WIND EFFECTS ON CHEMICAL SPILL IN ST ANDREW BAY SYSTEM

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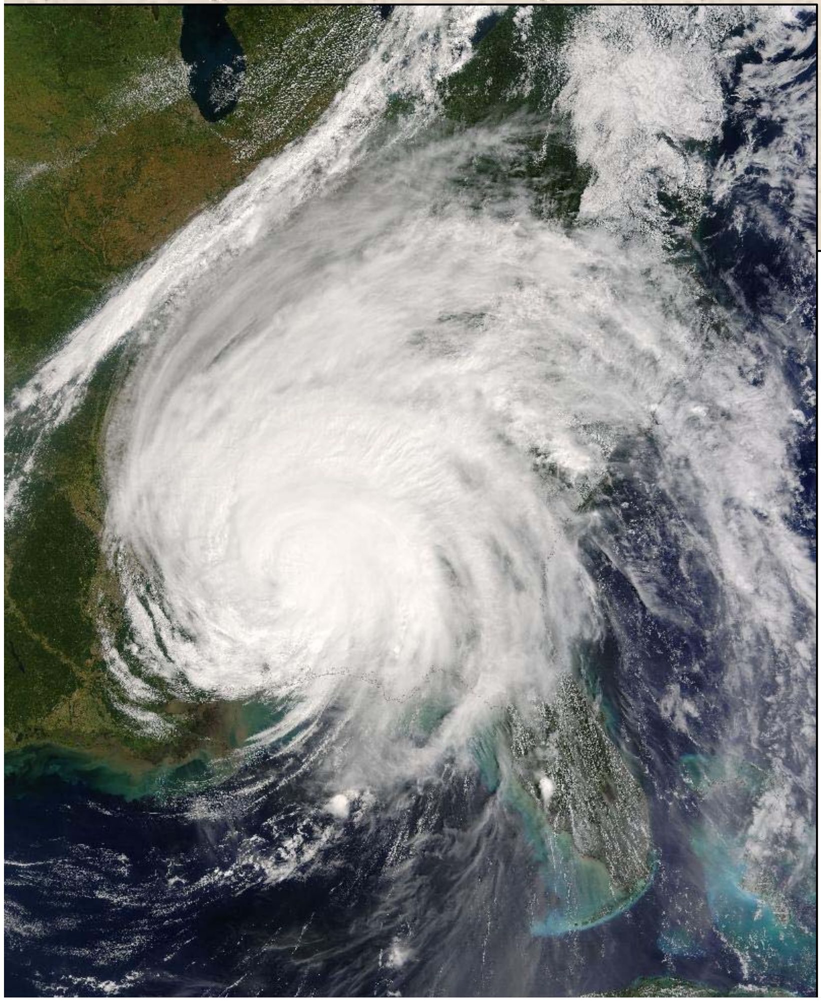
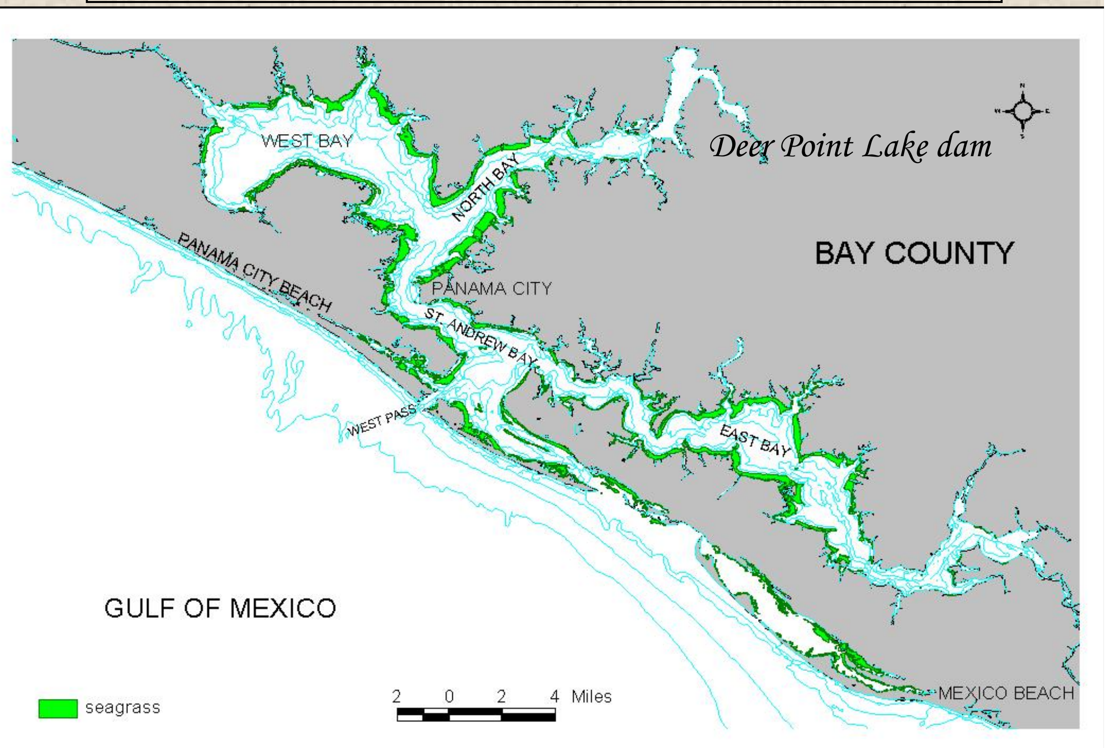
Outlines

- Geographic Environment
- Hydrodynamic model
- Forcing mechanisms
- Hydrochemical model
- Conclusions

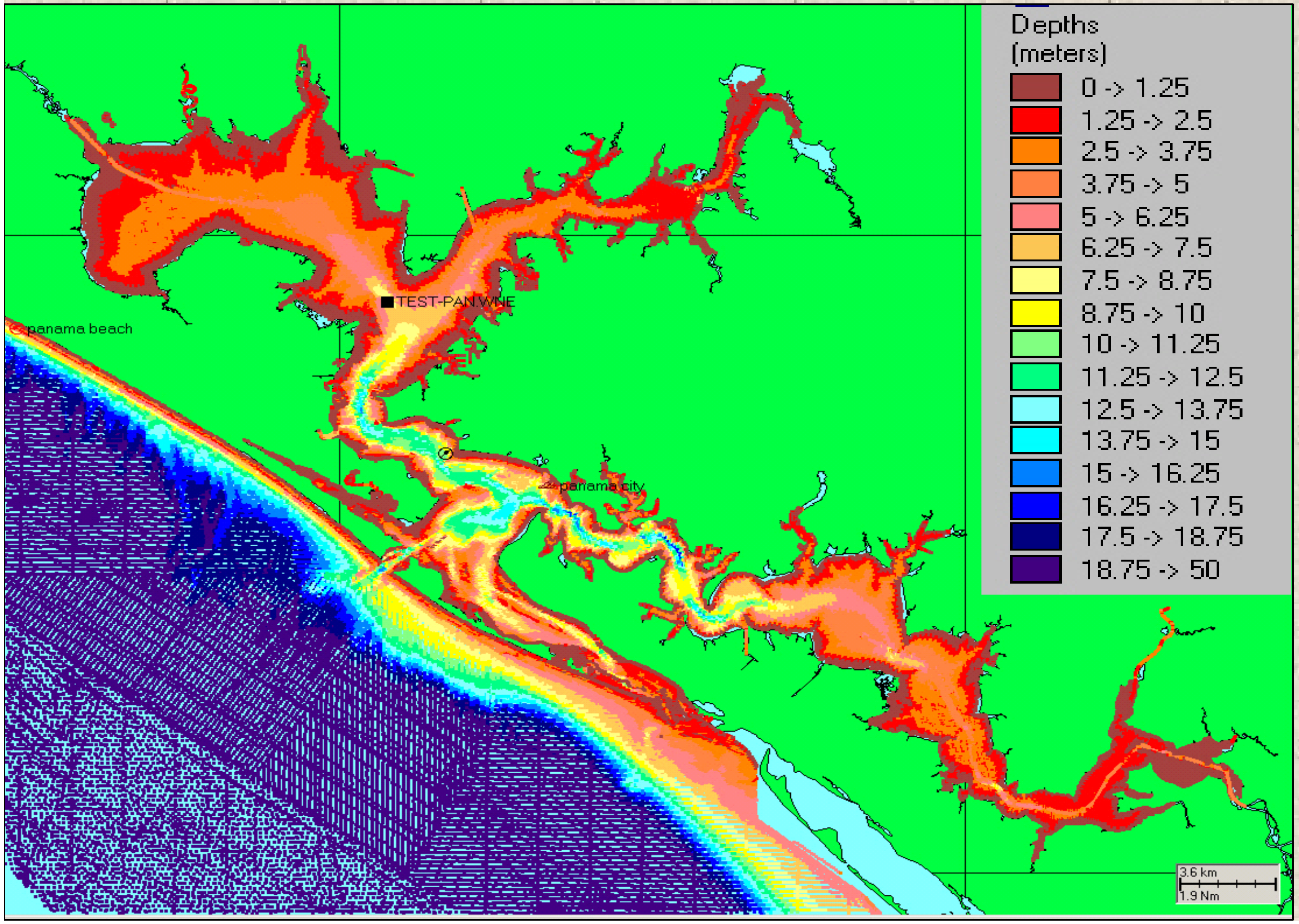
Geographic location - overview



- *Northeastern Gulf of Mexico*
- *Part of the Intracoastal highway*
- *Fed by Deer Point Lake dam*



