Post Processing of Bathymetric Data

Post Processing of Bathymetric Data

- Data noise
  - Generated by machines
  - Machines, like humans, are fallible
  - Can generate erroneous values
  - Need to determine how to “catch” these
- Tide fluctuations
  - The simple case
  - A complex case solved
  - A complex case unresolved

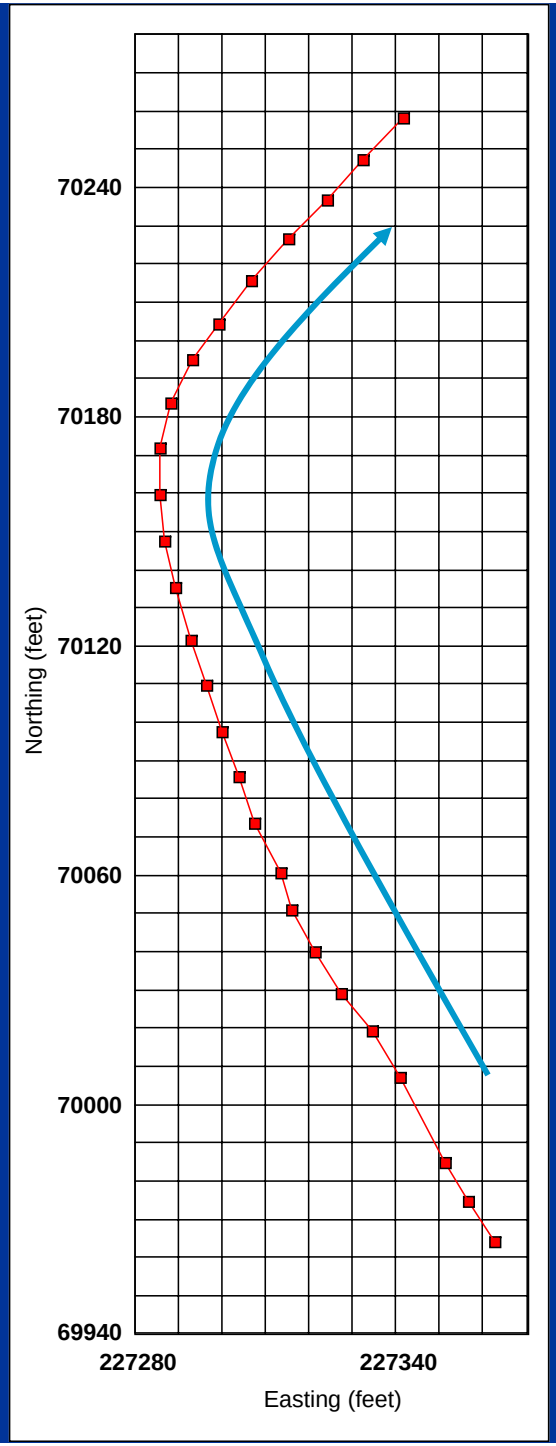
Examples of Data Output

- Different systems will have different output
- Details will differ, but the concepts should be the same
- These examples will be from:
  - Raytheon D719 Fathometer
  - PLGR+ GPS
  - Geolink software (by Michael Baker Inc.)

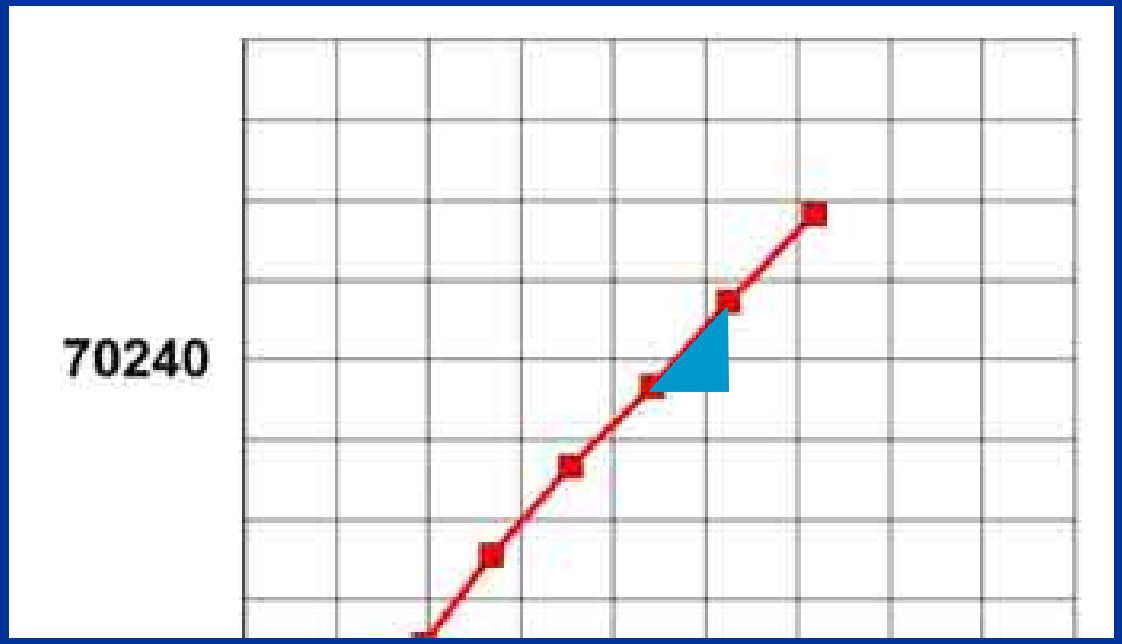
meters					GMT	
Depth	TIME_	LAT	LONG	LOGDATE	LOGTIME	
2.03	681228264.55	38.6299	-75.1024	08/07/2001	14:04:25	
1.95	681228269.48	38.63	-75.1025	08/07/2001	14:04:29	
1.74	681228274.50	38.6301	-75.1026	08/07/2001	14:04:35	
1.67	681228284.50	38.6303	-75.1027	08/07/2001	14:04:45	
1.58	681228289.54	38.6304	-75.1027	08/07/2001	14:04:50	
1.55	681228294.55	38.6305	-75.1028	08/07/2001	14:04:55	
1.5	681228299.54	38.6306	-75.1029	08/07/2001	14:05:00	
1.48	681228304.49	38.6307	-75.103	08/07/2001	14:05:04	
1.49	681228309.60	38.6307	-75.103	08/07/2001	14:05:10	
1.57	6					
1.65	6					
1.76	6					
1.77	6					
1.68	681228334.49	38.6313	-75.1032	08/07/2001	14:05:34	
1.53	681228339.48	38.6314	-75.1033	08/07/2001	14:05:39	
1.5	681228344.50	38.6315	-75.1033	08/07/2001	14:05:45	
1.46	681228349.54	38.6316	-75.1033	08/07/2001	14:05:50	
0.53	681228354.55	38.6317	-75.1033	08/07/2001	14:05:55	
1.22	681228359.48	38.6319	-75.1033	08/07/2001	14:05:59	
1.22	681228364.49	38.632	-75.1032	08/07/2001	14:06:04	
0.57	681228369.48	38.632	-75.1031	08/07/2001	14:06:09	
1.23	681228374.50	38.6321	-75.1031	08/07/2001	14:06:15	
1.35	681228379.49	38.6322	-75.103	08/07/2001	14:06:19	
1.67	681228384.55	38.6323	-75.1029	08/07/2001	14:06:25	
1.76	681228389.54	38.6324	-75.1028	08/07/2001	14:06:30	
2.01	681228394.49	38.6325	-75.1027	08/07/2001	14:06:34	

There is potential “noise” in the bathymetric data

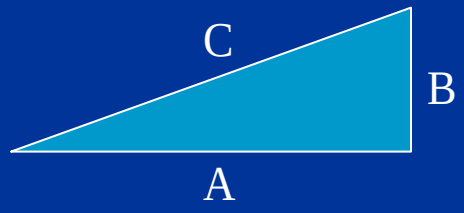
How can you tell if the data are correct?



Calculating distance between adjacent points



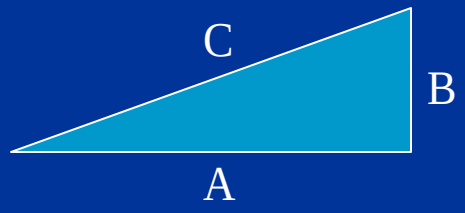
$$C^2 = \sqrt{A^2 + B^2}$$



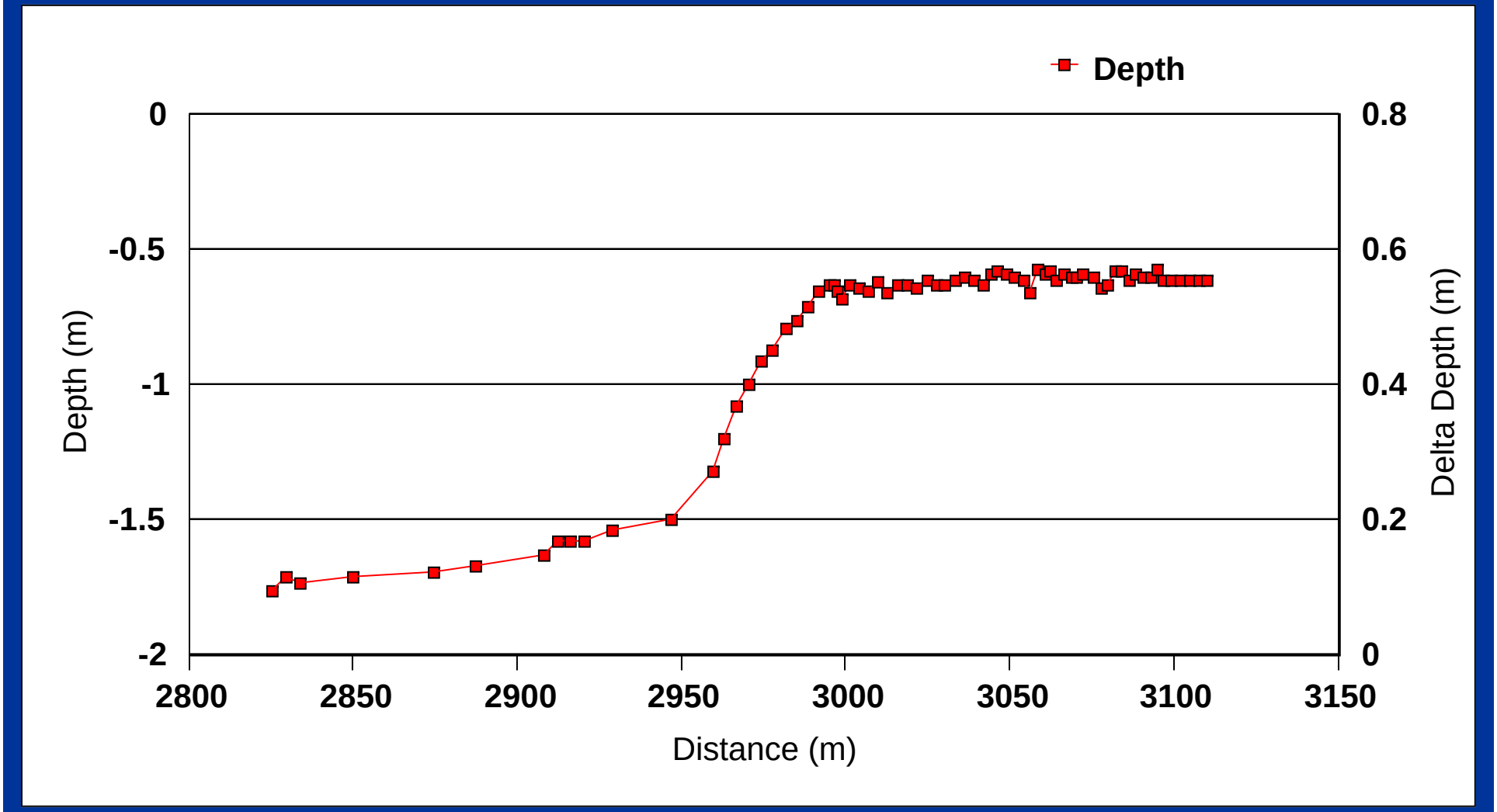
meters					GMT	Local Time	ft	ft
Depth	TIME_	LAT	LONG	LOGDATE	LOGTIME		X-Easting	Y-Northing
2.03	681228264.55	38.6299	-75.1024	08/07/2001	14:04:25	19:04:25	227362.7	69964.25
1.95	681228269.48	38.63	-75.1025	08/07/2001	14:04:29	19:04:29	227356.58	69974.72
1.74	681228274.50	38.6301	-75.1026	08/07/2001	14:04:35	19:04:35	227351.45	69984.94
1.67	681228284.50	38.6303	-75.1027	08/07/2001	14:04:45	19:04:45	227340.85	70007.1
1.58	681228289.54	38.6304	-75.1027	08/07/2001	14:04:50	19:04:50	227334.62	70019.22
1.55	681228294.55	38.6305	-75.1028	08/07/2001	14:04:55	19:04:55	227327.65	70028.89
1.5	681228299.54	38.6306	-75.1029	08/07/2001	14:05:00	19:05:00	227321.48	70039.95
1.48	681228304.49	38.6307	-75.103	08/07/2001	14:05:04	19:05:04	227316.05	70050.94
1.49	681228309.60	38.6307	-75.103	08/07/2001	14:05:10	19:05:10	227313.53	70060.76
1.57	681228314.54	38.6309	-75.1031	08/07/2001	14:05:15	19:05:15	227307.58	70073.71
1.65	681228319.59	38.631	-75.1031	08/07/2001	14:05:20	19:05:20	227303.88	70085.86
1.76	681228324.55	38.6311	-75.1031	08/07/2001	14:05:25	19:05:25	227300.24	70097.76
1.77	681228329.53	38.6312	-75.1032	08/07/2001	14:05:30	19:05:30	227296.58	70109.72
1.68	681228334.49	38.6313	-75.1032	08/07/2001	14:05:34	19:05:34	227292.94	70121.62
1.53	681228339.48	38.6314	-75.1033	08/07/2001	14:05:39	19:05:39	227289.27	70135.46
1.5	681228344.50	38.6315	-75.1033	08/07/2001	14:05:45	19:05:45	227287.04	70147.53
1.46	681228349.54	38.6316	-75.1033	08/07/2001	14:05:50	19:05:50	227285.91	70159.66
0.53	681228354.55	38.6317	-75.1033	08/07/2001	14:05:55	19:05:55	227285.87	70171.72
1.22	681228359.48	38.6319	-75.1033	08/07/2001	14:05:59	19:05:59	227288.35	70183.56
1.22	681228364.49	38.632	-75.1032	08/07/2001	14:06:04	19:06:04	227293.4	70195.18
0.57	681228369.48	38.632	-75.1031	08/07/2001	14:06:09	19:06:09	227299.52	70204.43
1.23	681228374.50	38.6321	-75.1031	08/07/2001	14:06:15	19:06:15	227306.76	70215.59
1.35	681228379.49	38.6322	-75.103	08/07/2001	14:06:19	19:06:19	227315.42	70226.7
1.67	681228384.55	38.6323	-75.1029	08/07/2001	14:06:25	19:06:25	227324.18	70236.6
1.76	681228389.54	38.6324	-75.1028	08/07/2001	14:06:30	19:06:30	227332.5	70247.21
2.01	681228394.49	38.6325	-75.1027	08/07/2001	14:06:34	19:06:34	227341.79	70258.25

