UNRAVELING ECOLOGICAL HOTSPOTS USING LAGRANGIAN COHERENT STRUCTURES IN THE CENTRAL CALIFORNIA WIND ENERGY AREA

Mazen M. Idriss[1], Casper N. Pratt[1], Andres E. Rocha Jayasinha[2], Ian Robbins[3], Leah Hoogstra[2], Ryan K. Walter[4], Paul F. Choboter[2]

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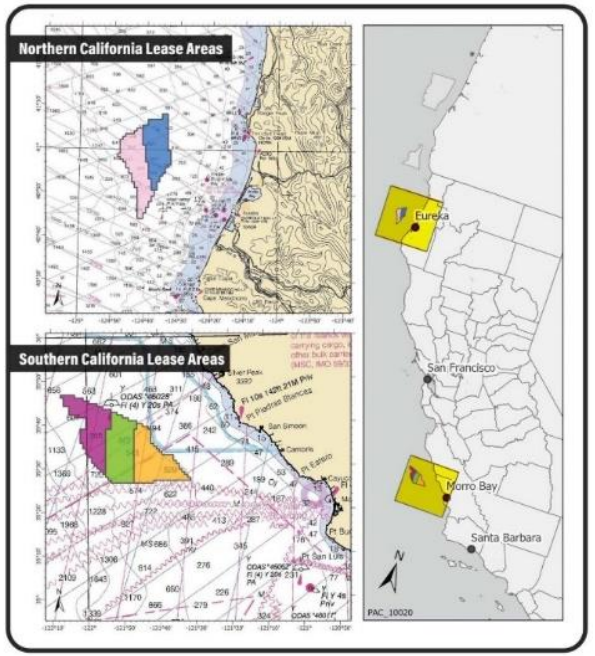
MORRO BAY WIND ENERGY AREA (WEA)

- SB 100 for CA Energy Requirements In Response to Climate Change
  - 60% Renewable / Zero Carbon by 2030
  - 100% Renewable / Zero Carbon by 2045
  - Potential to Power 1,000,000+ Homes
- Need to Understand and predict Ecological Impacts (fisheries, whales, oil spills, etc.)

Provisional Winners of the California Lease Areas, $757,100,000 in High Bids

LEASE AREA		
OCS-P0561	RWE Offshore Wind Holding, LLC	$157,700,000
OCS-P0562	California North Floating LLC	$173,800,000
OCS-P0563	Equinor Wind US LLC	$130,000,000
OCS-P0564	Central California Offshore Wind LLC	$150,300,000
OCS-P0565	Invenergy California Offshore LLC	$145,300,000

BOEM Bureau of Ocean Energy Management



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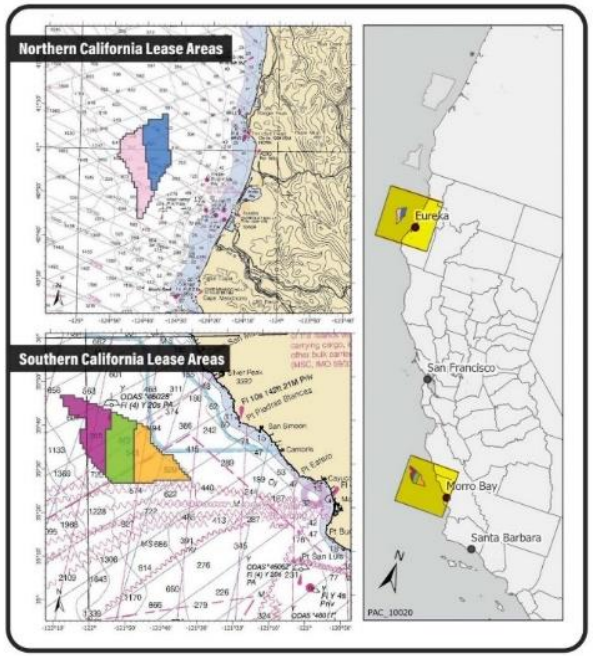
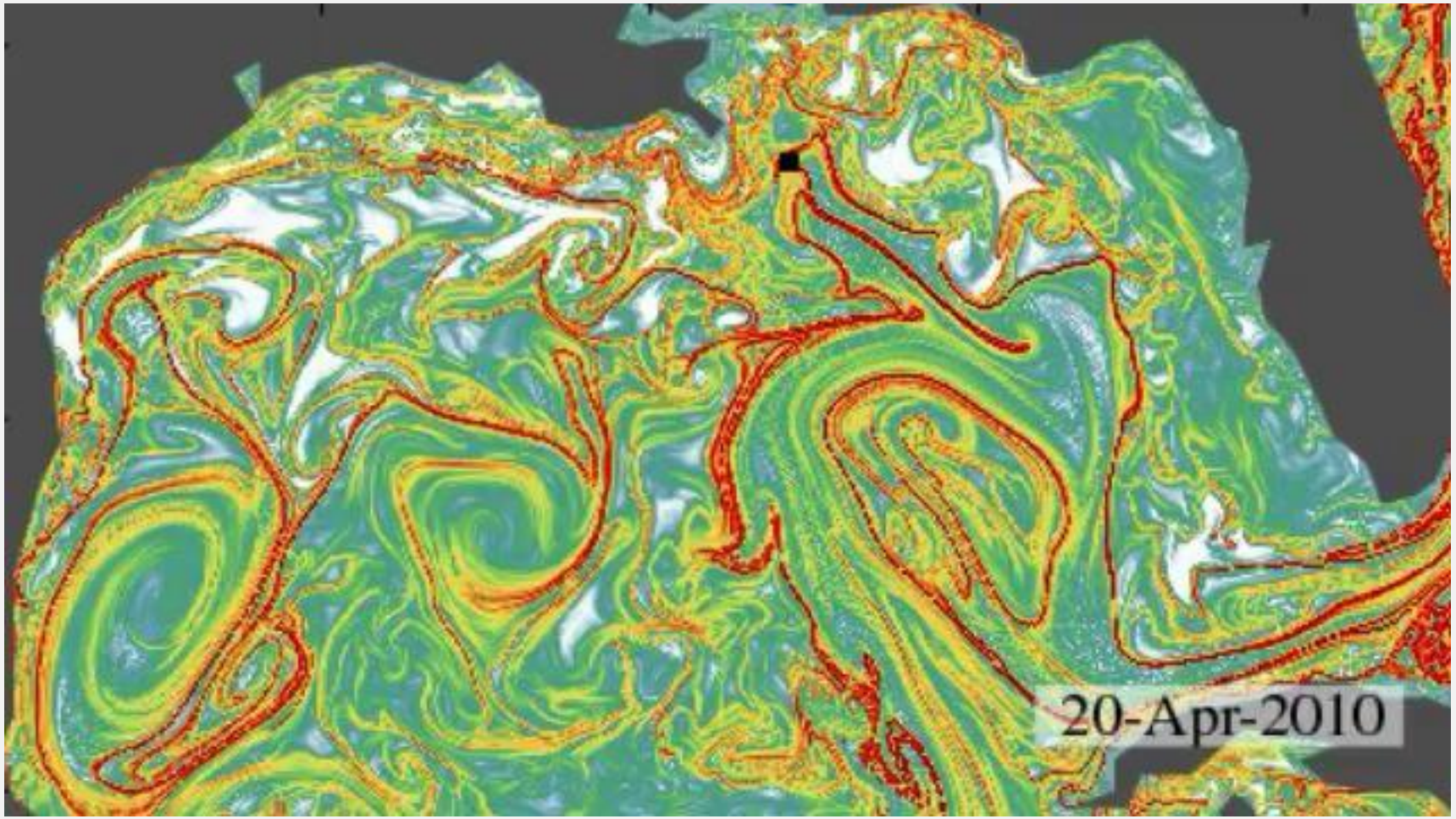


