Forecasting Oil Spills in Extreme Oceanographic Environments

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Contents

1. **Project motivation**
2. **What are ‘extreme’ oceanographic conditions?**
3. **Modelling the Ocean**
4. **What About the Oil?**

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Contents

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Project motivation

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Deepwater Horizon spilled…

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Deepwater Horizon spilled…

780,000 cubic metres of oil…

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Deepwater Horizon spilled…

… or 4.9 million barrels…

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Deepwater Horizon spilled…

…or 206 million gallons…

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…with that amount in petrol…

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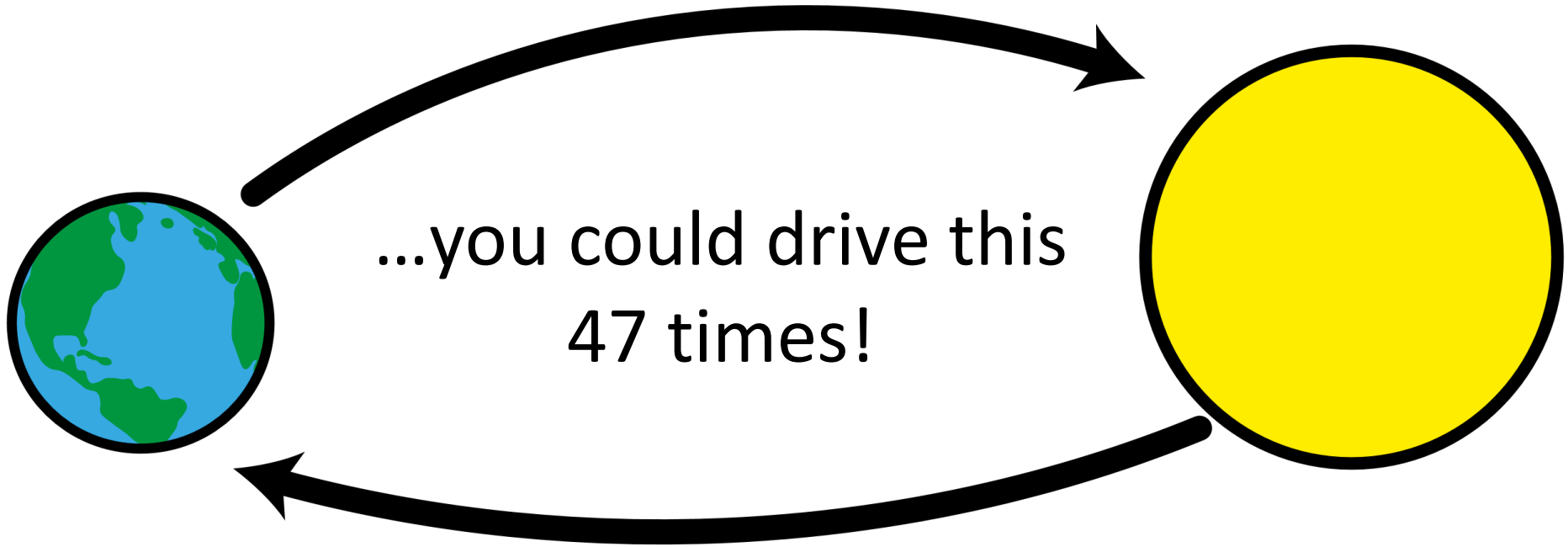

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- The Faroe-Shetland Channel is a primary UK Location for future oil exploration

- Can we reliably forecast spills in this area?

‘Extreme’… really?

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Faroe-Shetland Channel: Physics

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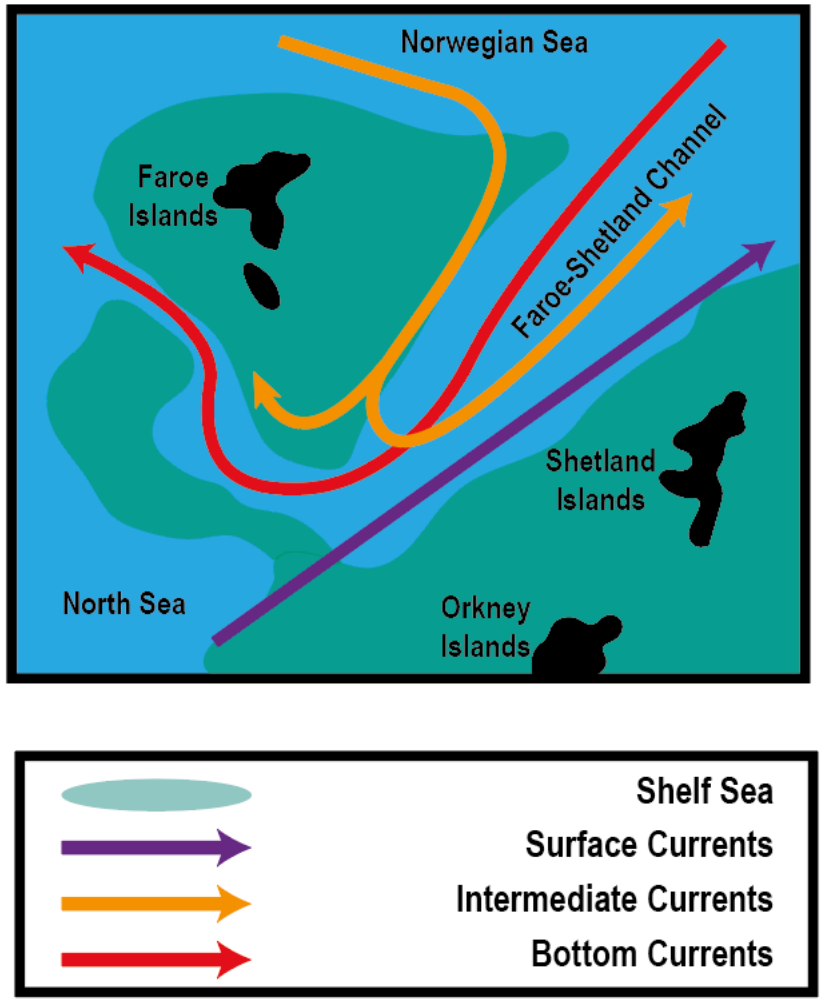
Faroe-Shetland Channel: Physics

