Wave Surge Mitigation Study

Harbor Centre Marina, City of Sheboygan

SMITHGROUP JJR

WISCONSIN COASTAL MANAGEMENT PROGRAM

City of Sheboygan
spirit on the lake.

Harbor Centre MARINA
SHEBOYGAN • WISCONSIN

Major Issues

Winterization

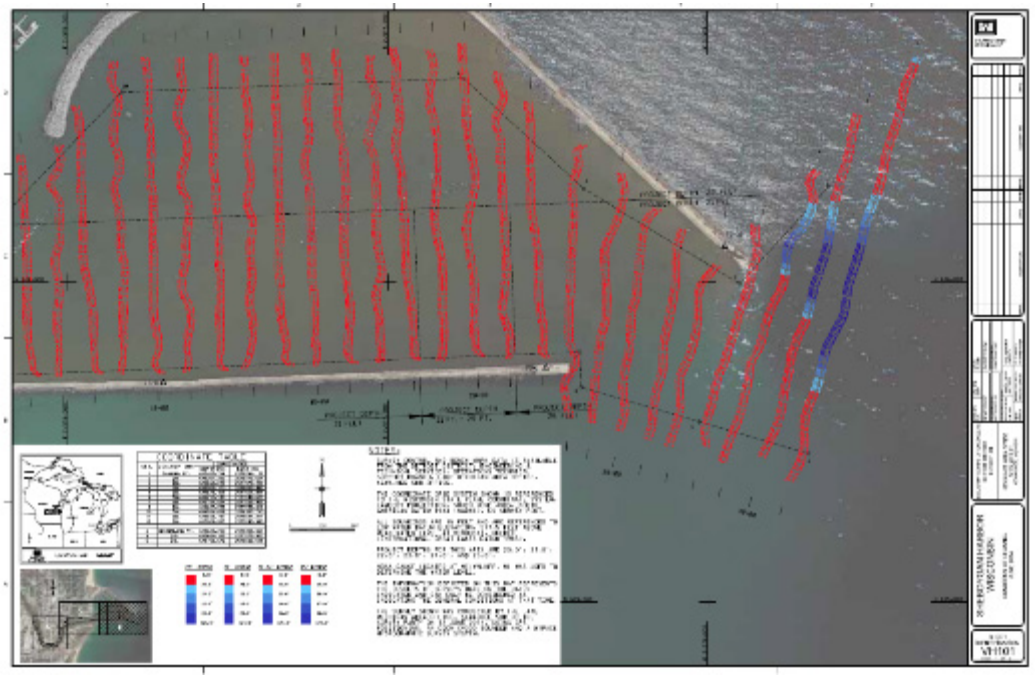
- Floatation Docking Systems Inc. Docks (~30 years old)
- Ice Related Damage Amounting to Approximately $45k-$60k, annually
- Ice Related Damage Associated with Strong Winds & Waves from Southeast
- Ice Damage Particularly Heavy over 2013-2014 & 2014-2015 Winters
- Dredging of the Harbor Completed in 2013. Damage for the 2013-2014 season amounted to $350,000.

Tasks

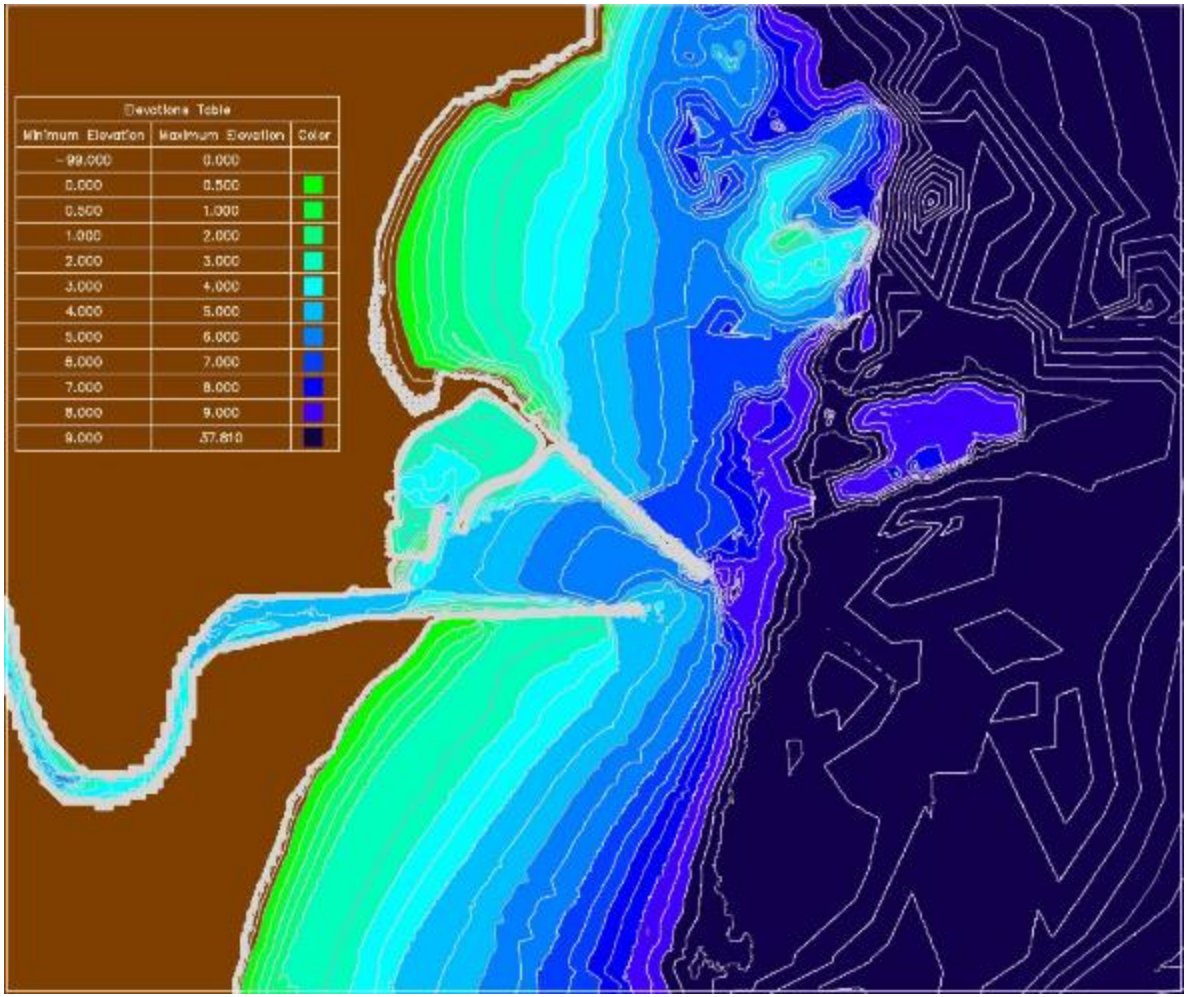
- Bathymetric Survey of Marina Entrance
- Establish Existing Conditions
- Develop Preliminary Concepts
- Perform Numerical Modeling of Preliminary Concepts
- Make Recommendations based on Cost Estimates and Cost Benefit Analysis