A

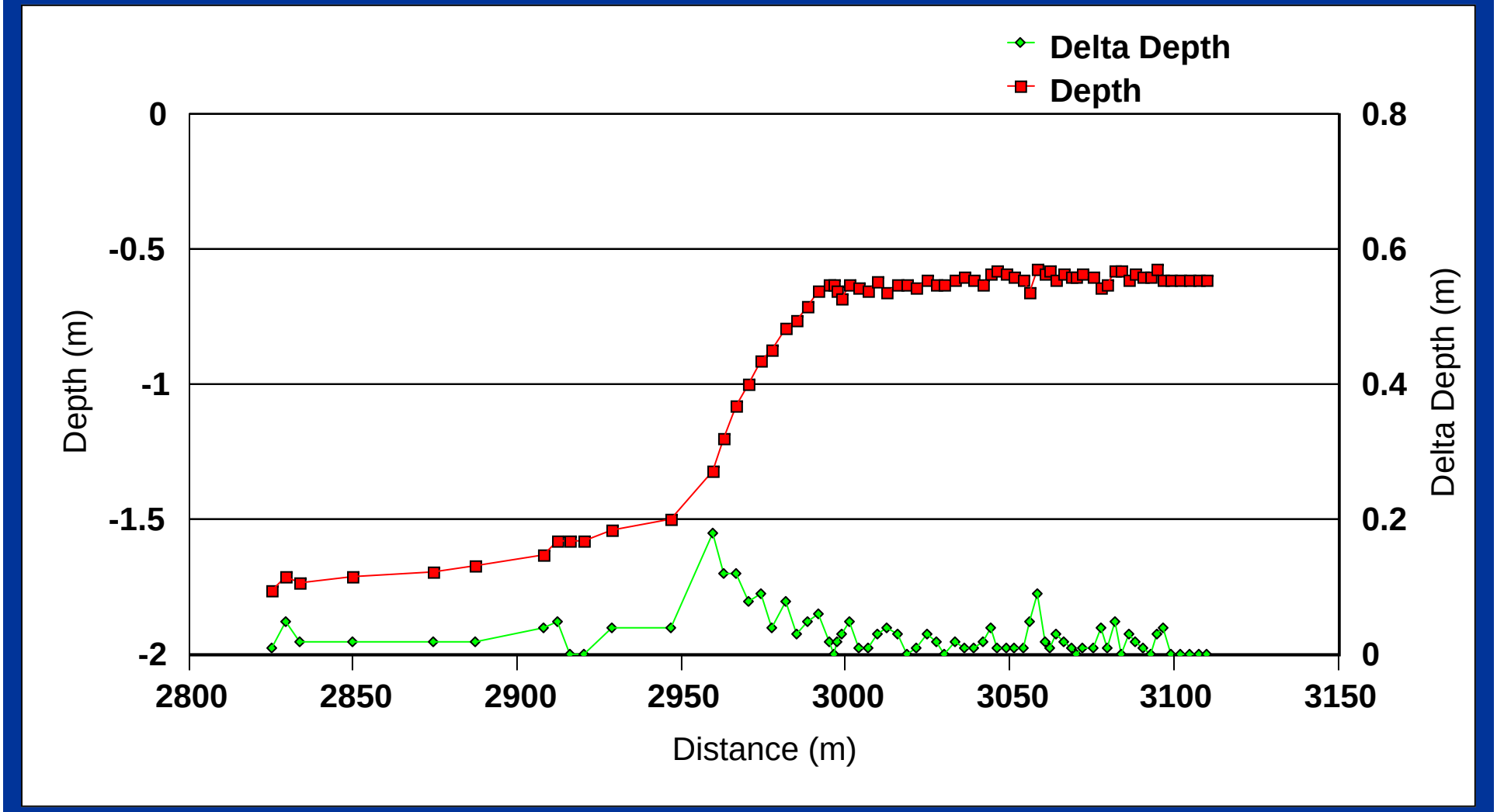
B



$$C^2 = \sqrt{A^2 + B^2}$$

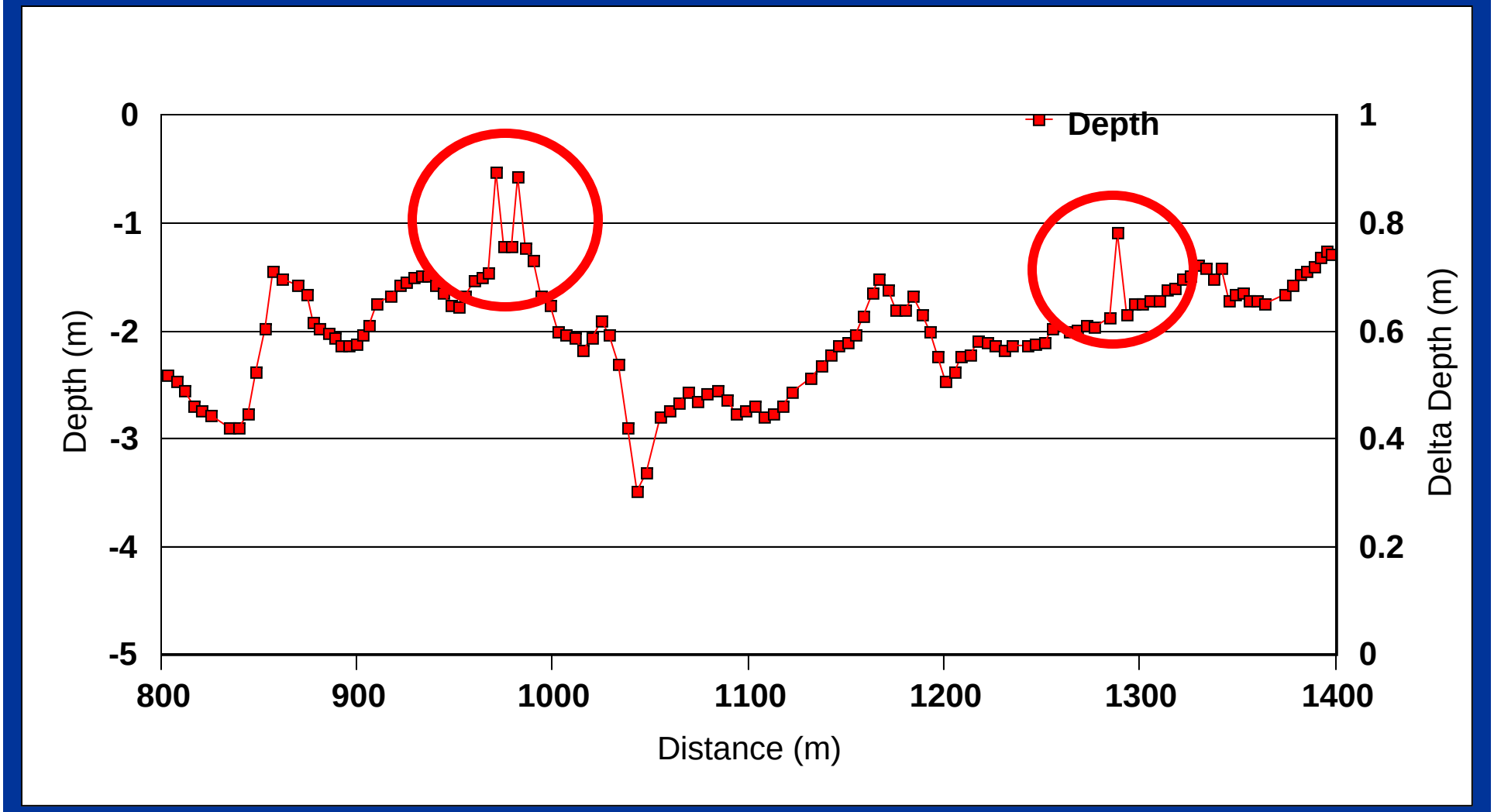


Some data sets are fairly straightforward, and don't seem to have problems.

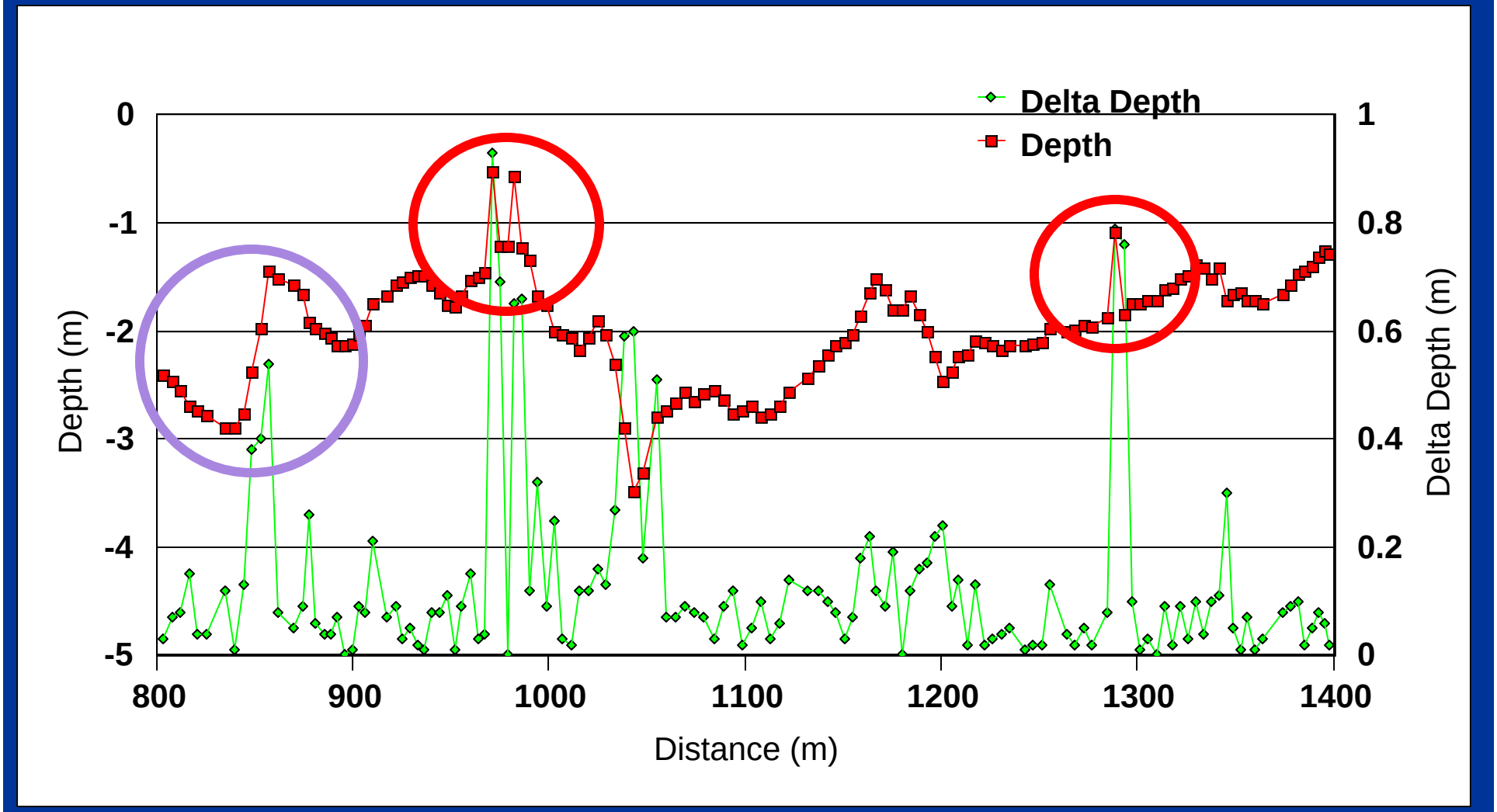


"Delta Depth" is the difference in depth between adjacent points

Are large Delta Depth values related to systematic changes, or random “noise”?

