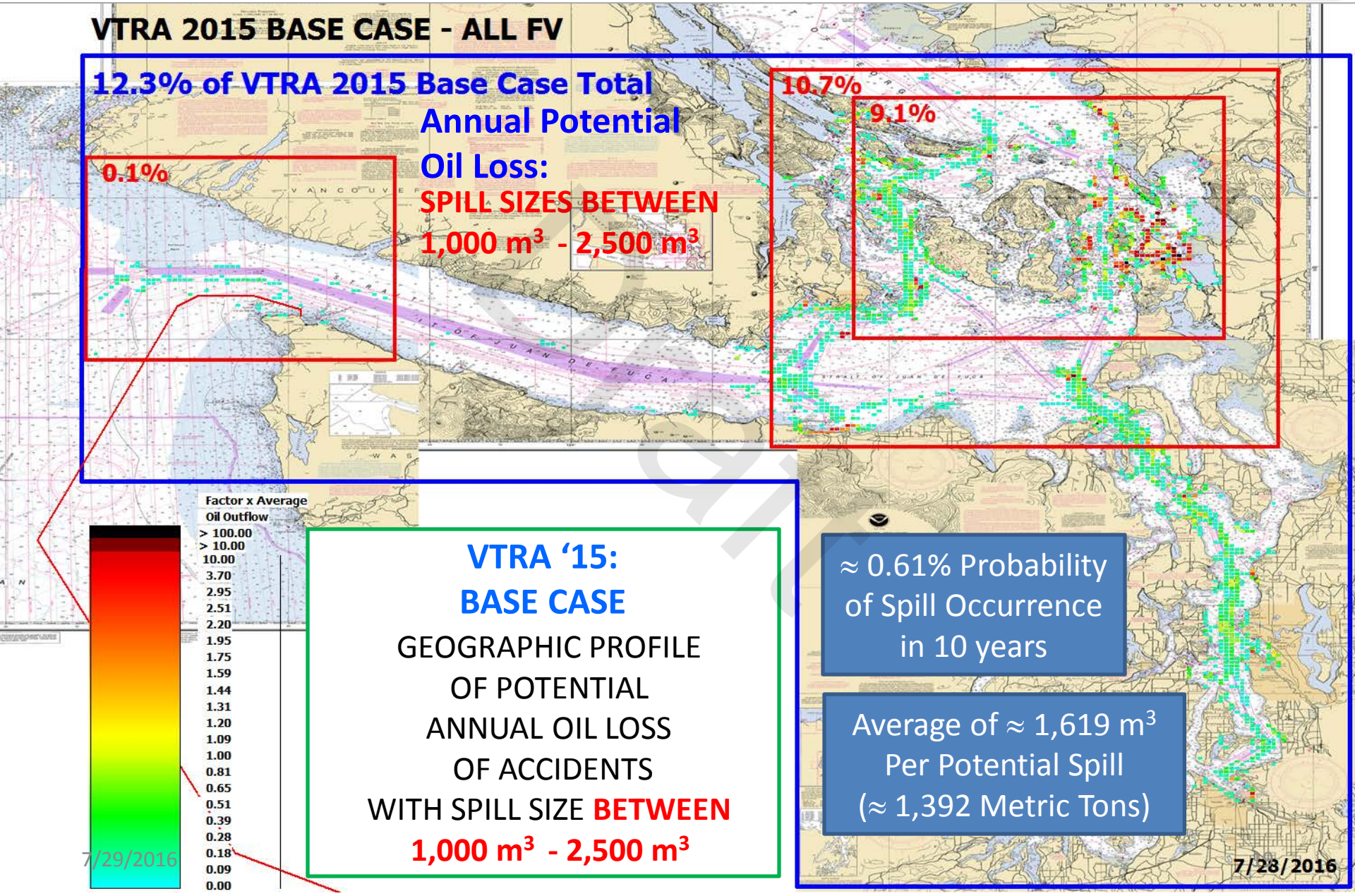

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

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