DEEPWATER HORIZON OIL SPILL: LAGRANGIAN COHERENT STRUCTURES



https://www.youtube.com/watch?v=cqSoLW2_CPg

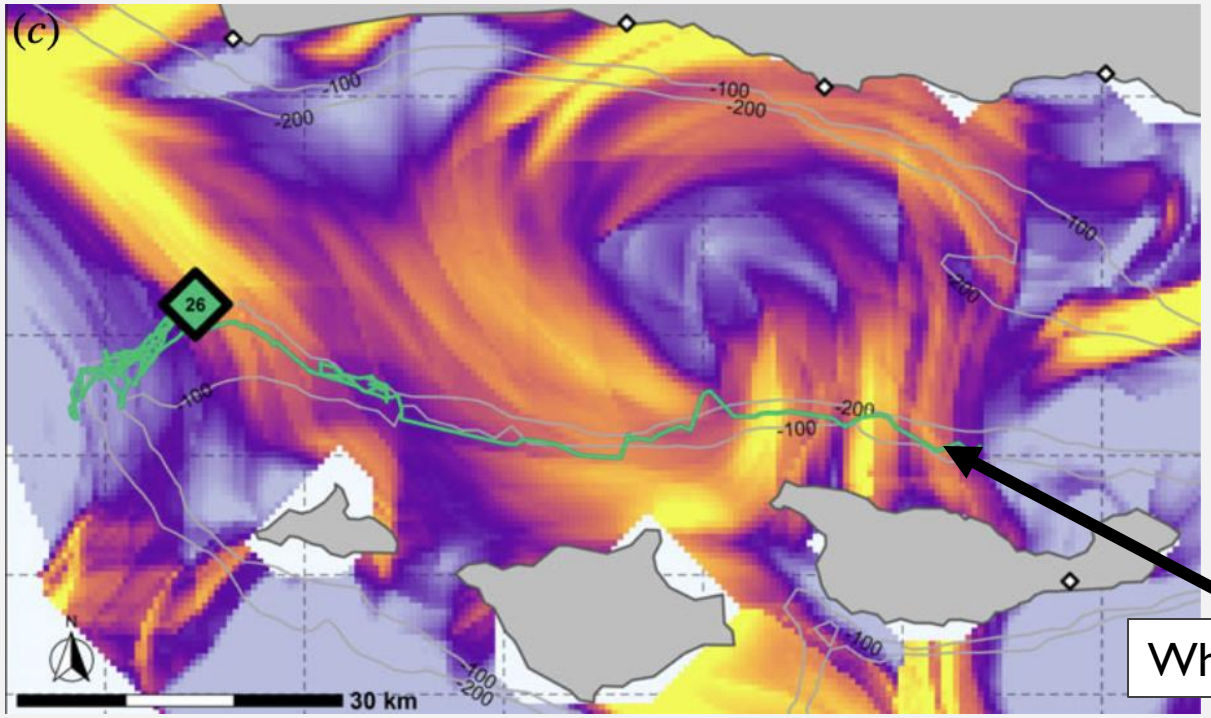
Blue whales increase feeding rates at fine-scale ocean features

James A. Fahlbusch[1,2], Max F. Czapanskiy[1], John Calambokidis[2], David E. Cade[1], Briana Abrahms[3], Elliott L. Hazen[1,4] and Jeremy A. Goldbogen[1]

