What do Coin Tosses, Decision Making under Uncertainty, The VTRA 2010 and Average Return Time Uncertainty have in common?

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Warsaw Workshop Presentation March 16 – March 18

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IMAGES FROM THE SALISH SEA

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

OUTLINE

1. Coin Tosses
2. Decision Making under Uncertainty
3. VTRA 2010
   - Base Case Traffic Description
   - What-If and Benchmark Cases
4. Return Time Uncertainty

1. Imagine we have a coin and we flip it repeatedly

2. When heads turns up you "win" when tails turns up you "lose"

Suppose we flip the coin four times, how many times do you expect to win?

2 times

Suppose we flip the coin ten times, how many times do you expect to win?

5 times

WHAT ASSUMPTION(S) DID YOU MAKE?

Conclusion: you made **reasonable assumptions** –

1. The coin has two different sides
2. When flipping it, each side turns up 50% of the time "on average".

Would it have made sense to assume the coin had only one face i.e. both sides show heads (or tails)?

No

Assuming both sides show heads or tails is equivalent to making a **worst case** or **best case** assumption.

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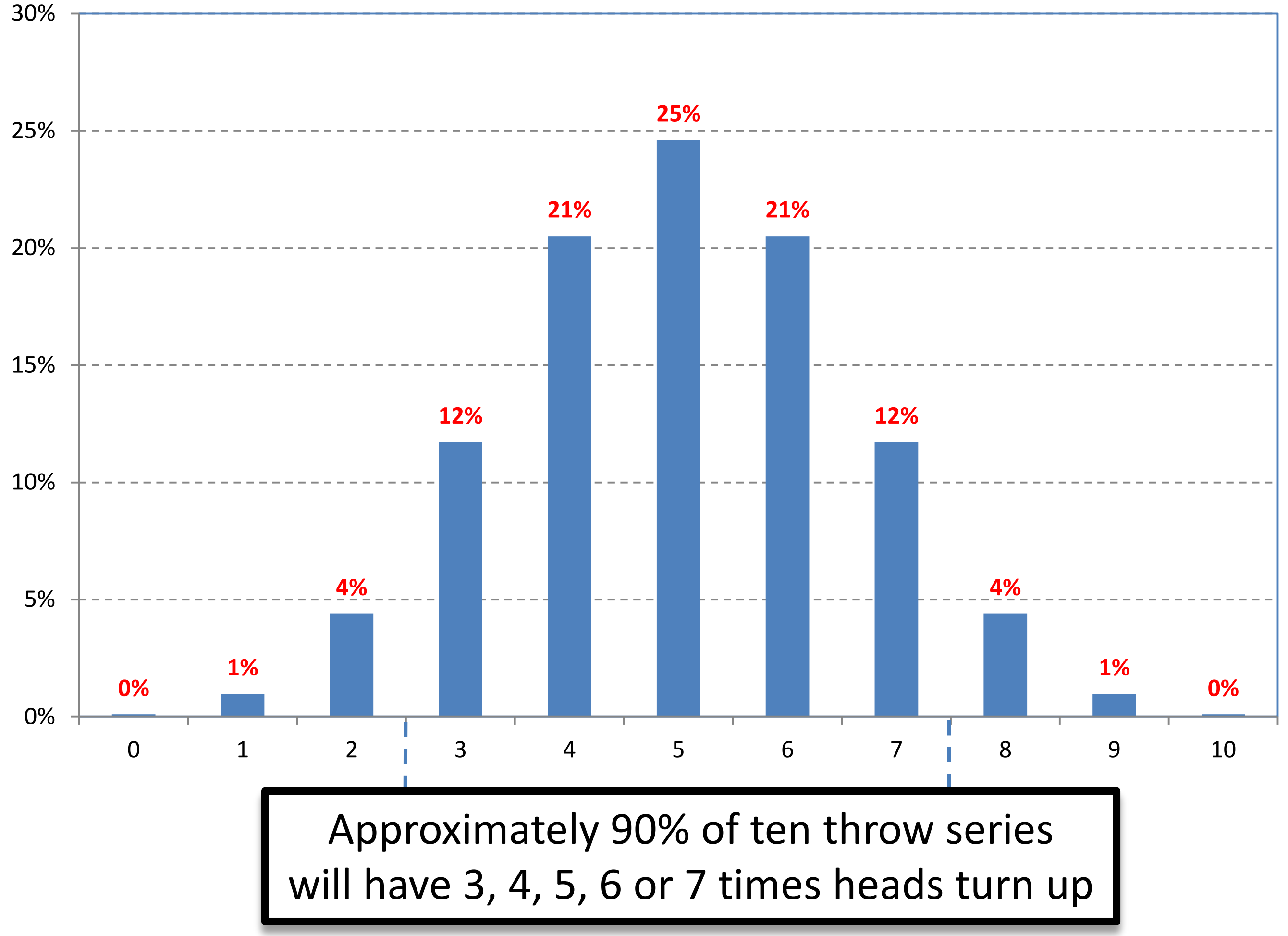
Suppose you actually flip the "fair" coin ten times

How many times will "heads" turn up?

Answer could vary from 0 to 10 times, for example,

First ten times : 3 times heads turns up
Second ten times : 7 times heads turns up
Third ten times : 6 times heads turns up
Fourth ten times : 4 times heads turns up
etc.

We say "on average" 5 out of ten times heads turns up



Conclusion: While we expect 5 times heads to turn up, the actual number is uncertain!

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1. Imagine we have two coins:

   Coin 1 shows heads 50% of the time

   Coin 2 shows heads 75% of the time

Coin 1

Coin 2

2. When heads turns up, you win a pot of money. When tails turns up, you do not get anything.

You have to choose between Coin 1 and Coin 2

Which one would you choose? **Coin 2**

WHAT ASSUMPTION DID YOU MAKE?

You assumed that the pot of money you win is the same regardless of the coin you chose!

1. Imagine we have two coins:
   Coin 1 shows heads 50% of the time
   Coin 2 shows heads 75% of the time

Coin 1

Coin 2

2. Each time heads turns up, you win the same pot of money. When tails turns up you do not get anything, regardless of the coin you throw.
   You have to choose between two alternatives
   Alternative 1: Throwing ten times with Coin 1
   Alternative 2: Throwing five times with Coin 2

Which alternative would you choose?

Alternative 1 you expect to win 5 times and
Alternative 2 you expect to win 3.75 times

CHOOSE ALTERNATIVE 1

Coin 1

Coin 2

1. Imagine we have two coins:

   Coin 1 shows heads 50% of the time

   Coin 2 shows heads 75% of the time

2. Each time heads turns up with Coin 1 you win $2. Each time heads turns up with Coin 2 you win $4. When tails turns up you do not get anything.

   You have to choose between two ALTERNATIVES

   Alternative 1: Throwing ten times with Coin 1

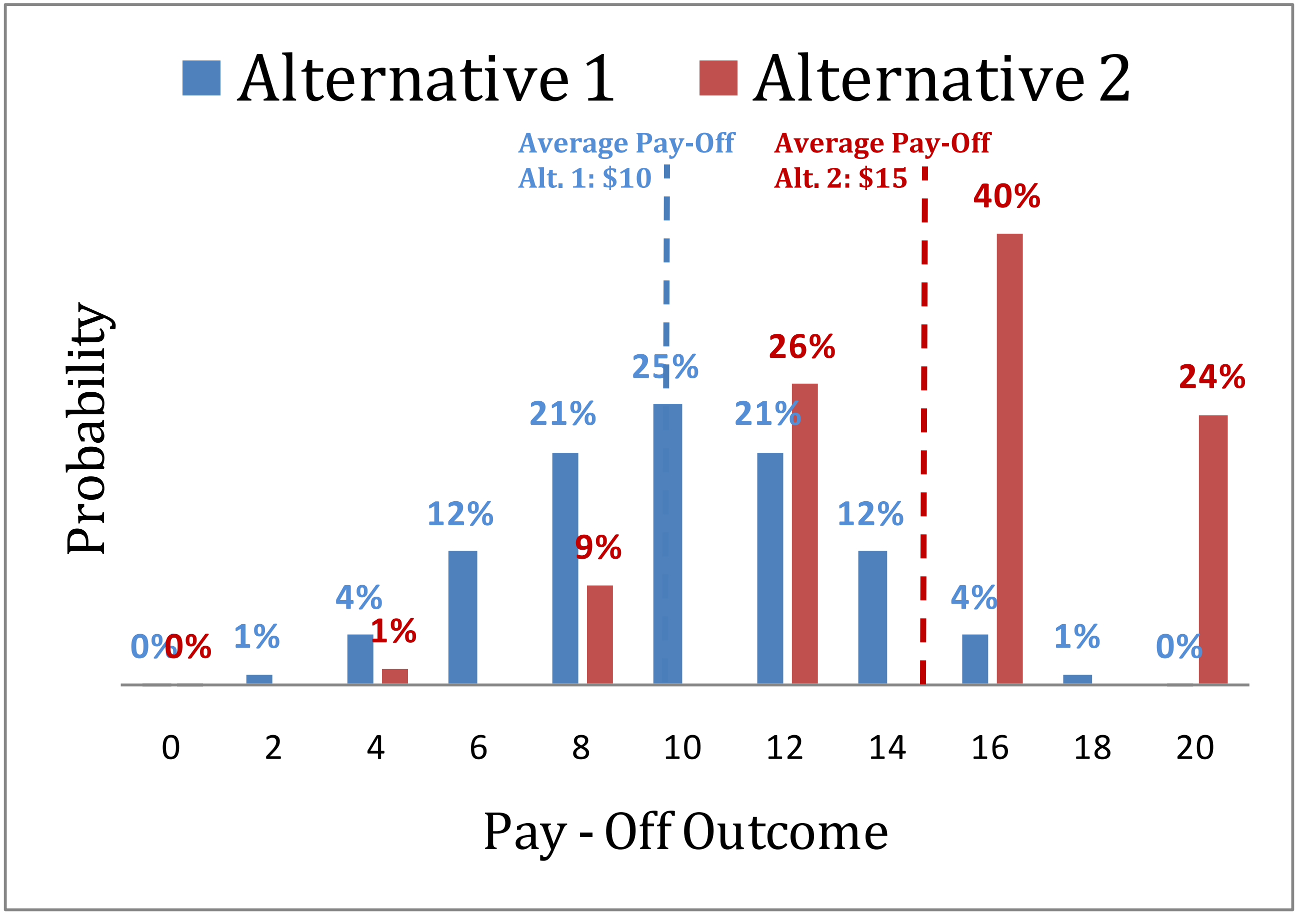
   Alternative 2: Throwing five times with Coin 2

Which alternative would you choose?

Alternative 1 you average 5 * $2 = $10

Alternative 2 you average 3.75 * $4 = $15

CHOOSE ALTERNATIVE 2



Our objective is to **maximize pay-off.** So **faced with uncertainty** of **pay-off outcomes** we choose the alternative with largest average pay-off.

Conclusion?

When choosing between **two alternatives** entailing a series of trials, the following comes into play:

1. The number of trials ***N*** in each alternative
2. The probability of success ***P*** per trial
3. The pay-off amount ***W*** per trial

AVERAGE PAY-OFF = N × P × W

Is it required to know the absolute value of N, P and W to choose between these two alternatives?

1. Imagine we have two coins:

   Coin 2 shows heads **1.5 times more** than Coin 1

2. When heads turns up with Coin 2 **you win 2 times the amount** when heads turns up with Coin 1.

   You have to choose between **Two Alternatives**

   Alternative 1: Throwing **2*N times** with Coin 1

   Alternative 2: Throwing **N times** with Coin 2

   P = % Heads turns up with Coin 1,

   W = $ amount you win with Coin 1.

$$\frac{\text{Average Pay – Off Alternative 2}: \quad \cancel{N} \times 1.5 \times \cancel{P} \times \cancel{2} \times \cancel{W}}{\text{Average Pay – Off Alternative 1}: \quad \cancel{2} \times \cancel{N} \times \cancel{P} \times \cancel{W}}$$

Average Pay-Off Alt. 2/Average Pay-Off Alt. 1 = 1.5

Conclusion?

When choosing between **two alternatives** entailing a series of trials, we can make a choice if we know **the multiplier between the average pay-offs**, even when the absolute pay-off values over the two alternative series are unknown/uncertain

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What was The Objective in Coin Toss Example?

Maximize Average Pay-Off

What is the Objective in a Maritime Risk Assessment?