Bathymetry

- Bathymetric Survey Performed December 2015
- Supplemental Bathymetric Information Taken from Navigation Charts, USACE Dredge Records, and LiDAR



Bathymetry


Elevations Table
Minimum Elevation
Maximum Elevation
Color
-99.000
0.000
0.000
0.500
0.500
1.000
1.000
2.000
2.000
3.000
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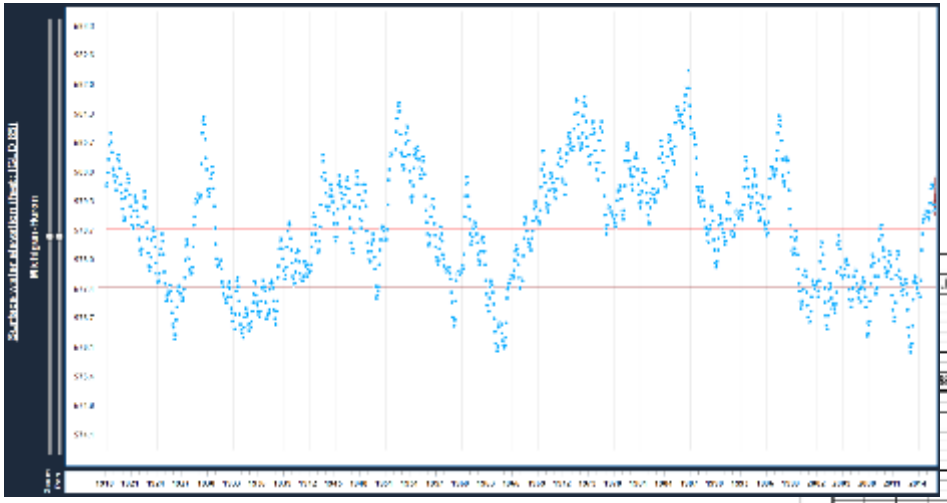
9.000
9.000
37.810

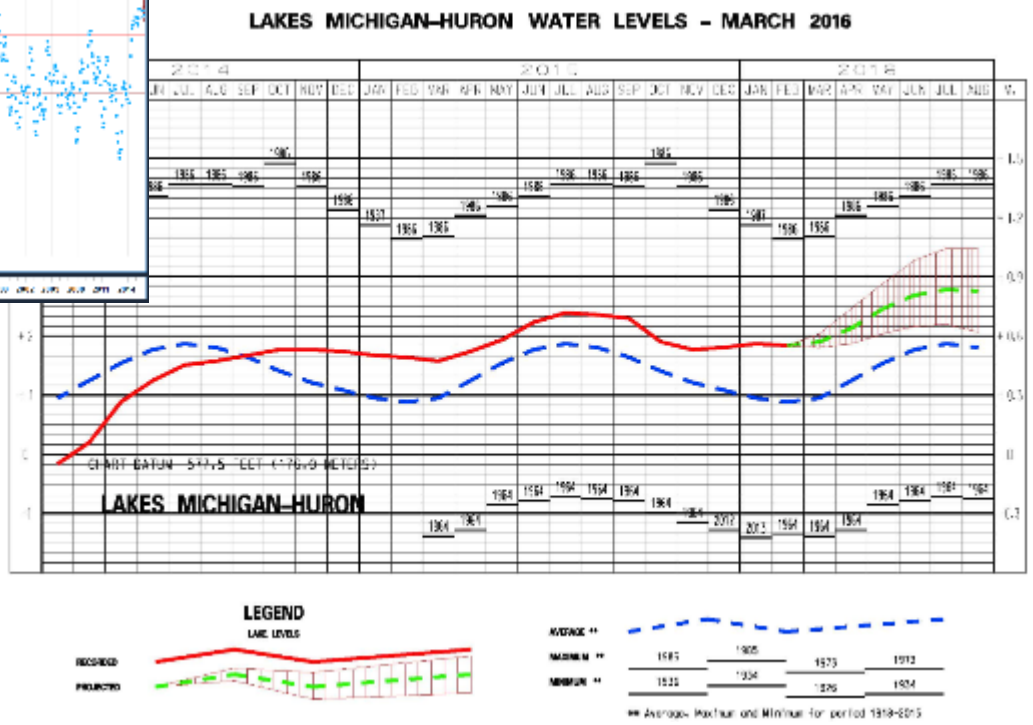
Existing Conditions

- Water Levels
- Waves
- Instrumentation Deployment
- Winds
- River Discharge
- Ice
  - Damage Analysis