- **Complex Circulation**



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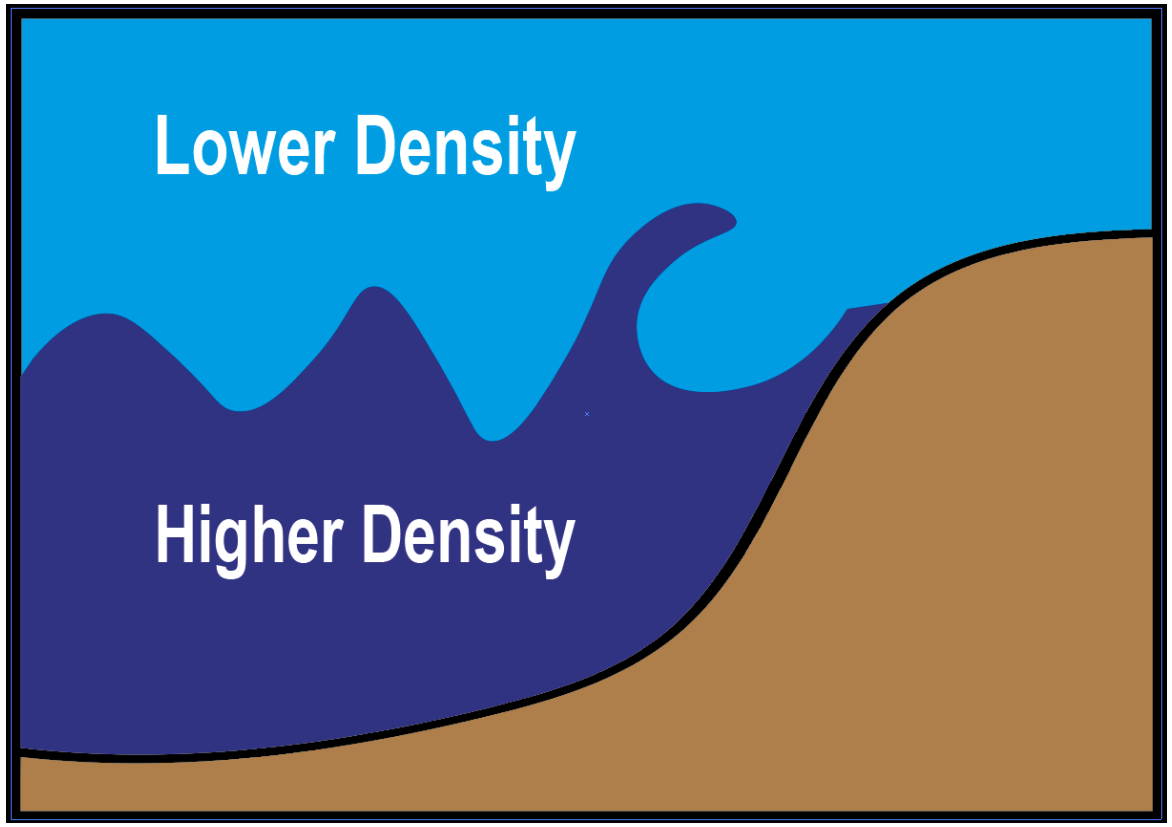
Faroe-Shetland Channel: Physics

- Complex Circulation
- **Internal wave breaking**



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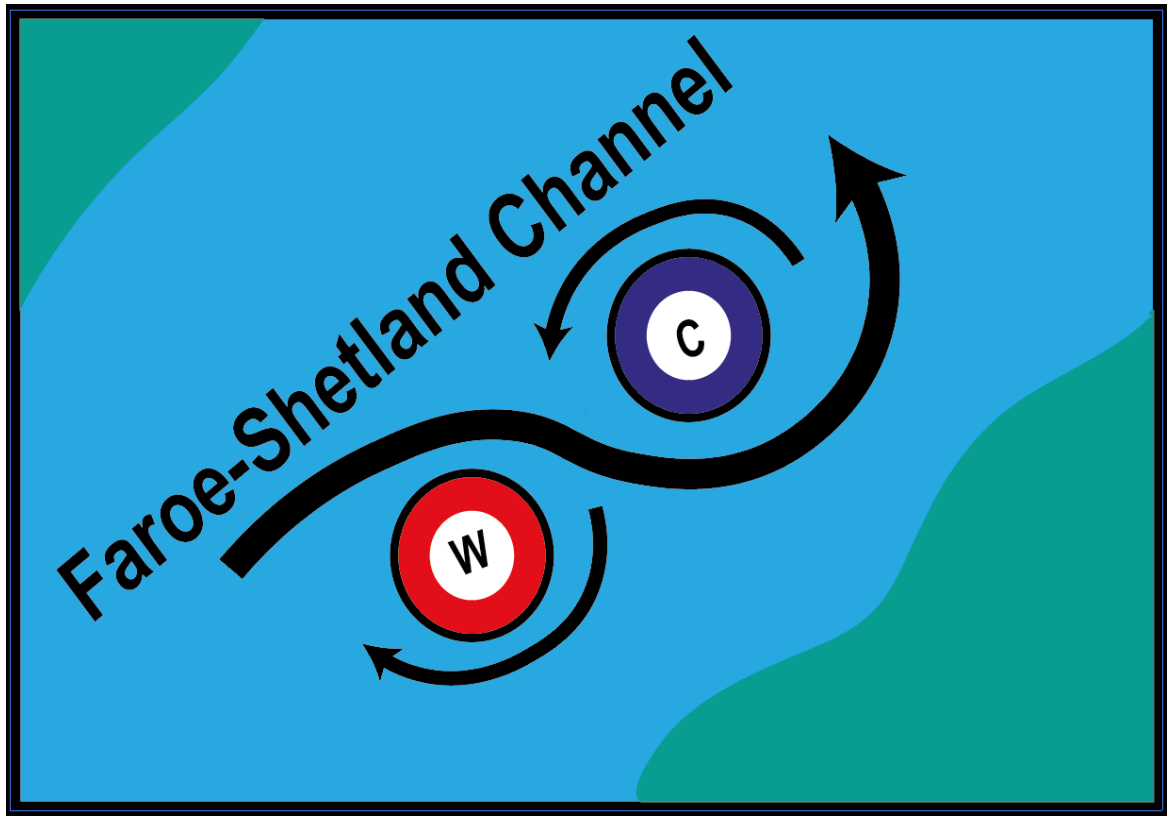
Faroe-Shetland Channel: Physics

- Complex Circulation
- Internal wave breaking
- **Eddies, meanders…**



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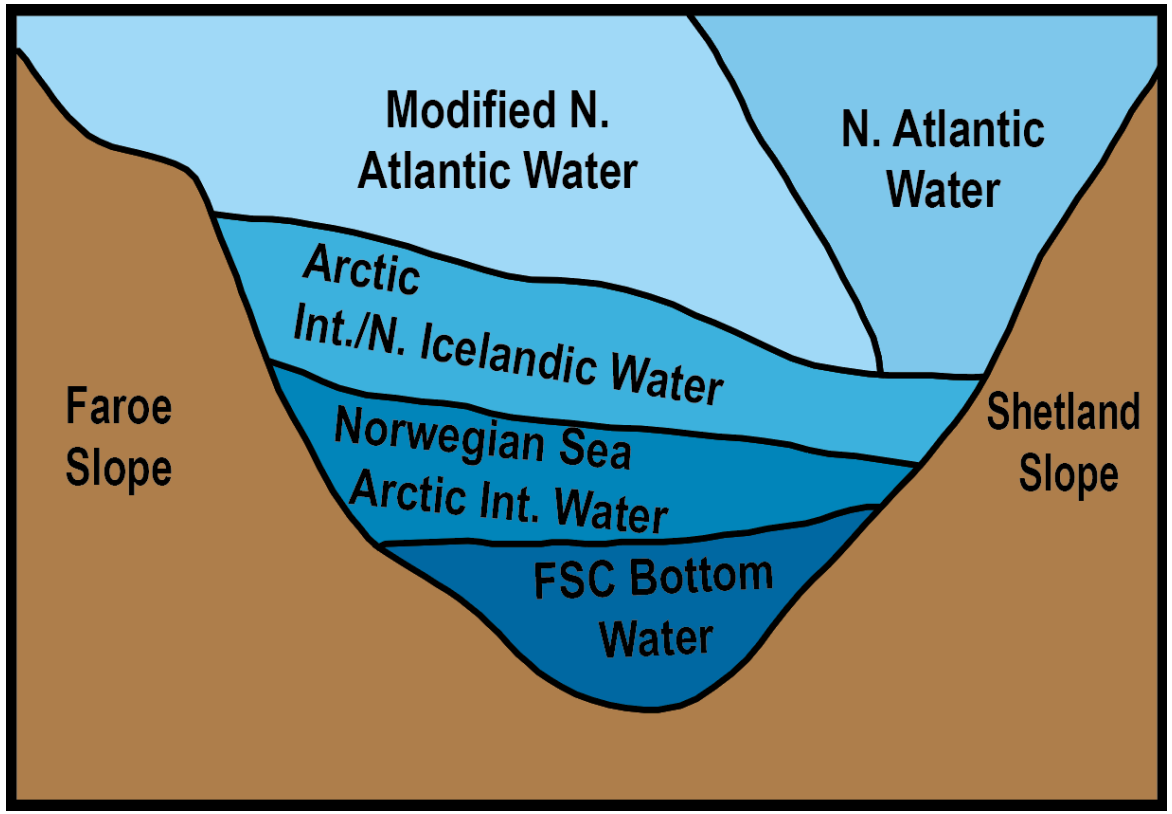
Faroe-Shetland Channel: Physics

