Horizon Marine

Eddy Lazarus & the Loop Current – Paralyzing the Gulf in 2014

AADE AMERICAN ASSOCIATION of DRILLING ENGINEERS

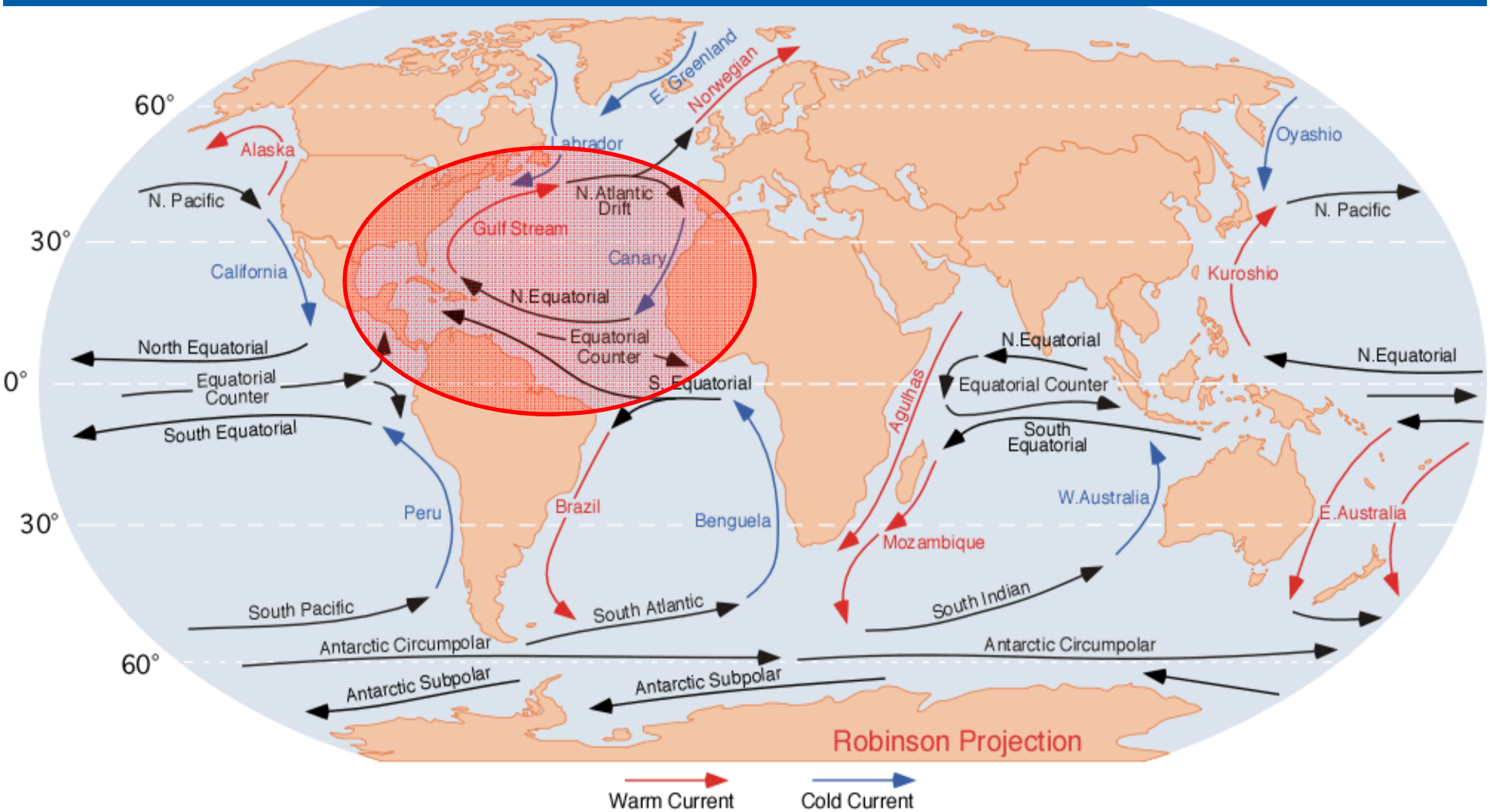
Deepwater and Emerging Technology Program

January 22, 2015

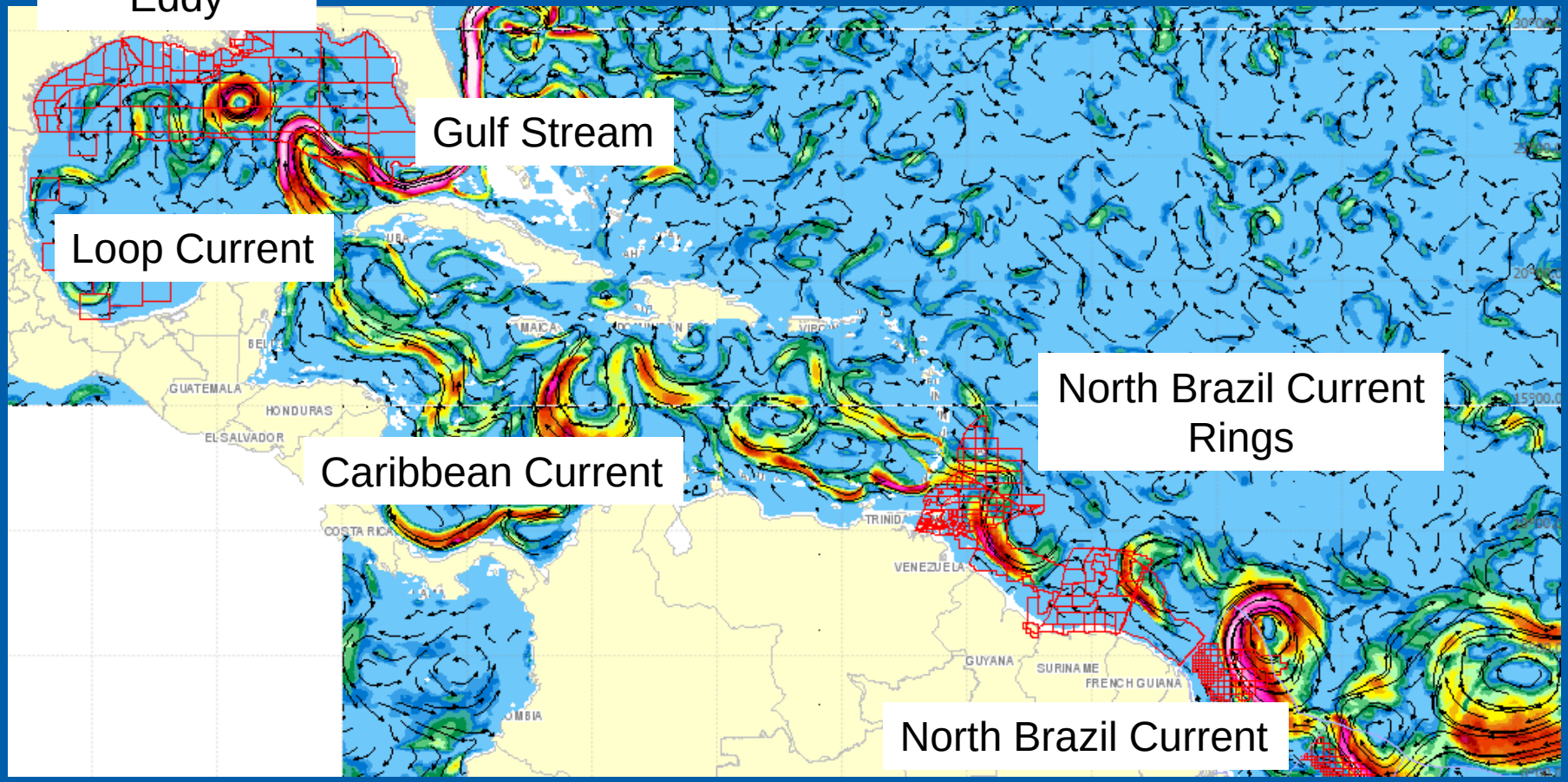
Since 1982

30 years in the Northern Gulf of Mexico - Loop Current & Eddies
12 years offshore Trinidad & Venezuela - North Brazil Current & Rings
6 years offshore Brazil - Brazil Current & Eddies
6 years in the Southern Gulf of Mexico - Jets & Eddies
6 years Vessel Routing & Tracking - Saving Time & Fuel

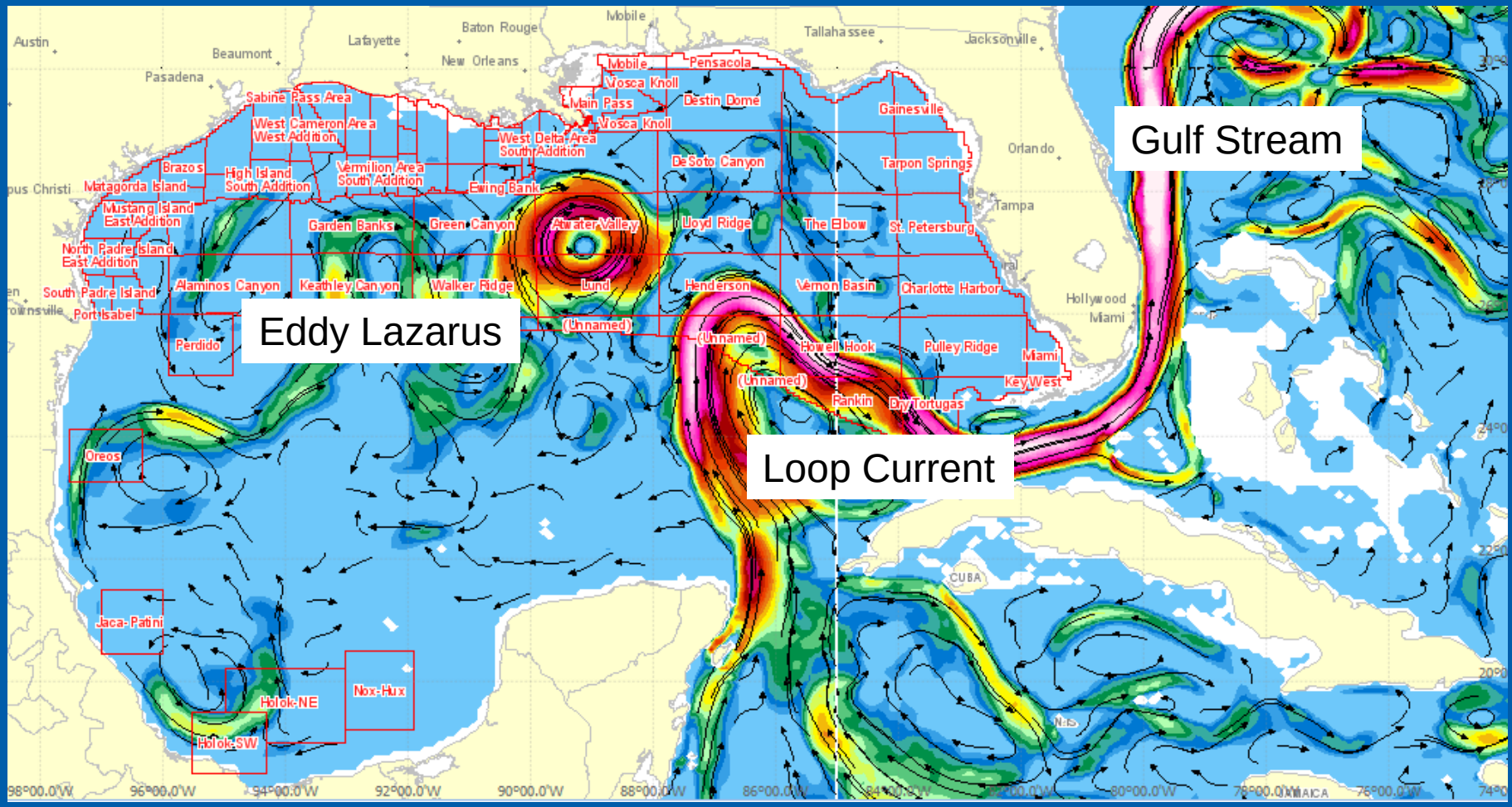
North Atlantic Gyre



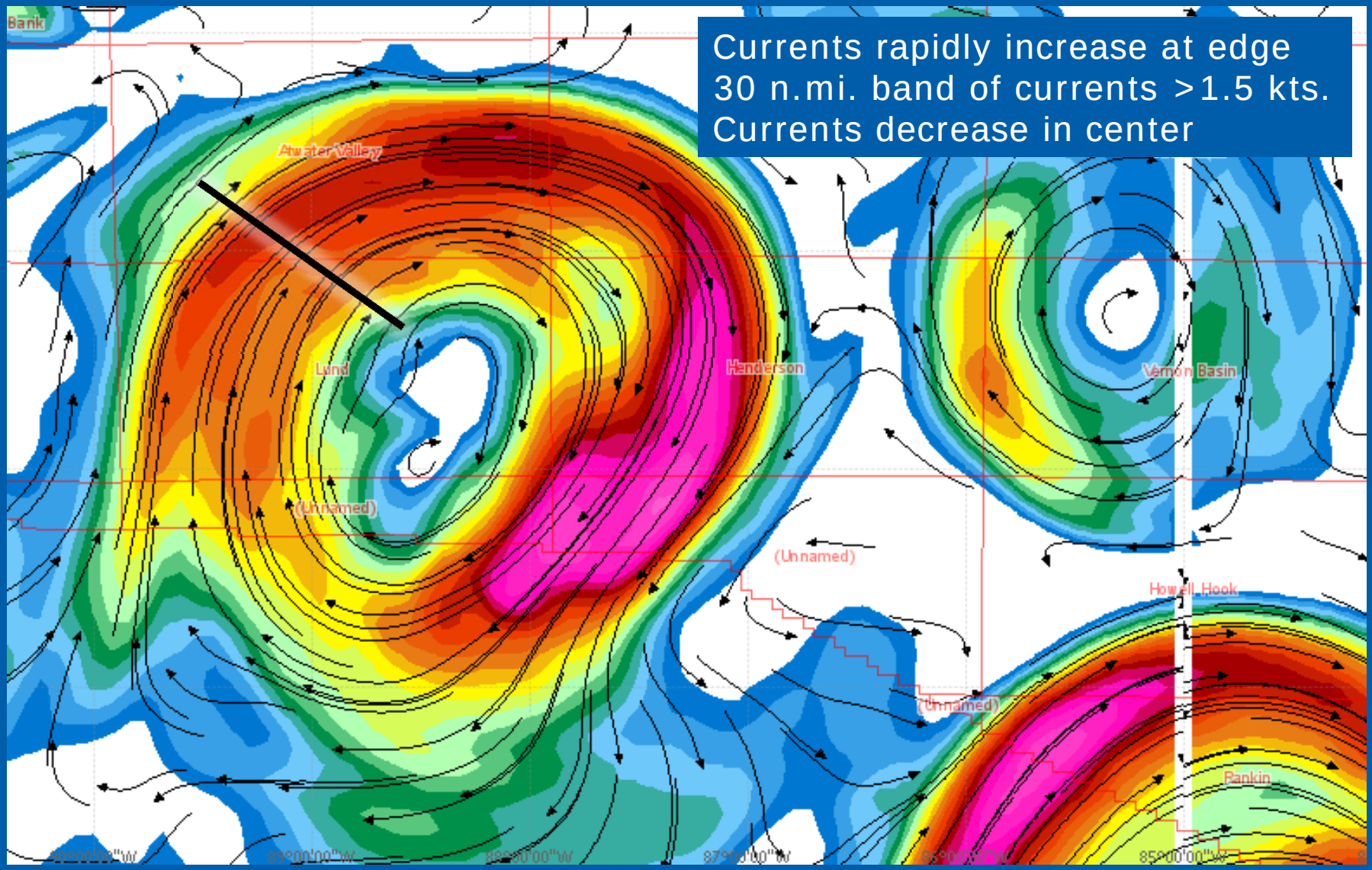
North Atlantic Gyre



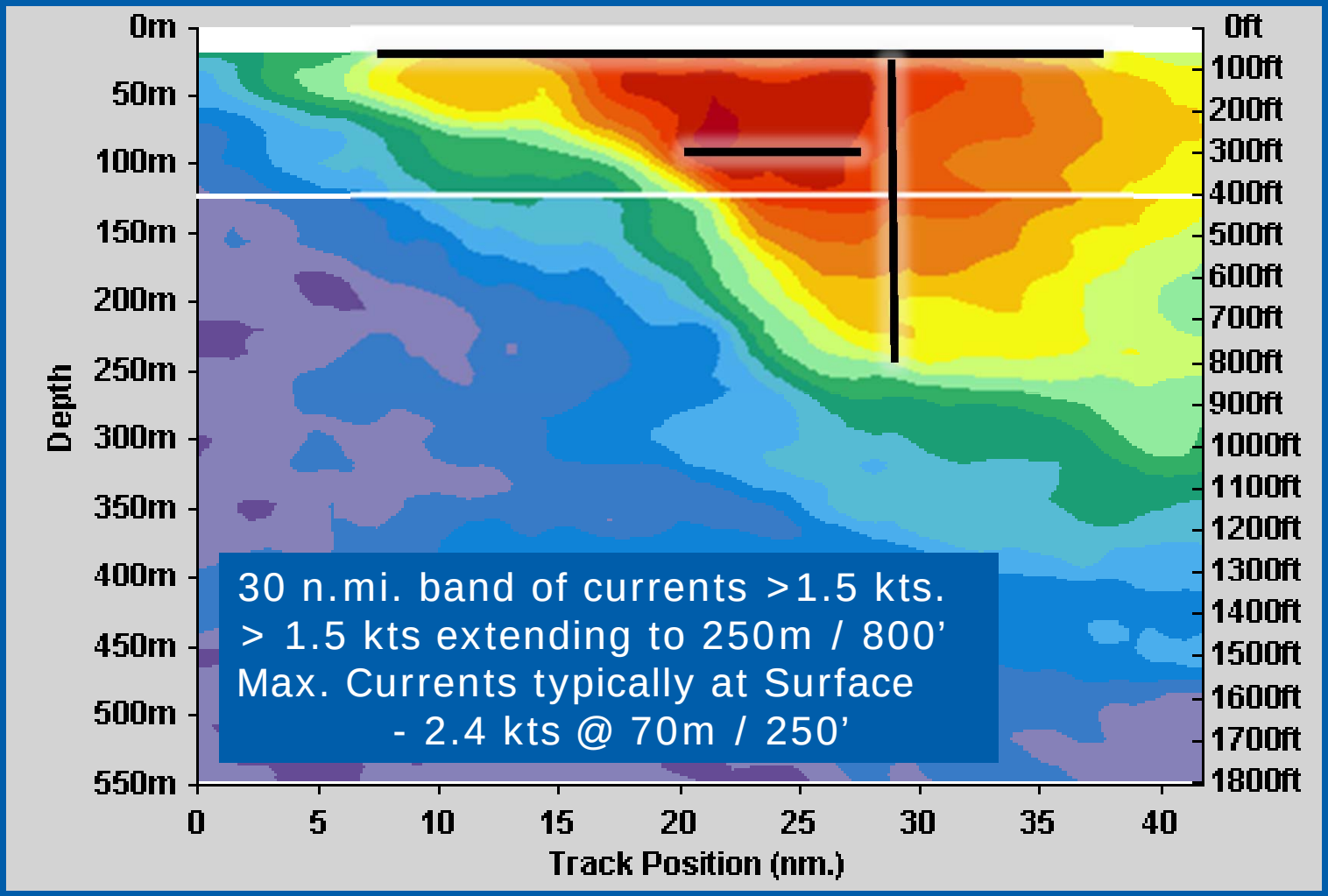
Loop Current & Loop Current Eddy



Loop Current & Loop Current Eddy – Surface Structure



Loop Current Eddy Sub-Surface Structure



Seismic Survey

Survey Planning

Currents impact ability to fly streamers

Increase infill rate, increase cost of survey

Station Keeping

ENSCO 8503 offshore French Guiana in 4.0+ kt. Currents

80 - 90% thrust just to hold station

Incredible fuel consumption, unnecessary wear and tear

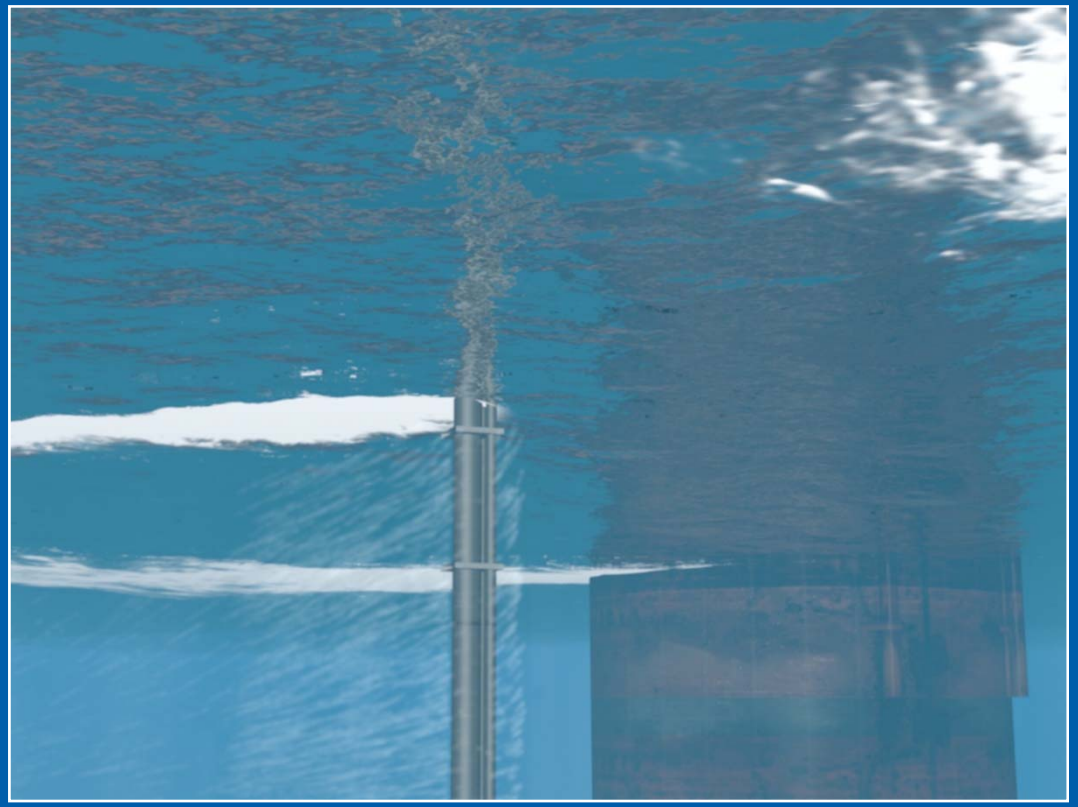
Rig selection is critical

Splashing BOP & Running Riser

Potential damage to BOP & Riser due to extreme angles

Drift-ins/offs can be risky:

– Field Design
– Bathymetry constraints of Sigsbee Escarpment must be considered, especially during hurricane season



Drilling

2.5 kts. On the ENSCO 8500

Potential to exceed Riser angle

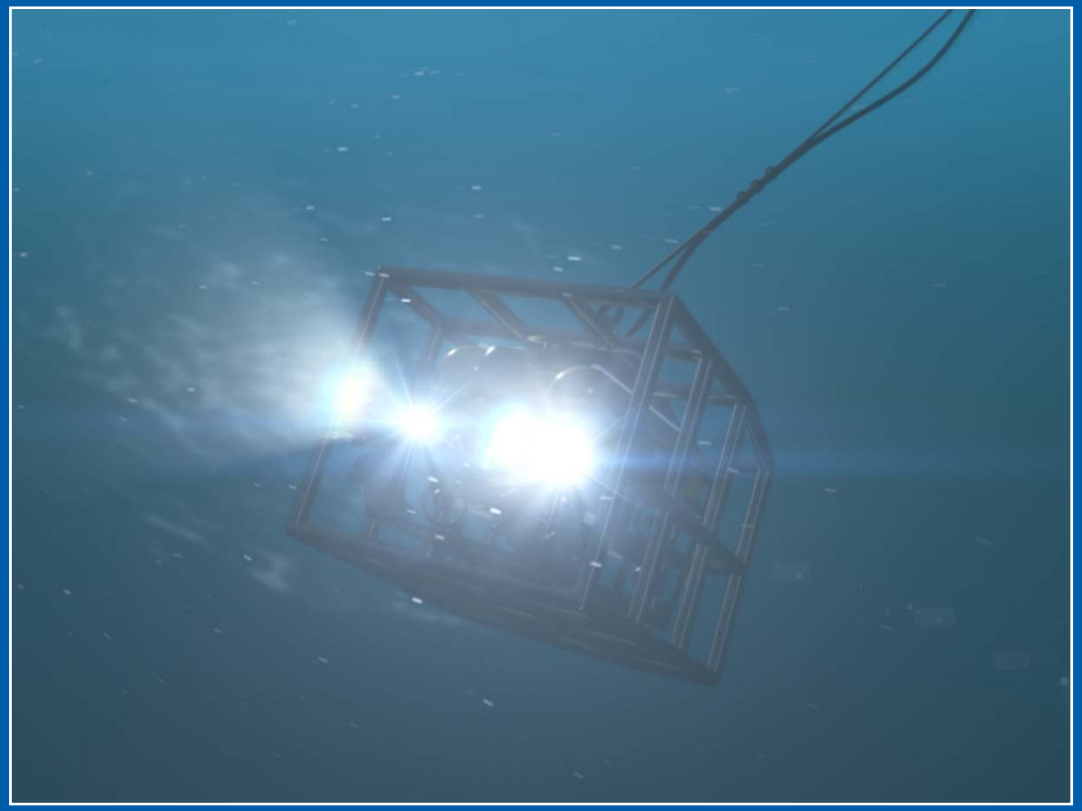
Vortex-Induced Vibration (VIV) - Riser fatigue

Often requires VIV Suppression

ROV

Jumping an ROV in currents >2.0 kts. is difficult

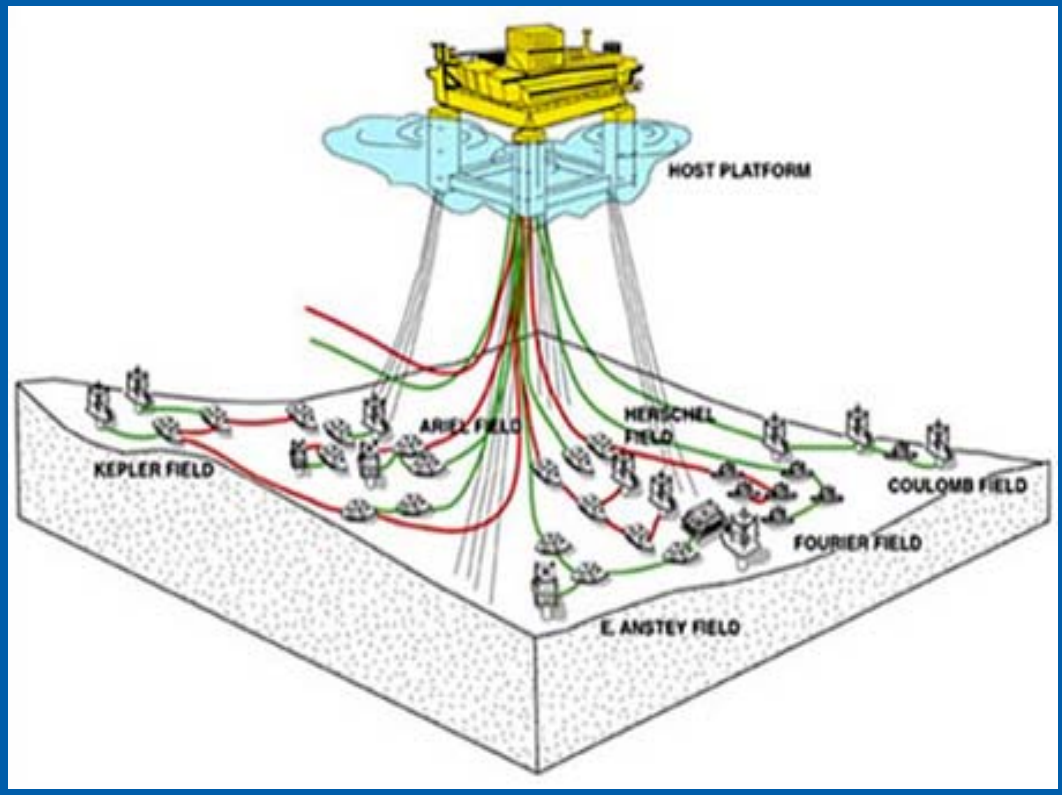
Drift-ins are possible to get below strong surface currents, but not always feasible



Design

Platform choice
- Semi-sub, Spar, TLP

Field layout for future development



Installation

Relies on capability of construction vessels to hold station

Excessive force on structures while being submerged

Pipelay

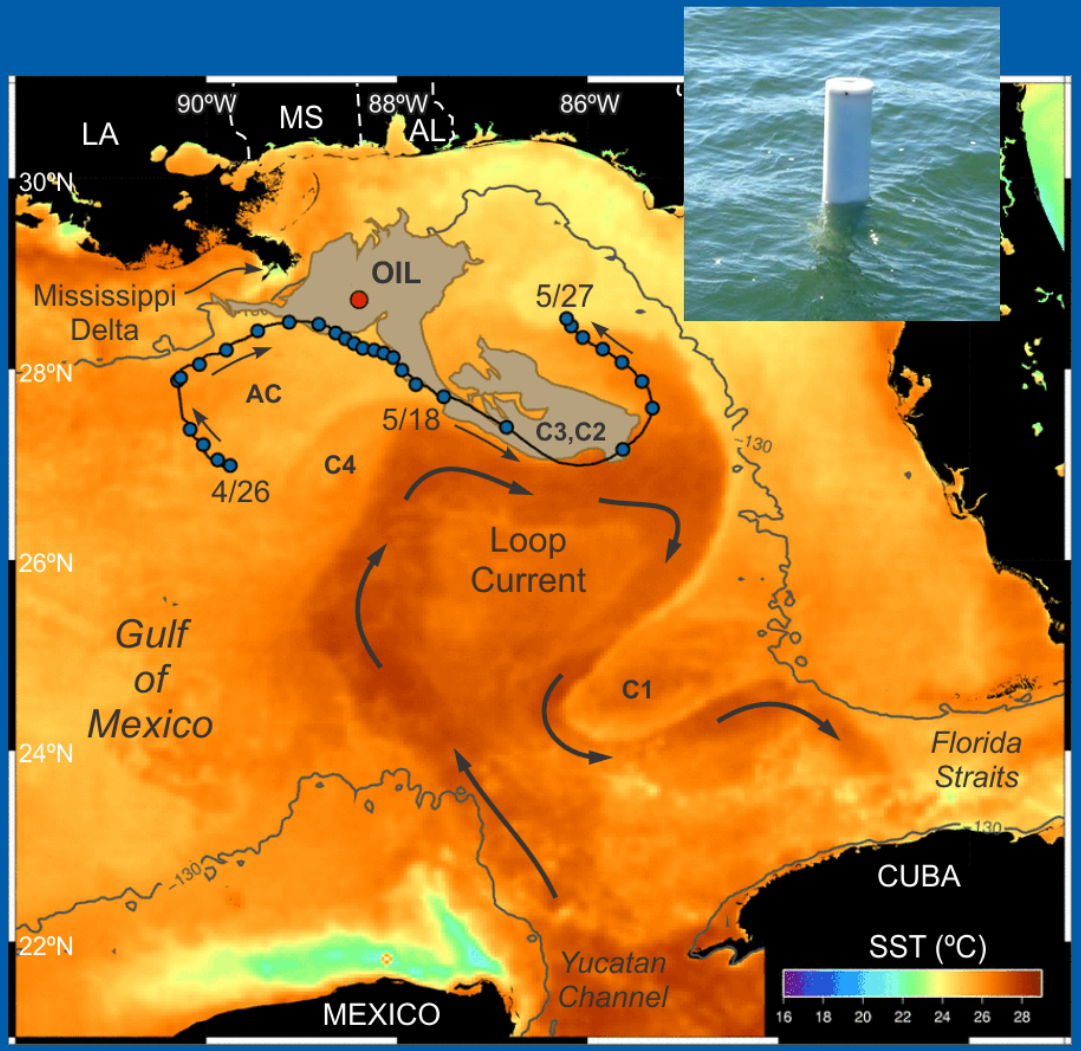
Relies on capability of vessel to hold course

Potential stress on pipe as it passes through ‘splash zone’

Diving

Dive operations are unsafe in currents greater than 1.0 kt.

Emergency Response – *Deepwater Horizon*



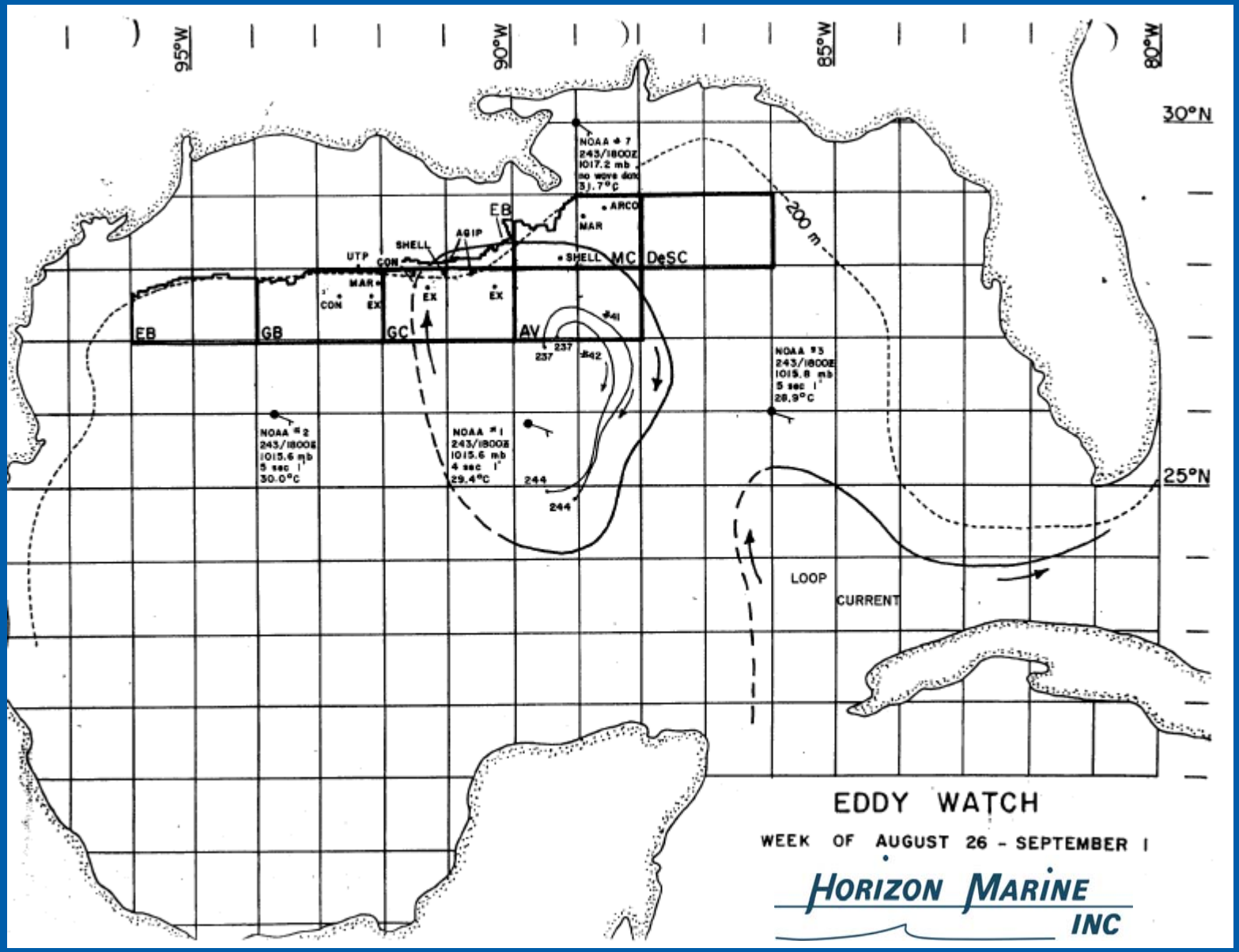
Immediate response for personnel

Spill response and directing of assets to limit environmental impact

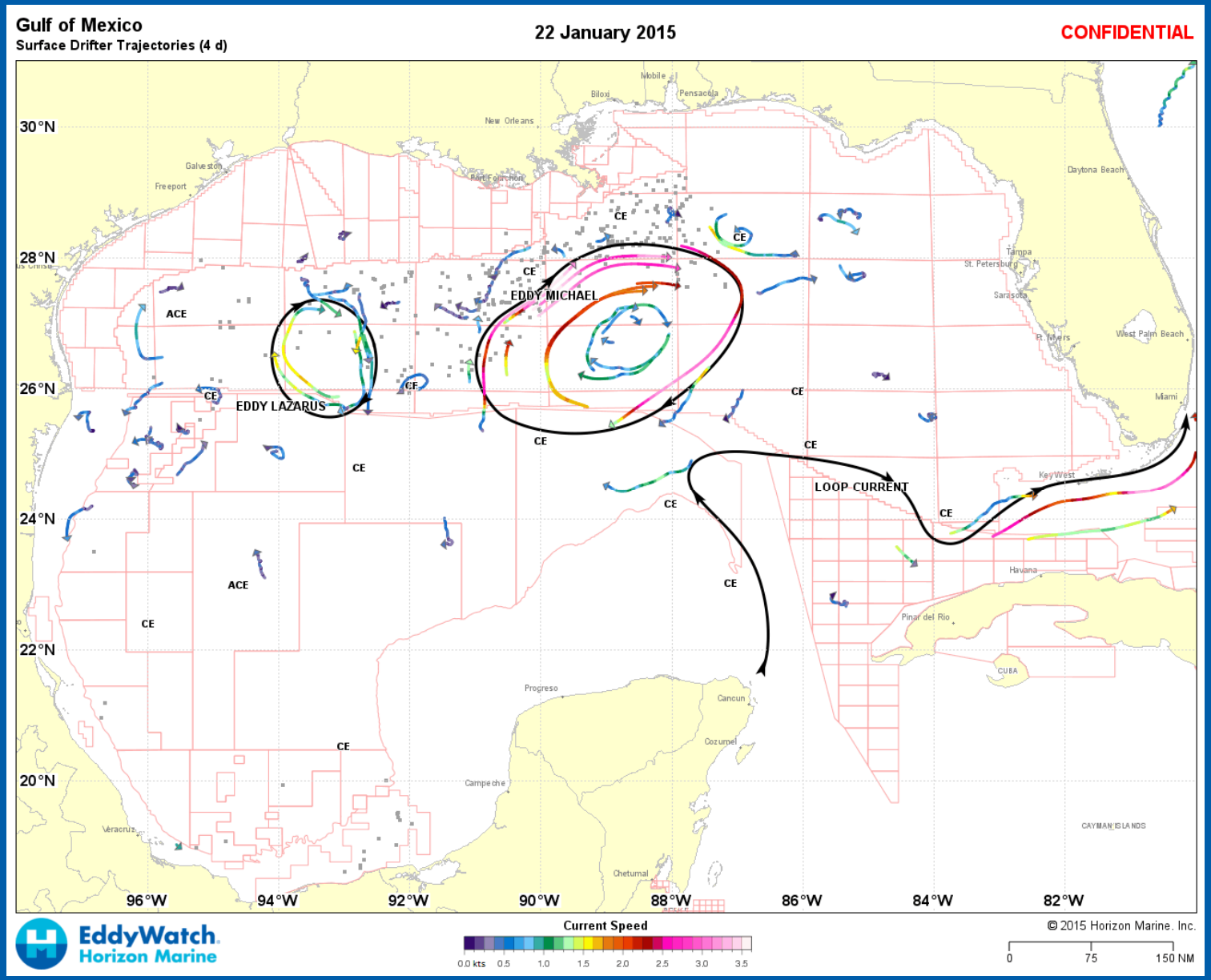
Currents can influence pollutant fate and accelerate transport from incident site