Existing Conditions

Water Levels



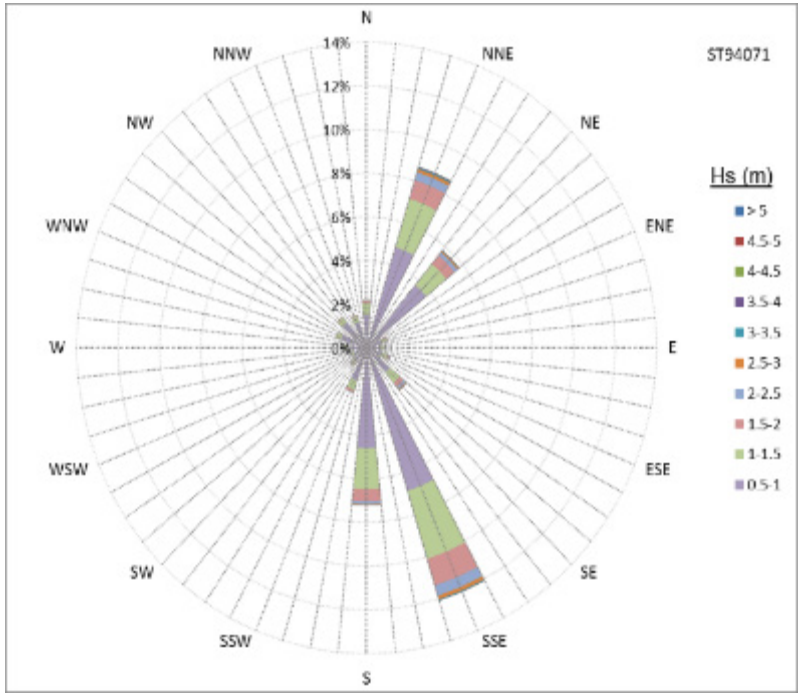


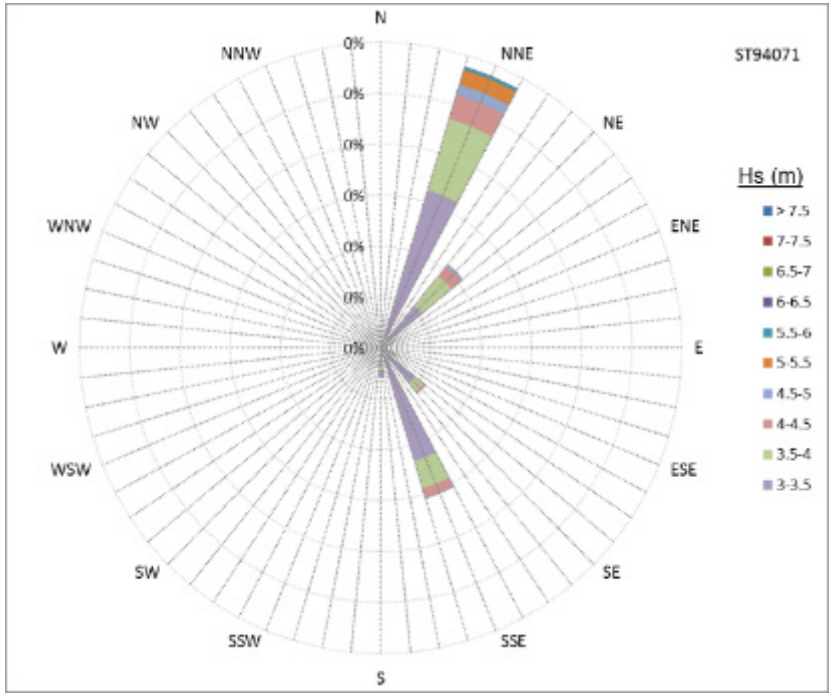
	IGLD85, ft	Ref CD, ft
Lowest Record	576.0	-1.5
10%	577.1	-0.4
Chart Datum	577.5	0
Average	578.8	+1.3
90%	580.6	+3.1
10yr	582.3	+4.8
50yr	583.4	+5.9
100yr	583.8	+6.3
500yr	584.7	+7.2

Existing Conditions

Waves

Wave Information Study (WIS) – Station 94071 (1979-2014)