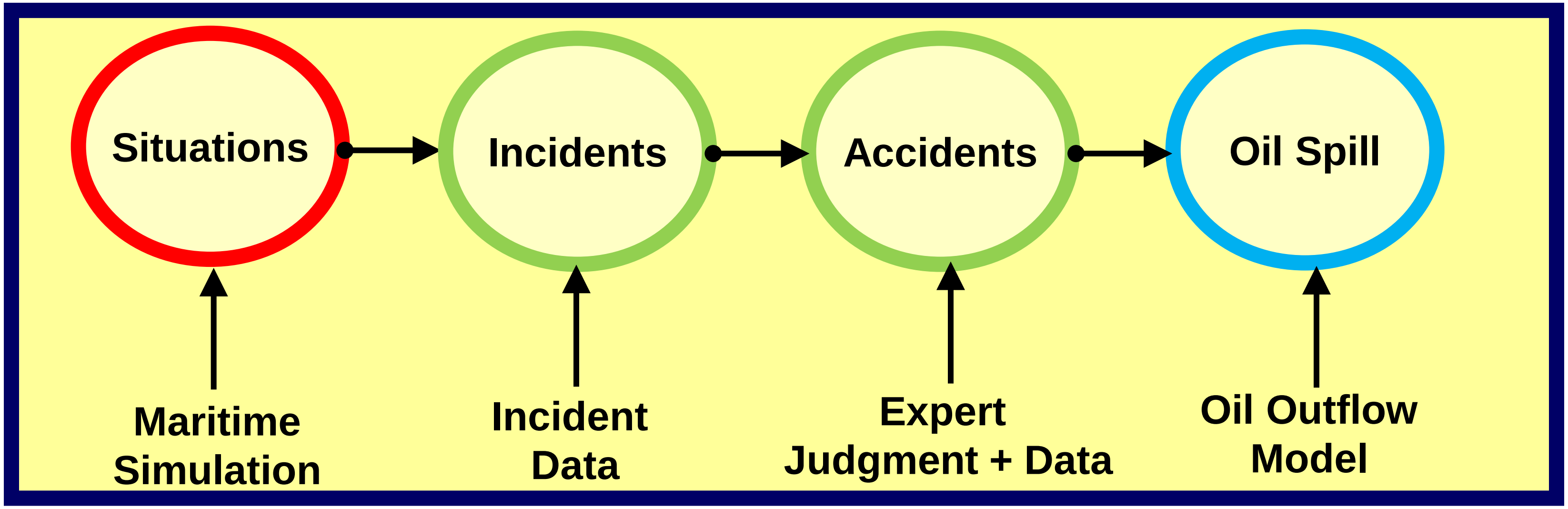
Minimize Average Potential Oil Loss

Truth be told, for some the objective is to Maximize Average Pay-Off, for some it is to Minimize Average Potential Oil Loss and for others it is to Achieve Both.

For sake of argument, lets take in Maritime Risk Assessment a focus towards Minimizing Average Potential Oil Loss, while recognizing the Maximize Average Pay-Off Objective is also at play.

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010

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



$$R = \{ < s_i , l_i , x_i > \}_c$$

Traffic Situations Likelihoods Consequences

Risk Analysis Objective:
Evaluate Oil Spill System Risk described by a **"complete" set of traffic situations**

Coin Toss Analogy: Trials % of Heads (P) Winnings ($)

Pay-off Risk was defined by **N identical Trials**

VTRA 2010 Analysis Approach

In light of uncertainties inherent to any risk analysis, we choose not to focus on;

- absolute evaluations of risk levels,

but to focus on

- relative risk changes from a base case scenario by adding or removing traffic to or from that base case.

VTRA 2010 Analysis Approach

A Base Case (BC) Analysis Framework is constructed while;

- making reasonable assumptions (not worst or best case), and
- What-if (WI), Bench-Mark (BM) and Risk Mitigation Measure (RMM) cases are analyzed within that framework.

VTRA 2010 Analysis Approach

- Base Case (BC) system wide risk levels are set at 100%, and
- System wide % changes up or down are evaluated for What-if (WI), Bench-Mark (BM) and Risk Mitigation Measure (RMM), moreover
- Location-Specific Multipliers are evaluated for 15 Waterway Zones.

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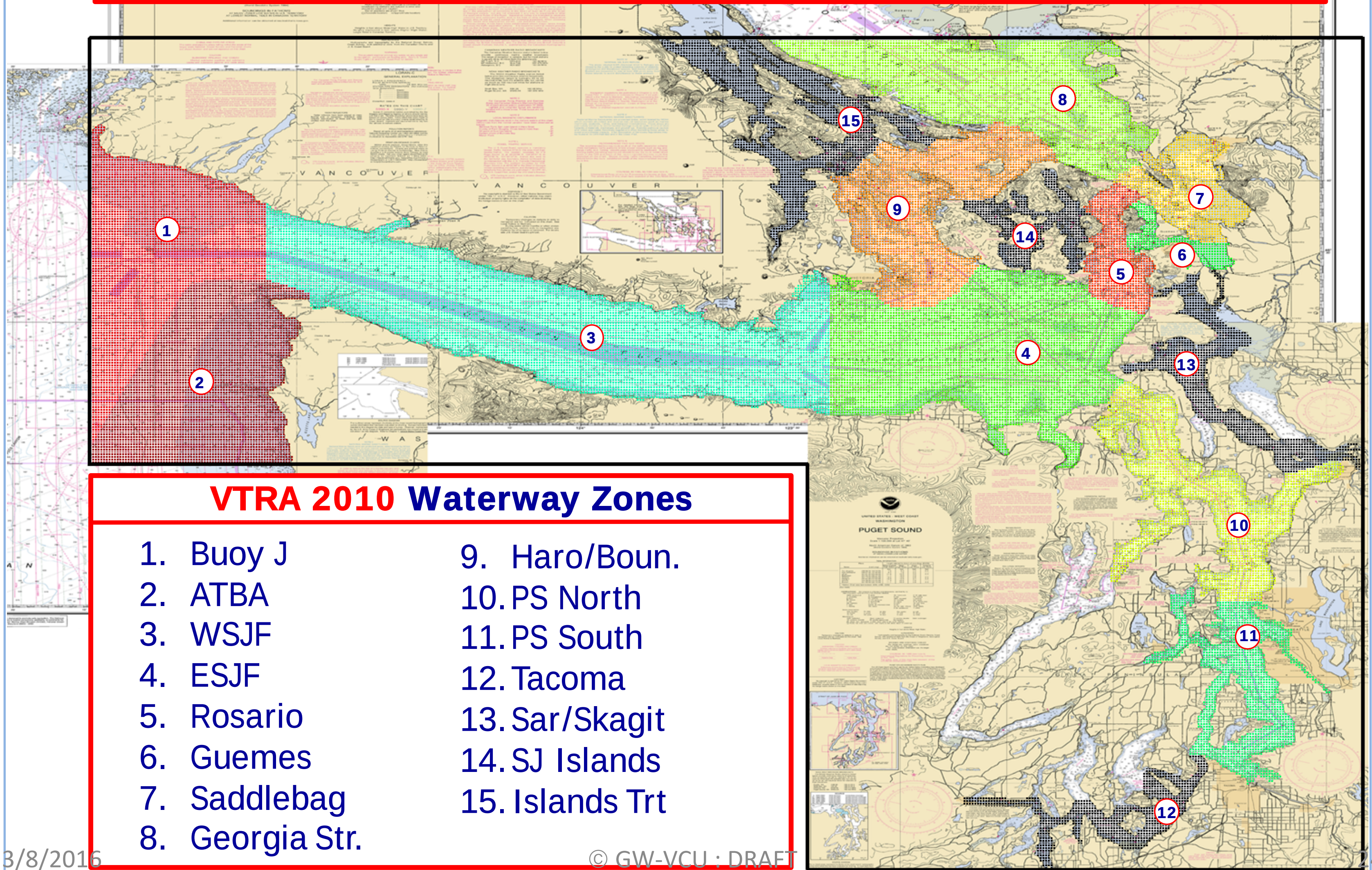
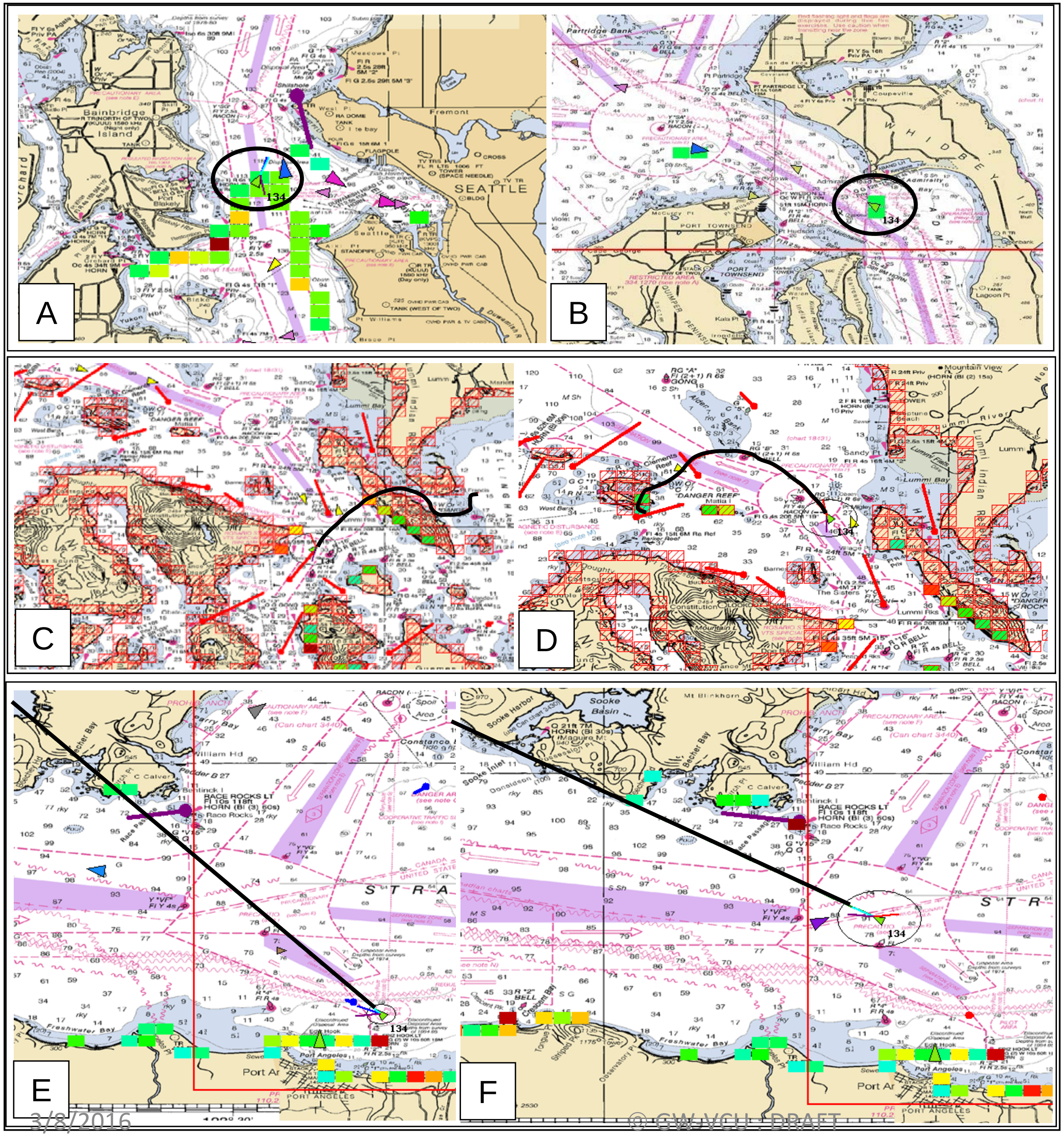
DEFINITION OF 15 WATERWAY ZONES



VTRA 2010 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. Islands Trt



Generating Traffic Situations:

Counting Collision Accident Scenario's

Counting Drift Grounding Accident Scenario's

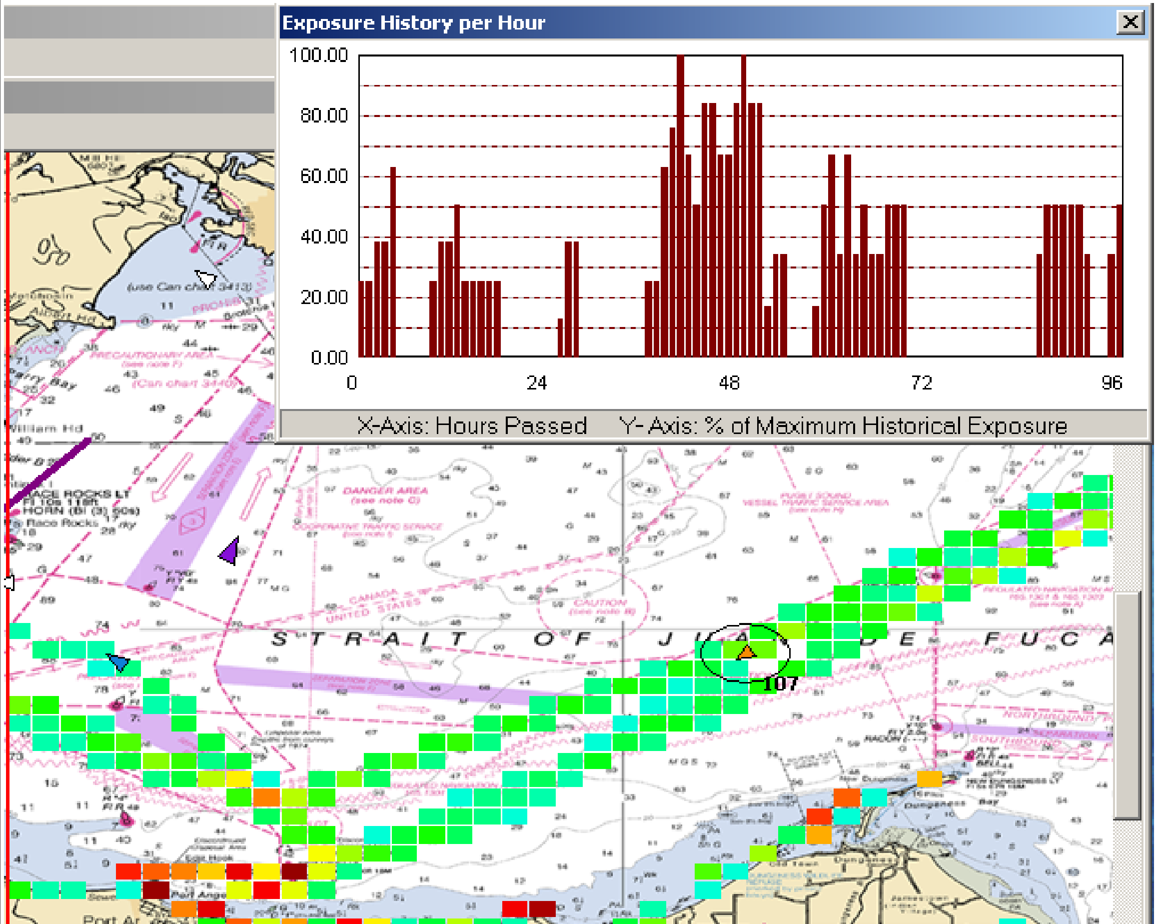
Counting Powered Grounding Accident Scenario's

VTRA 2010 Analysis Approach

- Map is divided in squares of grid cells with dimension half nautical mile by half nautical mile and The VTRA 2010

Evaluates per Grid Cell!