Down Time

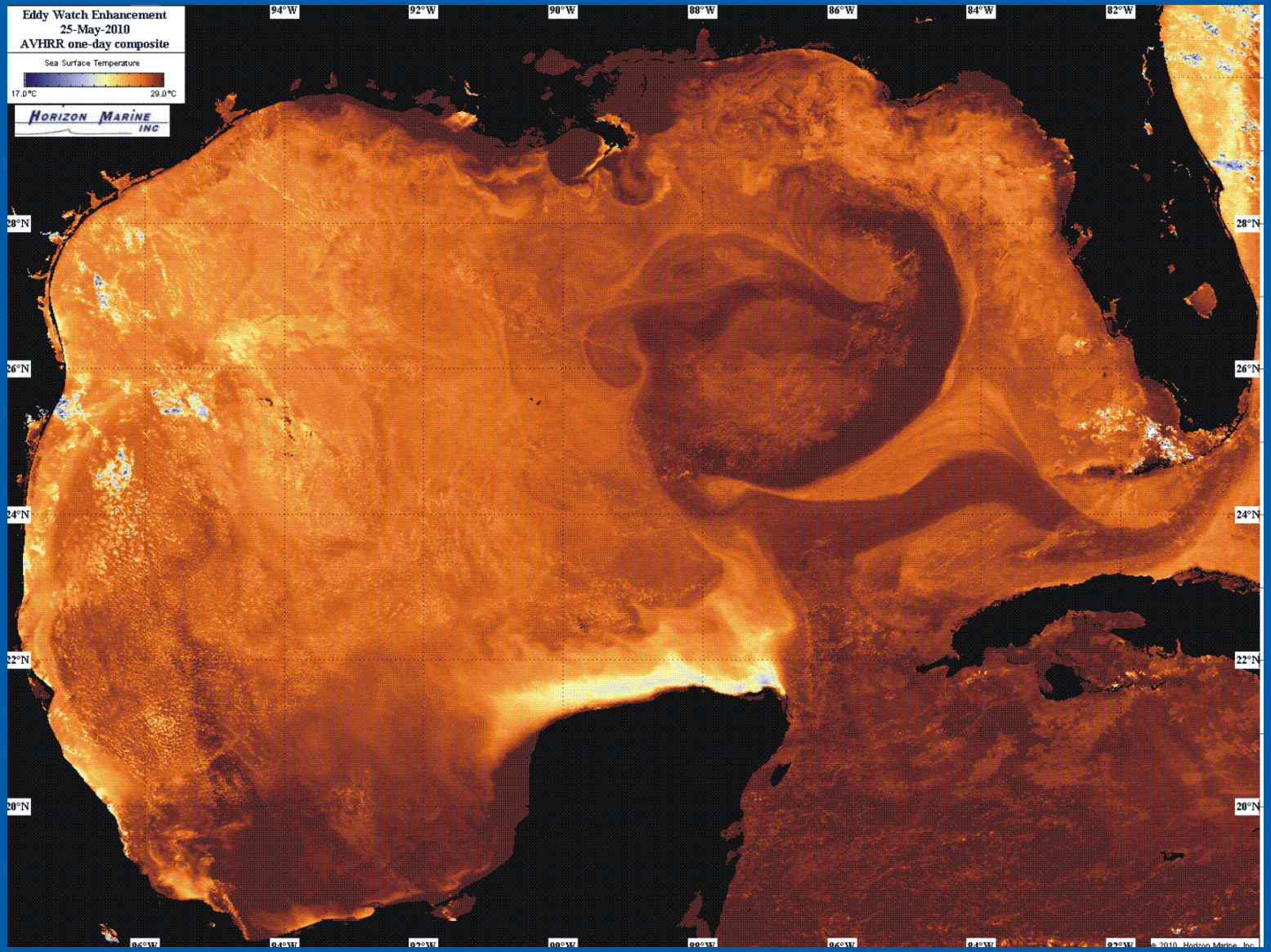
Since 1984, but Eddy Nelson in 1989 was the real start of the service…



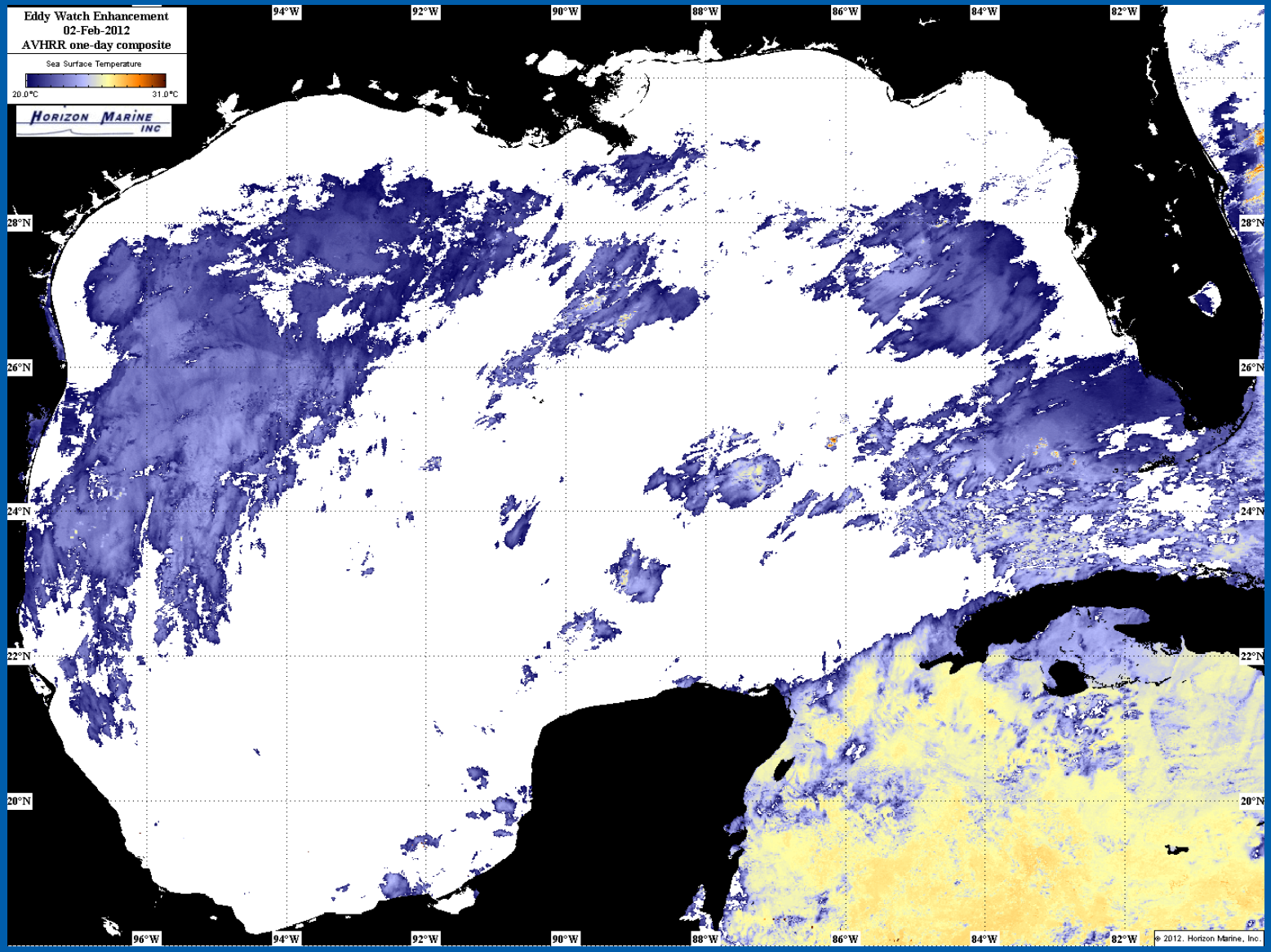
…and in 2015 Eddy Lazarus and Eddy Michael are impacting operations in the Gulf.



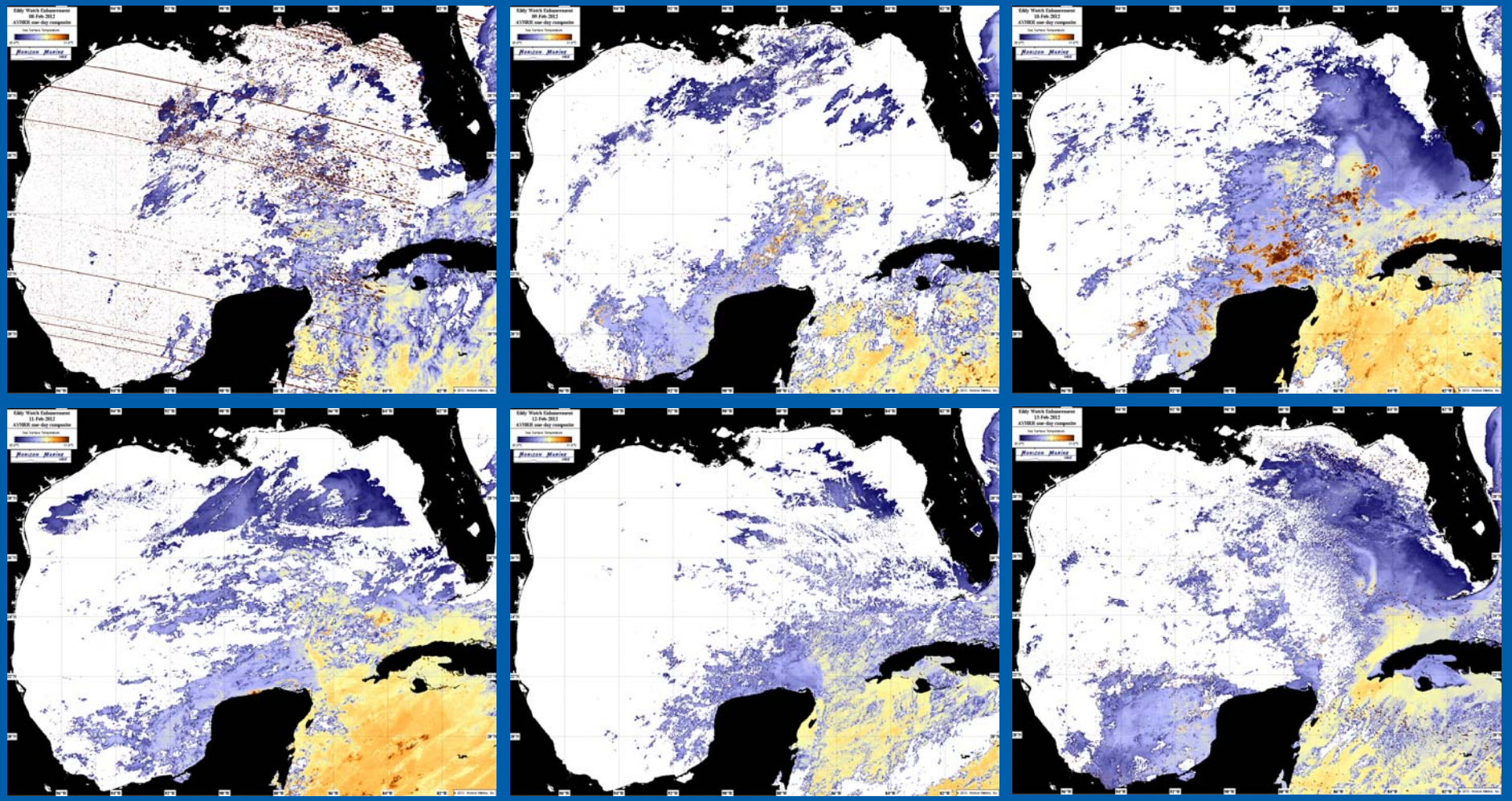
Gulf of Mexico – Sea Surface Temperature Satellite Imagery (no clouds)



Gulf of Mexico – Sea Surface Temperature Satellite Imagery (clouds)



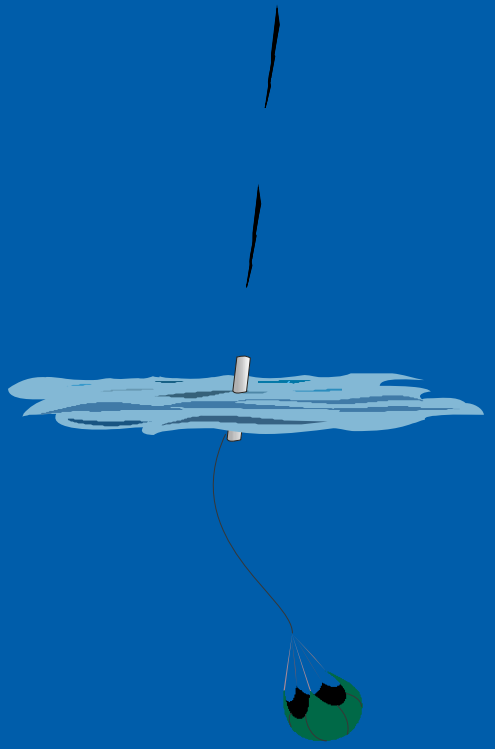
Gulf of Mexico – Sea Surface Temperature Satellite Imagery (a week of clouds)



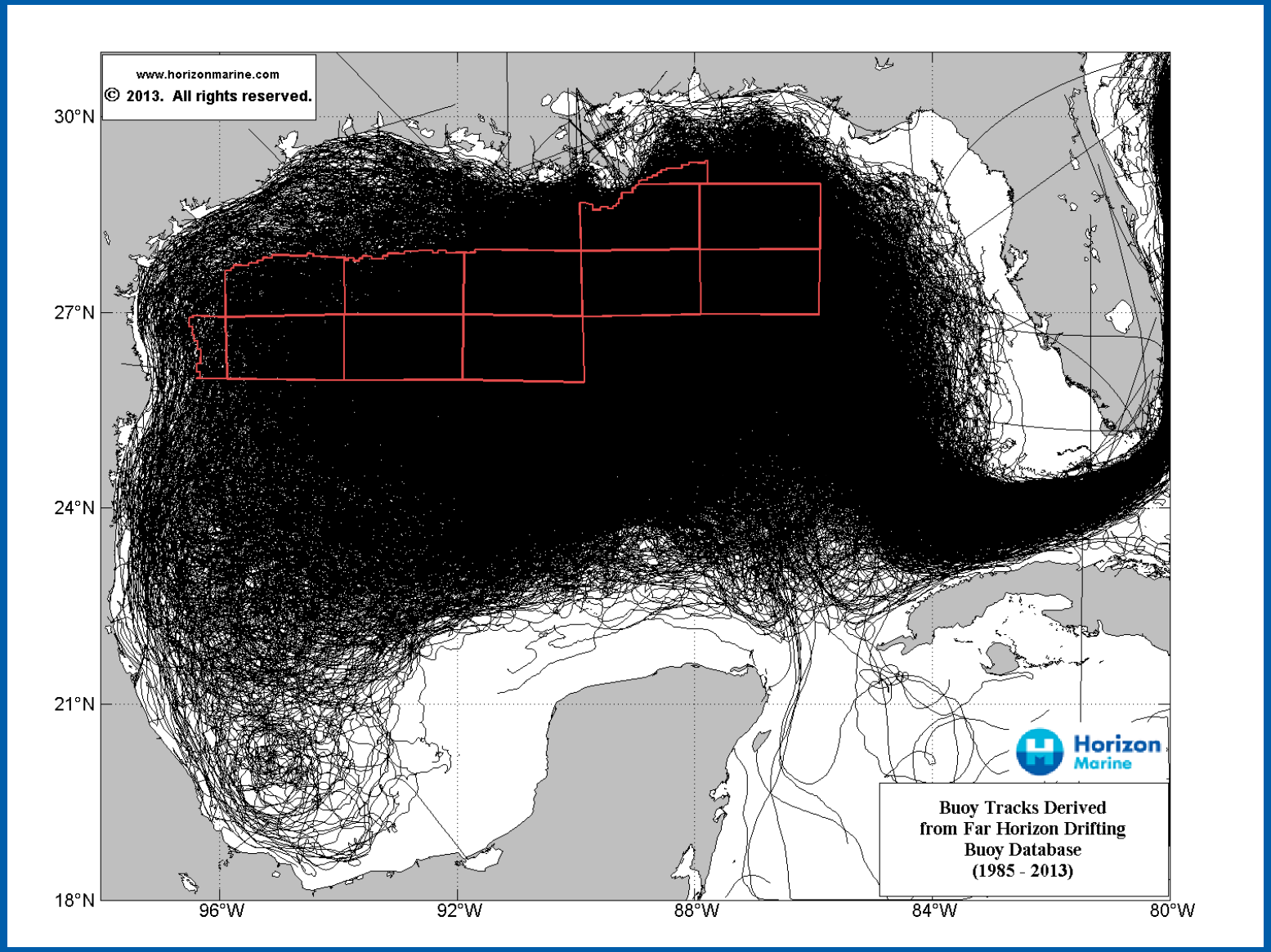
Gulf of Mexico - Far Horizon Drifting GPS Buoys

Over 4000 FHDs successfully deployed

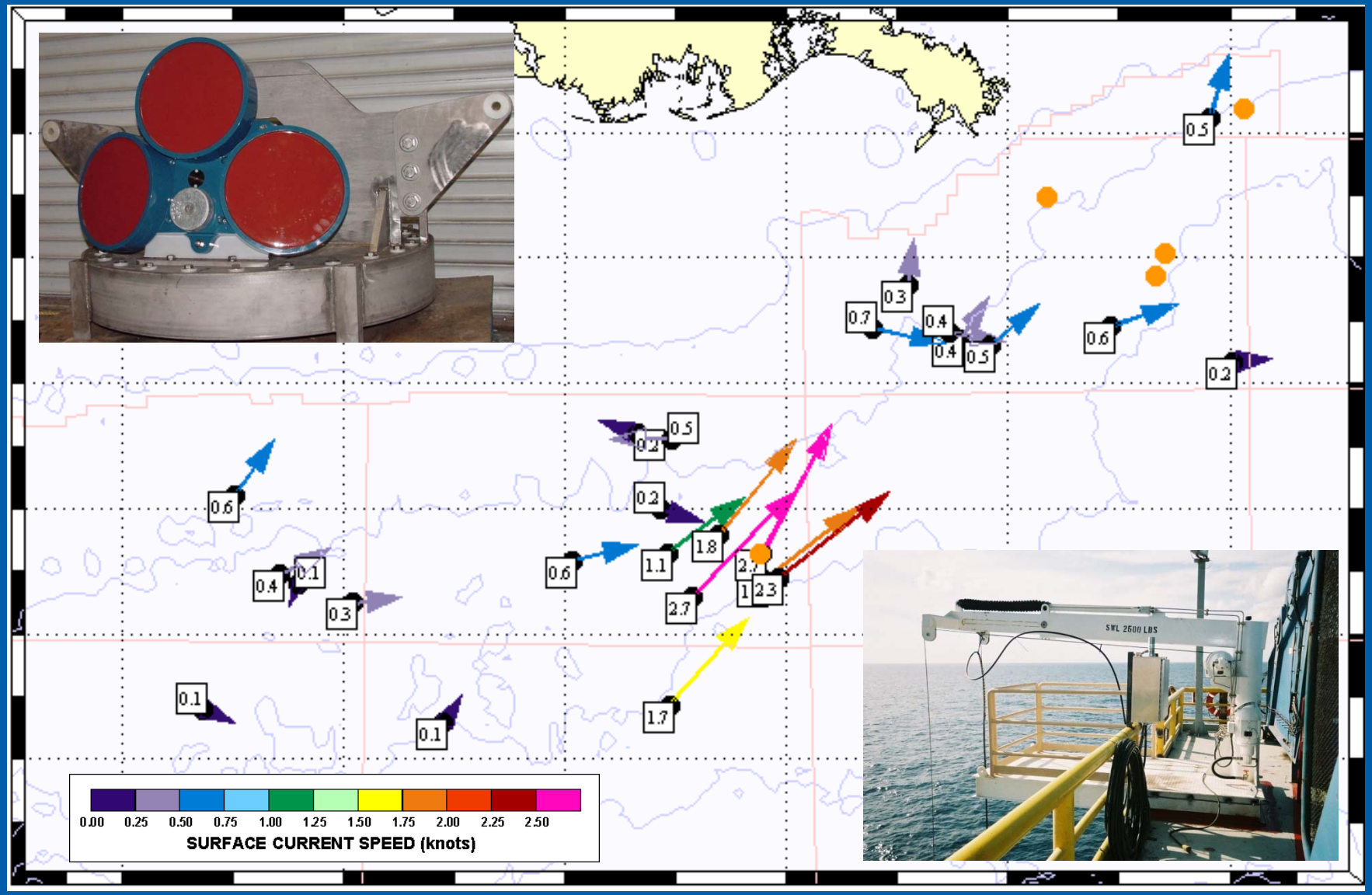
- EddyWatch – Northern Gulf (>3500)
- EddyWatch – Trinidad (>700)
- EddyWatch – Southern Gulf (>500)
- EddyWatch – Brazil & Australia (>250)
- Macondo (60)
- Circulation Studies (>100)



