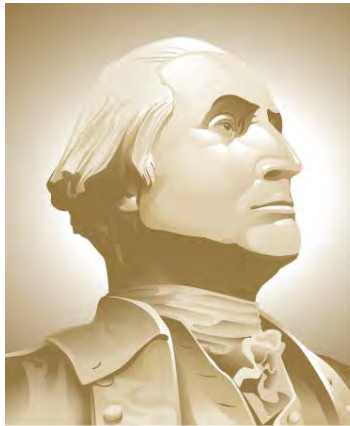


DRAFT VTRA 2010 TRAFFIC DENSITIES BY NON – FOCUS VESSEL (FV), CARGO – FV and TANK FV

Presentation by: J. Rene van Dorp



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GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

OCTOBER 10, 2013

Table. Focus Vessel (FV) Classification for the 26 VTOSS vessel type classification used in the GW/VCU MTS simulation model.

NON – FV : Those vessels that are only considered as Interacting Vessels (IV) with Focus Vessels (FV) in this study

CARGO – FV : Bulk Carriers, Container Vessels, Other Cargo Vessels

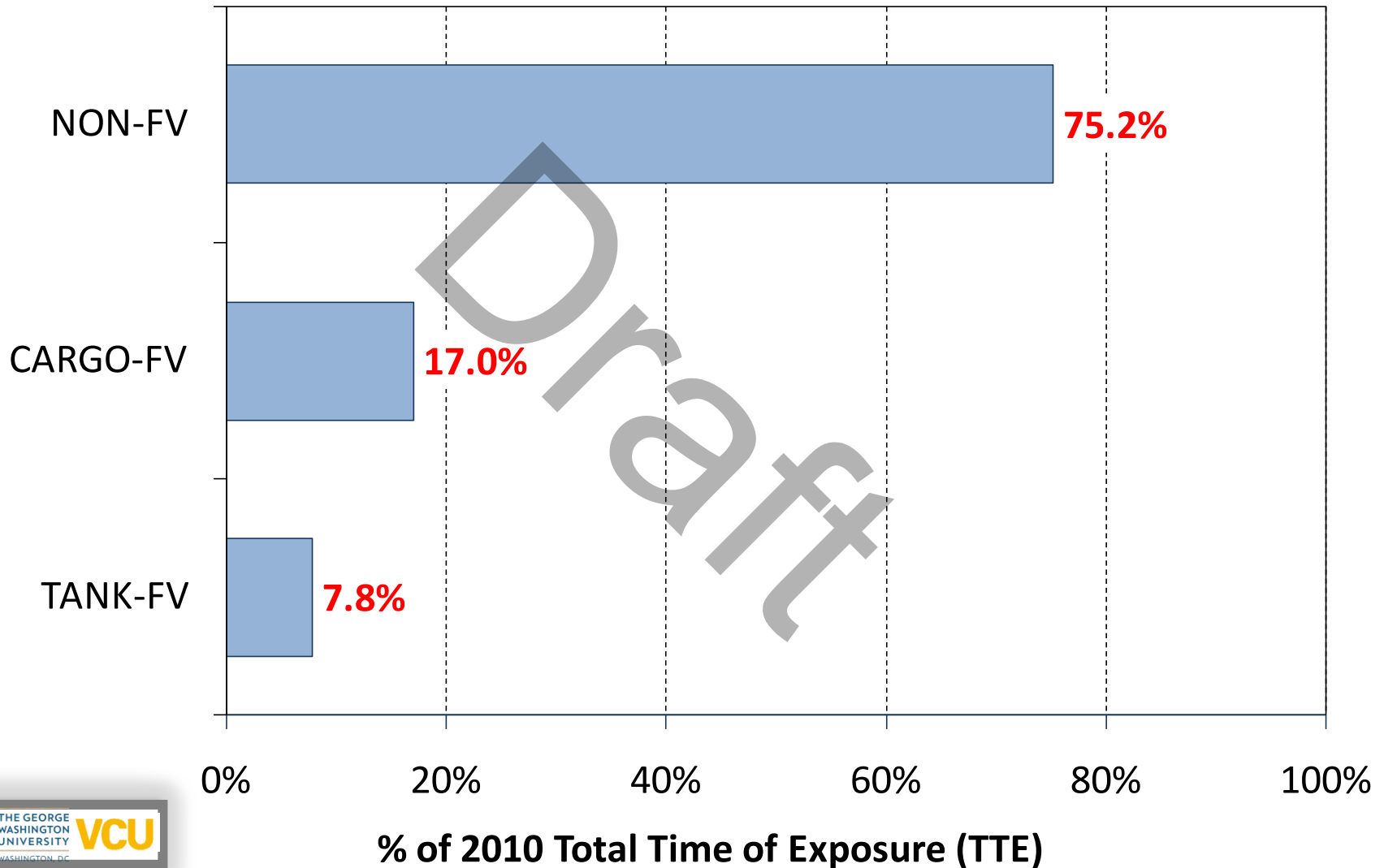
TANK – FV : Oil Barge, Oil Tankers, Chem-Carrier, ATB

Note: Focus Vessels (FV's) are also considered as Interacting Vessels (IV's) when interacting with another Focus Vessel.

#	VESSEL TYPE	FOCUS VESSEL?	#	VESSEL TYPE	FOCUS VESSEL?
1	BULKCARRIER	CARGO - FV	14	PASSENGERSHIP	NO
2	CHEMICALCARRIER	TANK - FV	15	REFRIGERATEDCARGO	CARGO-FV
3	CONTAINERSHIP	CARGO - FV	16	RESEARCHSHIP	NO
4	DECKSHIPCARGO	CARGO - FV	17	ROROCARGOSHIP	CARGO-FV
5	FERRY	NO	18	ROROCARGOCONTSHIP	CARGO-FV
6	FERRYNONLOCAL	NO	19	SUPPLYOFFSHORE	NO
7	FISHINGFACTORY	NO	20	TUGTOWBARGE	NO
8	FISHINGVESSEL	NO	21	UNKNOWN	NO
9	LIQGASCARRIER	TANK - FV	22	USCOASTGUARD	NO
10	NAVYVESSEL	NO	23	VEHICLECARRIER	CARGO-FV
11	OILTANKER	TANK - FV	24	YACHT	NO
12	OTHERSPECIALCARGO	CARGO - FV	25	ATB	TANK - FV
13	OTHERSPECIFICSERV	NO	26	OIL BARGE	TANK - FV

VTRA MODEL - VTOSS 2010

VESSEL CLASSIFICATION



100% of Total Traffic Density

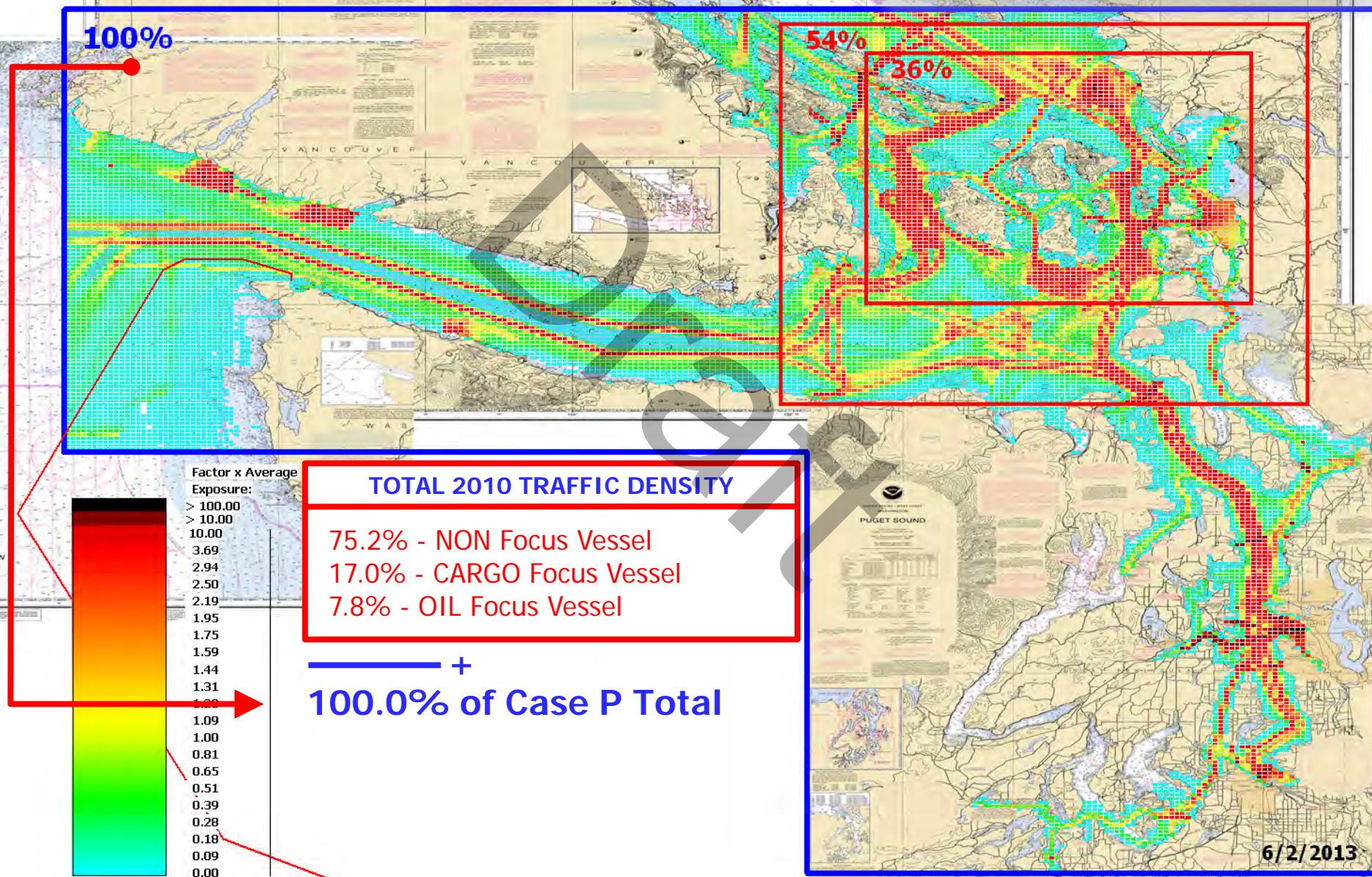


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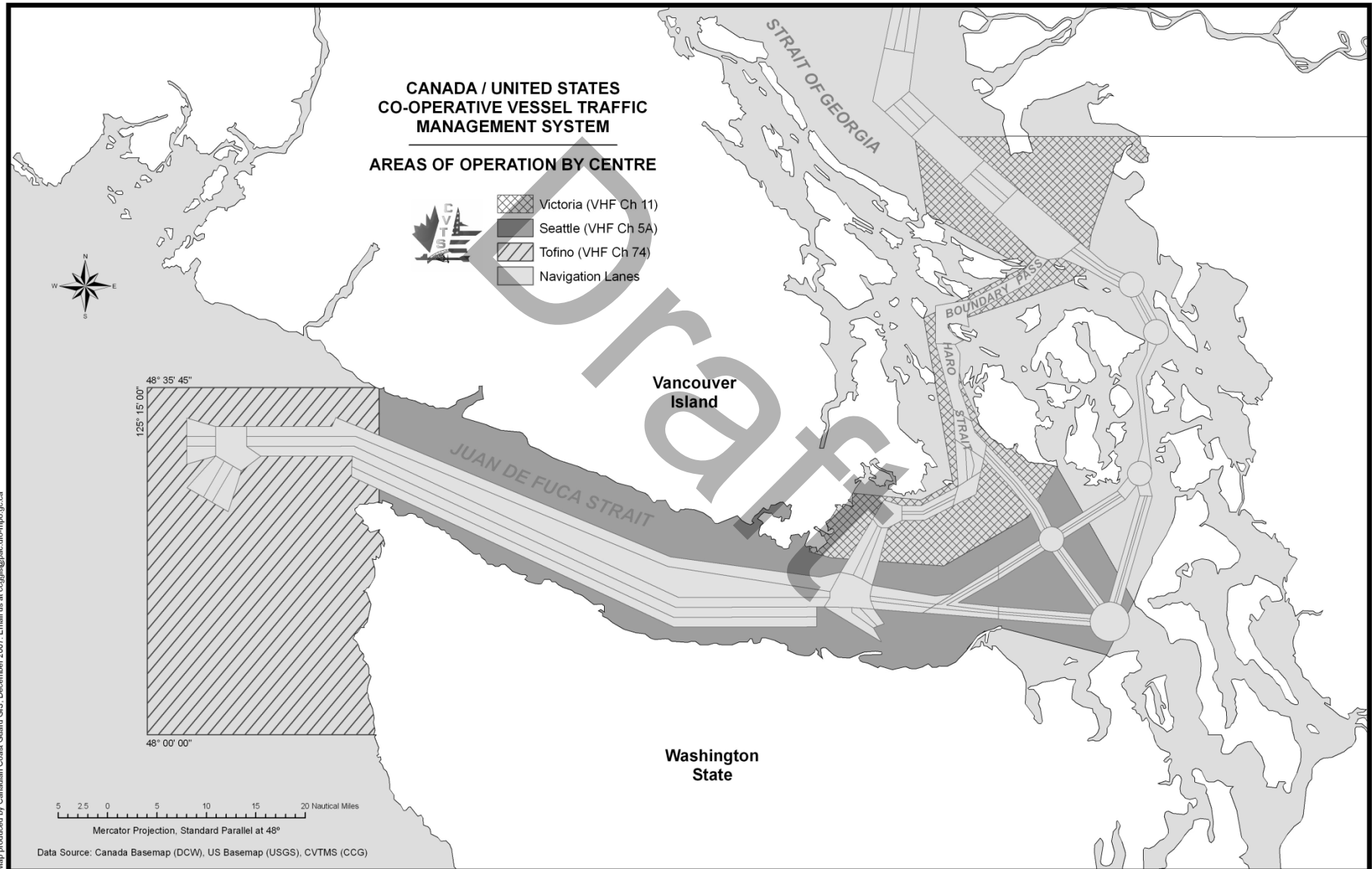
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P: VTRA 2010 - Total Density



The Vessel Traffic Operation Support System (VTOSS)



Main Data Source for VTS Responding Traffic for VTRA Simulation Construction was the VTOSS Database:

NAME	LAST_UDDTG	VSL_ID	CALLSIGN	LLOYDS_ID	FLAG	SATCOMNUM	TYPE_ENC	TYPE_DEC	POS_LAT	POS_LONG	POS_SRC	CVTS_ZONE	FROM_AT	NEXT_TO
ITB BALTIMORE	200503112017	2005111414	WXKM	8001189	US		OT	OIL TANKER	48.233	123.715	AIS	PUG	SAN F	SEAT
ITB BALTIMORE	200503112022	2005111414	WXKM	8001189	US		OT	OIL TANKER	48.233	123.686	AIS	PUG	SAN F	SEAT
ITB BALTIMORE	200503112028	2005111414	WXKM	8001189	US		OT	OIL TANKER	48.234	123.655	AIS	PUG	SAN F	SEAT
ITB BALTIMORE	200503112034	2005111414	WXKM	8001189	US		OT	OIL TANKER	48.232	123.628	AIS	PUG	SAN F	SEAT
ITB BALTIMORE	200503112037	2005111414	WXKM	8001189	US		OT	OIL TANKER	48.231	123.611	AIS	PUG	SAN F	SEAT
ITB BALTIMORE	200503112043	2005111414	WXKM	8001189	US		OT	OIL TANKER	48.229	123.594	AIS	PUG	SAN F	SEAT
ITB BALTIMORE	200503112046	2005111414	WXKM	8001189	US		OT	OIL TANKER	48.228	123.588	AIS	PUG	SAN F	SEAT
ITB BALTIMORE	200503112051	2005111414	WXKM	8001189	US		OT	OIL TANKER	48.225	123.572	AIS	PUG	SAN F	SEAT
ITB BALTIMORE	200503112057	2005111414	WXKM	8001189	US		OT	OIL TANKER	48.221	123.546	AIS	PUG	SAN F	SEAT
ITB BALTIMORE	200503112103	2005111414	WXKM	8001189	US		OT	OIL TANKER	48.213	123.522	AIS	PUG	SAN F	SEAT

From this VTOSS Database routes and input files were constructed that describe vessel movements arrivals to routes:

Main Conclusion:

VTOSS DATA was and is best available data Source to describe **the movement of a vessel** in the base case **throughout The Maritime Transportation System.**
BUT IT IS NOT PERFECT!

**We updated 2005 VTOSS Data to 2010
And Validated it with AIS 2010 data**

And Validated it with AIS 2010 data									Beam	Draft	
Vessel Name											
ITB BALTIMORE	CALIF								32.23	12.8	
ITB BALTIMORE	SEAT								32.23	12.8	
ITB BALTIMORE	CHERRY PT							179.9	32.23	12.8	
ITB BALTIMORE	CALIF	CHERRY PT	3/25/05 6:26 AM	9.18	3012560 Product	ITB	48067 DB/SS	10357	179.9	32.23	12.8
ITB BALTIMORE	CHERRY PT	CALIF	3/26/05 10:41 PM	1.17	3001714 Product	ITB	48067 DB/SS	10357	179.9	32.23	12.8
ITB BALTIMORE	CALIF	CHERRY PT	4/6/05 9:10 PM	10.47	3012560 Product	ITB	48067 DB/SS	10357	179.9	32.23	12.8
ITB BALTIMORE	CHERRY PT	CALIF	4/8/05 2:14 PM	1.20	3001714 Product	ITB	48067 DB/SS	10357	179.9	32.23	12.8
ITB BALTIMORE	CALIF	CHERRY PT	4/19/05 3:21 PM	10.58	3012560 Product	ITB	48067 DB/SS	10357	179.9	32.23	12.8
ITB BALTIMORE	CHERRY PT	CALIF	4/21/05 1:10 AM	0.90	3001714 Product	ITB	48067 DB/SS	10357	179.9	32.23	12.8

VTS responding traffic moves over route segments according to their arrivals in the VTOSS database