- Complex Circulation
- Internal wave breaking
- Eddies, meanders…
- **Strong stratification**



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Faroe-Shetland Channel: Physics

- Complex Circulation
- Internal wave breaking
- Eddies, meanders…
- Strong stratification
- **Stormy weather**

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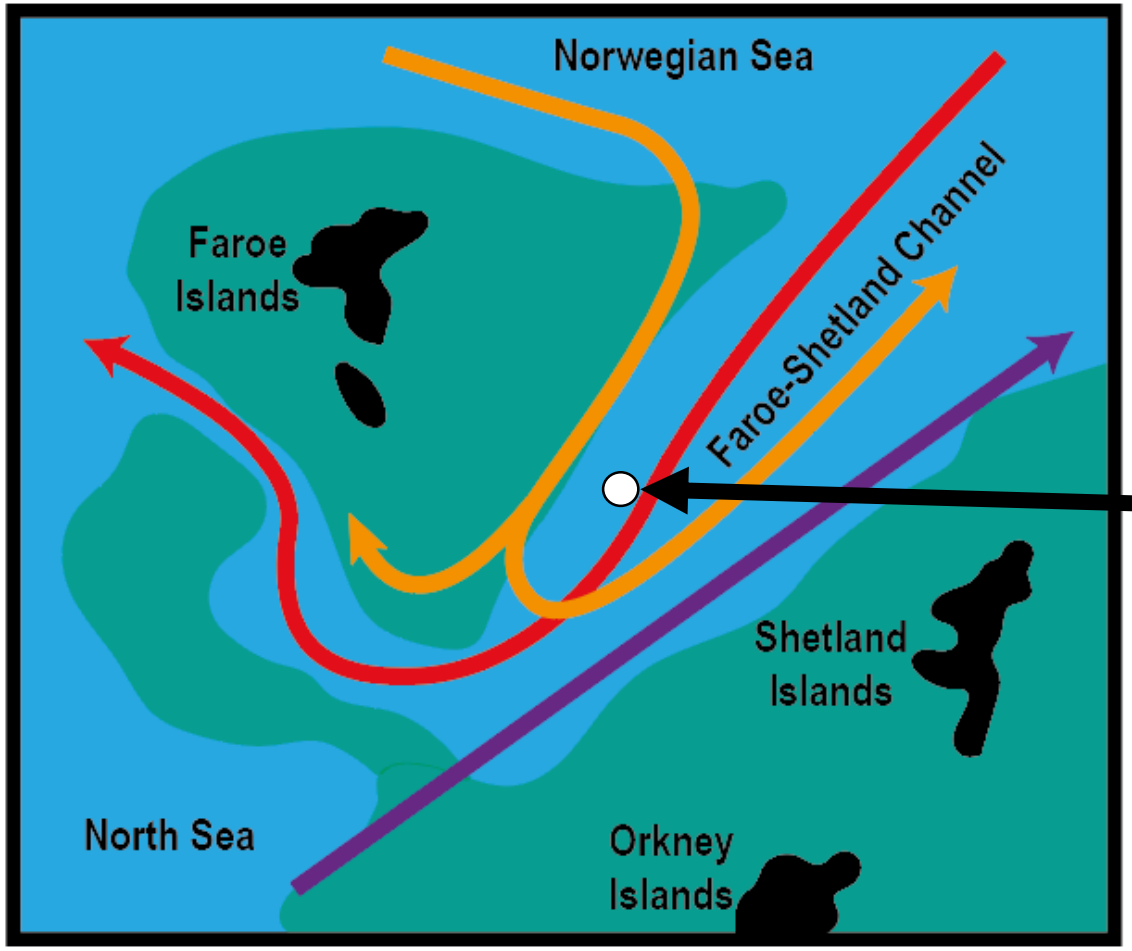

What if a spill happened here?