- # of traffic situations per year
- potential accident frequency per year
- potential oil loss per year



Data base - Vessel Interactions

Index 1	Index 2	Index 3	Index 4	Index 5	Index 6	Index 7	No of Occurrences
425120095	410901300	110222107	111122130	628013199	121094074	301132018	2
425121095	410901300	110222107	111122130	626009190	126094032	223021000	1
425121095	410901300	110222107	111122130	628013199	122094074	301132018	1
425121095	410901300	110222107	111122230	626009190	126094032	223021000	1
425121095	410901300	110222107	111122230	628013199	122094074	301132018	1
425126095	410901300	110222107	112122130	626009190	127094032	223022018	3
425127095	410901300	110222107	112122130	626009190	127094032	223022018	4
425128095	410901300	110222107	112122130	626009190	127094032	223022018	2
425174081	321004200	120262107	111112130	626009190	176082032	223032000	1

A

```
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; { 26000000}
        VOI_X                     :Longint; {   500000}
        VOI_Y                     :Longint; {      500}

        {Index 2 - VOI Attributes}
        VOI_Location              :Longint; {900000000}
        VOI_Inbound_Outbound:Longint; { 20000000}
        VOI_Speed                 :Longint; {  3000000}
        VOI_DP                    :longint; {    12500}
        IV_Cargo                  :Longint; {       20}
        IV_Barge_Type             :Longint; {        5}

        {Index 3 - VOI Attributes}
        VOI_Cargo                 :Longint; {20000000}
        VOI_Tethered_State        :Longint; {  200000}
        VOI_Barge_Type            :Longint; {   50000}
        VOI_Hook_Up               :Longint; {    4000}
        VOI_ID                    :longint; {     999}

        {Index 4 - Environment Info}
        Visibility                :longint; {20000000}
        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;
```

B

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Recall Coin Toss Analogy: Trials (N) % of Heads (P) Winnings (W)

EVALUATE AVERAGE PAY-OFF = **N** × **P** × **W**

Risk Assessment: Traffic Situations Likelihoods Consequences

$$R = \{< s_i, l_i, x_i >\}_c$$

Oil Spill System Risk is described **by "complete" set of traffic situations**

Per Grid Cell!!

EVALUATE AVERAGE VESSEL TIME EXPOSURE — Driver for

EVALUATE AVERAGE OIL TIME EXPOSURE — Driver for

EVALUATE AVERAGE ANNUAL POTENTIAL ACC. FREQ.

EVALUATE AVERAGE ANNUAL POTENTIAL OIL LOSS

Display results visually in 2D and 3D geographic profiles

VTRA 2010 Analysis Approach

Collision System Exposure in Base Case:

- Approximately **10,000 grid cells of 0.5 x 0.5 mile** in VTRA study area with Vessel to Vessel traffic situations.
- Approximately **1.8 Million Vessel to Vessel Traffic Situations per year** generated by VTRA 2010 Model.
- **Vessel to Vessel Traffic Situations per cell per year range from 1 – 7,000** (or on average about 0 – 20 per day per cell) .

Recall Coin Toss – Traffic Situation Analogy:
"1.8 Million Coin Tosses with very small probability of Tails"

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VTRA 2010 Analysis Approach

Grounding System Risk in Base Case:

- Approximately **4,000 grid cells of 0.5 x 0.5 mile** in VTRA study area with Vessel to Shore traffic situations.
- Approximately **10 Million Vessel to Shore Traffic Situations per year** generated by VTRA 2010 Model.
- **Vessel to Shore Traffic Situations <u>per cell</u> per year range from 1 – 55,000** (or on average about 0 – 150 per day) .

Recall Coin Toss – Traffic Situation Analogy:
"10 Million Coin Tosses with <u>very small probability</u> of Tails"

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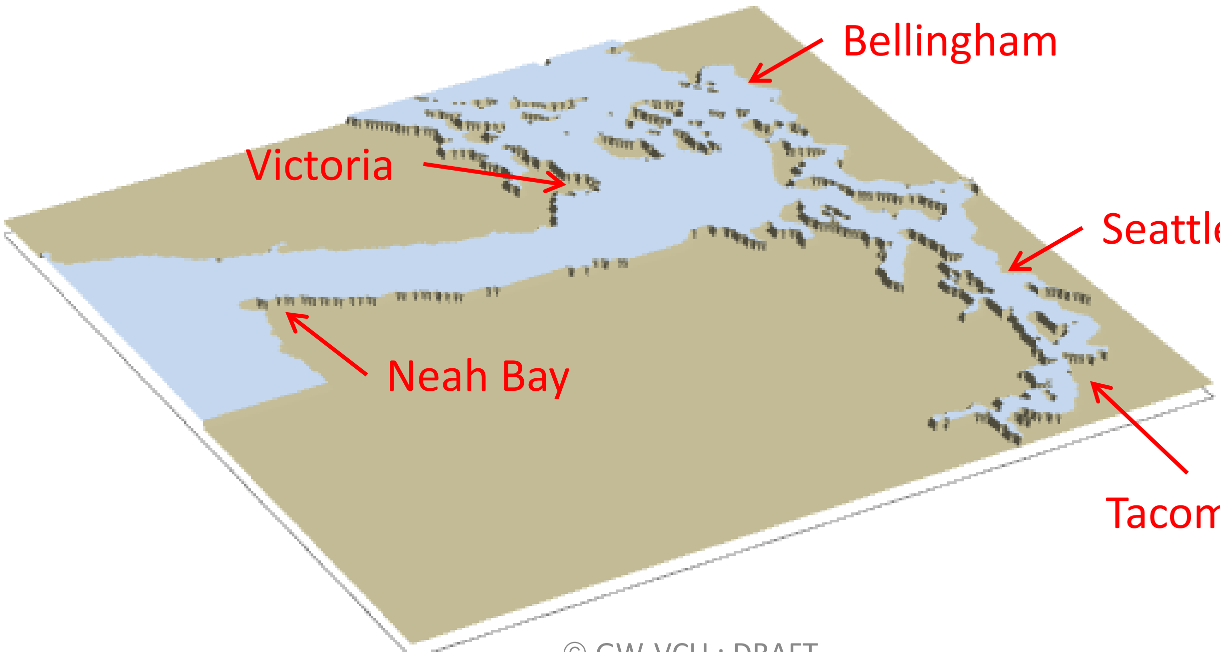
P: Base Case 3D Risk Profile
MAP TO DISPLAY - Vessel Time Exposure

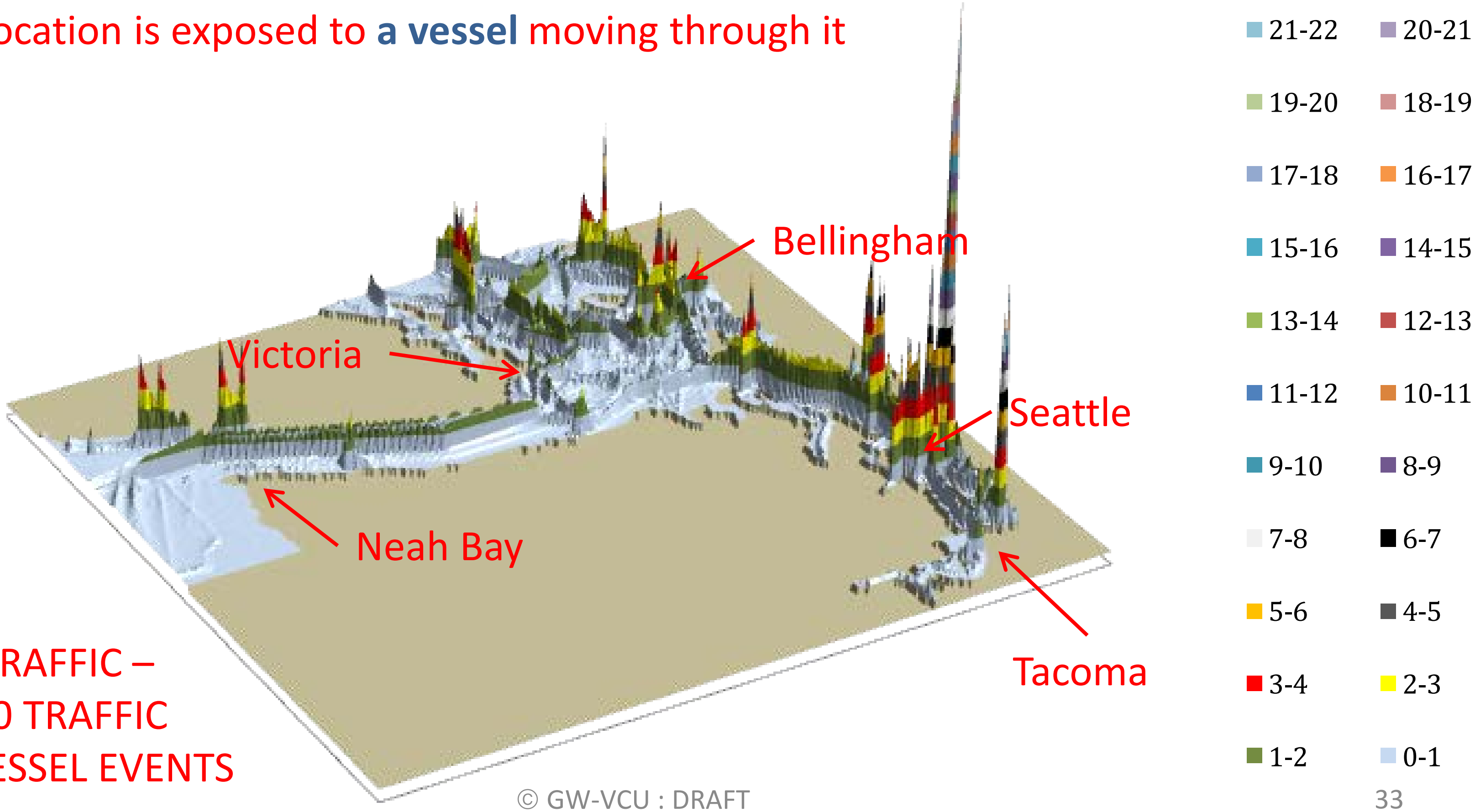
VESSEL TIME EXPOSURE (VTE) = Annual amount of time a location is exposed to a vessel moving through it



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

P: Base Case 3D Risk Profile
ALL TRAFFIC - Vessel Time Exposure: 100%Total VTE

VESSEL TIME EXPOSURE (VTE) = Annual amount of time a location is exposed to **a vessel** moving through it