Geographic location - bathymetry



Panama City Beach

Panama City

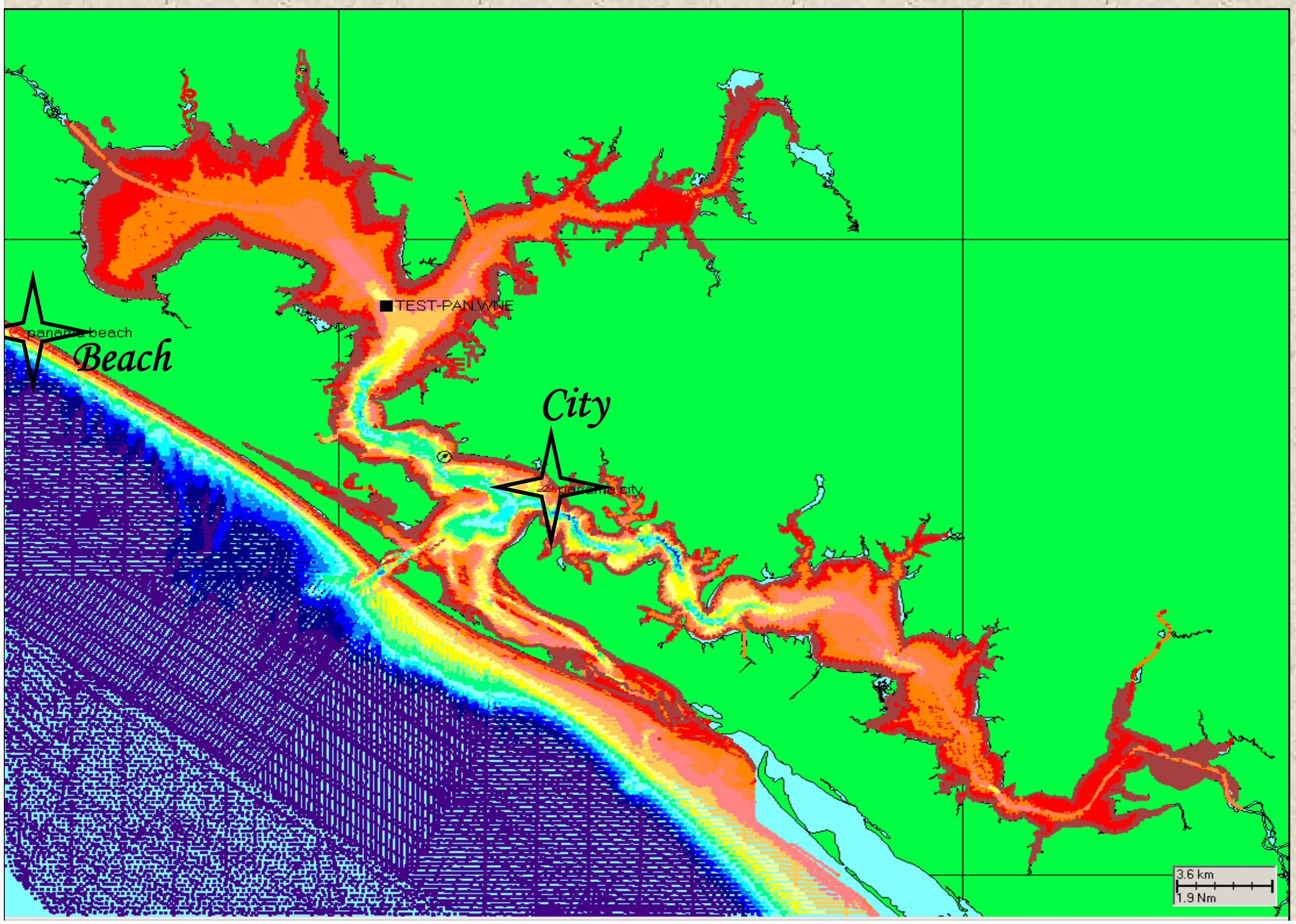
West boundary

East boundary

West Pass

East Pass

Geographic location - bathymetry



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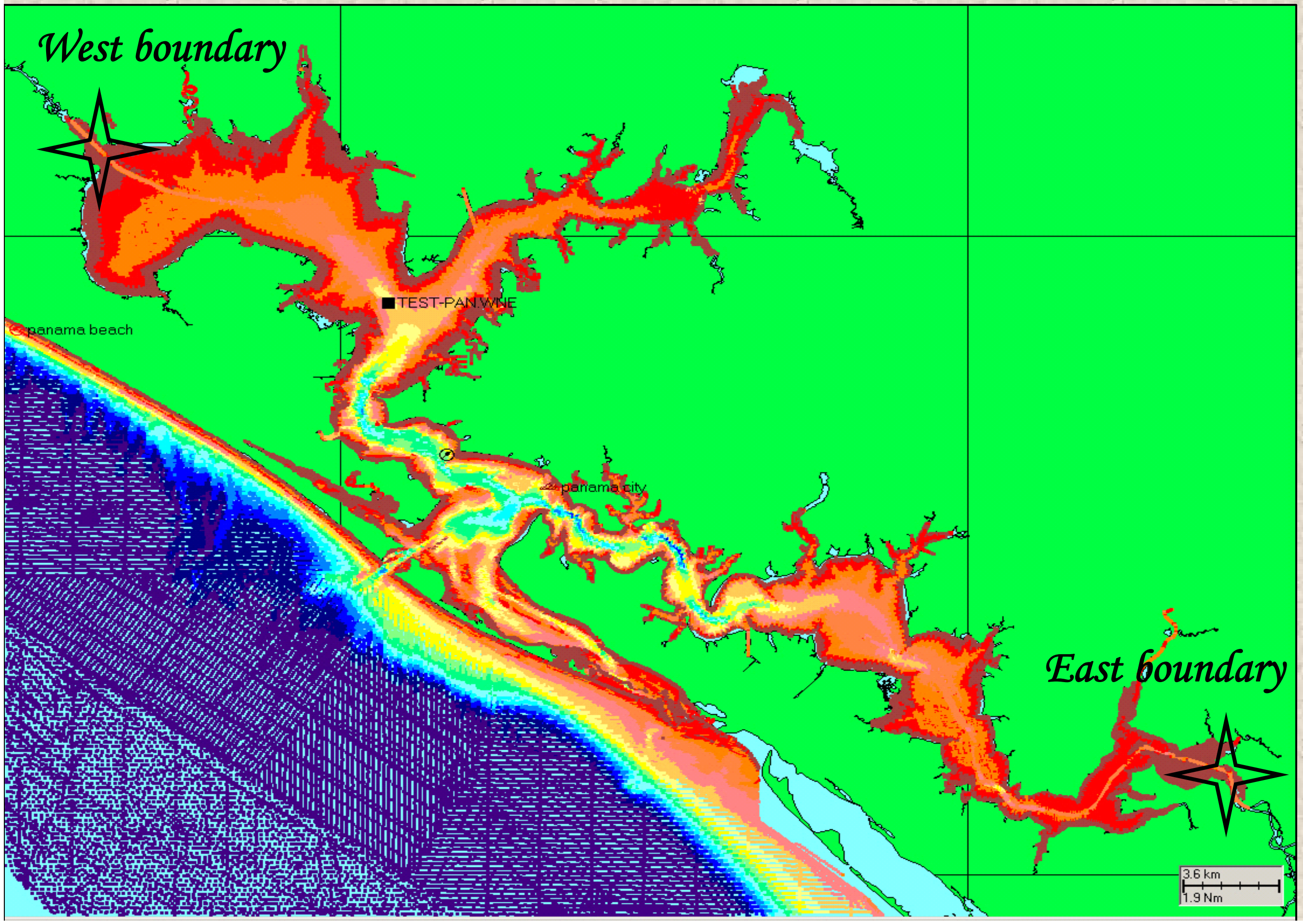