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Modelling the Ocean

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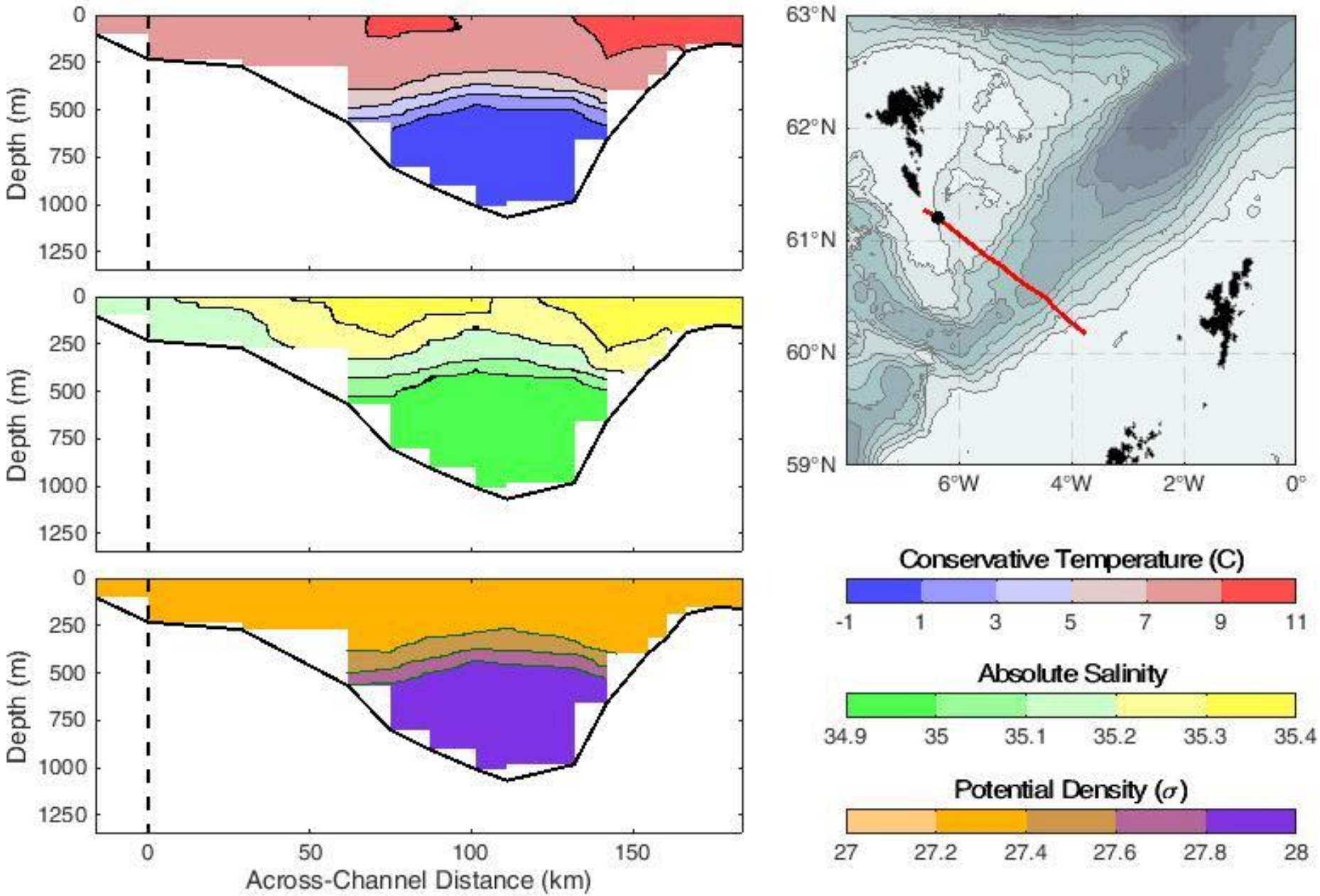
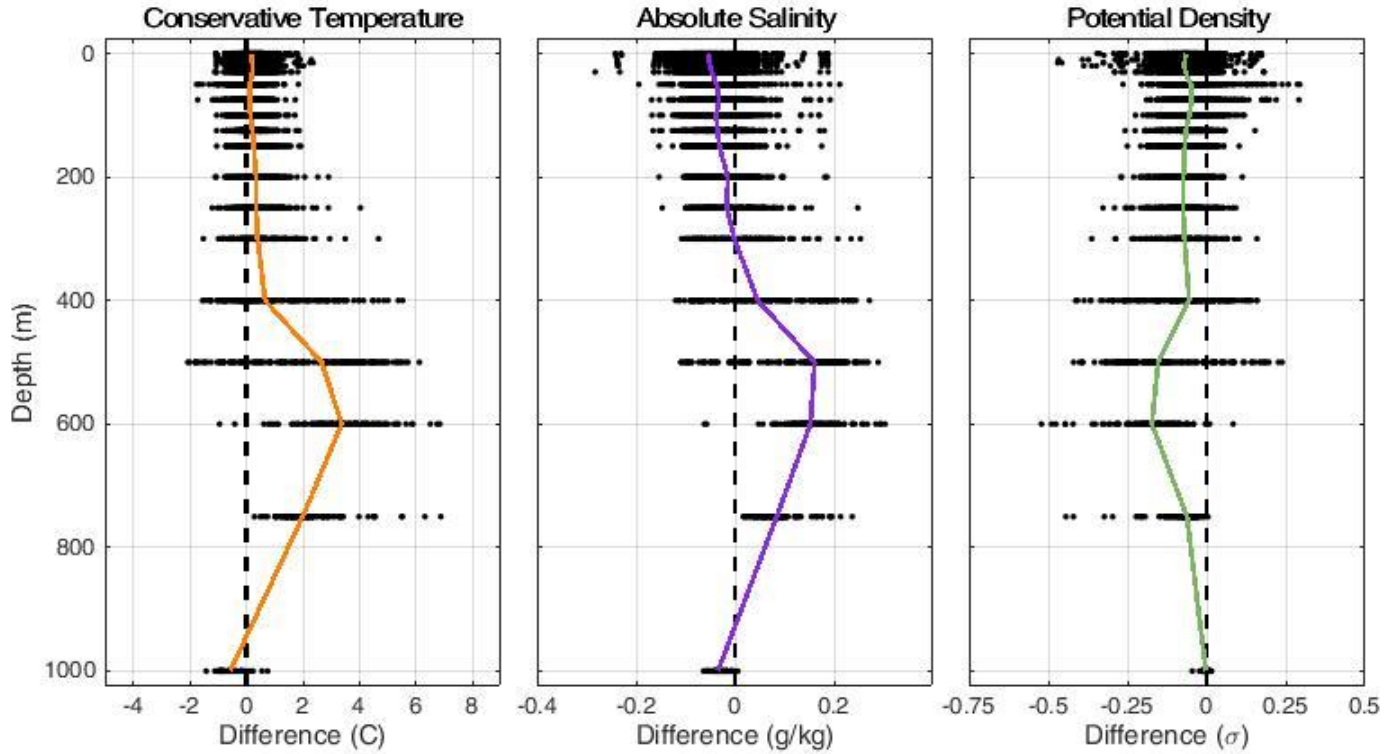
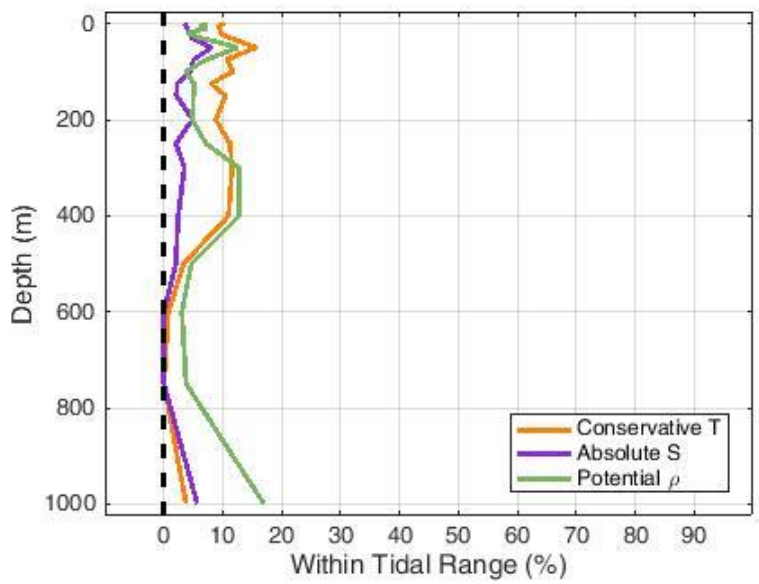
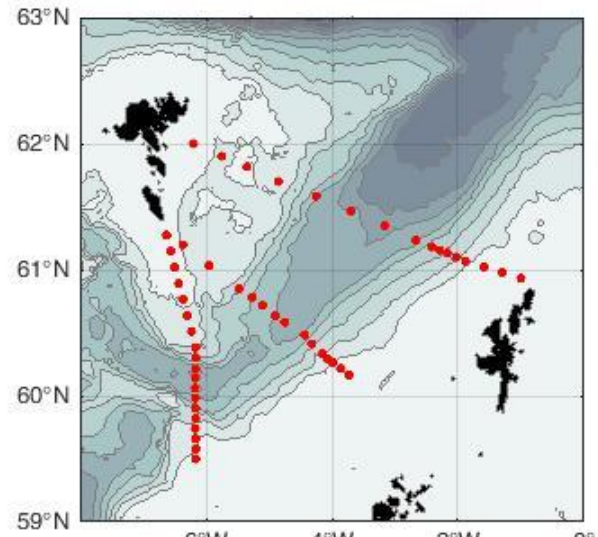
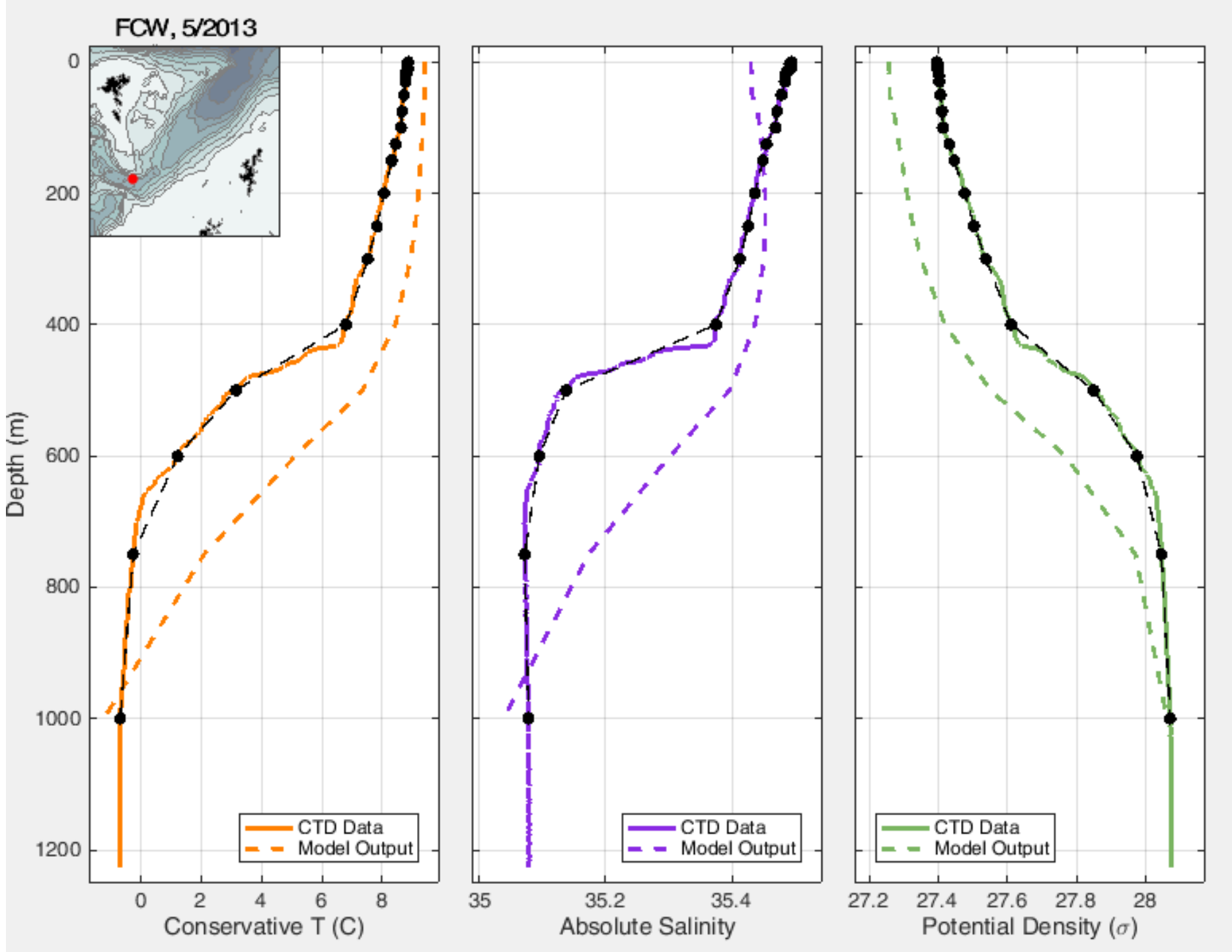