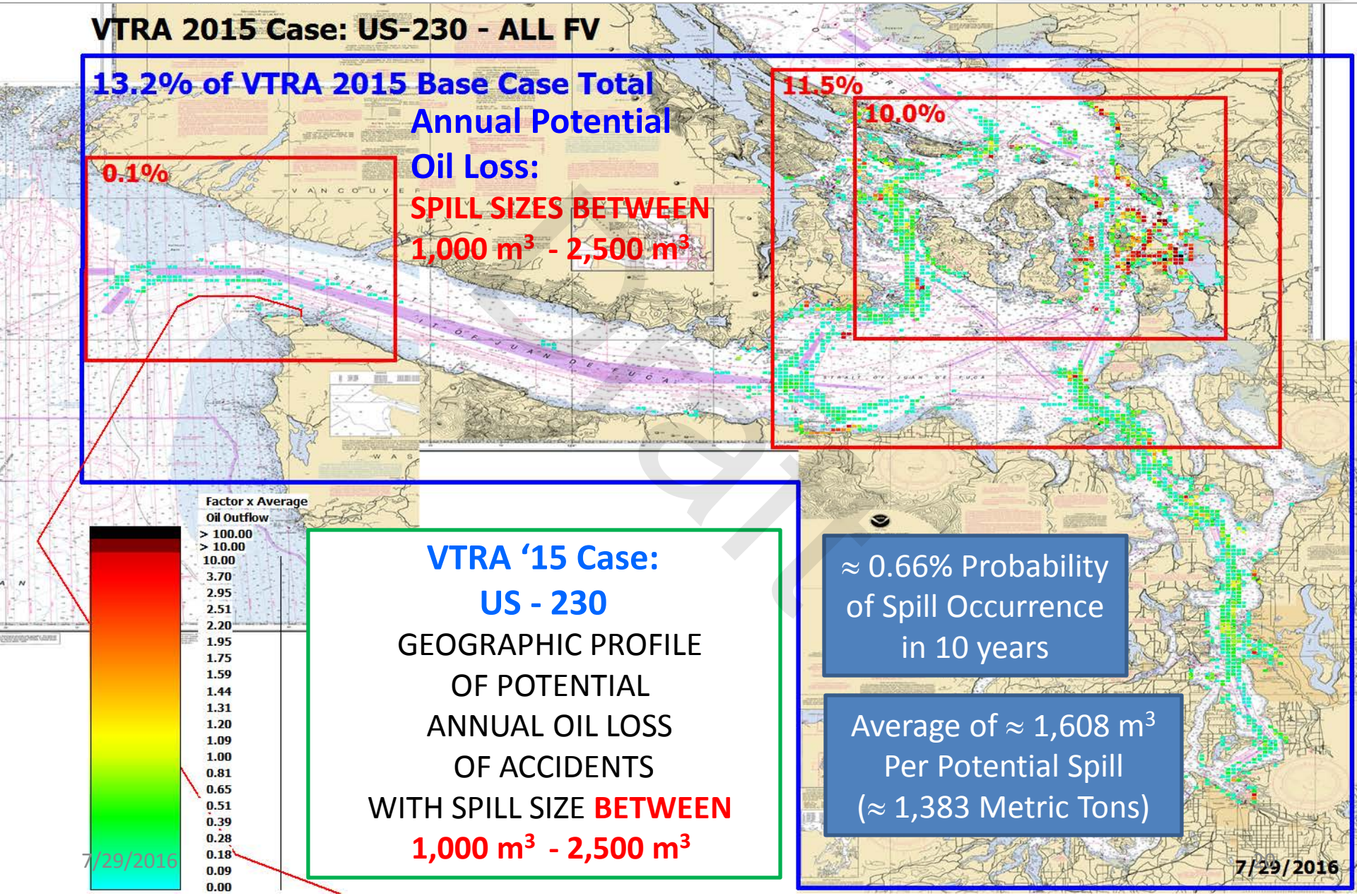
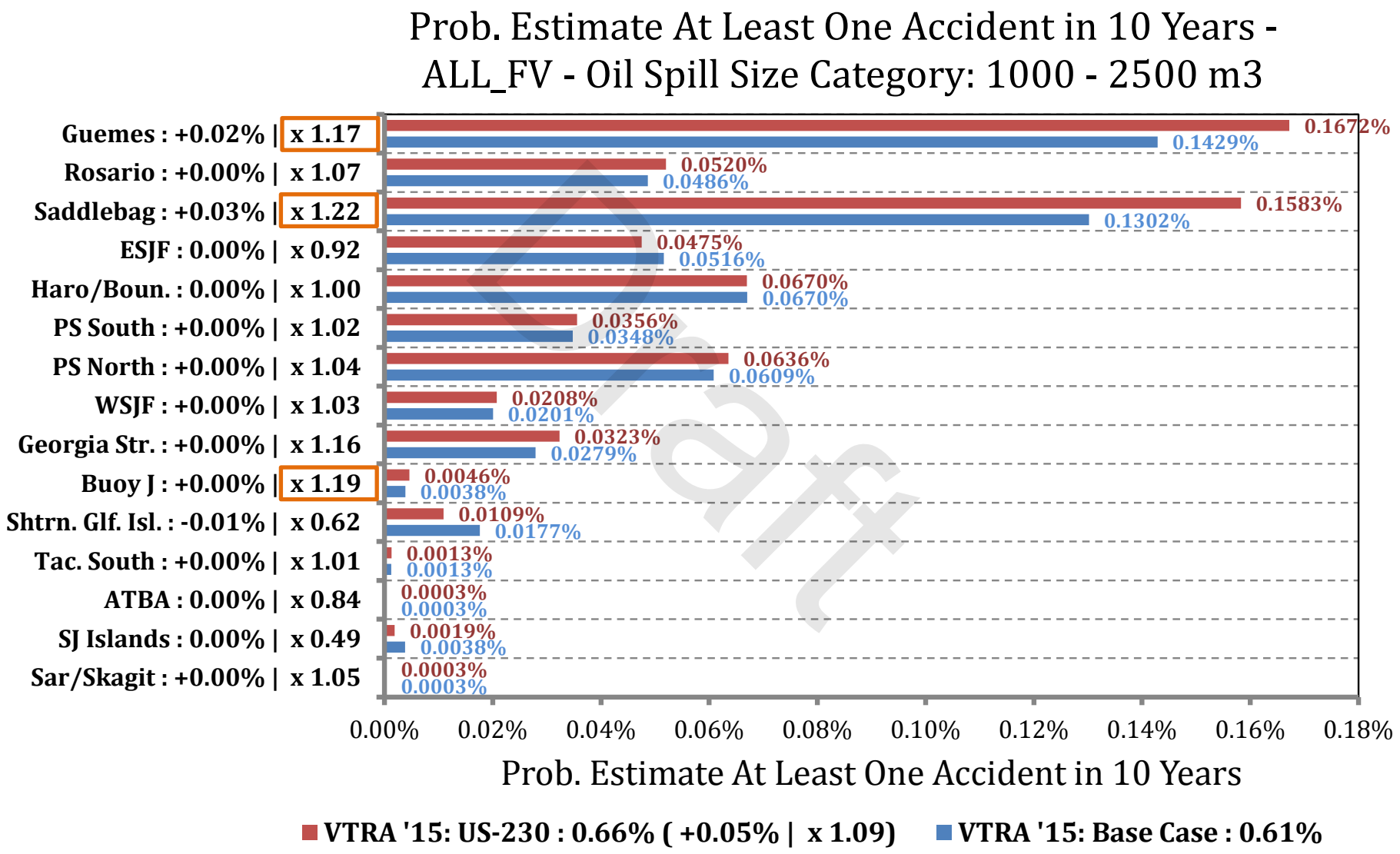
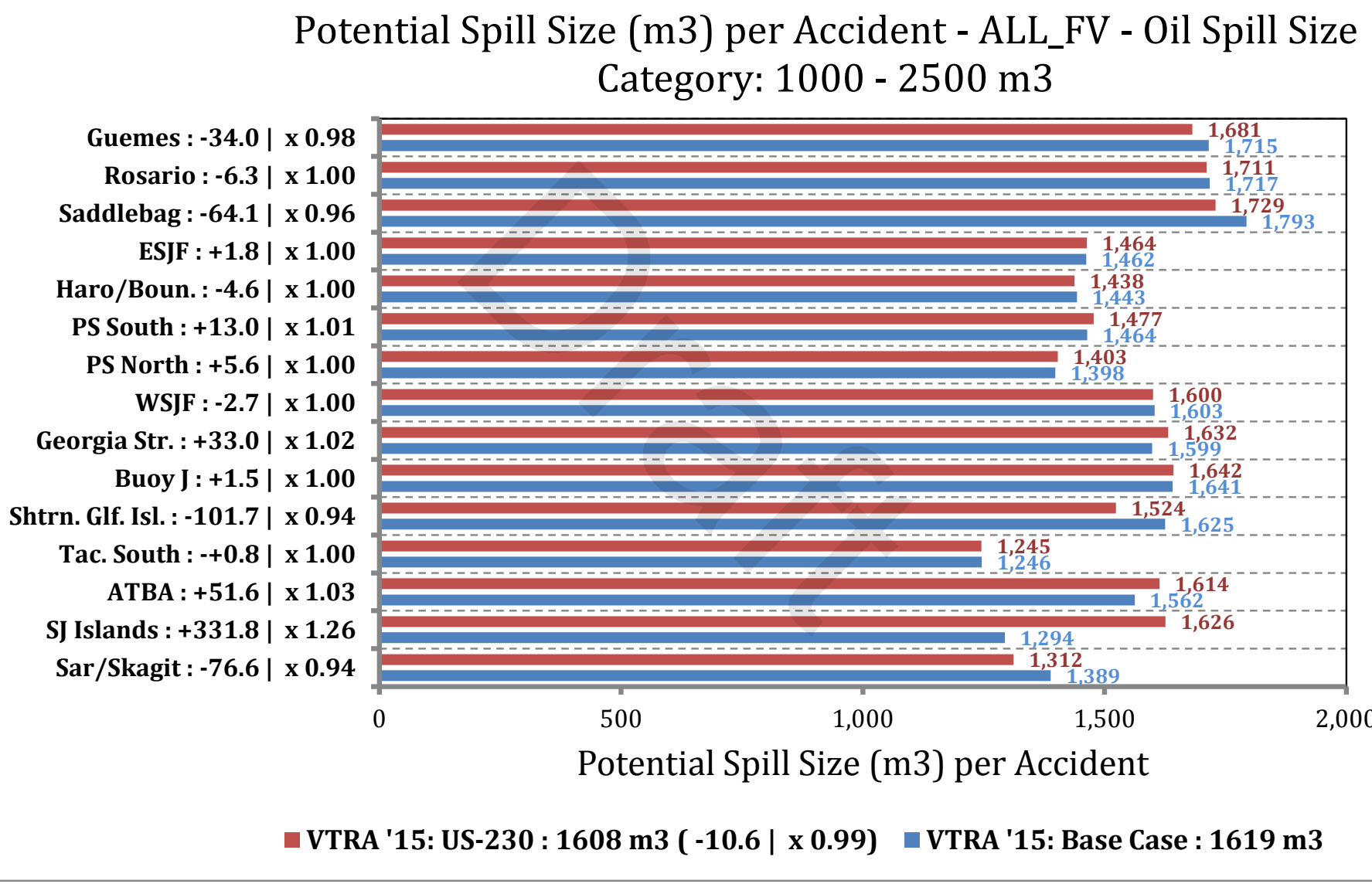