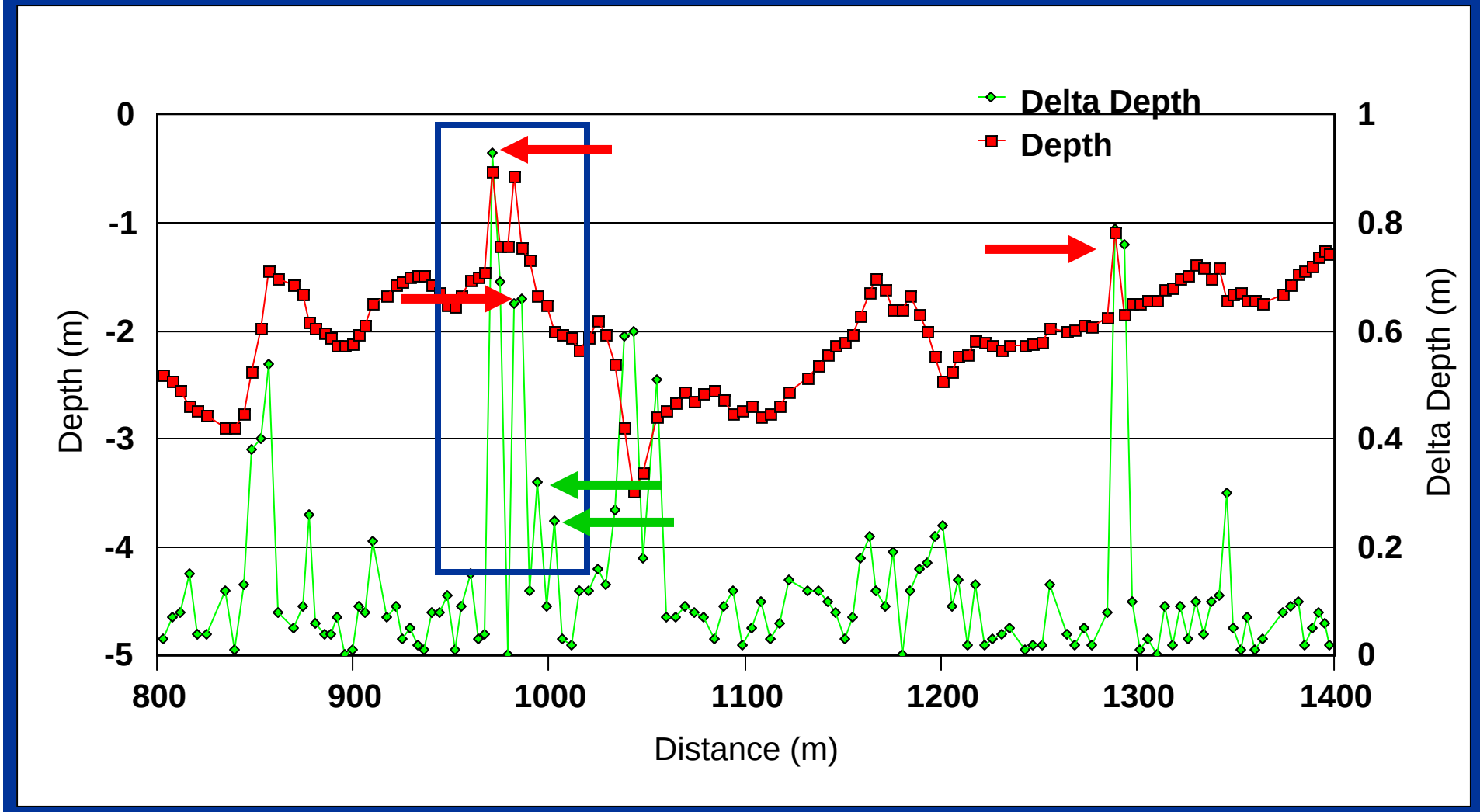


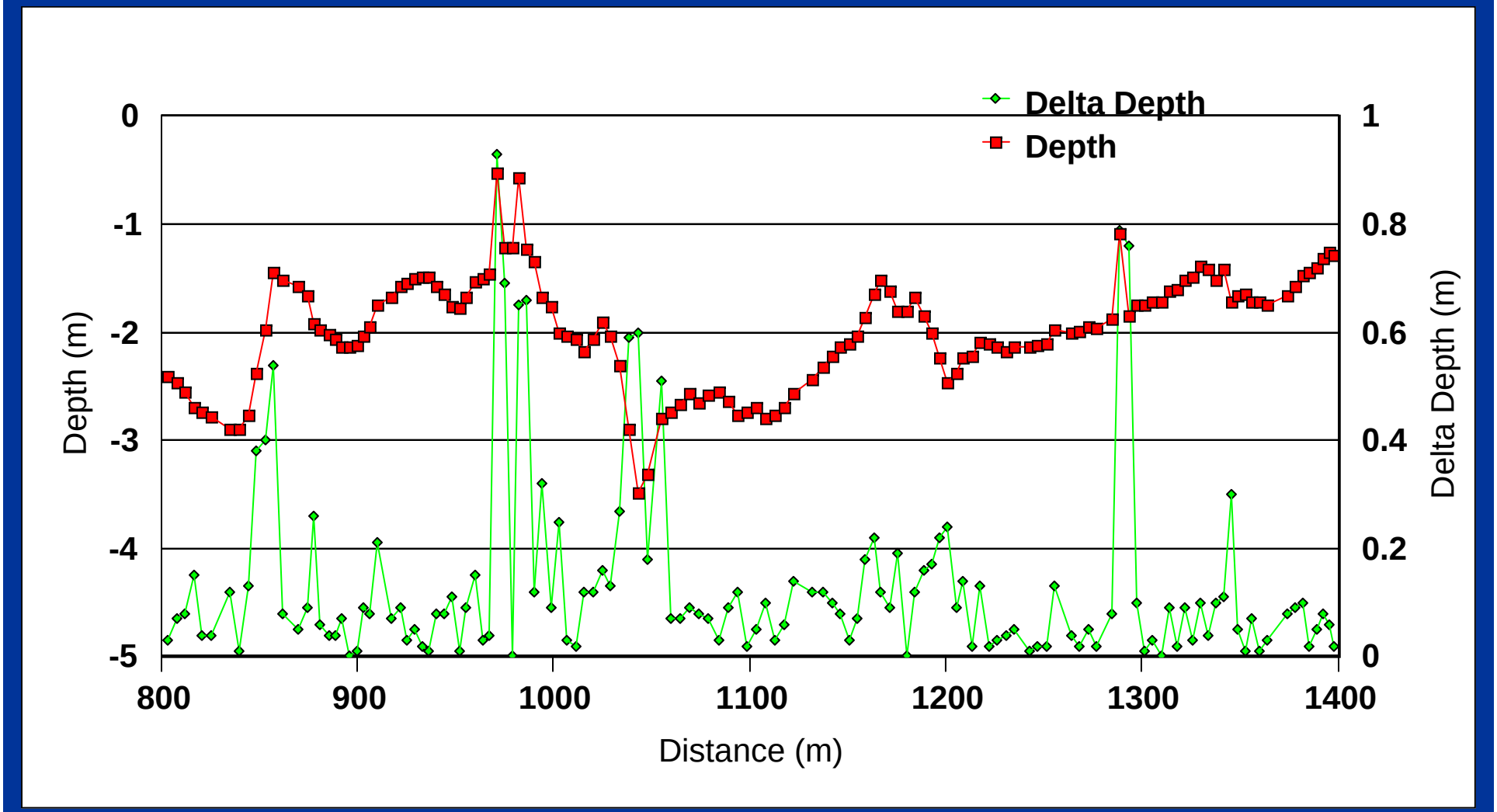
Other data sets are seem to have problem values and must be “cleaned”

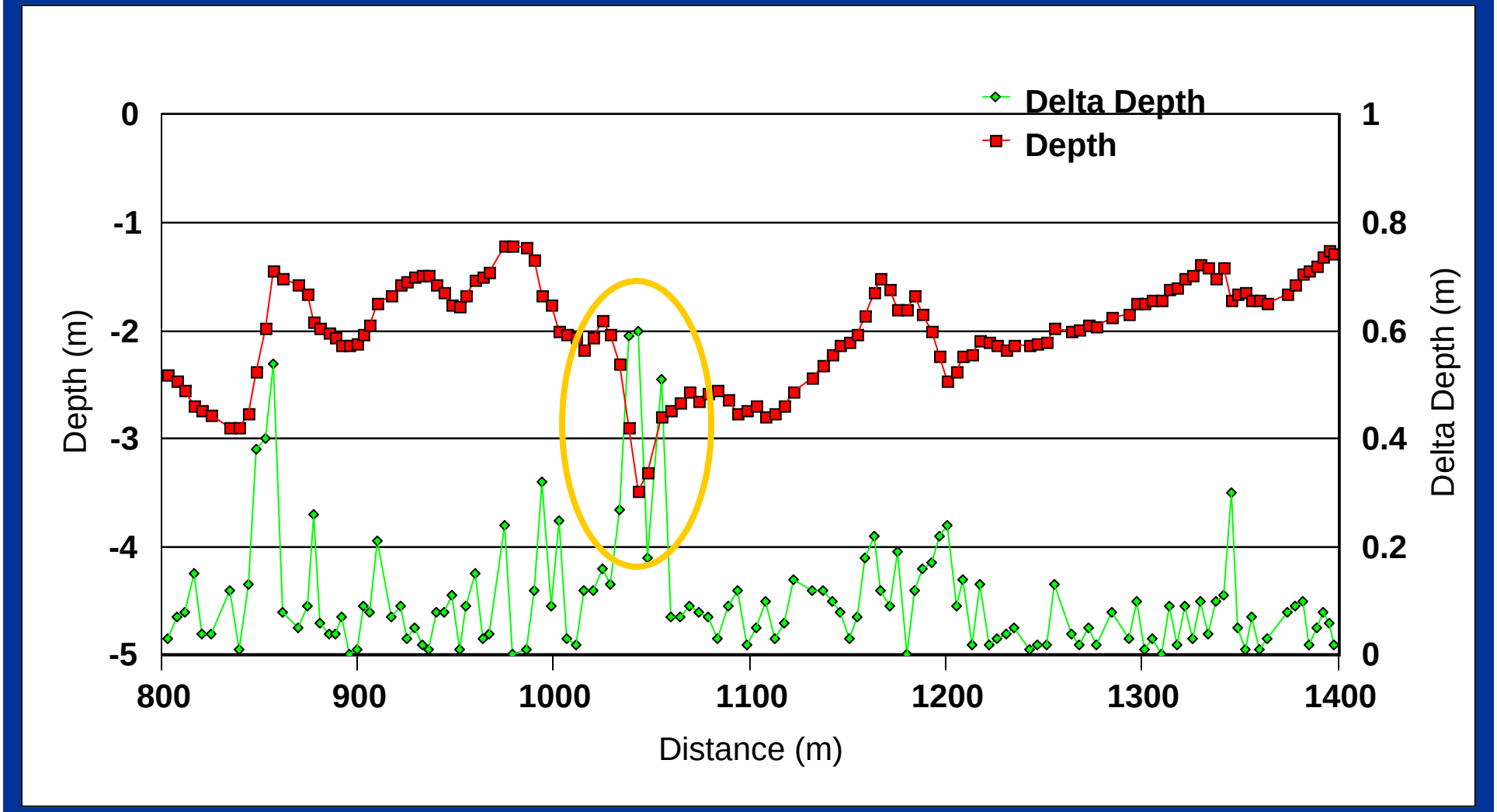

Delta Depth
Depth
0
-1
-2
-3
-4
-5
1
0.8
0.6
0.4
0.2
0
Depth (m)
Delta Depth (m)
800
900
1000
1100
1200
1300
1400
Distance (m)

Local Time	ft	ft	ft	meters	meters
	X-Easting	Y-Northing	distance	distance	Depth
19:04:35	227351.45	69984.94	11.4	3.5	1.74
19:04:45	227340.85	70007.1	24.6	7.5	1.67
19:04:50	227334.62	70019.22	13.6	4.2	1.58
19:04:55	227327.65	70028.89	11.9	3.6	1.55
19:05:00	227321.48	70039.95	12.7	3.9	1.5
19:05:04	227316.05	70050.94	12.3	3.7	1.48
19:05:10	227313.53	70060.76	10.1	3.1	1.49
19:05:15	227307.58	70073.71	14.3	4.3	1.57
19:05:20	227303.88	70085.86	12.7	3.9	1.65
19:05:25	227300.24	70097.76	12.4	3.8	1.76
19:05:30	227296.58	70109.72	12.5	3.8	1.77
19:05:34	227292.94	70121.62	12.4	3.8	1.68
19:05:39	227289.27	70135.46	14.3	4.4	1.53
19:05:45	227287.04	70147.53	12.3	3.7	1.5
19:05:50	227285.91	70159.66	12.2	3.7	1.46
19:05:55	227285.87	70171.72	12.1	3.7	0.53
19:05:59	227288.35	70183.56	12.1	3.7	1.22
19:06:04	227293.4	70195.18	12.7	3.9	1.22
19:06:09	227299.52	70204.43	11.1	3.4	0.57
19:06:15	227306.76	70215.59	13.3	4.1	1.23
19:06:19	227315.42	70226.7	14.1	4.3	1.35
19:06:25	227324.18	70236.6	13.2	4.0	1.67
19:06:30	227332.5	70247.21	13.5	4.1	1.76
19:06:34	227341.79	70258.25	14.4	4.4	2.01

IF Delta-Depth < 0.20; Then = 0; Else = 9999999


Delta Depth
Depth
0
-1
-2
-3
-4
-5
1
0.8
0.6
0.4
0.2
0
Depth (m)
Delta Depth (m)
800
900
1000
1100
1200
1300
1400
Distance (m)


Delta Depth
Depth
0
-1
-2
-3
-4
-5
1
0.8
0.6
0.4
0.2
0
Depth (m)
Delta Depth (m)
800
900
1000
1100
1200
1300
1400
Distance (m)



These are judgment calls – and some may be more difficult

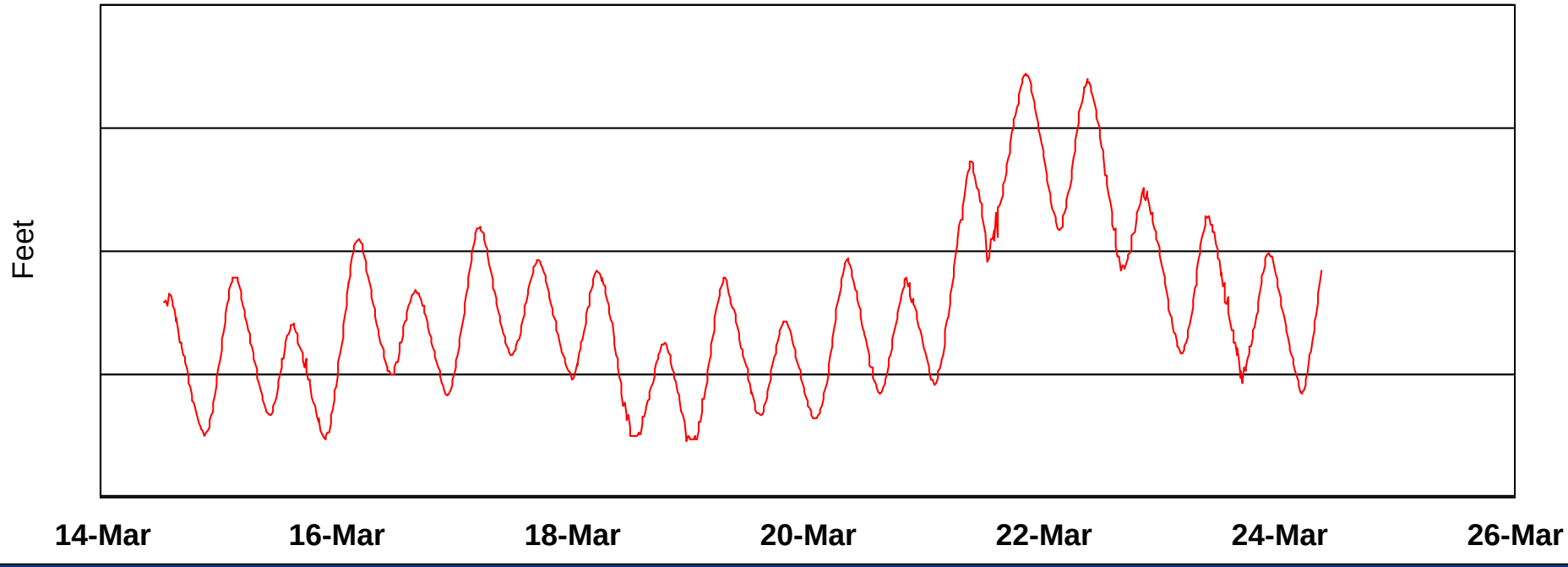
Try to establish rules and guidelines for what is considered outside the acceptable range