Panama City Beach

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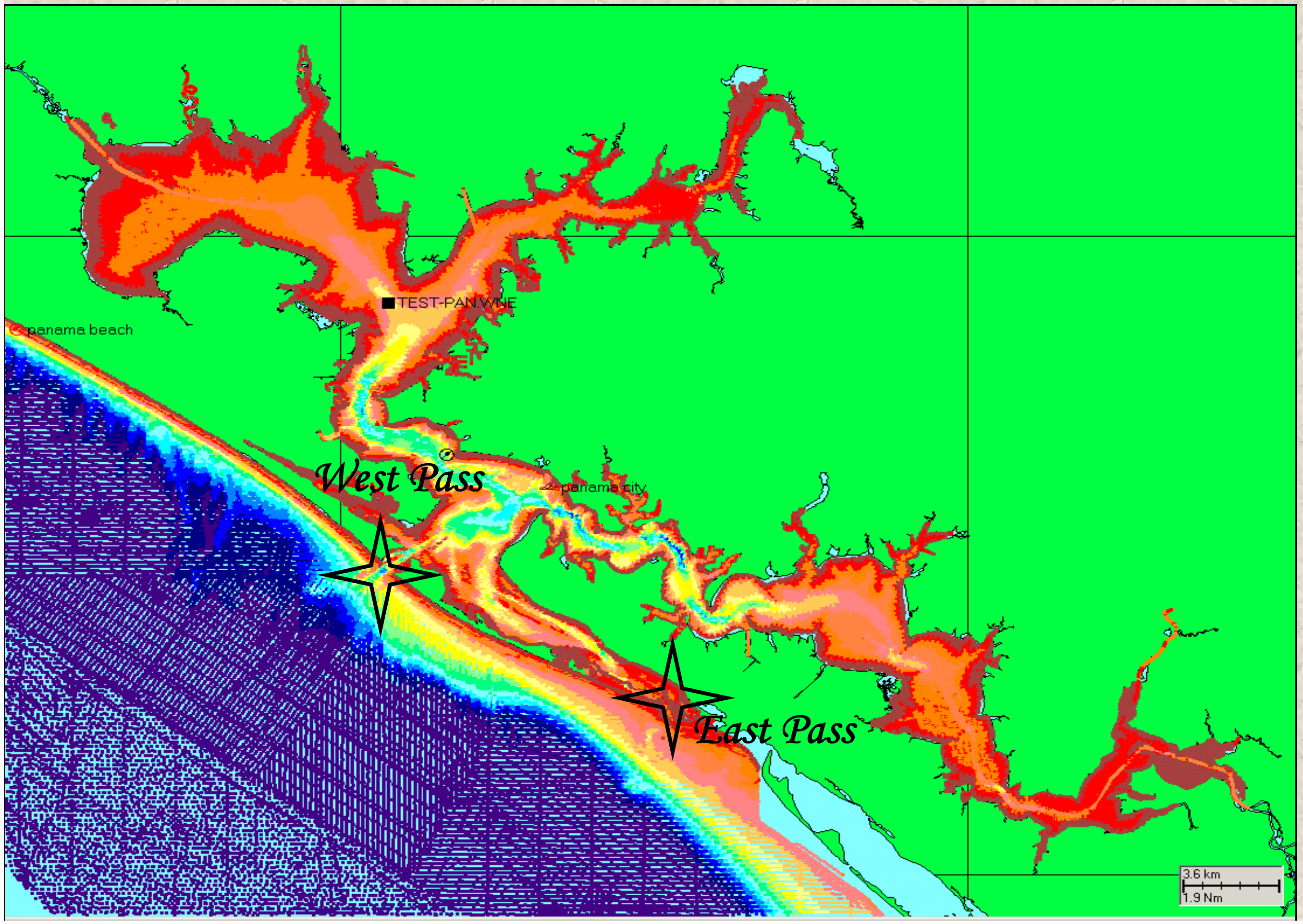
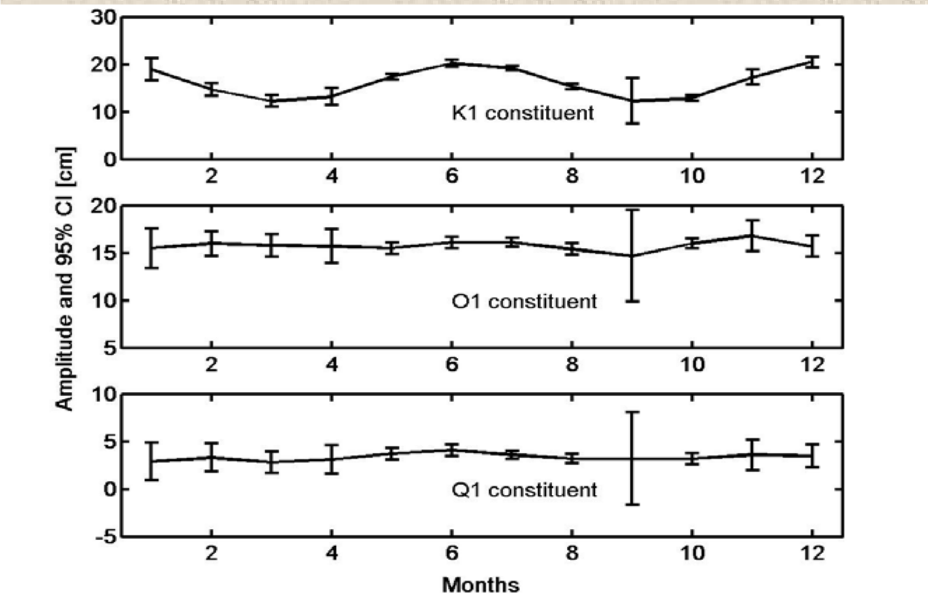
Geographic location - bathymetry

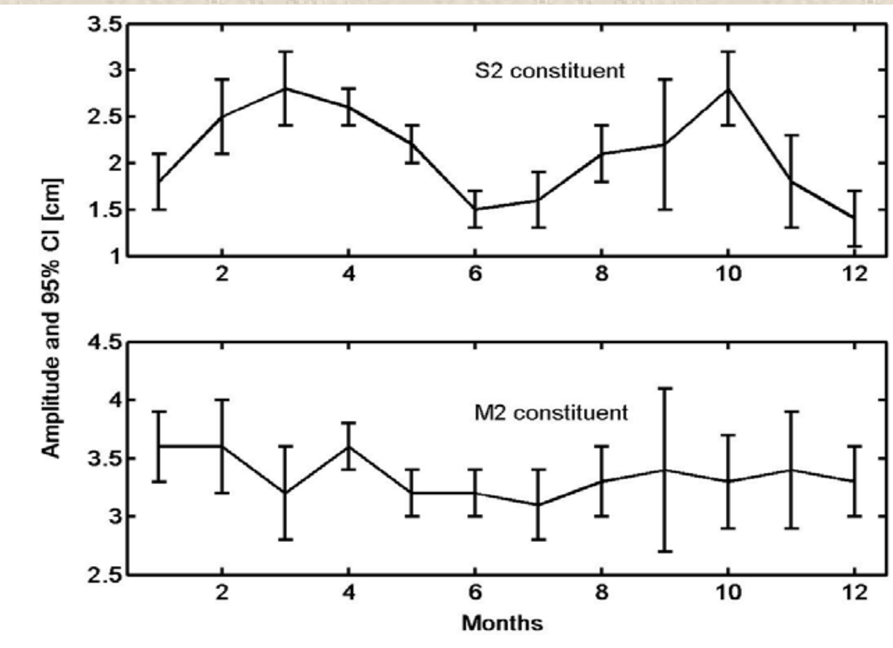


Panama City Beach
Panama City

West boundary
East boundary
West Pass
East Pass

Seasonal variability of tidal constituents at Panama City Beach.





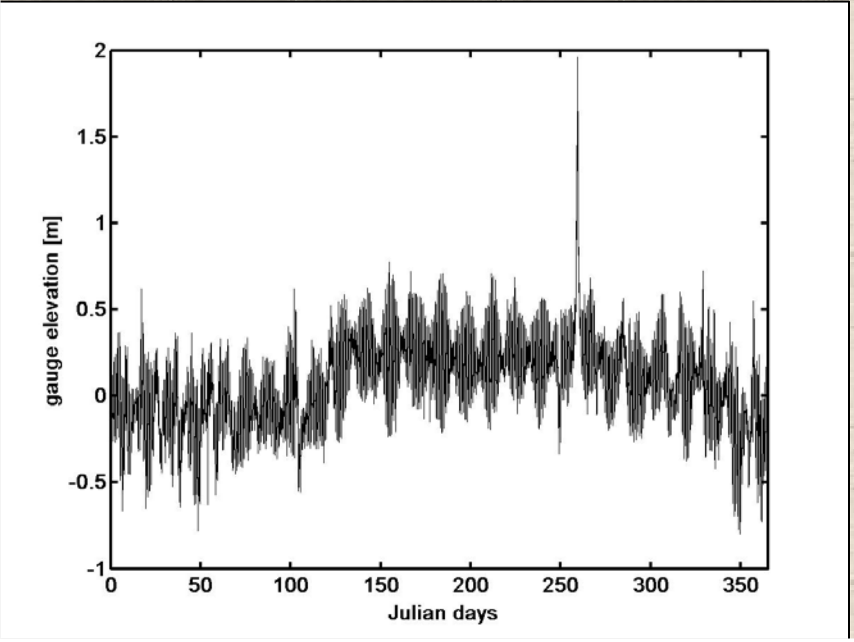
Tides from NOAA

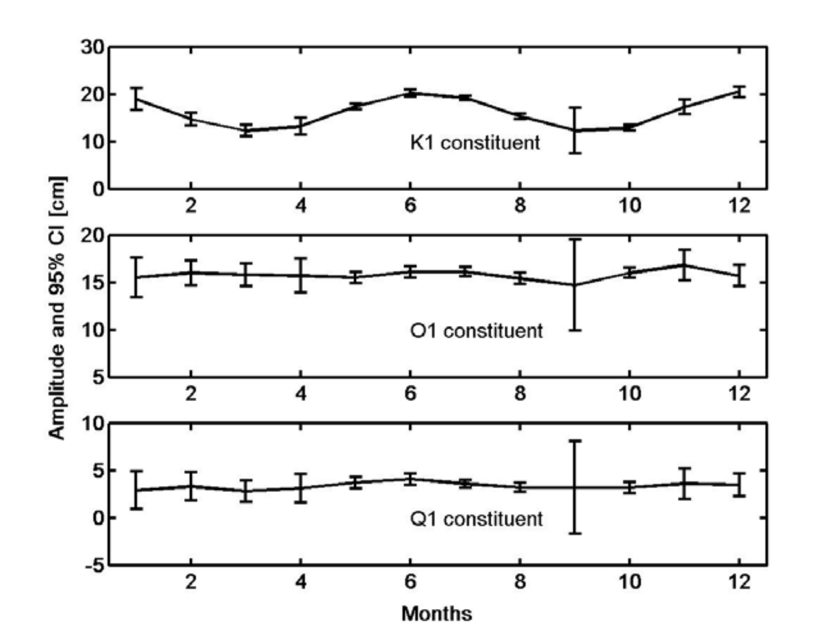
NOAA website provides:

- Tidal gauge time series
- Tidal constituents

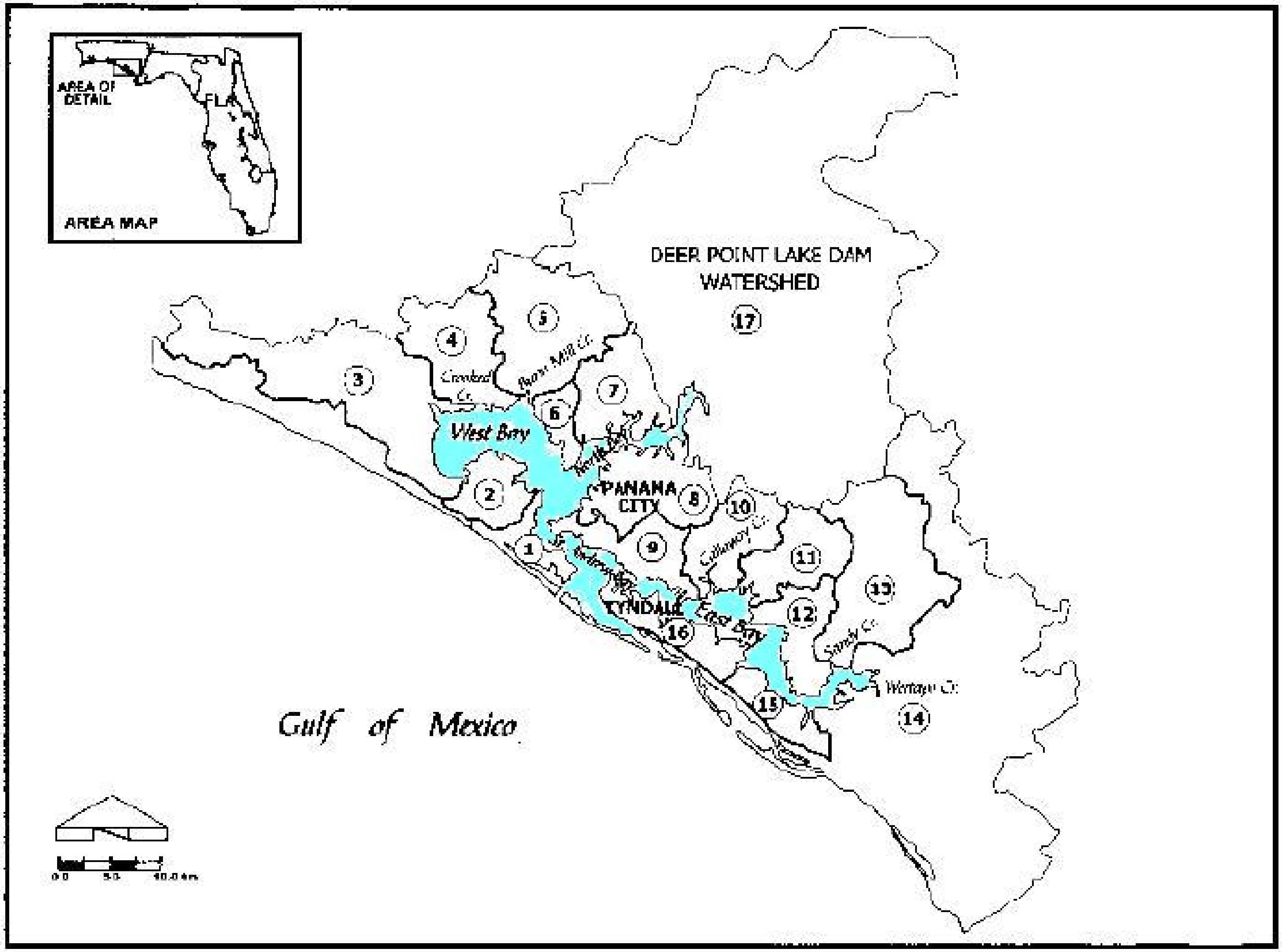
Panama City Beach station:

	amplitude in cm		phase in deg.	
K1:	15.89	(0.3)	296.2	(1)
O1:	15.84	(0.3)	284.8	(1)
Q1:	3.4	(0.3)	270.7	(5.5)
M2:	3.4	(0.1)	287.4	(1.5)
S2:	2	(0.1)	303.1	(2.5)





Watershed (Fresh-water influx)



Bay county sub-basins flow	
number	flow [m^3/s]
1	0.5
2	0.8
3	------
4	1.3
5	1.4
6	0.4
7	1.4
8	1.7
9	1
10	1.2
11	1.2
12	1
13	3.8
14	-------
15	0.7
16	0.9
17	38.1

Low Monthly mean winds

	Jan.	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
dir.	N	N	SSE	S	S	WSW	WSW	E	ENE	N	N	N
speed	3.5	3.5	4	3.5	3	3	3	2.5	3	3	3	3.5

Wind values (m/s) averaged over the past 60 years.

2004 average:

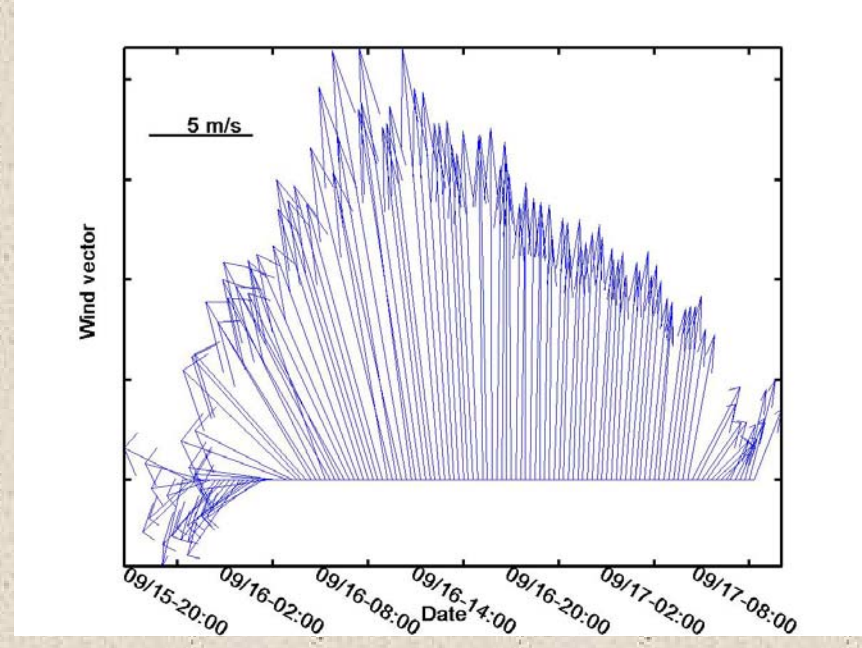
0.12m/s northwesterlies

May through September average:

4m/s.

High Synoptic Winds

Can easily reach 20 m/s and more during hurricane events



Water Quality Management and Analysis Package (WQMAP)

- **WQMAP** is an integrated modeling system designed to study surface water quality issues. The system allows the engineer or scientist to develop numerical grids, perform hydrodynamic simulations, conduct single constituent pollutant transport and multiple constituent eutrophication studies in a geographic context all from one application.

Features of WQMAP

- Integrated Geographic Information System
- Grid Generation
- Hydrodynamic Model
- Pollutant Transport Model
- Eutrophication Model
- All models use same computational grid
- Applicable within regions such as rivers, lakes, estuaries, bays and coastal seas.

Hydrodynamic Model

Continuity

$$R\sqrt{g_{11}g_{22}}\frac{\partial\zeta}{\partial t}+\frac{\partial\left(UD\sqrt{g_{22}}\right)}{\partial\xi}+\frac{\partial\left(VD\sqrt{g_{11}}\right)}{\partial\eta}=0$$

Momentum Equation in ξ-direction

$$\frac{\partial UD}{\partial t}+\frac{1}{\sqrt{g_{11}g_{22}}}\left[\frac{\partial\left(U^2D\sqrt{g_{22}}\right)}{\partial\xi}+\frac{\partial\left(UVD\sqrt{g_{11}}\right)}{\partial\eta}+UVD\frac{\partial\left(\sqrt{g_{11}}\right)}{\partial\eta}-V^2\frac{\partial\left(\sqrt{g_{22}}\right)}{\partial\xi}\right]-fDV$$

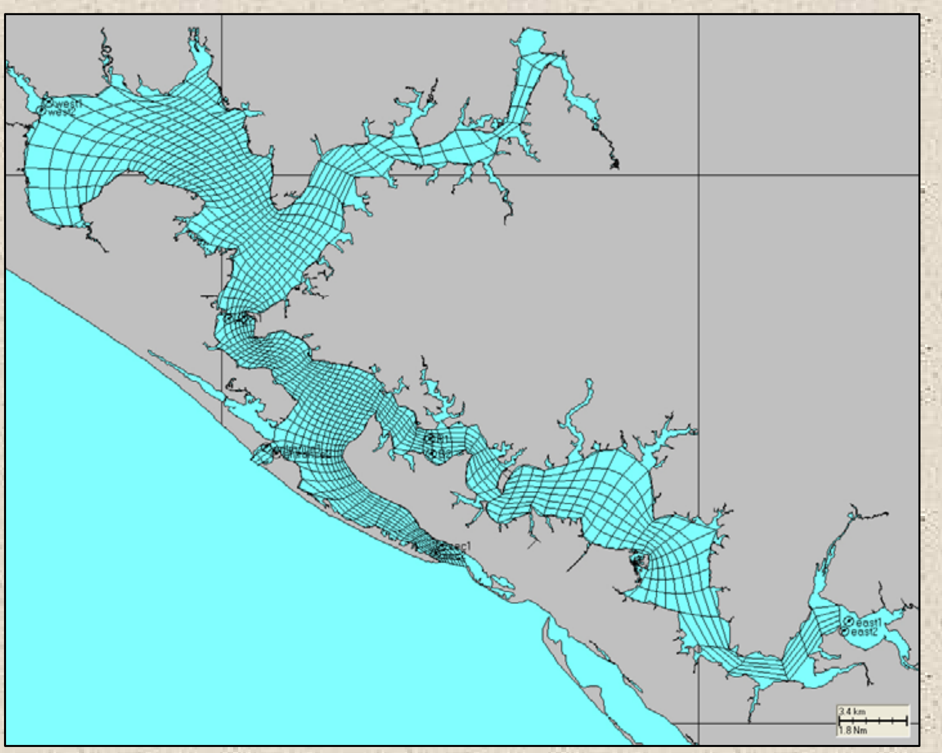
$$=-\frac{gD}{R\sqrt{g_{11}}}\left[\frac{\partial\zeta}{\partial\xi}+\frac{D}{\rho_0}\int_{-1}^{0}\int_{\sigma}^{0}\left(\frac{\partial\rho}{\partial\xi}-\frac{\sigma}{D}\frac{\partial D}{\partial\xi}\frac{\partial\rho}{\partial\sigma}\right)d\sigma\right]$$