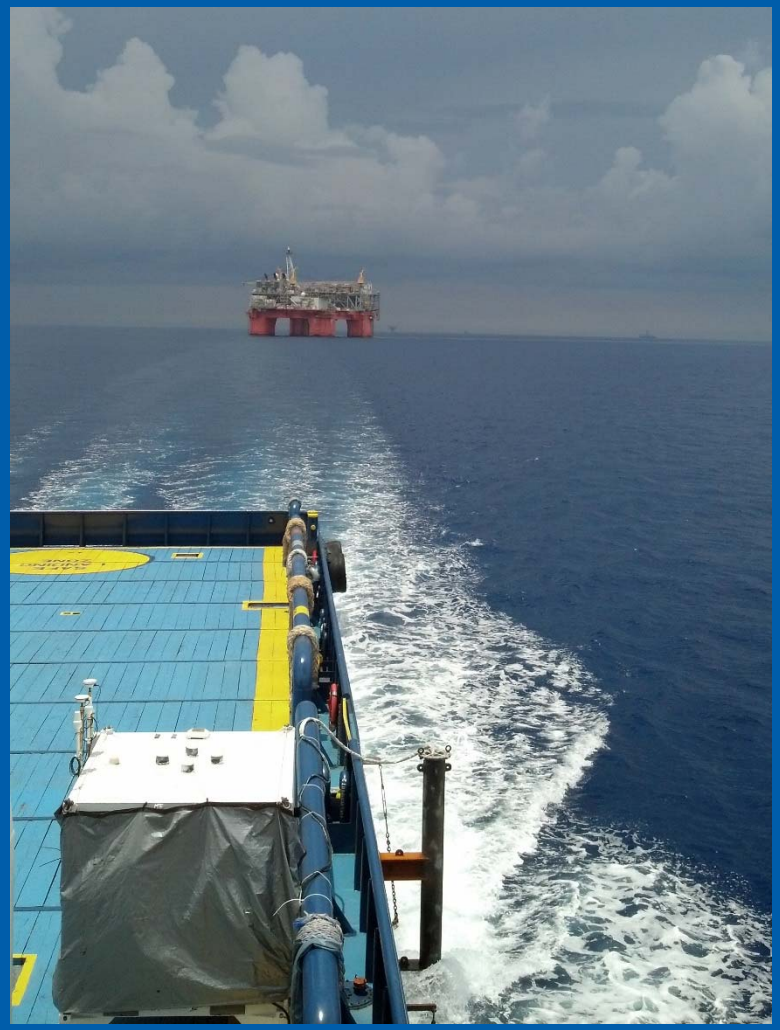
Gulf of Mexico - Maximum Observed Currents 1985 – present (3500+buoys)



Gulf of Mexico – Rig-mounted ADCP Measurements

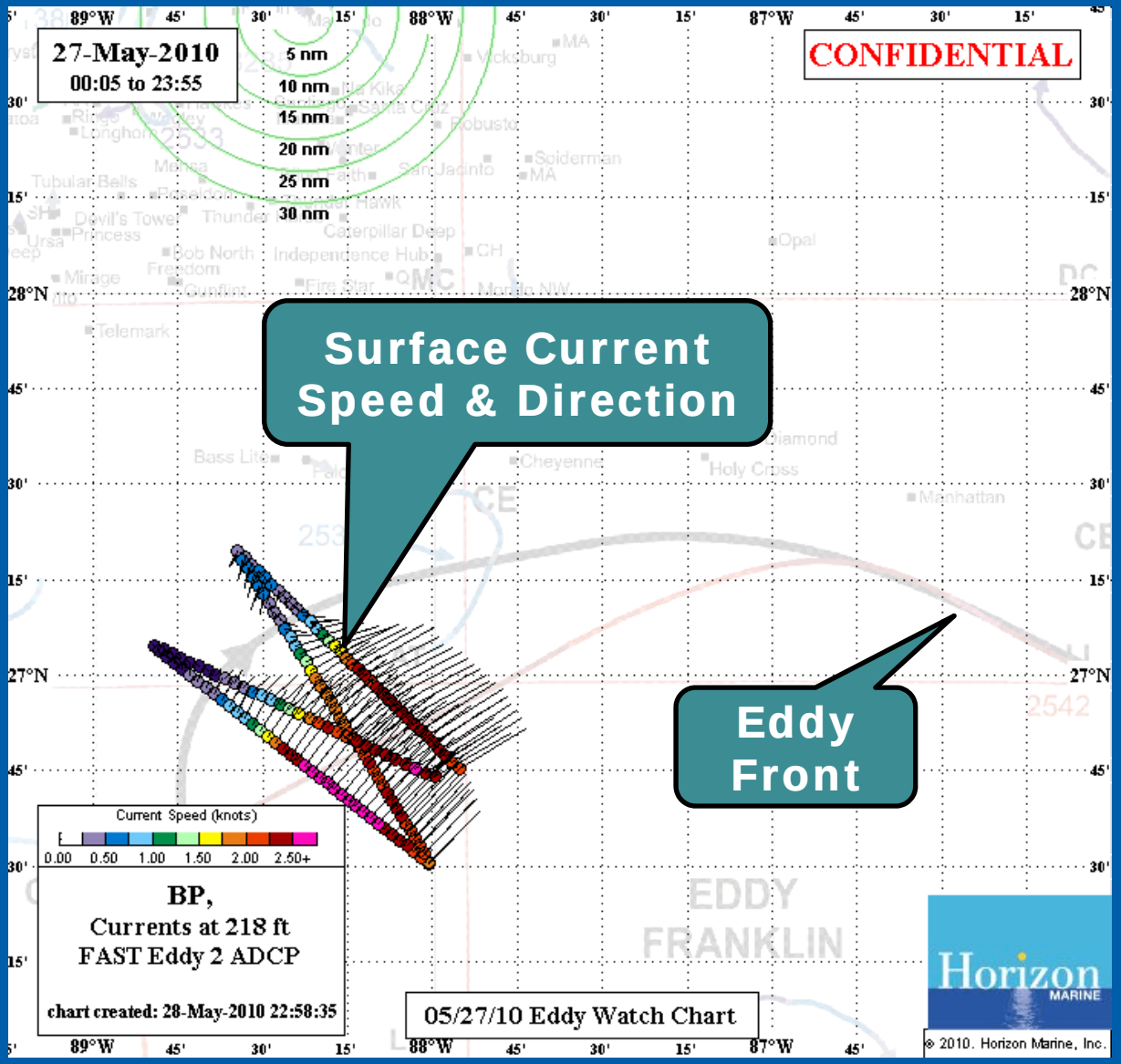


FAST Eddy: Fast Autonomous Survey Technology



Dual Acoustic Doppler Current Profile System (150 & 75 kHz) post-mounted, welded, & chained to the hull of a vessel

FAST Eddy: Monitoring Eddy Movement



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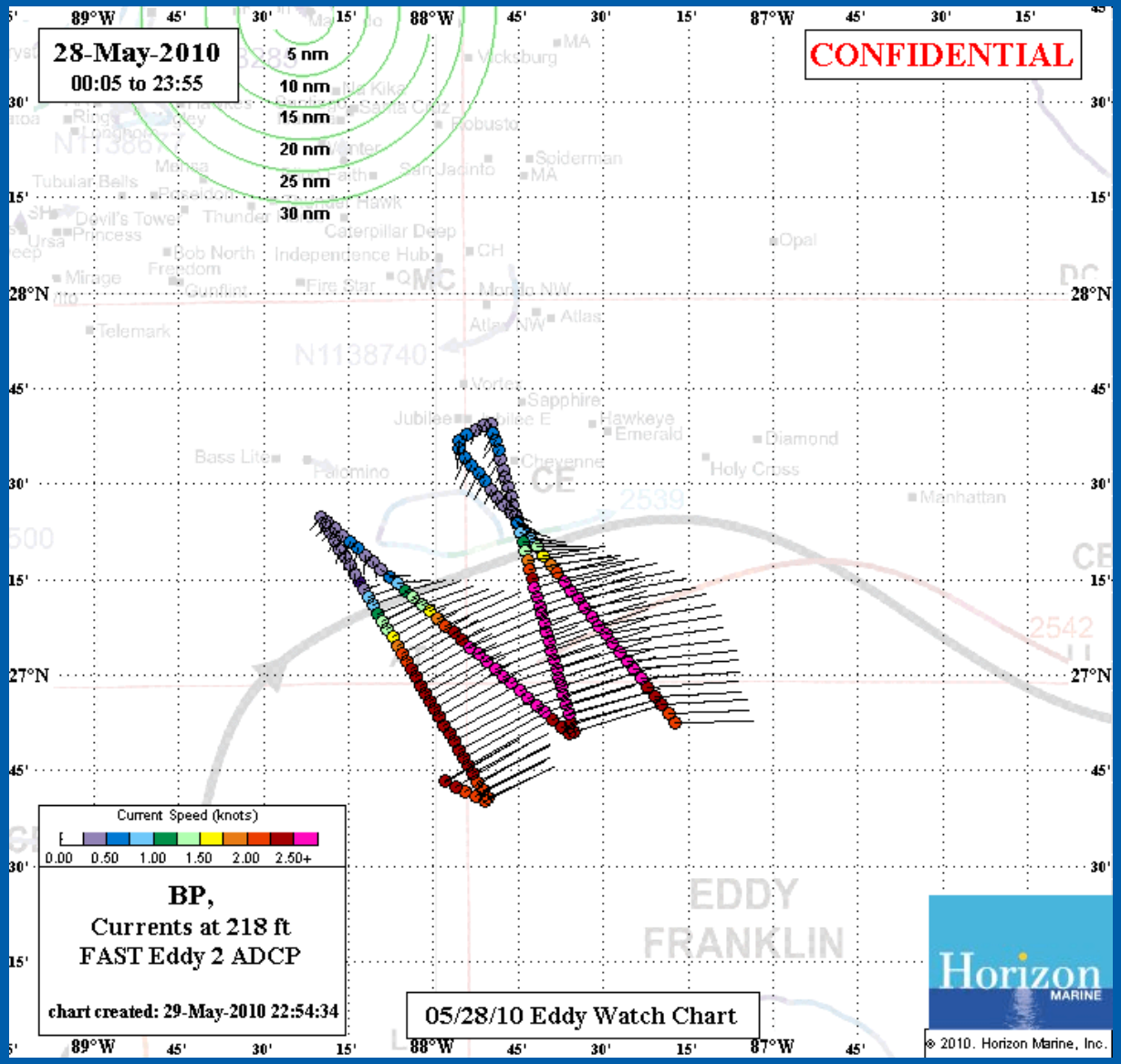
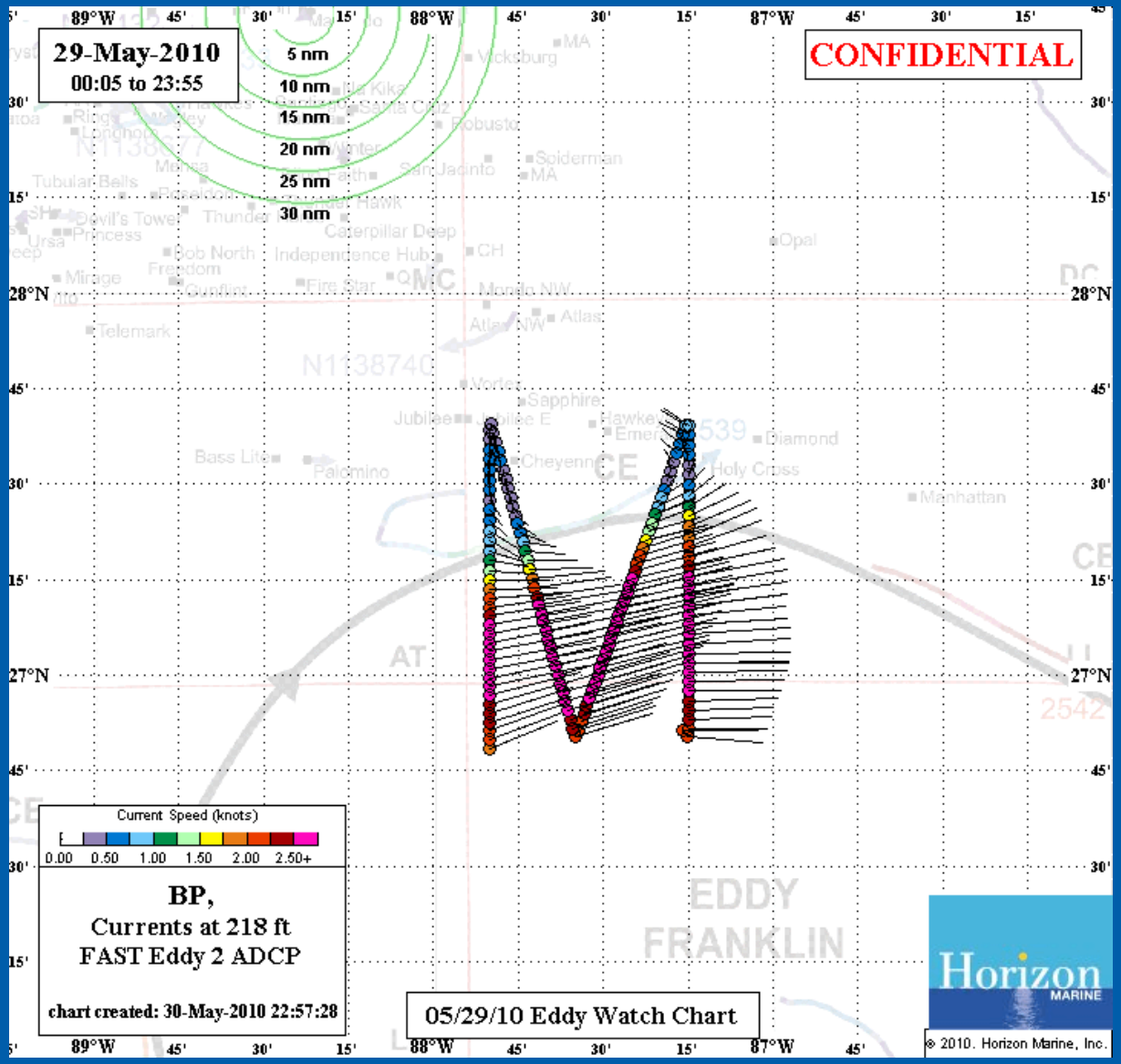
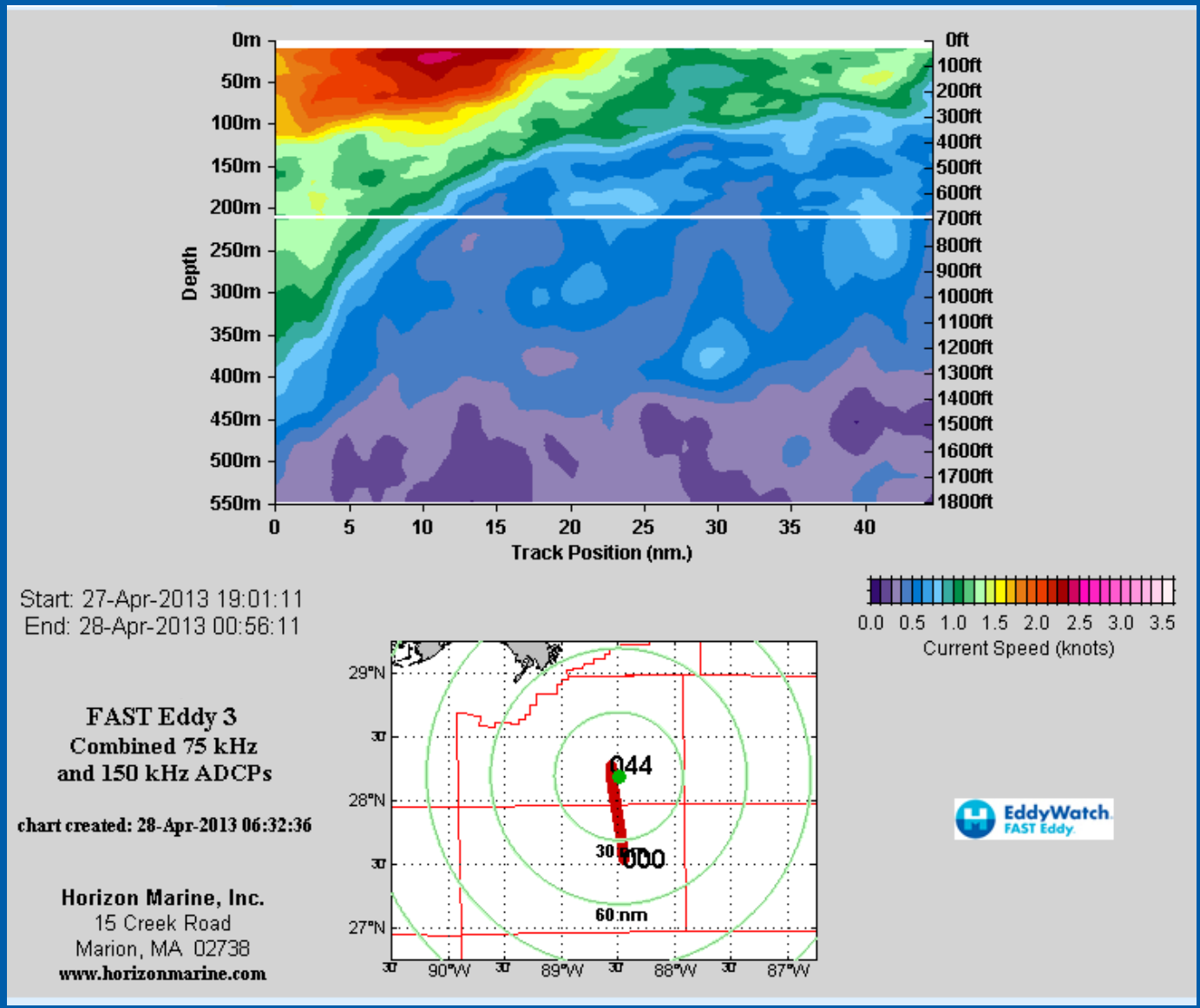