Adjusting for Tidal Fluctuations

- There is a wide range in the magnitude of tides
  - May be as small as a few inches
  - May be as large as several meters
- Driven by lunar cycles
  - Two cycles per day
    - Approximately 12.5 hrs
    - Approximately 6 hrs for full tidal range
  - Monthly and seasonal effects

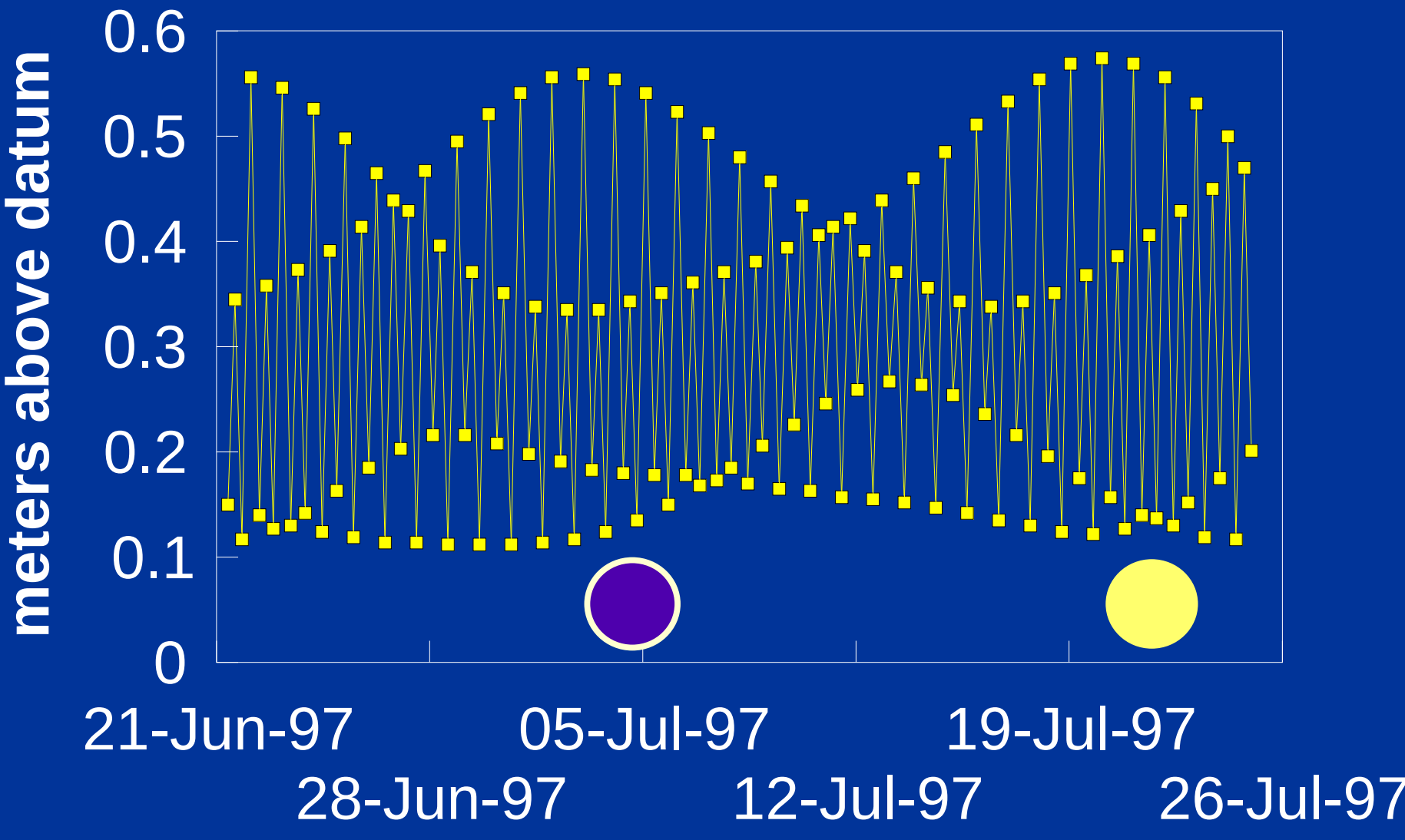
Rehoboth Bay - Dewey Beach

Tidal Variations



Simulated Tidal Heights

Solomons Island, MD



The Simple Case Sinepuxent Bay

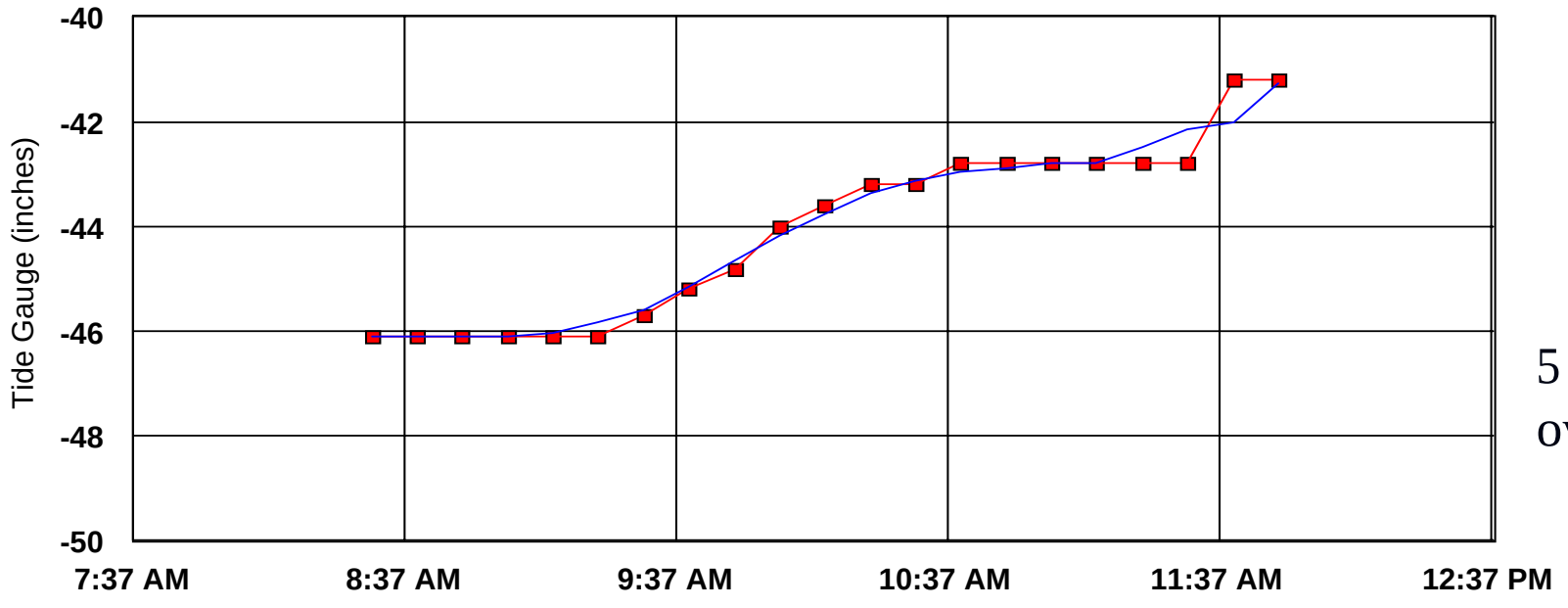
Small portion (1300 Ha) of larger estuary
Short distance across area
Open on both ends
No severe constrictions to tides

Reasonable to assume tide levels uniform across study area

Pilot Study Site
Sinepuxent Bay, MD

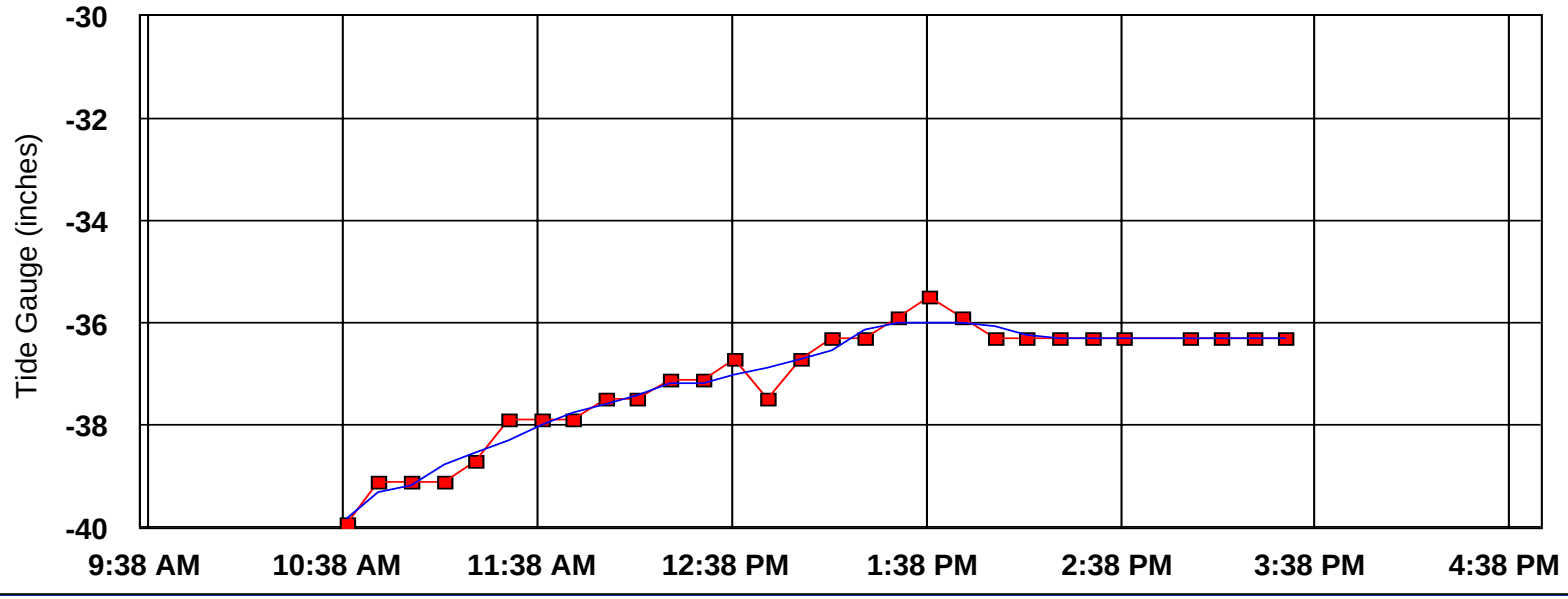
Obtaining Tide Data

June 5, 1996



5 inch change over 3 hours

June 20, 1996



4 inch change over 5 hours

Relatively easy to adjust for tidal fluctuations because:

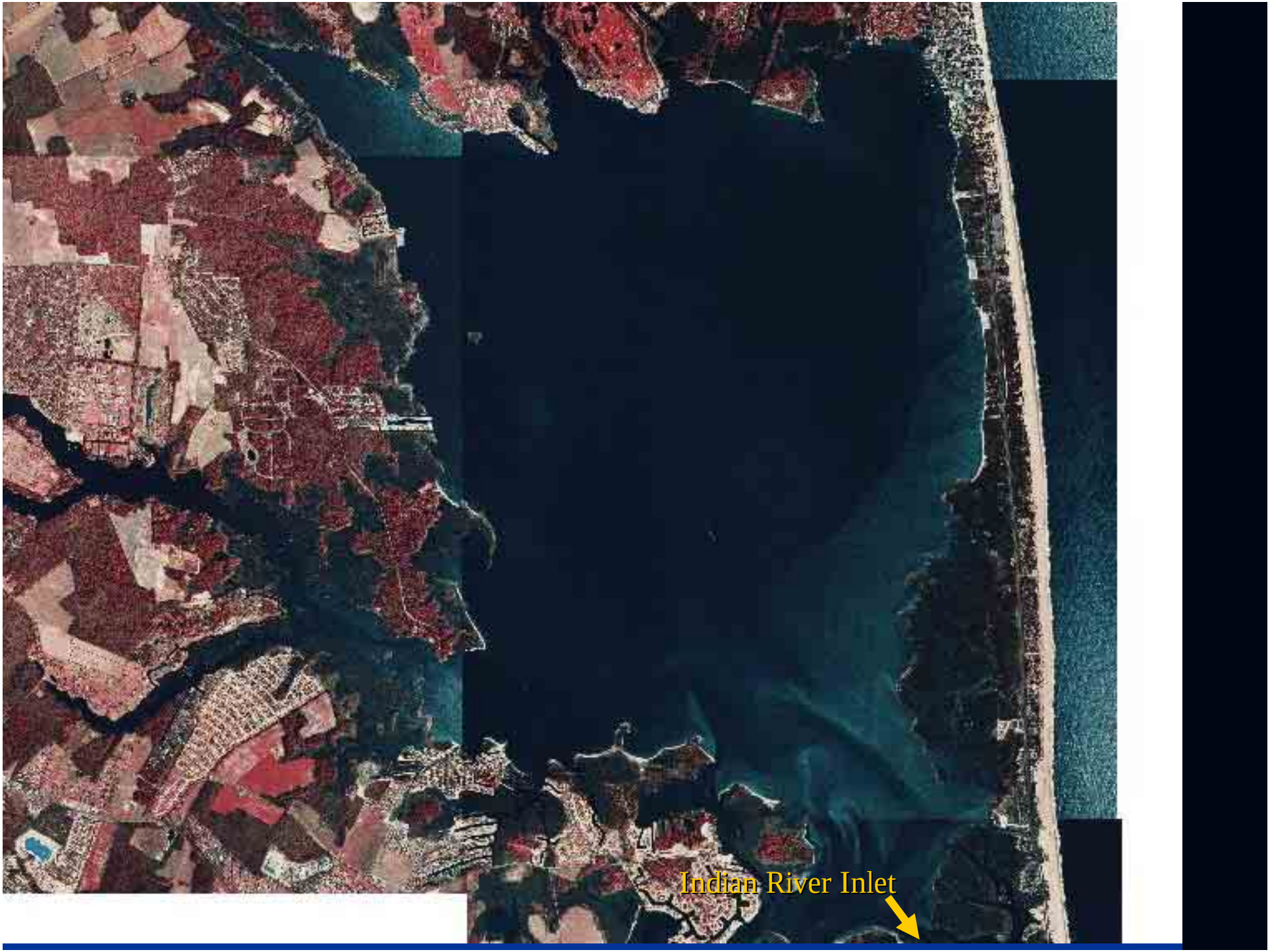
- We assume that the change is uniform over the survey area
- The magnitude of tidal change is fairly small (errors are less significant)