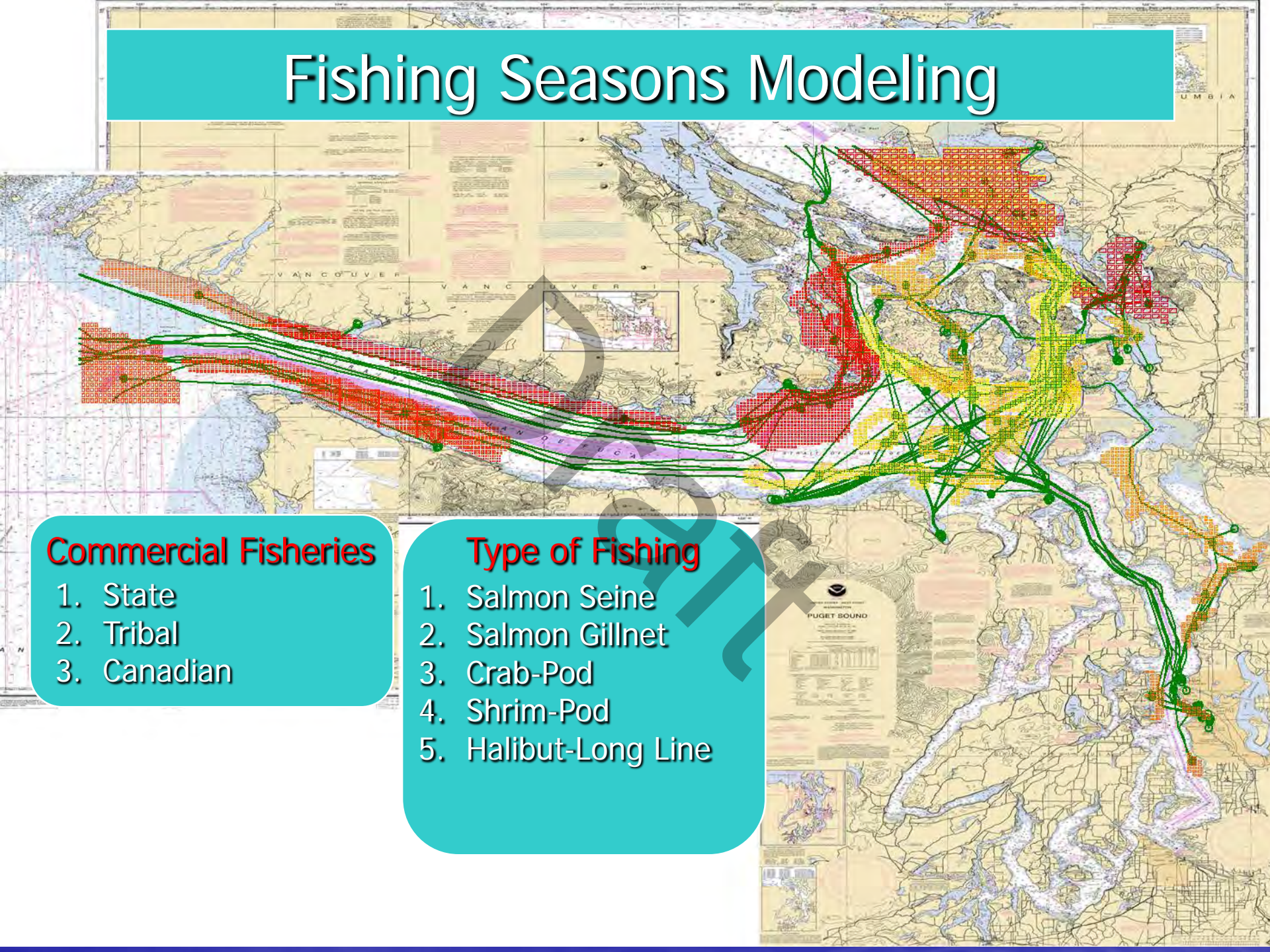
Fishing Seasons Modeling

Commercial Fisheries

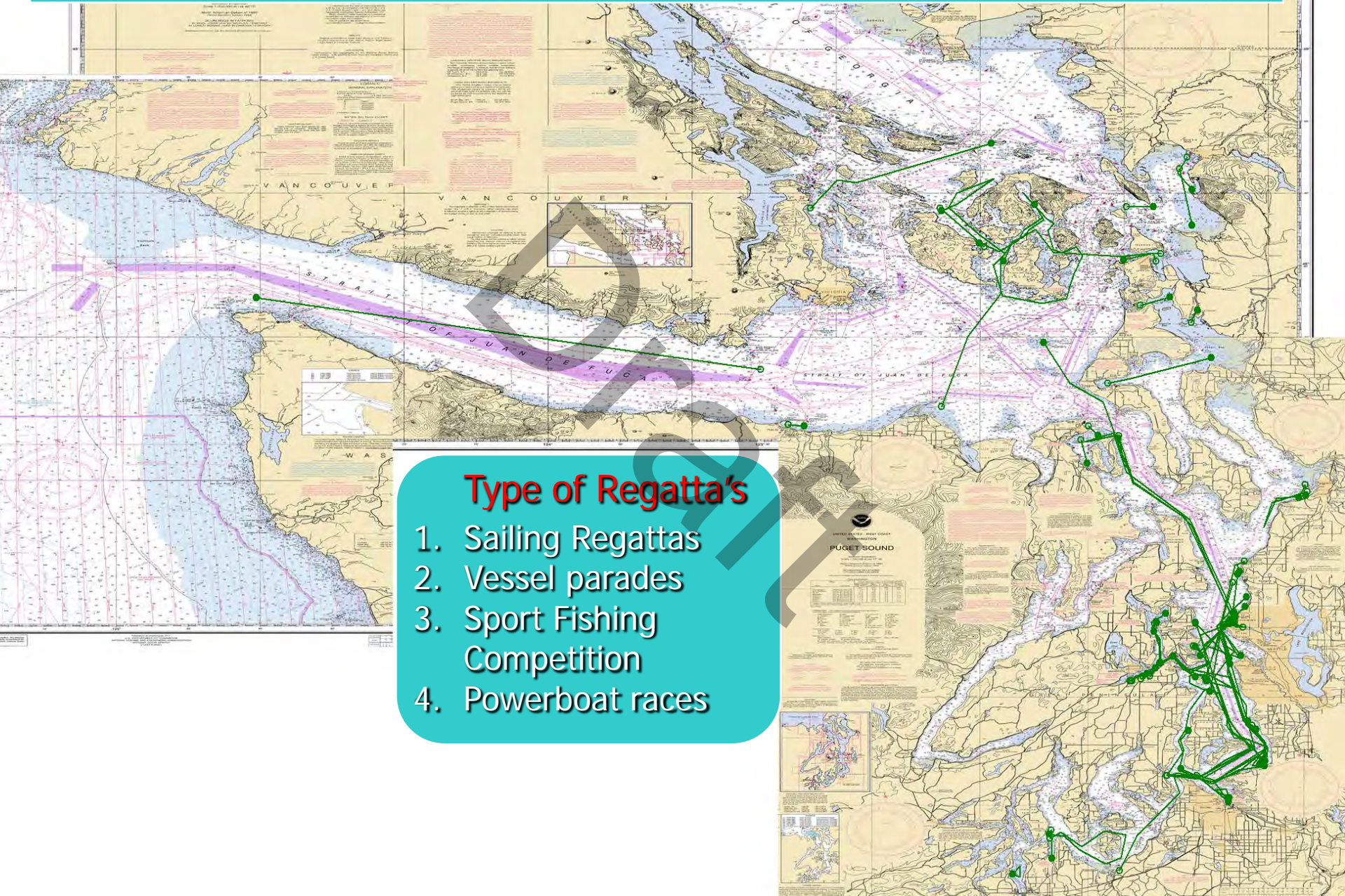
1. State
2. Tribal
3. Canadian

Type of Fishing

1. Salmon Seine
2. Salmon Gillnet
3. Crab-Pod
4. Shrim-Pod
5. Halibut-Long Line



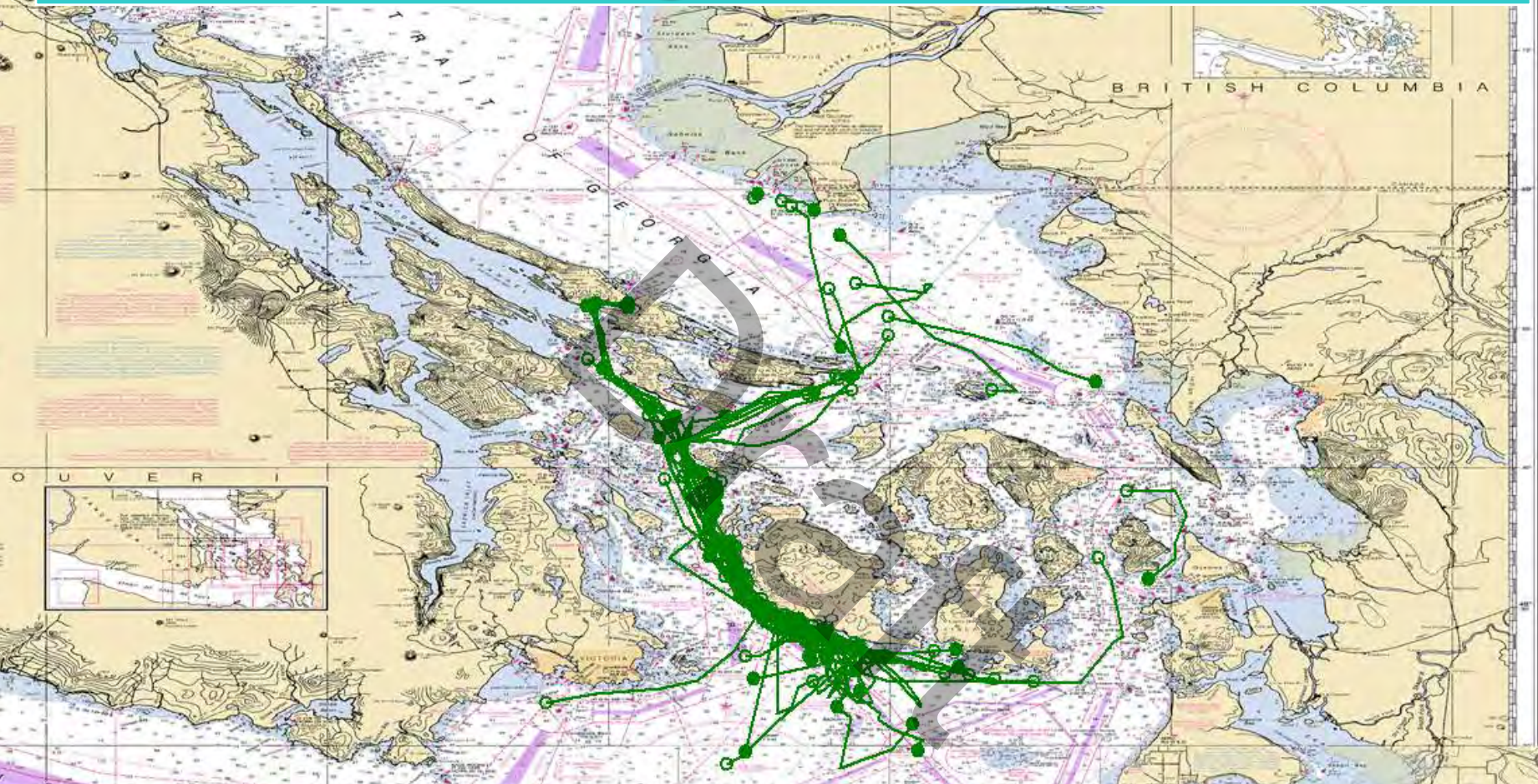
USCG Permitted Non-Commercial Traffic



Type of Regatta's

1. Sailing Regattas
2. Vessel parades
3. Sport Fishing Competition
4. Powerboat races

Whale Watching – Sound Watch Data



The movements of whale watching vessels are determined by the movements of the orca pods. The Sound Watch data gives the location of the orcas and then the number of vessels within a 2 mile radius of them. We move the orcas in the simulation and then add a swarm whale watching vessels around them. The number of vessels in the swarm is varied over time according to the counts in the Sound Watch data.

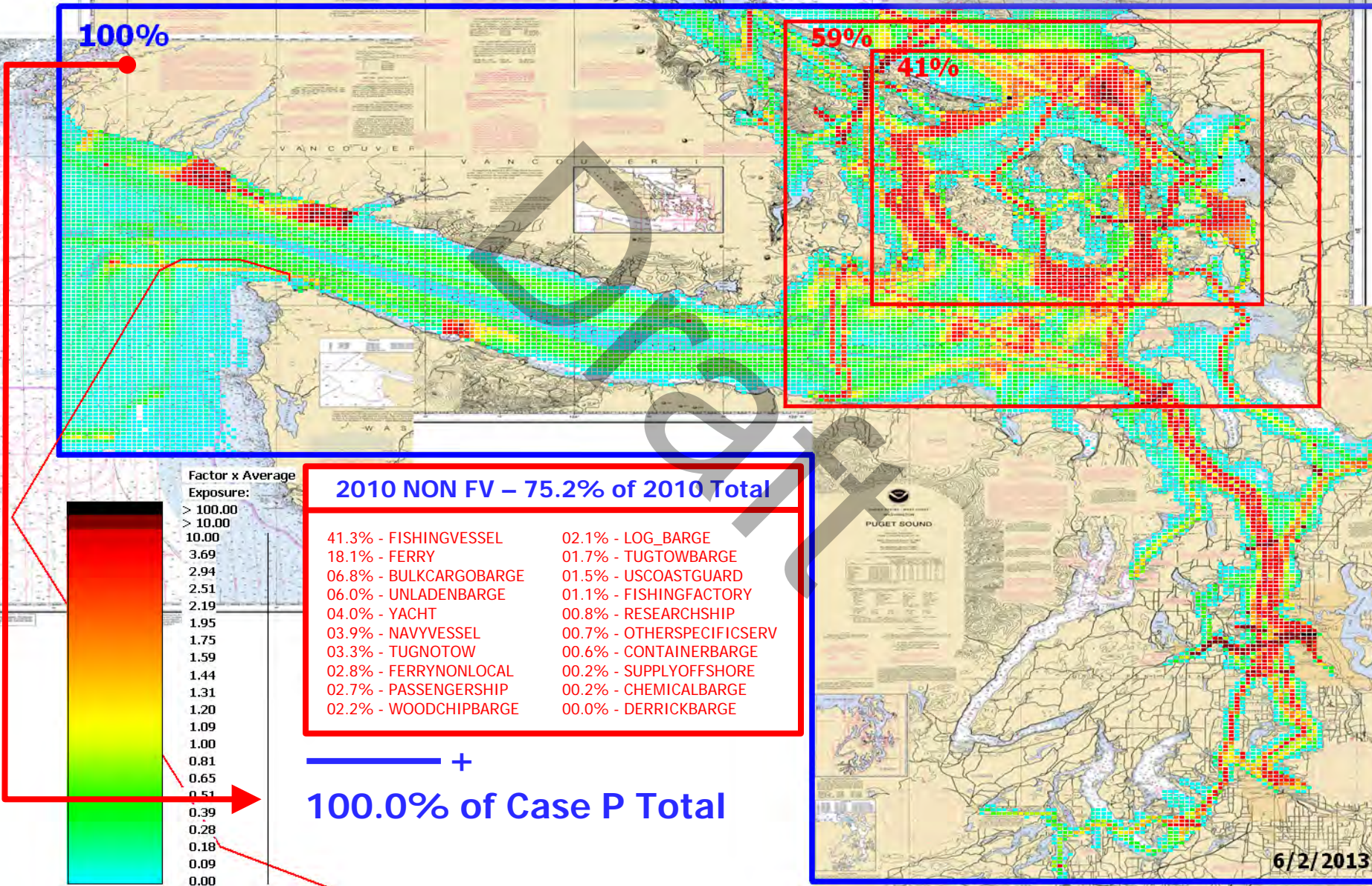
75.2% of Total Traffic Density



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P: VTRA 2010 - NON Focus Vessel Density



17.0% of Total Traffic Density

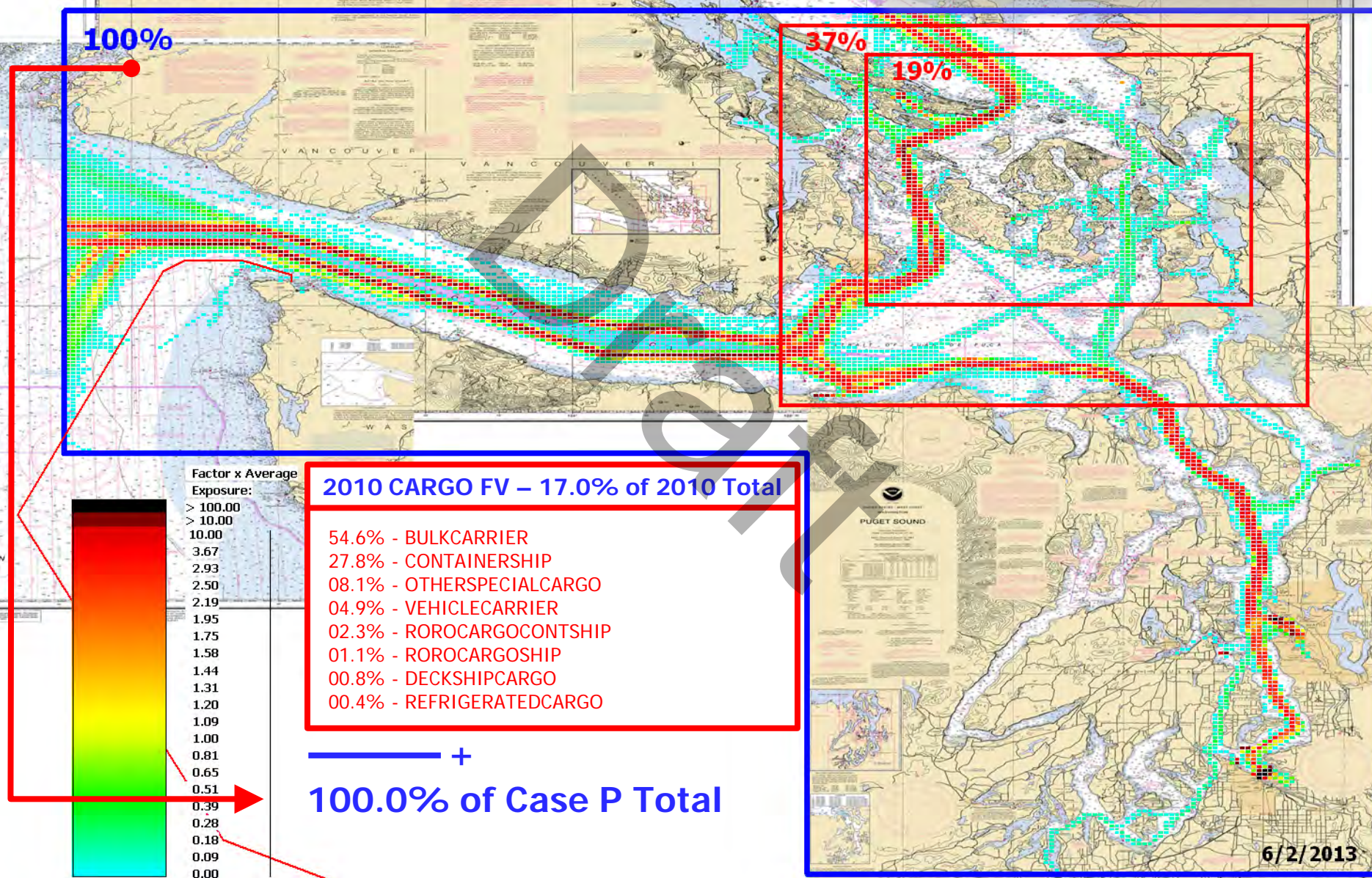


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P: VTRA 2010 - CARGO Focus Vessel Density



7.8% of Total Traffic Density

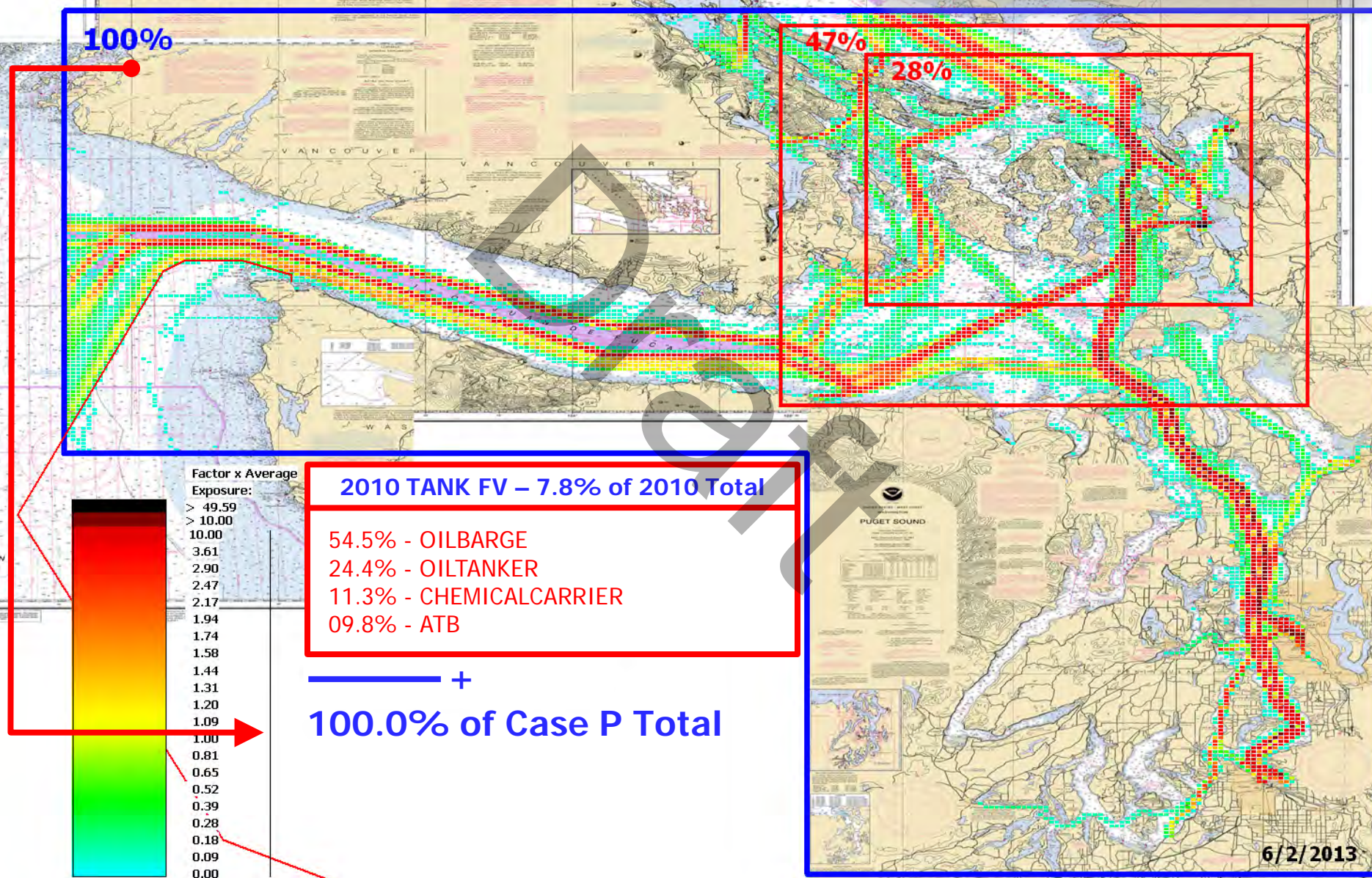


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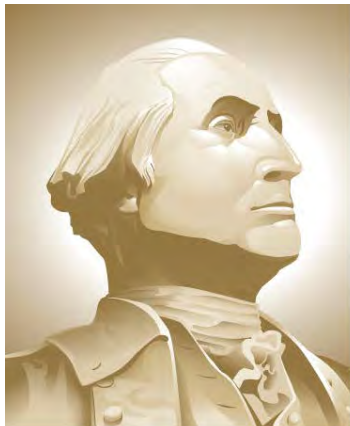
VCU

P: VTRA 2010 - Tank Focus Vessel Density



VTRA 2010 TRAFFIC DENSITIES BY CARGO – FV and TANK- FV A WATERWAY BY LOCATION ANALYSIS

Presentation by: J. Rene van Dorp



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CASE T: Gateway, Kinder Morgan, Delta Port

GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

AUGUST 26, 2013

PRELIMINARY

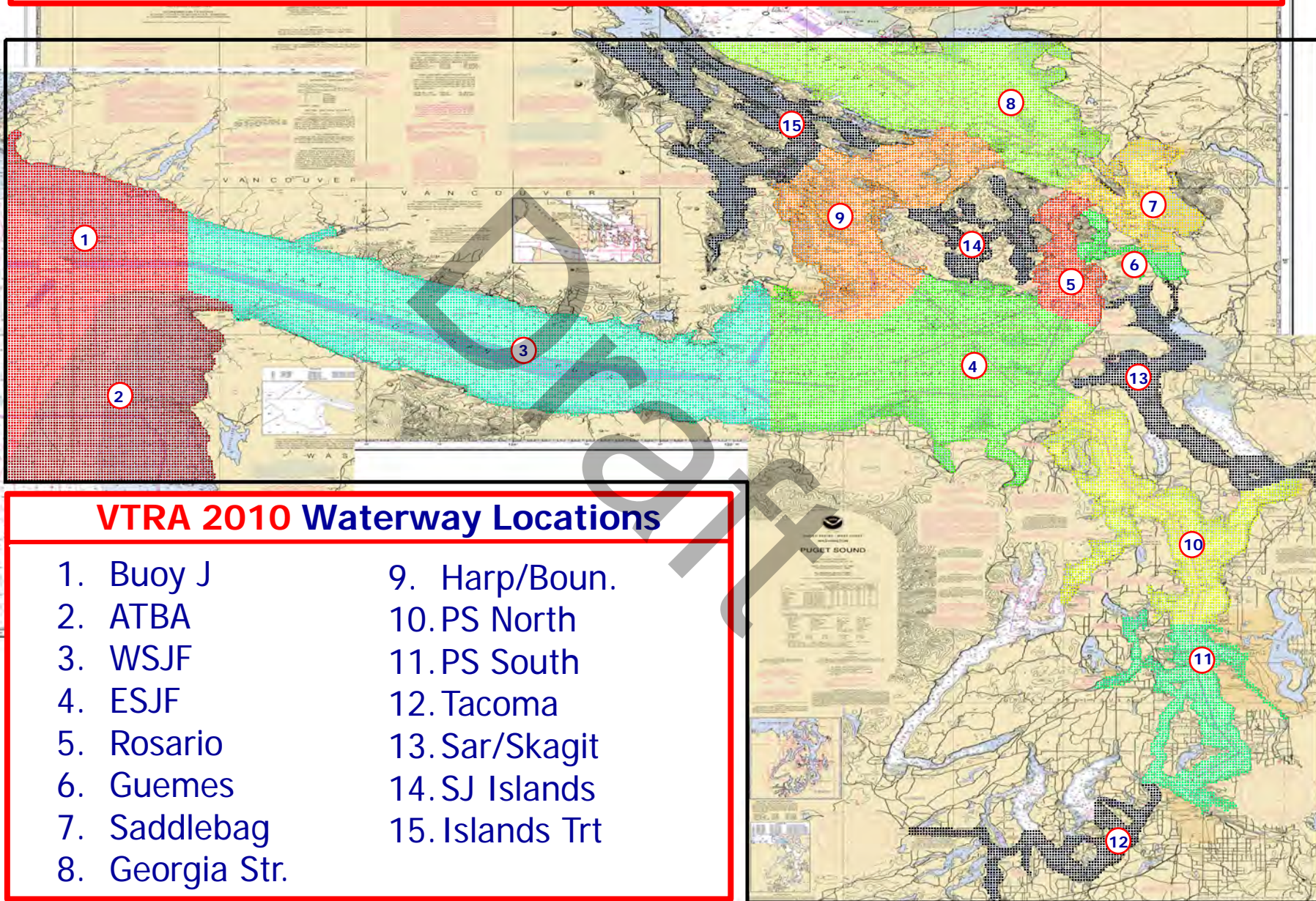
Table. Focus Vessel (FV) Classification for the 26 VTOSS vessel type classification used in the GW/VCU MTS simulation model.

- NON – FV** : Those vessels that Interacting Vessels (IV) with Focus Vessels (FV)
- BASE CASE CARGO – FV** : Bulk Carriers, Container Vessels, Other Cargo Vessels that travel in VTRA 2010 Base Case
- BASE CASE TANK – FV** : Oil Barge, Oil Tankers, Chemical Carrier, ATB 's that travel in VTRA 2010 Base Case
- WHAT IF – FV** : CARGO AND TANK FV'S added to VTRA 2010 Base Case to model What-If Scenario

Note: Focus Vessels (FV's) are also considered as Interacting Vessels (IV's) when interacting with another Focus Vessel.

#	VESSEL TYPE	FOCUS VESSEL?	#	VESSEL TYPE	FOCUS VESSEL?
1	BULKCARRIER	CARGO - FV	14	PASSENGERSHIP	NO
2	CHEMICALCARRIER	TANK - FV	15	REFRIGERATEDCARGO	CARGO-FV
3	CONTAINERSHIP	CARGO - FV	16	RESEARCHSHIP	NO
4	DECKSHIPCARGO	CARGO - FV	17	ROROCARGOSHIP	CARGO-FV
5	FERRY	NO	18	ROROCARGOCONTSHIP	CARGO-FV
6	FERRYNONLOCAL	NO	19	SUPPLYOFFSHORE	NO
7	FISHINGFACTORY	NO	20	TUGTOWBARGE	NO
8	FISHINGVESSEL	NO	21	UNKNOWN	NO
9	LIQGASCARRIER	TANK - FV	22	USCOASTGUARD	NO
10	NAVYVESSEL	NO	23	VEHICLECARRIER	CARGO-FV
11	OILTANKER	TANK - FV	24	YACHT	NO
12	OTHERSPECIALCARGO	CARGO - FV	25	ATB	TANK - FV
13	OTHERSPECIFICSERV	NO	26	OIL BARGE	TANK - FV

DEFINITION OF 15 WATERWAY LOCATIONS



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**.