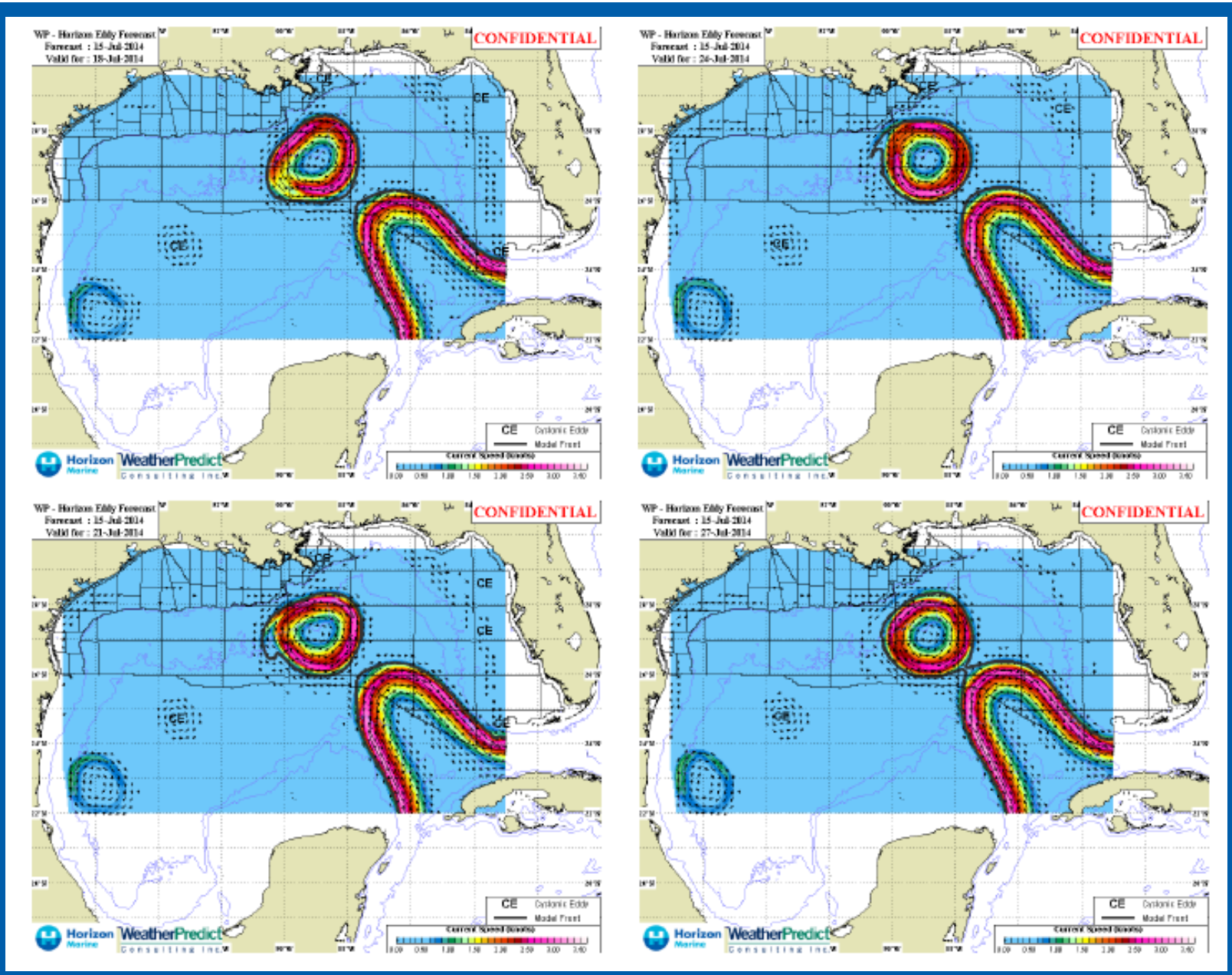
FAST Eddy: Monitoring Eddy Movement



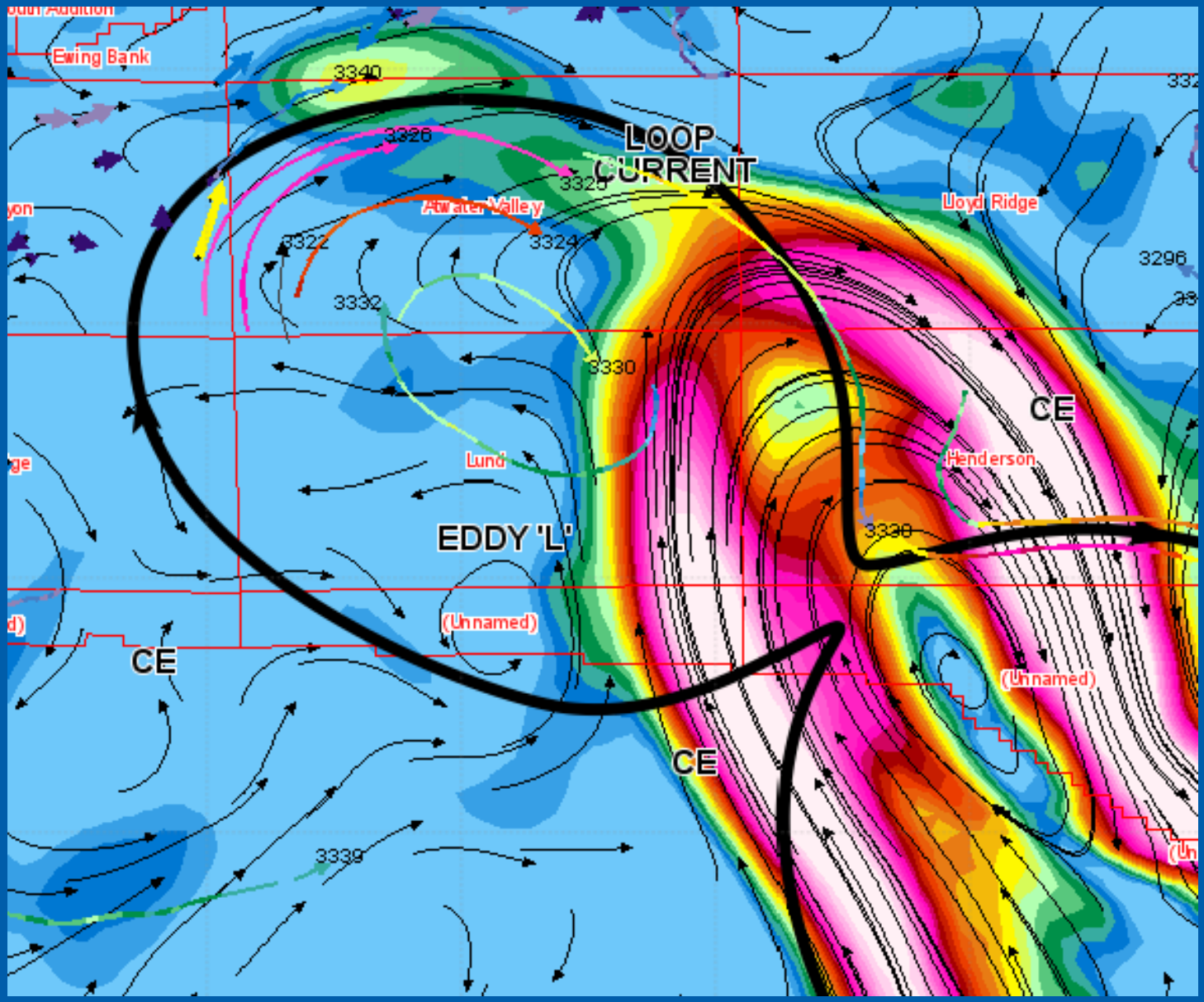
FAST Eddy: Upper 550m Water Column Data



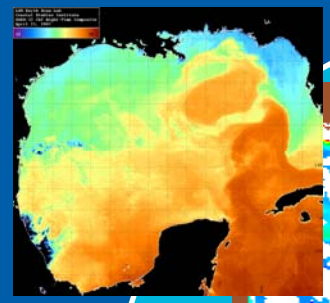
Gulf of Mexico – Eddy Forecast Model Initialized with Proprietary Data

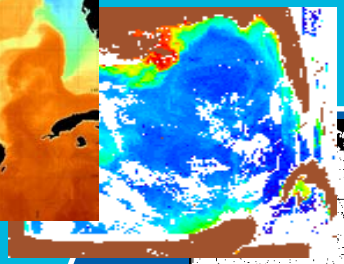


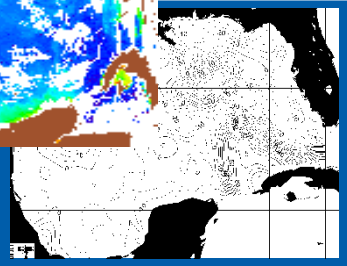
Gulf of Mexico – Global HYCOM (all models are wrong, some are useful sometimes)

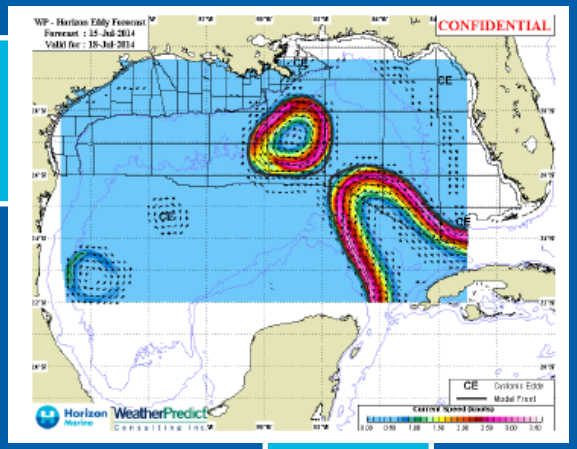


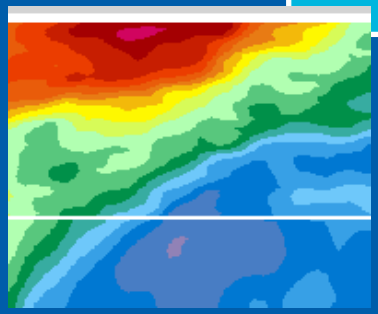
Gulf of Mexico - Analysis of Data & Identification of Major Features