ALL VTRA TRAFFIC –
VTOSS 2010 TRAFFIC
+ SMALL VESSEL EVENTS

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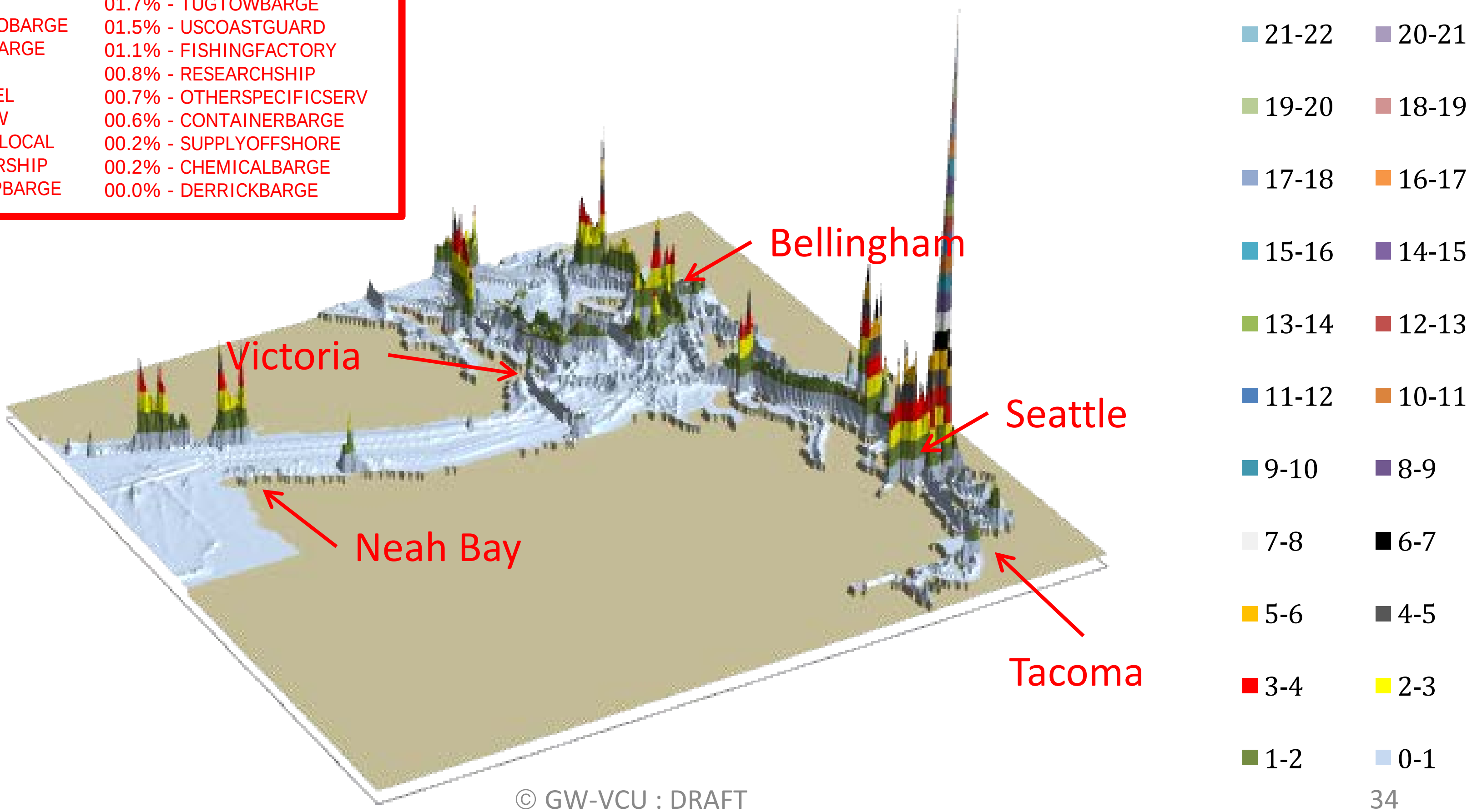
NON – FV TRAFFIC

P: Base Case 3D Risk Profile
NON FV - Vessel Time Exposure: 75%Total VTE

2010 NON FV – 75% of 2010 Total

41.3% - FISHINGVESSEL	02.1% - LOG_BARGE
18.1% - FERRY	01.7% - TUGTOWBARGE
06.8% - BULKCARGOBARGE	01.5% - USCOASTGUARD
06.0% - UNLADENBARGE	01.1% - FISHINGFACTORY
04.0% - YACHT	00.8% - RESEARCHSHIP
03.9% - NAVYVESSEL	00.7% - OTHERSPECIFICSERV
03.3% - TUGNOTOW	00.6% - CONTAINERBARGE
02.8% - FERRYNONLOCAL	00.2% - SUPPLYOFFSHORE
02.7% - PASSENGERSHIP	00.2% - CHEMICALBARGE
02.2% - WOODCHIPBARGE	00.0% - DERRICKBARGE



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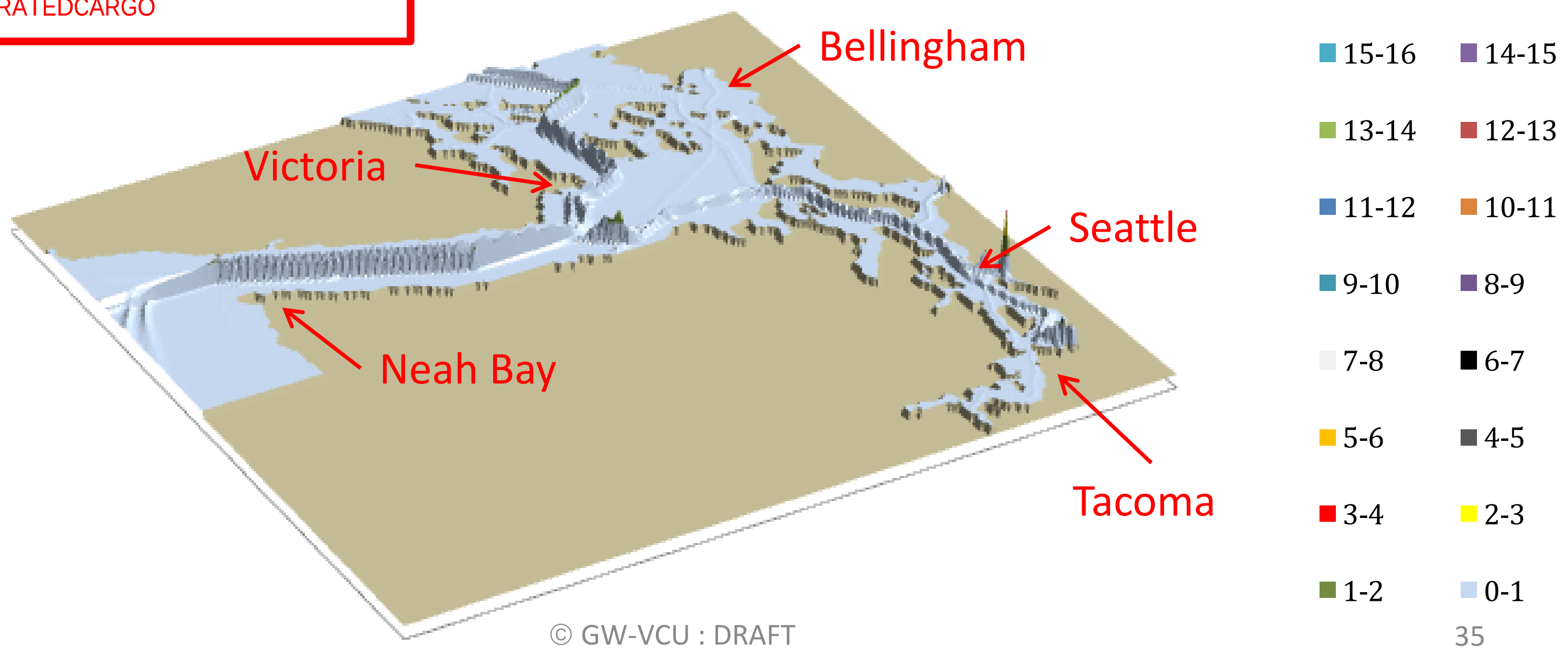
P: Base Case 3D Risk Profile
Cargo FV - Vessel Time Exposure: 17% of Base Case VTE

2010 CARGO FV – 17.0 % of 2010 Total

54.6% - BULKCARRIER
27.8% - CONTAINERSHIP
08.1% - OTHERSPECIALCARGO
04.9% - VEHICLECARRIER
02.3% - ROROCARGOCONTSHIP
01.1% - ROROCARGOSHIP
00.8% - DECKSHIPCARGO
00.4% - REFRIGERATEDCARGO



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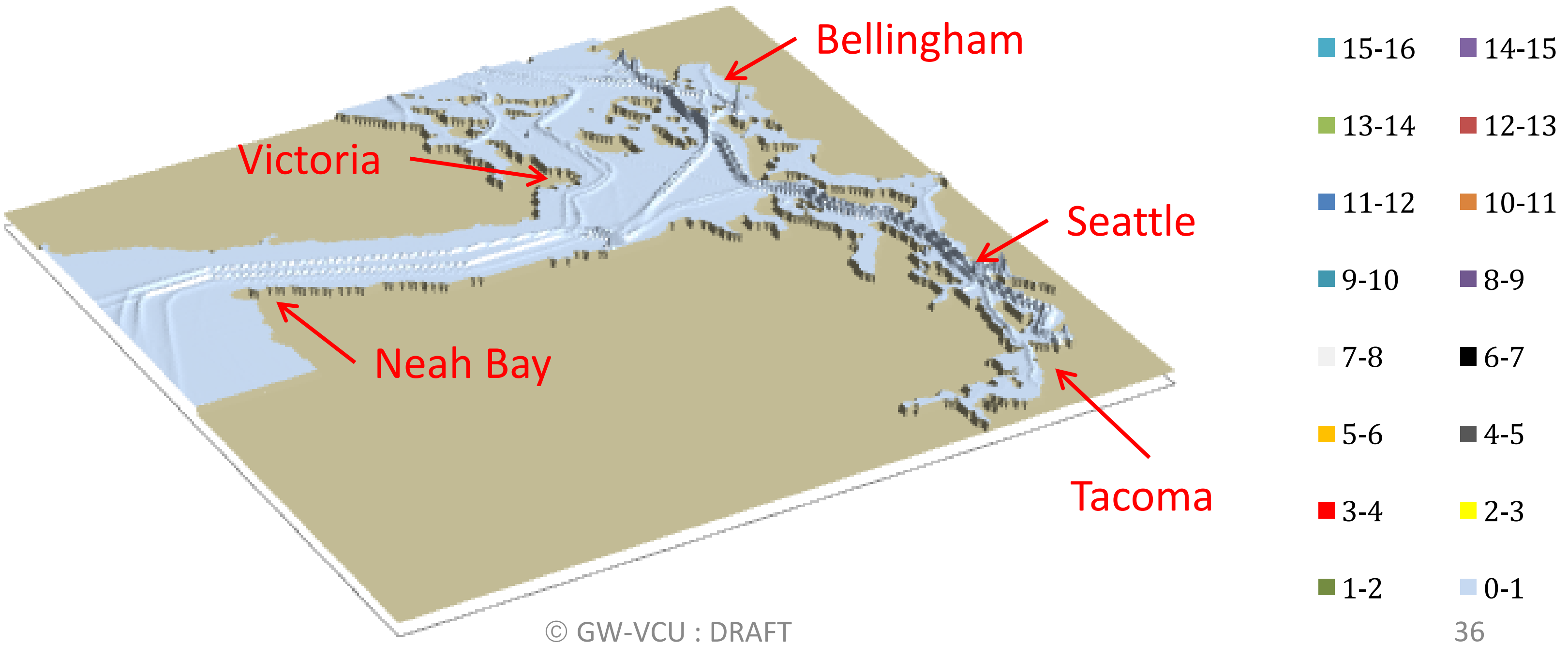
P: Base Case 3D Risk Profile
Tank FV - Vessel Time Exposure: 8% of Base Case VTE

2010 TANK FV – 8% of 2010 Total

54.5% - OILBARGE
24.4% - OILTANKER
11.3% - CHEMICALCARRIER
09.8% - ATB



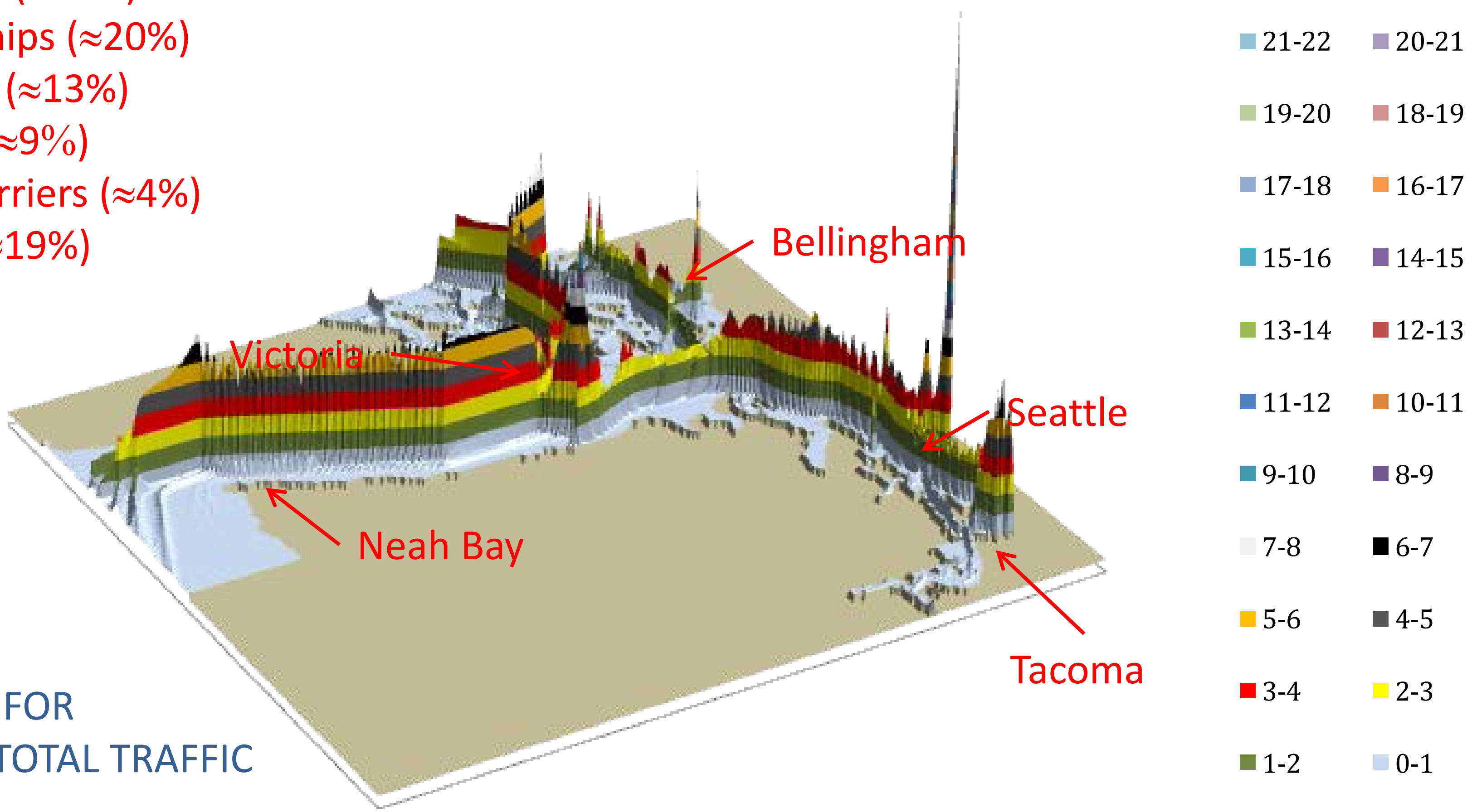
FV = Focus Vessel

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

Where do Focus Vessels Travel?