CASE T: GW 487, KM 348, DP 348 and 67:

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

487 Gateway Bulk Carriers + Bunkering Barges

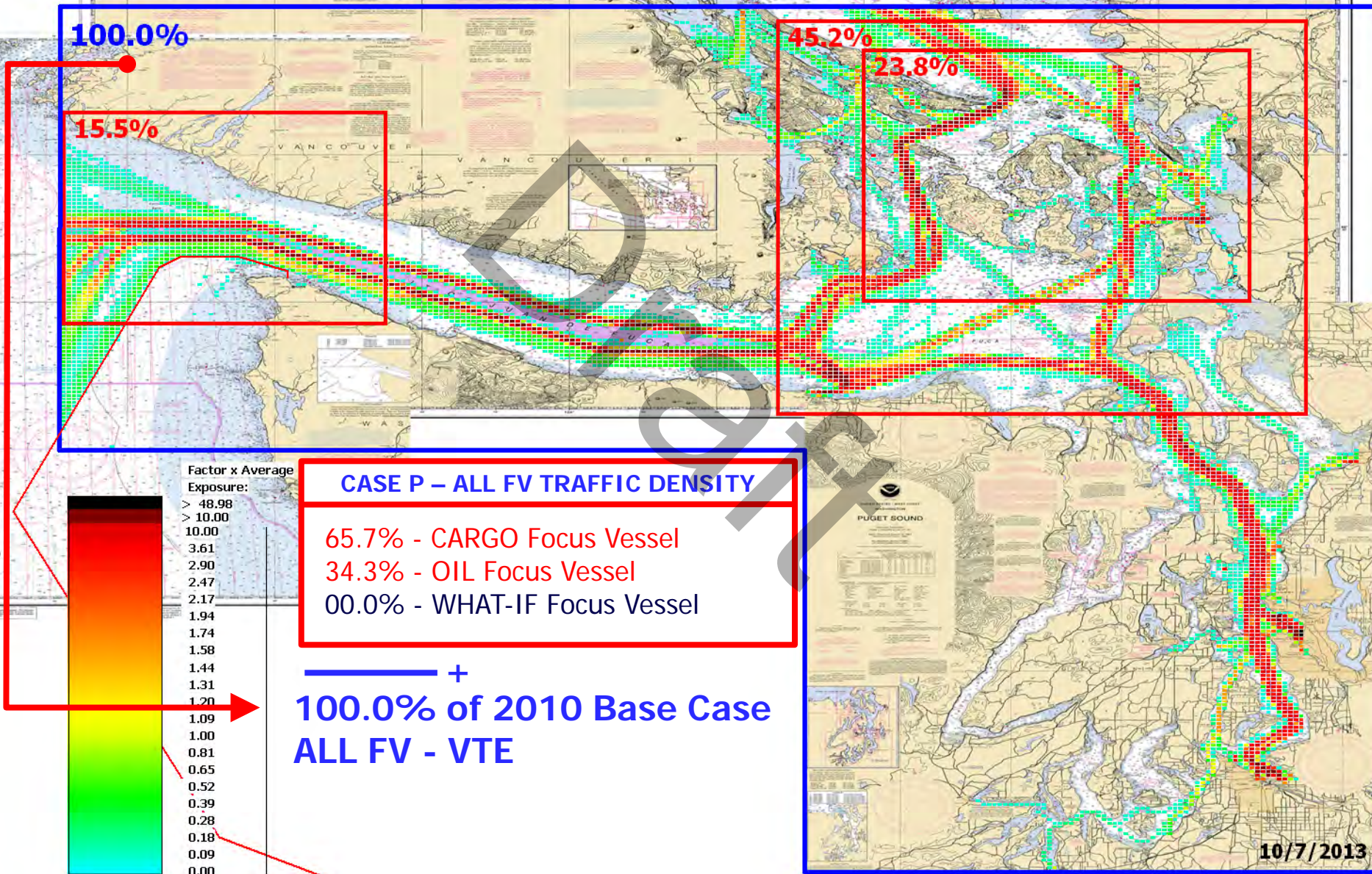
348 Kinder Morgan Tankers + Bunkering Barges

348 Delta Port Bulk Carriers + Bunkering Barges

67 Delta Port Container Ships+ Bunkering Barges

P: ALL FV Traffic Density

P: VTRA 2010 - BASE CASE - All FV



T: ALL FV Traffic Density

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

124.7%

19.9%

59.2%

33.5%

Factor x Average Exposure:

> 48.98
> 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

CASE T – ALL FV TRAFFIC DENSITY

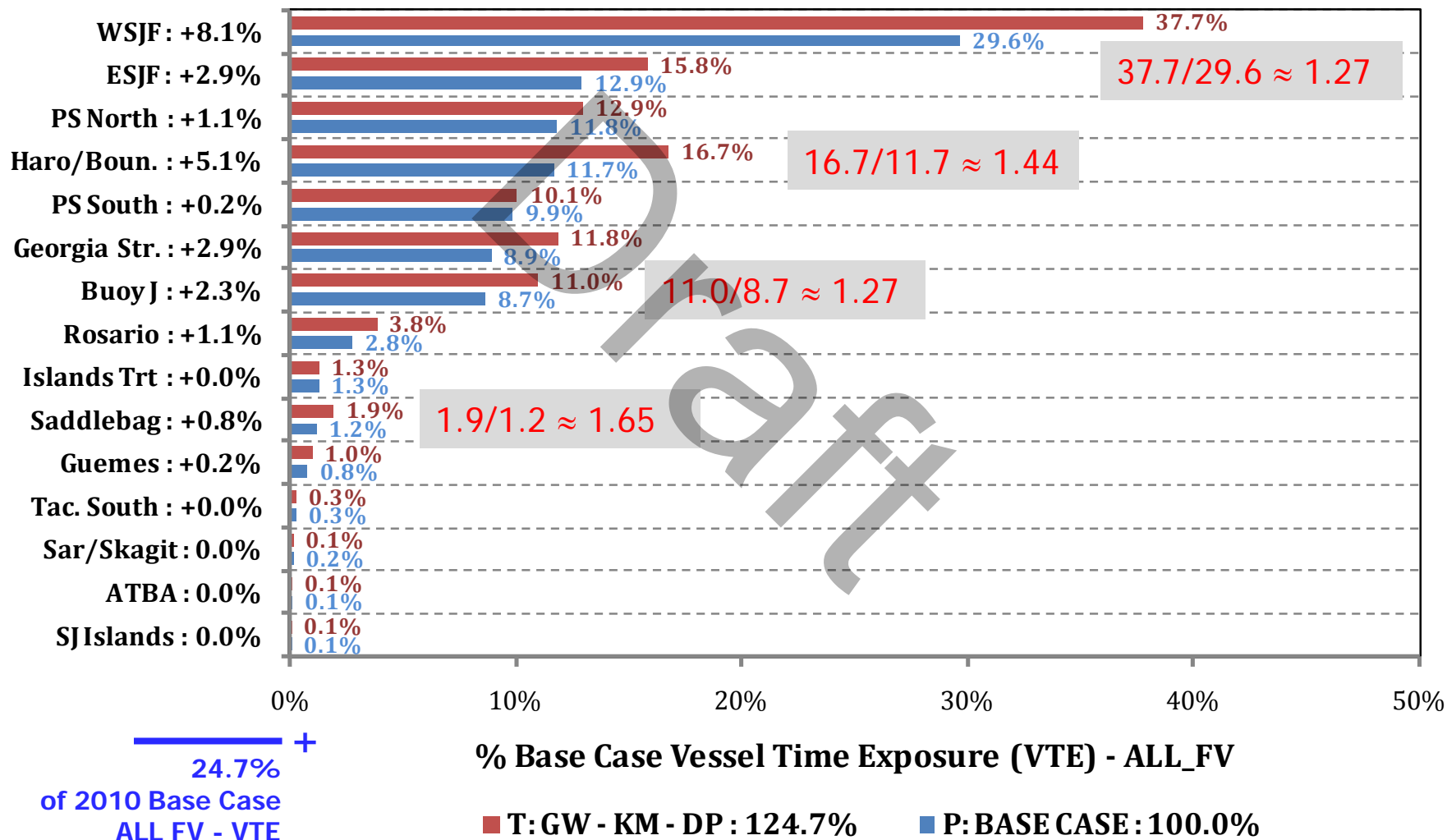
- 66.3% - CARGO Focus Vessel
- 34.0% - TANK Focus Vessel
- 24.4% - WHAT IF Focus Vessel

+
124.7% of 2010 Base Case
ALL FV - VTE

WATERWAY LOCATION

VESSEL TIME EXPOSURE ANALYSIS – ALL FOCUS VESSELS

% Base Case Vessel Time Exposure (VTE) - ALL_FV



T: WHAT-IF FOCUS VESSEL Traffic Density



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

24.4%

4.5%

13.5%

9.2%

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

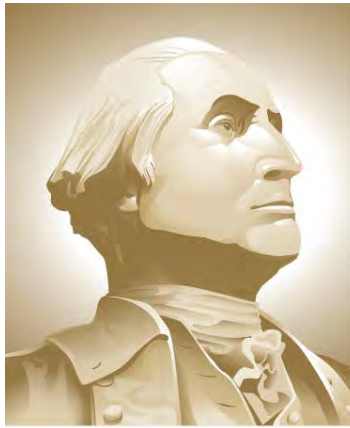
T : WHAT-IF FV TRAFFIC DENSITY

12.5% - BULK CARGO
01.8% - CONTAINERSHIP
07.3% - TANKER
02.7% - OILBARGE

24.4% of 2010 Base Case
ALL FV - VTE

VTRA 2010 POTENTIAL COLLISION FREQUENCY BY ALL FV, CARGO – FV, TANK- FV AND WHAT-IF FV

Presentation by: J. Rene van Dorp



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CASE T: Gateway, Kinder Morgan, Delta Port

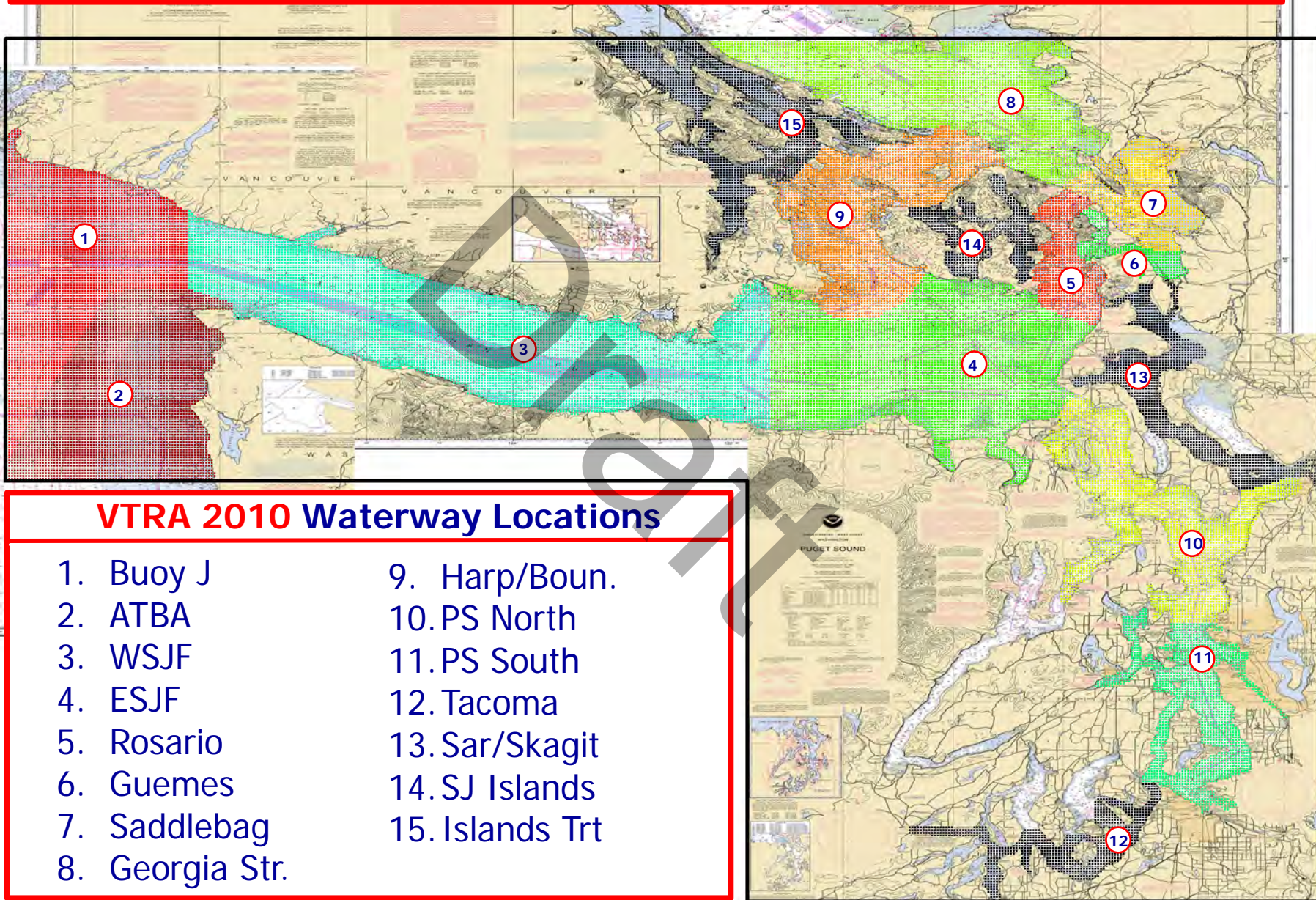
GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

AUGUST 26, 2013

PRELIMINARY

DEFINITION OF 15 WATERWAY LOCATIONS



P: ALL FV POTENTIAL COLL. FREQUENCY (PCF)

P: VTRA 2010 - BASE CASE - All FV

100.0%

1.7%

69.6%

53.4%

Factor x Average
of Accidents

> 100.00
> 10.00
10.00
3.69
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

CASE P: POTENTIAL COLL. FREQ. (PCF)

20.3% - CARGO Focus Vessel
79.7% - TANK Focus Vessel
00.0% - WHAT-IF Focus Vessel

100.0% of 2010 Base Case
ALL FV - PCF

T: ALL FV POTENTIAL COLL. FREQUENCY (PCF)

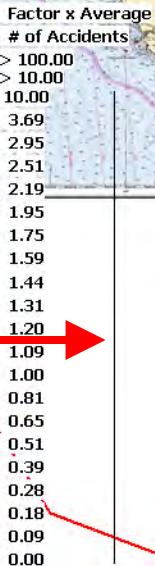
T: VTRA 2010 - GW 487- KM 348 - DP Cont. 67 and Bulk 348 - All FV

120.6%

2.7%

85.8%

67.7%



CASE T: POTENTIAL COLL. FREQ. (PCF)

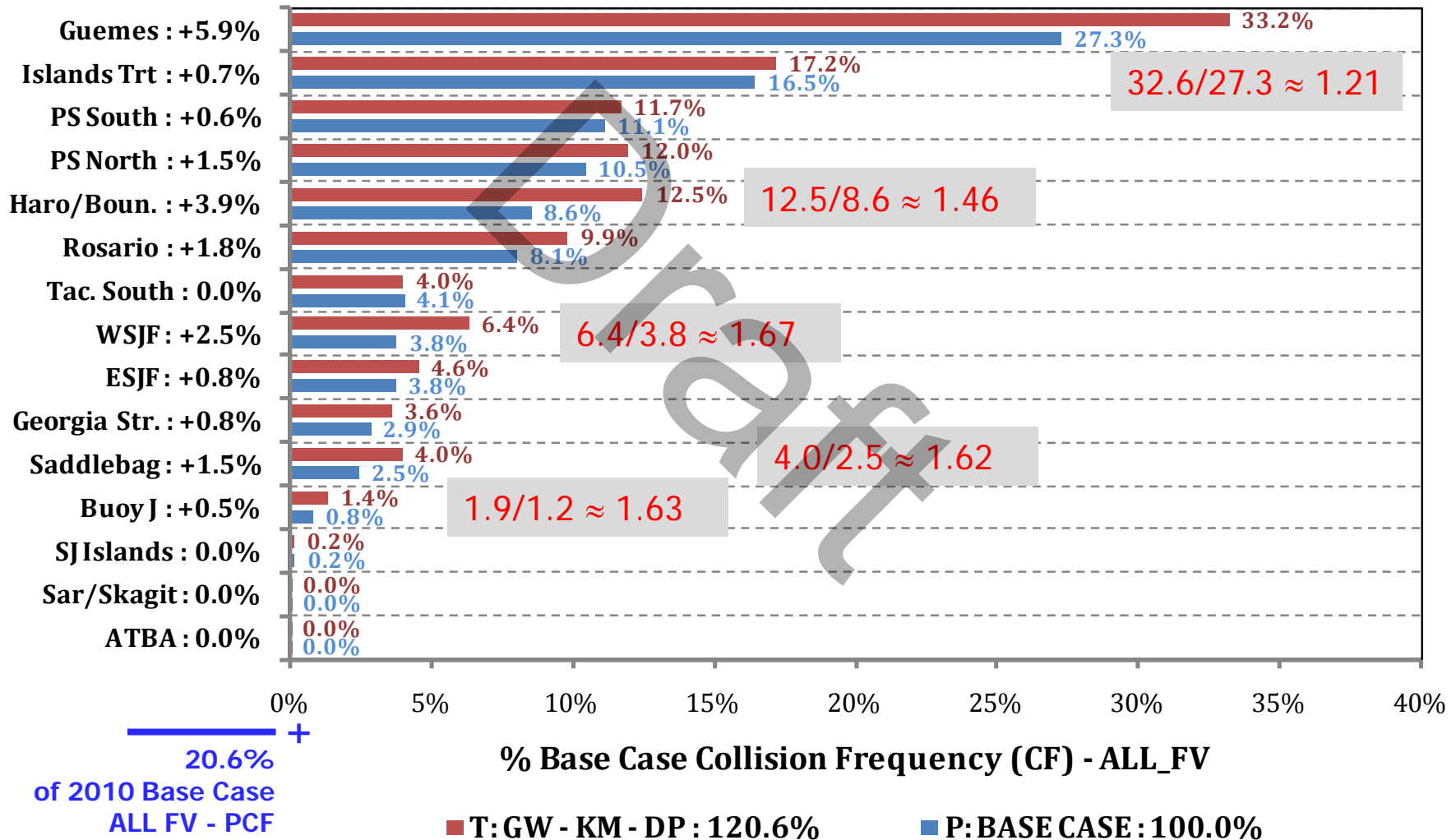
- 21.1% - CARGO Focus Vessel
- 81.1% - TANK Focus Vessel
- 18.4% - WHAT-IF Focus Vessel

**+
120.6% of 2010 Base Case
ALL FV - PCF**

WATERWAY LOCATION

Potential Collision Freq. Comparison – ALL FV

% Base Case Collision Frequency - ALL_FV





T: WHAT-IF FV POTENTIAL COLLISION FREQUENCY (PCF)

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

18.4%

0.7%

14.6%

13.1%

Factor x Average
of Accidents

> 100.00
> 10.00
10.00
3.69
2.95
2.51
2.19
1.95
1.75
1.59
1.44
1.31
1.20
1.00
0.81
0.65
0.51
0.39
0.28
0.18
0.09
0.00

T: POTENTIAL COLL. FREQ. (PCF)

03.6% - BULK CARGO
00.7% - CONTAINERSHIP
03.1% - TANKER
10.9% - OILBARGE

**18.4% of 2010 Base Case
WHAT-IF FV - PCF**

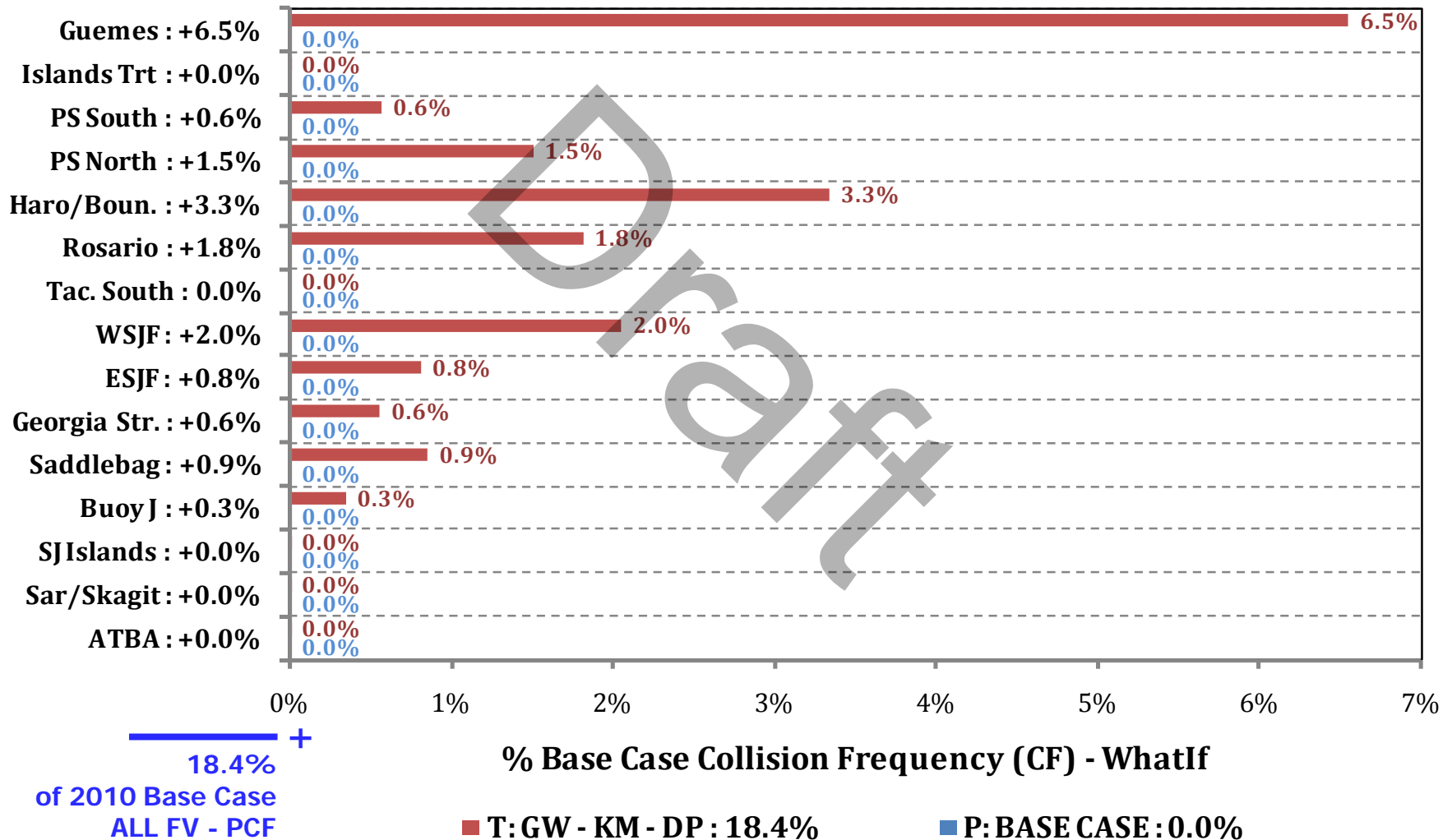
**T: 88.4% OF 18.4% PCF
BY INTERACTING
VESSEL TYPE**

8.8% - FISHINGVESSEL
1.9% - BULKCARRIER
1.6% - FERRY
1.1% - OILTANKER
0.8% - BULKCARGOBARGE
0.5% - FERRYNONLOCAL
0.5% - UNLADENBARGE
0.4% - CONTAINERSHIP
0.3% - NAVYVESSEL
0.3% - OILBARGE

WATERWAY LOCATION

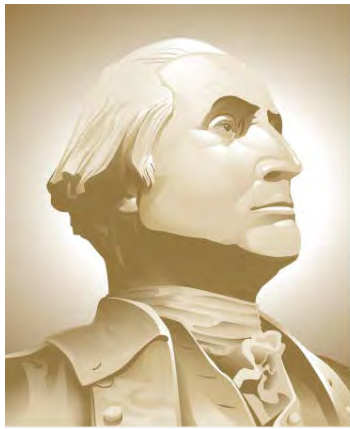
Potential Collision Freq. Comparison – WHAT-IF FV

% Base Case Collision Frequency - WhatIf



VTRA 2010 POTENTIAL COLLISION LOSSES BY ALL FV, CARGO – FV, TANK- FV AND WHAT-IF FV

Presentation by: J. Rene van Dorp



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CASE T: Gateway, Kinder Morgan, Delta Port

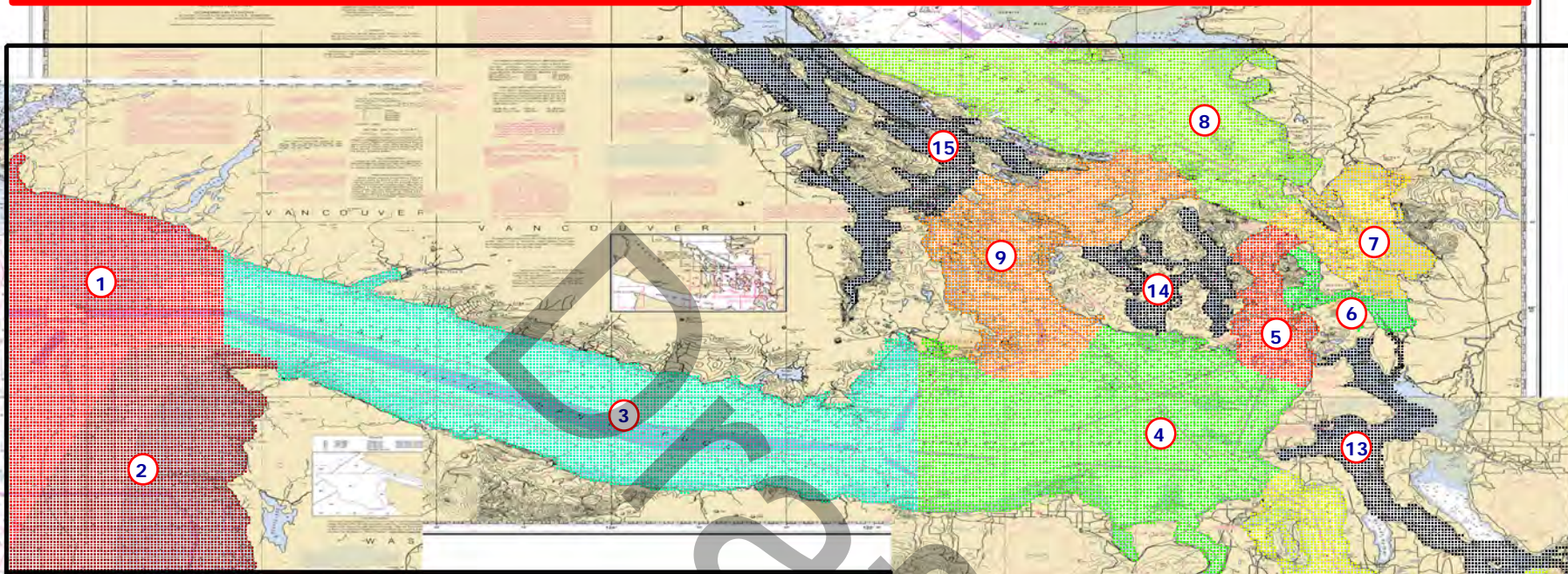
GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