Tide Correction

- Assume tide height is uniform across the area
- Get date time stamp from bathymetry file
- Compare tide level at that point in time with MSL
- Adjust water depth for deviation from mean level

A more complex case
Rehoboth Bay, DE

- Approx. 3300 Ha
- Size is approximately 3X that of Sinepuxent Bay
- Has tidal inlet at one end only
- Fairly constricted inlet

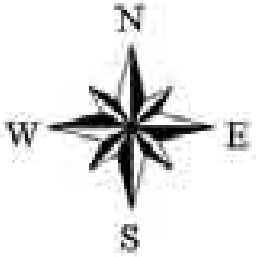

Indian River Inlet

Data collected on six days in 2001

- July 5
- Aug 1
- Aug 6
- Aug 7
- Aug 15
- Sept 7

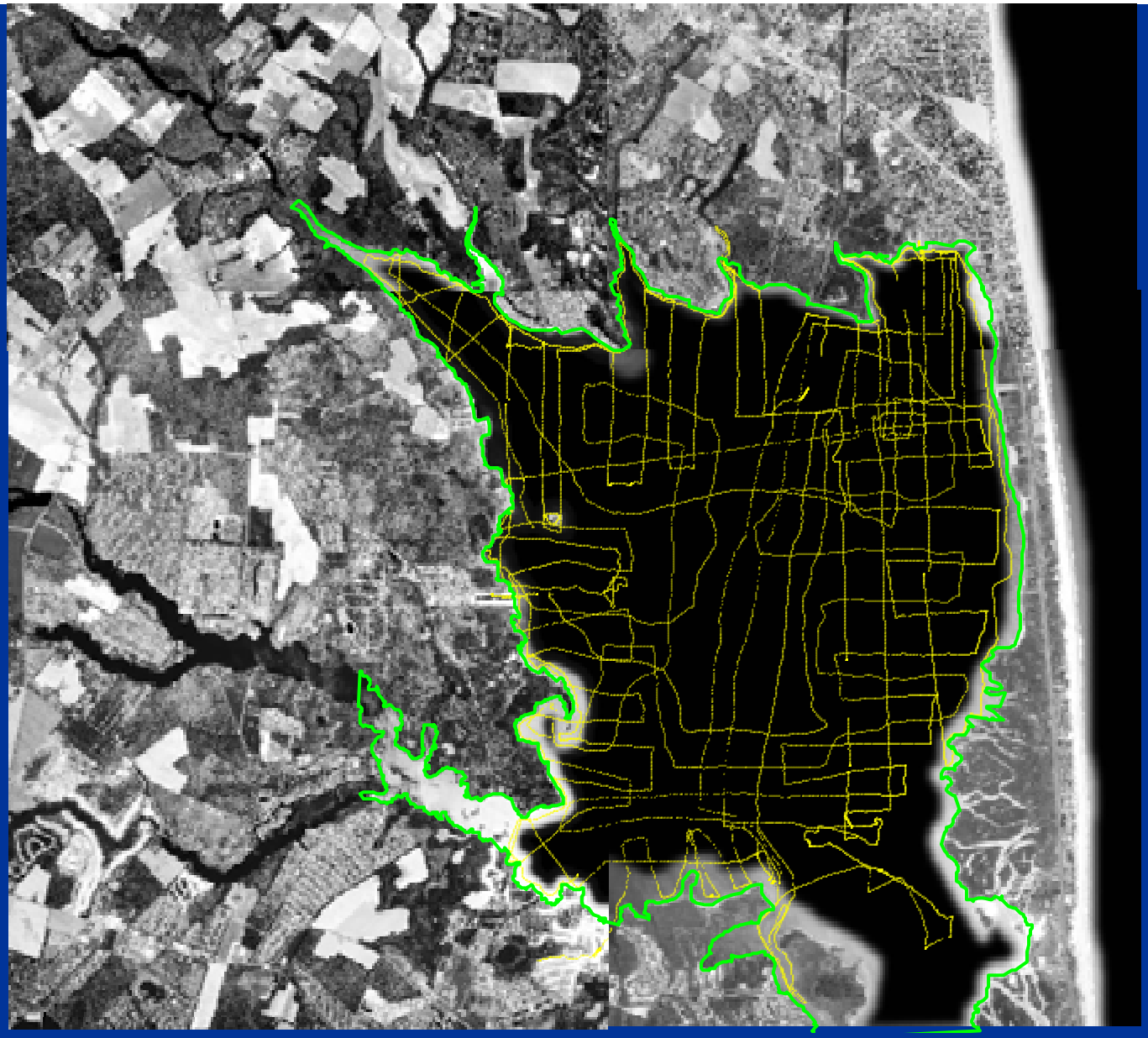
Rehoboth Bay - Bathymetry (UMD)

Initial data collection 2001



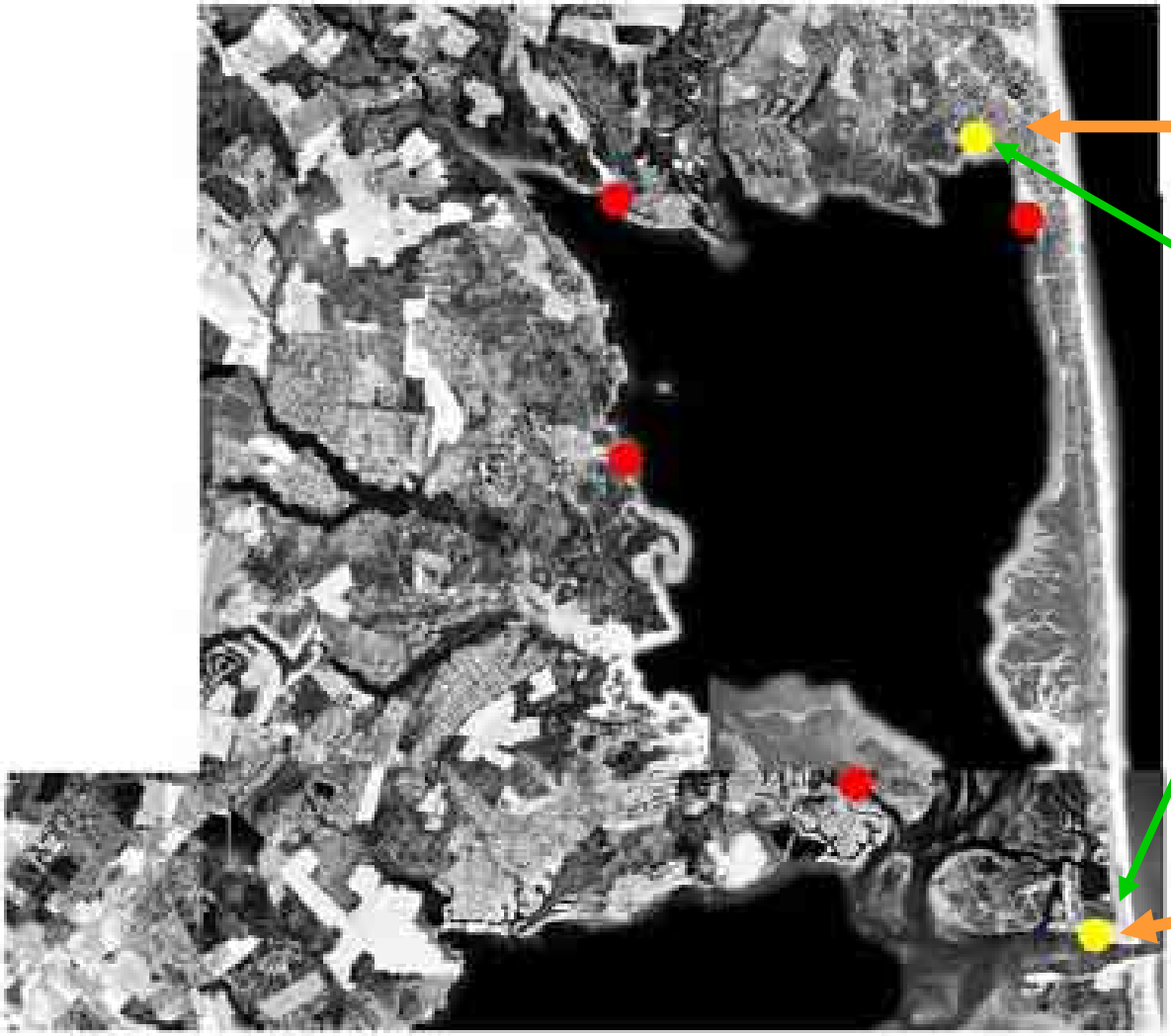
5 0 5 10 Kilometers

2001 Bathymetric Data plus Roxanne data
Eventually Roxanne data discarded due to lack poor quality



2001-2002 Bathymetric data sets without Roxanne data

Tide Gauge Locations



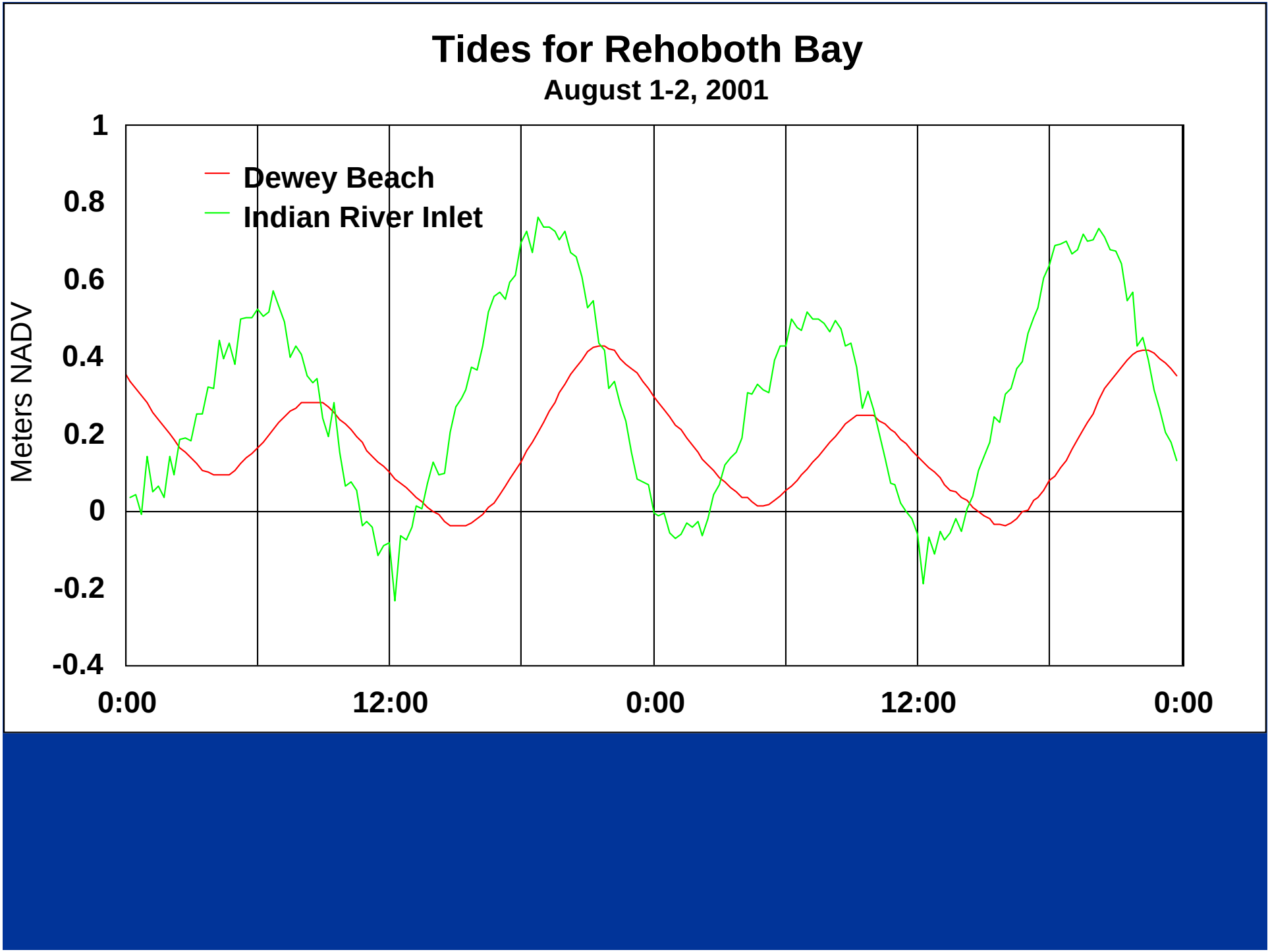
Dewey Beach

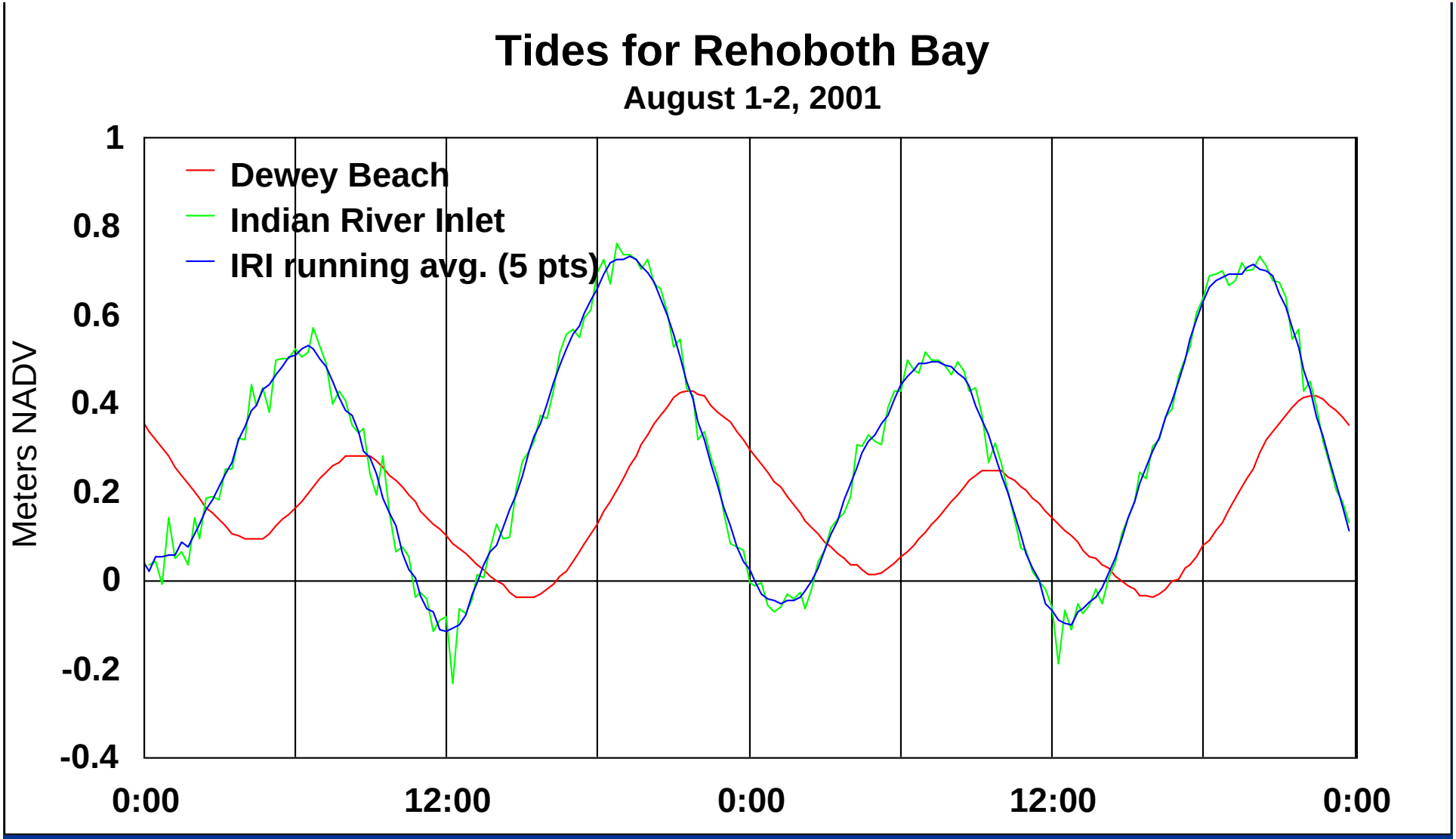
USGS Gauges
Continuous
long term
data collection