Depth (m)
0
250
500
750
1000
1250
0
50
100
150
Across-Channel Distance (km)
63°N
62°N
61°N
60°N
59°N
6°W
4°W
2°W
0°
Conservative Temperature (C)
-1
1
3
5
7
9
11
Absolute Salinity
34.9
35
35.1
35.2
35.3
35.4
Potential Density (σ)
27
27.2
27.4
27.6
27.8
28


Conservative Temperature
Absolute Salinity
Potential Density
Depth (m)
0
200
400
600
800
1000
-4 -2 0 2 4 6 8
Difference (C)
-0.4 -0.2 0 0.2
Difference (g/kg)
-0.75 -0.5 -0.25 0 0.25 0.5
Difference (σ)


Depth (m)
0
200
400
600
800
1000
0 10 20 30 40 50 60 70 80 90
Within Tidal Range (%)
Conservative T
Absolute S
Potential ρ


63°N
62°N
61°N
60°N
59°N
6°W
4°W
2°W
0°


FCW, 5/2013
Depth (m)
0
200
400
600
800
1000
1200
CTD Data
Model Output
0
2
4
6
8
Conservative T (C)
CTD Data
Model Output
35
35.2
35.4
Absolute Salinity
CTD Data
Model Output
27.2
27.4
27.6
27.8
28
Potential Density (σ)

What About the Oil?

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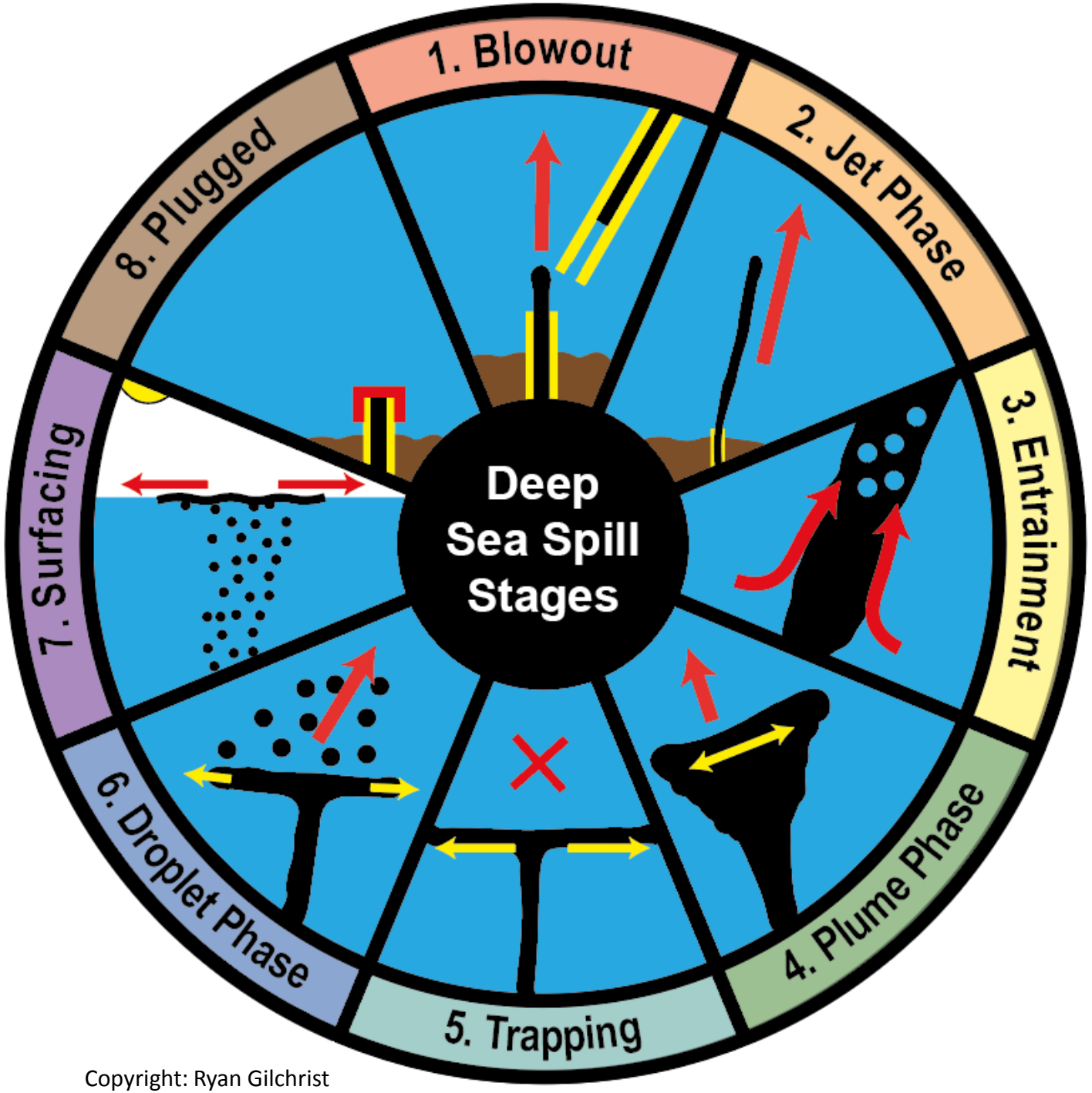