AUGUST 26, 2013

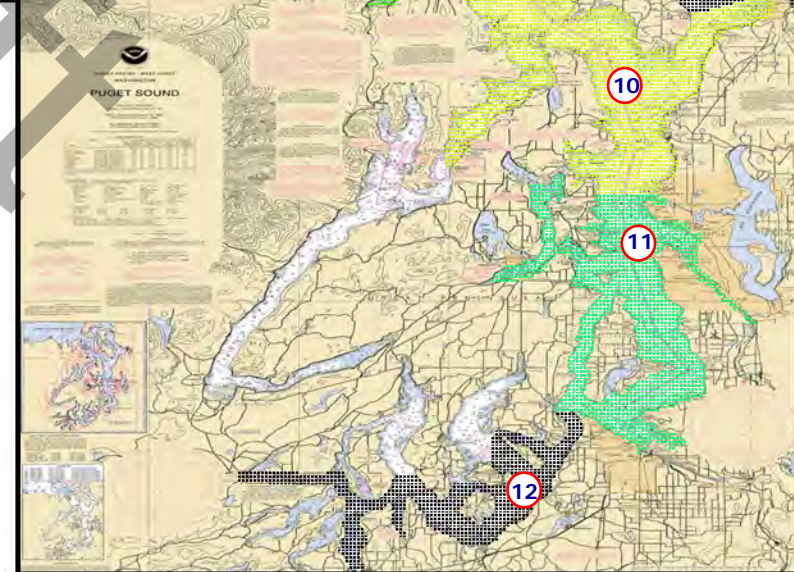
PRELIMINARY

DEFINITION OF 15 WATERWAY LOCATIONS



VTRA 2010 Waterway Locations

- | | |
|-----------------|-----------------|
| 1. Buoy J | 9. Harp/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. Islands Trt |
| 8. Georgia Str. | |





P: ALL FV POTENTIAL COLLISION OIL (FUEL + CARGO) LOSS (PCO)

P: VTRA 2010 - BASE CASE - All FV

100.0%

2.8%

82.7%

67.5%

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
 0.38
 0.28
 0.18
 0.09
 0.00

P: POTENTIAL COLL. OIL LOSS (PCO)

03.0% - BULK CARGO
 04.1% - CONTAINERSHIP
 01.4% - OTHER CARGO
 21.4% - OIL BARGE
 54.2% - TANKER
 13.3% - CHEMICAL CARRIER
 02.6% - ATB
 00.0% - WHAT-IF FV

+
**100.0% of 2010 Base Case
ALL FV – PCO**



T: ALL FV POTENTIAL COLLISION OIL (FUEL + CARGO) LOSS (PCO)

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

188.8%

11.6%

158.3%

125.6%

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
 0.38
 0.28
 0.18
 0.09
 0.00

T: POTENTIAL COLL. OIL LOSS (PCO)

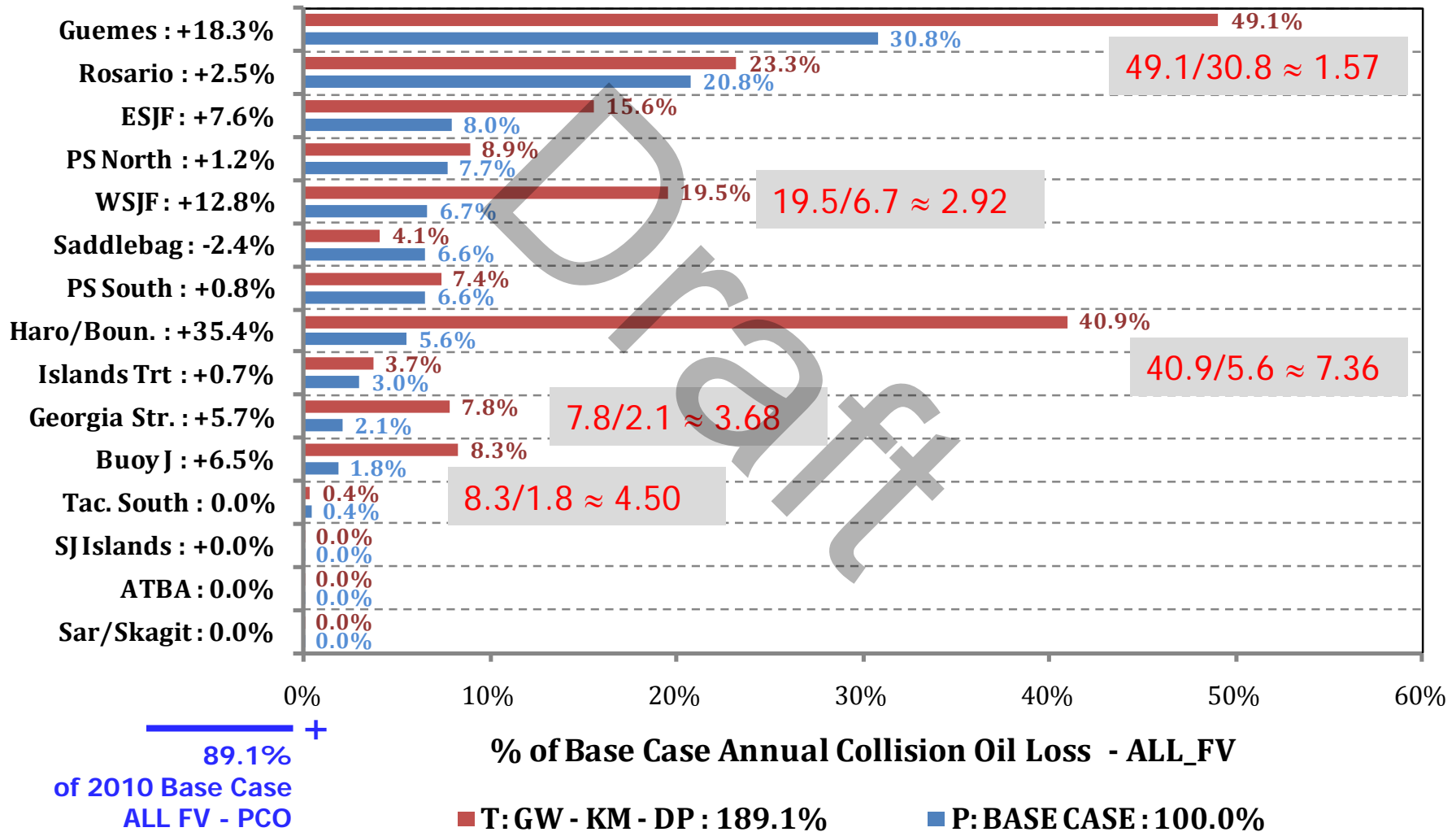
04.9% - BULK CARGO
 05.6% - CONTAINERSHIP
 02.4% - OTHER CARGO
 18.1% - OIL BARGE
 83.6% - TANKER
 09.2% - CHEMICAL CARRIER
 03.2% - ATB
 62.0% - WHAT-IF FV

+
**188.8% of 2010 Base Case
ALL FV – PCO**

WATERWAY LOCATION

Potential Collision Oil Loss Comparison – ALL FV

% Base Case Collision Oil Loss - ALL_FV



**T: WHAT-IF FV POTENTIAL
COLLISION OIL (FUEL+CARGO) LOSS (PCO)**

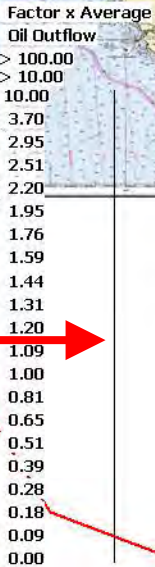
T: VTRA 2010 - GW 487- KM 348 - DP Cont. 67 and Bulk 348

62.0%

6.3%

51.4%

36.0%



T: POTENTIAL COLL. OIL LOSS (PCO)

15.2% - BULKCARRIER
00.7% - CONTAINERSHIP
41.3% - OIL TANKER
04.8% - OIL BARGE

**62.0% of 2010 Base Case
ALL FV – PCO**

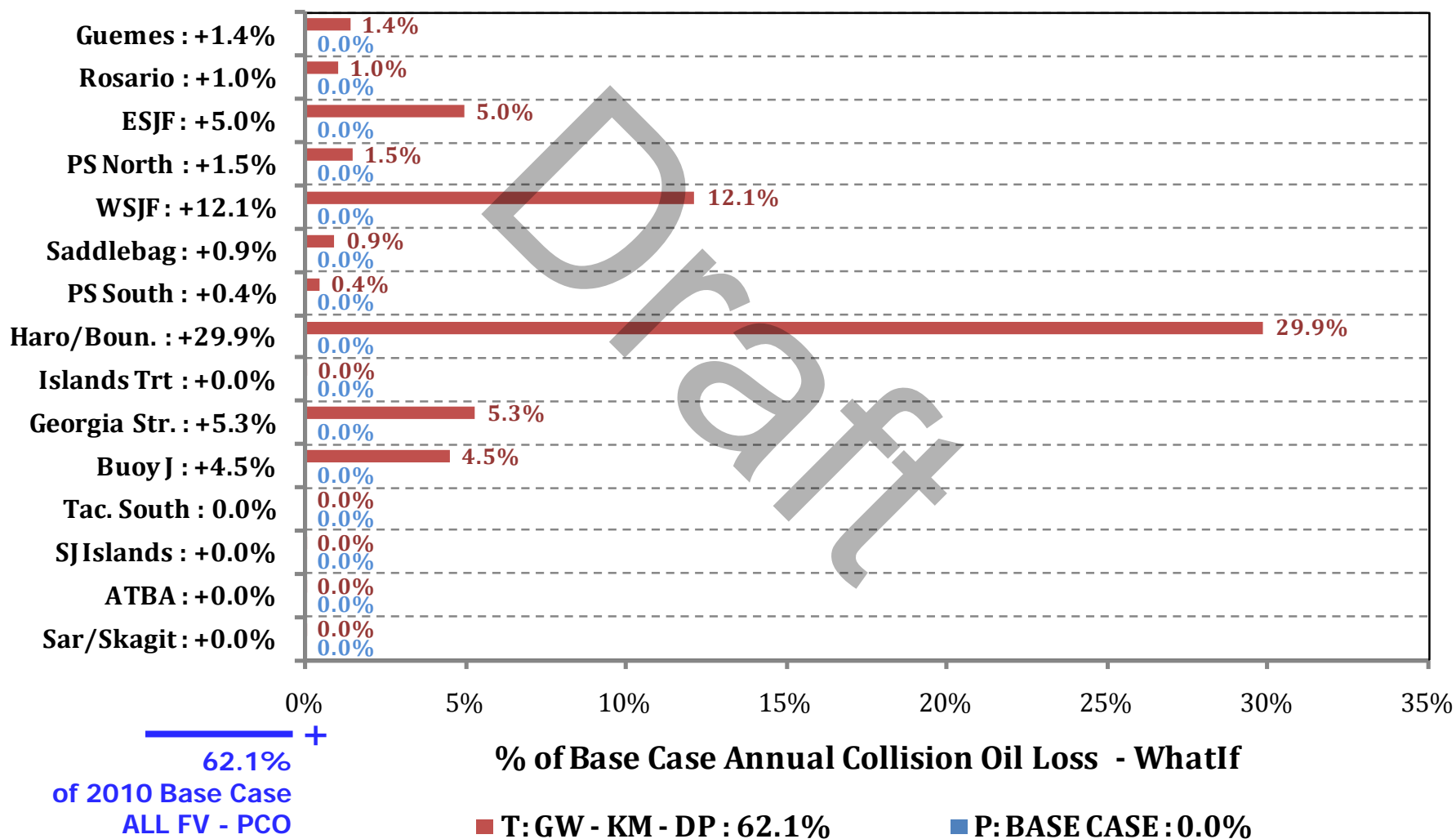
**T: 91.9% OF 62.0% PCO
BY INTERACTING
VESSEL TYPE**

19.7% - OILTANKER
18.3% - BULKCARRIER
06.5% - FERRY
03.7% - CONTAINERSHIP
03.5% - FISHINGVESSEL
01.2% - PASSENGERSHIP
01.1% - NAVYVESSEL
01.0% - OILBARGE
00.9% - BULKCARGOBARGE
00.9% - FERRYNONLOCAL

WATERWAY LOCATION

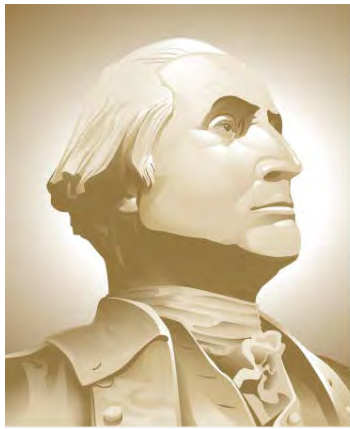
Potential Collision Oil Loss Comparison – WHAT-IF FV

% Base Case Collision Oil Loss - WhatIf



VTRA 2010 POTENTIAL COLLISION FREQUENCY BY WHAT-IF FV: SOME RISK MGT ANALYSIS

Presentation by: J. Rene van Dorp



**THE GEORGE
WASHINGTON
UNIVERSITY**

WASHINGTON, DC

VCU

CASE T: Gateway, Kinder Morgan, Delta Port

GWU Personnel: Dr. J. Rene van Dorp

VCU Personnel: Dr. Jason R. W. Merrick

AUGUST 26, 2013

PRELIMINARY

CASE X: GW 487 NB, KM 348, DP 348 and 67:

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

487 Gateway Bulk Carriers + ~~Bunkering Barges~~

348 Kinder Morgan Tankers + Bunkering Barges

348 Delta Port Bulk Carriers + Bunkering Barges

67 Delta Port Container Ships + Bunkering Barges

T: WHAT-IF FV POTENTIAL COLLISION FREQUENCY (PCF)



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

18.4%

0.7%

14.6%

13.1%

Factor x Average
of Accidents

> 100.00
> 10.00
10.00
3.69
2.95
2.51
2.19
1.95
1.75
1.59
1.44
1.31
1.20
1.00
0.81
0.65
0.51
0.39
0.28
0.18
0.09
0.00

CASE T: POTENTIAL COLL. FREQ. (PCF)

03.6% - BULK CARGO
00.7% - CONTAINERSHIP
03.1% - TANKER
10.9% - OILBARGE

18.4% of 2010 Base Case
WHAT-IF FV - PCF

T: 88.4% OF 18.4% PCF BY INTERACTING VESSEL TYPE

8.8% - FISHINGVESSEL
1.9% - BULKCARRIER
1.6% - FERRY
1.1% - OILTANKER
0.8% - BULKCARGOBARGE
0.5% - FERRYNONLOCAL
0.5% - UNLADENBARGE
0.4% - CONTAINERSHIP
0.3% - NAVYVESSEL
0.3% - OILBARGE

X: WHAT-IF FV POTENTIAL COLLISION FREQUENCY (PCF)



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X: VTRA 2010 - GW 487 NB - KM 348 - DP Cont. 67 & Bulk 348

7.5%

0.7%

5.6%

4.6%

Factor x Average
of Accidents

> 100.00
> 10.00
10.00
3.69
2.95
2.51
2.19
1.95
1.75
1.59
1.44
1.31
1.20
1.00
0.81
0.65
0.51
0.39
0.28
0.18
0.09
0.00

CASE X: POTENTIAL COLL. FREQ. (PCF)

03.6% - BULK CARGO
00.8% - CONTAINERSHIP
03.1% - TANKER
00.1% - OILBARGE

7.5% of 2010 Base Case
WHAT-IF FV - PCF

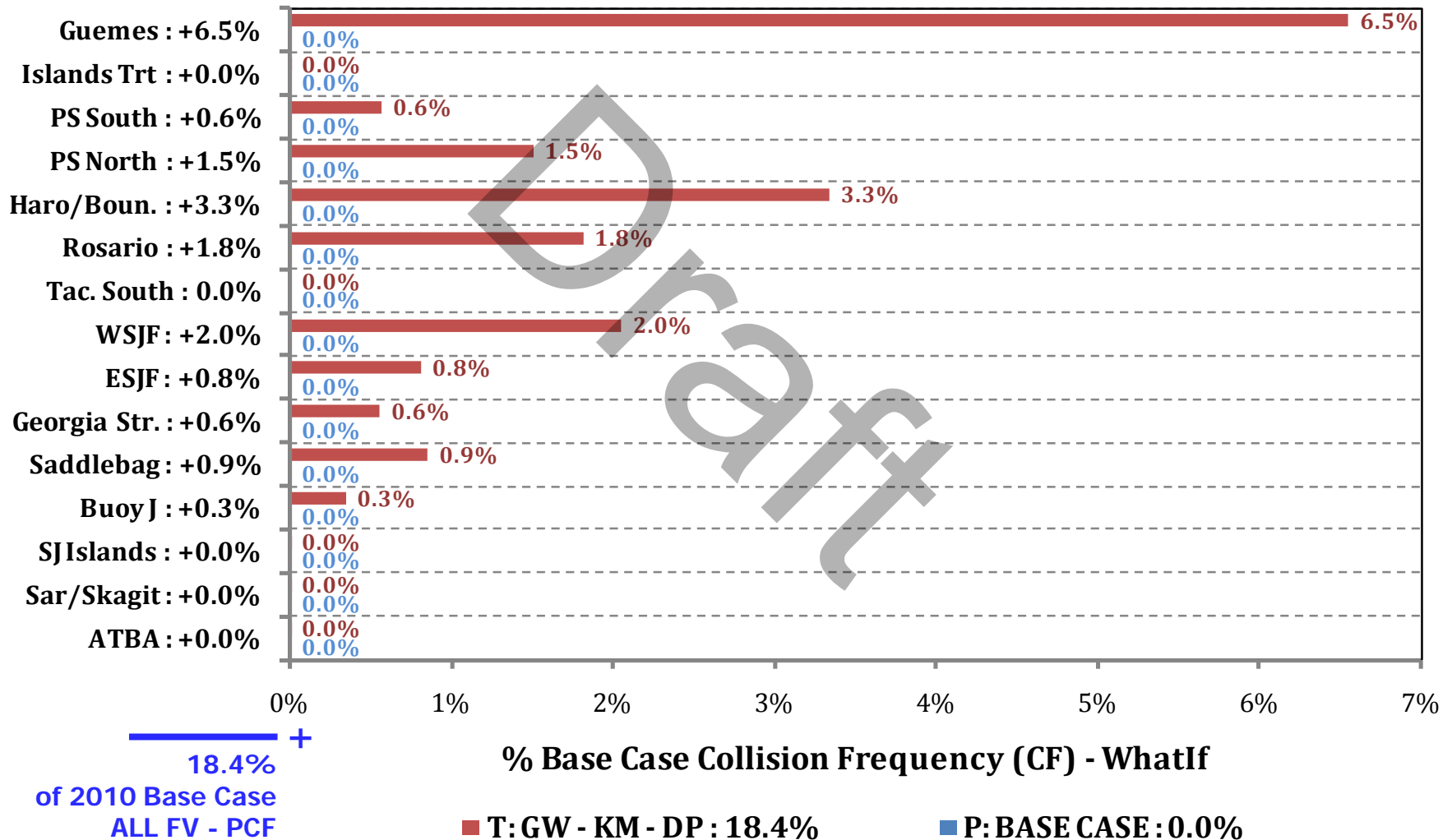
X: 85.4% OF 7.5% PCF BY INTERACTING VESSEL TYPE

2.1% - FISHINGVESSEL
1.7% - BULKCARRIER
0.3% - FERRY
1.1% - OILTANKER
0.2% - BULKCARGOBARGE
0.1% - FERRYNONLOCAL
0.2% - UNLADENBARGE
0.4% - CONTAINERSHIP
0.3% - NAVYVESSEL
0.1% - OILBARGE

WATERWAY LOCATION

Potential Collision Freq. Comparison – WHAT-IF FV

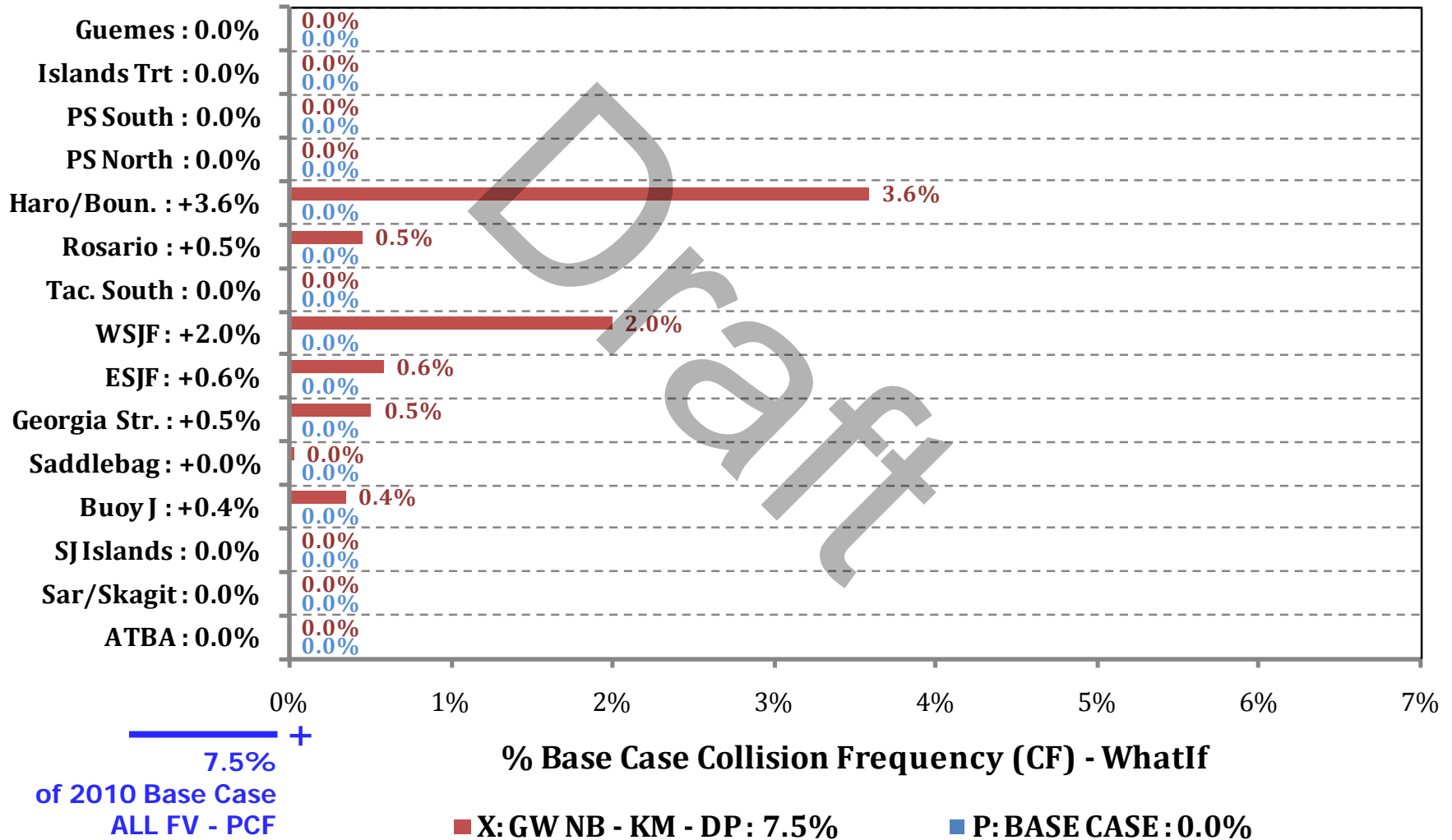
% Base Case Collision Frequency - WhatIf



WATERWAY LOCATION

Potential Collision Freq. Comparison – WHAT-IF FV

% Base Case Collision Frequency - WhatIf



CASE Y: GW 487 NB OH, KM 348, DP 348 and 67:

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

+ Travel only through Haro

487 Gateway Bulk Carriers + ~~Bunkering Barges~~

348 Kinder Morgan Tankers + Bunkering Barges

348 Delta Port Bulk Carriers + Bunkering Barges

67 Delta Port Container Ships + Bunkering Barges

T: WHAT-IF FV POTENTIAL COLLISION FREQUENCY (PCF)