W E S

Indian River Inlet

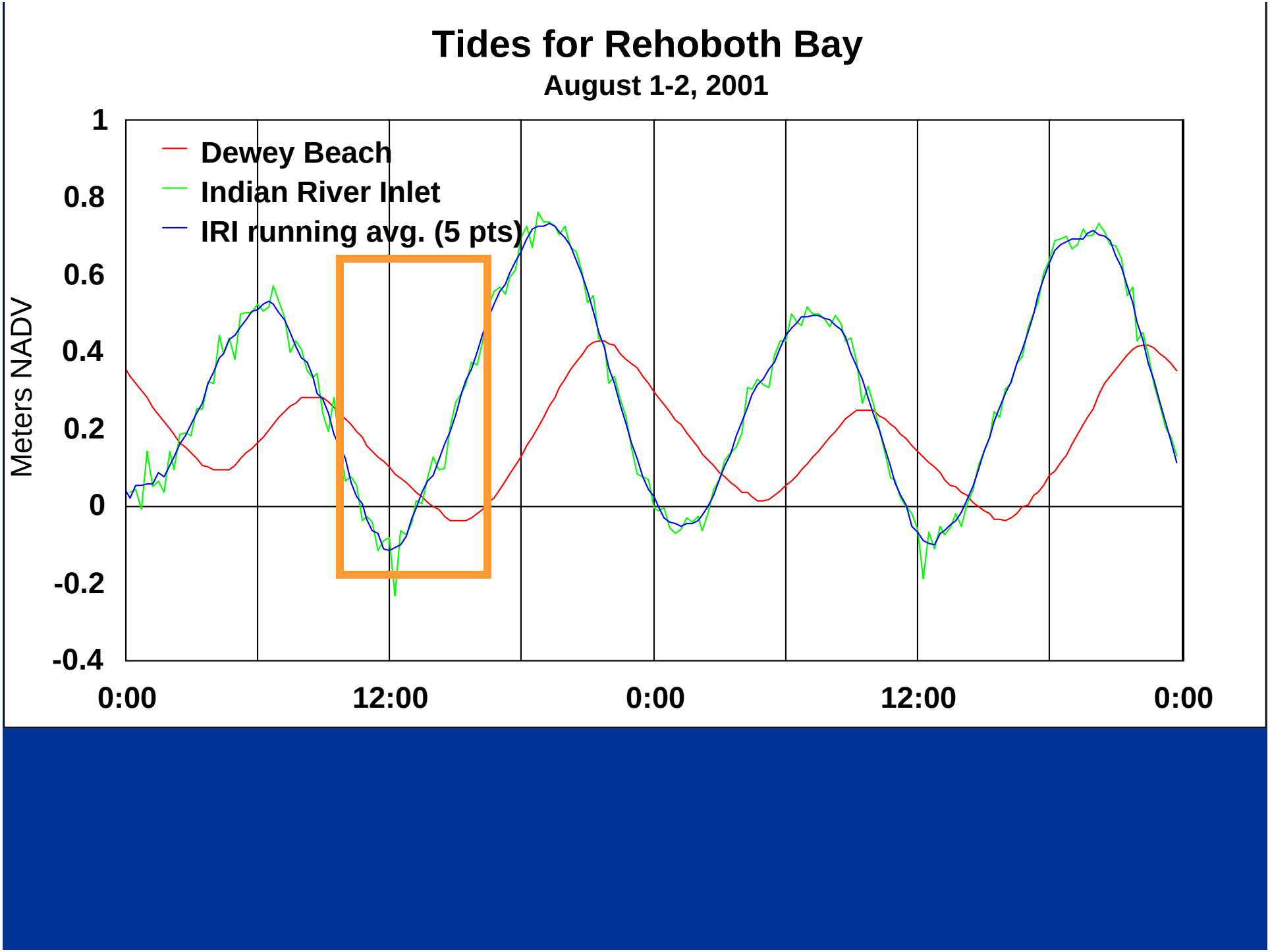
5 0 5 10 Kilometers


Tides for Rehoboth Bay
August 1-2, 2001
Dewey Beach
Indian River Inlet
Meters NADV
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0:00
12:00
0:00
12:00
0:00

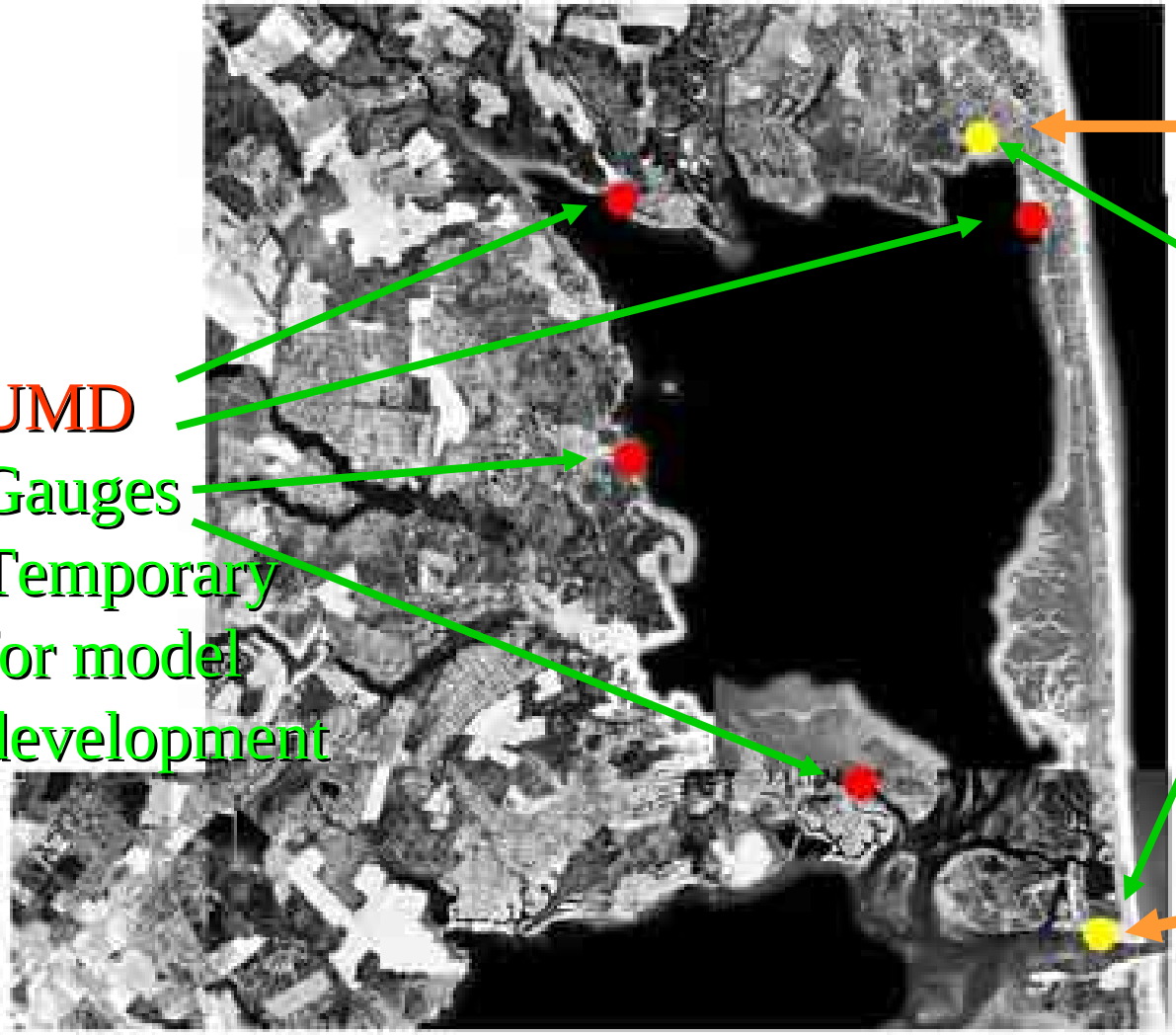


Greater amplitude at IRI (greater tidal range)

Approximately 3 hr lag time for tide to move up the estuary from the inlet


Tides for Rehoboth Bay
August 1-2, 2001
Dewey Beach
Indian River Inlet
IRI running avg. (5 pts)
Meters NADV
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0:00
12:00
0:00
12:00
0:00

Tide Gauge Locations



Dewey Beach

USGS Gauges
Continuous
long term
data collection

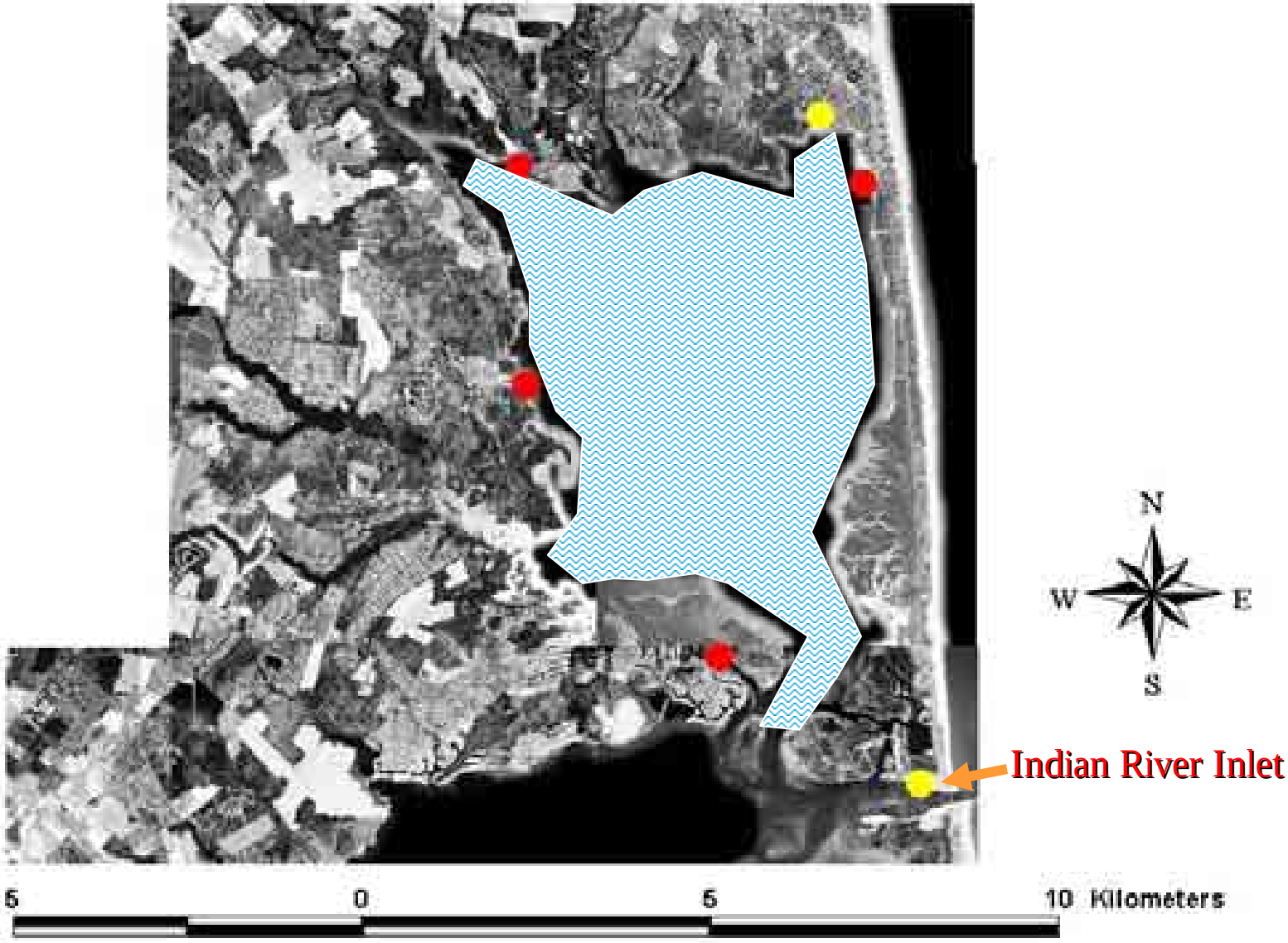
UMD
Gauges
Temporary
for model
development