Prob. Estimate At Least One Accident in 10 Years - ALL_FV - Oil Spill Size Category: 1000 - 2500 m3
Guemes : +0.02% | x 1.17
Rosario : +0.00% | x 1.07
Saddlebag : +0.03% | x 1.22
ESJF : 0.00% | x 0.92
Haro/Boun. : 0.00% | x 1.00
PS South : +0.00% | x 1.02
PS North : +0.00% | x 1.04
WSJF : +0.00% | x 1.03
Georgia Str. : +0.00% | x 1.16
Buoy J : +0.00% | x 1.19
Shtrn. Glf. Isl. : -0.01% | x 0.62
Tac. South : +0.00% | x 1.01
ATBA : 0.00% | x 0.84
SJ Islands : 0.00% | x 0.49
Sar/Skagit : +0.00% | x 1.05
0.1672%
0.1429%
0.0520%
0.0486%
0.1583%
0.1302%
0.0475%
0.0516%
0.0670%
0.0670%
0.0356%
0.0348%
0.0636%
0.0609%
0.0208%
0.0201%
0.0323%
0.0279%
0.0046%
0.0038%
0.0109%
0.0177%
0.0013%
0.0013%
0.0003%
0.0003%
0.0019%
0.0038%
0.0003%
0.0003%
0.00%
0.02%
0.04%
0.06%
0.08%
0.10%
0.12%
0.14%
0.16%
0.18%
Prob. Estimate At Least One Accident in 10 Years
VTRA '15: US-230 : 0.66% (+0.05% | x 1.09)
VTRA '15: Base Case : 0.61%
Draft


Potential Spill Size (m3) per Accident - ALL_FV - Oil Spill Size
Category: 1000 - 2500 m3
Guemes : -34.0 | x 0.98
Rosario : -6.3 | x 1.00
Saddlebag : -64.1 | x 0.96
ESJF : +1.8 | x 1.00
Haro/Boun. : -4.6 | x 1.00
PS South : +13.0 | x 1.01
PS North : +5.6 | x 1.00
WSJF : -2.7 | x 1.00
Georgia Str. : +33.0 | x 1.02
Buoy J : +1.5 | x 1.00
Shtrn. Glf. Isl. : -101.7 | x 0.94
Tac. South : -+0.8 | x 1.00
ATBA : +51.6 | x 1.03
SJ Islands : +331.8 | x 1.26
Sar/Skagit : -76.6 | x 0.94
1,681
1,715
1,711
1,717
1,729
1,793
1,464
1,462
1,438
1,443
1,477
1,464
1,403
1,398
1,600
1,603
1,632
1,599
1,642
1,641
1,524
1,625
1,245
1,246
1,614
1,562
1,626
1,294
1,312
1,389
0
500
1,000
1,500
2,000
Potential Spill Size (m3) per Accident
VTRA '15: US-230 : 1608 m3 (-10.6 | x 0.99)
VTRA '15: Base Case : 1619 m3

By Waterway Zone Risk Comparison

Oil Spill Size Category:
1 m^3 - 1000 m^3

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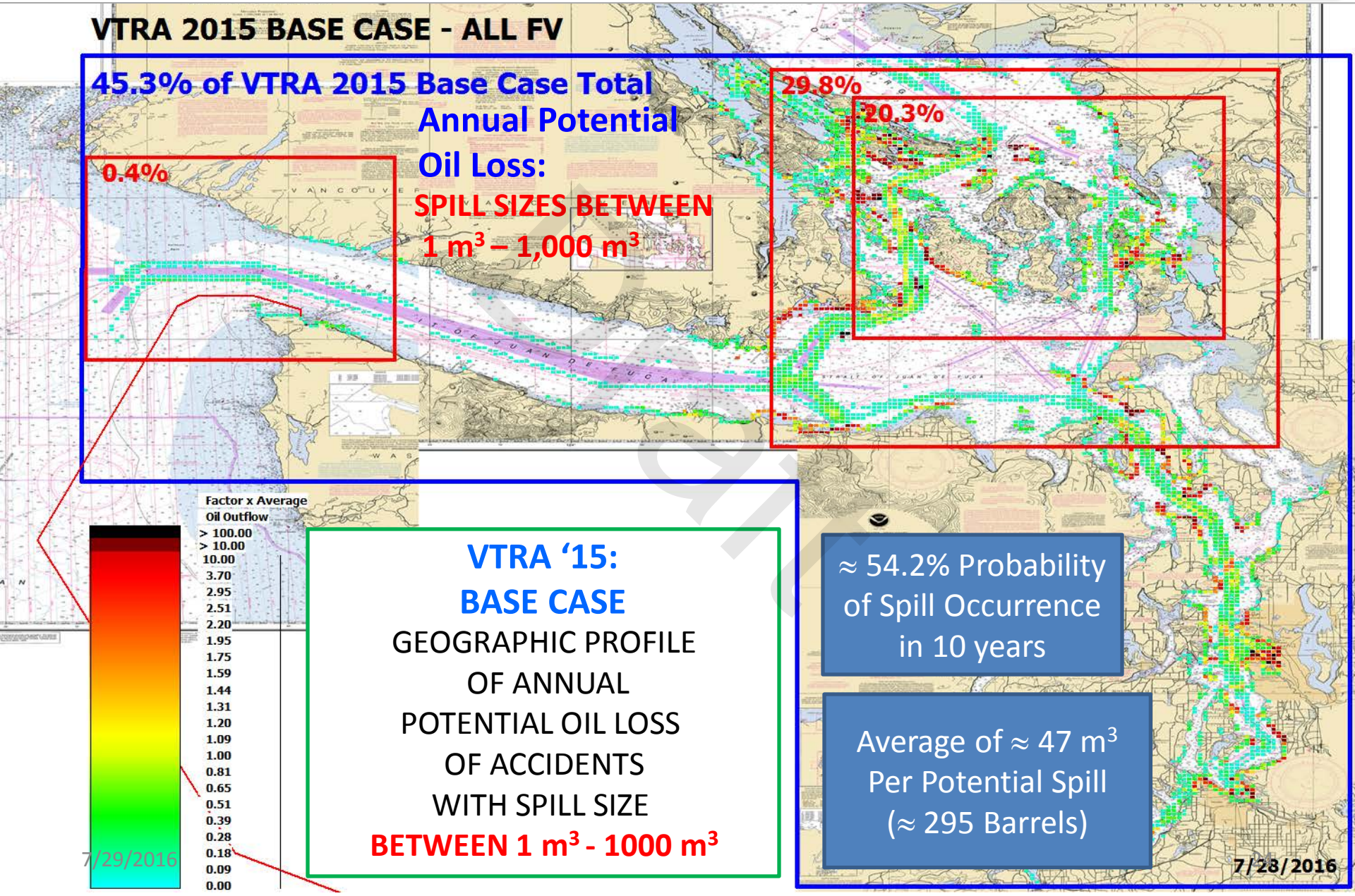