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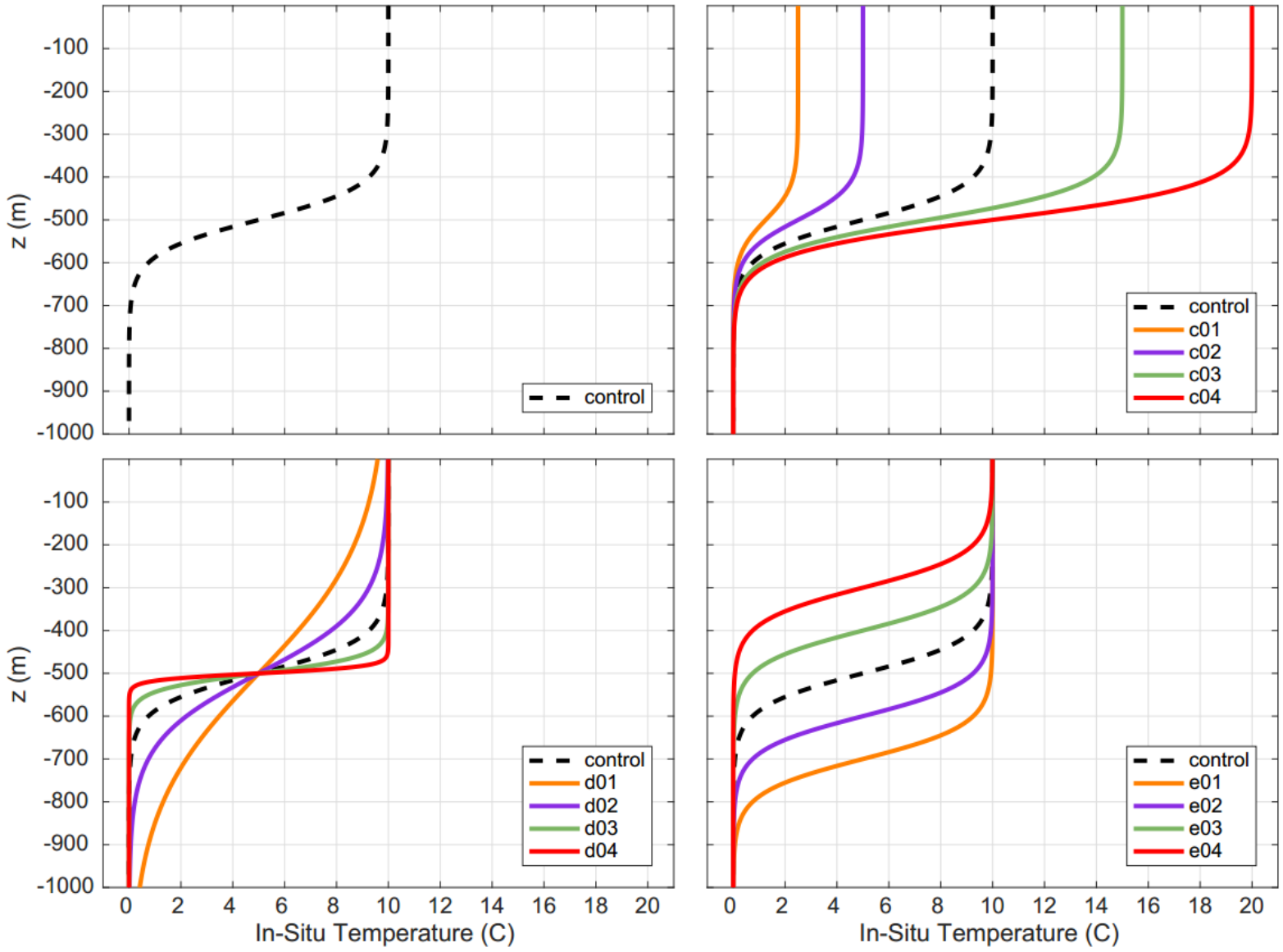