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

18.4%

0.7%

14.6%

13.1%

Factor x Average
of Accidents

> 100.00
> 10.00
10.00
3.69
2.95
2.51
2.19
1.95
1.75
1.59
1.44
1.31
1.20
1.00
0.81
0.65
0.51
0.39
0.28
0.18
0.09
0.00

CASE T: POTENTIAL COLL. FREQ. (PCF)

03.6% - BULK CARGO
00.7% - CONTAINERSHIP
03.1% - TANKER
10.9% - OILBARGE

18.4% of 2010 Base Case
WHAT-IF FV - PCF

T: 88.4% OF 18.4% PCF BY INTERACTING VESSEL TYPE

8.8% - FISHINGVESSEL
1.9% - BULKCARRIER
1.6% - FERRY
1.1% - OILTANKER
0.8% - BULKCARGOBARGE
0.5% - FERRYNONLOCAL
0.5% - UNLADENBARGE
0.4% - CONTAINERSHIP
0.3% - NAVYVESSEL
0.3% - OILBARGE

Y: WHAT-IF FV POTENTIAL COLLISION FREQUENCY (PCF)



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Y: VTRA 2010 - GW 487 NB OH - KM 348 - DP Cont. 67 & Bulk 348

8.1%

0.7%

6.2%

5.1%

Factor x Average
of Accidents

> 100.00
> 10.00
10.00
3.69
2.95
2.51
2.19
1.95
1.75
1.59
1.44
1.31
1.20
1.00
0.81
0.65
0.51
0.39
0.28
0.18
0.09
0.00

CASE Y: POTENTIAL COLL. FREQ. (PCF)

04.1% - BULK CARGO
00.8% - CONTAINERSHIP
03.1% - TANKER
00.1% - OILBARGE

**8.1% of 2010 Base Case
WHAT-IF FV - PCF**

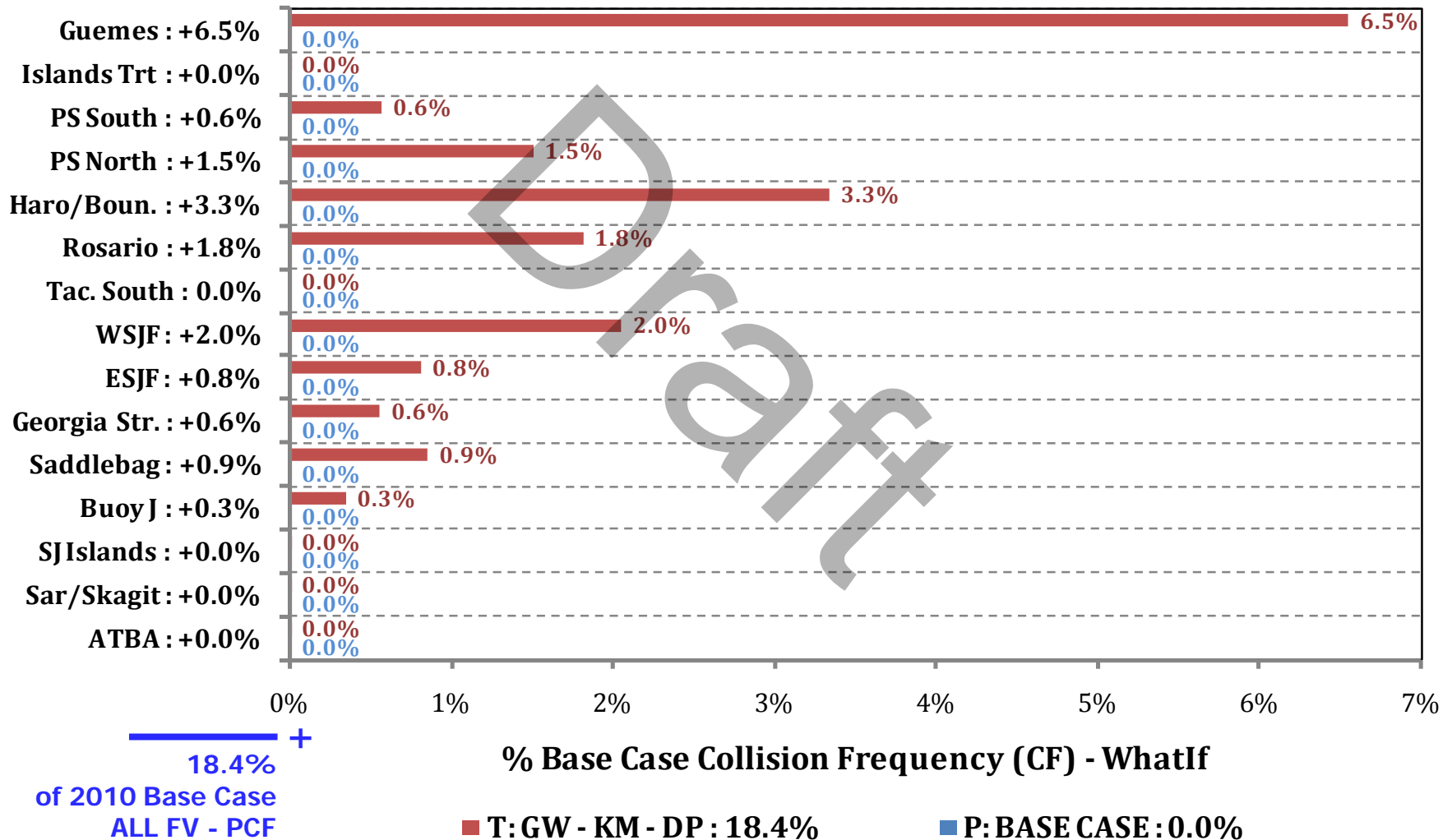
Y: 85.5% OF 8.1% PCF BY INTERACTING VESSEL TYPE

2.4% - FISHINGVESSEL
1.9% - BULKCARRIER
0.3% - FERRY
1.1% - OILTANKER
0.1% - BULKCARGOBARGE
0.1% - FERRYNONLOCAL
0.2% - UNLADENBARGE
0.4% - CONTAINERSHIP
0.3% - NAVYVESSEL
0.0% - OILBARGE

WATERWAY LOCATION

Potential Collision Freq. Comparison – WHAT-IF FV

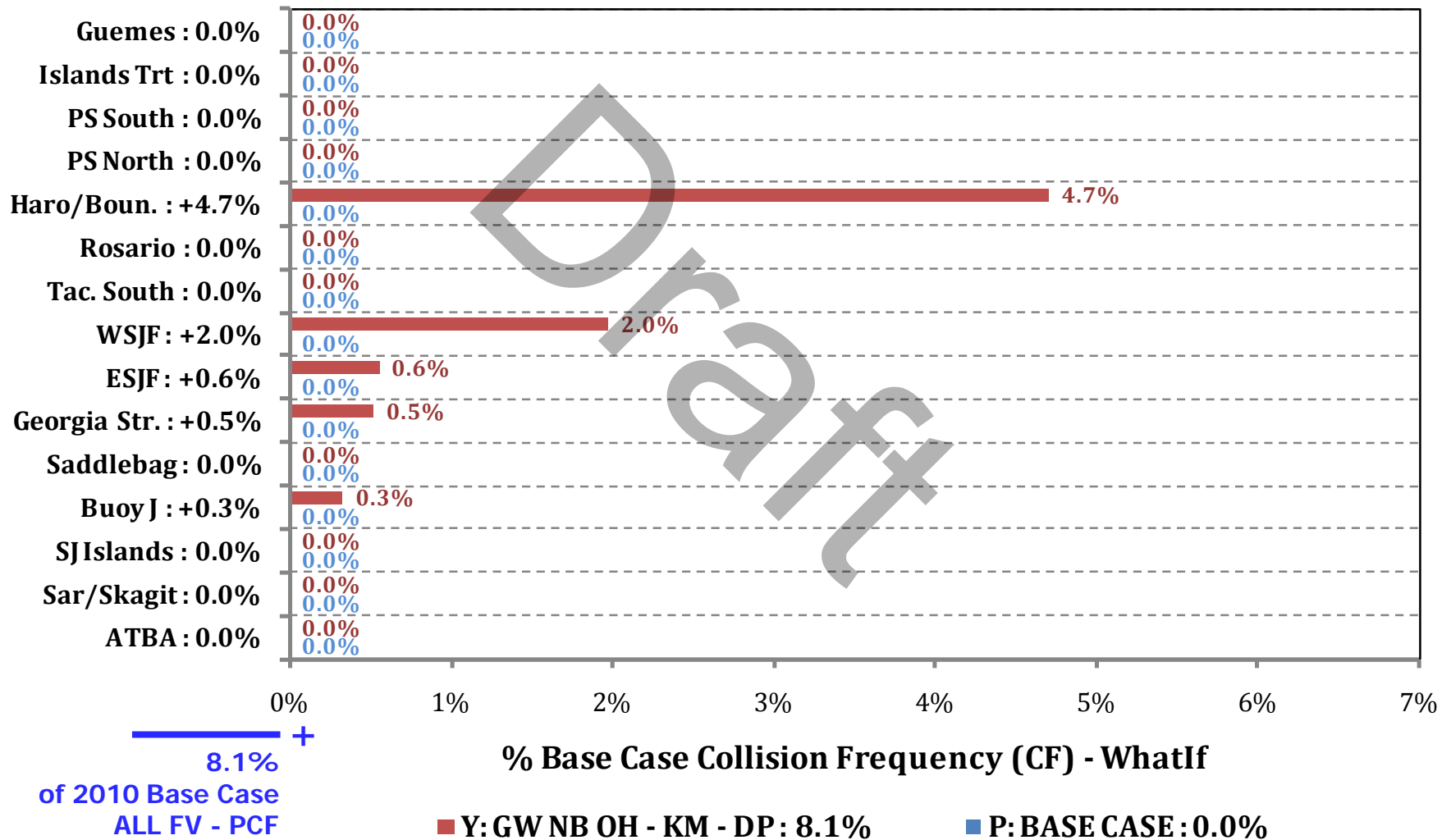
% Base Case Collision Frequency - WhatIf



WATERWAY LOCATION

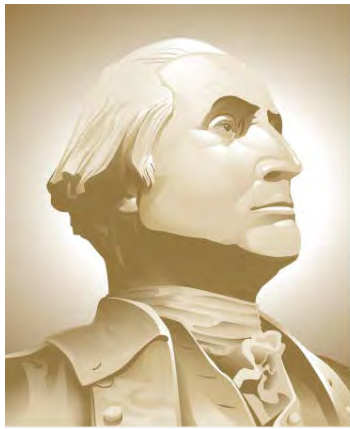
Potential Collision Freq. Comparison – WHAT-IF FV

% Base Case Collision Frequency - WhatIf



VTRA 2010 POTENTIAL COLLISION LOSSES BY WHAT-IF FV: SOME RISK MGT ANALYSIS

Presentation by: J. Rene van Dorp



**THE GEORGE
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CASE T: Gateway, Kinder Morgan, Delta Port

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AUGUST 26, 2013

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487 Gateway Bulk Carriers + ~~Bunkering Barges~~

348 Kinder Morgan Tankers + Bunkering Barges

348 Delta Port Bulk Carriers + Bunkering Barges

67 Delta Port Container Ships + Bunkering Barges



T: WHAT-IF FV POTENTIAL COLLISION OIL (FUEL+CARGO) LOSS (PCO)

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

62.0%

6.3%

51.4%

36.0%

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

T: POTENTIAL COLL. OIL LOSS (PCO)

15.2% - BULKCARRIER
 00.7% - CONTAINERSHIP
 41.3% - OIL TANKER
 04.8% - OIL BARGE

+
**62.0% of 2010 Base Case
ALL FV – PCO**

**T: 91.9% OF 62.0%
PCO BY INTERACTING
VESSEL TYPE**

19.7% - OILTANKER
 18.3% - BULKCARRIER
 06.5% - FERRY
 03.7% - CONTAINERSHIP
 03.5% - FISHINGVESSEL
 01.2% - PASSENGERSHIP
 01.1% - NAVYVESSEL
 01.0% - OILBARGE
 00.9% - BULKCARGOBARGE
 00.9% - FERRYNONLOCAL



X: WHAT-IF FV POTENTIAL COLLISION OIL (FUEL+CARGO) LOSS (PCO)

X: VTRA 2010 - GW 487 NB - KM 348 - DP Cont. 67 & Bulk 348

54.9%

5.2%

47.4%

32.5%

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

X: POTENTIAL COLL. OIL LOSS (PCO)

15.0% - BULKCARRIER
 00.7% - CONTAINERSHIP
 39.0% - OIL TANKER
 00.2% - OIL BARGE

+
**54.9% of 2010 Base Case
ALL FV – PCO**

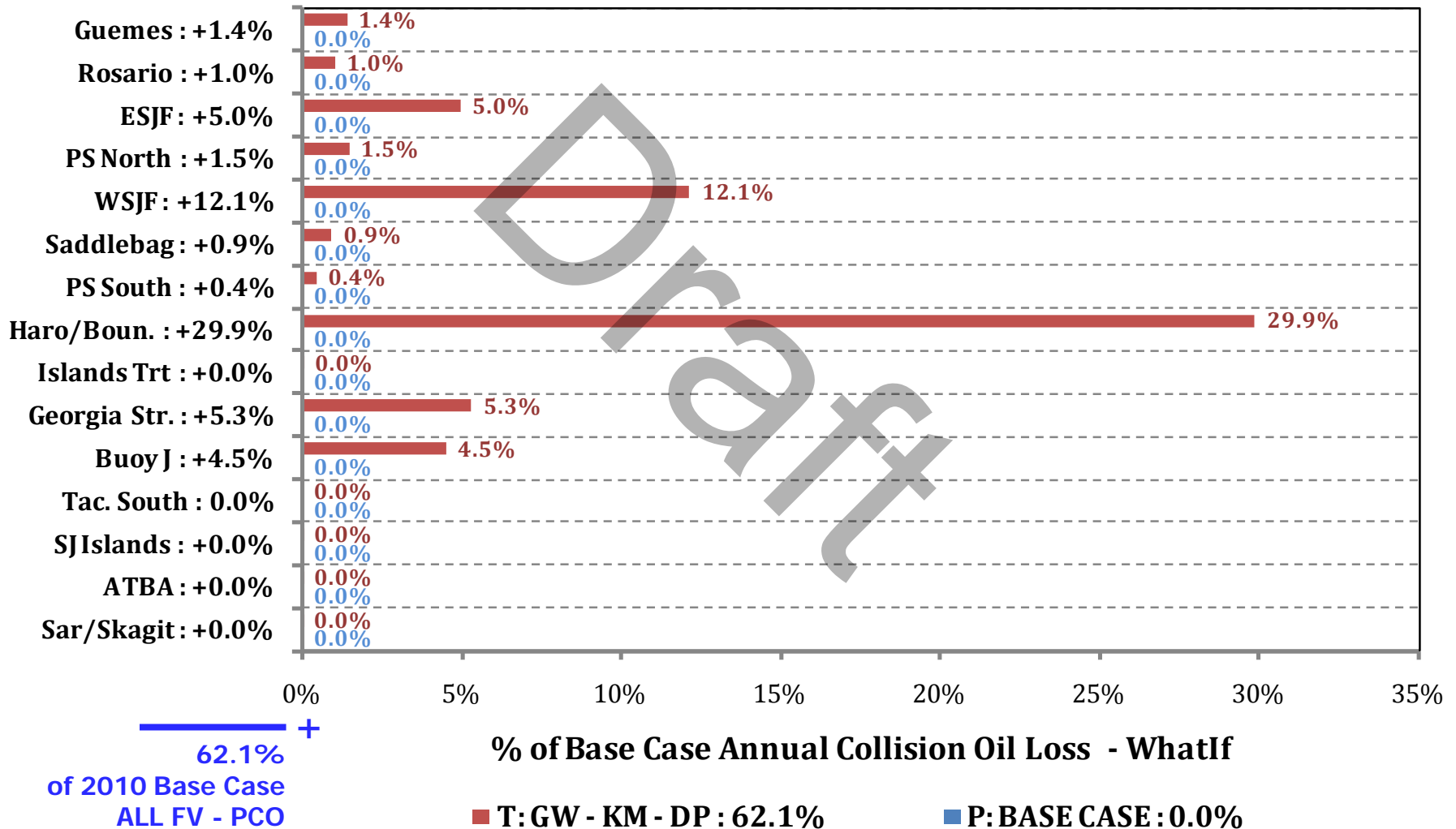
X: 92.0% OF 54.9% PCO BY INTERACTING VESSEL TYPE

17.3% - OILTANKER
 17.0% - BULKCARRIER
 05.8% - FERRY
 03.4% - CONTAINERSHIP
 03.0% - FISHINGVESSEL
 00.9% - PASSENGERSHIP
 01.1% - NAVYVESSEL
 00.7% - OILBARGE
 00.7% - BULKCARGOBARGE
 00.6% - FERRYNONLOCAL

WATERWAY LOCATION

Potential Collision Freq. Comparison – WHAT-IF FV

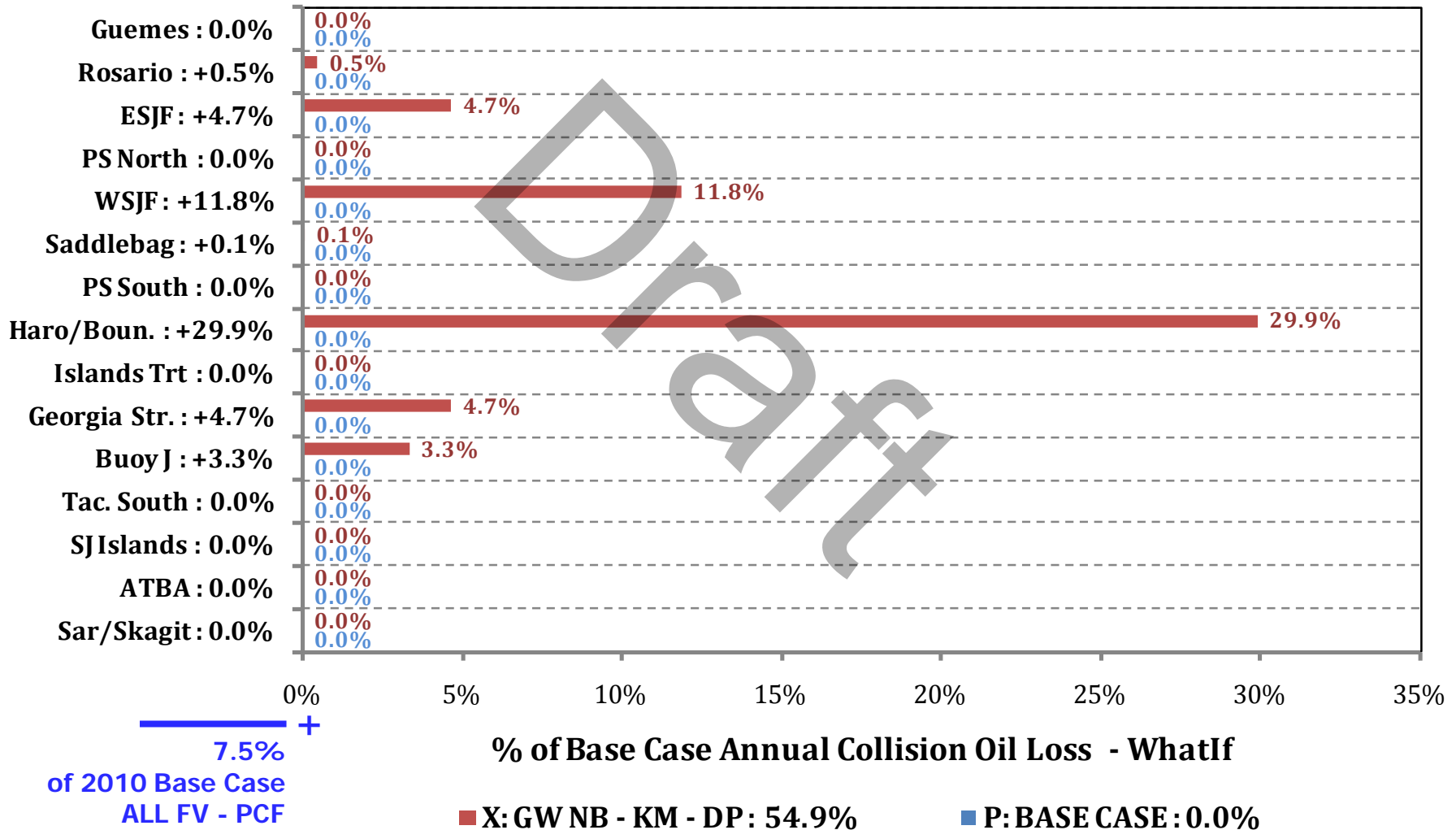
% Base Case Collision Oil Loss - WhatIf



WATERWAY LOCATION

Potential Collision Freq. Comparison – WHAT-IF FV

% Base Case Collision Oil Loss - WhatIf



CASE Y: GW 487 NB OH, KM 348, DP 348 and 67:

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

+ Travel only through Haro

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348 Delta Port Bulk Carriers + Bunkering Barges

67 Delta Port Container Ships + Bunkering Barges



T: WHAT-IF FV POTENTIAL COLLISION OIL (FUEL+CARGO) LOSS (PCO)

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

62.0%

6.3%

51.4%

36.0%

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

T: POTENTIAL COLL. OIL LOSS (PCO)

15.2% - BULKCARRIER
 00.7% - CONTAINERSHIP
 41.3% - OIL TANKER
 04.8% - OIL BARGE

+
**62.0% of 2010 Base Case
ALL FV – PCO**

**T: 91.9% OF 62.0%
PCO BY INTERACTING
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19.7% - OILTANKER
 18.3% - BULKCARRIER
 06.5% - FERRY
 03.7% - CONTAINERSHIP
 03.5% - FISHINGVESSEL
 01.2% - PASSENGERSHIP
 01.1% - NAVYVESSEL
 01.0% - OILBARGE
 00.9% - BULKCARGOBARGE
 00.9% - FERRYNONLOCAL



Y: WHAT-IF FV POTENTIAL COLLISION OIL (FUEL+CARGO) LOSS (PCO)

Y: VTRA 2010 - GW 487 NB OH - KM 348 - DP Cont. 67 & Bulk 348

57.3%

6.4%

48.9%

33.3%

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

Y: POTENTIAL COLL. OIL LOSS (PCO)

15.6% - BULKCARRIER
00.7% - CONTAINERSHIP
40.8% - OIL TANKER
00.2% - OIL BARGE

**57.3% of 2010 Base Case
ALL FV – PCO**

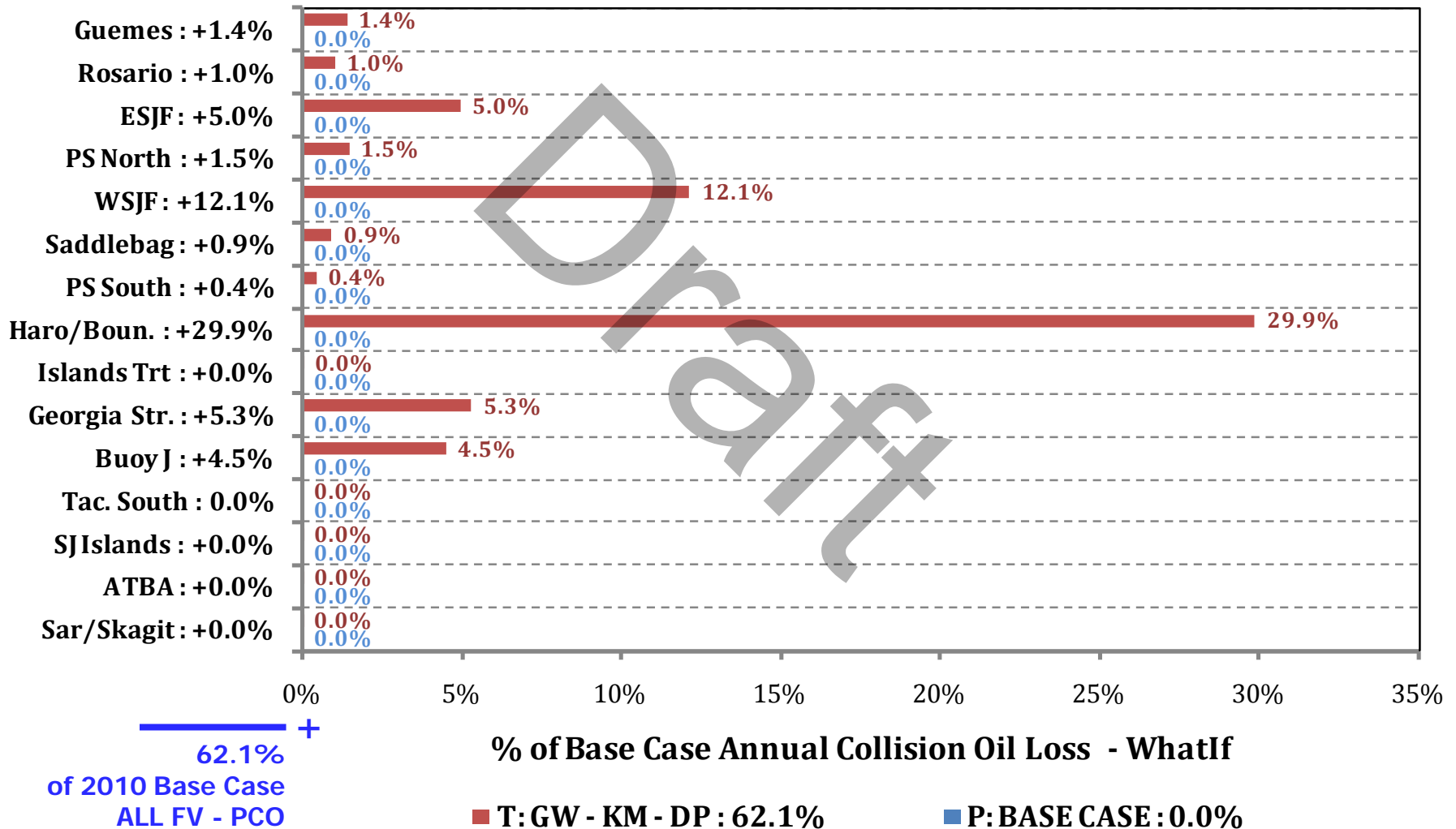
Y: 92.3% OF 57.3%
PCO BY INTERACTING
VESSEL TYPE