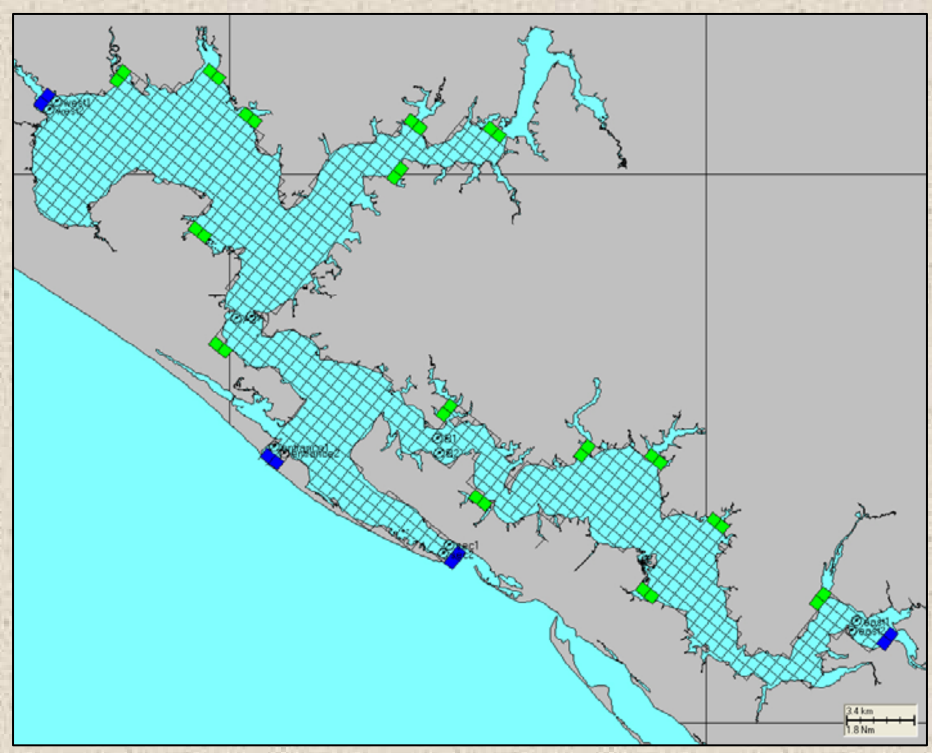
Momentum Equation in η-direction

$$\frac{\partial VD}{\partial t}+\frac{1}{\sqrt{g_{11}g_{22}}}\left[\frac{\partial\left(UVD\sqrt{g_{22}}\right)}{\partial\xi}+\frac{\partial\left(V^2D\sqrt{g_{11}}\right)}{\partial\eta}+UVD\frac{\partial\left(\sqrt{g_{22}}\right)}{\partial\xi}-U^2\frac{\partial\left(\sqrt{g_{11}}\right)}{\partial\eta}\right]+fDV$$

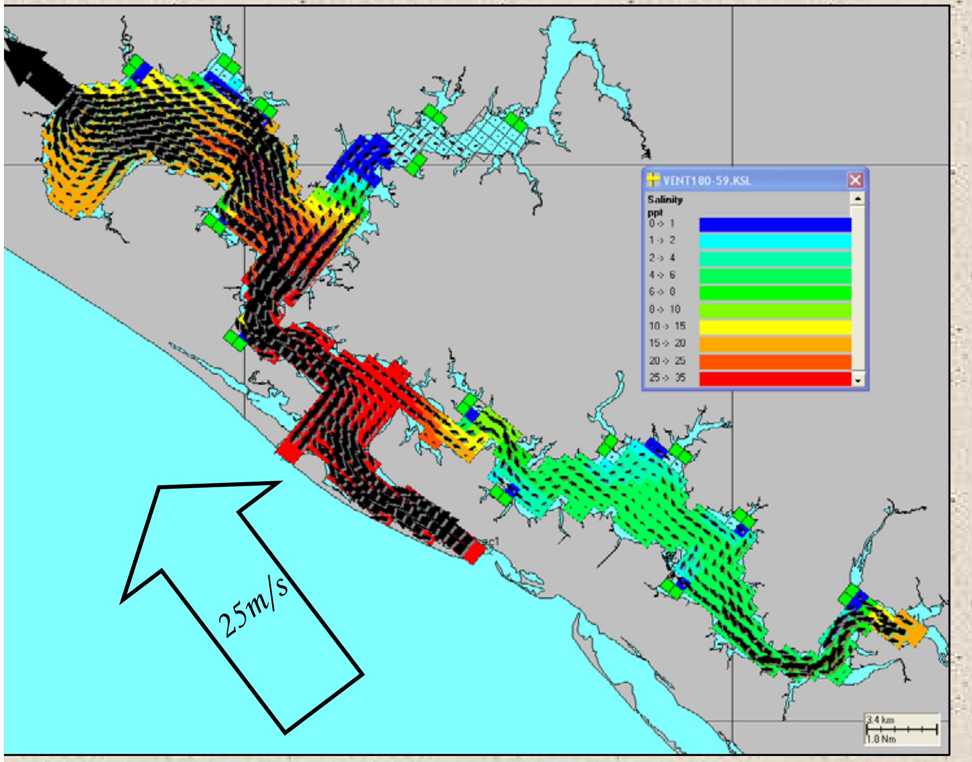
$$=-\frac{gD}{R\sqrt{g_{22}}}\left[\frac{\partial\zeta}{\partial\eta}+\frac{D}{\rho_0}\int_{-1}^{0}\int_{\sigma}^{0}\left(\frac{\partial\rho}{\partial\eta}-\frac{\sigma}{D}\frac{\partial D}{\partial\eta}\frac{\partial\rho}{\partial\sigma}\right)d\sigma\right]$$

Hydrodynamic model – grid generation

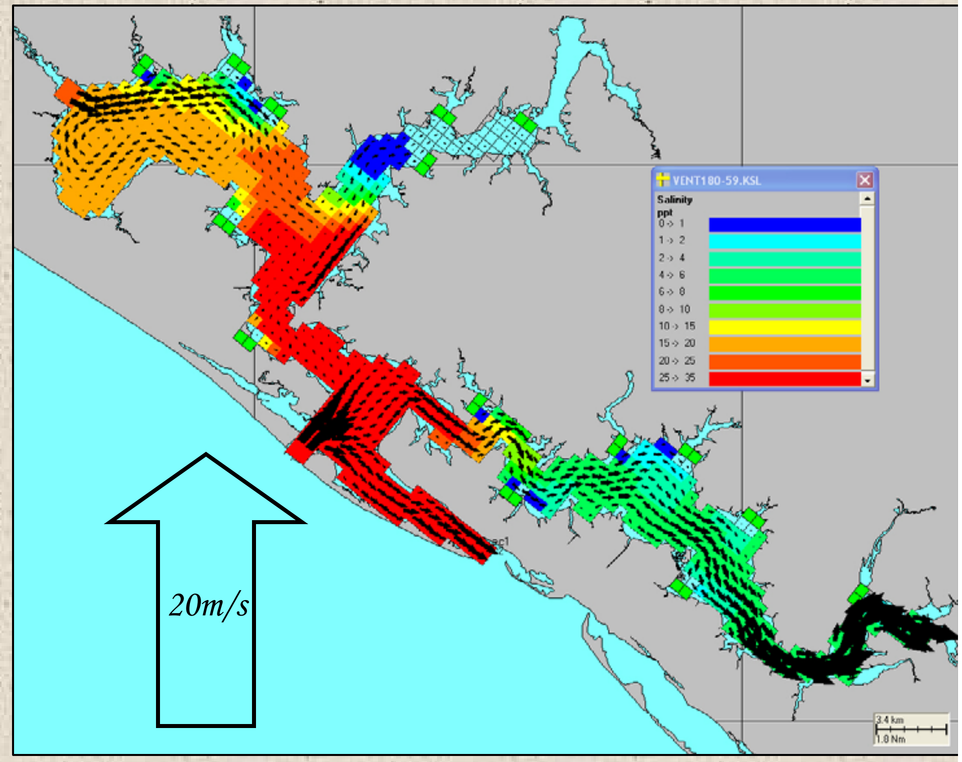




Wind impacts



09/16 at 05:00 AM



09/16 at 01:20 PM

Errors overview

		Runoff fluctuation					
		u		v		salinity	
		surface	bottom	surface	bottom	surface	bottom
West Pass	rme	0.05	0.05	0.05	0.05	0.00	0.00
	rmse	0.00	0.00	0.00	0.00	0.16	0.15
	ecv	0.05	0.05	0.05	0.05	0.00	0.00
	cor	1.00	1.00	1.00	1.00	1.00	1.00
East Bay	rme	0.02	0.02	-0.02	-0.02	0.04	0.04
	rmse	0.00	0.00	0.00	0.00	0.17	0.17
	ecv	0.02	0.02	-0.03	-0.03	0.07	0.07
	cor	1.00	1.00	1.00	1.00	1.00	1.00
West Bay	rme	-0.05	-0.04	0.05	0.04	0.10	0.10
	rmse	0.01	0.01	0.01	0.01	1.57	1.57
	ecv	-0.05	-0.05	0.05	0.05	0.12	0.12
	cor	1.00	1.00	1.00	1.00	0.99	0.99

Chemical Spill (Ethylene Glycol)

- 10 tons of the aforementioned chemical constituent is released at depth of 0.5 m.

- The release locations are selected in order to identify the tidal pumping effect and the vertical mixing process.

Chemical Discharge Model System (CHEMMAP)

- **CHEMMAP** is a chemical discharge model designed to predict the trajectory, fate, impacts and biological effects of a wide variety of chemical substances three-dimensionally.