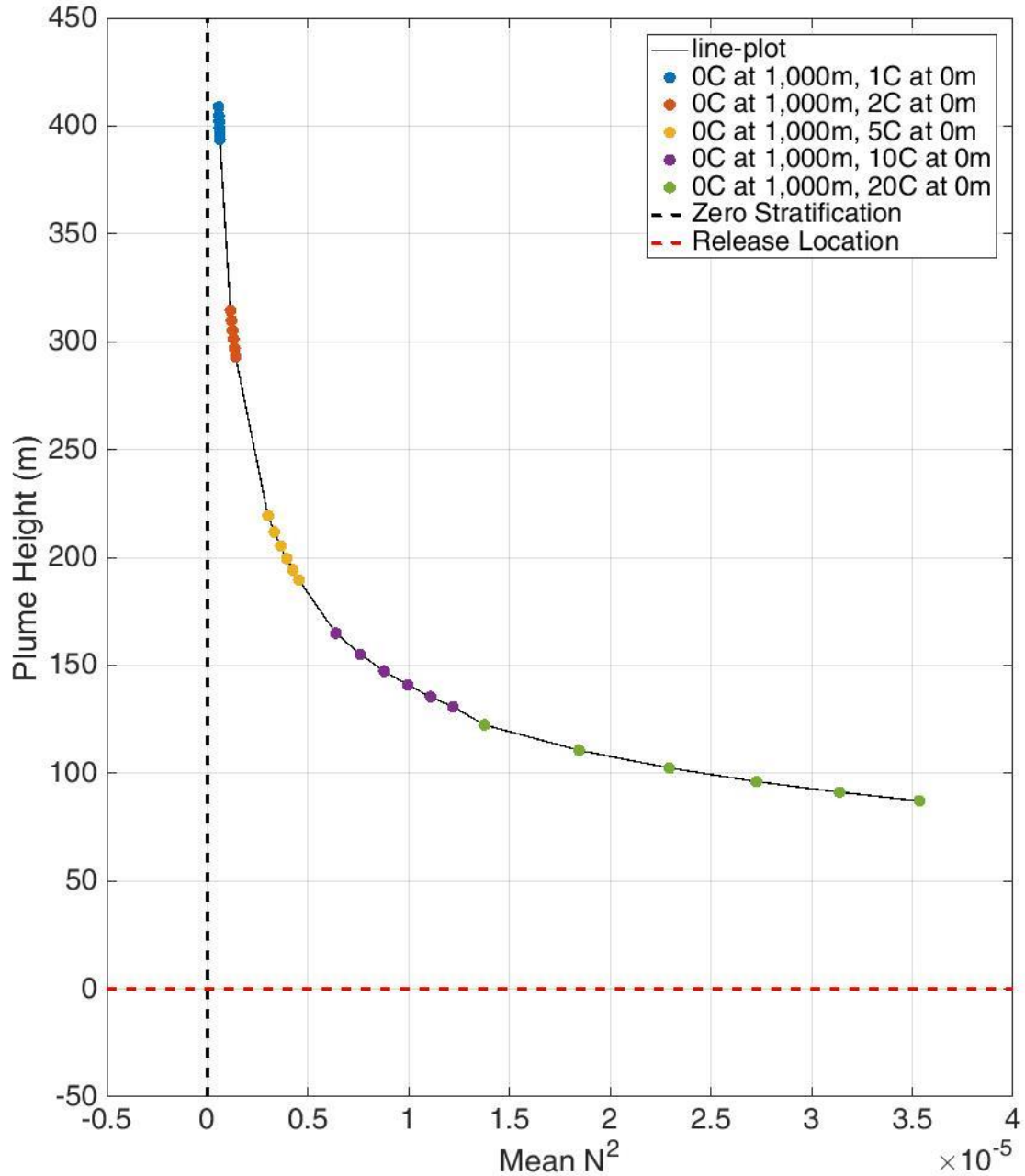
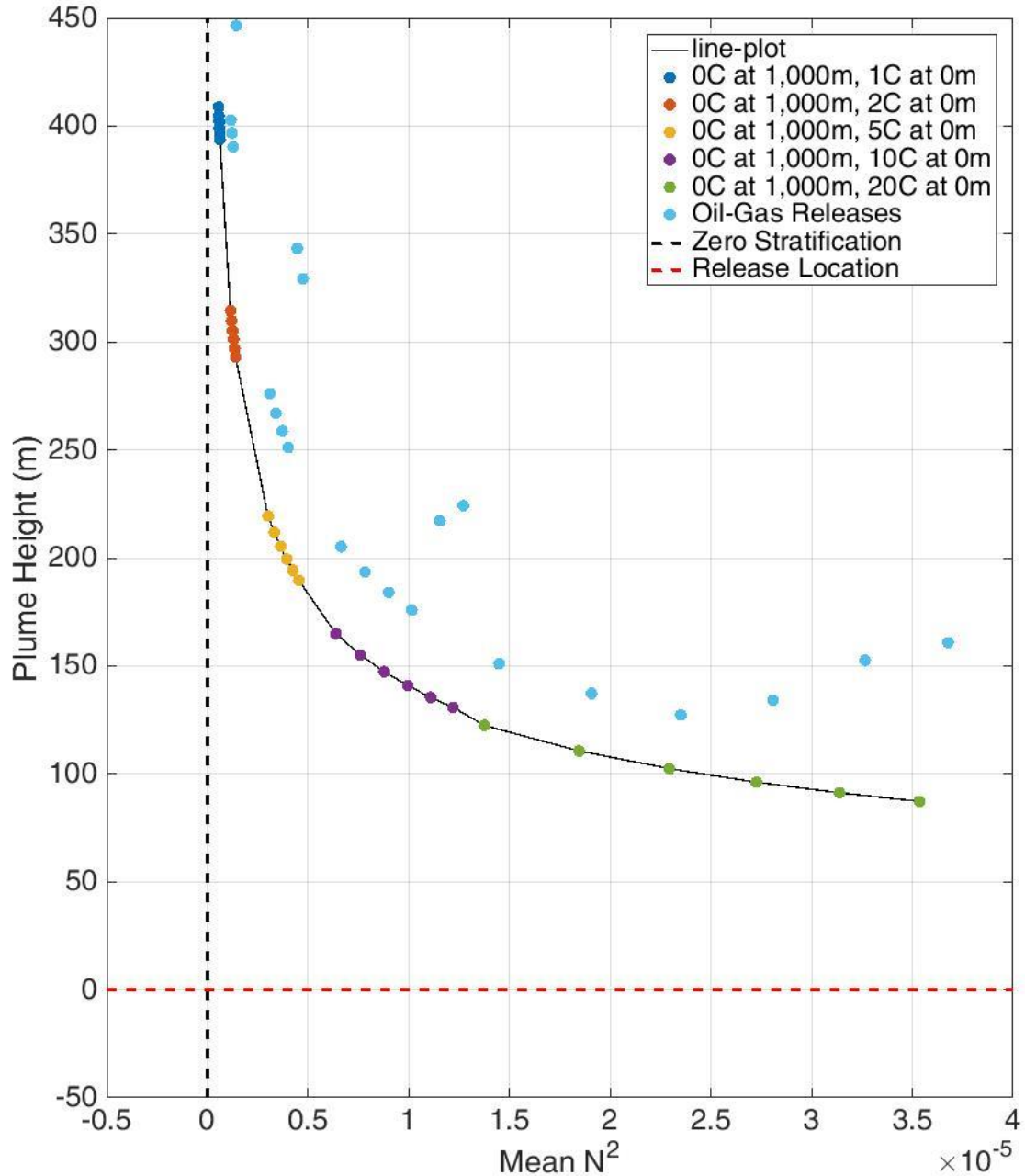
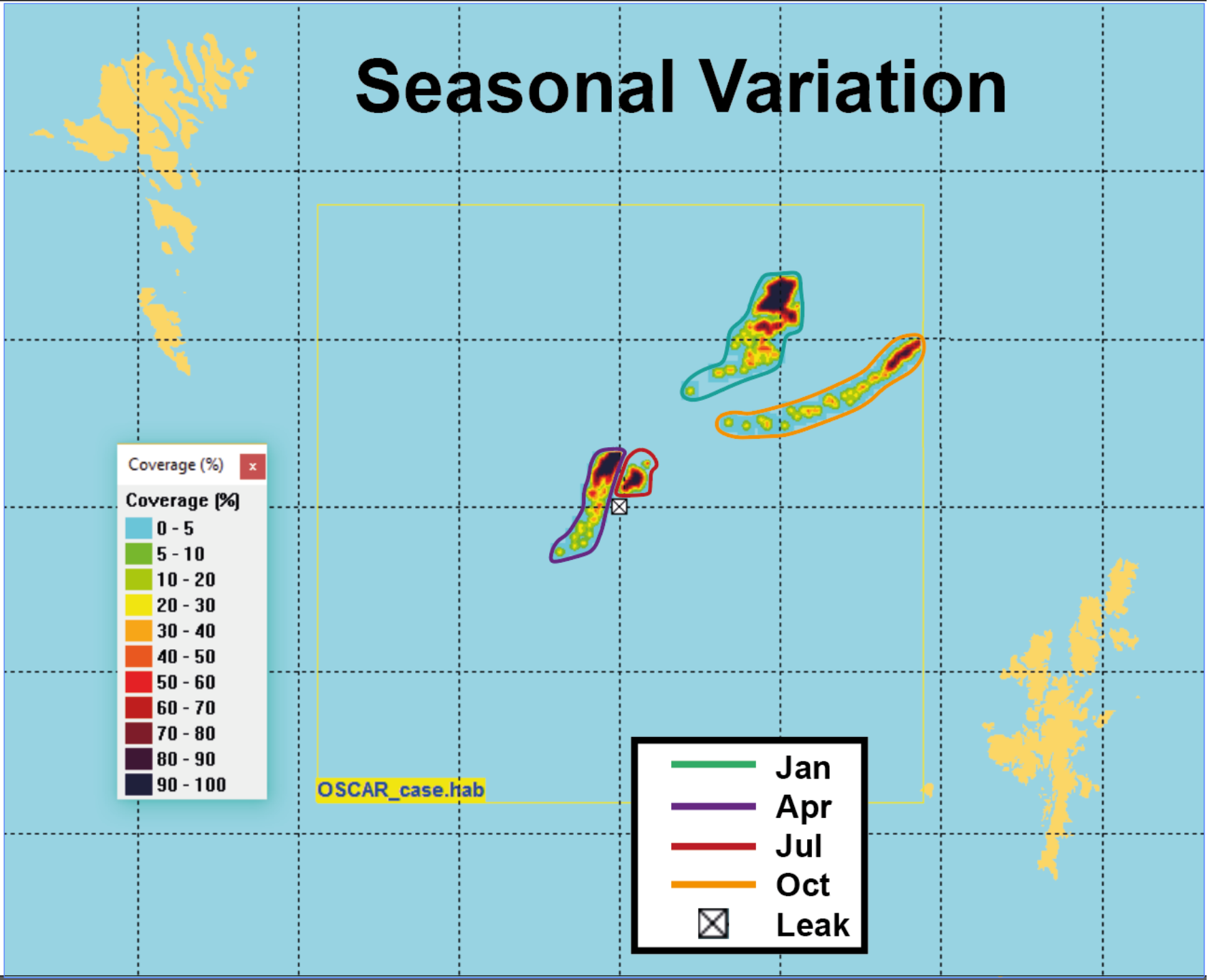