W E S

Indian River Inlet

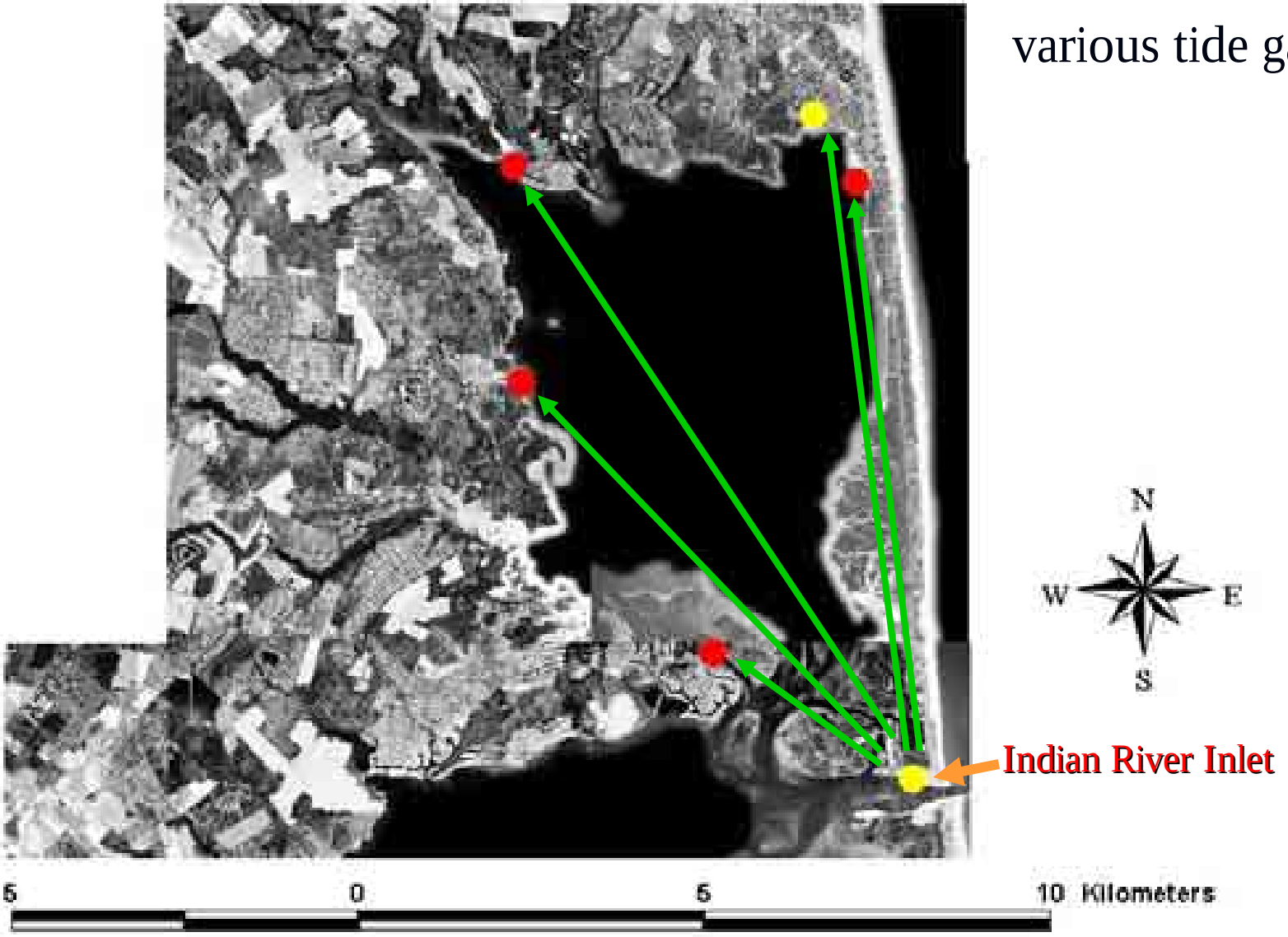
5 0 5 10 Kilometers

Tide Gauge Locations

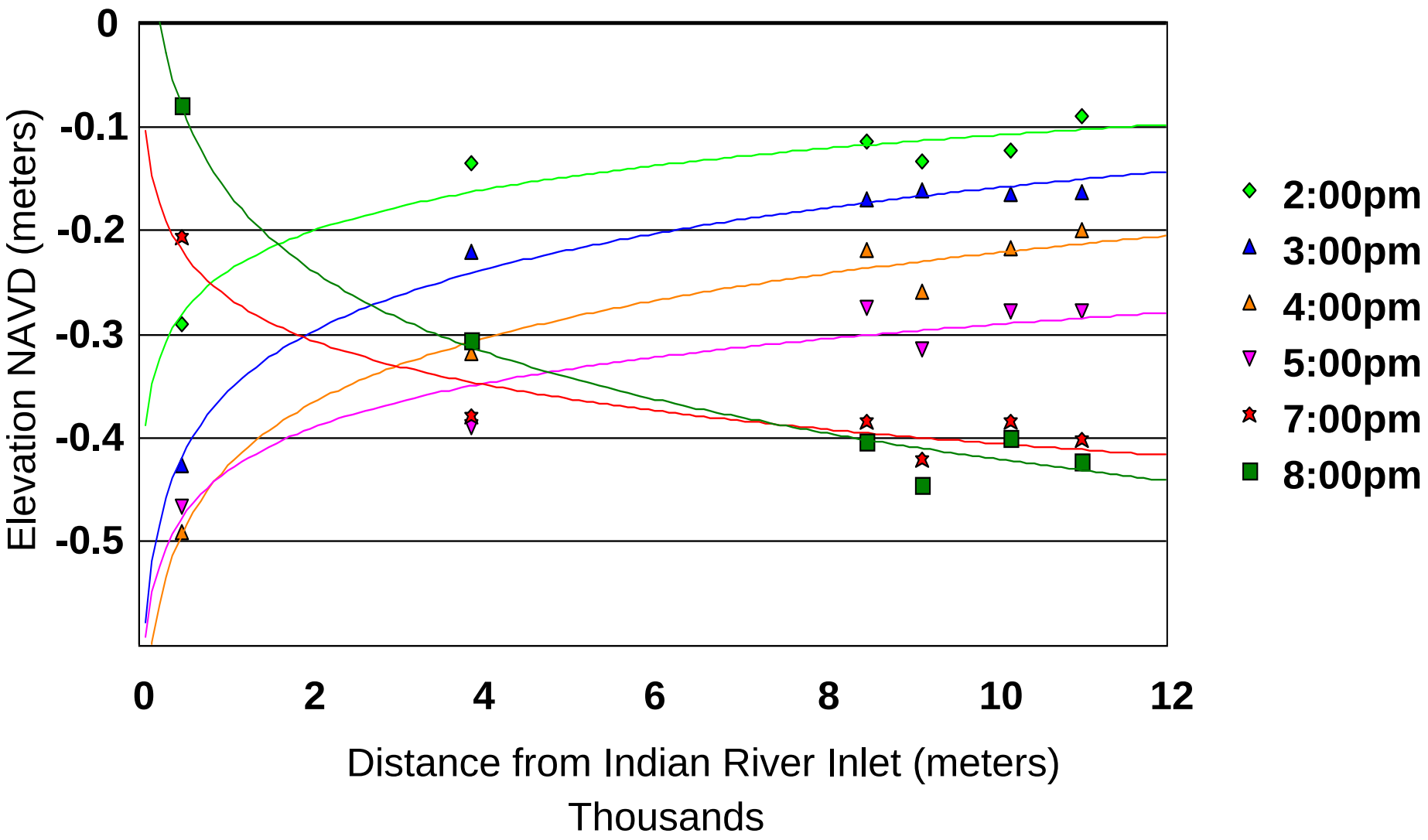


Tide Gauge Locations

Distance from IRI to various tide gauges



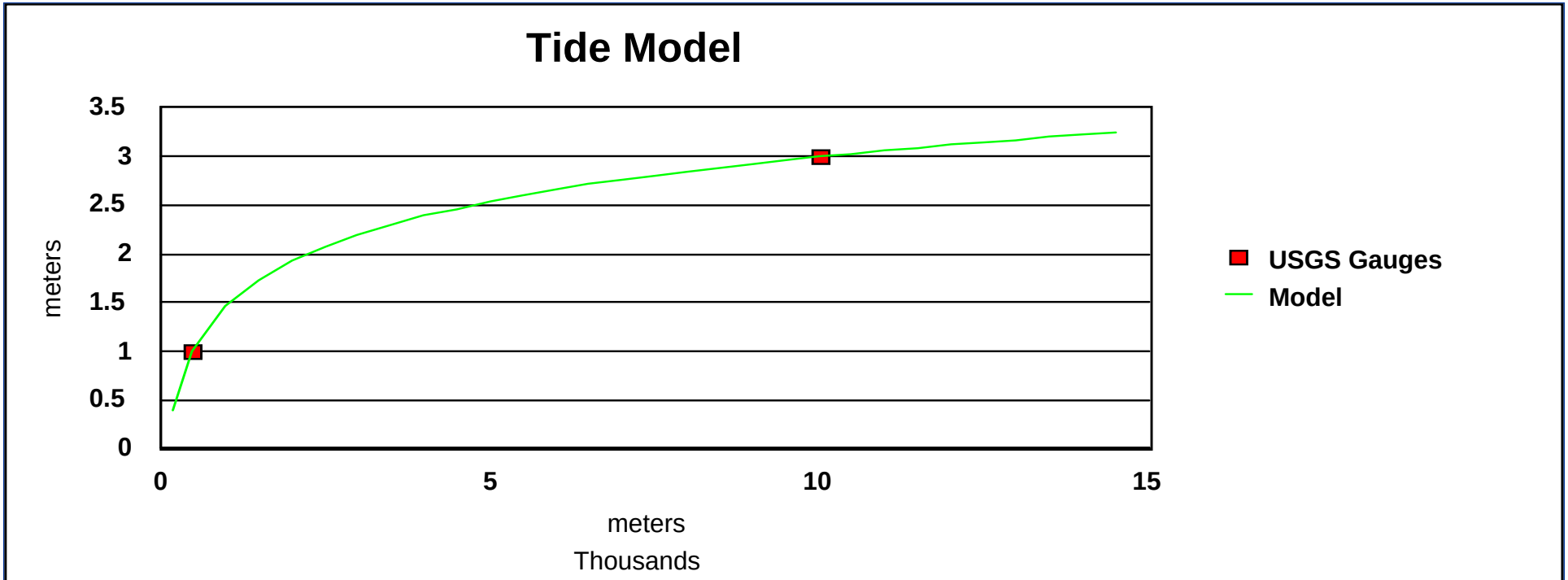
Modeling of Tide Levels in the Rehoboth Bay Estuary

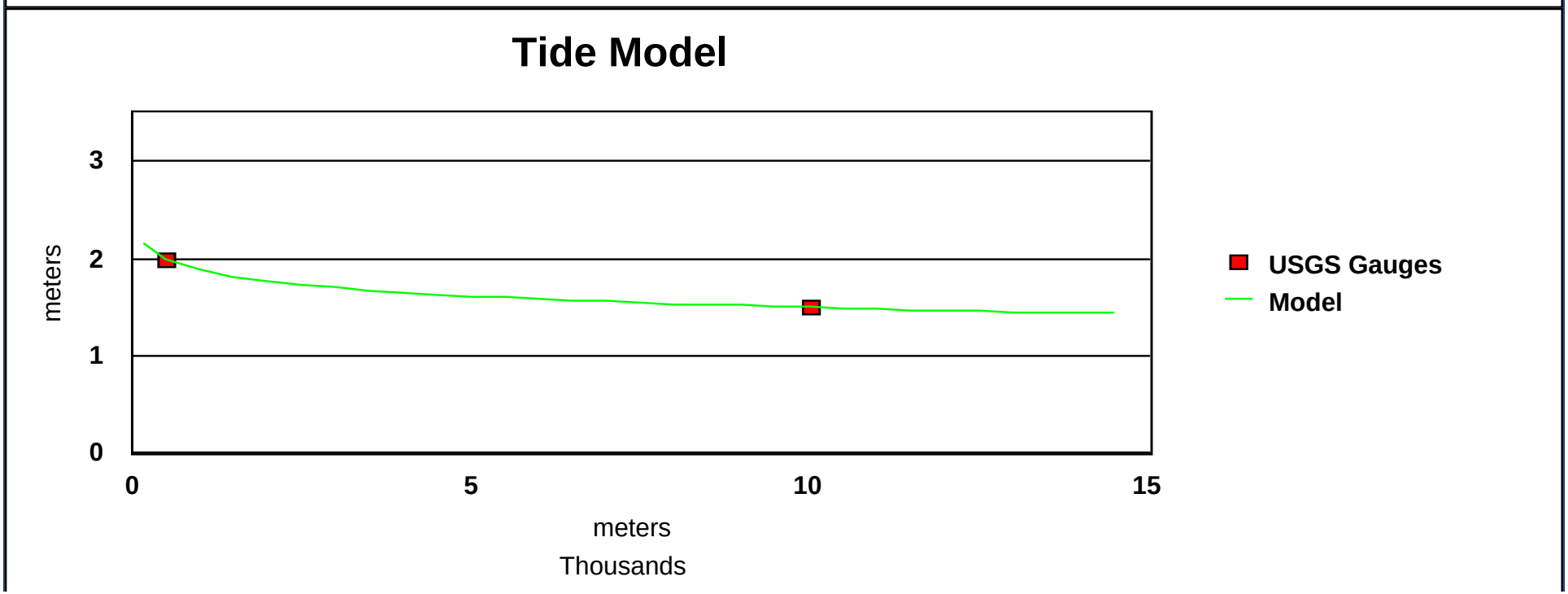


For two points
point 1 (X1, Y1)
point 2 (X2, Y2)