Fishermen Follow Fine-Scale Physical Ocean Features for Finance

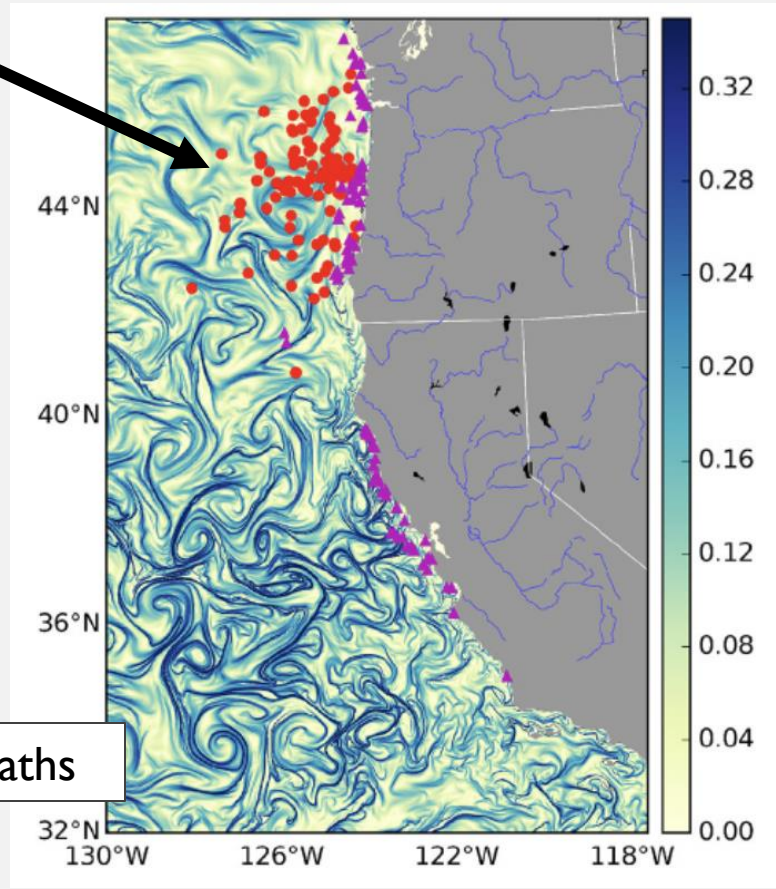
James R. Watson[1,2], Emma C. Fuller[3], Frederic S. Castruccio[4] and Jameal F. Samhouri[5]*

[1] College of Earth, Ocean and Atmospheric Sciences, Oregon State University, Corvallis, OR, United States, [2] Stockholm Resilience Centre, Stockholm University, Stockholm, Sweden, [3] Department of Ecology and Evolutionary Biology, Princeton University, Princeton, NJ, United States, [4] Climate and Global Dynamics Group, National Center for Atmospheric Research, Boulder, CO, United States, [5] Northwest Fisheries Science Center, National Oceanic and Atmospheric Administration, Seattle, WA, United States



Fisheries

Whale Feeding Paths

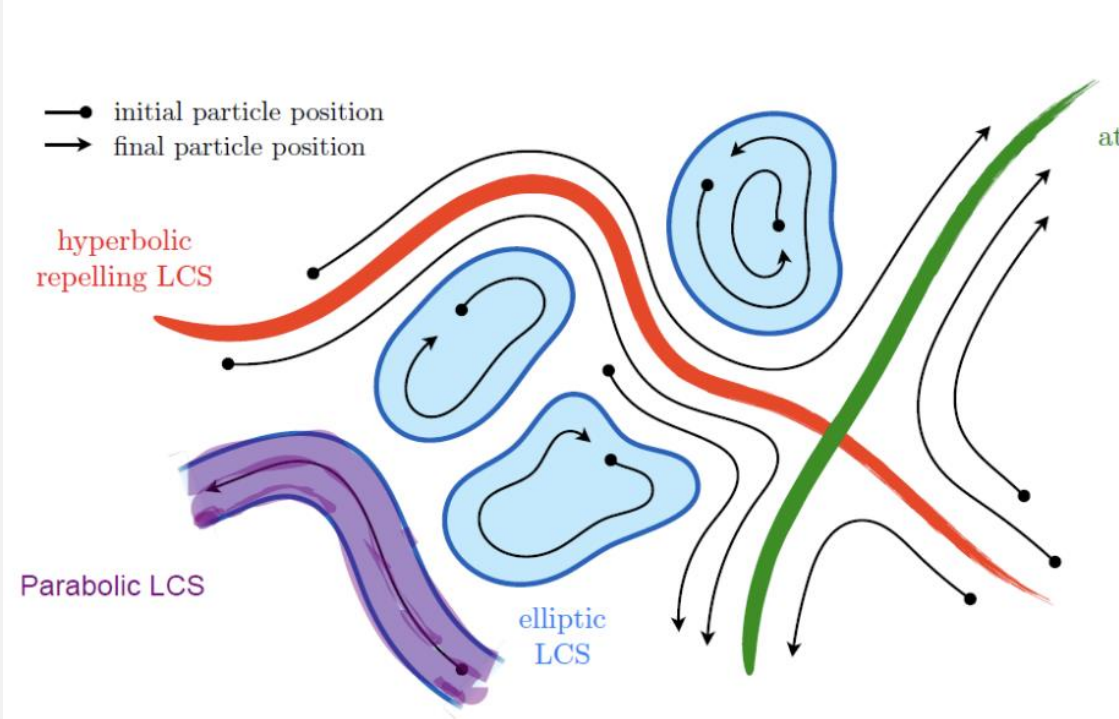


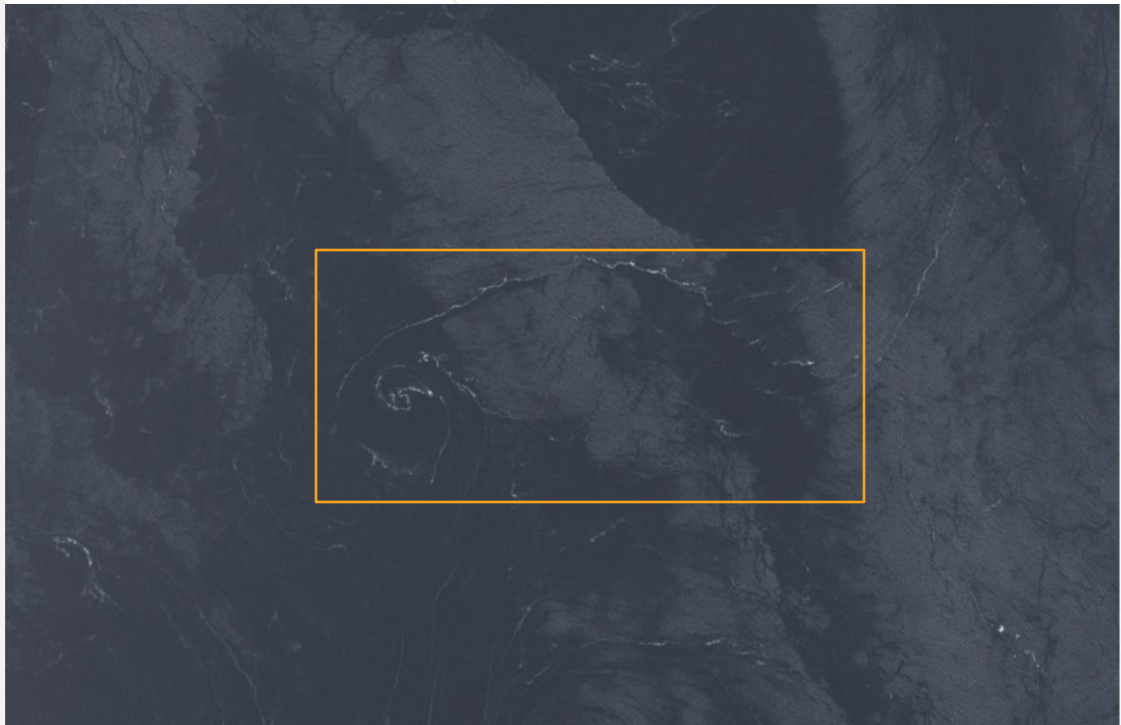
LAGRANGIAN COHERENT STRUCTURES (LCS)