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

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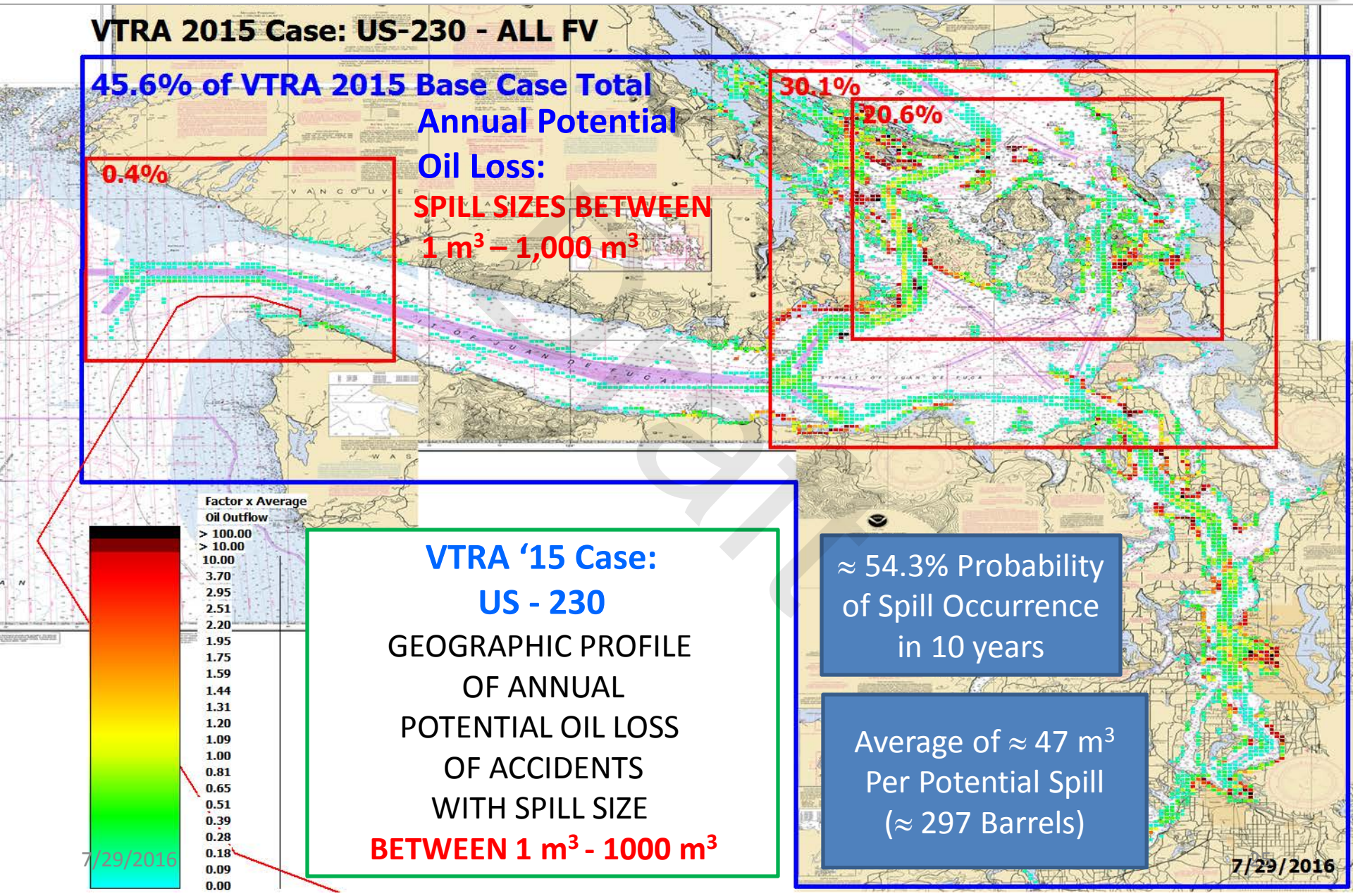
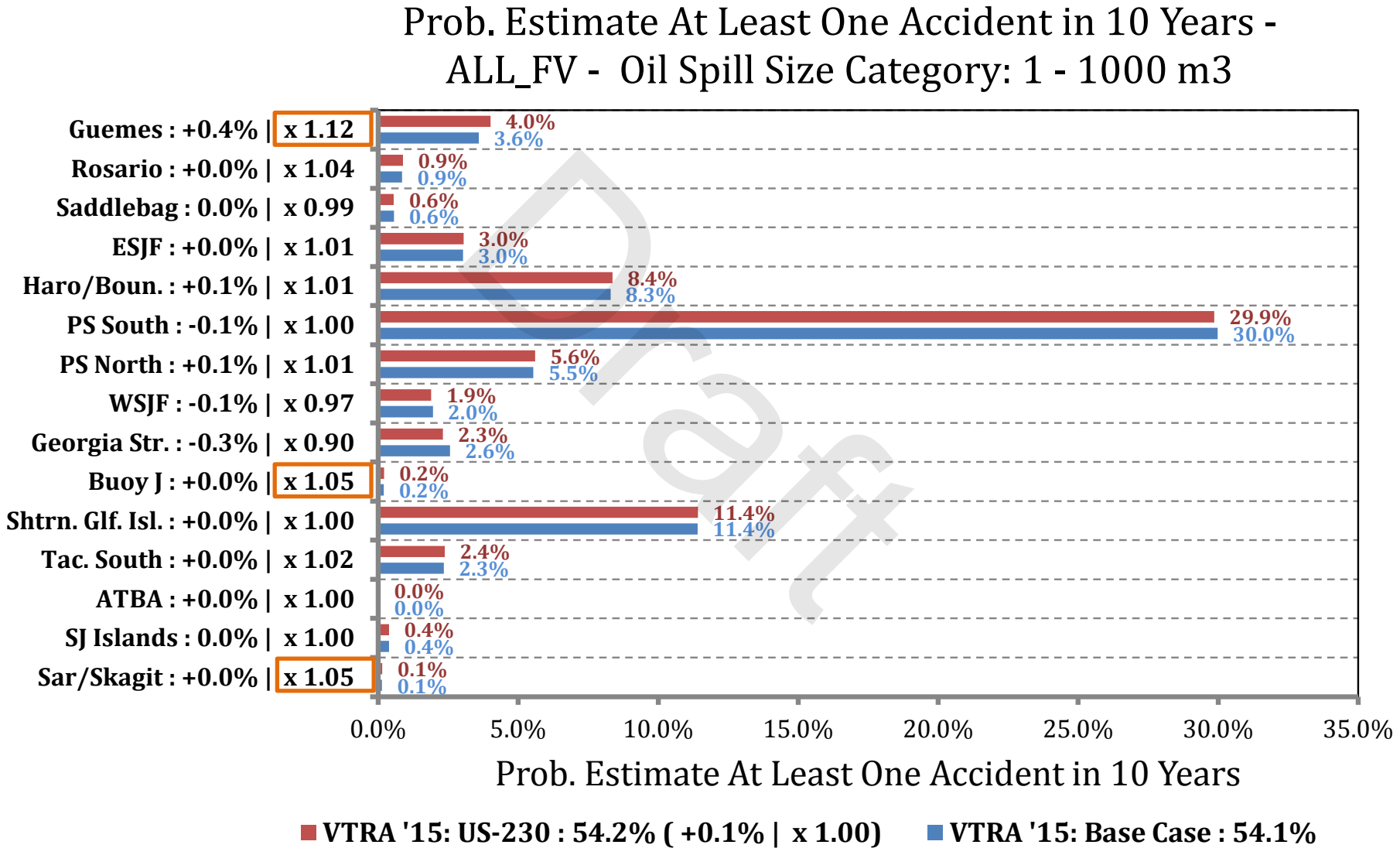
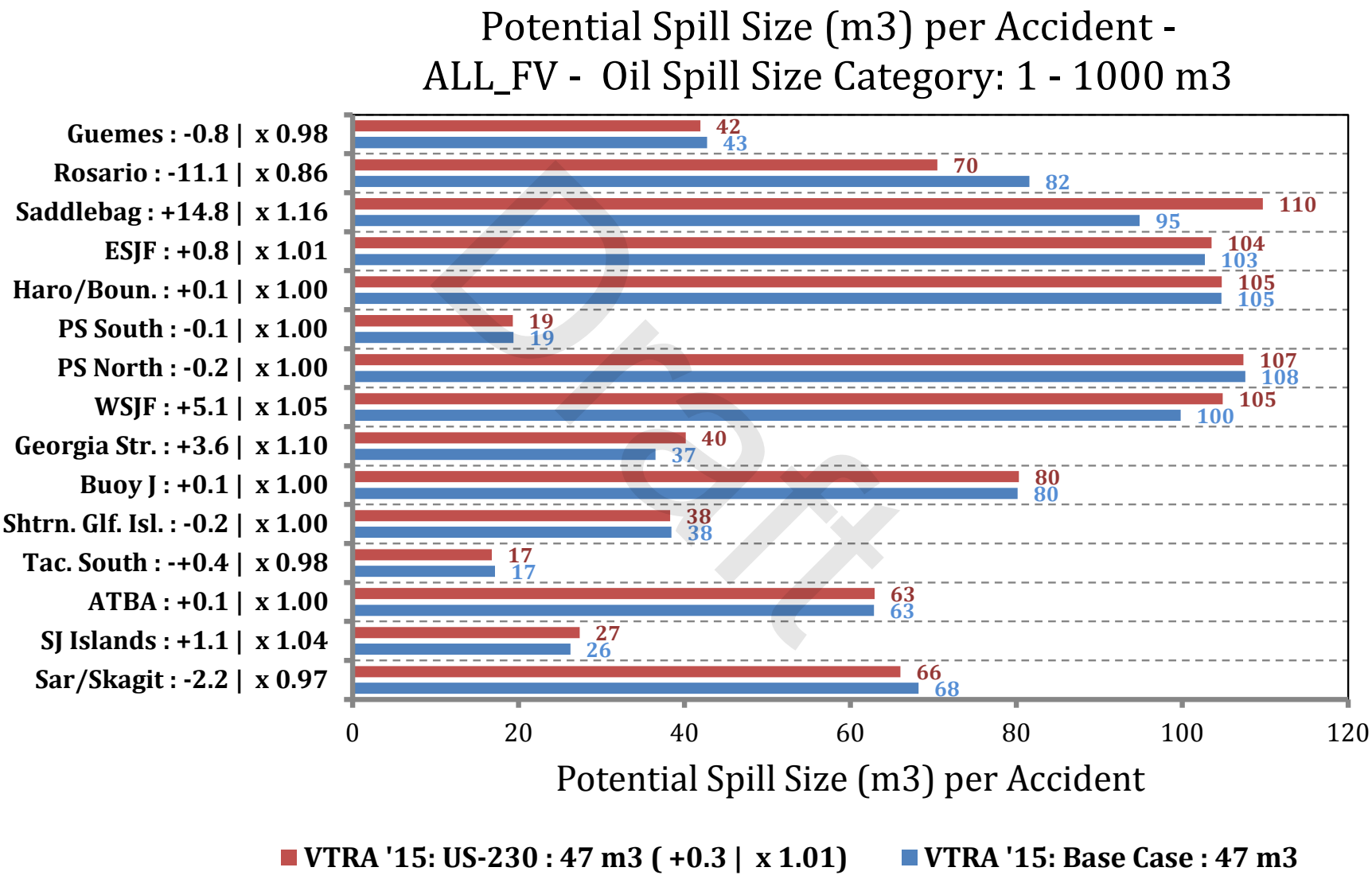


VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015



By Waterway Zone Risk Comparison

Oil Spill Size Category:

0 m^3 - 1 m^3

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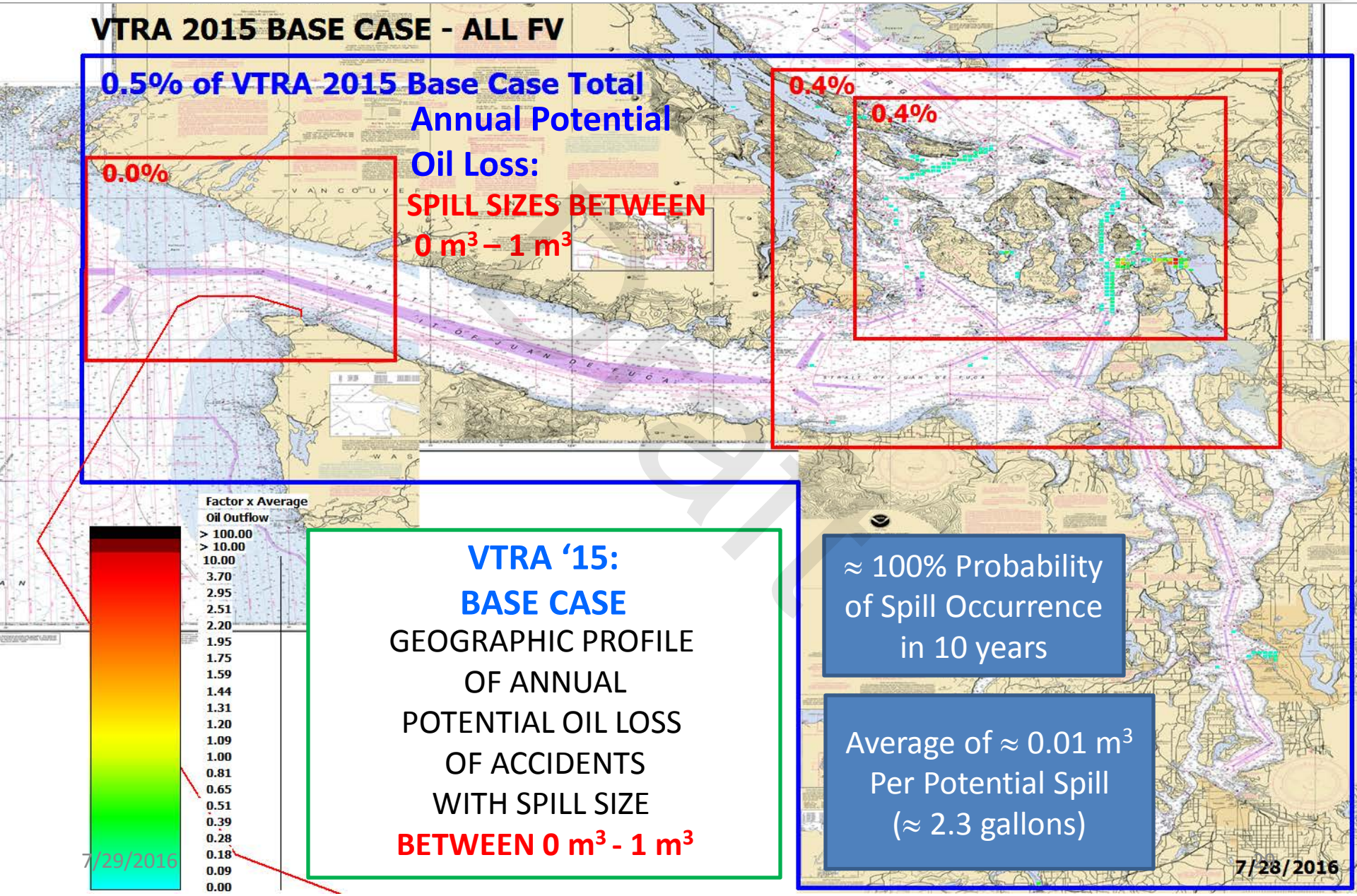