ALL FV (100%)

- Bulk Carriers (≈33%)
- Container Ships (≈20%)
- Other Cargo (≈13%)
- Oil Tankers (≈9%)
- Chemical Carriers (≈4%)
- Oil Barges (≈19%)
- ATB's (≈3%)



FV TRAFFIC ACCOUNTS FOR (≈25%) OF TOTAL TRAFFIC

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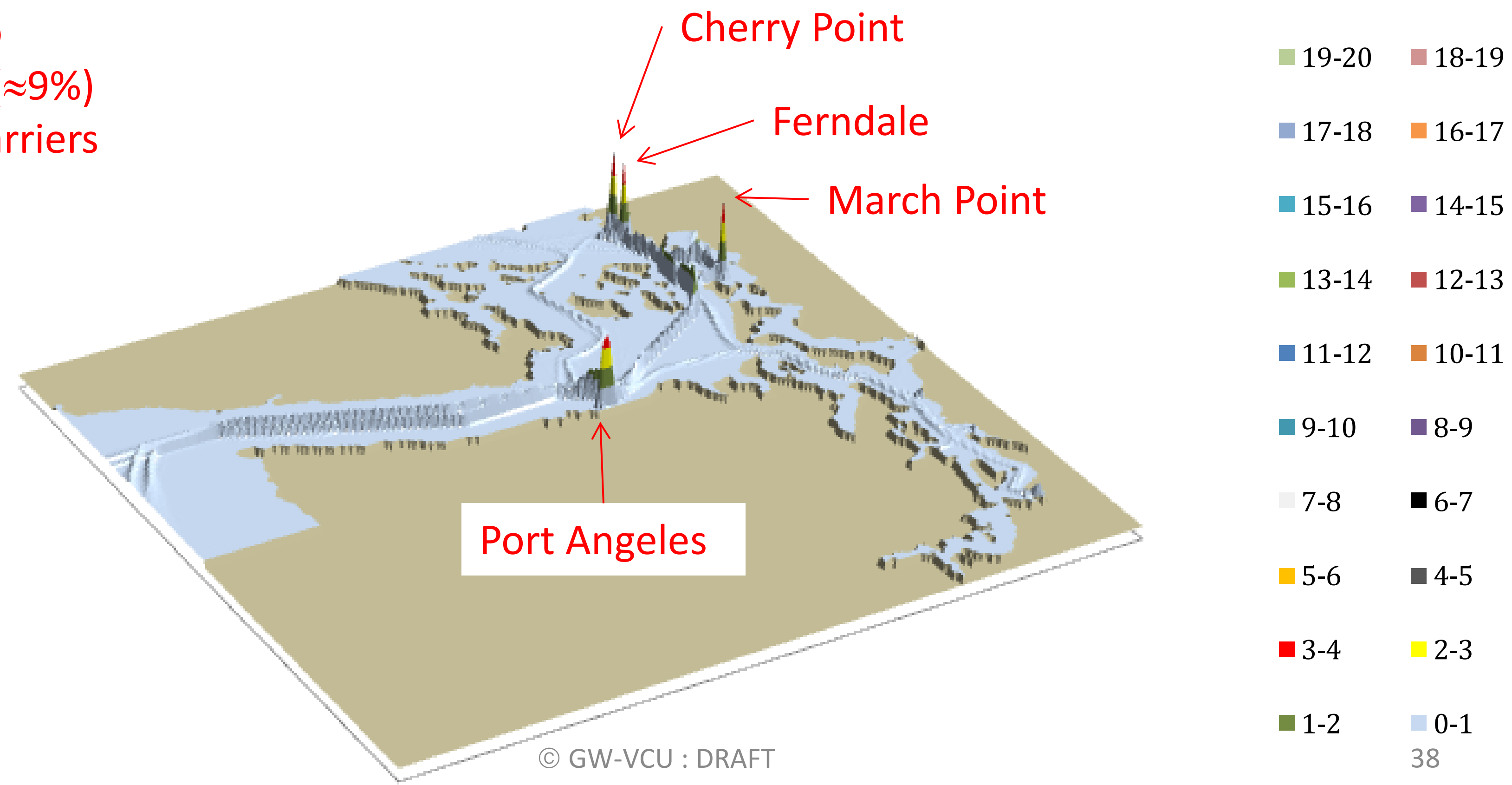
FV = Focus Vessel

P: Base Case 3D Risk Profile
Tanker - Vessel Time Exp.: 9% of Base Case VTE

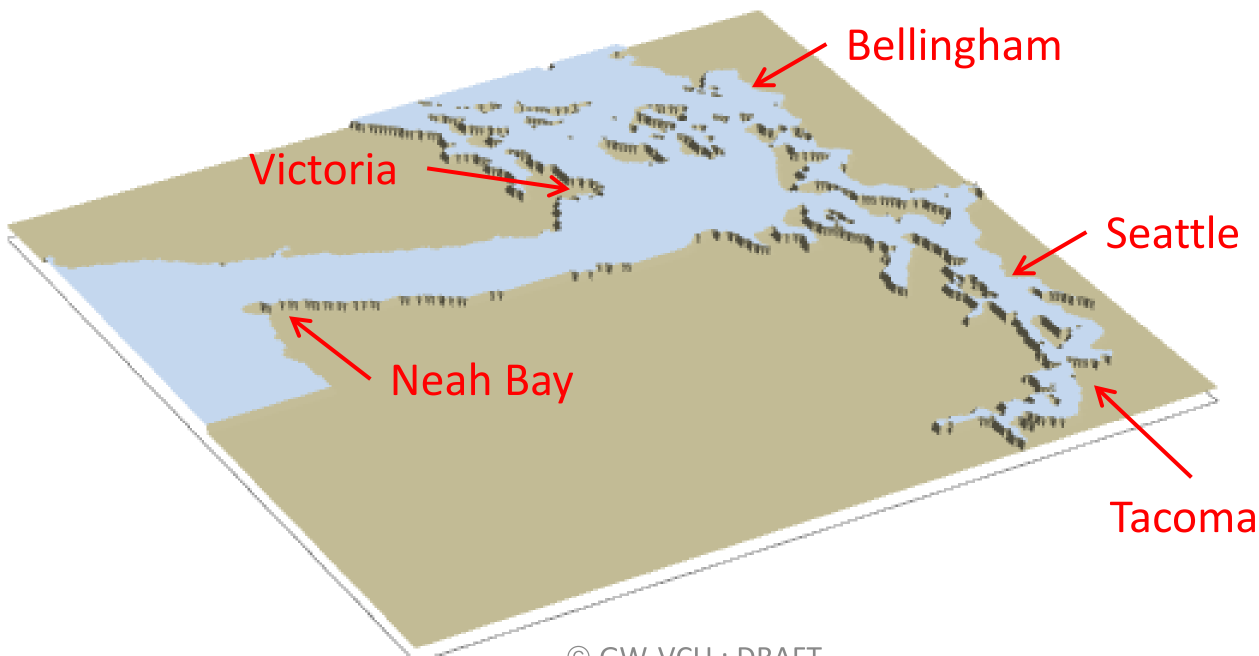
Where do Tankers Travel?

ALL FV
- Bulk Carriers
- Container Ships
- Other Cargo
- Oil Tankers (≈9%)
- Chemical Carriers
- Oil Barges
- ATB's



P: Base Case 3D Risk Profile
MAP TO DISPLAY - ~~Vessel~~ Oil Time Exposure

OIL TIME EXPOSURE (OTE) = Annual amount of time a location is exposed to **a cubic meter of oil** moving through it



FV = Focus Vessel

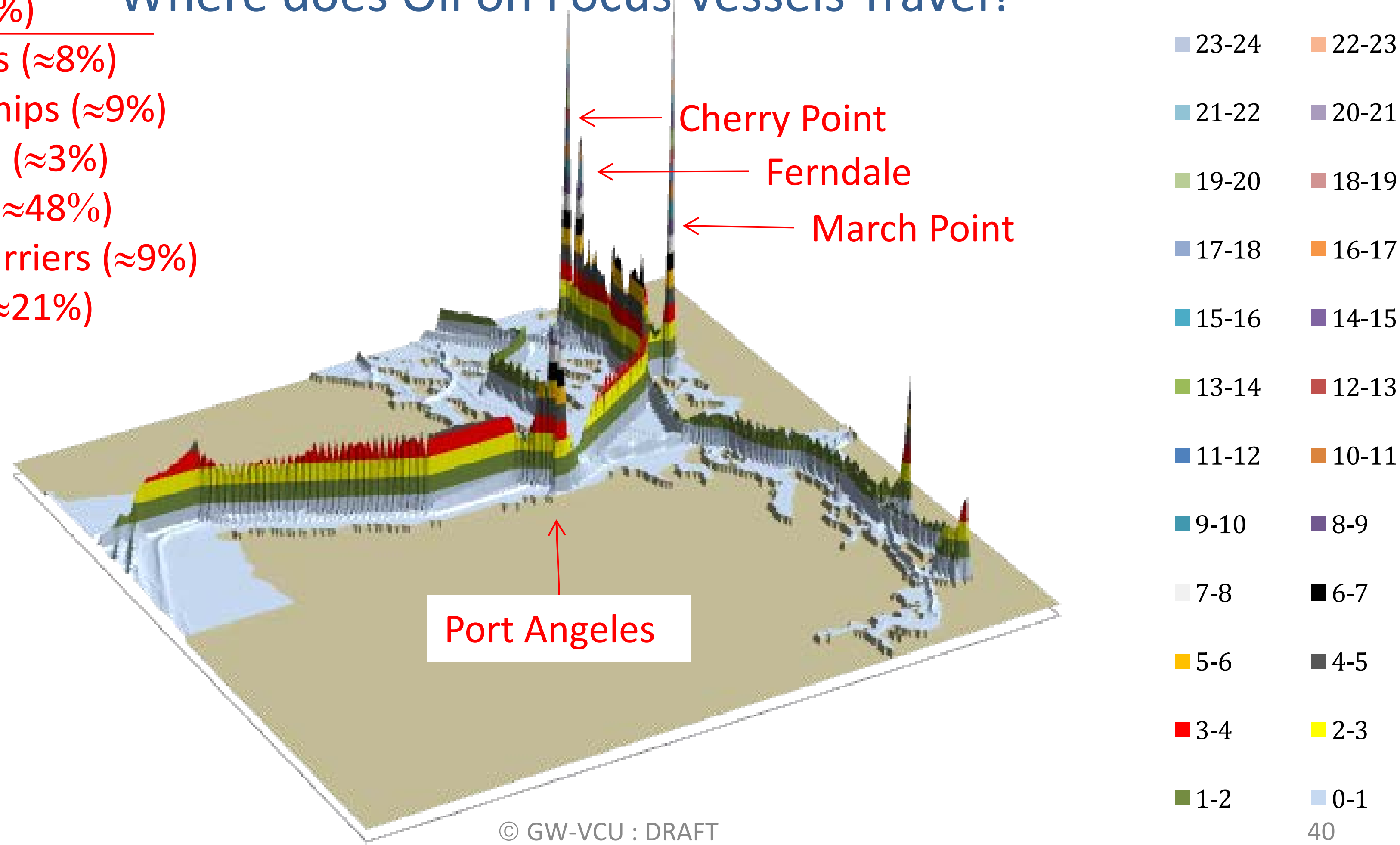
P: Base Case 3D Risk Profile

All FV - Oil Time Exposure: 100% of Base Case OTE

Where does Oil on Focus Vessels Travel?