Definition of LCS:

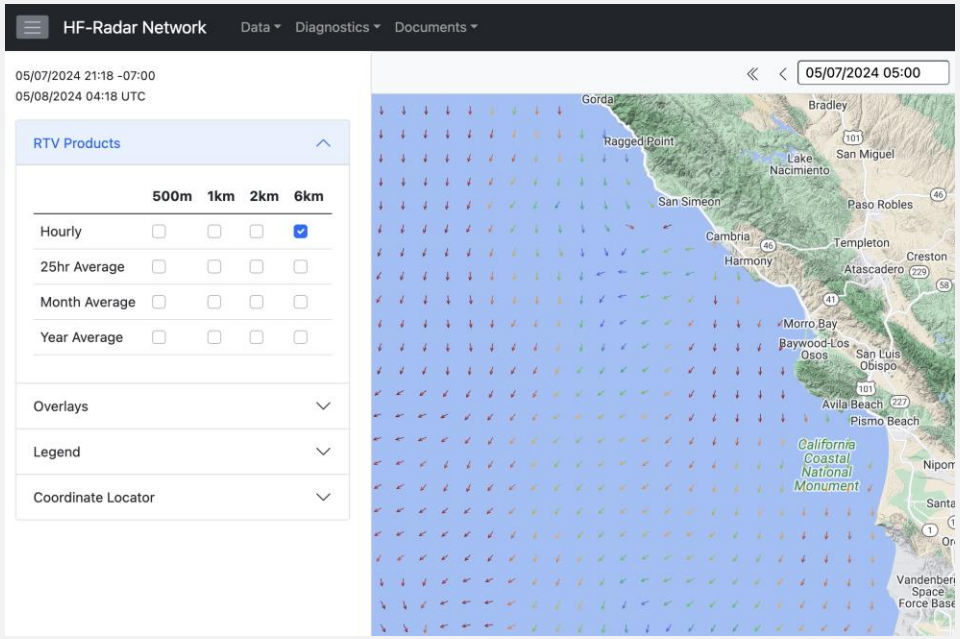
- A LCS is a locally dominant transport structure that can be calculated from particle trajectories.
- More simply, a hyperbolic LCS is an area of repulsion or accumulation in a flow.