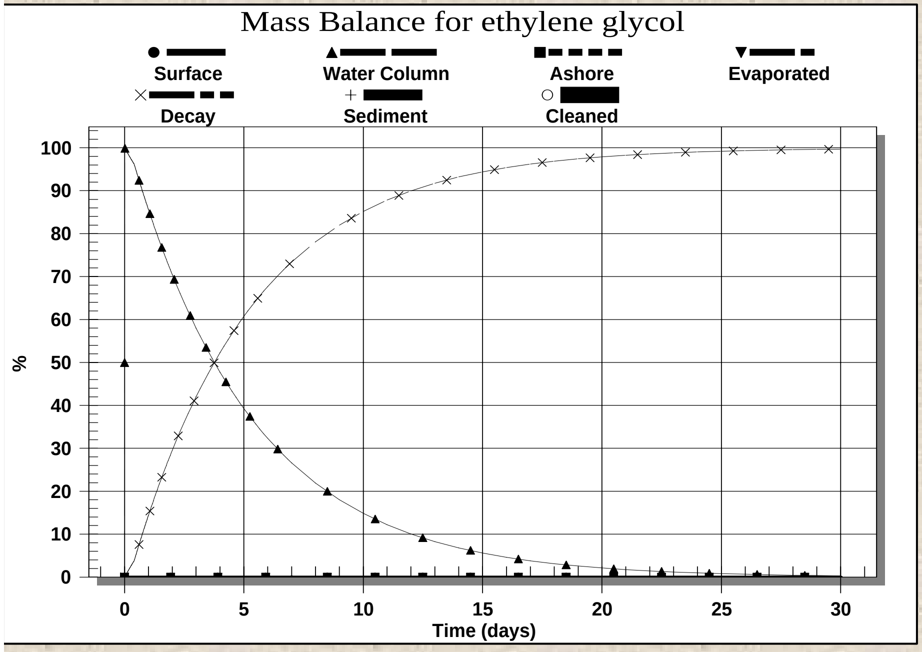
Features of CHEMMAP

- Contains ASA's own GIS or can be used in other GIS software such as ArcView.
- Location specific environmental/ biological data applied to any fresh or salt aquatic environment in the world.
-
- Can utilize a variety of hydrodynamic file formats.
- Easily interpreted visual displays of concentrations over time.
- 3D Viewer capabilities.
- Biological exposure model to predict exposed fish and wildlife impacts.
- MSDS database linked to the physical-chemical database.
- Extensive chemical database providing physical-chemical data.

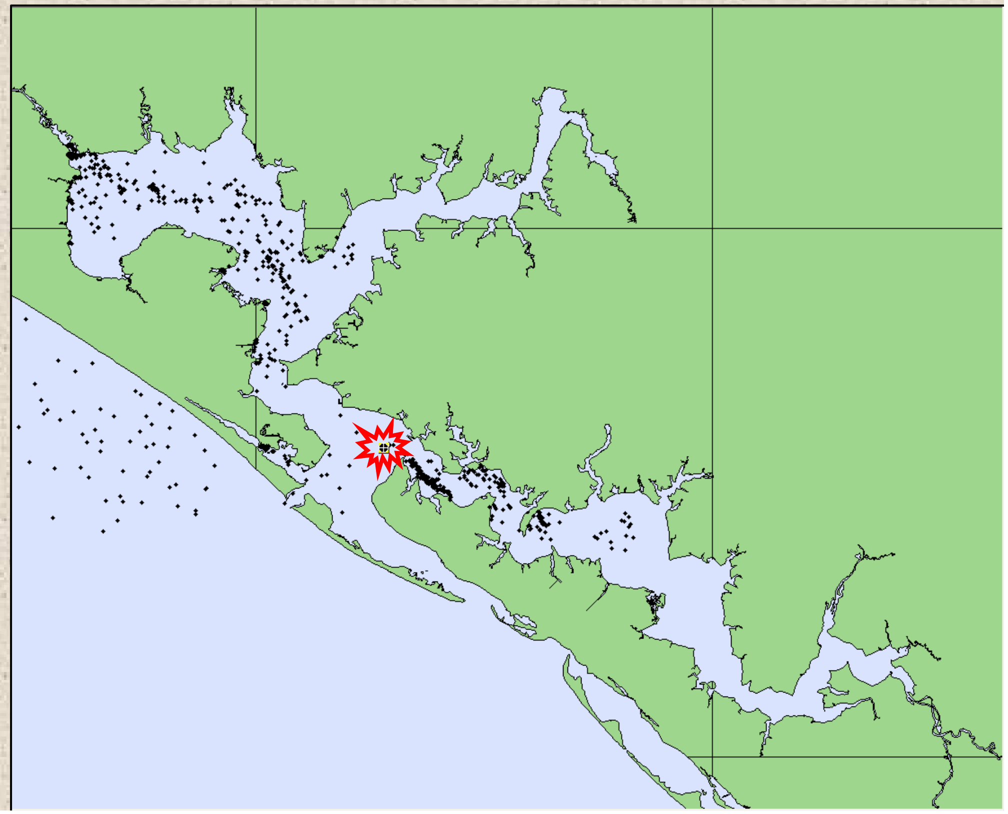
Chemical Fates Model

- Initial plume dynamics.
- Slick spreading, transport, and entrainment of floating materials.
- Evaporation and volatilization (to atmosphere).
- Transport and dispersion of dissolved and particulate materials in the water column and in the atmosphere.
- Dissolution and adsorption to suspended sediments.
- Sedimentation and resuspension.
- Natural degradation.
- Shoreline entrainment.
- Boom effectiveness.

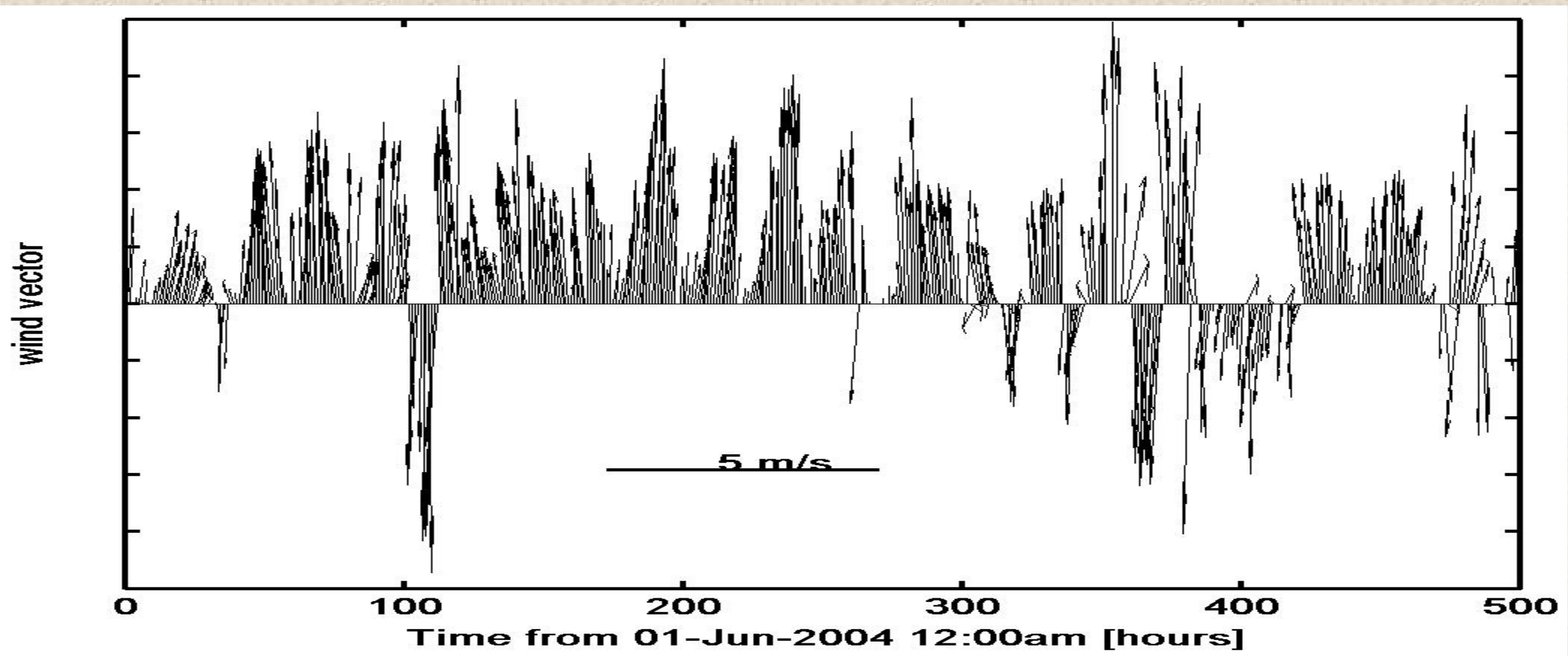
Control Case (Chemical Release on June 1 2004)