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

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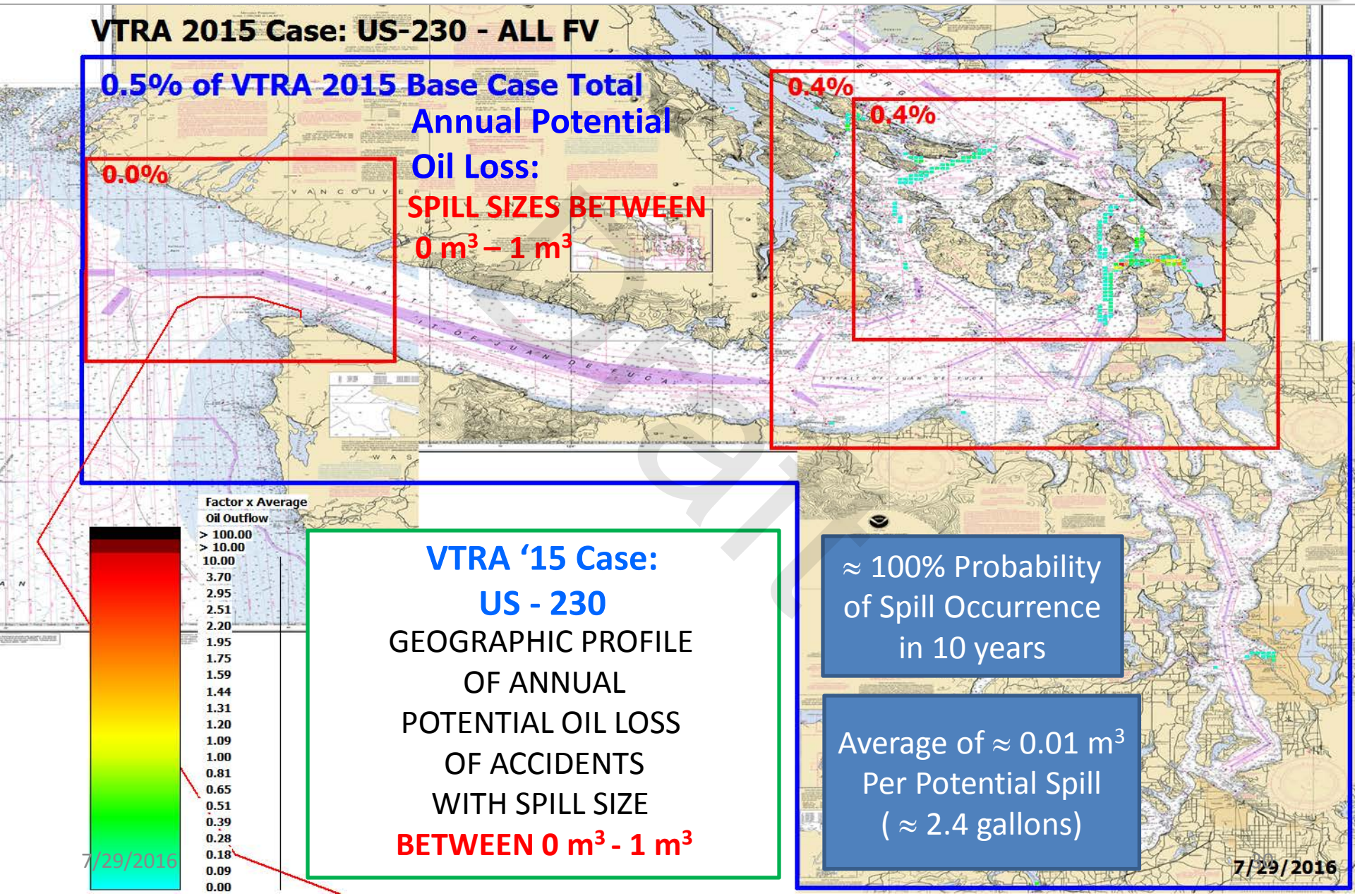

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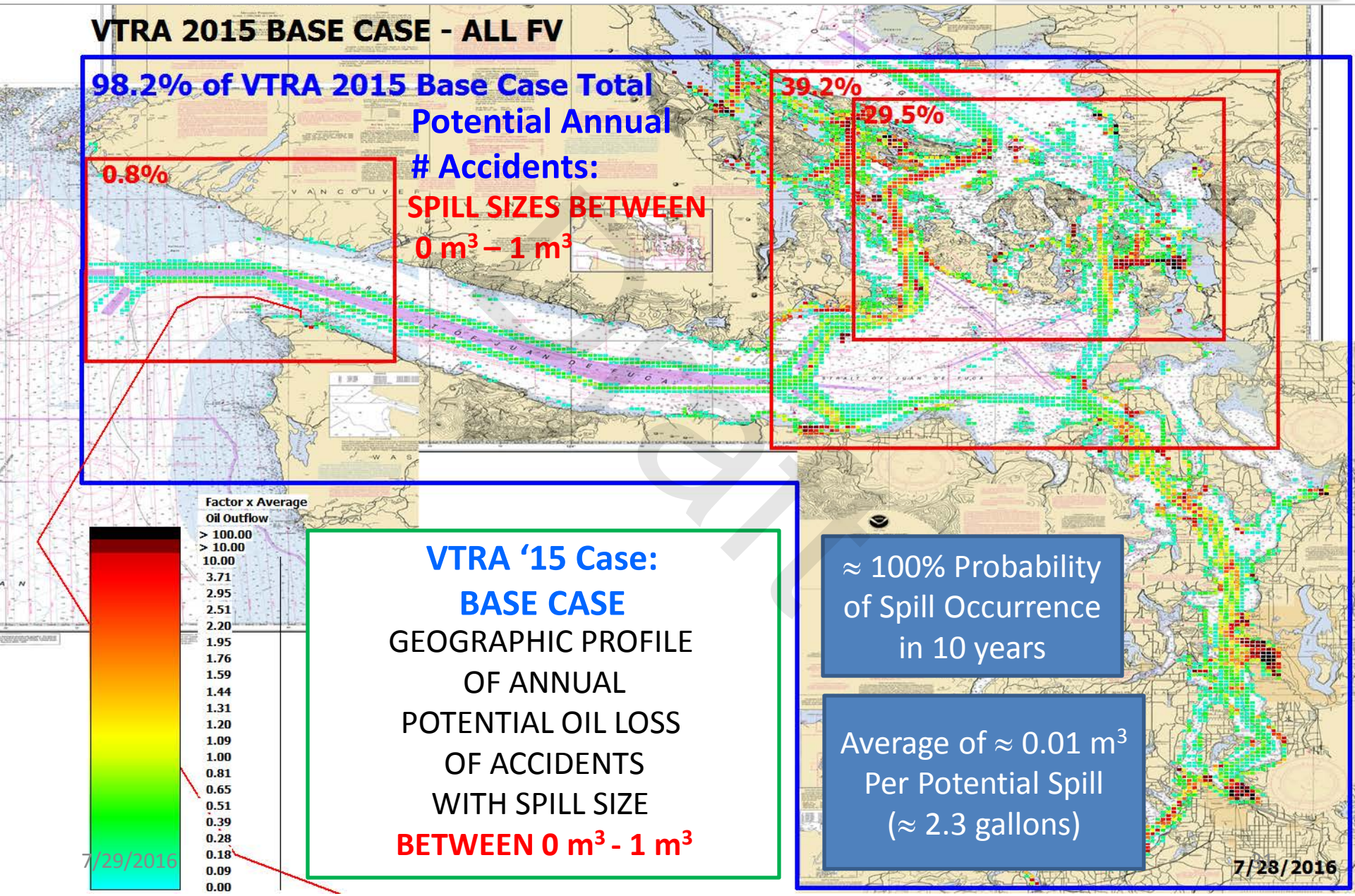

VTRA '15 Case:
BASE CASE
GEOGRAPHIC PROFILE OF ANNUAL POTENTIAL OIL LOSS OF ACCIDENTS WITH SPILL SIZE
BETWEEN 0 m³ - 1 m³

≈ 100% Probability of Spill Occurrence in 10 years

Average of ≈ 0.01 m³ Per Potential Spill (≈ 2.3 gallons)