**Our research focuses on the detection of hyperbolic repelling and attracting LCSs over the last decade in the WEA.*

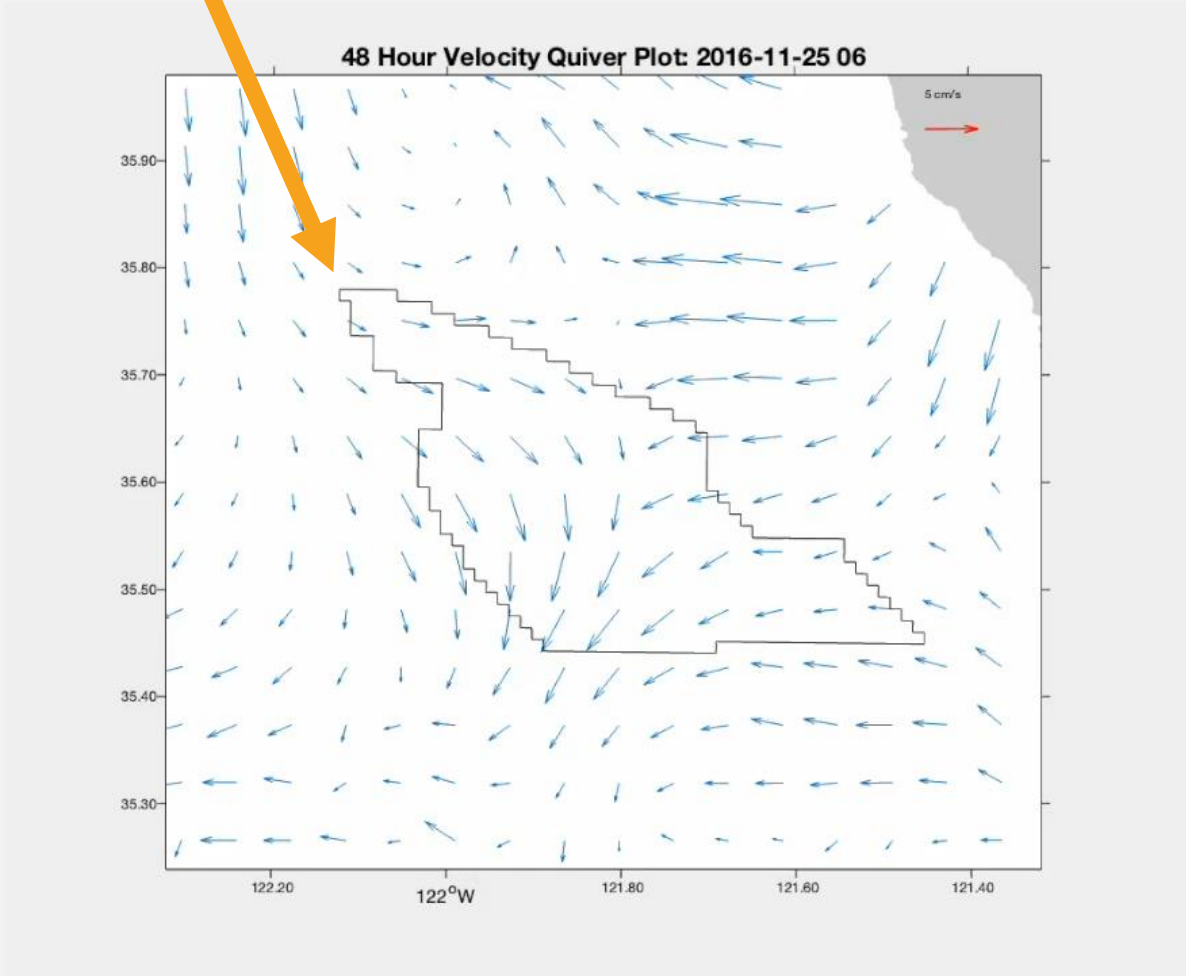




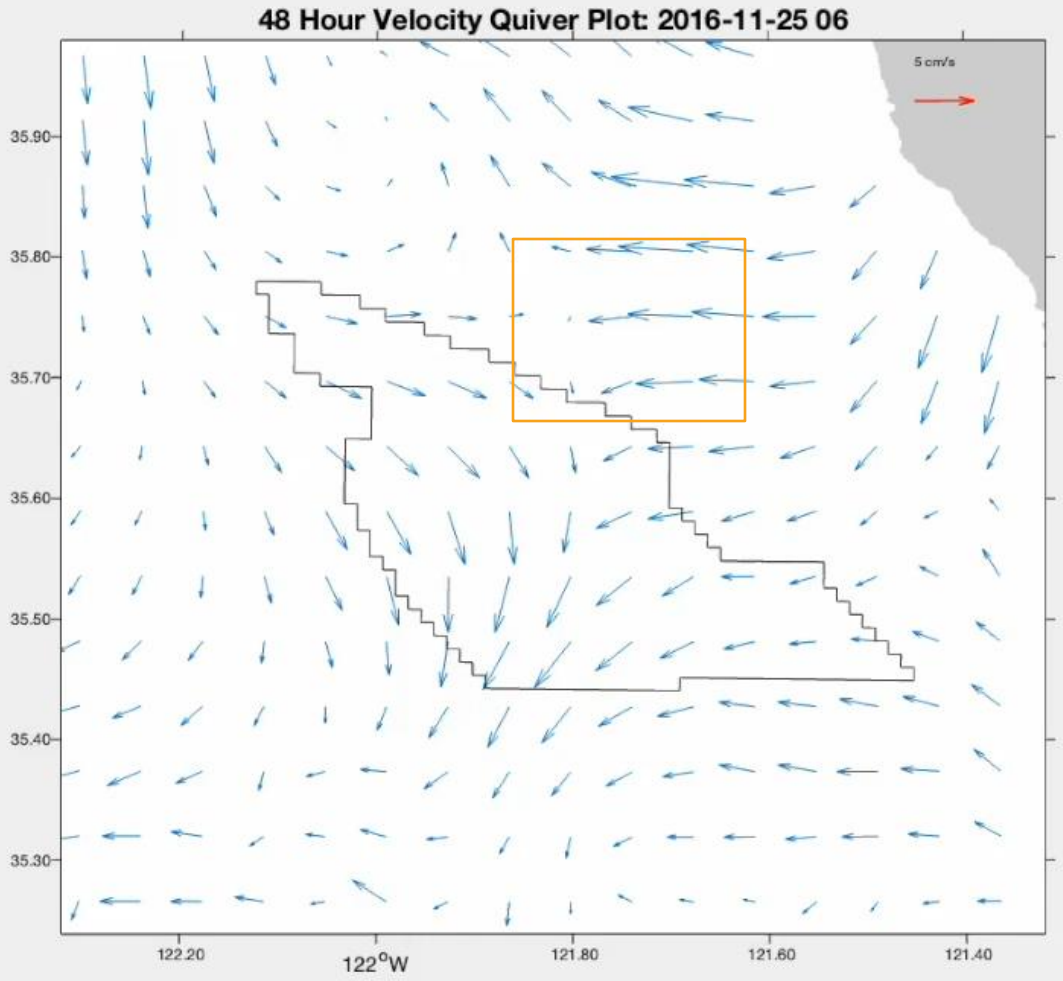
HIGH FREQUENCY RADAR

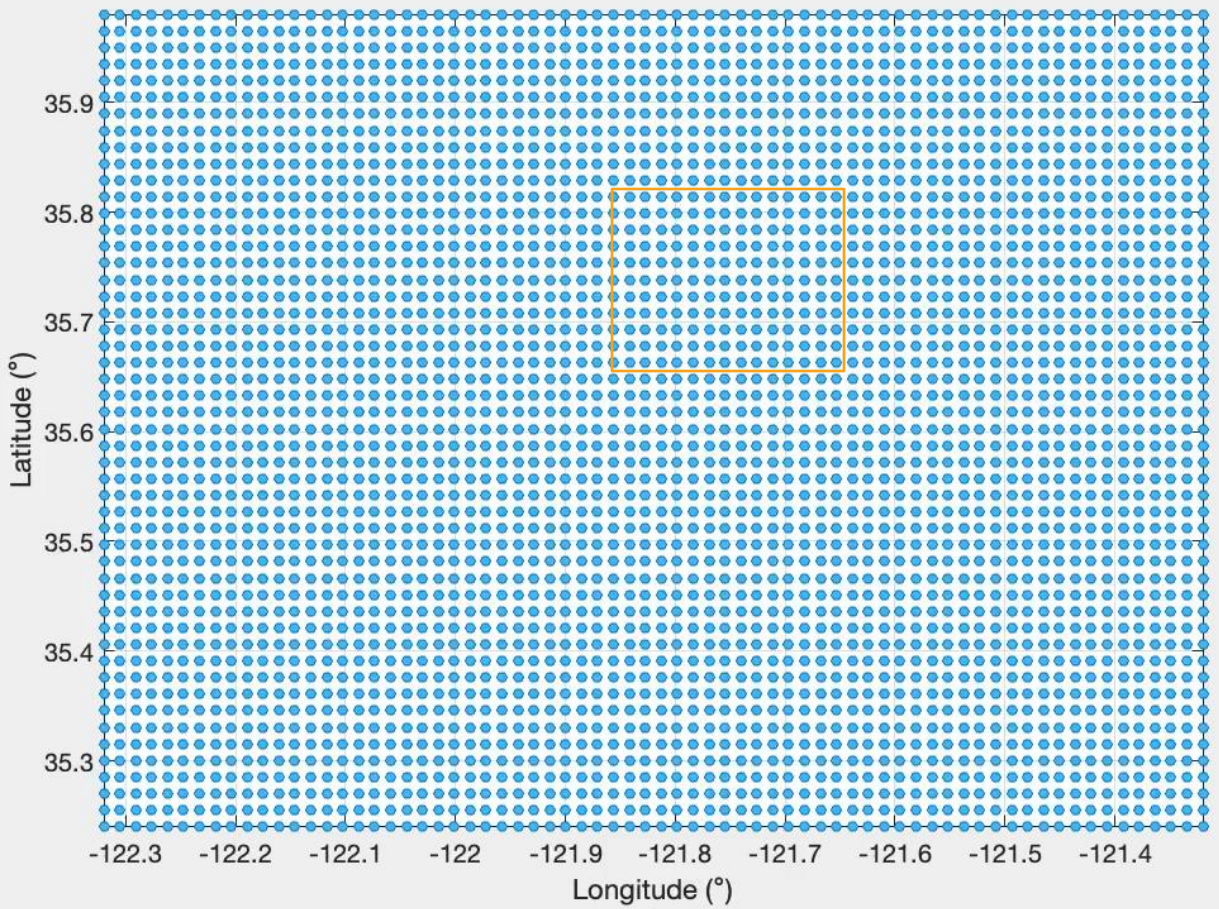


Wind Energy Area Outlined



CONVERGENCE REGION EXAMPLE

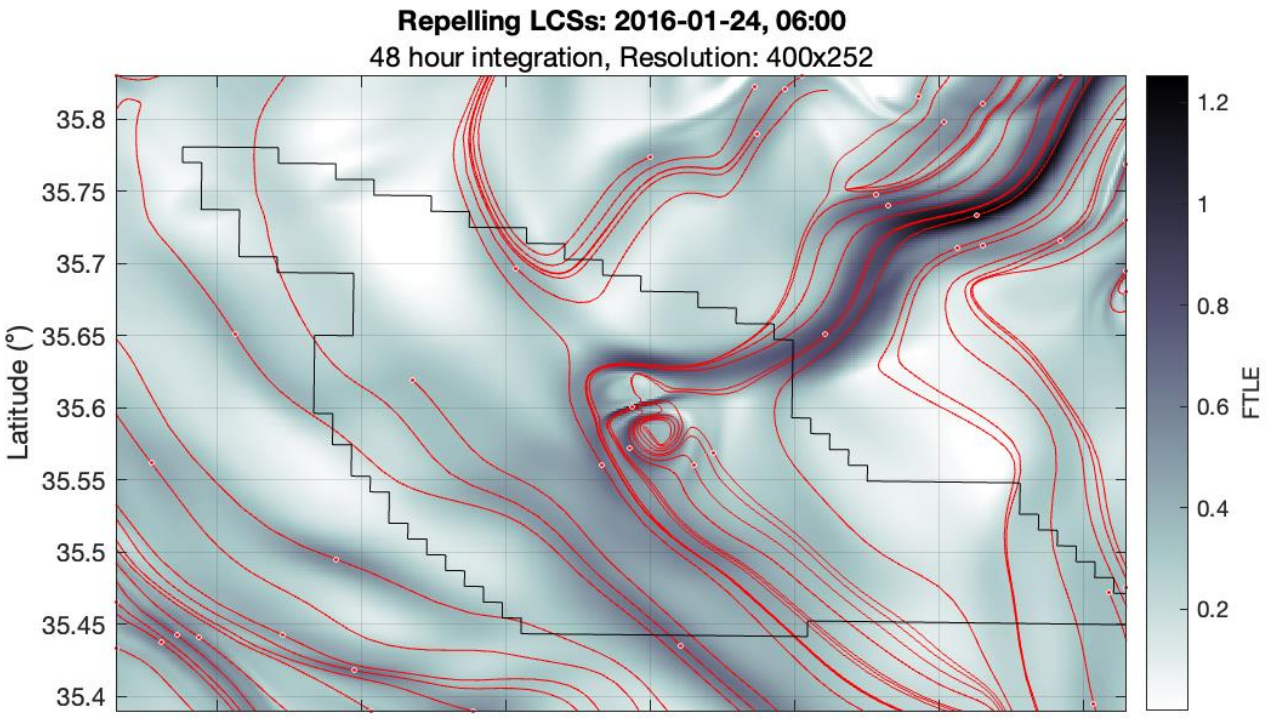


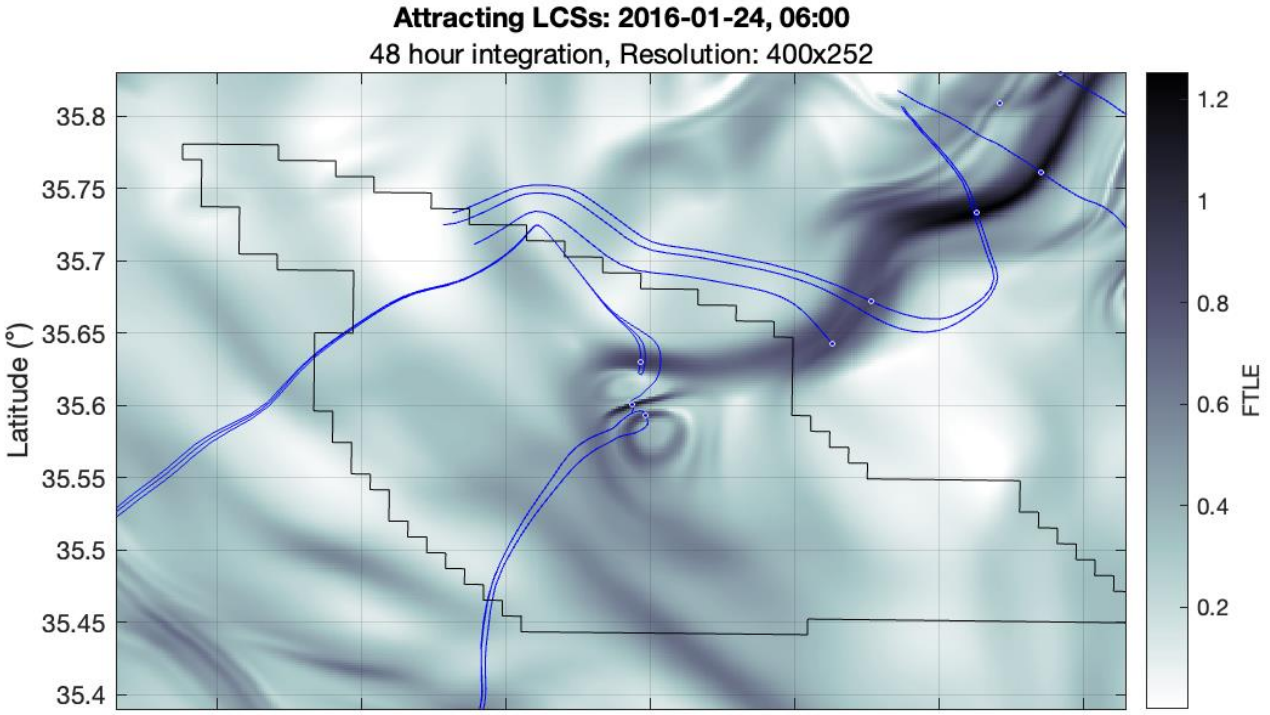


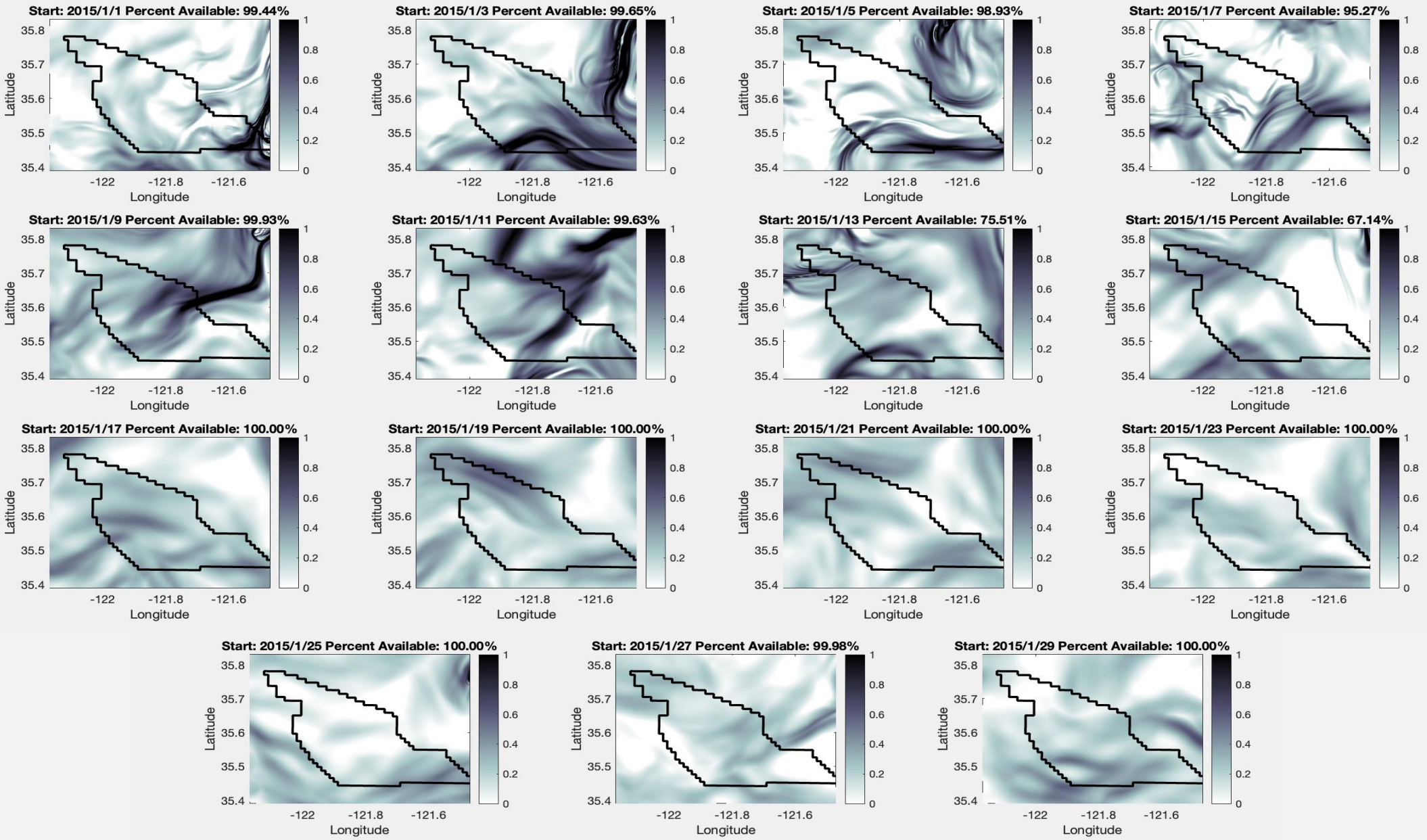
LCS IN WEA

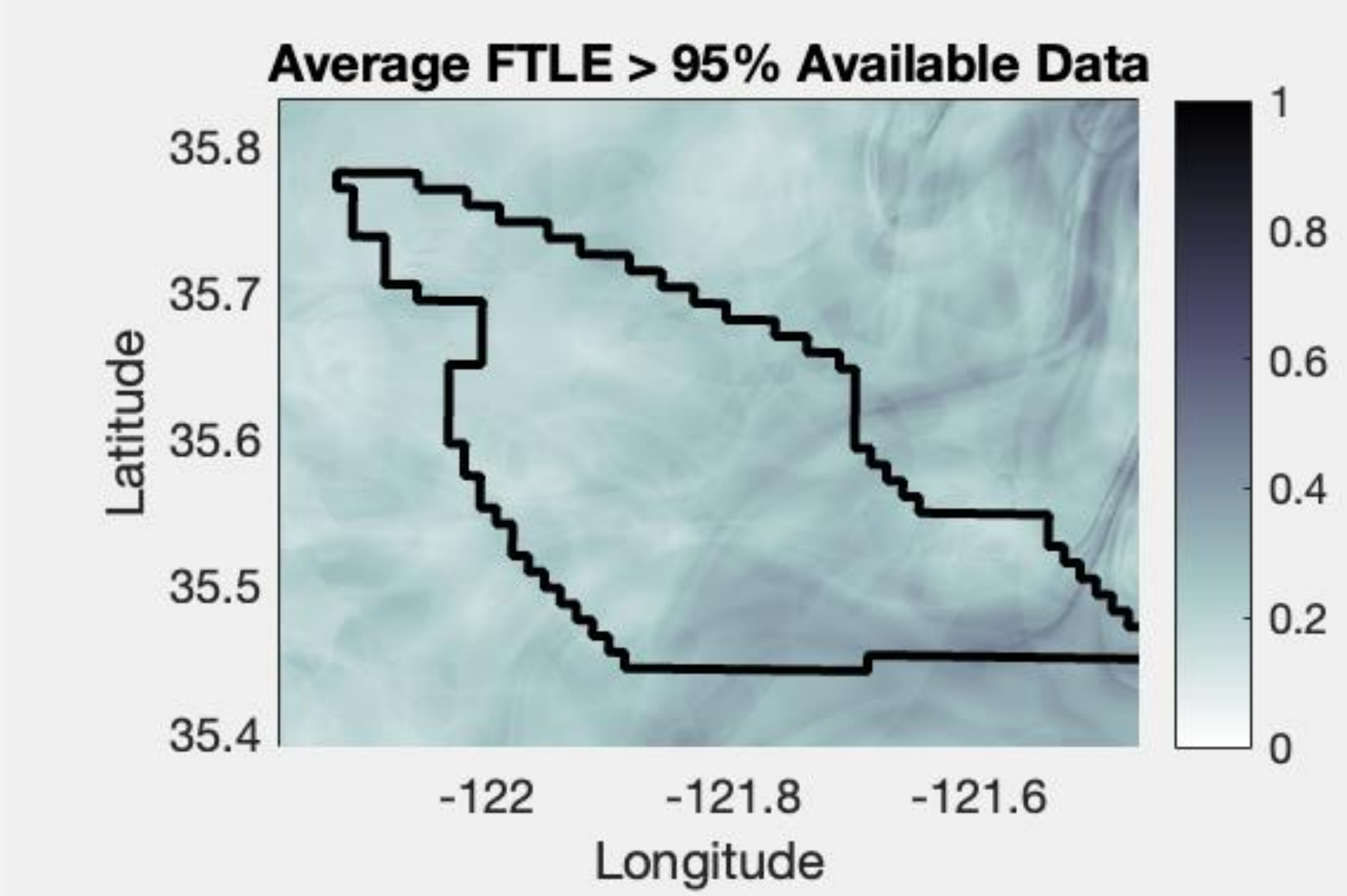
- Configured MATLAB tool to calculate LCS from HFR data in Wind Energy Area