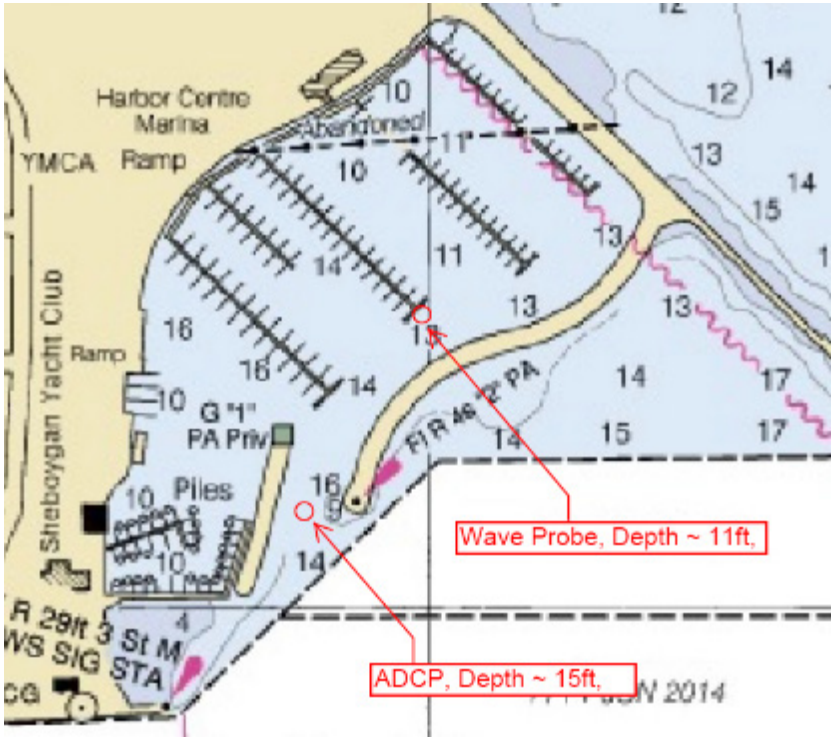


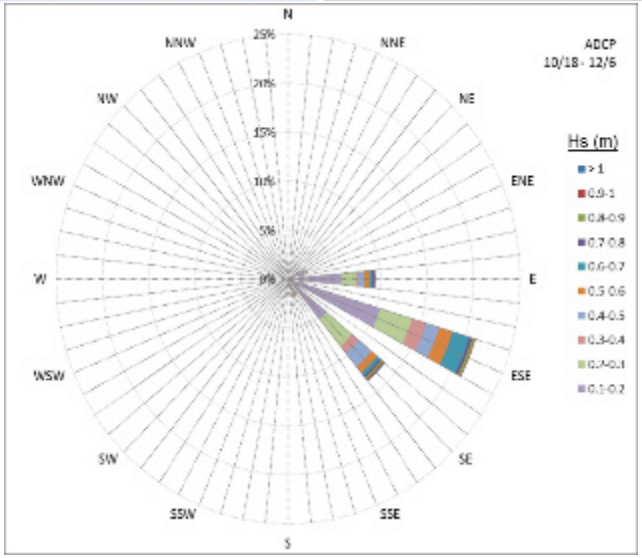


Existing Conditions

Instrumentation Deployment

- Acoustic Doppler Current Profiler (ADCP)
- Pressure Wave Probe



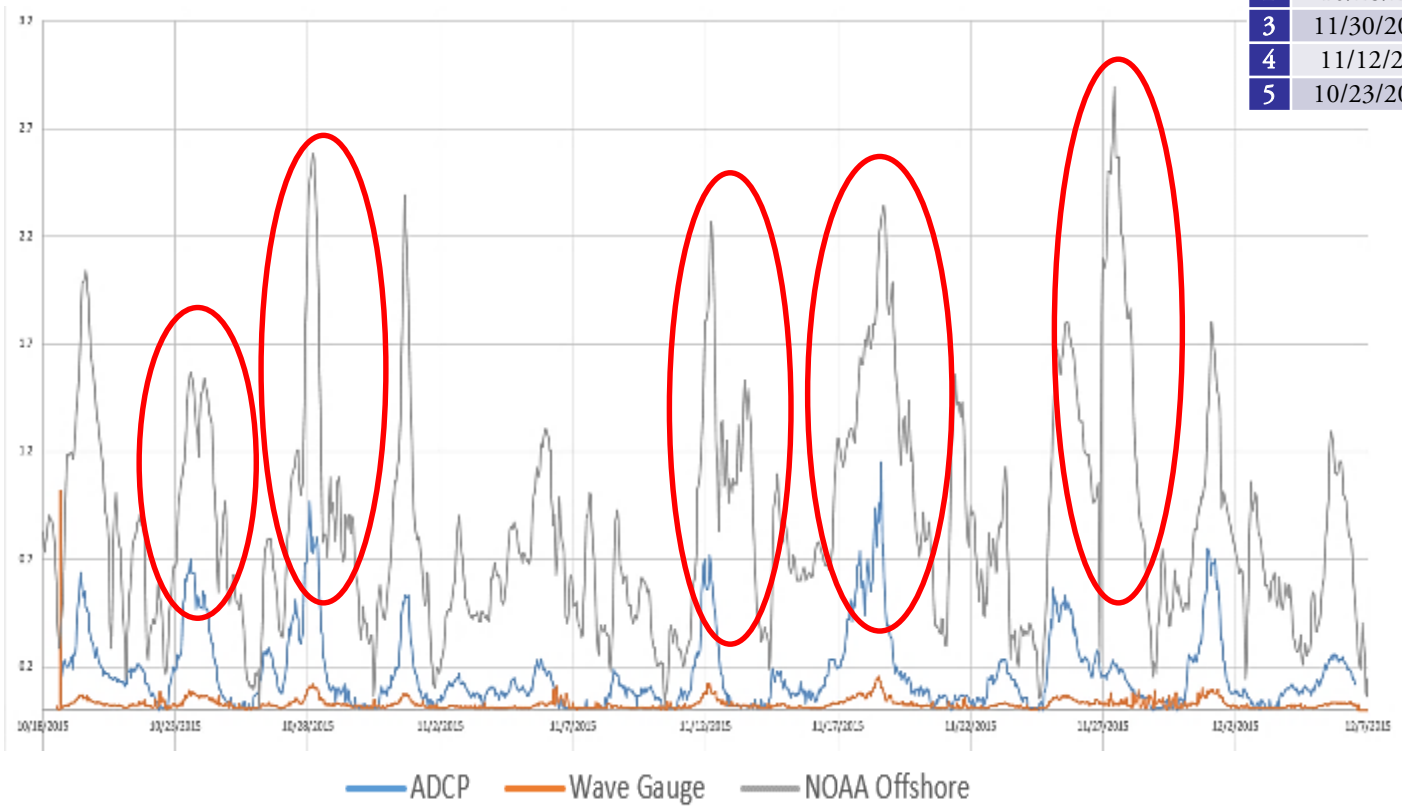


Existing Conditions

Instrumentation Deployment

Storms

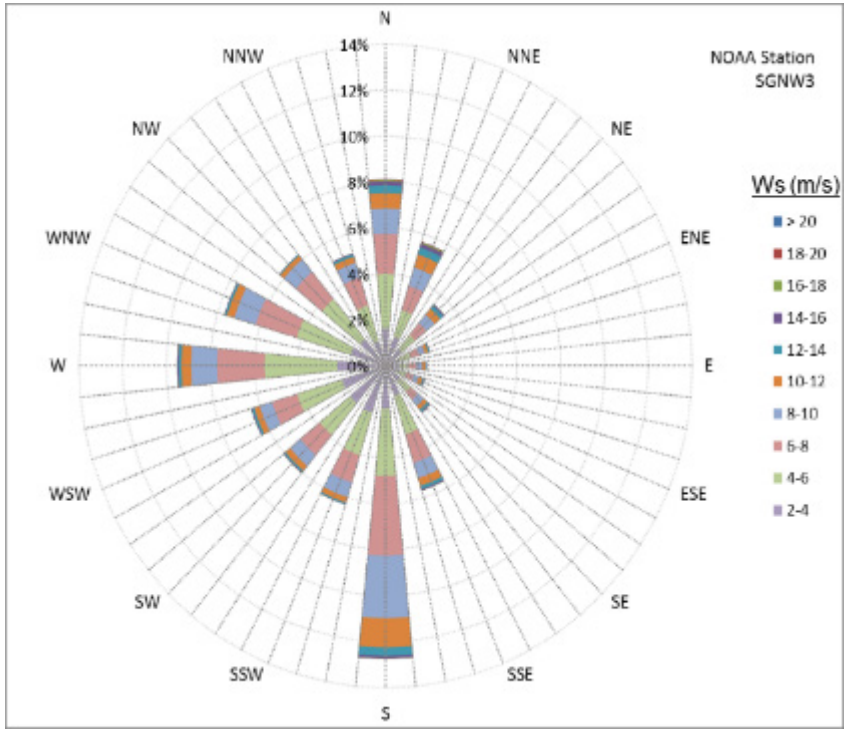
	Date (M/D/Y)	Hs (m)	Tp (s)
1	11/18/2015 15:00	1.15	7.50
2	10/28/2015 2:00	0.97	7.50
3	11/30/2015 23:00	0.75	6.10
4	11/12/2015 4:00	0.72	7.50
5	10/23/2015 14:00	0.70	6.10

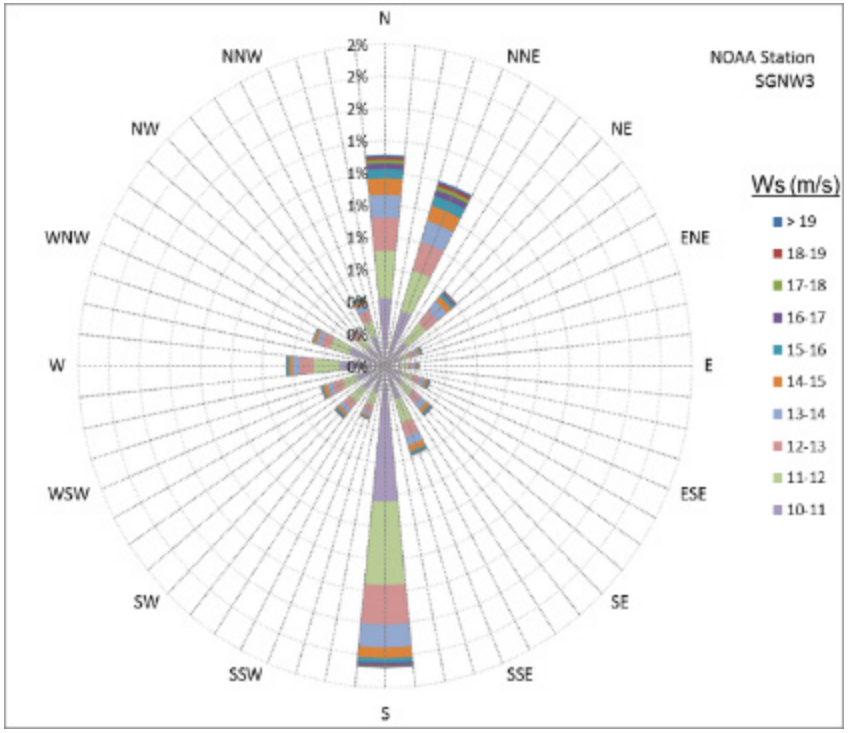


Existing Conditions

Winds

NOAA/National Data Buoy Center – Station SGNW3 (1983-2015)