… and no stratification/linear temperature gradients


line-plot
0C at 1,000m, 1C at 0m
0C at 1,000m, 2C at 0m
0C at 1,000m, 5C at 0m
0C at 1,000m, 10C at 0m
0C at 1,000m, 20C at 0m
Zero Stratification
Release Location
Plume Height (m)
Mean N2
×10-5
450
400
350
300
250
200
150
100
50
0
-50
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4


line-plot
0C at 1,000m, 1C at 0m
0C at 1,000m, 2C at 0m
0C at 1,000m, 5C at 0m
0C at 1,000m, 10C at 0m
0C at 1,000m, 20C at 0m
Oil-Gas Releases
Zero Stratification
Release Location
Plume Height (m)
Mean N2
×10-5
450
400
350
300
250
200
150
100
50
0
-50
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4



Location of oil five days after a release

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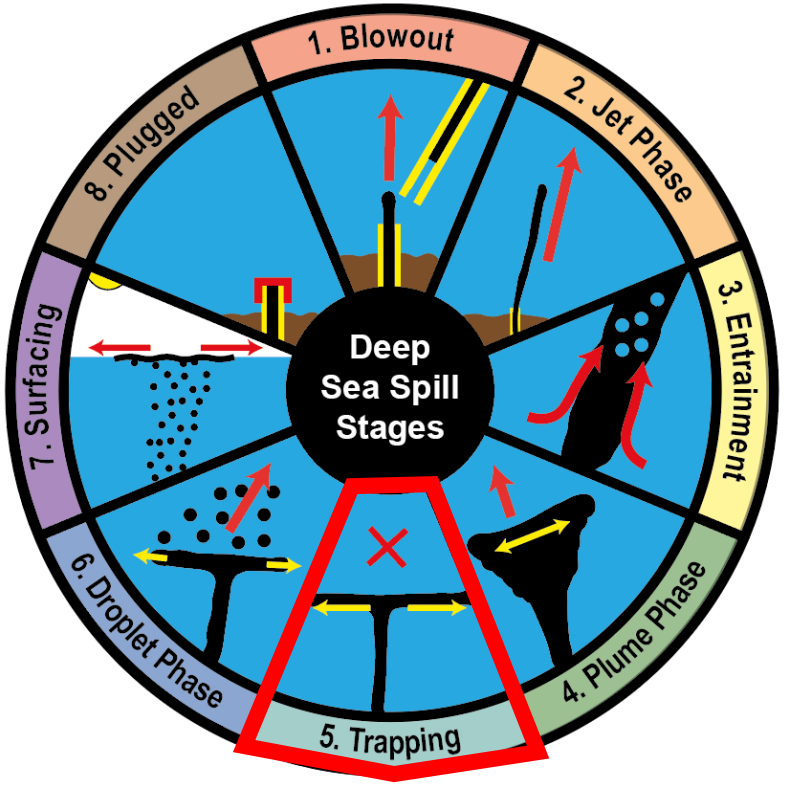
Research Questions

What influence does stratification have on the depth in which pollutant trapping occurs?



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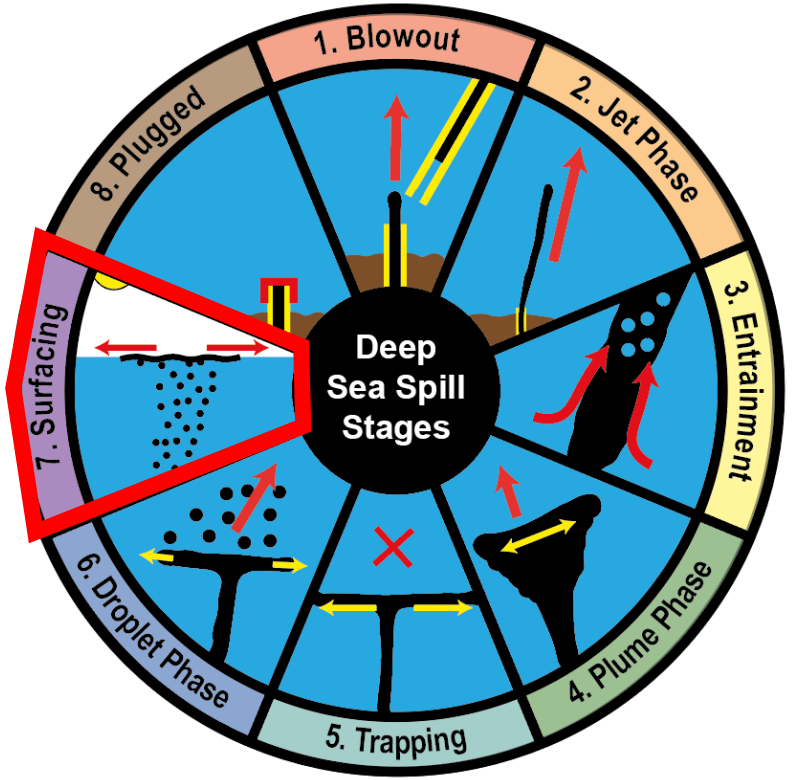

How does the complex circulation within the channel influence oil trajectory and fate?

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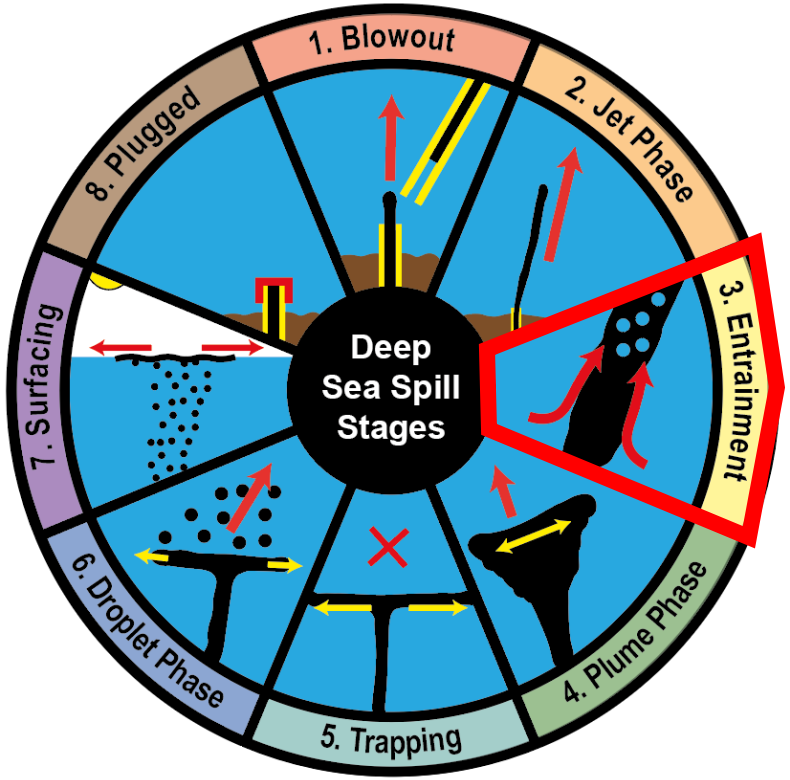
Research Questions

What influence does stratification have on the depth in which pollutant trapping occurs?

How does the complex circulation within the channel influence oil trajectory and fate?

Do mesoscale eddies enhance or inhibit water entrainment and oil dispersion?



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