18.3% - OILTANKER
18.7% - BULKCARRIER
05.9% - FERRY
03.1% - CONTAINERSHIP
02.2% - FISHINGVESSEL
01.5% - PASSENGERSHIP
01.4% - NAVYVESSEL
00.6% - OILBARGE
00.6% - BULKCARGOBARGE
00.6% - FERRYNONLOCAL

WATERWAY LOCATION

Potential Collision Freq. Comparison – WHAT-IF FV

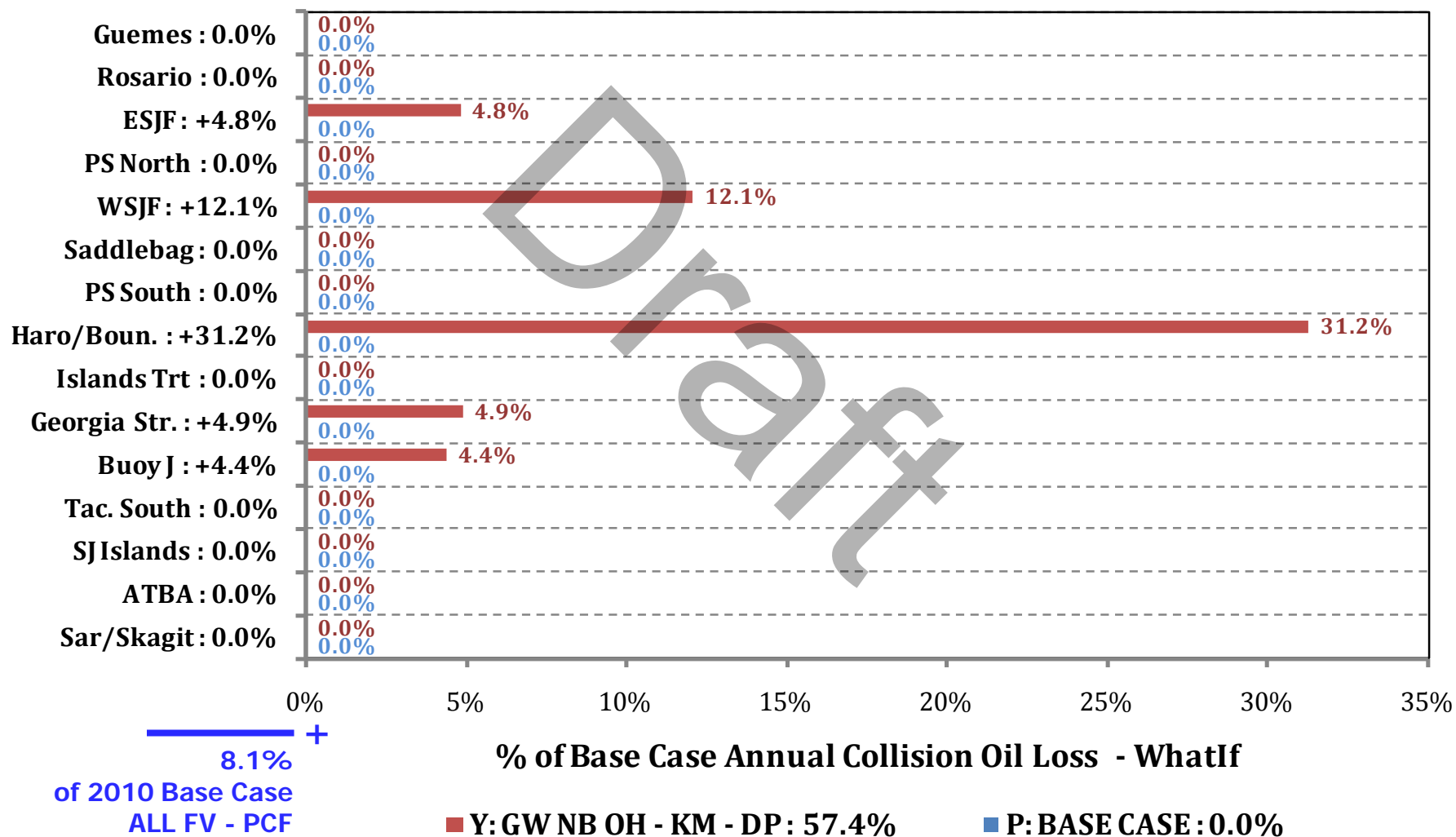
% Base Case Collision Oil Loss - WhatIf



WATERWAY LOCATION

Potential Collision Freq. Comparison – WHAT-IF FV

% Base Case Collision Oil Loss - WhatIf



Towards the Development of a Comprehensive Vessel Traffic Risk Management Tool

Presentation by: J. Rene van Dorp



GWU Personnel: Dr. J. Rene van Dorp, Dr. Jack Harrauld, Dr. Greg Shaw, Adil Caner Sener, Christian Salmon

VCU Personnel: Dr. Jason R. W. Merrick, Christina Werner

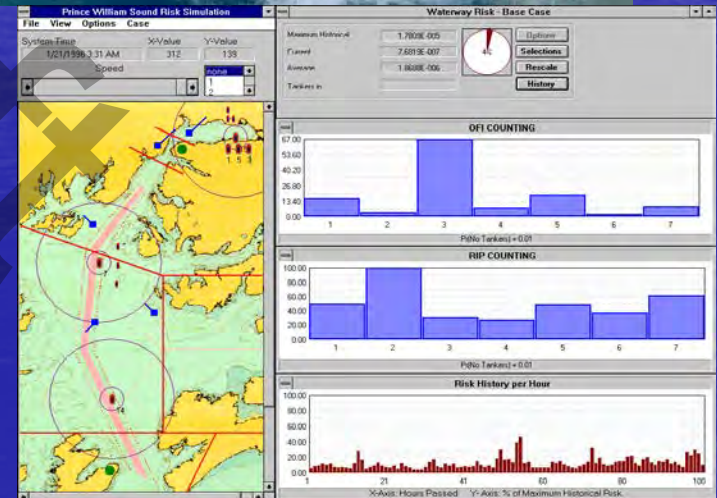
RPI Personnel: Dr. Martha Grabowski, Zhi Zhou, Michael Steward, Brittany Steward, Huawei Song, Zhuyu You

TU Delft Personnel: Giel van de Wiel

Puget Sound Harbor Safer Committee Presentation April 2012

Previous Work

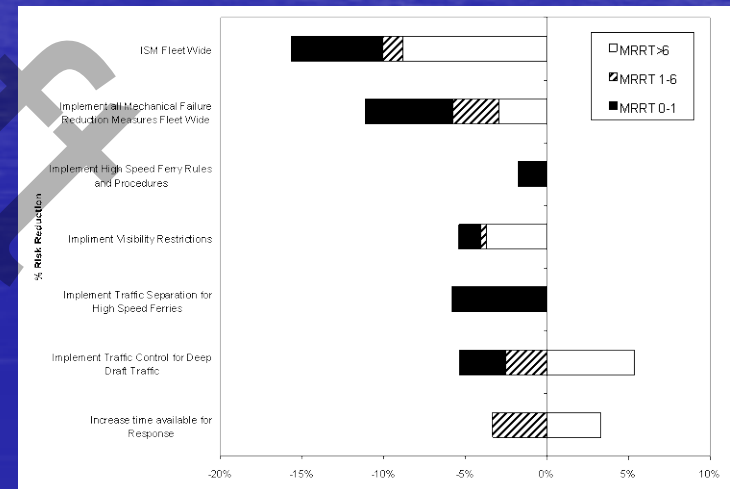
- **Prince William Sound Risk Assessment**
 - Site of the Exxon Valdez Disaster
 - Objective—reduce oil spill risk
 - Model used system simulation, data analysis and expert judgment
 - Capable of modeling systemic effects of proposed interventions
 - Multi-million dollar investments made to reduce risk of further oil spills



Merrick, J. R. W., J. R. van Dorp, T. Mazzuchi, J. Harrald, J. Spahn, M. Grabowski.
2002. The Prince William Sound Risk Assessment. *Interfaces* 32(6) 25-40.

Previous Work

- **Washington State Ferries Risk Assessment**
 - Largest ferry system in the United States
 - Objective—Subchapter W determination, reduce risk alternatives to lifeboats
 - Simulation/expert judgment model improved based on NRC review of PWS study
 - Legislature approved funding of Safety Management System, training and emergency preparedness exercises

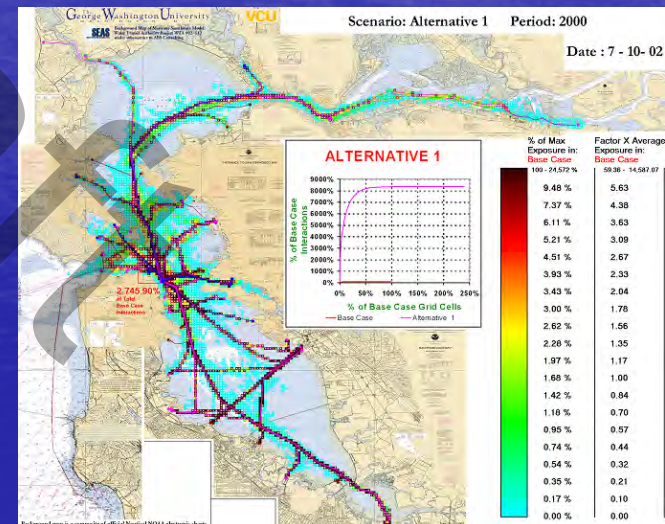
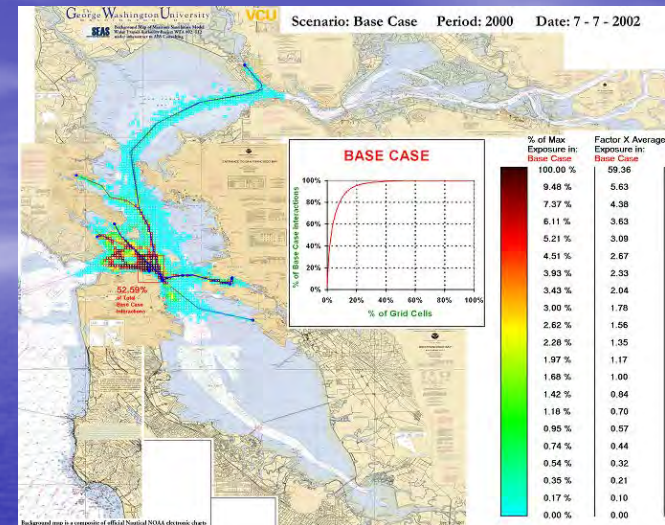


van Dorp, J. R., J. R. W. Merrick, J. Harrauld, T. Mazzuchi, M. Grabowski. 2001. A Risk Management Procedure for the Washington State Ferries. *Risk Analysis* 21(1) 127-142.

Previous Work

- **San Francisco Bay Exposure Assessment**

- California legislature examining the effects of major expansion of ferry services
- Objective—fulfill environmental impact requirement
- Simulation model tested the impact of proposed expansion on vessel interactions
- Legislature considering implementing proposed expansions



Merrick, J. R. W., J. R. van Dorp, J. P. Blackford, G. L. Shaw, J. Harrauld, T.A. Mazzuchi.
 2003. Traffic Density Analysis of Proposed Ferry Service Expansion in San Francisco Bay
 Using a Maritime Simulation Model. *Reliability Engineering and System Safety* 81(2) 119-132.

Map

Satellite

Hybrid

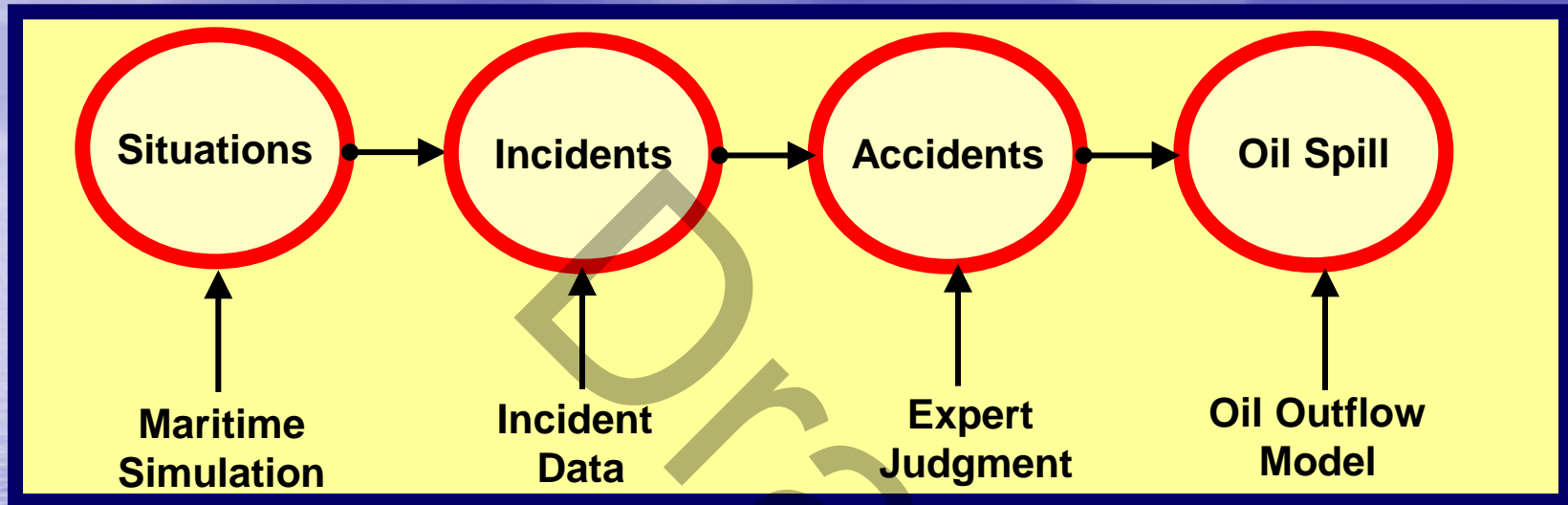
North-Wing Pier
at Cherry Point

CONTEXT OF VTRA STUDY

500 ft
100 m

©2006 Google - Imagery ©2006 DigitalGlobe, Map data ©2006 NAVTEQ™ - [Terms of Use](#)

An Oil Spill is a series of cascading events referred to as a Causal Chain



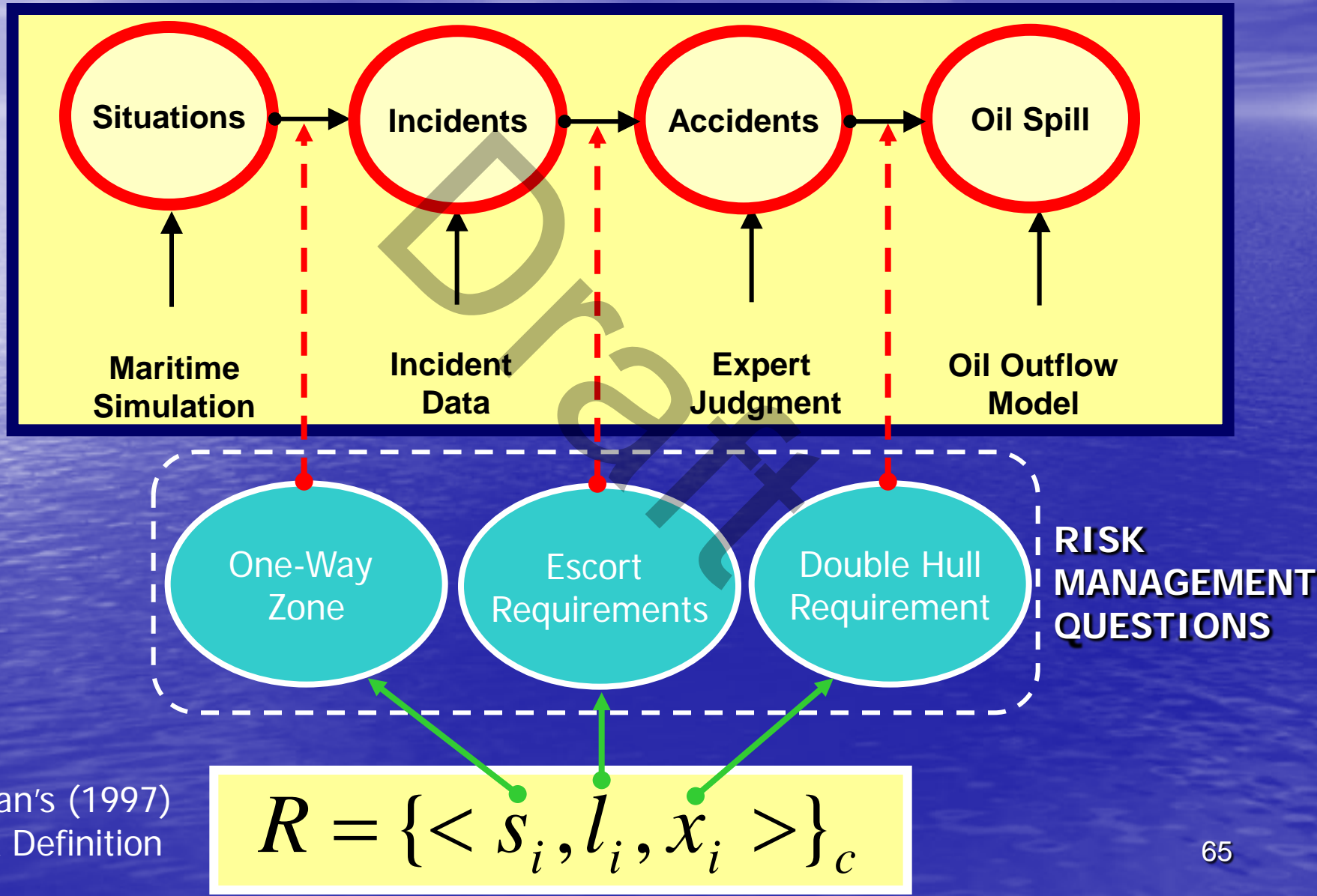
$$R = \{ \langle s_i, l_i, x_i \rangle \}_c$$

Complete Set

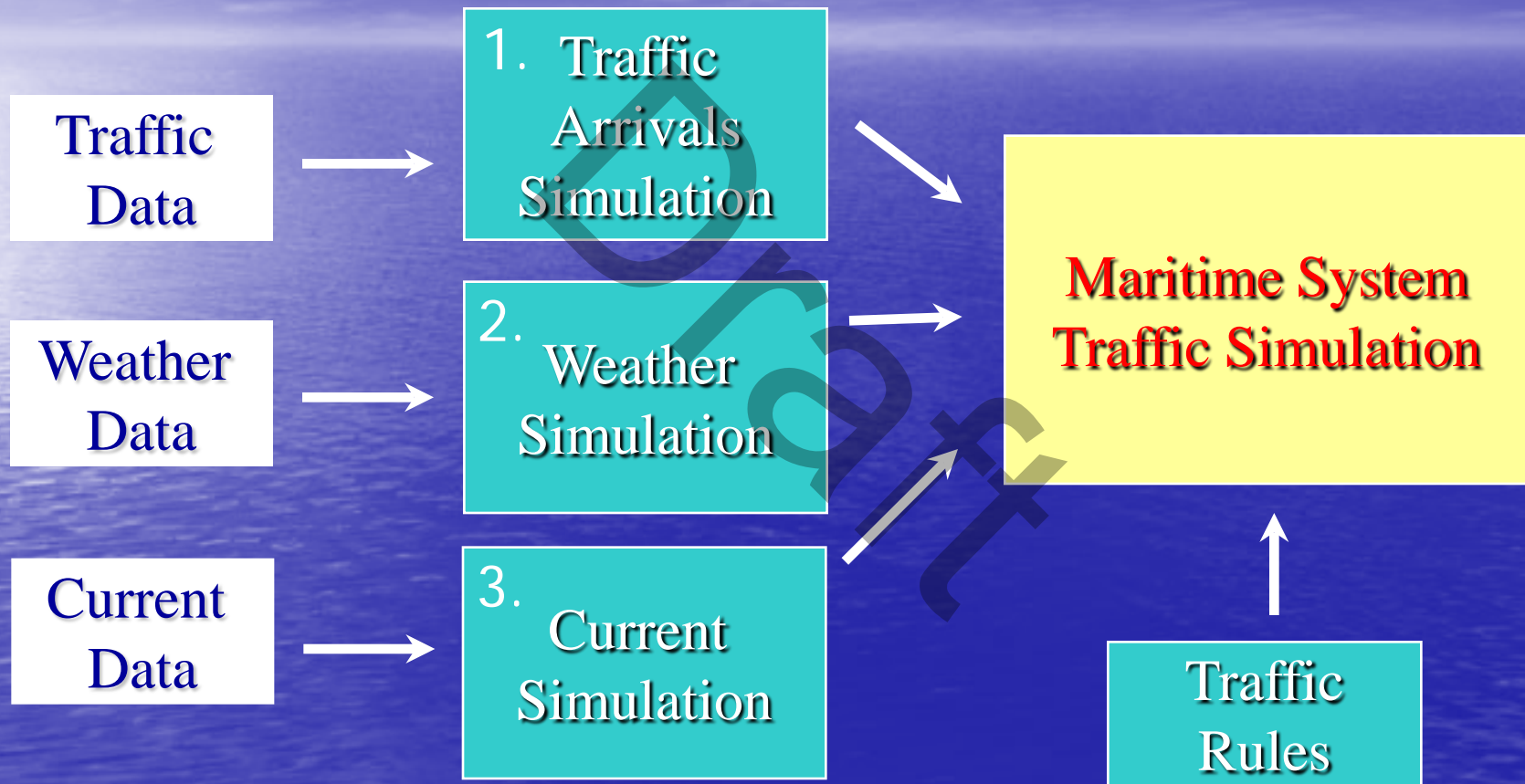
Scenario i Likelihood i Consequence i

Use Kaplan's (1997) definition of system risk in:
"The Words of Risk Analysis", Risk Analysis 17 (4), 407-417

Risk Management of a Causal Chain



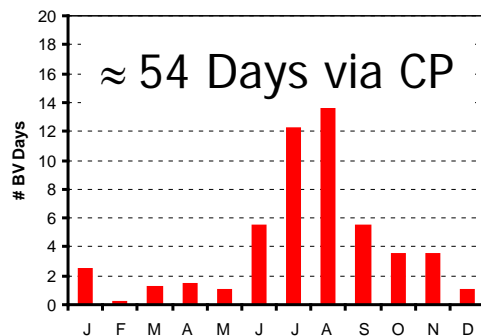
Step 1a: Model Maritime Traffic Simulation (MTS) Model



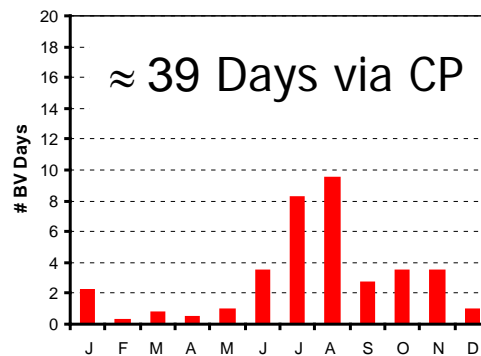
Required close cooperation with the USCG VTS and **Puget Sound Harbor Safety Committee** for data + validation