Existing Conditions

River Discharge

YEAR	Monthly mean in ft3/s (Calculation Period: 1980-01-01 -> 2010-01-31)											
	Period-of-record for statistical calculation restricted by user											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1980	141	84	206	593	171	350	175	301	399	222	172	176
1981	75	473	295	387	121	102	70	125	276	523	265	219
1982	109	110	909	1137	337	185	122	90	94	101	449	505
1983	153	328	917	1246	585	295	93	89	167	202	282	204
1984	116	887	326	540	551	789	188	81	138	446	565	422
1985	280	437	1229	831	157	79	102	124	191	450	1372	297
1986	211	232	1316	558	200	257	174	112	1143	741	226	190
1987	152	147	449	499	242	127	74	169	146	113	233	421
1988	124	329	411	535	143	46	49	68	126	121	460	177
1989	135	91	652	525	365	669	111	83	64	65	90	65
1990	94	85	712	275	372	213	110	179	224	185	228	268
1991	101	263	809	672	175	270	107	69	59	177	330	495
1992	275	147	770	730	180	74	70	44	83	80	336	284
1993	160	105	539	1994	412	685	607	135	187	173	157	132
1994	80	342	804	338	193	77	82	86	55	68	100	104
1995	79	73	333	463	210	81	41	60	43	87	196	101
1996	126	259	415	420	321	927	154	69	47	66	88	112
1997	162	370	754	475	277	628	268	115	78	71	76	75
1998	120	448	732	1115	261	122	70	509	53	79	133	96
1999	248	465	286	629	476	629	483	170	70	100	88	114
2000	115	327	361	324	321	380	207	147	369	125	182	117
2001	182	398	727	944	361	352	77	209	213	209	188	239
2002	136	318	565	592	369	290	124	76	68	105	88	76
2003	55	37	156	211	509	122	77	93	43	61	368	200
2004	114	168	1022	389	1765	1898	294	143	81	88	150	355
2005	521	748	808	432	180	71	56	39	52	42	69	111
2006	236	159	485	378	597	252	73	34	41	123	193	514
2007	215	119	927	525	243	112	60	87	46	73	63	118
2008	472	164	876	1399	224	1794	309	152	89	90	97	149
2009	237	359	993	772	490	237	75	62	49	105	127	249
Mean Dis- charge	179	282	659	664	360	404	150	124	156	170	246	219

Existing Conditions

Ice

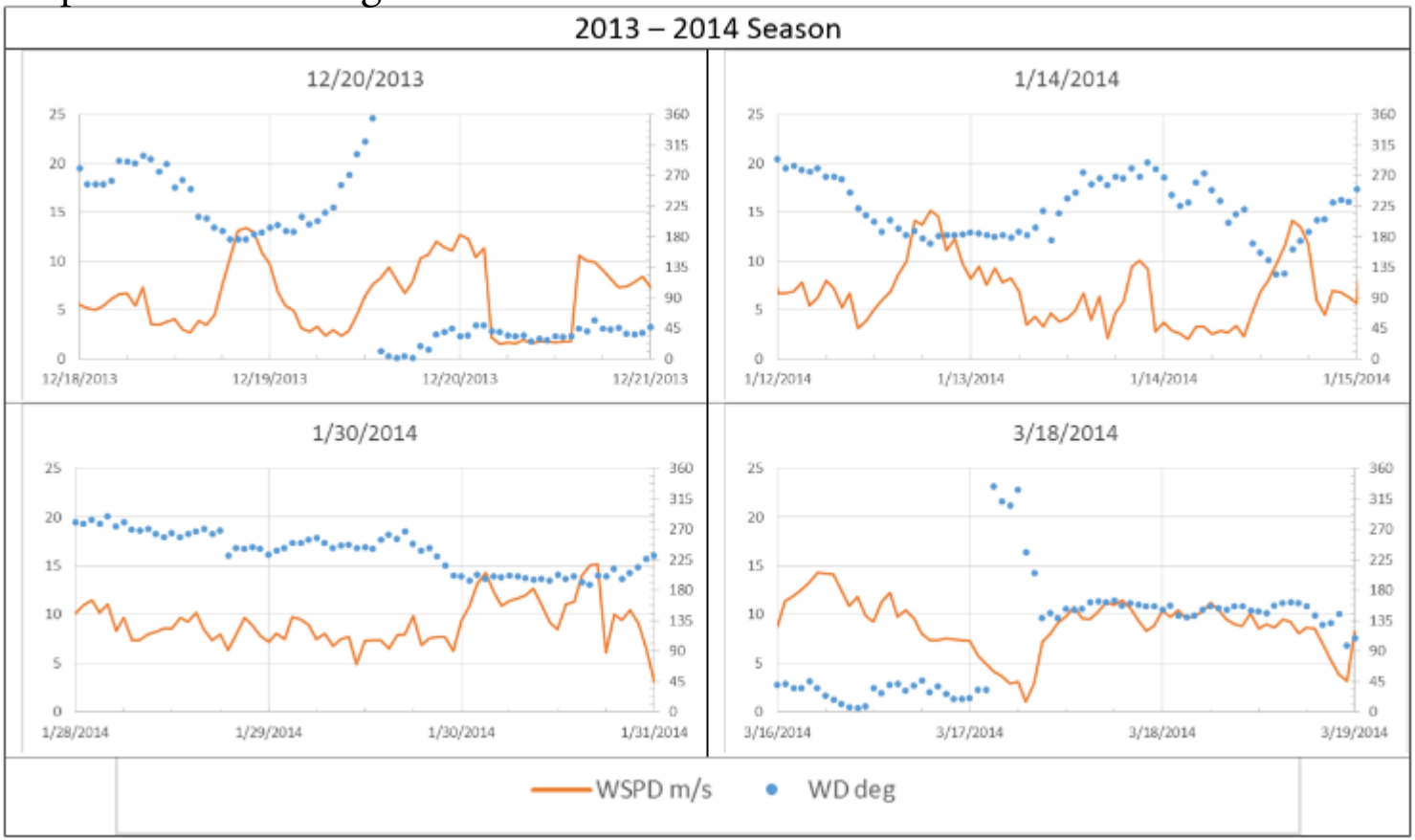
Year	AFDD (F°)	Thickness (in), α = 0.5	Thickness (mm)
2013-2014	1627	20	508
1993-1994	1305	18	457
1985-1986	1269	18	457
2008-2009	1243	18	457
2014-2015	1225	17	432

Year	AFDD (F°)	Thickness (in), α = 0.5	Damage Expenses ($)
2004-2005	773	14	107,097
2005-2006	660	13	3,649
2006-2007	754	14	14,112
2007-2008	1047	16	26,751
2008-2009	1243	18	250,860
2009-2010	704	13	31,350
2010-2011	994	16	14,969
2011-2012	352	9	6,511
2012-2013	709	13	33,793
2013-2014	1627	20	308,901