ALL FV (100%)

- Bulk Carriers (≈8%)
- Container Ships (≈9%)
- Other Cargo (≈3%)
- Oil Tankers (≈48%)
- Chemical Carriers (≈9%)
- Oil Barges (≈21%)
- ATB's (≈3%)



FV = Focus Vessel

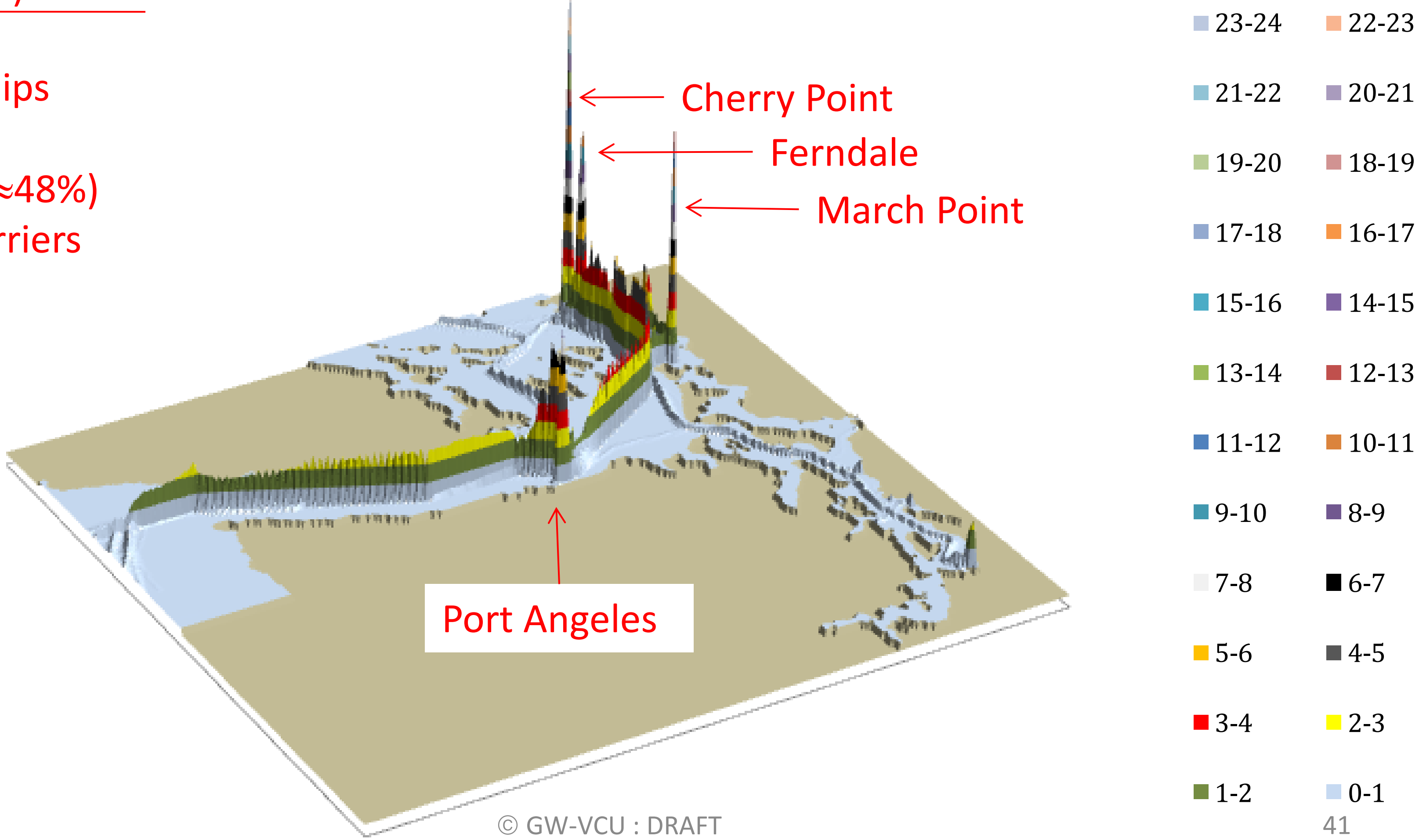
P: Base Case 3D Risk Profile

Tanker - Oil Time Exposure: 48% of Base Case OTE

Where does Oil on board Tankers Travel?

ALL FV (100%)

- Bulk Carriers
- Container Ships
- Other Cargo
- Oil Tankers (≈48%)
- Chemical Carriers
- Oil Barges
- ATB's



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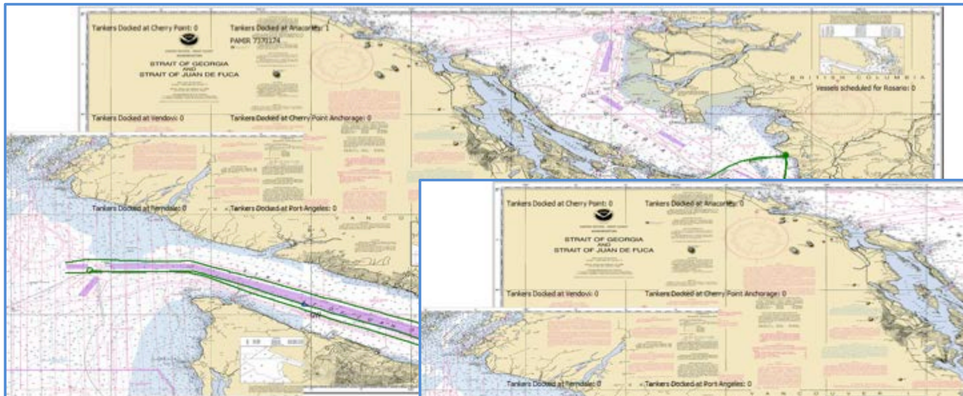
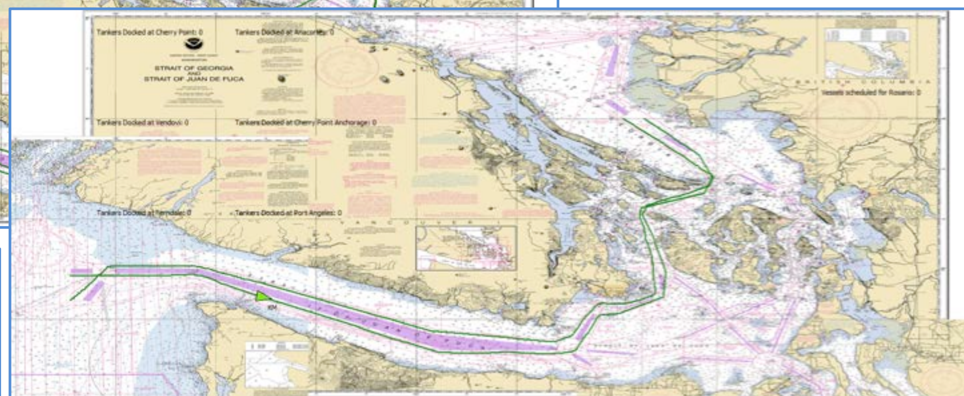
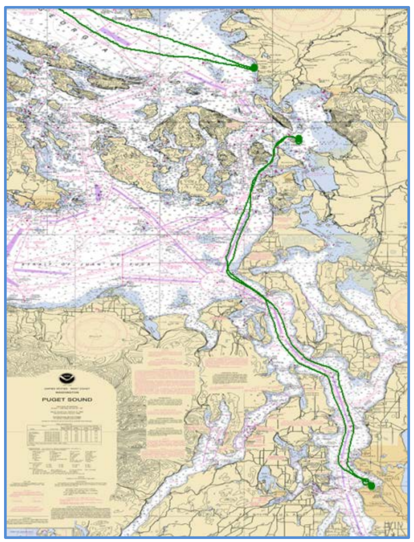
WHAT – IF SCENARIO ROUTES



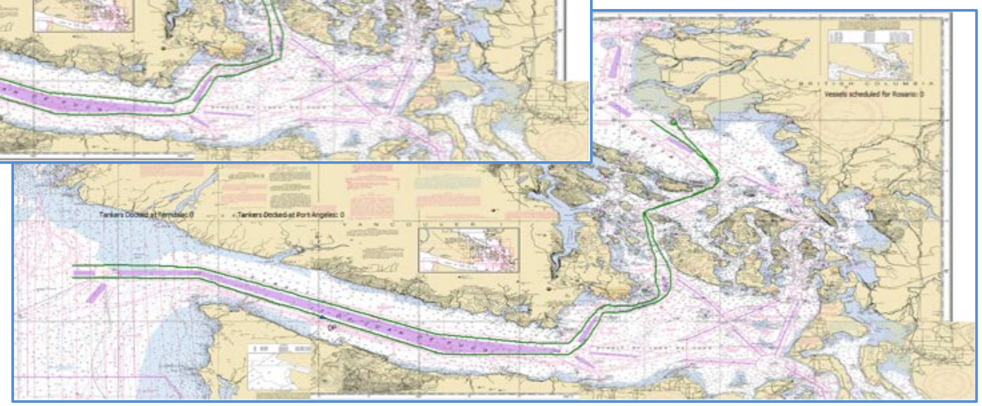
GW487: + 487 BULK CARRIERS
+ Bunkering Support