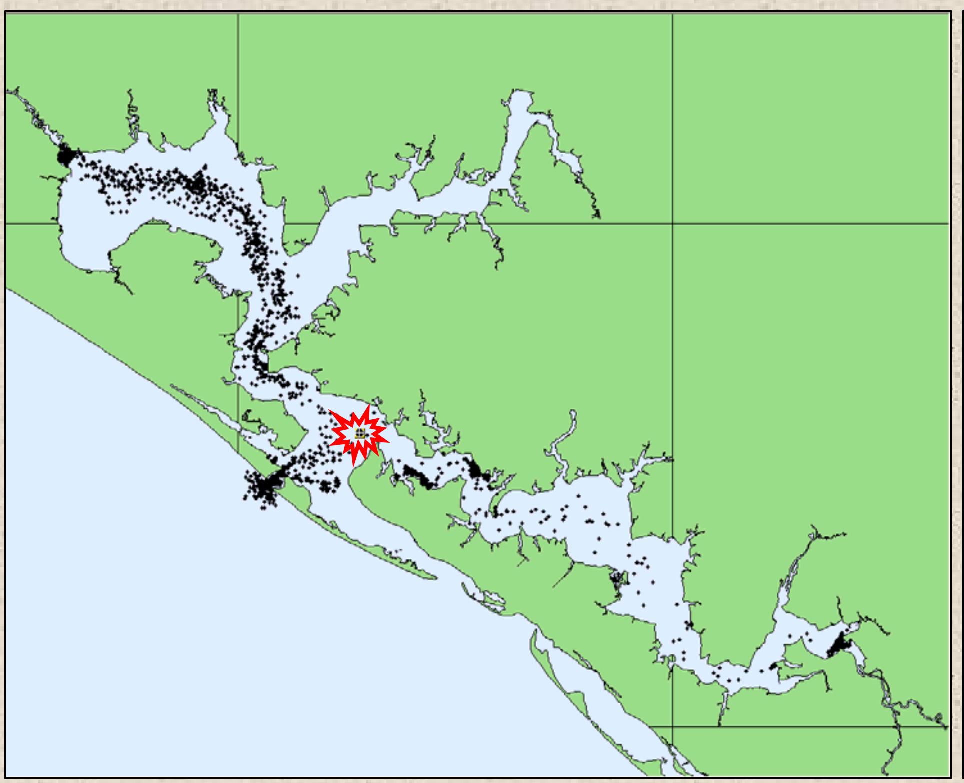
Spill dispersion after 3 weeks

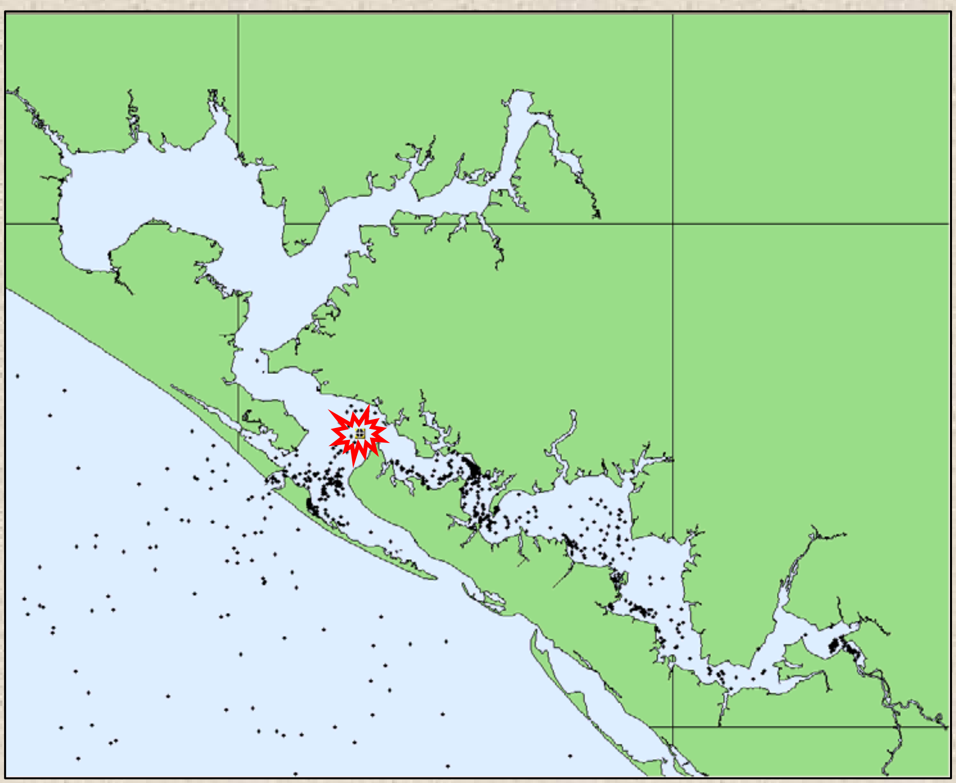


Wind Vectors



Wind effects on spill propagation



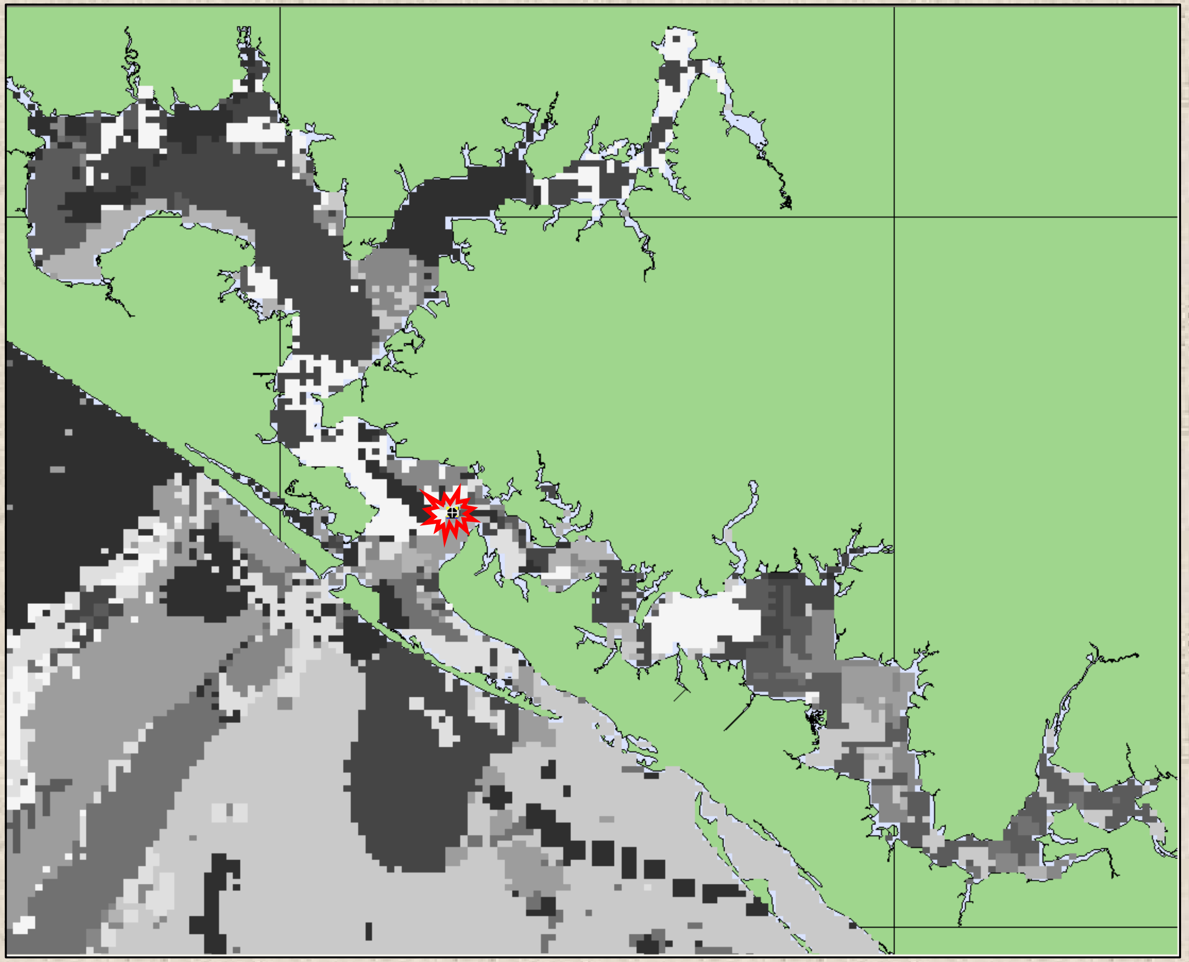


No wind simulation

Reversed wind simulation

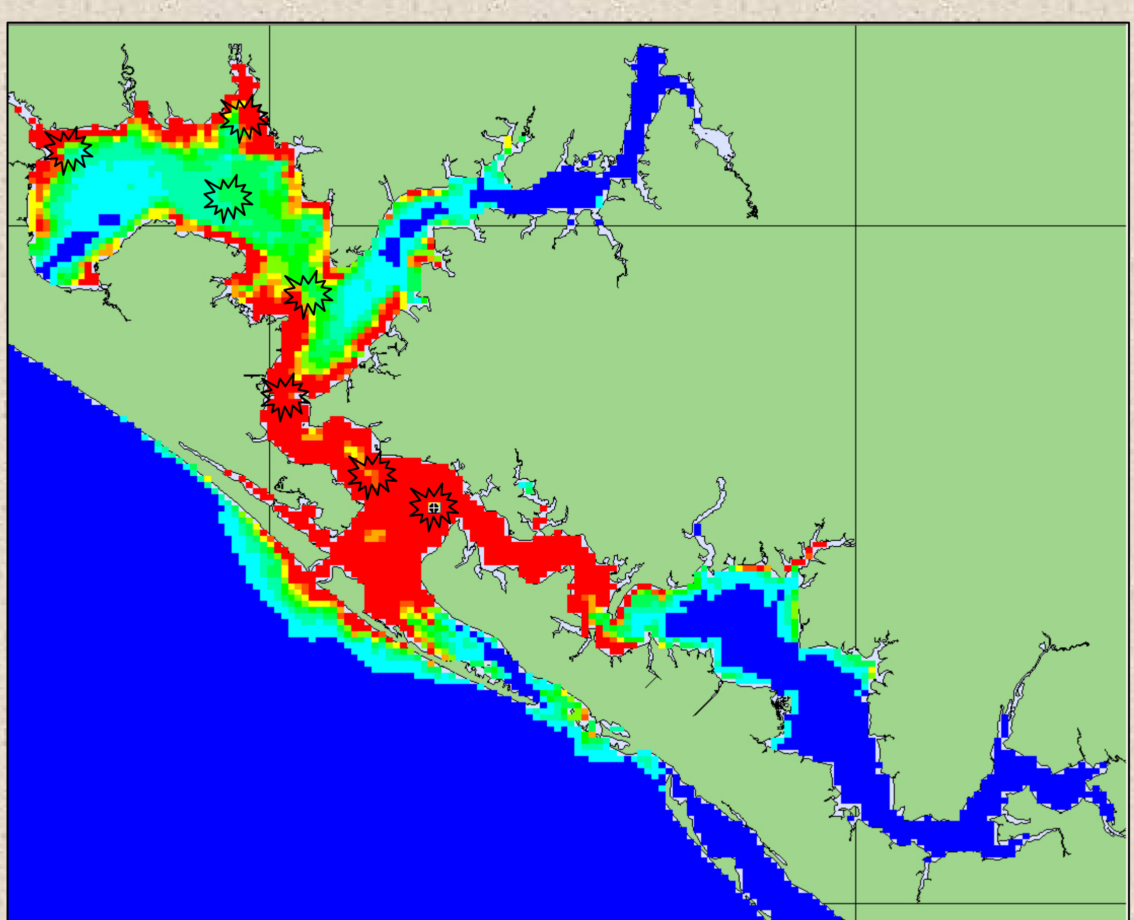
Release time influence – stochastic model