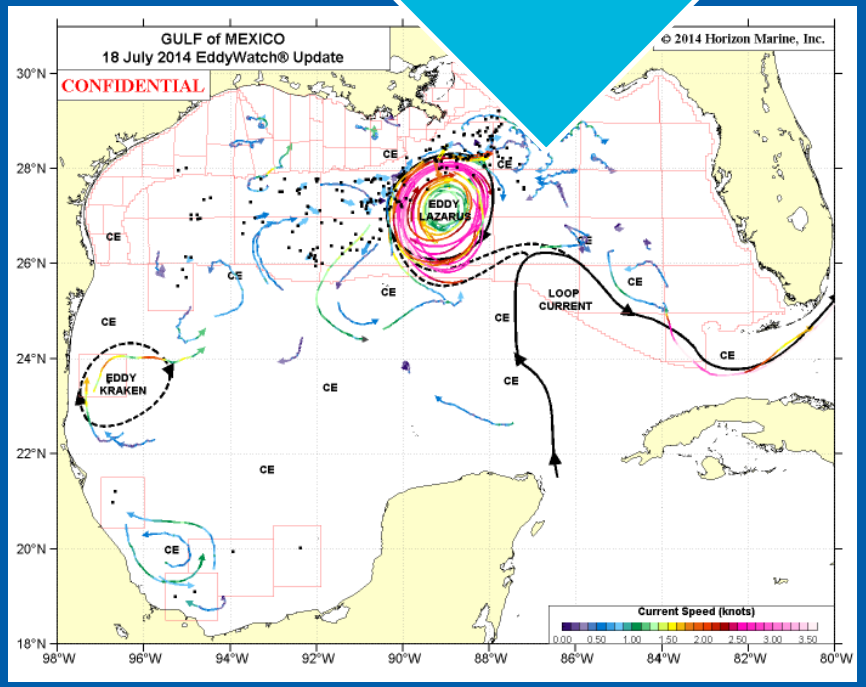




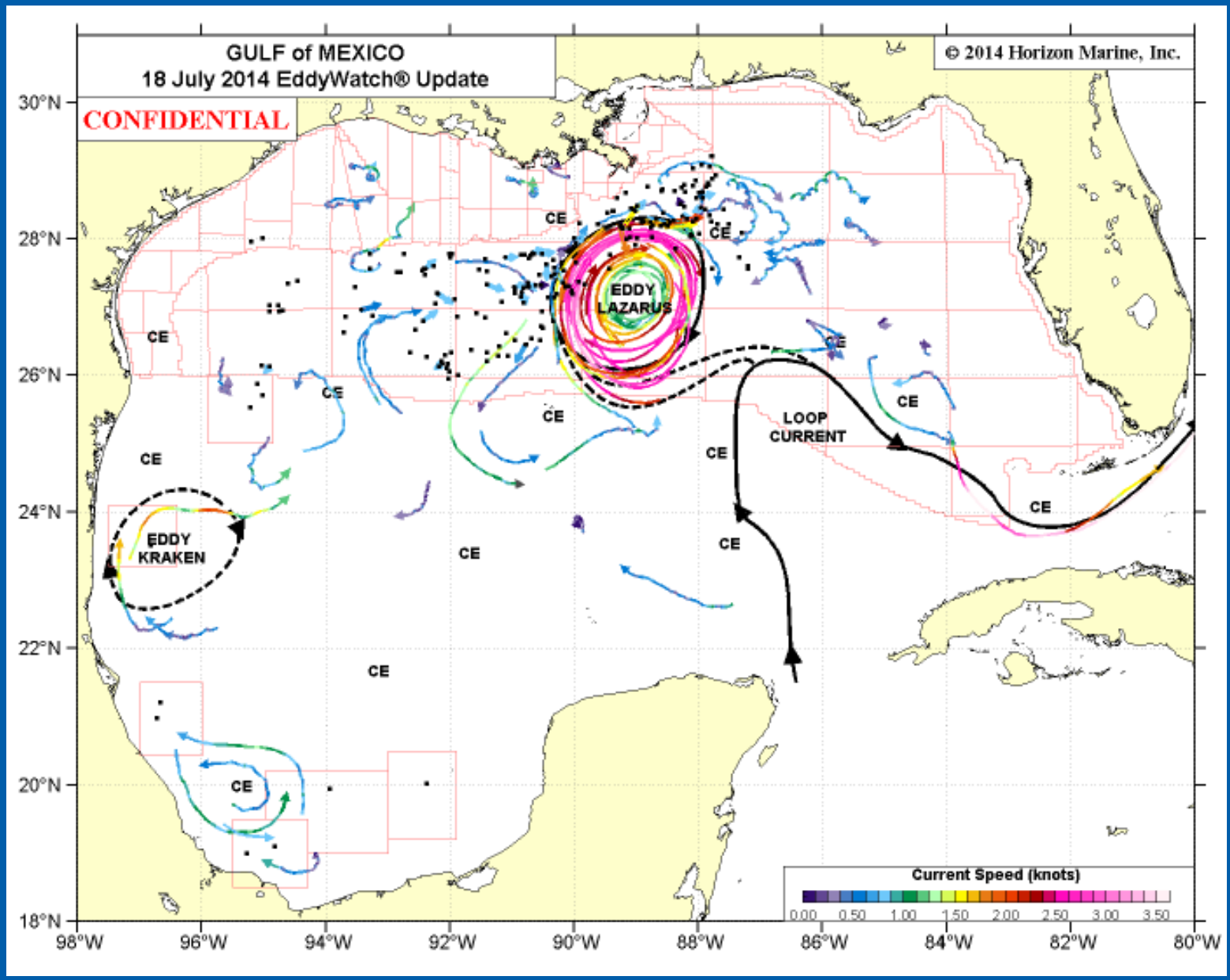




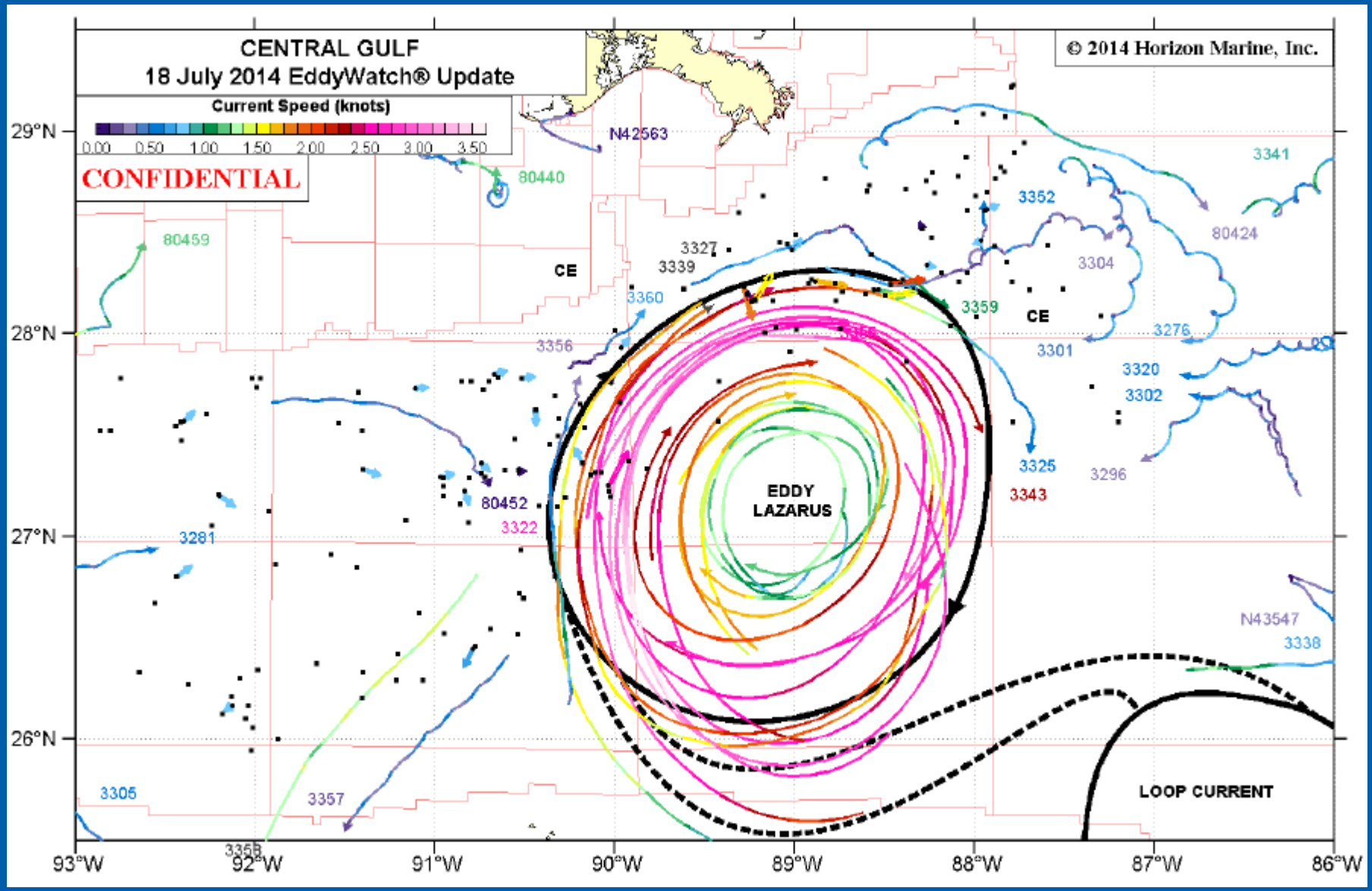




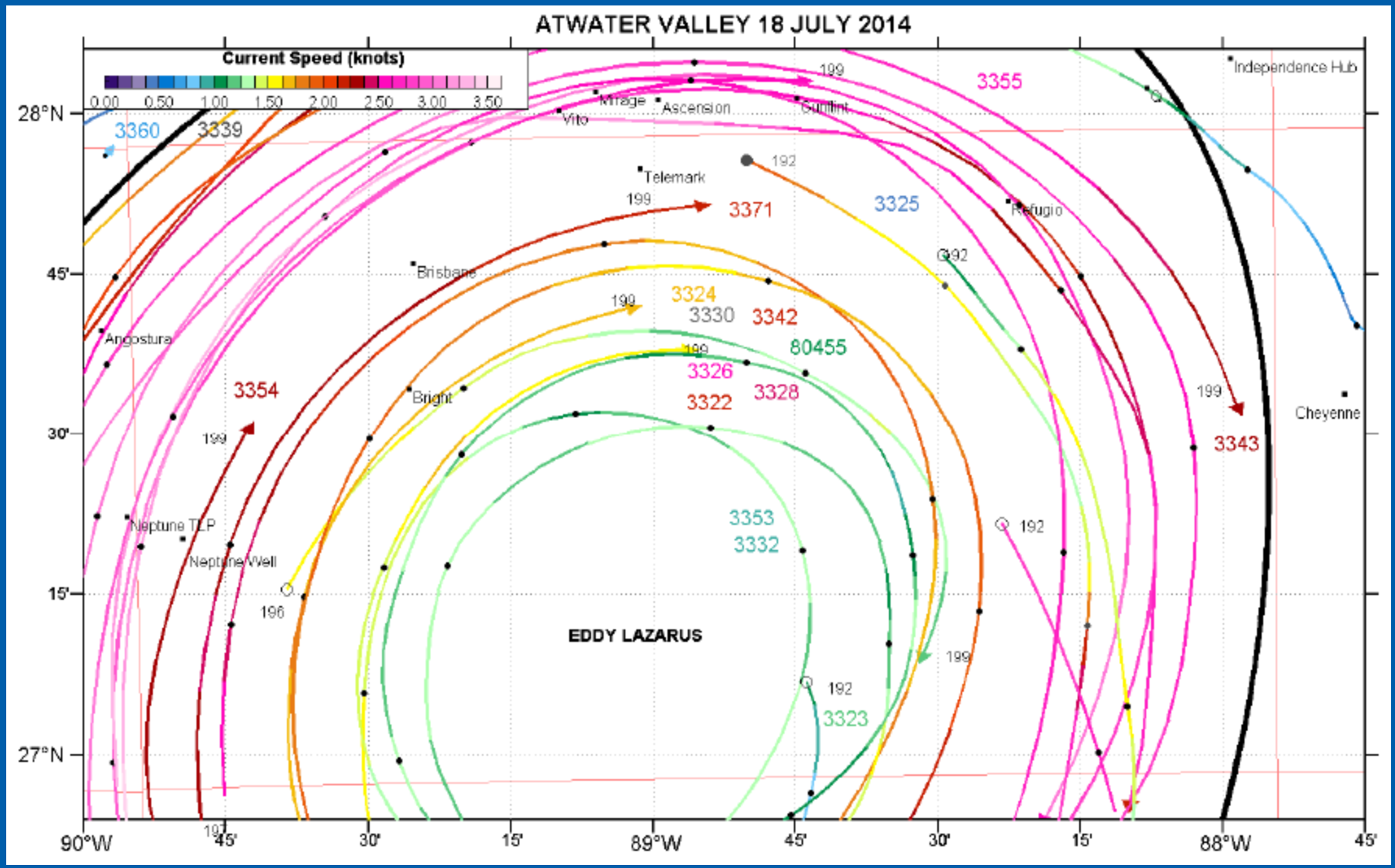
Gulf of Mexico - Gulf Chart



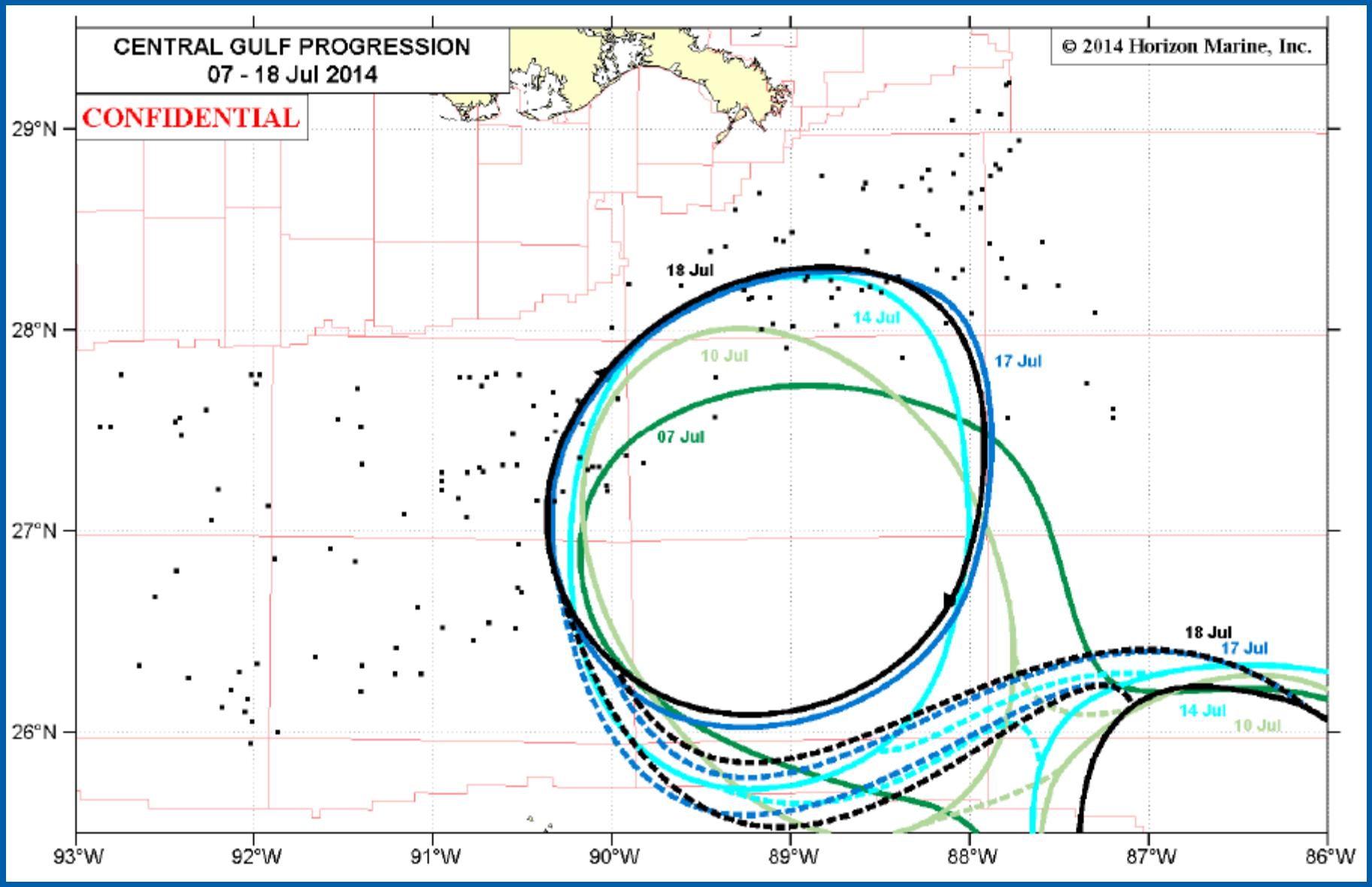
Gulf of Mexico - Central Gulf Chart



Gulf of Mexico - Lease Block Charts

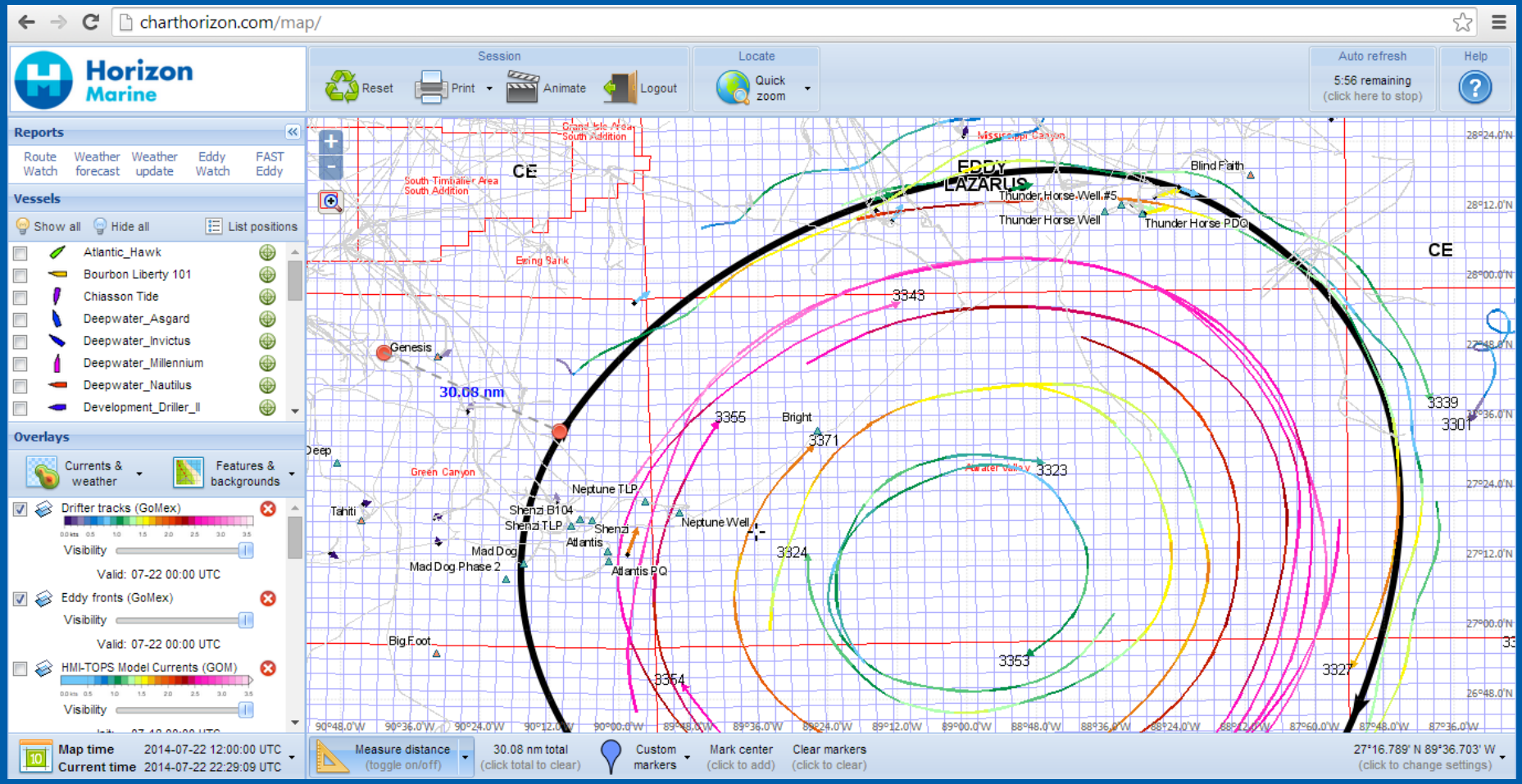


Gulf of Mexico - Progression Chart



Gulf of Mexico – MetOcean Mapper as a Common Operating Picture

EddyWatch data and analysis for ocean currents



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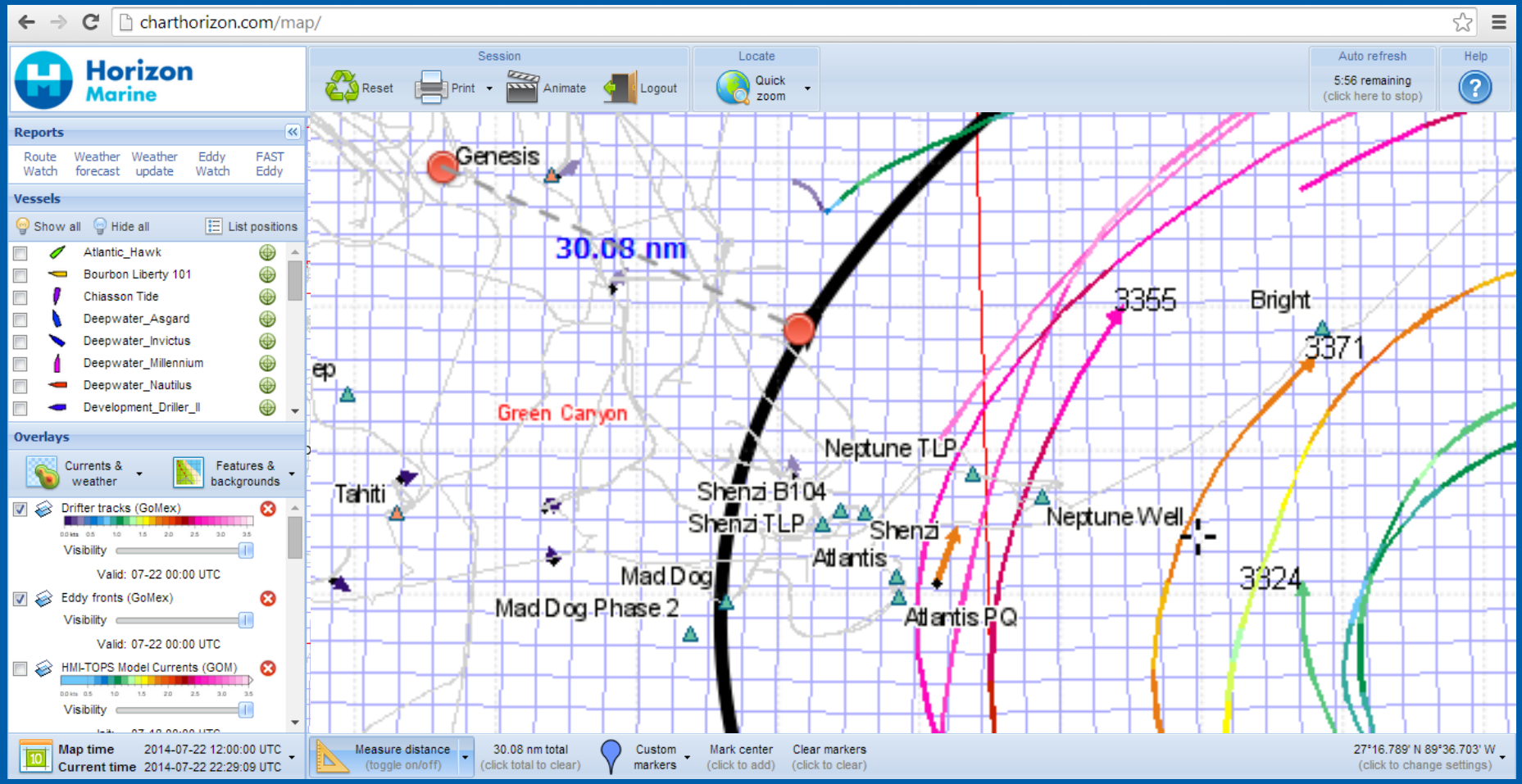

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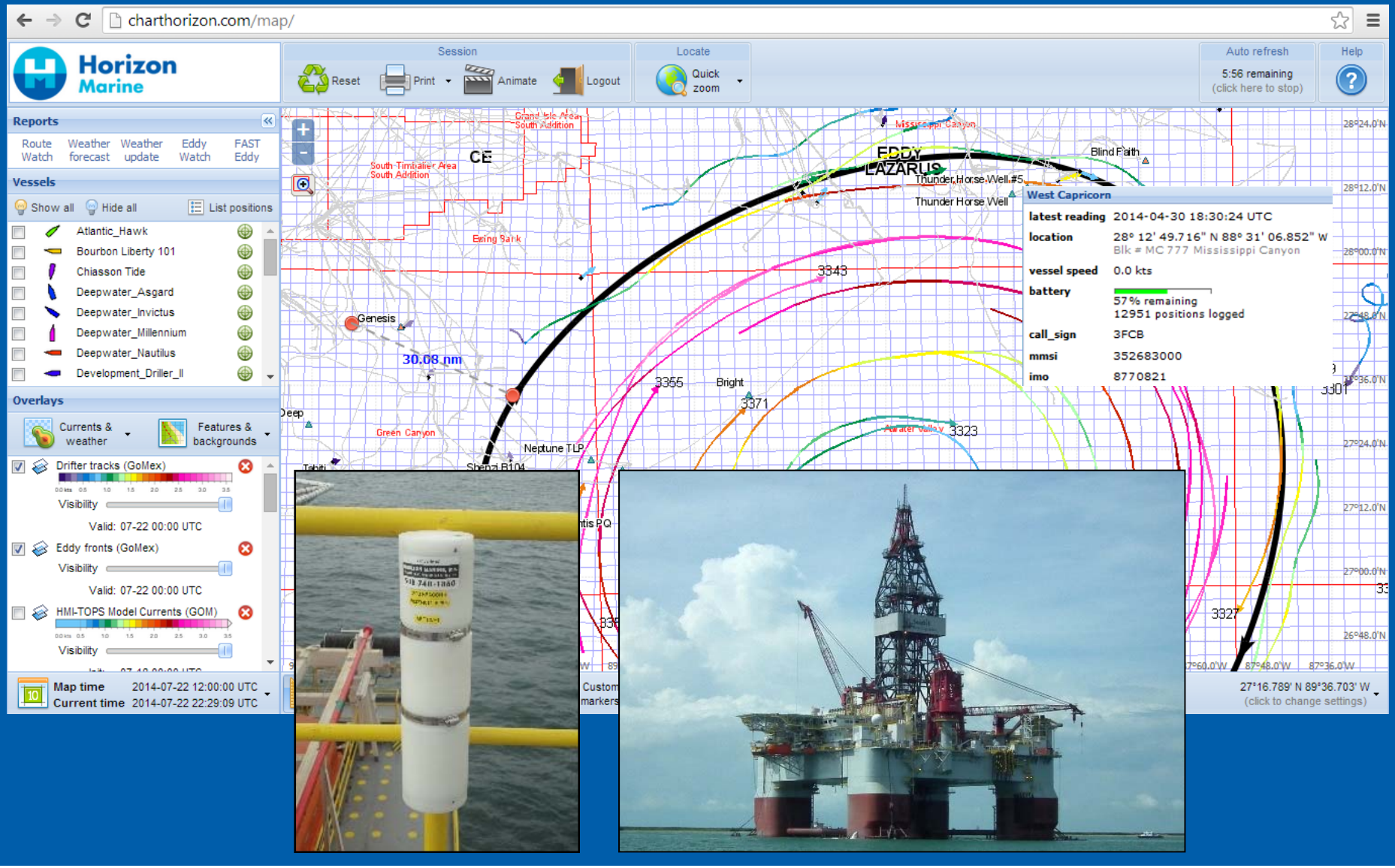
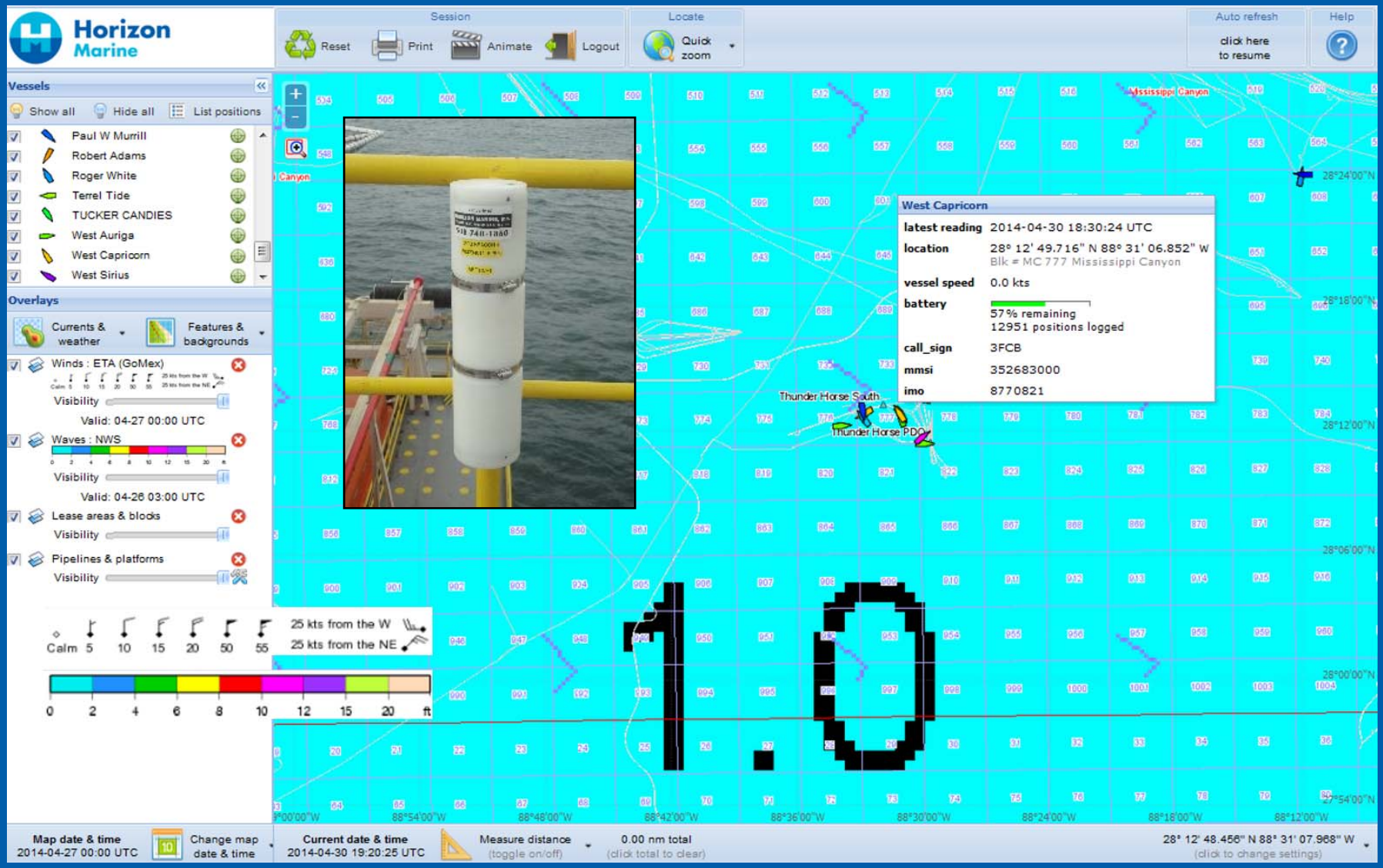
GPS tracking to place assets in context with currents



Gulf of Mexico – MetOcean Mapper as a Common Operating Picture

GPS tracking to place assets in context with weather



Gulf of Mexico – Human Element

EddyWatch
FAST Eddy

GULF OF MEXICO
UPDATE: 17 JULY 2014

Executive Summary

Over the past 24 hours, Eddy Lazarus has exhibited continued clockwise rotation and slight northeastward movement. Current intensities measured by FAST Eddy IV have placed the northern front ~4.9 n.mi. to the north-northeast of the Thunder Horse PDQ site. Directly upstream of the PDQ, east-southeastward surface currents of 2.1 knots were observed today at 0547 hours CST. Current intensities greater than 1.0 knot extend down to 90 m in the water column. Similar surface currents are being observed upstream of the *West Vela*. Similar currents are observed upstream of the *West Vela* and *West Capricorn*, where FAST eddy measured currents greater than 2.0 knots and 1.0 knot to a dept respectively. Surface currents 0.8 n.mi. downstrea Throughout the Thunder Horse field, surface current The northern band of maximum currents is located al PDQ, current speeds as strong as 3.0 knots are being band of maximum currents, speeds up to 1.5 knots a the water column, respectively.

Over the past 24 hours, Eddy Lazarus has exhibited movement of 0.8 n.mi. of the western front. Presently to the west of the *DDIII*. Recently, FAST Eddy III h knots 0.6 n.mi. to the northeast of the Atlantis site a knots down to 70 m and 270 m in the water column, the Atlantis field is consistently 15° of true north.

Forecast

The clockwise rotation and slight northward movement of Eddy Lazarus is expected to continue over the next week. The movement of the eddy will be limited by the bathymetry of the shelf break along the eddies' western front. These developments will likely bring the Thunder Horse PDQ deeper within the band of maximum currents in the northern front. Currents within the band of maximum currents are expected to fluctuate between 2.0 and 3.0 knots. The eastward direction of the current will likely remain the same for the next week or more.

Eddy Lazarus' continued clockwise rotation and gradual north-northeastward migration will result in little change in conditions in the Atlantis field. The movement of the western front of the eddy is constrained by the shelf break. The continued rotation of the eddy will likely result in fluctuating currents between 2.5 and 3.5 knots for the next week or longer. The northward direction of currents throughout the water column will likely remain unchanged over the coming week.

www.horizonmarine.com
eddywatch@horizonmarine.com
508-748-1860

CONFIDENTIAL

Situational Awareness for Safe & Efficient Operations

Situational Awareness for Safe & Efficient Operations

"....we contracted the FAST Eddy service from Horizon Marine, Inc. and we were very pleased with the amount of data it provided concerning Eddy Darwin. BHP Billiton were installing the Shenzi umbilicals at that time, and the FAST Eddy support allowed vessel captains to execute the work the best way possible..."
– Nektaria Zois, Subsea Systems Delivery Manager, BHPB.