- Blue: Attracting Lines
- Red: Repelling Lines
- Colormap: FTLE value
  - Higher = more divergence of flow






Start: 2015/1/1 Percent Available: 99.44%
Start: 2015/1/3 Percent Available: 99.65%
Start: 2015/1/5 Percent Available: 98.93%
Start: 2015/1/7 Percent Available: 95.27%
Start: 2015/1/9 Percent Available: 99.93%
Start: 2015/1/11 Percent Available: 99.63%
Start: 2015/1/13 Percent Available: 75.51%
Start: 2015/1/15 Percent Available: 67.14%
Start: 2015/1/17 Percent Available: 100.00%
Start: 2015/1/19 Percent Available: 100.00%
Start: 2015/1/21 Percent Available: 100.00%
Start: 2015/1/23 Percent Available: 100.00%
Start: 2015/1/25 Percent Available: 100.00%
Start: 2015/1/27 Percent Available: 99.98%
Start: 2015/1/29 Percent Available: 100.00%
Latitude
Longitude
35.8
35.7
35.6
35.5
35.4
-122
-121.8
-121.6
1
0.8
0.6
0.4
0.2
0


Average FTLE > 95% Available Data
35.8
35.7
35.6
35.5
35.4
Latitude
-122
-121.8
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Longitude
1
0.8
0.6
0.4
0.2
0

FUTURE WORK / ACKNOWLEDGEMENTS

- Develop a reverse tracking program that calculates attracting FTLEs
- Statistical analysis to determine FTLE trends with oceanographic phenomenon
- Compare results to biological observations

- Hoogstra, L. (2023). *Detecting coherent transport structures in ocean surface flows* (Master's thesis, California Polytechnic State University, San Luis Obispo).
- Haller, George. "Lagrangian Coherent Structures." *Annual Review of Fluid Mechanics*, vol. 47, no. 1, 2015, pp. 137–62, https://doi.org/10.1146/annurev-fluid-010313-141322.

CENTRAL & NORTHERN CALIFORNIA OCEAN OBSERVING SYSTEM

SOUTHERN CALIFORNIA COASTAL OCEAN OBSERVING SYSTEM