Bad Visibility Days by Month

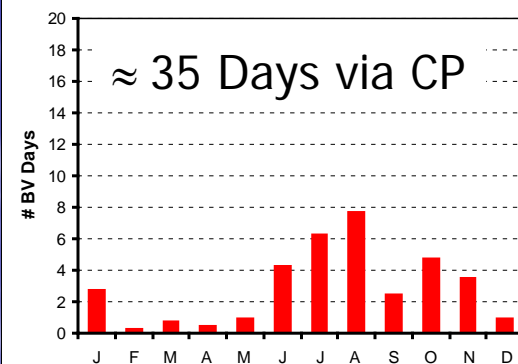
BUOY J ENTRANCE



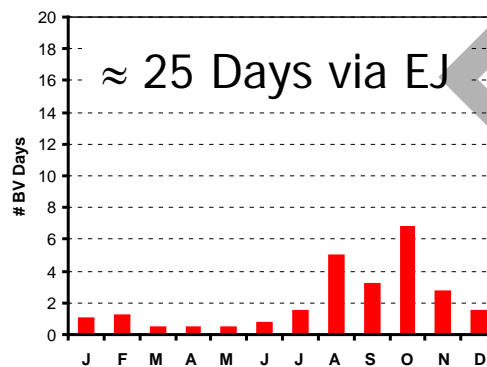
WEST STRAIT OF JUAN DE FUCA



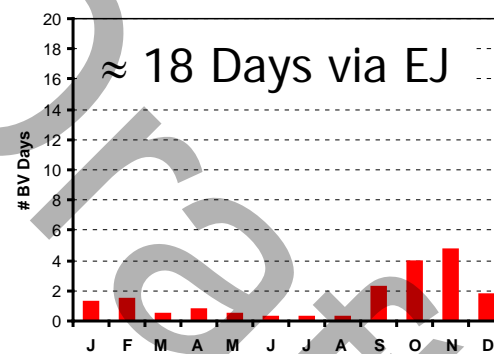
EAST STRAIT OF JUAN DE FUCA



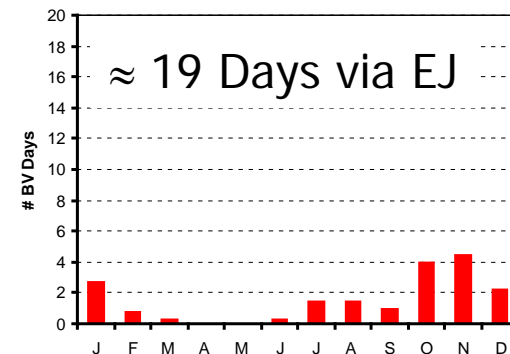
ROSARIO STRAIT



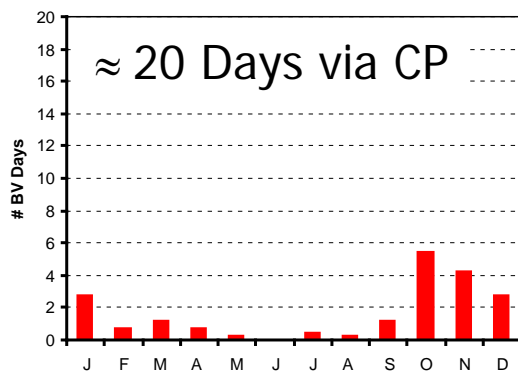
SADDLE BAG AND GUEMES CHANNEL



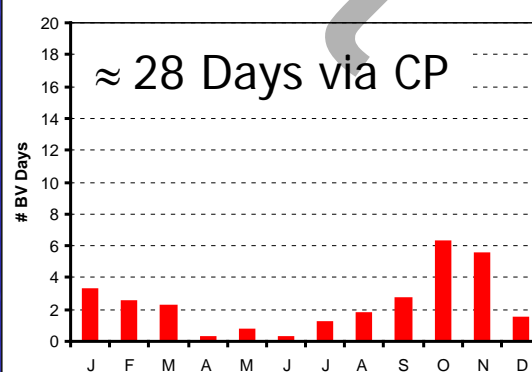
HARO ST/B. PASS



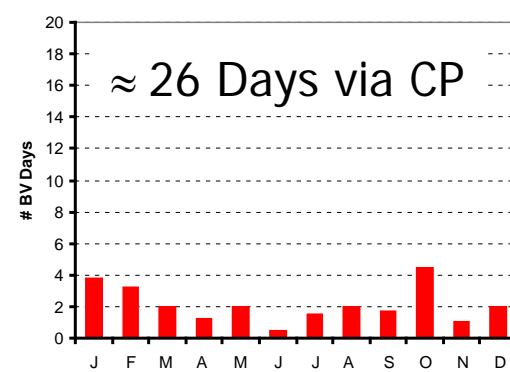
CHERRY POINT

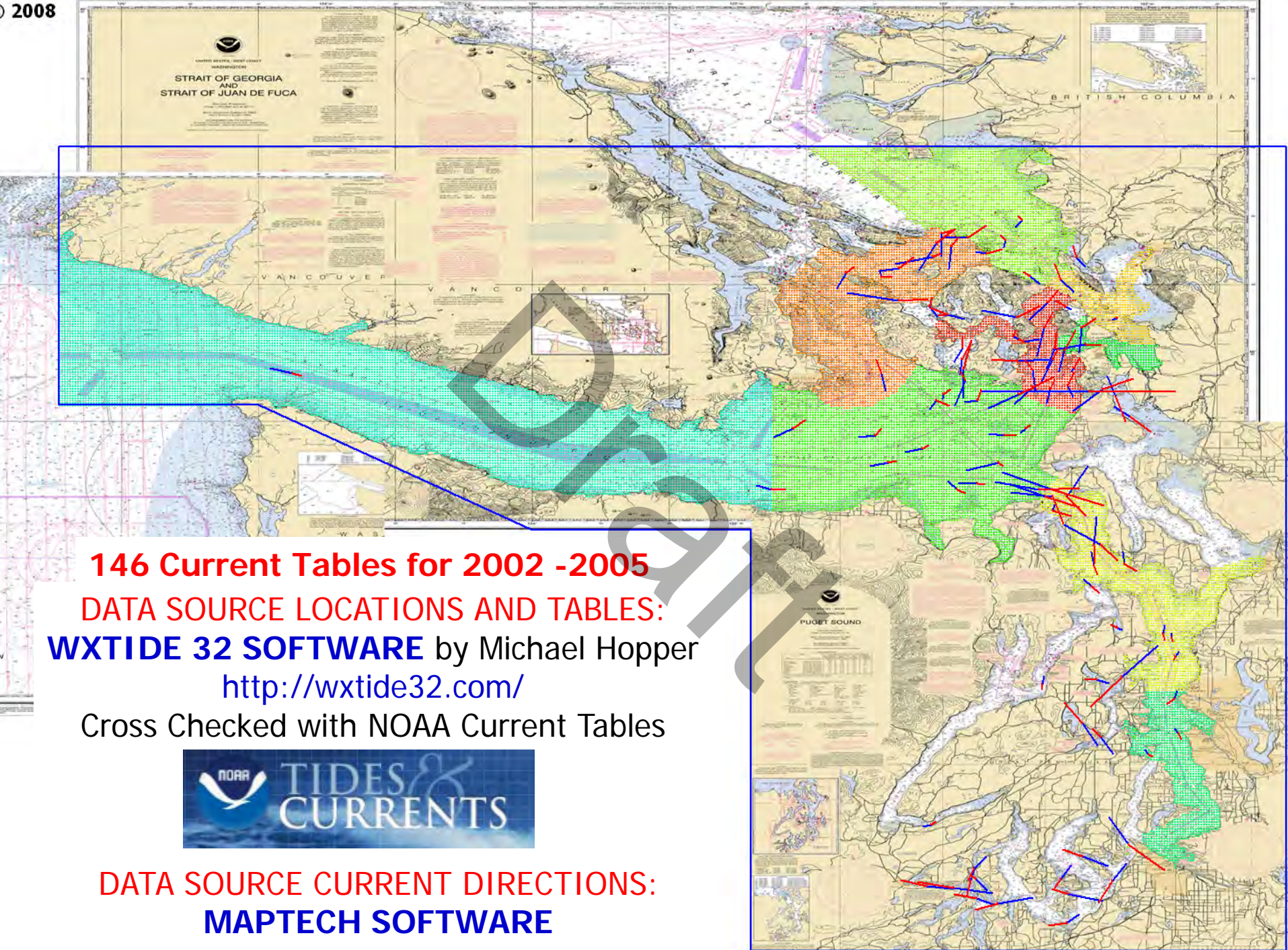


PUGET SOUND NORTH

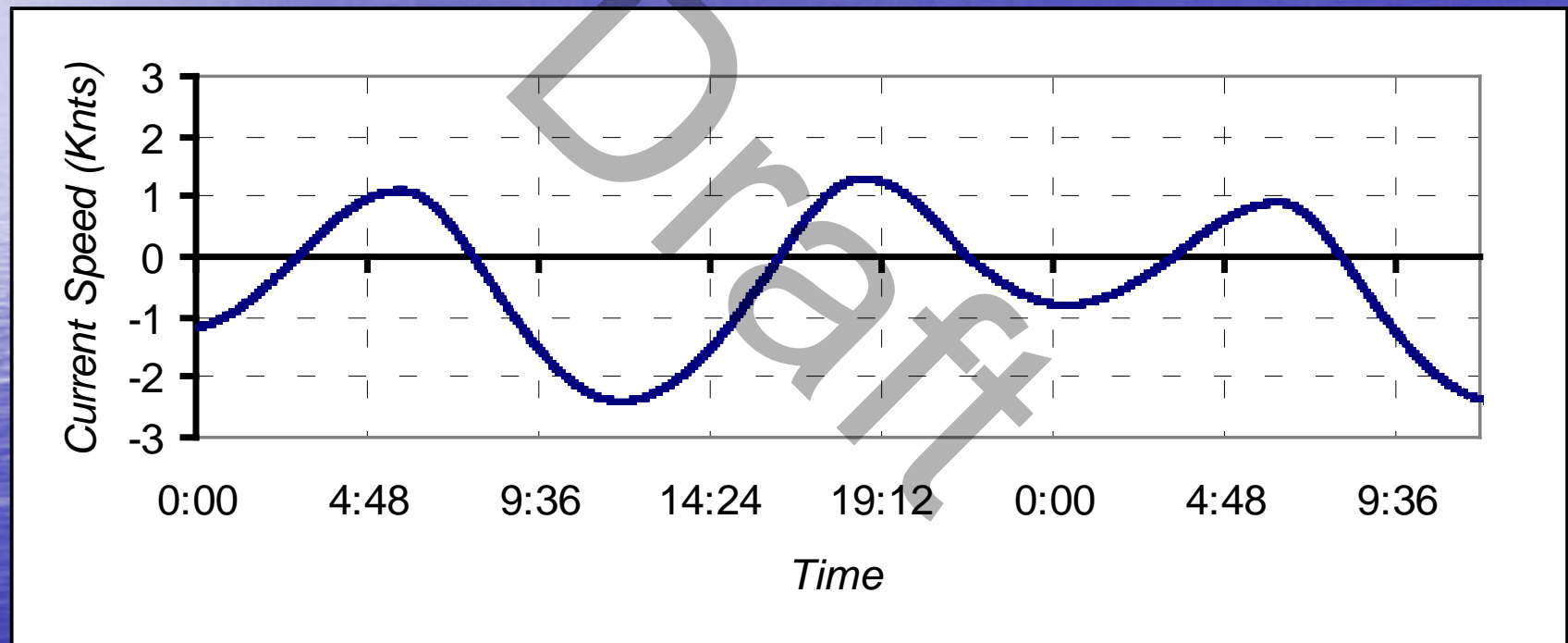


PUGET SOUND SOUTH

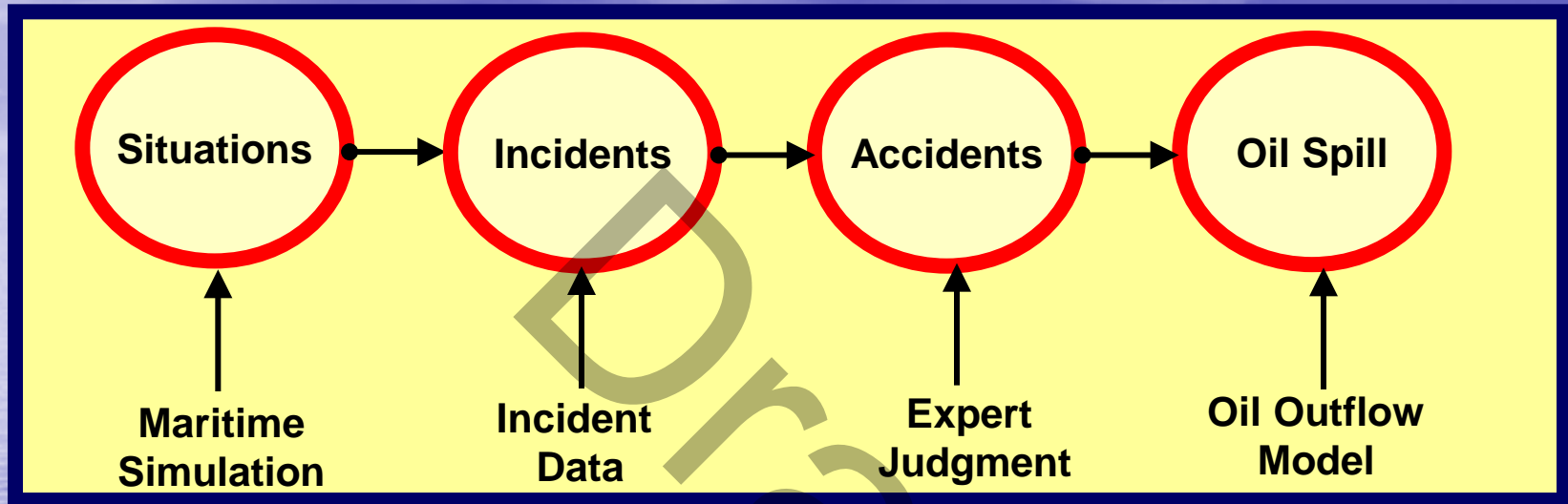




Modeled Harmonic Curve between Eb, Slack, Flood, Eb, Slack, Flood, etc.



An Oil Spill is a series of cascading events referred to as a Causal Chain



$$R = \{ \langle s_i, l_i, x_i \rangle \}_c$$

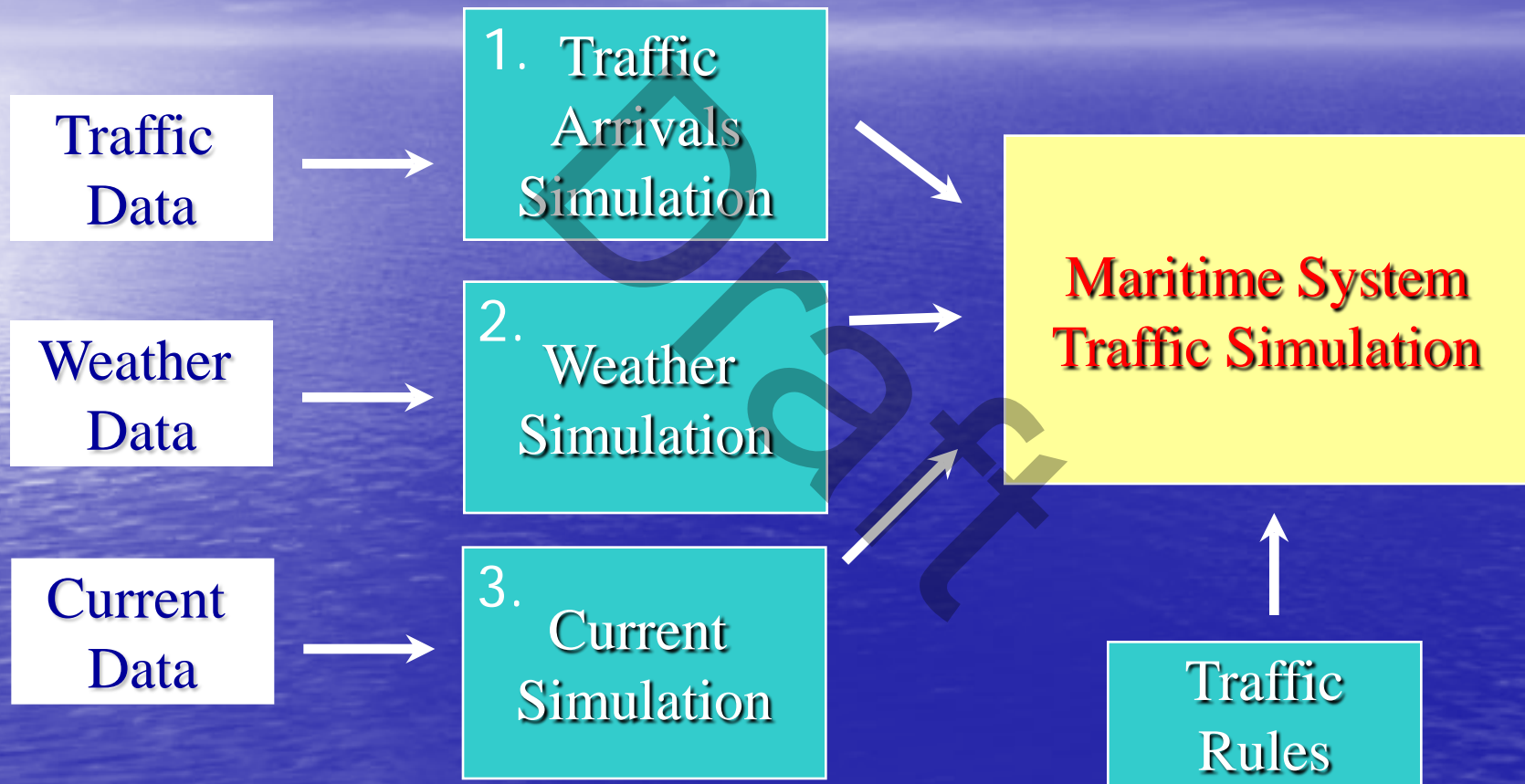
Complete Set

Scenario i Likelihood i Consequence i

Use Kaplan's (1997) definition of system risk in:
"The Words of Risk Analysis", Risk Analysis 17 (4), 407-417

Step 1b: Generate Accident Scenarios

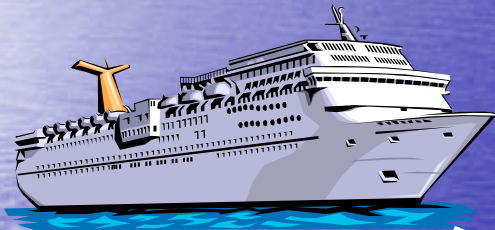
Using The Maritime System Simulation Model



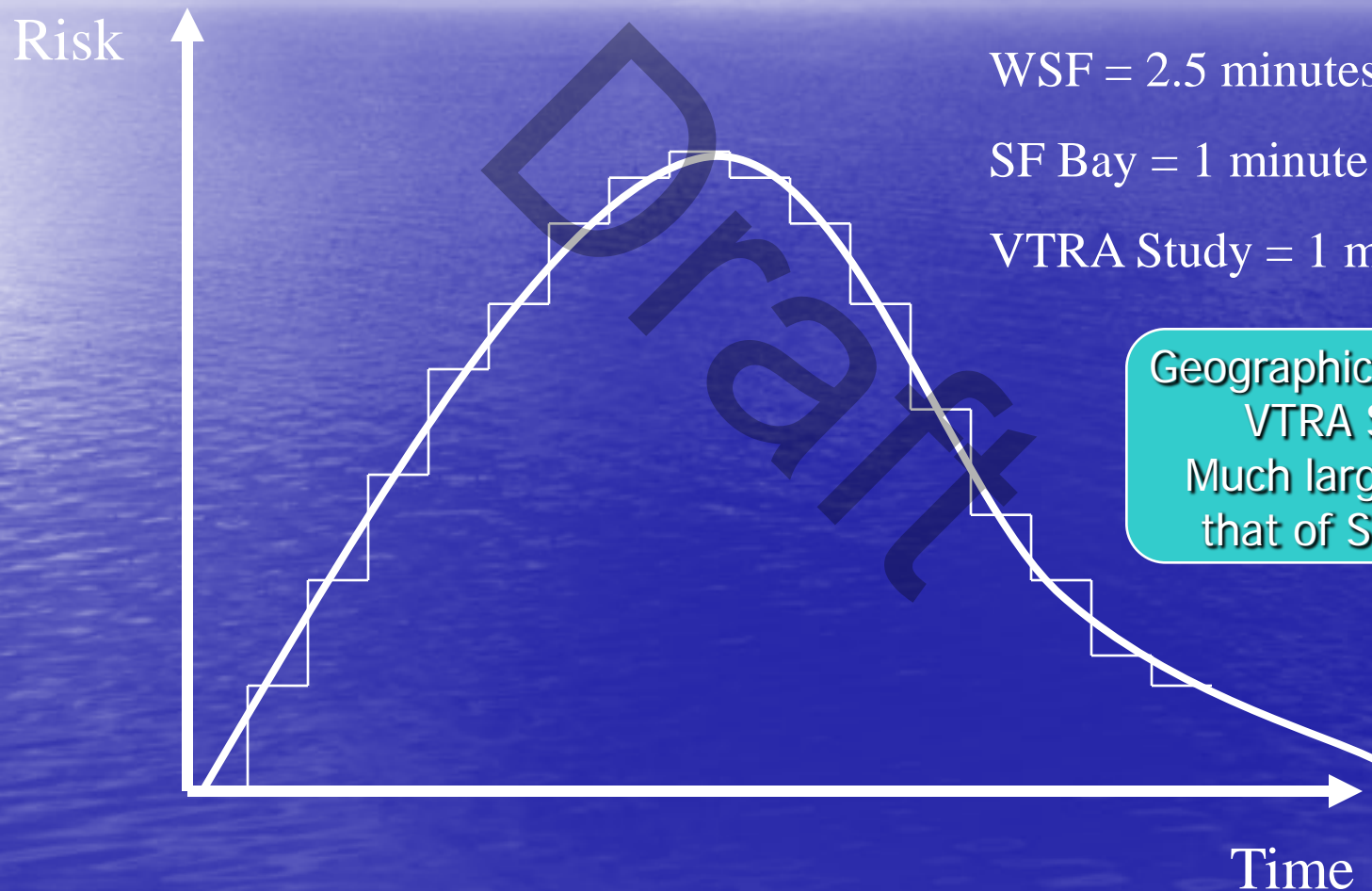
Required close cooperation with the USCG VTS and **Puget Sound Harbor Safety Committee** for data + validation

Count Accident Scenarios

Interacting Vessels



Risk During Interactions



PWS = 5 minutes

WSF = 2.5 minutes

SF Bay = 1 minute

VTRA Study = 1 minute

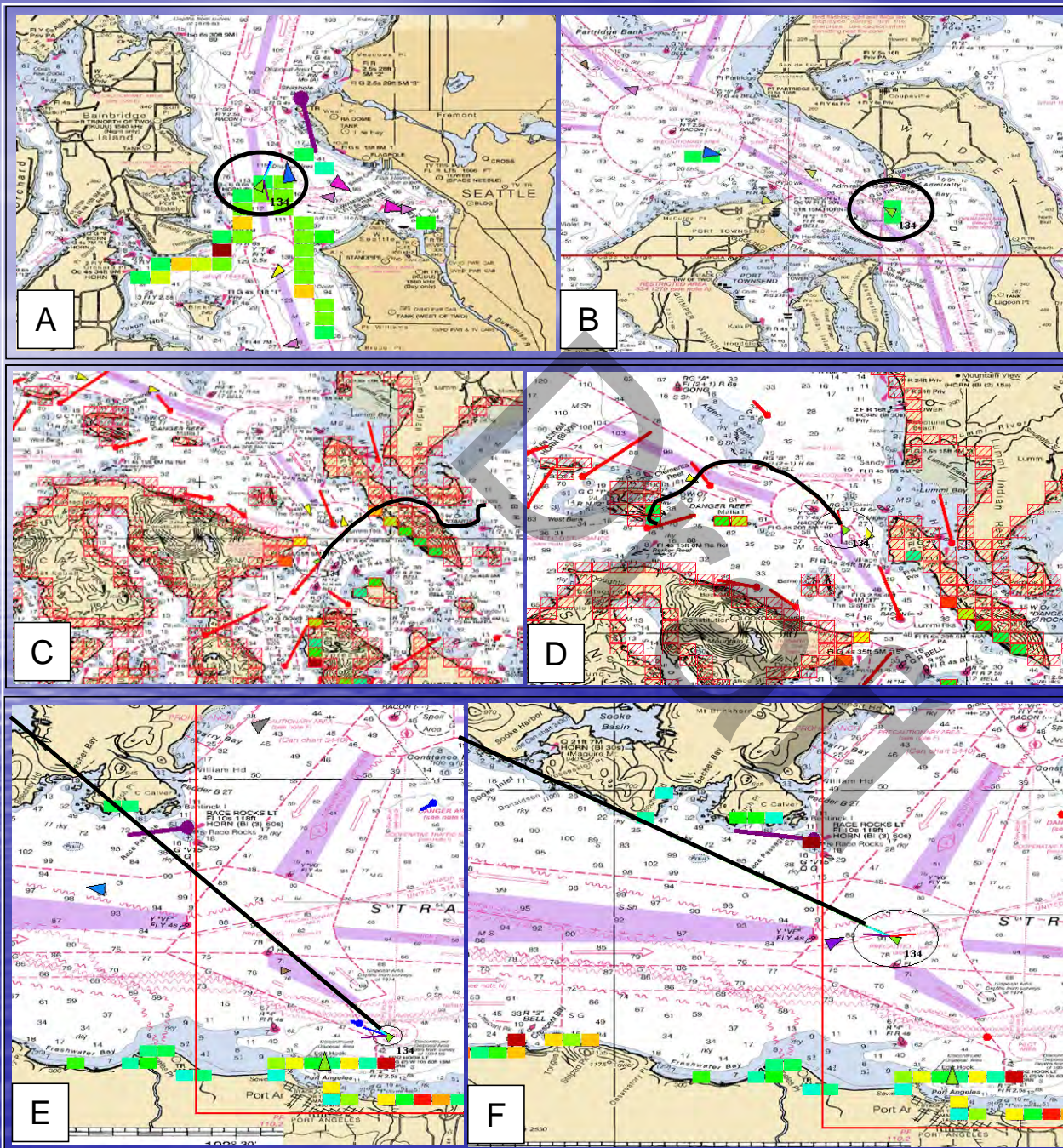
Geographic Scope of
VTRA Study
Much larger than
that of SF Study