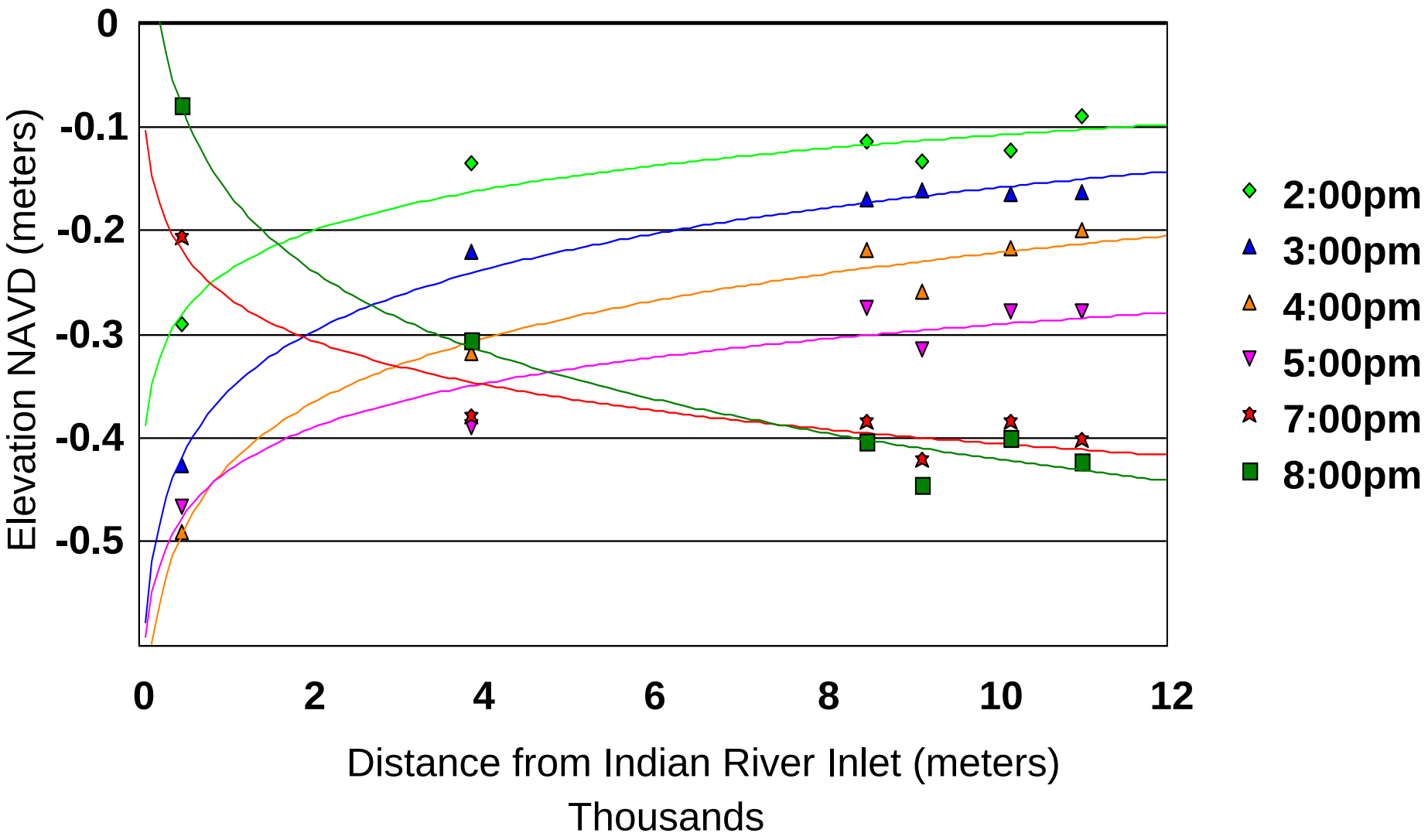
To pass a logarithmic function through these two points

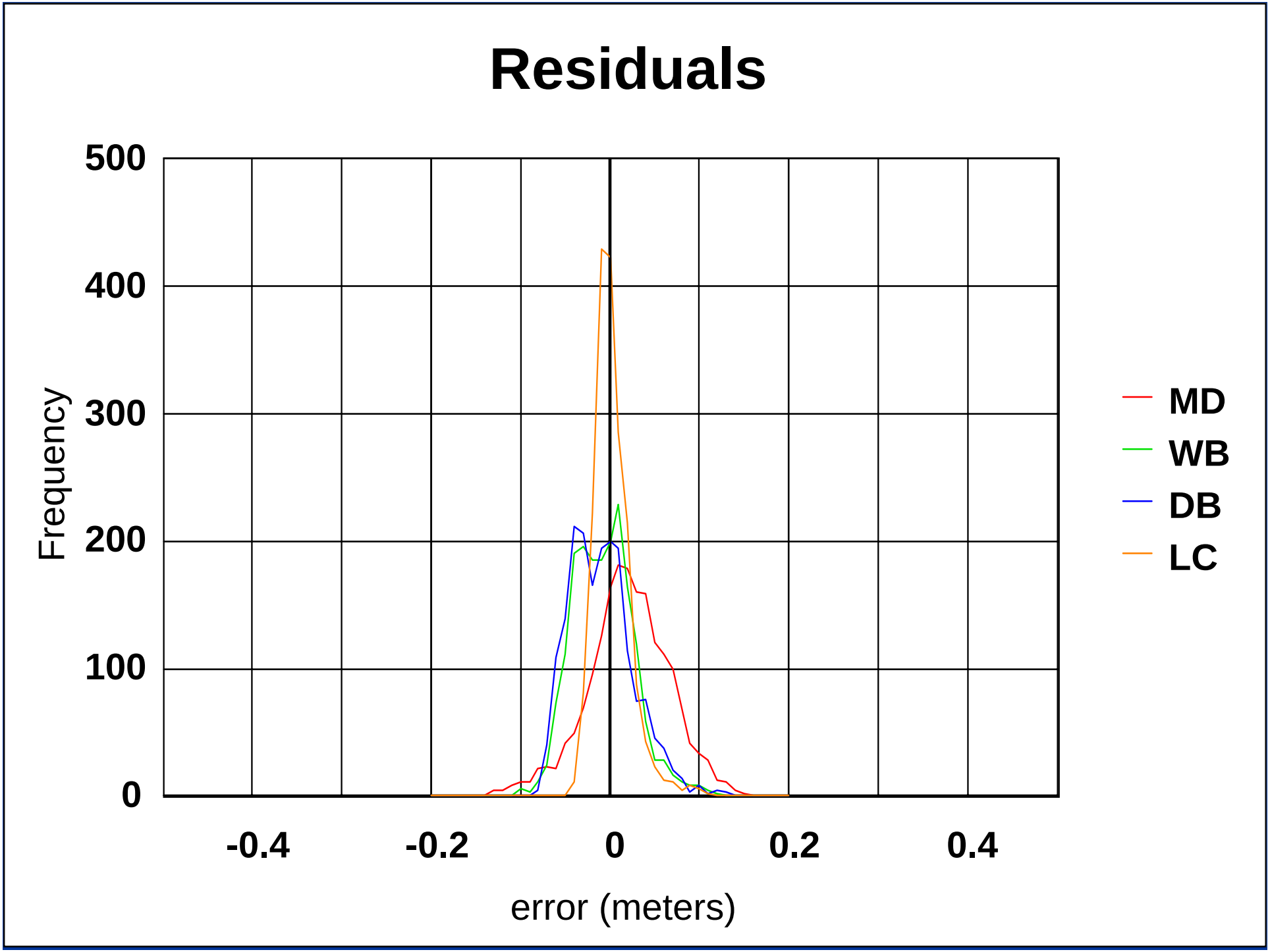
$$\mathbf{Y} = Y1 + (Y2-Y1)/(\ln X2 - \ln X1)*(\ln \mathbf{X} - \ln X1)$$


Tide Model
3.5
3
2.5
2
1.5
1
0.5
0
meters
0
5
10
15
meters
Thousands
USGS Gauges
Model


Tide Model
3
2
1
0
meters
0
5
10
15
meters
Thousands
USGS Gauges
Model

Modeling of Tide Levels in the Rehoboth Bay Estuary




Residuals
500
400
300
200
100
0
Frequency
-0.4
-0.2
0
0.2
0.4
error (meters)
MD
WB
DB
LC

Applying Model to Rehoboth Bay

- Must solve for Y at a particular point in the estuary at a particular time
- For each data point
  - Use pythagorean theorem to calculate distance from IRI = X
  - Consult date-time stamp for each data point
  - Determine tide height at IRI and DB at that particular date and time
- For two gauges (points 1 and 2)
  - IRI Gauge (distance and tide height) (X1, Y1)
  - Dewey Beach Gauge (distance and tide height) (X2, Y2)
- **Y** = Y1 + (Y2-Y1)/(lnY2 - lnY1)*(ln**X** - lnY1)

Correct Water Depth

								(X2,Y2)		(X1,Y1)		Normalized
							Distance from		Time Match		Tide Correction	Bathymetry
Depth							IRI	DB	Row	IRI	NAVD	NAVD
	LATITUDE	LONGITUDE	LOGDATE	X	Y	Local Time	meters	Tide height	(closest 15 min)	Tide Height	(meters)	(meters)
0.84	38.63520	-75.10600	07/05/2001	227048.0	70554.2	10:43 AM	4332	0.155	427	0.088	0.139	0.701
1.04	38.63540	-75.10610	07/05/2001	227042.9	70581.8	10:44 AM	4354	0.155	427	0.088	0.139	0.901
1.10	38.63600	-75.10630	07/05/2001	227021.6	70639.1	10:44 AM	4408	0.155	427	0.088	0.139	0.961
1.18	38.63630	-75.10650	07/05/2001	227008.5	70674.3	10:44 AM	4441	0.155	427	0.088	0.139	1.041
1.60	38.63710	-75.10690	07/05/2001	226966.1	70766.5	10:45 AM	4534	0.155	427	0.088	0.140	1.460
2.05	38.63860	-75.10790	07/05/2001	226880.7	70927.3	10:46 AM	4705	0.155	427	0.088	0.141	1.909
1.93	38.63970	-75.10900	07/05/2001	226786.7	71052.8	10:47 AM	4859	0.155	427	0.088	0.141	1.789
1.98	38.64020	-75.10960	07/05/2001	226735.3	71106.0	10:48 AM	4933	0.155	427	0.088	0.141	1.839
1.97	38.64060	-75.11030	07/05/2001	226673.2	71156.1	10:48 AM	5013	0.155	427	0.088	0.142	1.828
2.02	38.64040	-75.11090	07/05/2001	226619.5	71128.2	10:49 AM	5033	0.155	427	0.088	0.142	1.878
1.88	38.64010	-75.11130	07/05/2001	226586.3	71094.9	10:49 AM	5036	0.155	427	0.088	0.142	1.738
1.86	38.63980	-75.11140	07/05/2001	226580.5	71059.6	10:50 AM	5017	0.155	427	0.088	0.142	1.718
1.81	38.63930	-75.11100	07/05/2001	226614.0	71004.4	10:50 AM	4955	0.155	427	0.088	0.142	1.668
1.77	38.63740	-75.10980	07/05/2001	226717.7	70799.4	10:51 AM	4743	0.155	427	0.088	0.141	1.629
1.63	38.63650	-75.10930	07/05/2001	226758.8	70692.0	10:52 AM	4642	0.146	428	0.107	0.137	1.493
1.39	38.63600	-75.10900	07/05/2001	226786.4	70637.7	10:53 AM	4587	0.146	428	0.107	0.137	1.253
1.05	38.63550	-75.10870	07/05/2001	226818.6	70583.1	10:53 AM	4527	0.146	428	0.107	0.137	0.913
1.13	38.63510	-75.10830	07/05/2001	226849.3	70536.9	10:53 AM	4474	0.146	428	0.107	0.137	0.993
1.00	38.63470	-75.10800	07/05/2001	226878.4	70498.3	10:54 AM	4427	0.146	428	0.107	0.137	0.863

For distance calculation

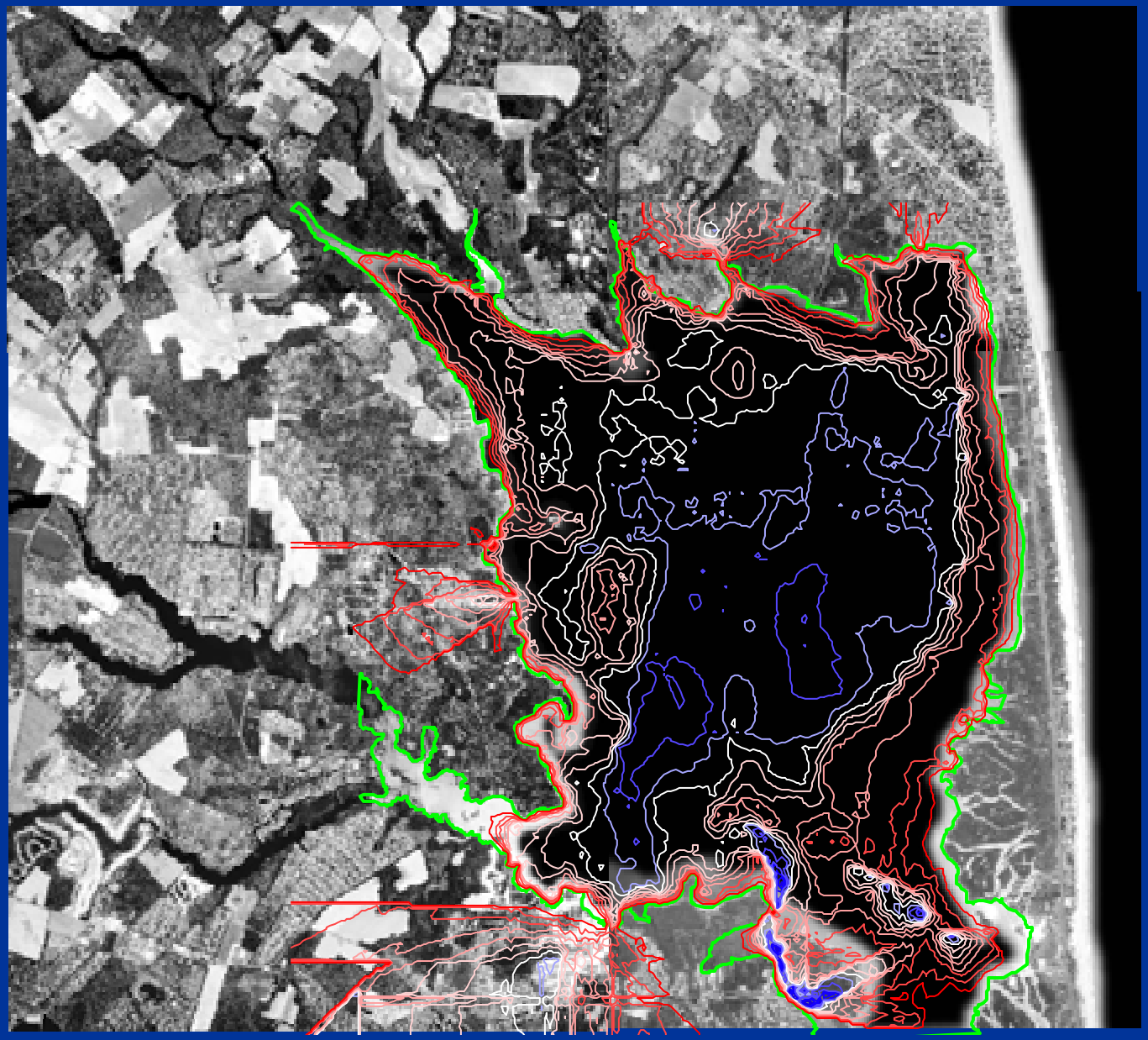
To calculate tide heights at IRI and Dewey Beach

Y2

Y1

Solve equation

$$Y = Y1 + (Y2-Y1)/(\ln X2 - \ln X1)*(\ln X - \ln X1)$$



Then check for internal consistency at points of intersection, especially on data sets from different days

The Complex Case Unsolved

Indian River Bay

- Some data collected in 1999 by George Demas and Phil King
- Additional data collected in 2000 by MCR
- Problems with quality of ancillary tide data collected

Indian River Bay Bathymetry