KM348: + 348 TANKERS
+ Bunkering Support

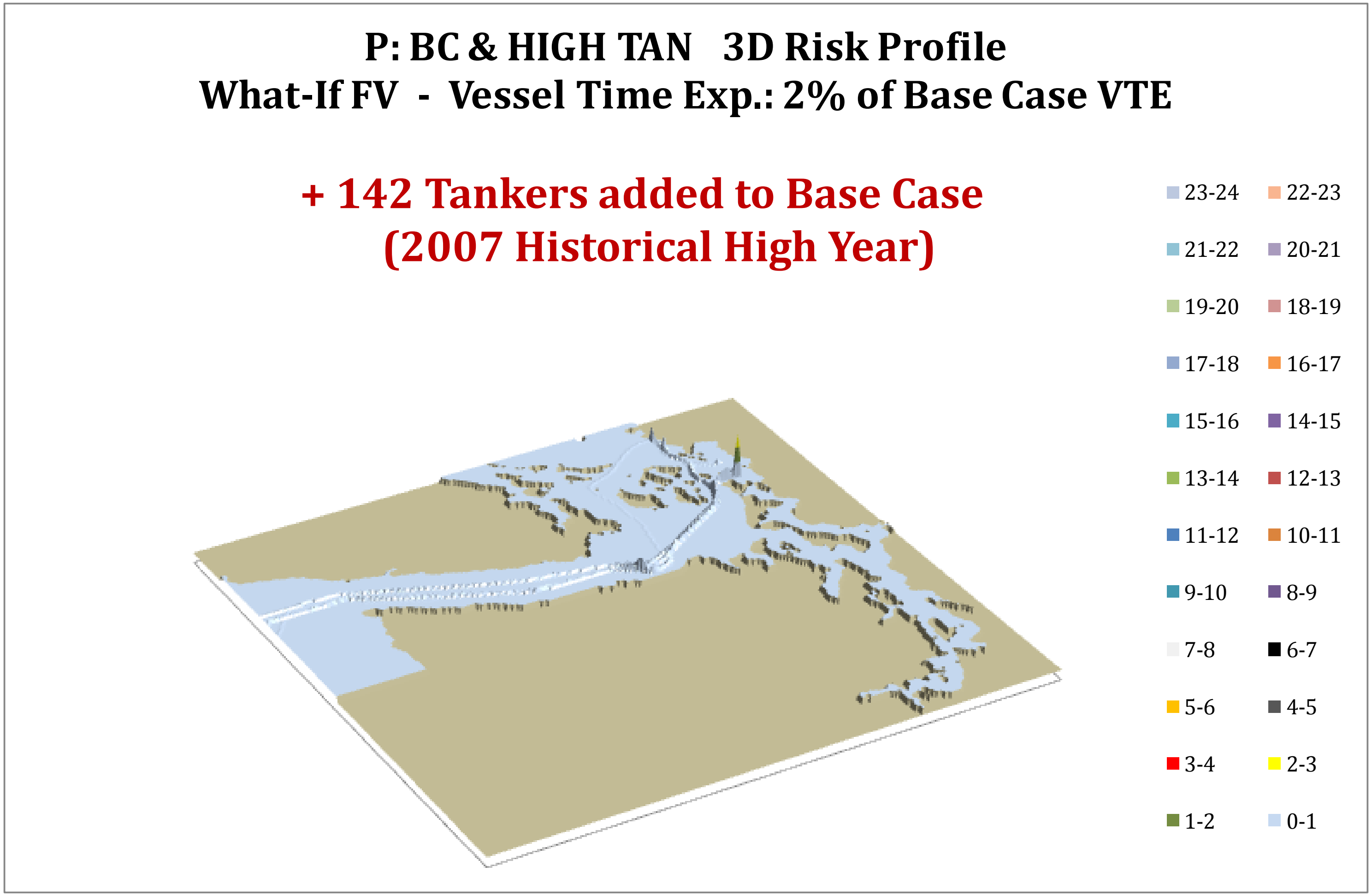


BUNKERING SUPPORT ROUTES

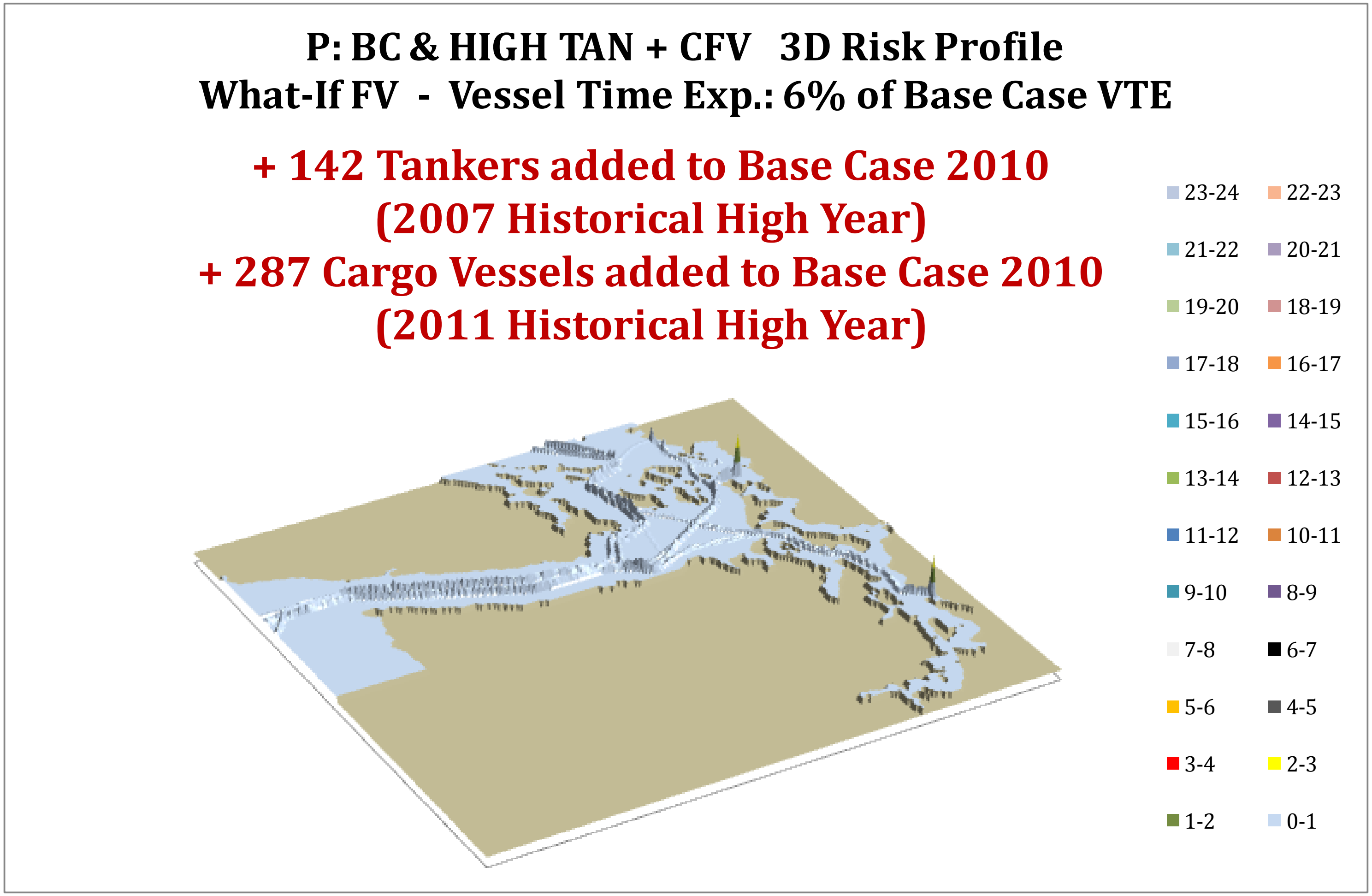


DP415: 348 BULK CARRIERS
+ 67 CONTAINER SHIPS
+ Bunkering Support

BENCH-MARK TANKER ROUTES



BENCH-MARK TANKER + CARGO ROUTES



WHAT – IF SCENARIO ANALYSES

	WHAT IF SCENARIO ANALYSIS			
	Vessel Time Exposure (VTE)	Oil Time Exposure (OTE)	Pot. Accident Frequency (PAF)	Pot. Oil Loss (POL)
P - Base Case	**100%**	**100%**	**100%**	**100%**

	WHAT IF SCENARIO ANALYSIS
P - Base Case	Modeled Base Case 2010 year informed by VTOSS 2010 data amongst other sources.
Q - GW - 487	Gateway expansion scenario with 487 additional bulk carriers and bunkering support
R - KM - 348	Transmountain pipeline expansion with additional 348 tankers and bunkering support
S - DP - 415	Delta Port Expansion with additional 348 bulk carriers and 67 container vessels
T - GW - KM - DP	Combined expansion scenario of above three expansion scenarios

	WHAT IF SCENARIO ANALYSIS			
	Vessel Time Exposure (VTE)	Oil Time Exposure (OTE)	Pot. Accident Frequency (PAF)	Pot. Oil Loss (POL)
P - Base Case	**100%**	**100%**	**100%**	**100%**
Q - GW - 487	**+13% | 113%**	**+5% | 105%**	**+12% | 112%**	**+12% | 112%**
R - KM - 348	**+7% | 107%**	**+51% | 151%**	**+5% | 105%**	**+36% | 136%**
S - DP - 415	+5% | 105%	+3% | 103%	+6% | 106%	+4% | 104%
T - GW - KM - DP	**+25% | 125%**	**+59% | 159%**	**+18% | 118%**	**+68% | 168%**

BENCH MARK ANALYSES ON CASE P

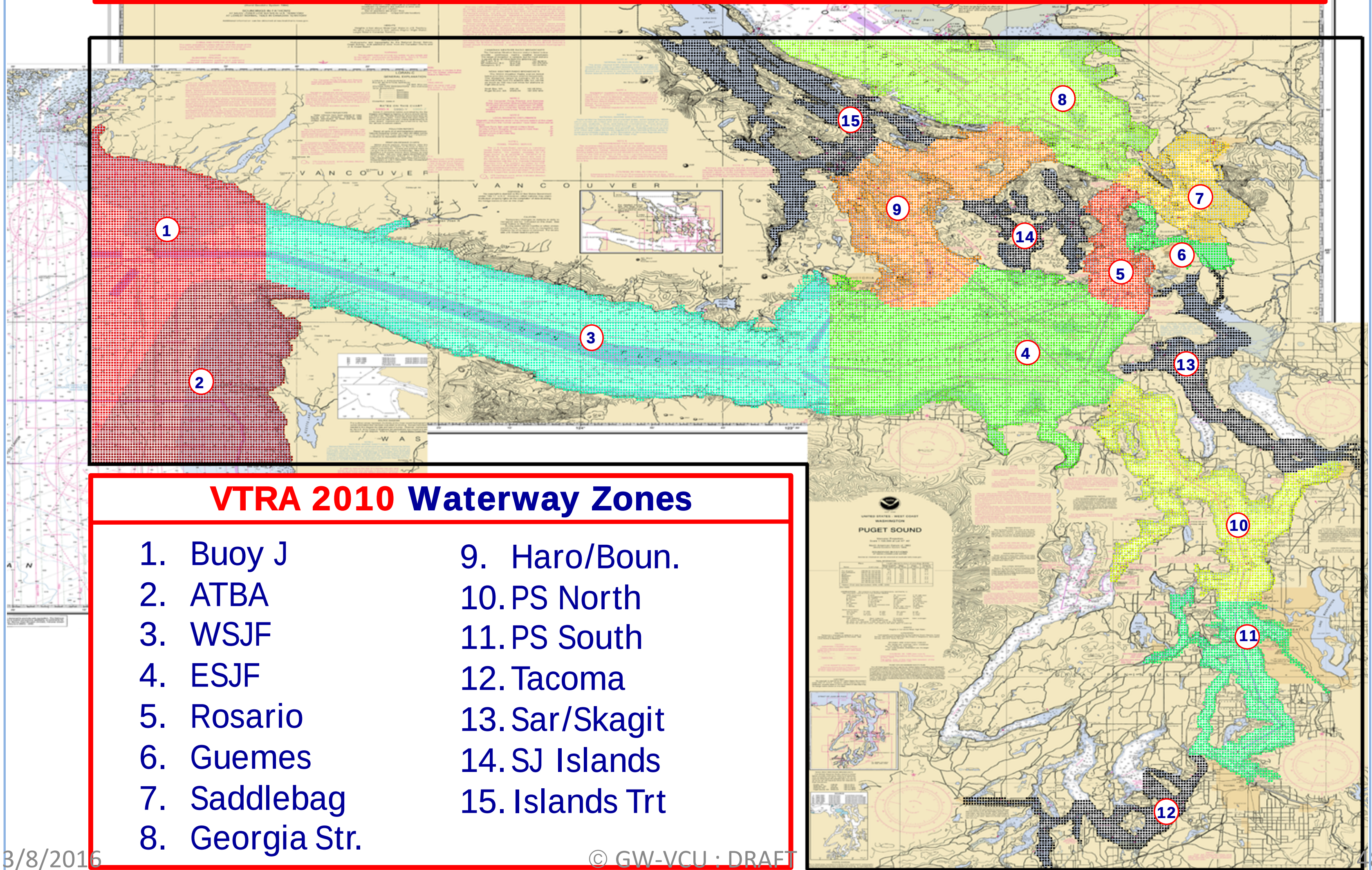
	P - RMM SCENARIO REFERENCE POINT			
	Vessel Time Exposure (VTE)	Oil Time Exposure (OTE)	Pot. Accident Frequency (PAF)	Pot. Oil Loss (POL)
P - Base Case	**100%**	**100%**	**100%**	**100%**

	CASE P BENCHMARK (BM) & SENSITIVITY ANALYSIS
P - Base Case	Modeled Base Case 2010 year informed by VTOSS 2010 data amongst other sources.
P - BC & LOW TAN + CFV	Base Case with Tankers and Cargo Focus Vessels set at a low historical year
P - BC & LOW TAN	Base Case with Tankers set at a low historical year
P - BC & HIGH TAN	Base Case with Tankers set at a high historical year
P - BC & HIGH TAN + CFV	Base Case with Tankers and Cargo Focus Vessels set at a high historical year

	CASE P BENCHMARK (BM) & SENSITIVITY ANALYSIS			
	Vessel Time Exposure (VTE)	Oil Time Exposure (OTE)	Pot. Accident Frequency (PAF)	Pot. Oil Loss (POL)
P - Base Case	**100%**	**100%**	**100%**	**100%**
P - BC & LOW TAN + CFV	-3% | 97%	-14% | 86%	-5% | 95%	-20% | 80%
P - BC & LOW TAN	-2% | 98%	-13% | 87%	-4% | 96%	-22% | 78%
P - BC & HIGH TAN	+2% | 102%	+14% | 114%	+3% | 103%	+9% | 109%
P - BC & **HIGH TAN + CFV**	**+7% | 107%**	**+15% | 115%**	**+4% | 104%**	**+8% | 108%**

THE GEORGE WASHINGTON UNIVERSITY WASHINGTON, DC VCU

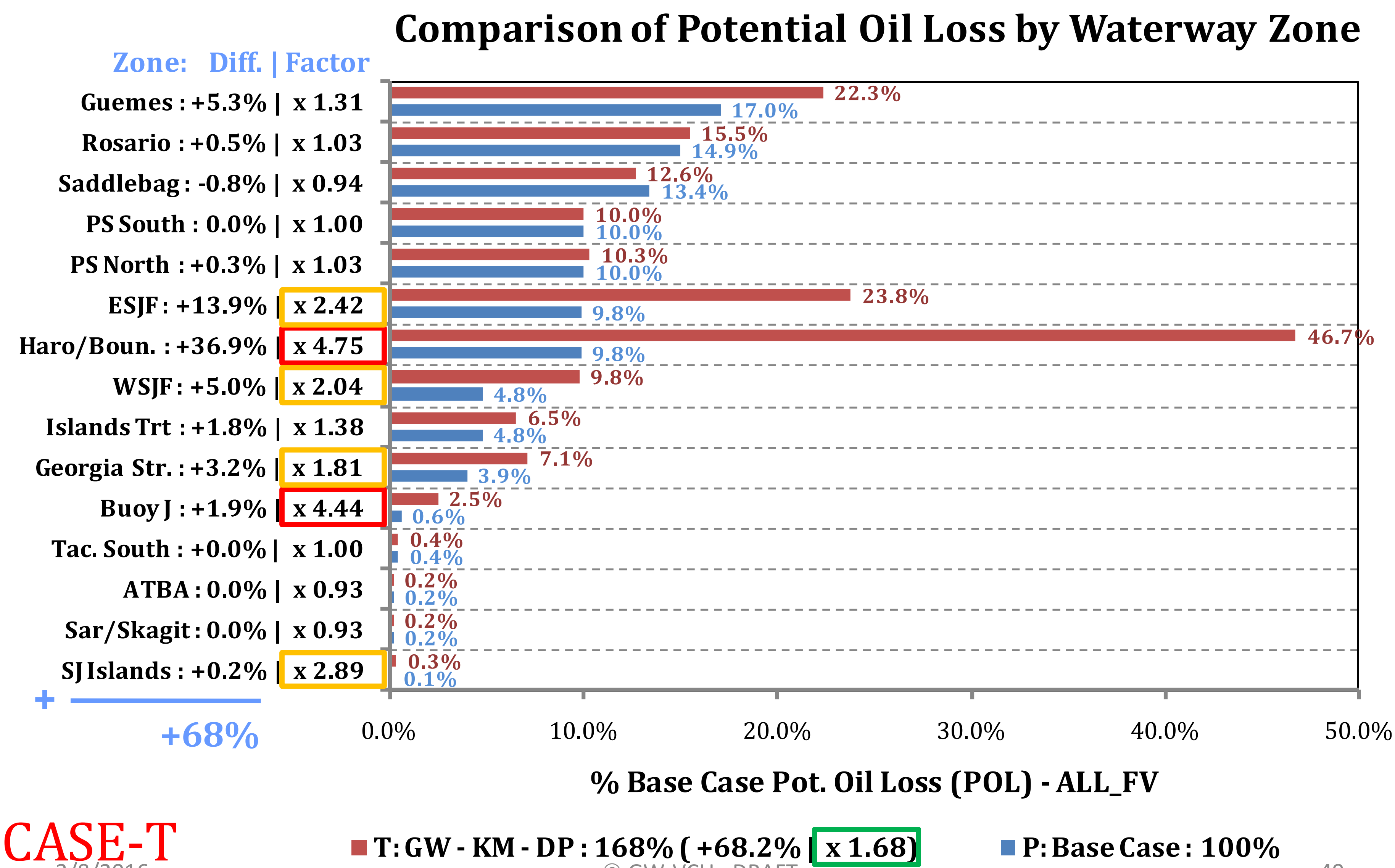
DEFINITION OF 15 WATERWAY ZONES



VTRA 2010 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. Islands Trt

VESSEL TRAFFIC RISK ASSESSMENT (VTRA) 2010



OUTLINE

1. Coin Tosses
2. Decision Making under Uncertainty
3. VTRA 2010
   - Base Case Traffic Description
   - What-If and Sensitivity Cases
4. Return Time Uncertainty

VTRA 2010 Analysis Approach

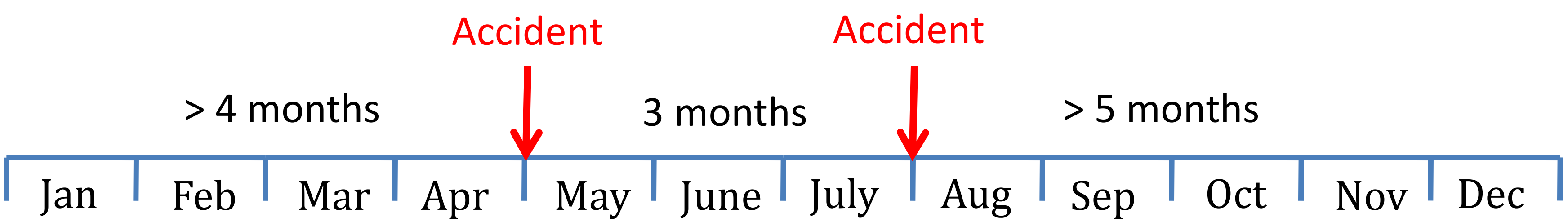
The ORIGINAL VTRA 2010 Study
did not evaluate average accident return times as its risk metric of choice.