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015

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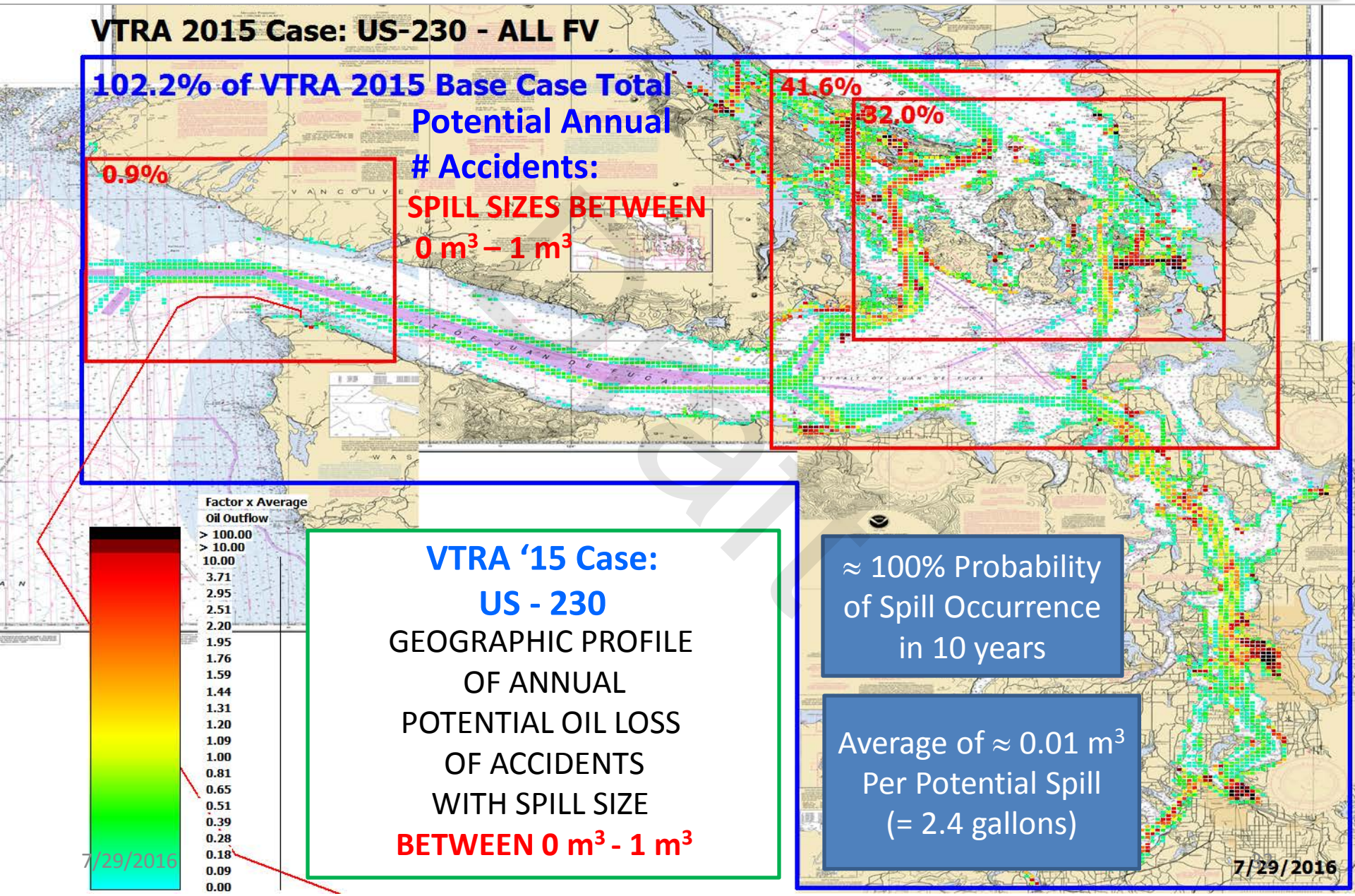
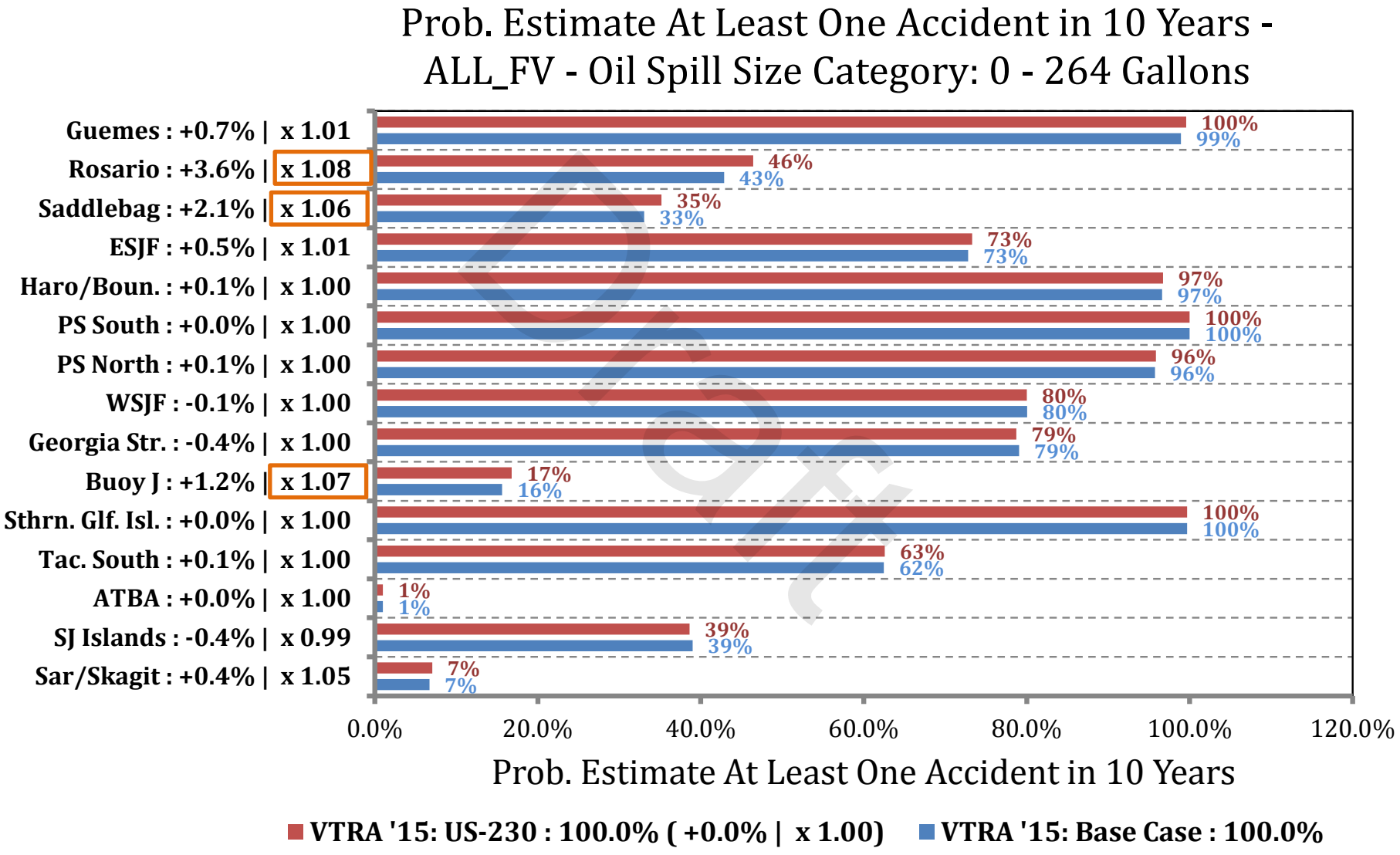
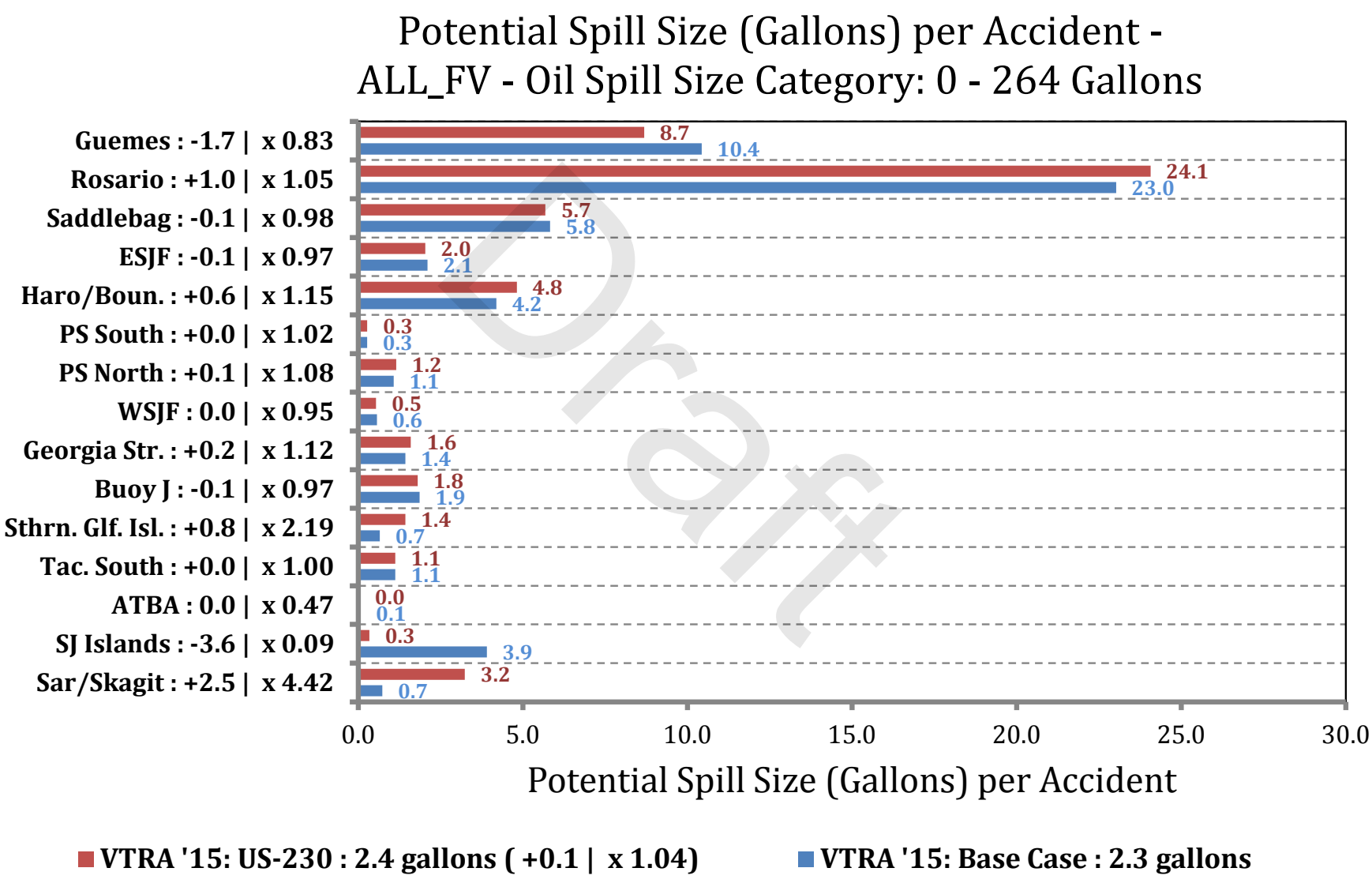


VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2015




Potential Spill Size (Gallons) per Accident -
ALL_FV - Oil Spill Size Category: 0 - 264 Gallons
Guemes : -1.7 | x 0.83
Rosario : +1.0 | x 1.05
Saddlebag : -0.1 | x 0.98
ESJF : -0.1 | x 0.97
Haro/Boun. : +0.6 | x 1.15
PS South : +0.0 | x 1.02
PS North : +0.1 | x 1.08
WSJF : 0.0 | x 0.95
Georgia Str. : +0.2 | x 1.12
Buoy J : -0.1 | x 0.97
Sthrn. Glf. Isl. : +0.8 | x 2.19
Tac. South : +0.0 | x 1.00
ATBA : 0.0 | x 0.47
SJ Islands : -3.6 | x 0.09
Sar/Skagit : +2.5 | x 4.42
8.7
10.4
24.1
23.0
5.7
5.8
2.0
2.1
4.8
4.2
0.3
0.3
1.2
1.1
0.5
0.6
1.6
1.4
1.8
1.9
1.4
0.7
1.1
1.1
0.0
0.1
0.3
3.9
3.2
0.7
0.0
5.0
10.0
15.0
20.0
25.0
30.0
Potential Spill Size (Gallons) per Accident
VTRA '15: US-230 : 2.4 gallons (+0.1 | x 1.04)
VTRA '15: Base Case : 2.3 gallons

Summary
Risk Comparison

Oil Spill Size Category:
All Spill Sizes

Summary Risk Comparison

		OIL_2500_MORE	OIL_1000_2500	OIL_1_1000	OIL_0_1	TOTAL_OIL
VTRA '15 BASE CASE	Base Case % Potential Annual Oil Loss	42.0%	12.3%	45.3%	0.5%	100.0%
	Base Case % Potenial Annual Accident Frequency	0.01%	0.01%	1.8%	98.2%	100.0%
	Average potential spill size per accident (in m^3)	6,798	1,619	46.9	0.01	1.8
	Probability of at least one accident in 1 year by spill size	0.05%	0.06%	7.5%	98.7%	98.8%
	Probability of at least one accident in 10 year by spill size	0.50%	0.61%	54.2%	100.0%	100.0%
	Probability of at least one accident in 25 years by spill size	1.24%	1.52%	85.8%	100.0%	100.0%
		OIL_2500_MORE	**OIL_1000_2500**	**OIL_1_1000**	**OIL_0_1**	**TOTAL_OIL**
VTRA '15 US - 230	Base Case % Potential Annual Oil Loss	72.3% (+30.28%| x1.72)	13.2% (+0.95%| x1.08)	45.6% (+0.37%| x1.01)	0.5% (+0.04%| x1.08)	131.6% (+31.6%| x1.32)
	Base Case % Potenial Annual Accident Frequency	0.02% (+0.01%| x1.61)	0.01% (+0.00%| x1.08)	1.8% (+0.00%| x1.00)	102.1% (+3.9%| x1.04)	103.9% (+3.9%| x1.04)
	Average potential spill size per accident (in m^3)	7289 (+491 | x1.07)	1608 (-11 | x0.99)	47.1 (+0.3 | x1.01)	0.01 (+0.00 | x1.04)	2.3 (+0.5 | x1.27)
	Probability of at least one accident in 1 year by spill size	0.08% (+0.03%| x1.60)	0.07% (+0.01%| x1.08)	7.5% (+0.02%| x1.00)	98.9% (+0.20% | x1.00)	99.0% (+0.19%| x1.00)
	Probability of at least one accident in 10 year by spill size	0.80% (+0.30%| x1.60)	0.66% (+0.05%| x1.08)	54.3% (+0.09%| x1.00)	100.0% (0.00%| x1.00)	100.0% (0.00%| x1.00)
	Probability of at least one accident in 25 years by spill size	1.98% (+0.74%| x1.60)	1.65% (+0.13%| x1.08)	85.9% (+0.07%| x1.00)	100.0% (0.00%| x1.00)	100.0% (0.00%| x1.00)