Existing Conditions

Ice – Damage Analysis

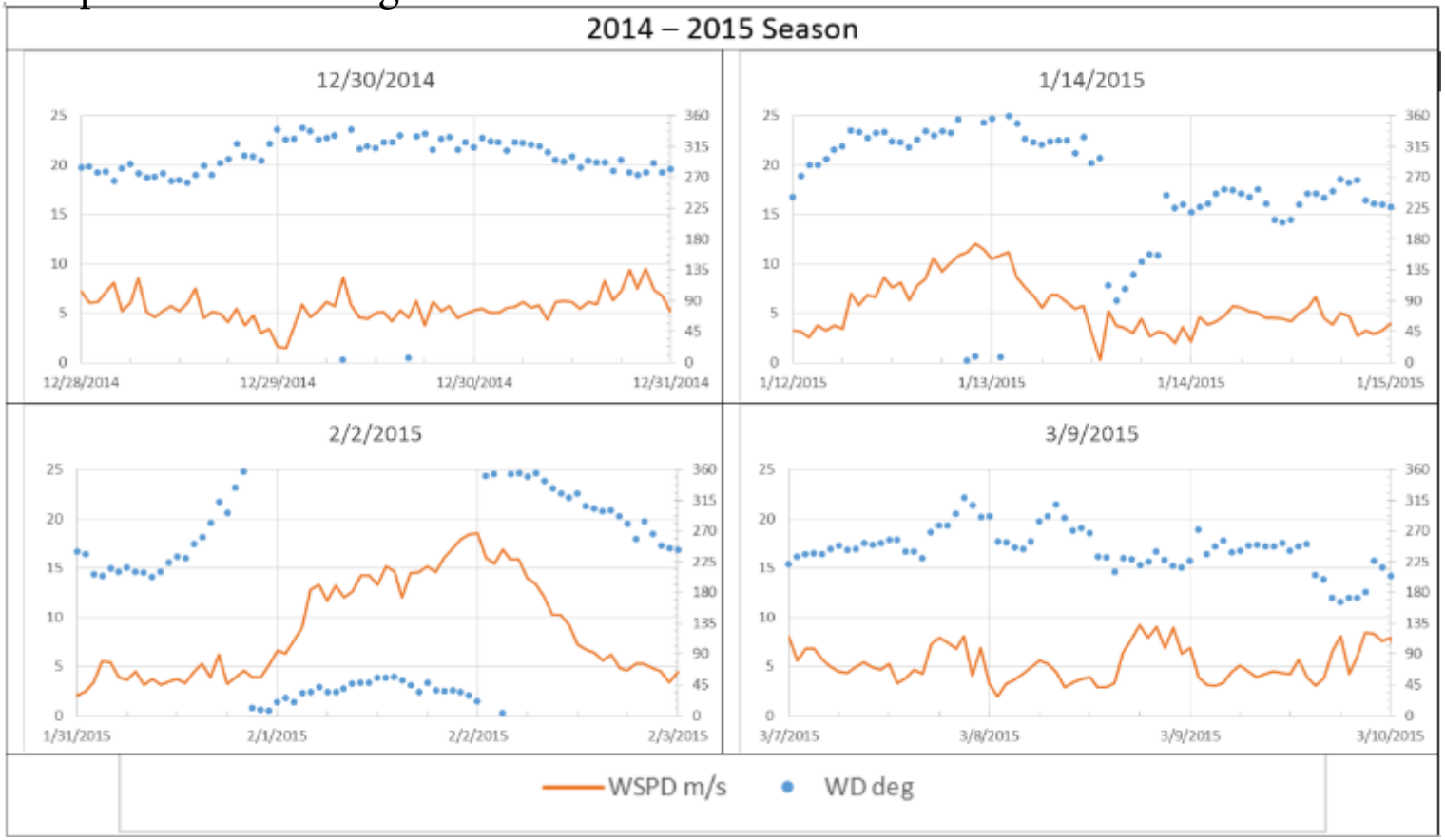
Dates of Reported Ice Damage



Existing Conditions

Ice – Damage Analysis

Dates of Reported Ice Damage



Existing Conditions

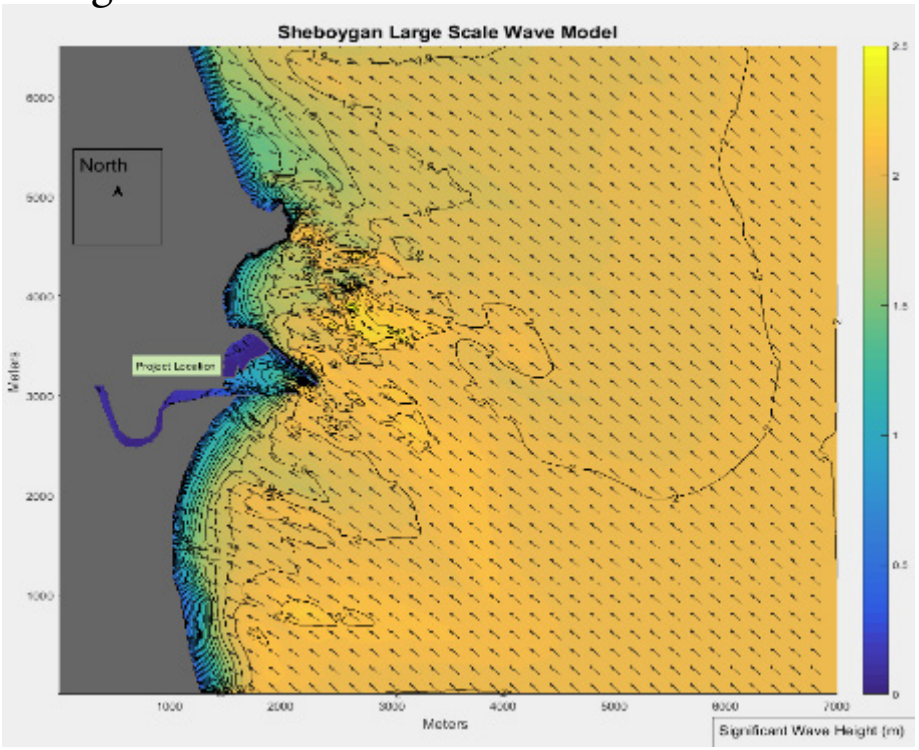
Ice – Damage Analysis

Date of Reported Ice Damage	Primary Wind Quadrant	Peak Wind Speed (m/s) & Quadrant	Calculated Ice Thickness (in)
12/20/2013	NE	12.7 / NE	8.4
1/14/2014	SW	14.2 / SSE	12.6
1/30/2014	SSW	15.2 / SSW	15.3
3/18/2014	SSE	11.2 / SSE	19.9
12/30/2014	NW-NNW	9.5 / W	7.7
1/14/2015	WSW	6.6 / WSW	11.5
2/2/2015	N	18.5 / NNE	12.5
3/9/2015	WSW	8.4 / S	17.3