"I would like to thank you and your colleagues for the excellent service we have receive the last period. It has helped us tremendously in our decision making process. I hope we can convince the various project teams to use the FAST Eddy service as well."
– A.D. Udo, Captain, HLV Thialf, Heerema.

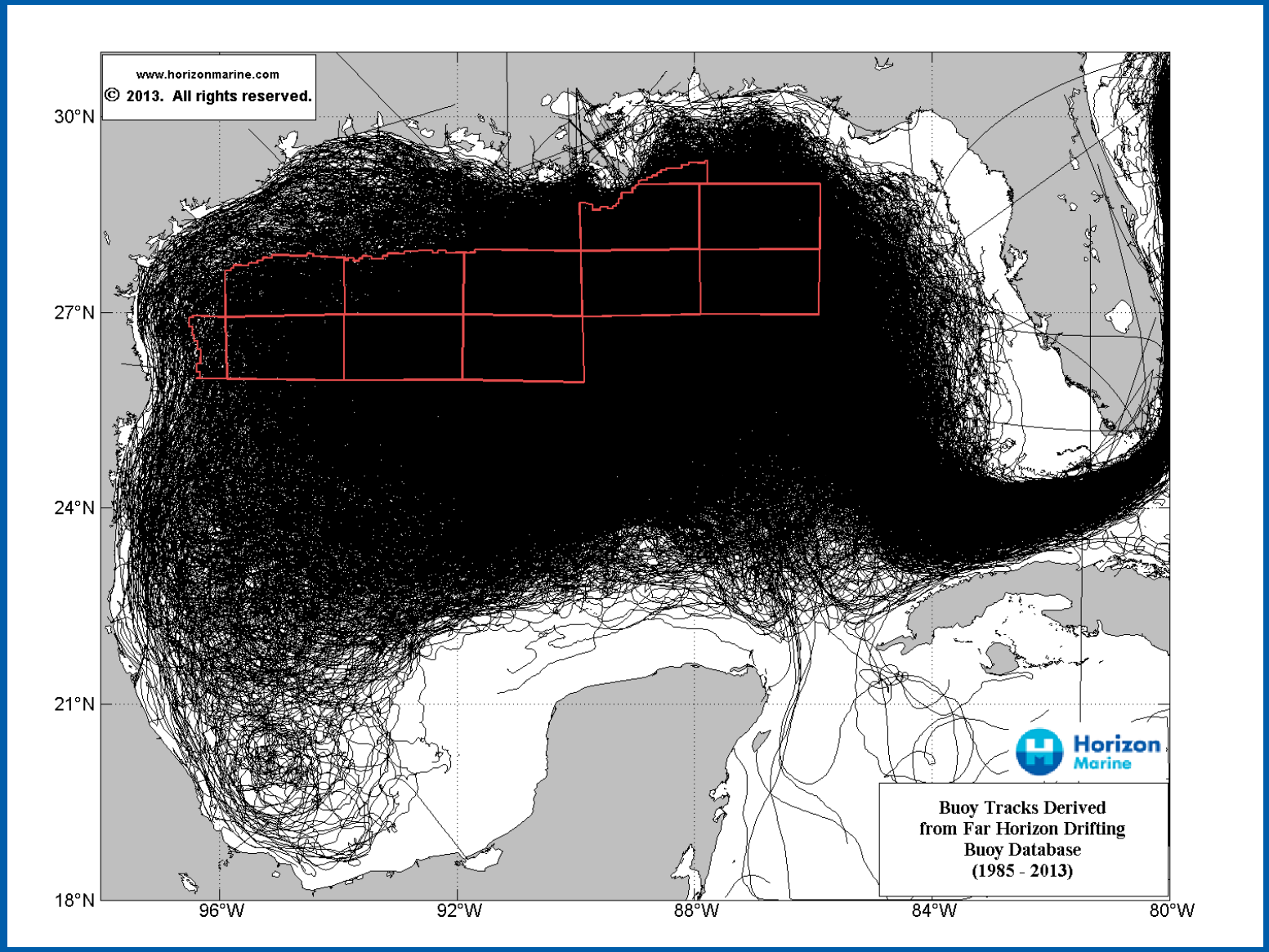
"Many thanks for all the help and vital information you provided us whilst we were offshore with the Balder through the summer – it was truly invaluable in our planning."
– Simon Webb, BP America.

"A slap in the face is not that bad when you know it's coming."
– Paul Kelly, BHP Billiton.

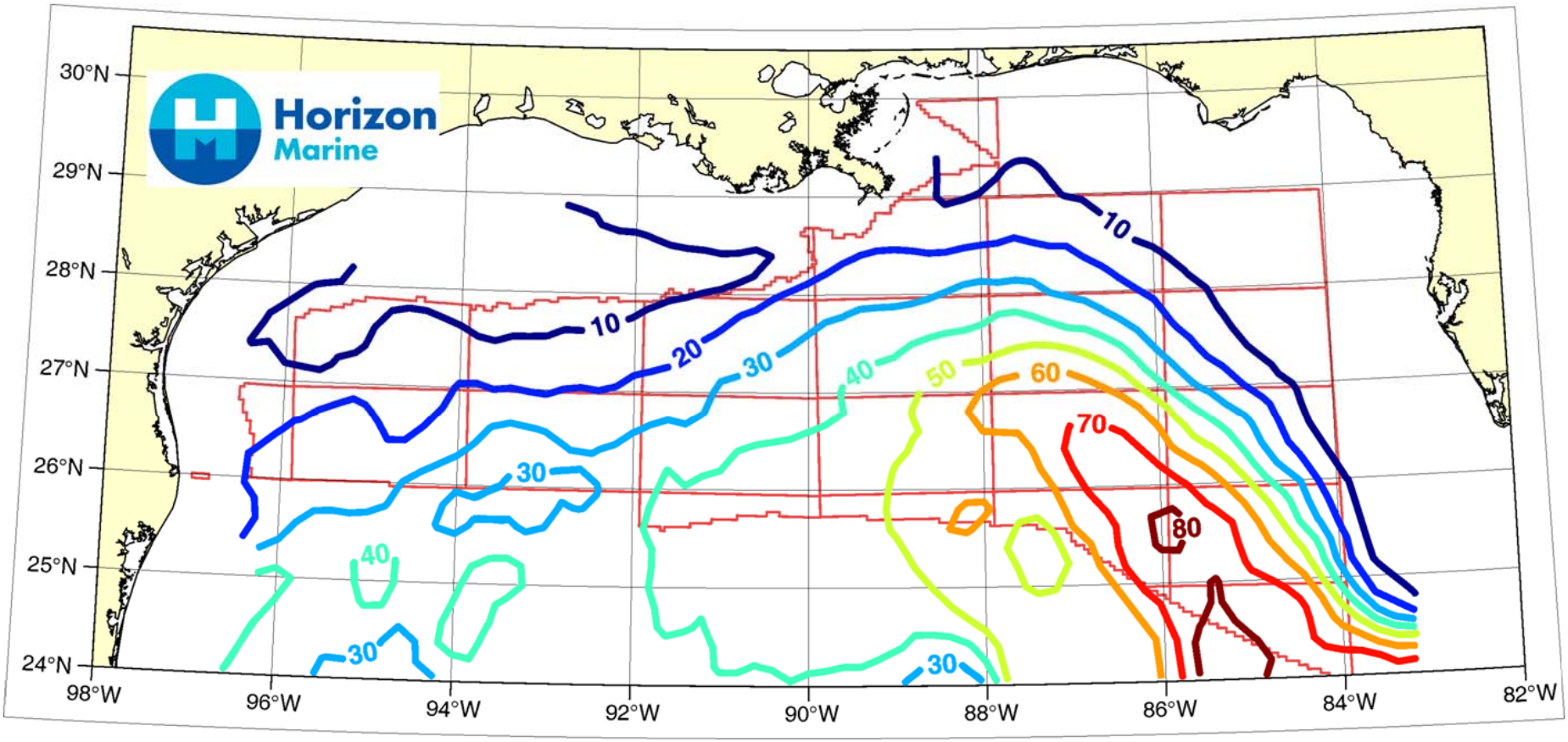
"FAST Eddy added tremendous value to our project for our planning and ability to mitigate cost due to current effects. Keep up the great work, it is much appreciated."
– Mike Lemker, Anadarko.

"Thanks to you and all the people at Horizon Marine for the help over the last few weeks, it has been a big help to our operations."
– Ian Nott, Chevron.

Mining the Data - Buoys

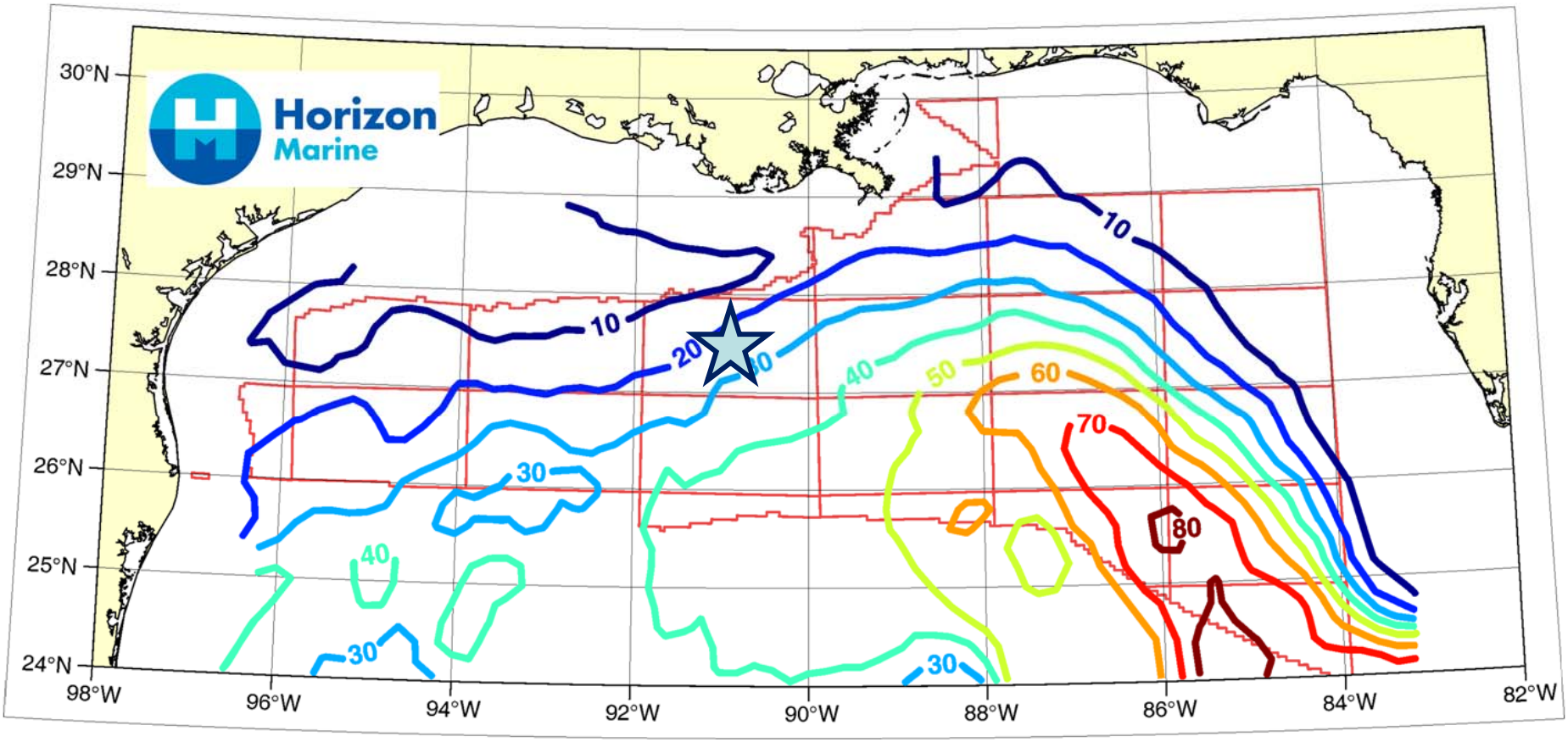


Mining the Data - Buoys



Percentage of time currents are greater than 1.0 knot

Mining the Data - Buoys



Percentage of time currents are greater than 1.0 knot

Buoys – Monthly Statistics

Site: XYZ			
Month	Mean Spd (kts)	Max Spd (kts)	Min Spd (kts)
January	1.11	2.47	0.42
February	1.18	1.83	0.83
March	1.46	2.26	0.73
April	1.94	2.75	1.20
May	1.42	2.38	0.55
June	0.85	1.11	0.77
July	1.50	2.14	0.64
August	1.40	2.18	0.70
September	1.08	2.43	0.26
October	1.53	2.13	0.82
November	0.84	1.89	0.24
December	0.89	2.21	0.27

Site: XYZ	
Speeds (knots)	% Occurrence
0.00-0.25	0.03
0.25-0.50	4.26
0.50-0.75	10.2
0.75-1.00	14.35
1.00-1.25	17.73
1.25-1.50	14.8
1.50-1.75	17.95
1.75-2.00	16.38
2.00-2.25	12.15
2.25-2.50	6.31
2.50-2.75	2.83
2.75-3.00	0.91

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May	1.42	2.38	0.55
June	0.85	1.11	0.77
July	1.50	2.14	0.64
August	1.40	2.18	0.70
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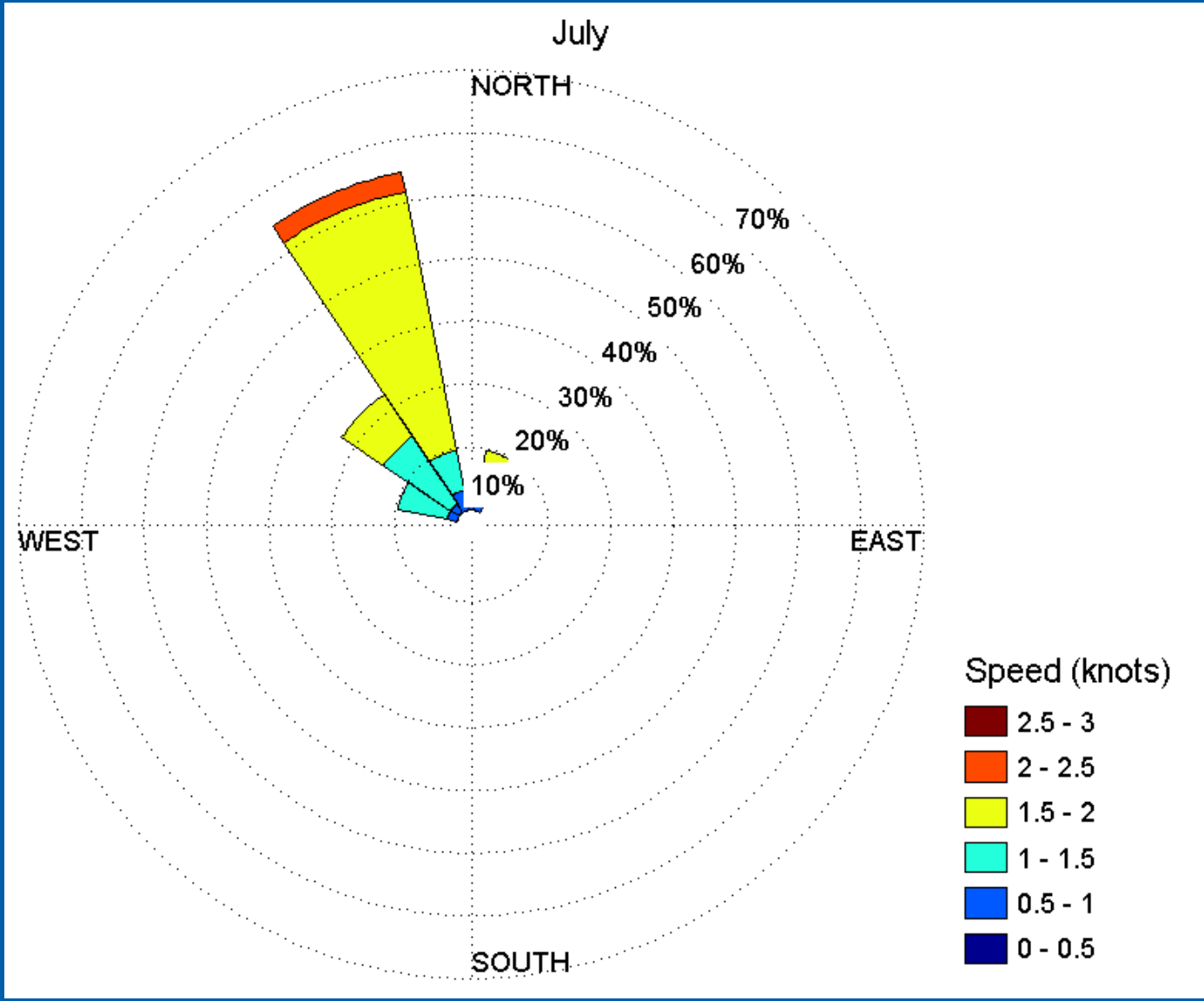
October	1.53	2.13	0.82
November	0.84	1.89	0.24
December	0.89	2.21	0.27

Site: XYZ	
Speeds (knots)	% Occurrence
0.00-0.25	0.03
0.25-0.50	4.26
0.50-0.75	10.2
0.75-1.00	14.35
1.00-1.25	17.73
1.25-1.50	14.8
1.50-1.75	17.95
1.75-2.00	16.38
2.00-2.25	12.15
2.25-2.50	6.31
2.50-2.75	2.83
2.75-3.00	0.91

Buoys - Distribution of Surface Current Speeds and Directions

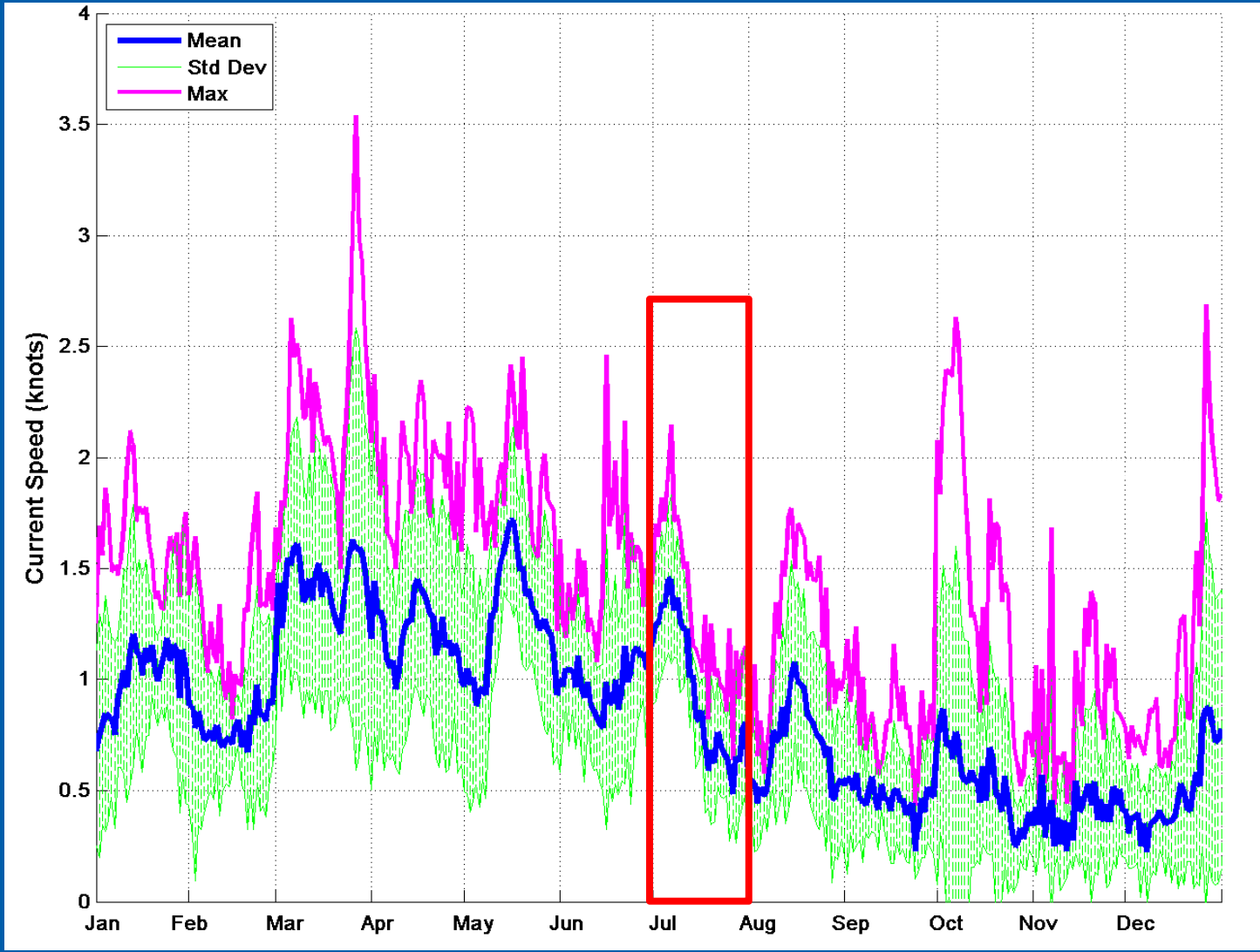


Buoys - Distribution of Surface Current Speeds and Directions

July Current Distributions (%)