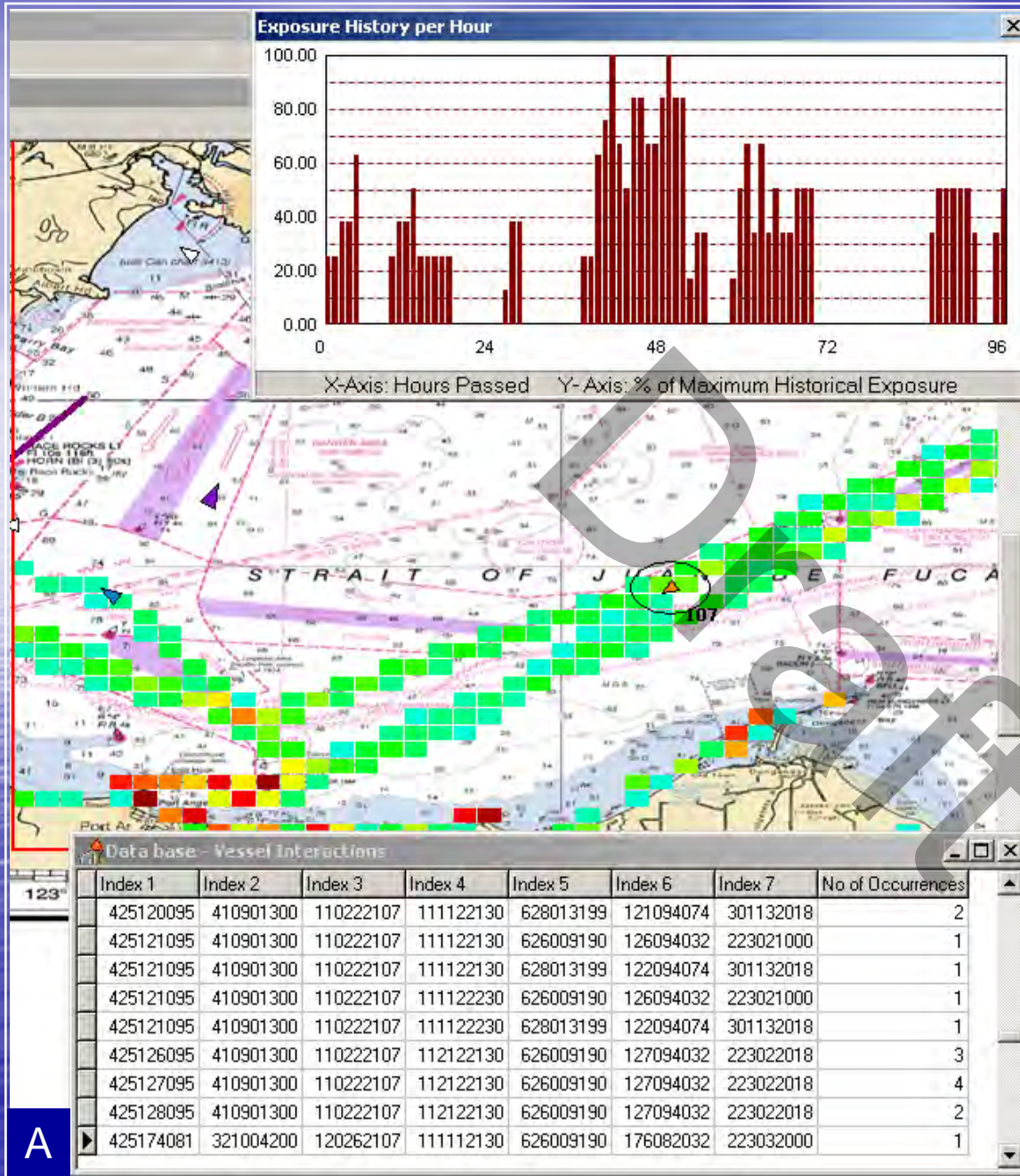
Generating Accident Scenarios:

Counting Collision
Accident Scenario's

Counting Drift
Grounding Accident
Scenario's

Counting Powered
Grounding Accident
Scenario's





```

type INTERACTION = record
    lex_number_1      : longint;
    lex_number_2      : longint;
    lex_number_3      : longint;
    lex_number_4      : longint;
    lex_number_5      : longint;
    lex_number_6      : longint;
    lex_number_7      : longint;

    {Index 1 - VOI Location Info}
    Interaction_Type   : longint; {400000000}
    VOI                : longint; {260000000}
    VOI_X              : longint; {5000000}
    VOI_Y              : longint; {500}

    {Index 2 - VOI Attributes}
    VOI_Location       : longint; {900000000}
    VOI_Inbound_Outbound : longint; {200000000}
    VOI_Speed          : longint; {3000000}
    VOI_DP             : longint; {12500}
    IV_Cargo           : longint; {20}
    IV_Barge_Type      : longint; {5}

    {Index 3 - VOI Attributes}
    VOI_Cargo          : longint; {200000000}
    VOI_Tethered_State : longint; {2000000}
    VOI_Barge_Type     : longint; {50000}
    VOI_Hook_Up        : longint; {4000}
    VOI_ID             : longint; {999}

    {Index 4 - Environment Info}
    Visibility          : longint; {200000000}
    wind_Direction     : longint; {2000000}
    Wind_Speed         : longint; {400000}
    Current            : longint; {30000}
    Current_Direction : longint; {3000}
    N_Vessels          : longint; {300}
    Escort_State       : longint; {20}

    {Index 5 - Shore Interaction Location}
    Shore_X            : longint; {500000000}
    Shore_Y            : longint; {500000}
    Time_To_Shore      : longint; {300}

    {Index 6 - Interacting Vessel Location}
    IV_X               : longint; {500000000}
    IV_Y               : longint; {500000}
    IV_DP              : longint; {125}

    {Index 7 - Interacting Vessel Info}
    IV_TrafficScenario : longint; {400000000}
    IV_TrafficType     : longint; {25000000}
    IV_Speed           : longint; {300000}
    IV_ProxVessel      : longint; {2000}
    IV_InterAngle      : longint; {180}
end;

```

Accident Attributes Model

LOCATION	DIRECTION	CARGO	ESCORTS	TETHERED
Cherry Point Area Puget Sound South Strait of Juan de Fuca East Strait of Juan de Fuca West Puget Sound North Saddle Bag Area Rosario Strait Haro Strait\Boundary Pass Guemes Channel	Inbound Outbound	Unladen Laden	2 Escorts 1 Escort No Escorts	tethered untethered

VESSEL TYPE	TRAFFIC PROXIMITY	TRAFFIC SCENARIO
Tug without Barge Tug ATB's or ITB's Tug Pushing Ahead Container Tanker Bulk carrier Freighter Passenger vessel Service vessel Public vessel Fishing Vessel Tug Towing Astern Recreational Vessel	1 to 5 miles Less than 1 mile	Crossing Astern Meeting Overtaking Crossing the Bow

VISIBILITY	WD	WIND SPEED	CURRENT	CUR_DIR
More than 0.5 mile Less than 0.5 mile	Along Vessel Abeam Vessel	Less than 10 knots 20 knots 30 knots More than 40 knots	Almost Slack Max Eb or Max Flood	Along Vessel - Opposite Along Vessel - Same Dir. Abeam Vessel

Organizations Participating in Expert Judgment Elicitations

- 1. Puget Sound Pilots
- 2. ATC
- 3. US and Canadian Tug Companies operating in the VTRA study area:
 - US-Based: Foss, Crowley, Olympic Tug and Barge (US), K-Sea, Sea Coast, Sause Bros.
 - Canadian Based: Seaspan, Island Tug and Barge
- 4. The Washington State Ferries
- 5. Seattle sector US Coast guard VTS.

9 QUESTIONNAIRES	38 EXPERTS - Numbers indicate years sailing experience in VTRA Study area	CUMULATIVE EXPERIENCE (YRS)	7 SESSIONS
Bradley-Terry Pair Wise Comparison Location Questionnaire	7 PILOTS (42,34,32,25,16,16) 6 TUG OPERATORS (39, 30, 30, 30, 15, 12) 4 FERRY OPERATORS (31, 30, 25, 8) 2 PORT CAPTAINS (27, 25) 1 VTS WATCH (25)	186 156 94 52 25	Dec-06 Feb-07
Bradley-Terry Pair Wise Comparison Traffic Scenario	7 PILOTS (42,34,32,25,16,16)	186	Dec-06 Feb-07
Bradley-Terry Pair Wise Comparison 1st			16 17
Bradley-Terry Pair Wise Comparison 2nd			17 17 17
Bradley-Terry Pair Wise Comparison Tug			17 17 17
Tanaka Accident Given			17 17
Tanaka Accident Given			17 17
Tanaka Accident Given Human Error			
Tanaka Accident Given Near By Vessel Failure			
Tug Pair Wise Situation Accident Probability Questionnaires	7 TUG OPERATORS (53, 21, 20, 32 30, 28, 18) 2 PORT CAPTAINS (32, 30)	202 52	Aug-07 Sep-07 Dec-07
Tug Pair Wise Situation Collision Accident Probability Questionnaires	7 TUG OPERATORS (53, 21, 20, 32 30, 28, 18) 2 PORT CAPTAINS (32, 30)	202 52	Aug-07 Sep-07 Dec-07
Given Steering Failure,			
Given Navigational Aid Failure			
Given Human Error			
Given Near By Vessel Failure			

Summary of Expert Judgment Data Source

- A total of 9 questionnaires
- 38 experts over 7 separate elicitation sessions dispersed over a 1 year period.
- Combined numbers of years sailing experience exceeds 922 years.

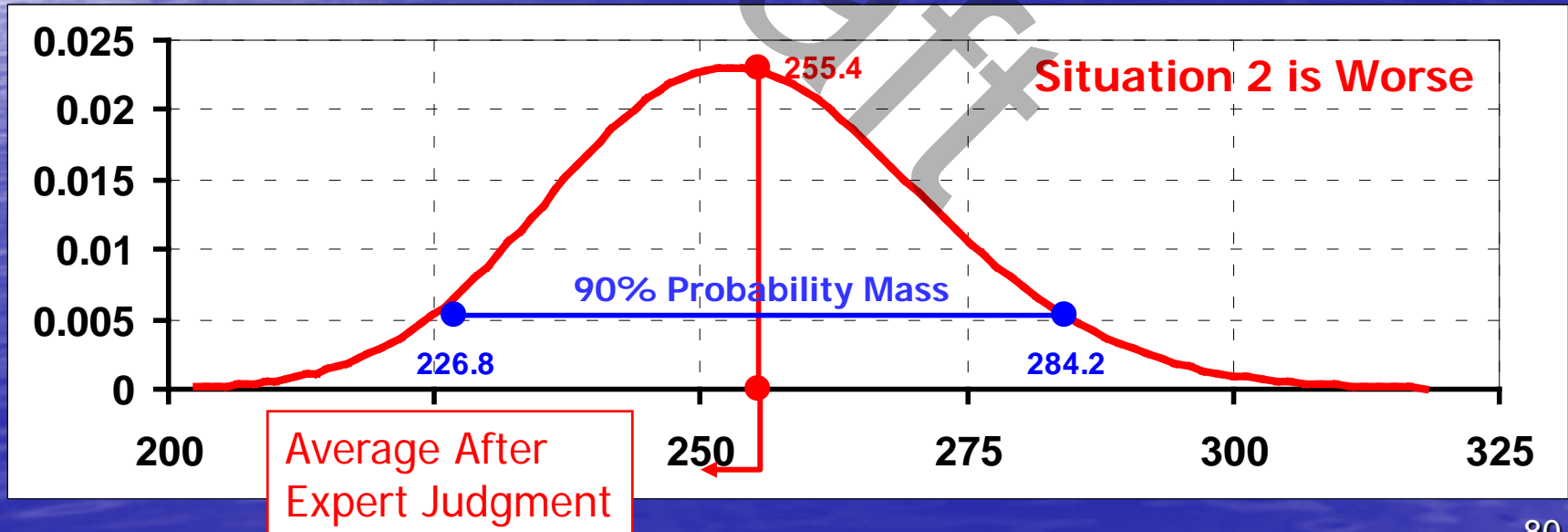
Conduct Expert Judgment Elicitations via Questionnaires

Q30

Situation 1	TANKER DESCRIPTION	Situation 2
Strait 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	-
<div> <div>More? : _____</div> <div>9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9</div> <div>: More?</div> </div>		
<div> <div>Situation 1 is worse</div> <div><=====X=====></div> <div>Situation 2 is worse</div> </div>		

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

Situation 1	TANKER DESCRIPTION	Situation 2
Rosario Strait	Location	Guemes Channel
Inbound	Direction	-
Laden	Cargo	-
1 Escort	Escorts	No Escorts
One Tethered	Tethering	Untethered
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	-
Along Vessel	Wind Direction	-
Less than 10 knots	Wind Speed	-
Almost Slack	Current	-
Along Vessel - Same Direction	Current Direction	-

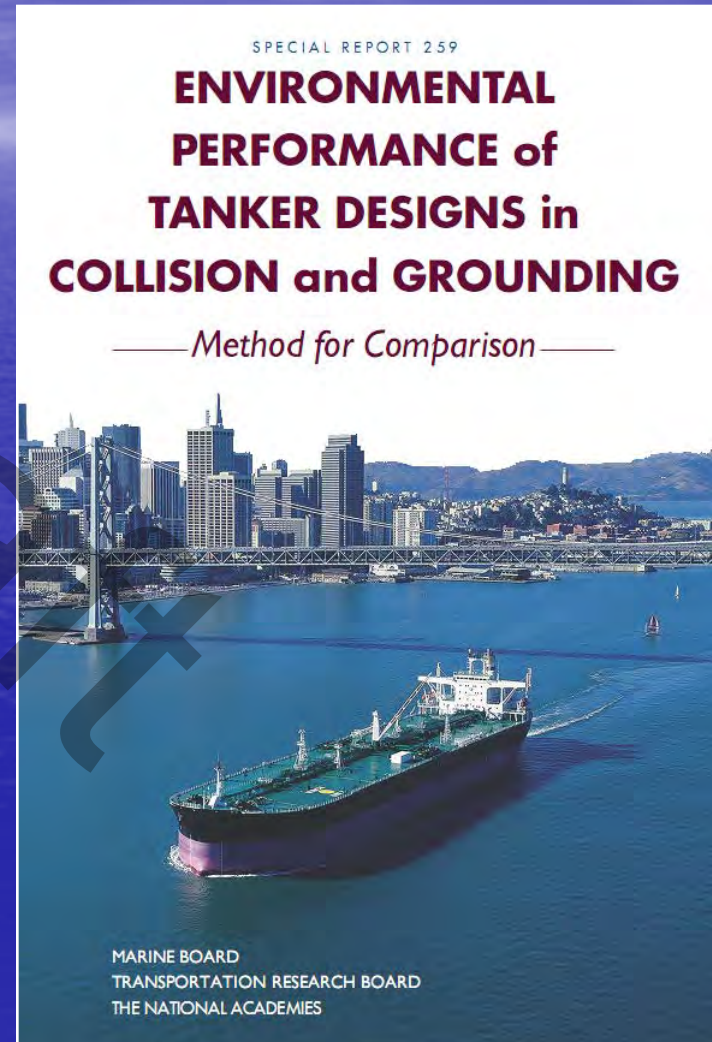


NATIONAL RESEARCH COUNCIL SPECIAL REPORT 259

“Given the status of previous efforts to establish a methodology for comparing the environmental performance of alternative tanker designs, **the committee concluded that the development of a new approach was warranted.**”

“The committee ran a total of 80,000 accident scenarios: 10,000 collision and 10,000 grounding events for each of two designs (single-hull and double-hull) of the two different sizes (150,000 and 40,000 DWT).”

Quoted from: NRC Special Report 259



Step 1
Damage
calculation

A SR 259 Collision Scenario

struck ship

- velocity
- displacement
- hull type

collision

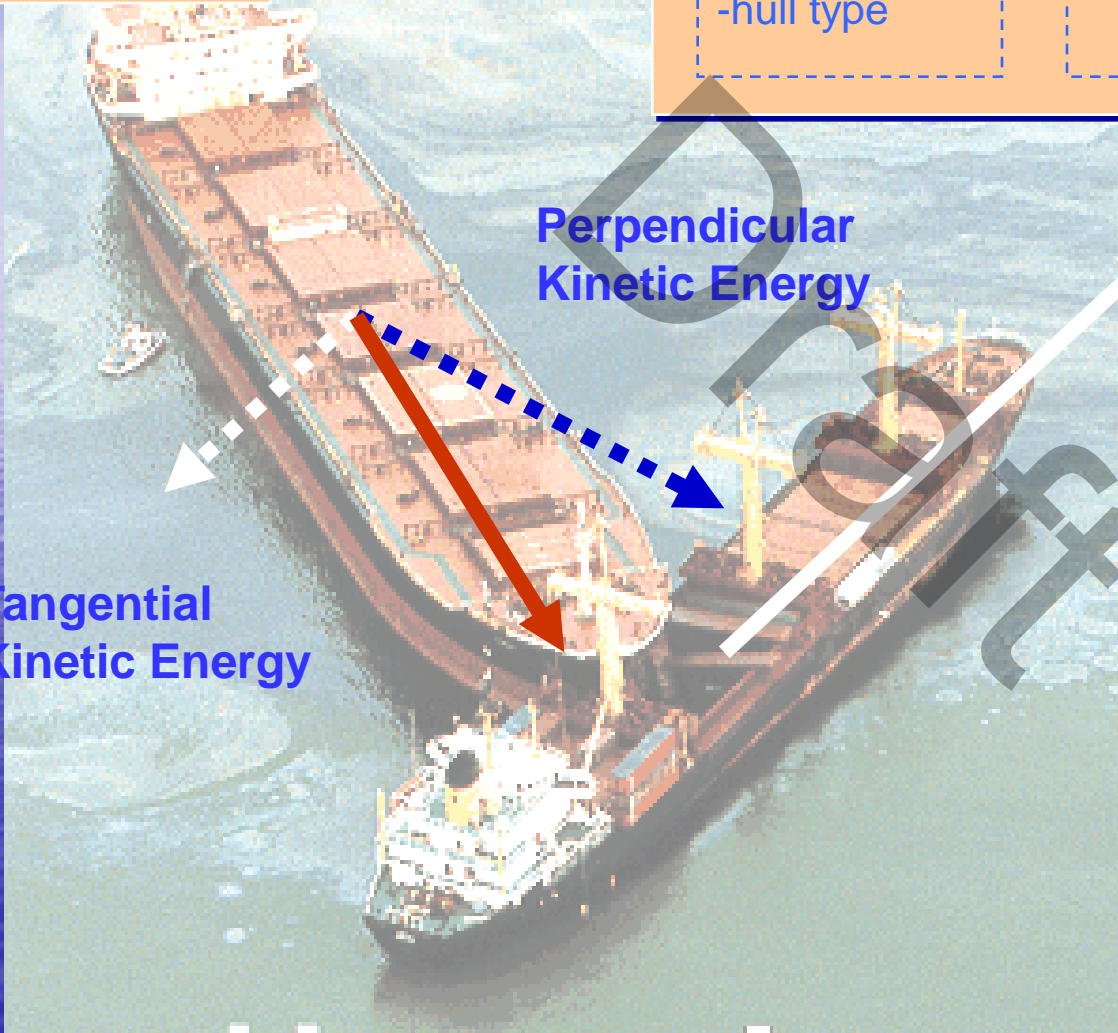
- location
- angle

striking ship

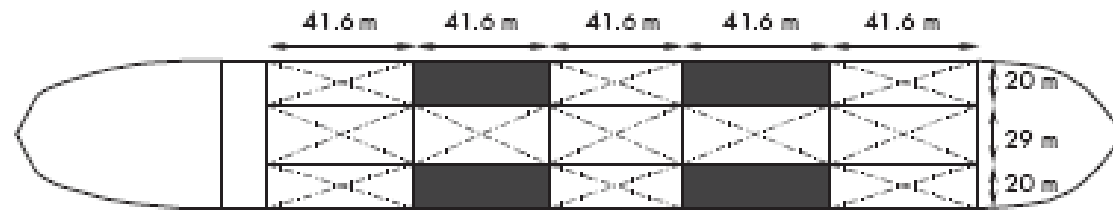
- velocity
- displacement
- bow angle

Perpendicular
Kinetic Energy

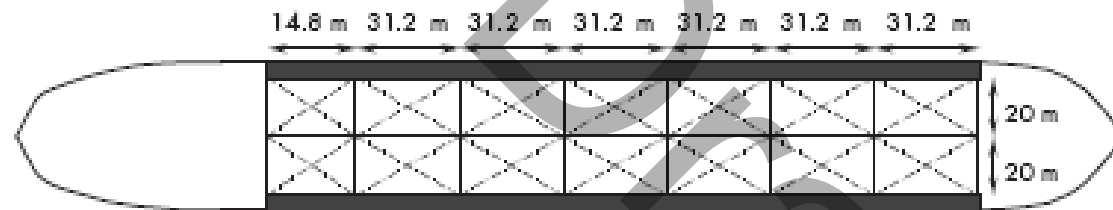
Tangential
Kinetic Energy



Tanker Configurations 150 kT

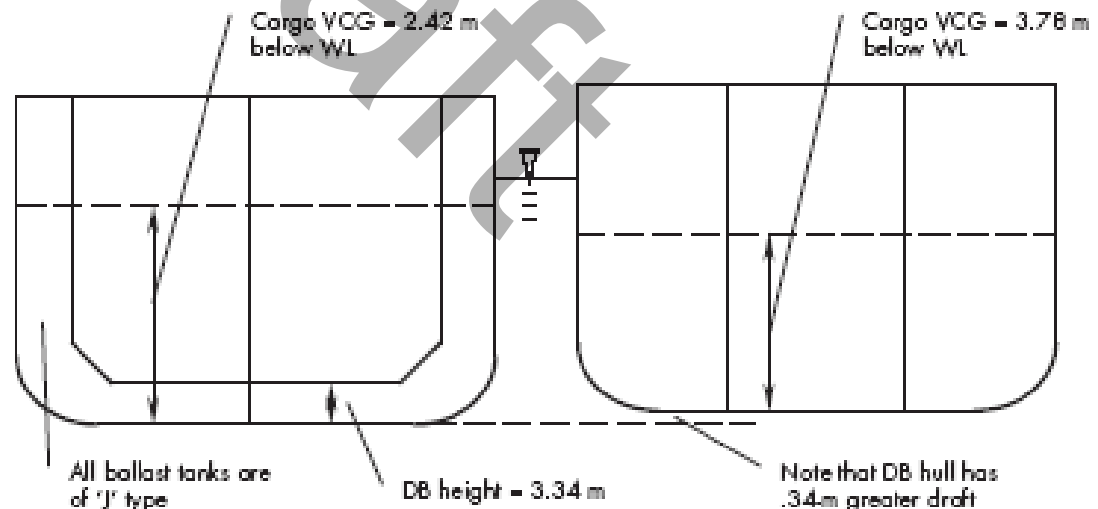


Single Hull



Double Hull

Taken From
NRC 259
Report



Special Thanks To:

- **US Coast Guard Sector Seattle** for being responsive to our countless data request during the enhancement and improvement of our MTS risk simulation methodology and recommending us to the Puget Sound Harbor Safety Committee.
- **Puget Sound Harbor Safety Committee** who served as a host for bimonthly meetings and provide us access to Seattle Maritime Community.
- **The Seattle Maritime Community** as a whole who unselfishly met with us and provided access to experts both for ship rides but also for their participation in many expert judgment elicitation sessions during which these experts **donated their time for the safety improvement in their Maritime Domain.**

THANK YOU!!!!

- Without their help, efficient and timely response to our repeated questions and data requests we would not have been able to further enhance and improve our MTS Risk Simulation Methodology.



QUESTIONS?