Other Maritime Risk Studies, however,
do evaluate average accident return times as its risk metric of choice.

I am presenting this type of analysis here
to allow for a comparison between these studies.

Why did we not use average return times as risk metric of choice?

Imagine we have had two accidents in a calendar year and we would like to evaluate the "average return time" over that year

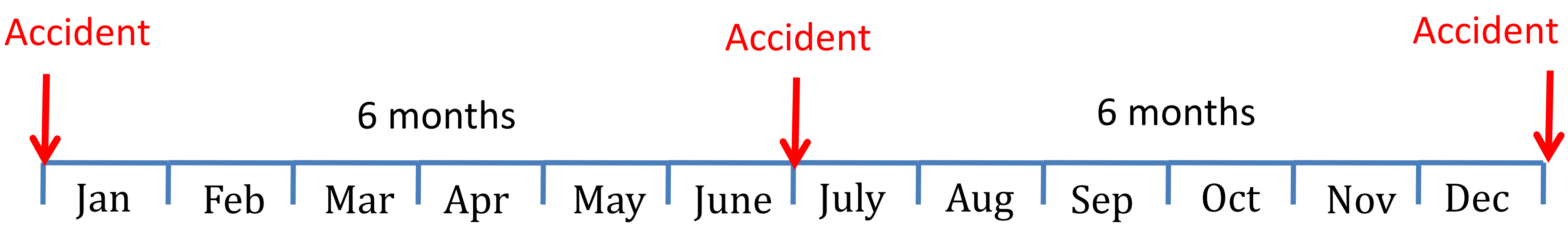


What is the value of the "average return time"?

$$> (4 + 3 + 5)/3 = 4 \text{ Months!!!}$$

Why did we not use average return times as risk metric of choice?

The prevailing wisdom, however, converts
2 accidents/year to
an "average return time" of
½ year = 6 months



Why did we not use average return times as risk metric of choice?

Conclusion? The definition:

Average Return Time = 1 / # Accidents per Year

Assumes that accidents are equally spaced, which they are not!!!

Some would argue:
"It's an average and thus this evens out in the long run"

This would only be true if
Accidents per year is large, which does not apply to low probability – high consequence events!!!

Why did we not use average return times as risk metric of choice?

Suppose you have multiple years of data

"Average Return Time" = 1 / # Accidents per Year

	# Accidents per year	Average Return Time
Year 1	1	12 months
Year 2	4	3 months
Year 3	4	3 months
Average	3	6 months

But: 1/3 year = 4 months

Conclusion?

1/ Average (# Accidents per Year) < Average (Average Return Time)

Both methods are used to evaluate average return times which only adds to confusion!

Evaluating average return uncertainty

Recall VTRA 2010 Maritime Simulation Model generated

- 1.8 Million Vessel to Vessel Traffic Situations **per Year**
- 10 Million Vessel to Shore Traffic Situations **per Year**

Used VTRA 2010 Model to create table of following format

	POTENTIAL OIL LOSS VOLUME (m^3) CATEGORY		
Accident Probability per Traffic Situation	(1000 - 7500]	(7500 - 15000]	(15000 or More)
1 e -10	N_1	N_2	N_3
1 e -9	N_4	N_5	N_6
1 e -8	N_7	N_8	N_9

Evaluating average return uncertainty

	POTENTIAL OIL LOSS VOLUME (m^3) CATEGORY		
Accident Probability per Traffic Situation	(1000 - 7500]	(7500 - 15000]	(15000 or More)
1 e -10	N_1	N_2	N_3
1 e -9	N_4	N_5	N_6
1 e -8	N_7	N_8	N_9

Recall coin Toss Analogy

"Probability of Tails"

"Trials"

Sample # Accidents per year using Coin Toss Analogies

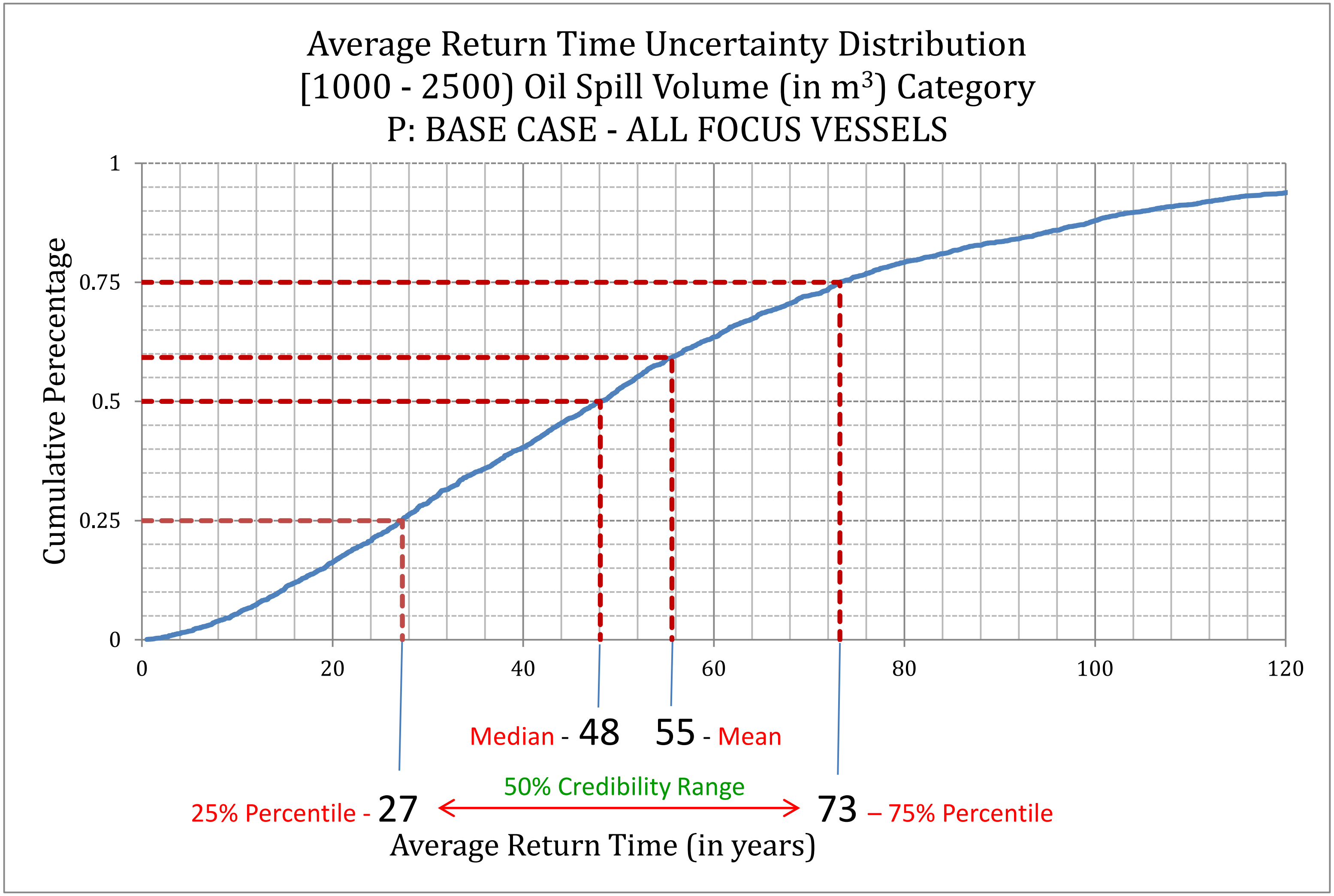
Step 1

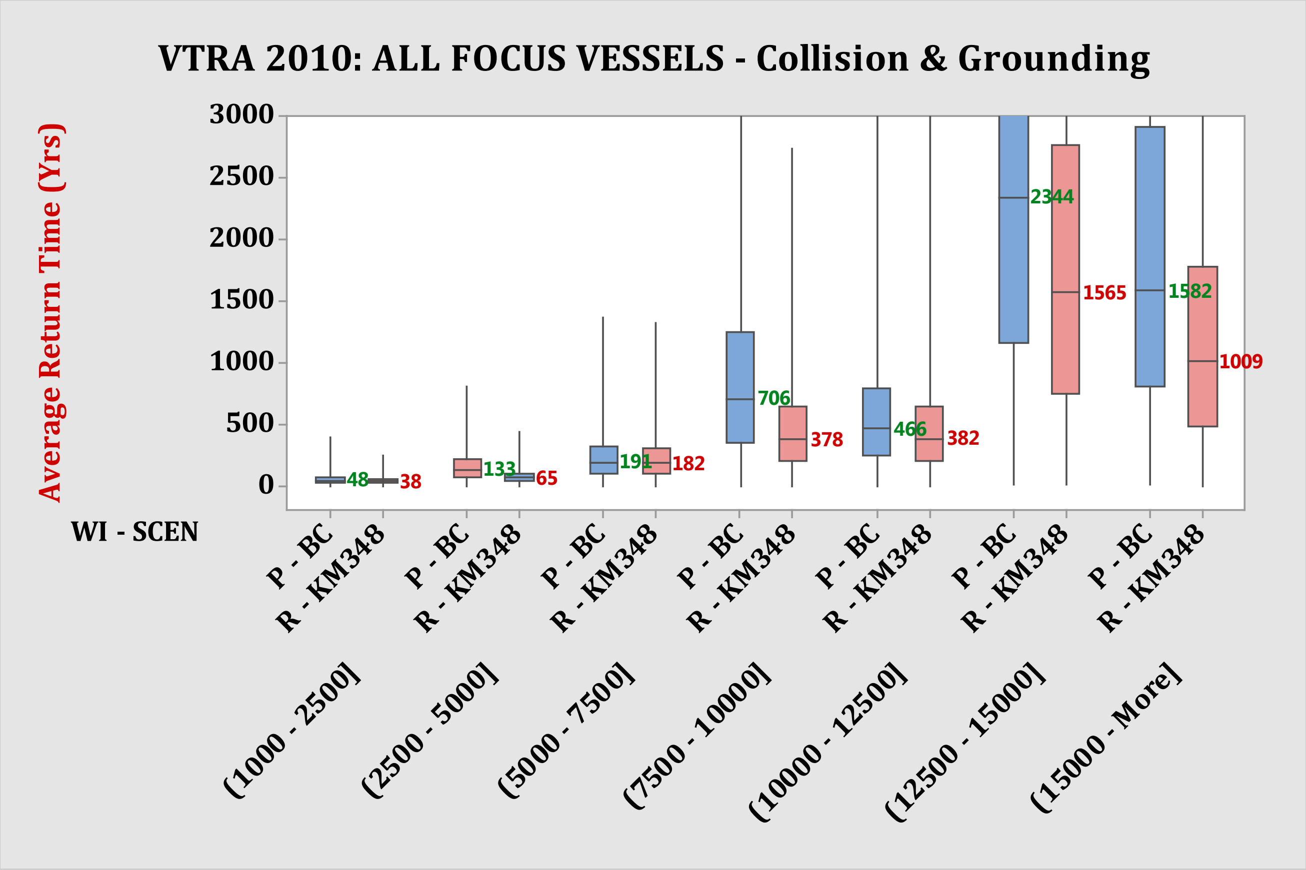
Set Average Return Time = 1/ # Accidents per year

Step 2

Repeat Step 1 and Step 2 (2500 Samples)

Explanation Average Return Time Statistics





UNCERTAINTY ANALYSIS AVERAGE RETURN TIMES BY SPILL SIZE CATEGORY – ALL FOCUS VESSELS

Comments for interpretation:

1. Spill Sizes are evaluated in **cubic meters**.
2. Average Return Time are evaluated in **years**.
3. Labels are **median values** of average return times.
4. Boxes provide **50% credibility range** of average return times.
5. **Average Return Time Uncertainty** tends to increase with spill size.
6. Observe **significant difference** in average return times in the following spill size categories:

(2500 – 5000],
(7500 – 10000],
(12500 – 15000],
(15000 – More).

QUESTIONS?