	N - NNE	NNE - NE	NE - ENE	ENE - E	E - ESE	ESE - SE	SE - SSE	SSE - S	S - SSW	SSW - SW	SW - WSW	WSW - W	W - WNW	WNW - NW	NW - NNW	NNW - N
0 - 0.5 kts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.5 - 1.0 kts	3.23	-	-	-	-	-	-	-	-	-	-	-	1.61	-	3.23	3.23
1.0 - 1.5 kts	-	3.23	-	-	-	-	-	-	-	-	-	-	1.61	17.74	8.06	-
1.5 - 2.0 kts	1.61	3.23	-	-	-	-	-	-	-	-	-	-	-	1.61	32.26	16.13
2.0 - 2.5 kts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3.23
2.5 - 3.0 kts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
> 3.0 kts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Models - Annual Variation of Surface Currents

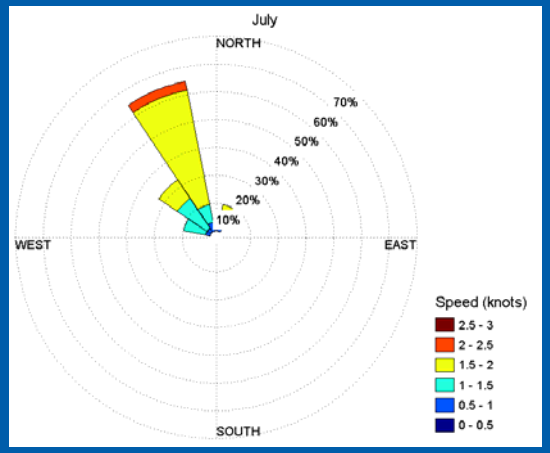


Models - Surface Current Statistics

	Speed (kts)		Direction (°)		Min Speed	Max Speed
Month	Mean	Std Dev	Mean	Std Dev	(kts)	(kts)
January	1.00	0.42	312.92	76.19	0.06	2.12
February	0.80	0.35	311.39	67.67	0.00	1.84
March	1.44	0.57	320.26	83.87	0.13	3.54
April	1.19	0.47	318.93	78.23	0.28	2.35
May	1.27	0.44	314.24	93.23	0.31	2.45
June	1.00	0.36	316.21	68.94	0.01	2.46
July	0.91	0.40	308.93	74.79	0.04	2.15
August	0.71	0.37	267.90	114.08	0.06	1.77
September	0.48	0.26	217.25	138.78	0.04	2.08
October	0.51	0.47	211.60	123.99	0.03	2.63
November	0.40	0.27	201.79	111.95	0.00	1.68
December	0.50	0.44	270.20	88.62	0.02	2.69

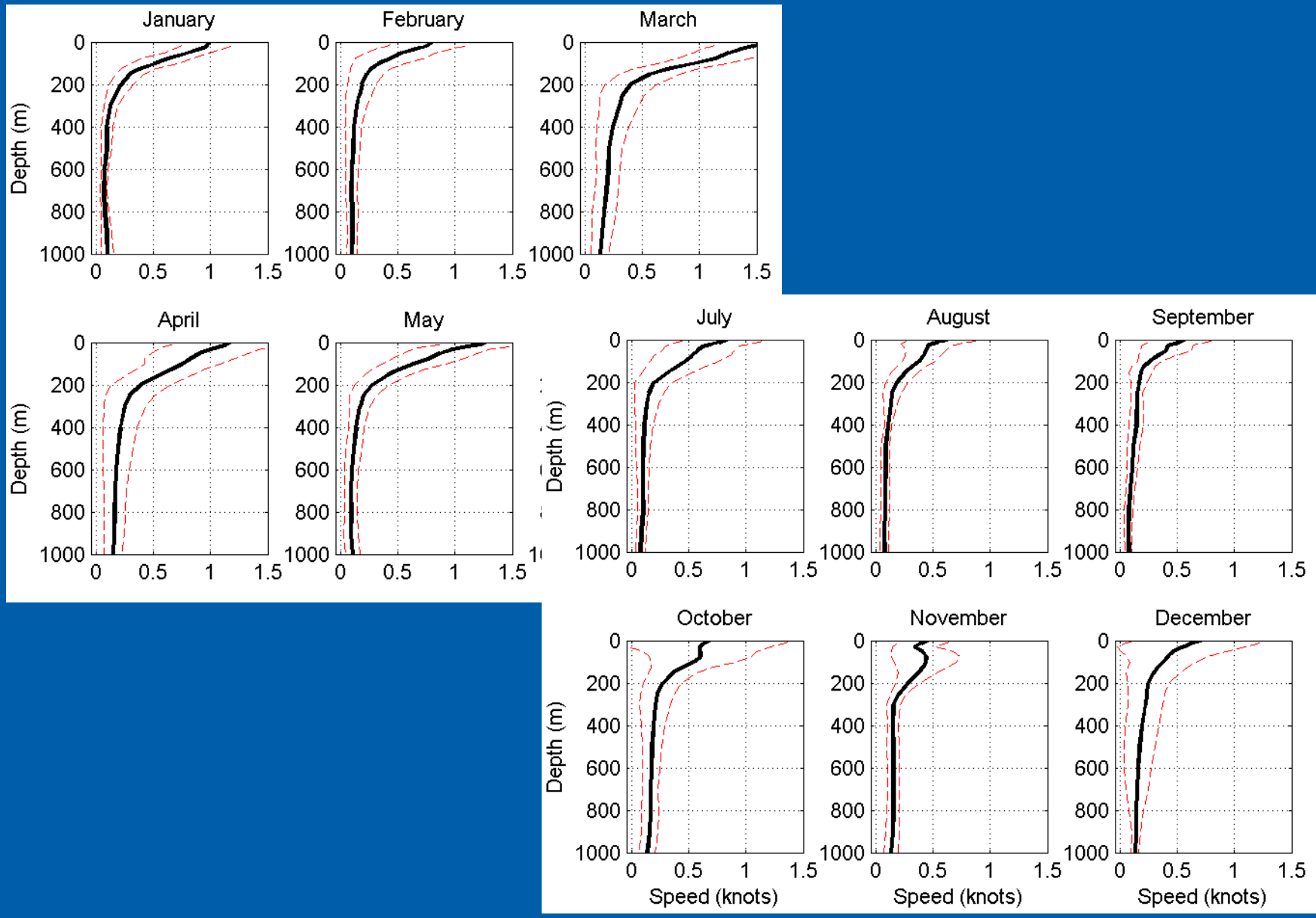
Model Comparison to *in-situ* Data – Greater Confidence in Synthetic Data

	Speed (kts)		Direction (°)		Min Speed	Max Speed
Month	Mean	Std Dev	Mean	Std Dev	(kts)	(kts)
January	1.00	0.42	312.92	76.19	0.06	2.12
February	0.80	0.35	311.39	67.67	0.00	1.84
March	1.44	0.57	320.26	83.87	0.13	3.54
April	1.19	0.47	318.93	78.23	0.28	2.35
May	1.27	0.44	314.24	93.23	0.31	2.45
June	1.00	0.36	316.21	68.94	0.01	2.46
July	**0.91**	**0.40**	**308.93**	**74.79**	**0.04**	**2.15**
August	0.71	0.37	267.90	114.08	0.06	1.77
September	0.48					
October	0.51					
November	0.40					
December	0.50					

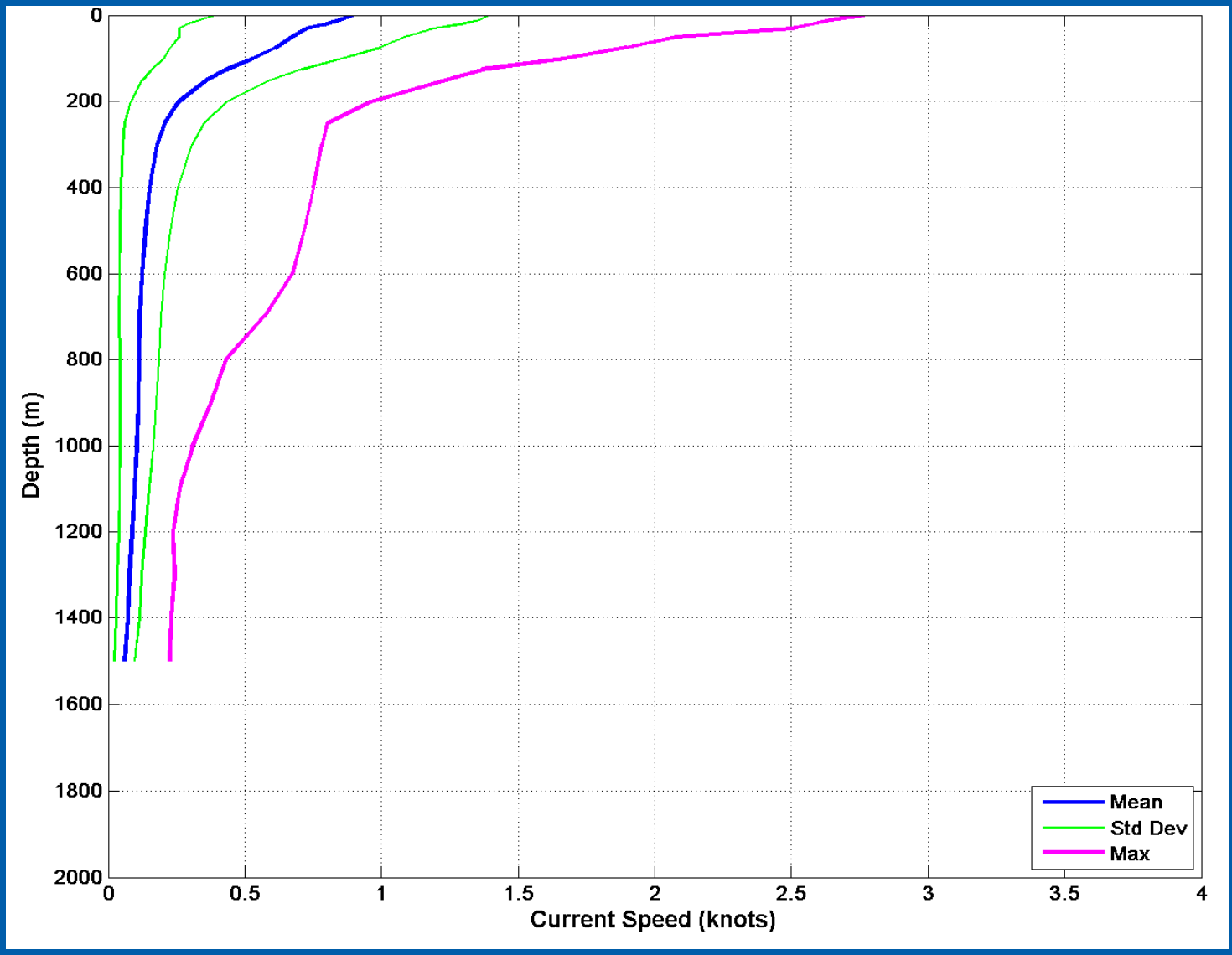


Site: XYZ			
Month	Mean Spd (kts)	Max Spd (kts)	Min Spd (kts)
January	1.11	2.47	0.42
February	1.18	1.83	0.83
March	1.46	2.26	0.73
April	1.94	2.75	1.20
May	1.42	2.38	0.55
June	0.85	1.11	0.77
July	**1.50**	**2.14**	**0.64**
August	1.40	2.18	0.70
September	1.08	2.43	0.26
October	1.53	2.13	0.82
November	0.84	1.89	0.24
December	0.89	2.21	0.27

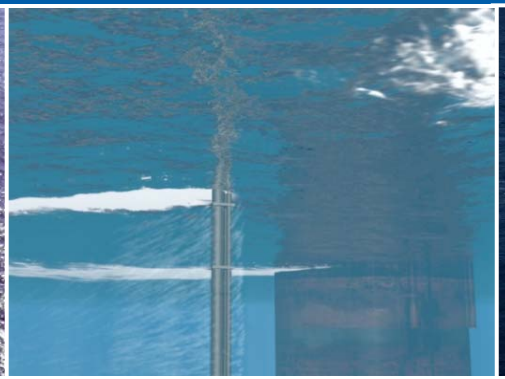
Models - Monthly Mean and Standard Deviation of Current Profiles

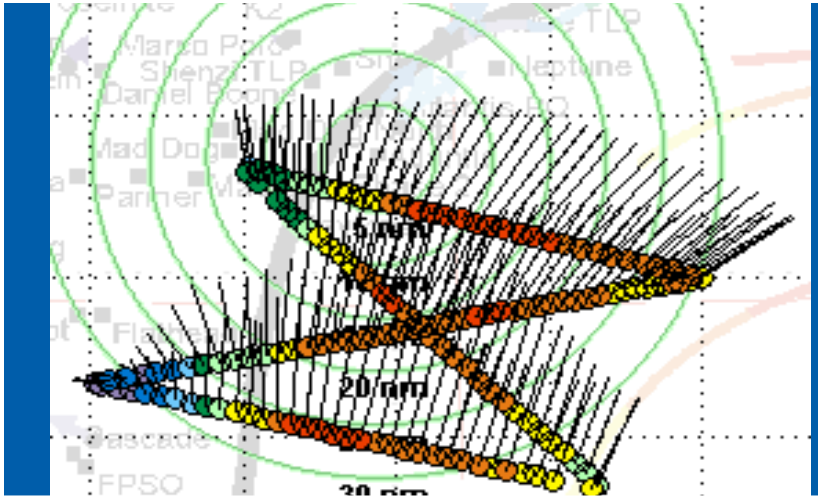


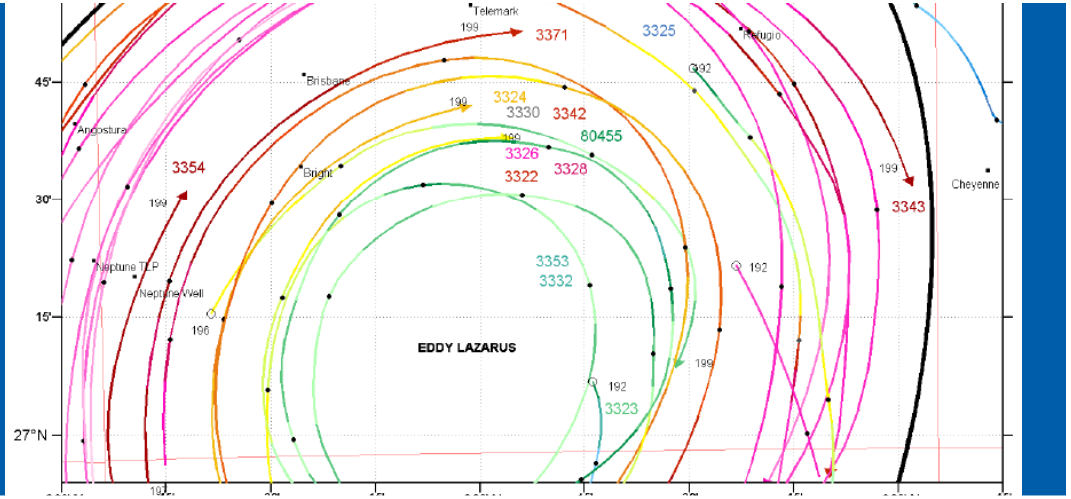
Models Provide Data for Riser Analysis, *in-situ* data provide confidence level in models

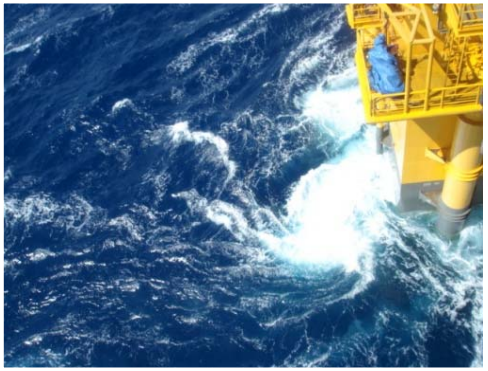


Better Data = Better Decisions…

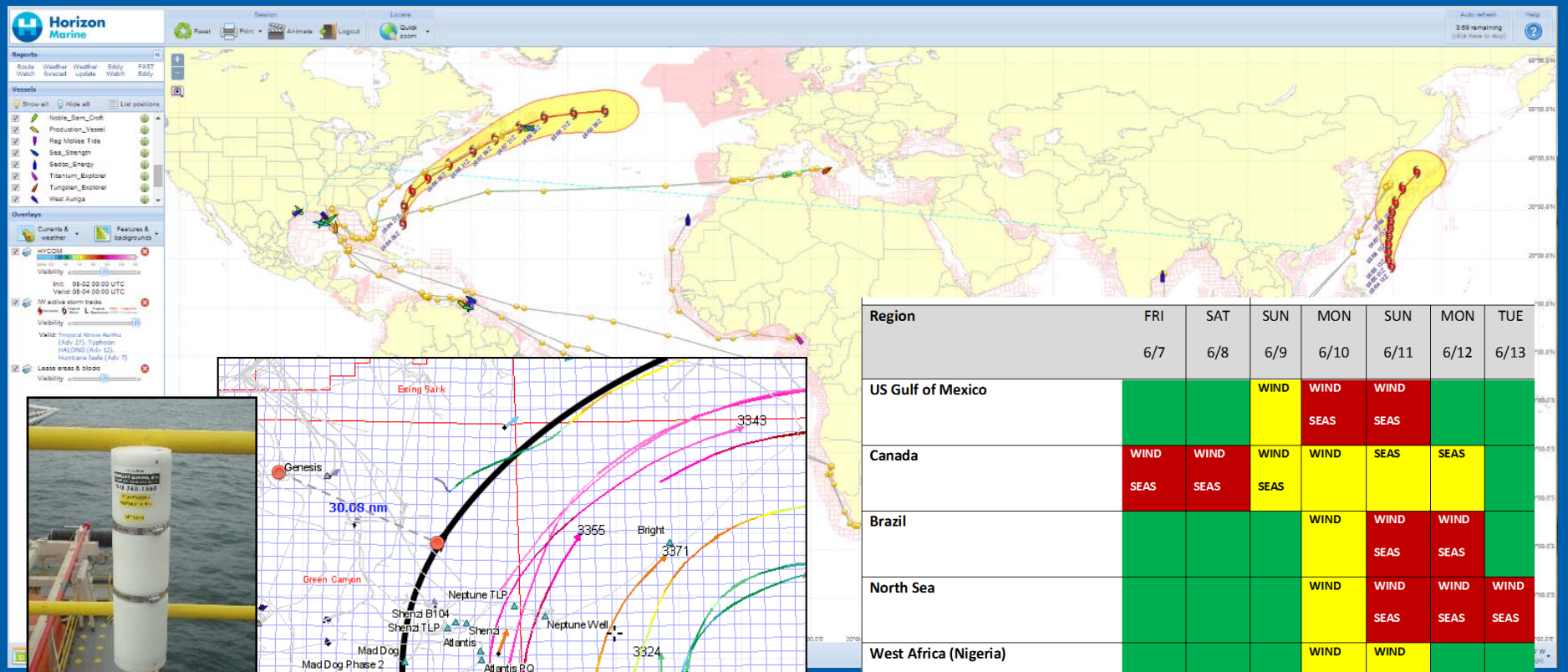








…when Presented Coherently and in Context



Region	FRI 6/7	SAT 6/8	SUN 6/9	MON 6/10	SUN 6/11	MON 6/12	TUE 6/13
US Gulf of Mexico			WIND	WIND SEAS	WIND SEAS		
Canada	WIND SEAS	WIND SEAS	WIND SEAS	WIND	SEAS	SEAS	
Brazil				WIND	WIND SEAS	WIND SEAS	
North Sea				WIND	WIND SEAS	WIND SEAS	WIND SEAS
West Africa (Nigeria)				WIND	WIND SEAS		
West Africa (Angola)				TSTRMS	TSTRMS		
East Africa					TSTRMS		
West Asia Pacific (Indian Ocean)				WIND	WIND SEAS		
East Asia Pacific (South China Sea)						WIND	SEAS
Australia	Tropical Cyclone	Tropical Cyclone					

GREEN – NO RISK | YELLOW – SLIGHT RISK | RED – MODERATE RISK

Thank You

Matt Cadwallader
Business Development Manager
matt@horizonmarine.com

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AMERICAN ASSOCIATION of DRILLING ENGINEERS

Deepwater and Emerging Technology Program

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