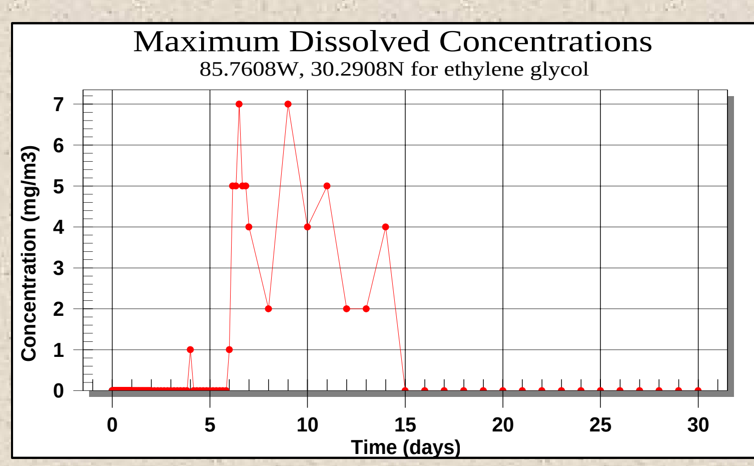
50 cases from
1st of June
to
31st of August

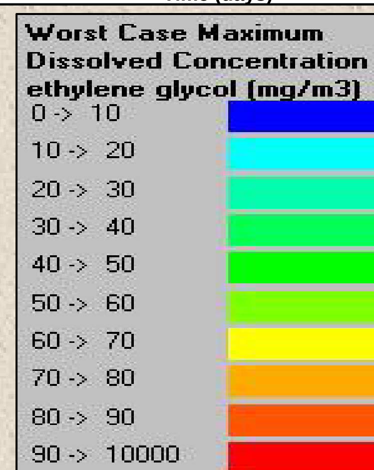


Run number for worst case scenario

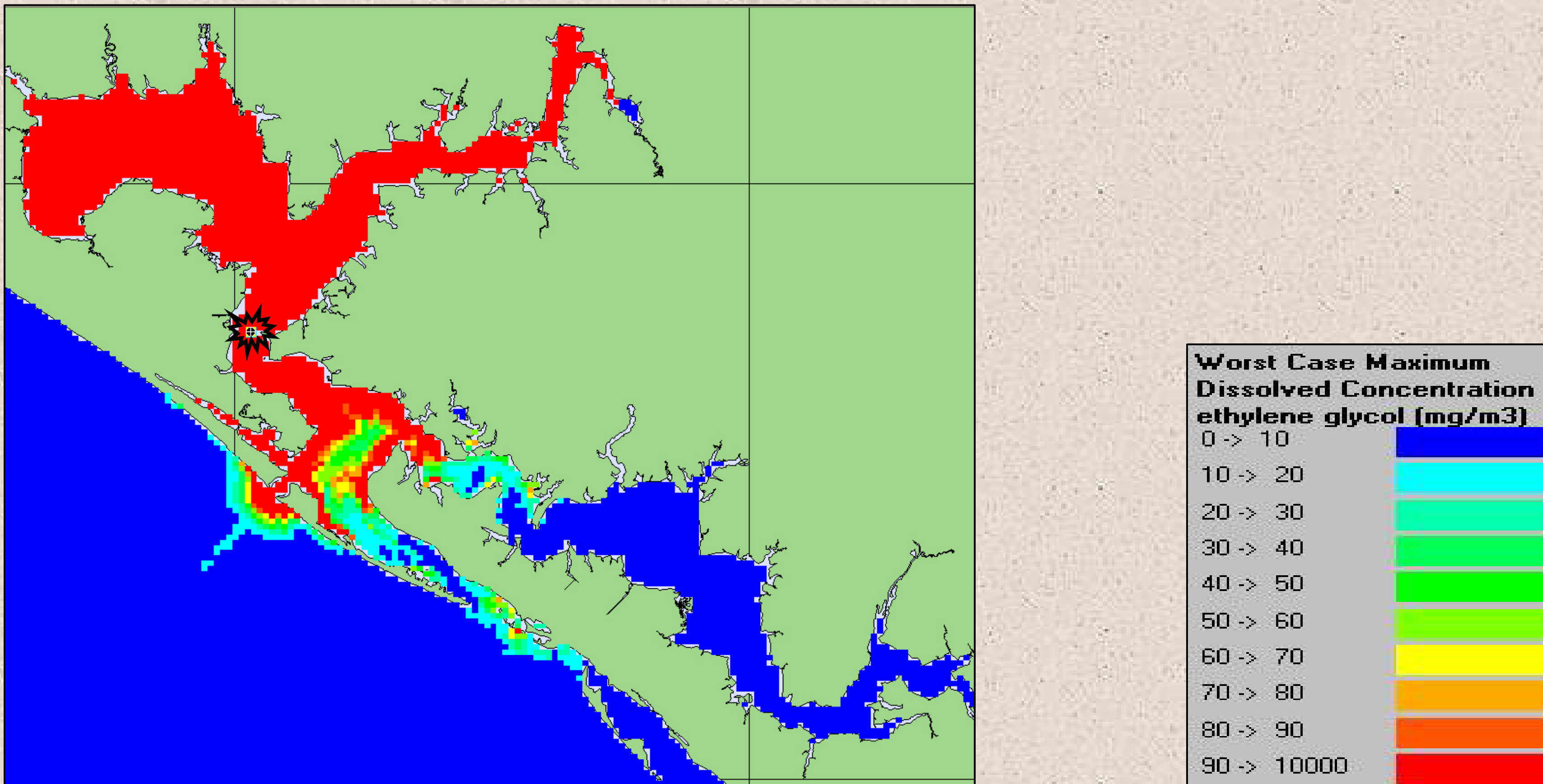
Release the 1st of June – 12:00am



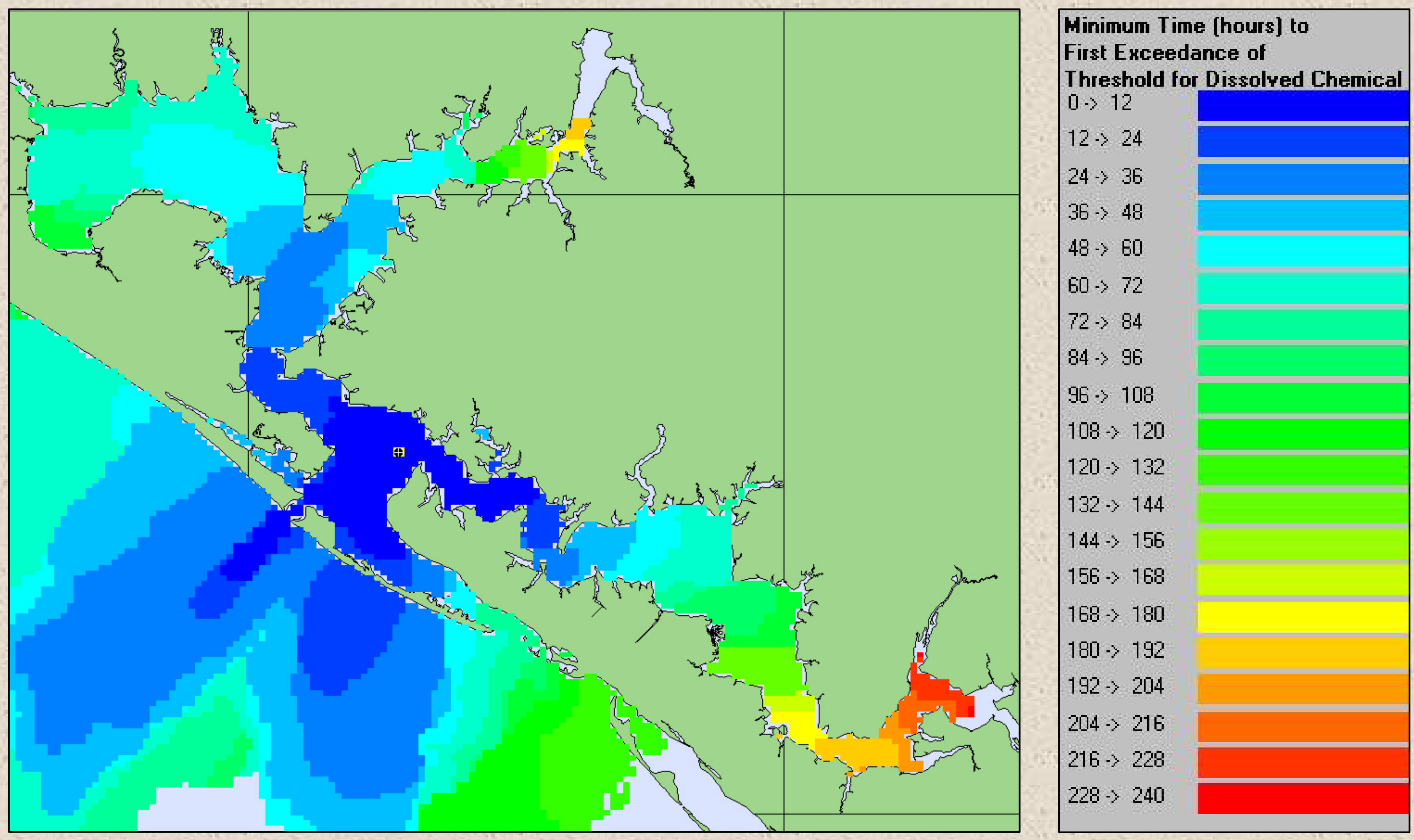




Release location influence



Time response delay



Minimum time to exceed a threshold

Conclusions

- Importance of the wind in the pollution drift, particularly in St Andrew Bay system.
- East-west bay bias of the chemical spill pattern is not crucial because it is largely affected by the winds.
- The tides impact on the estuarine circulation with imbalanced ebb and flood periods.