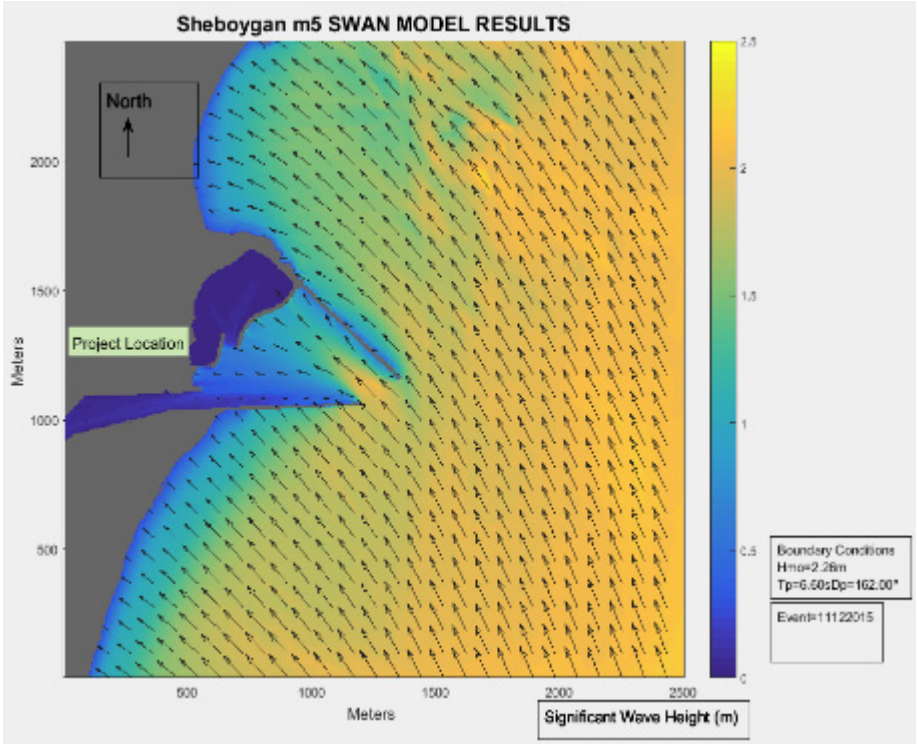
Existing Conditions

Numerical Modeling

Large Scale Model



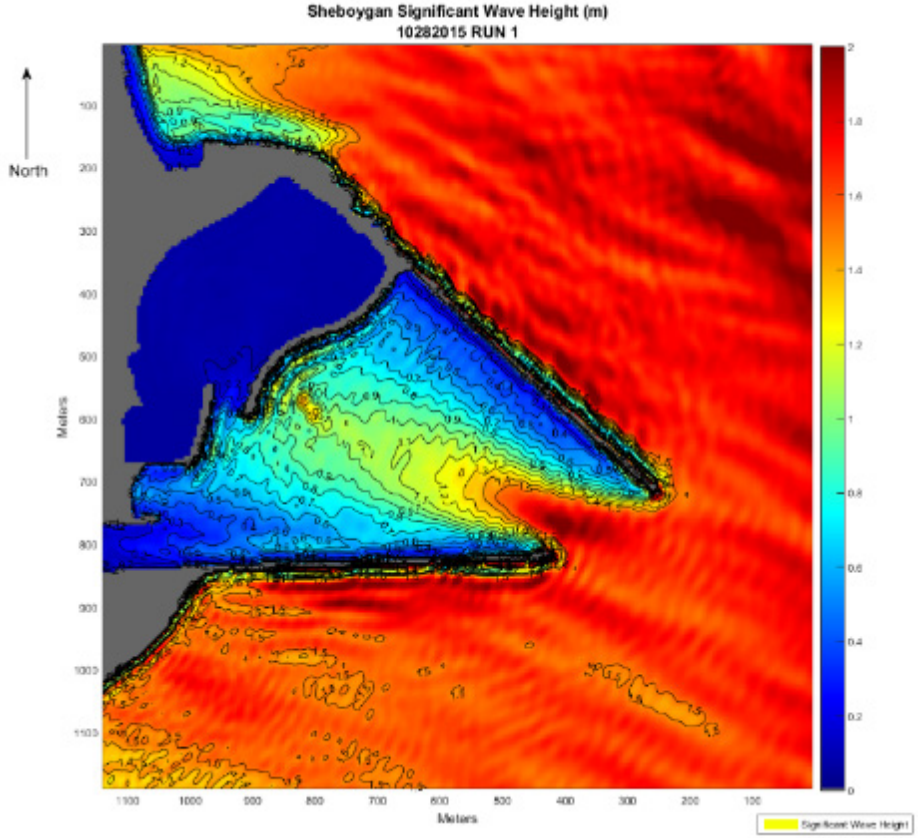
Nearshore Wave Model

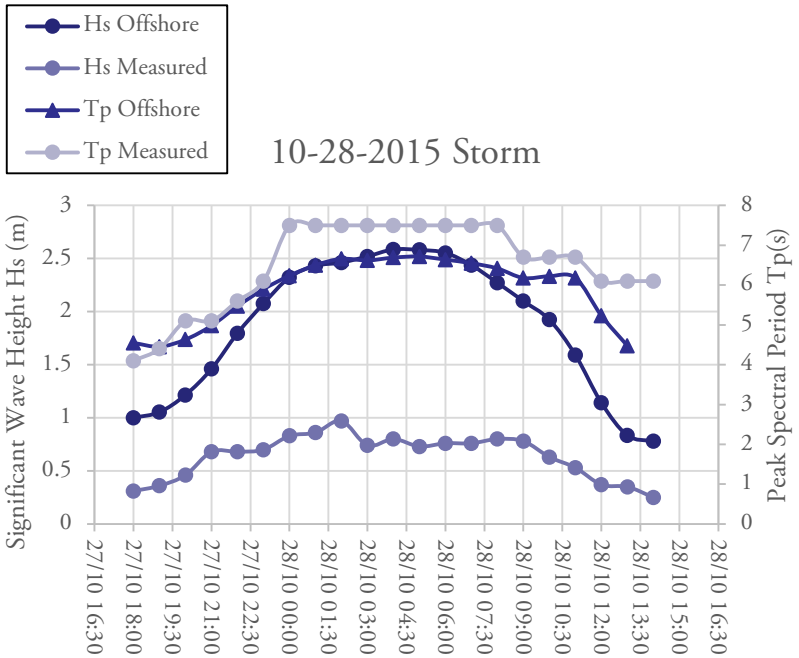


Existing Conditions

Numerical Modeling

Uncalibrated Storm

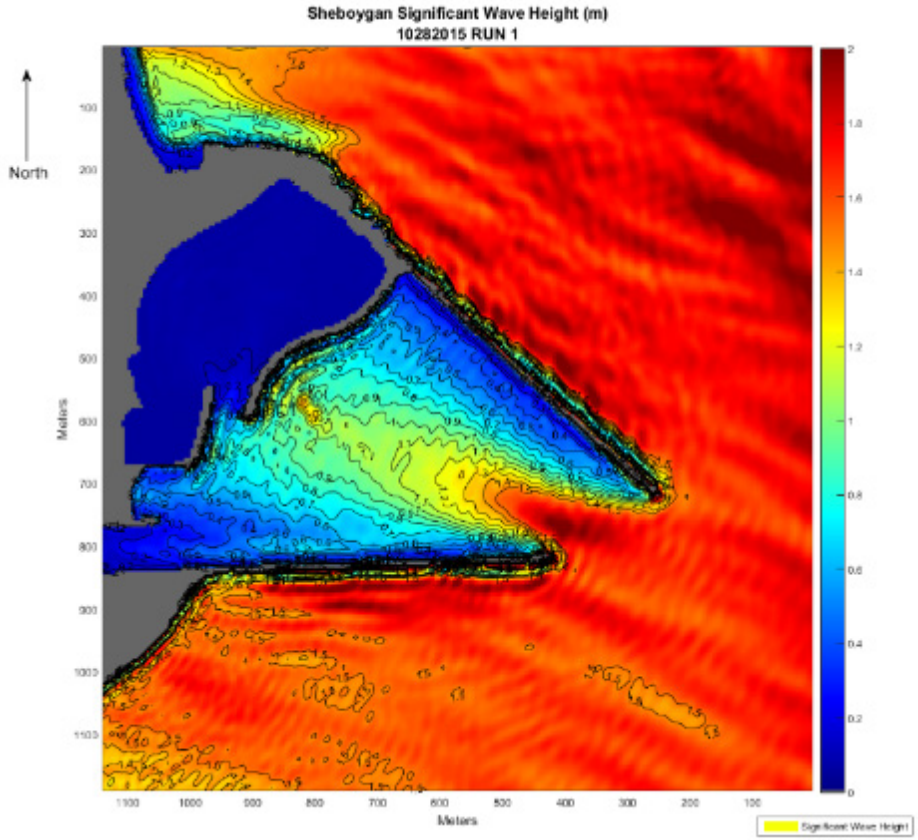




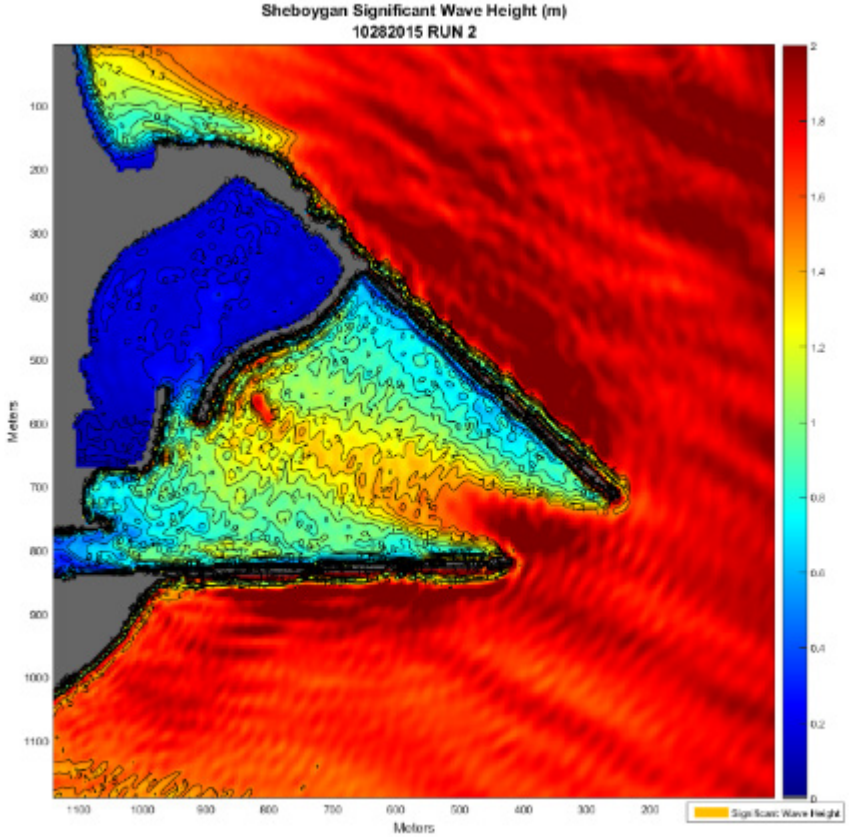
Existing Conditions

Numerical Modeling

Uncalibrated Storm



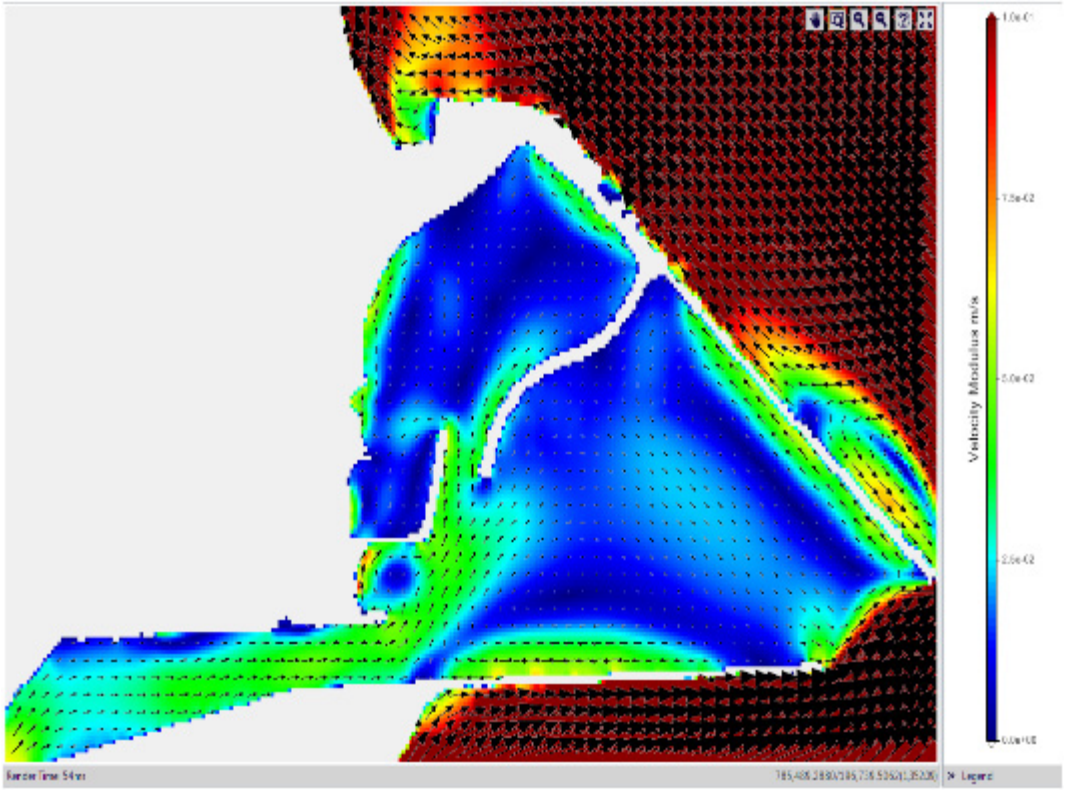
Calibrated Storm



Existing Conditions

Numerical Modeling

River Discharge with SE Wind



Preliminary Concepts

- Main Issues: Agitation, Current Circulation
- Alternatives:
  - A. Construct a bin wall under Pier "E" within the basin to hold the ice in place during the winter.
  - B. Place a gate across the marina entrance over the winter months to restrict flow and movement.
  - C. Add a spur just inside the entrance to direct current flow toward the shoreline.
  - D. Open the northeast corner of the basin to allow more flow out of the basin therefore eliminating a gyre.
  - E. Extend the existing bin wall along the main navigation channel to divert river flow away from the marina entrance (possibly hard to permit due to navigation channel line)
  - F. Deploy an ice boom during the winter months to hold ice in place.
  - G. Move all dockage to one side of the basin and secure. Protect from moving ice.
  - H. Replace current dockage with new dockage more suitable to ice conditions.
  - I. Replace cross chain and anchor bracing.
  - J. Potentially relocate entrance to Northeast corner.
  - K. De-Icer– Aerators
  - L. Public Design – "U" Shape Breakwater Extension
  - M. Public Design – "J" Shape Breakwater Extension

Preliminary Concepts

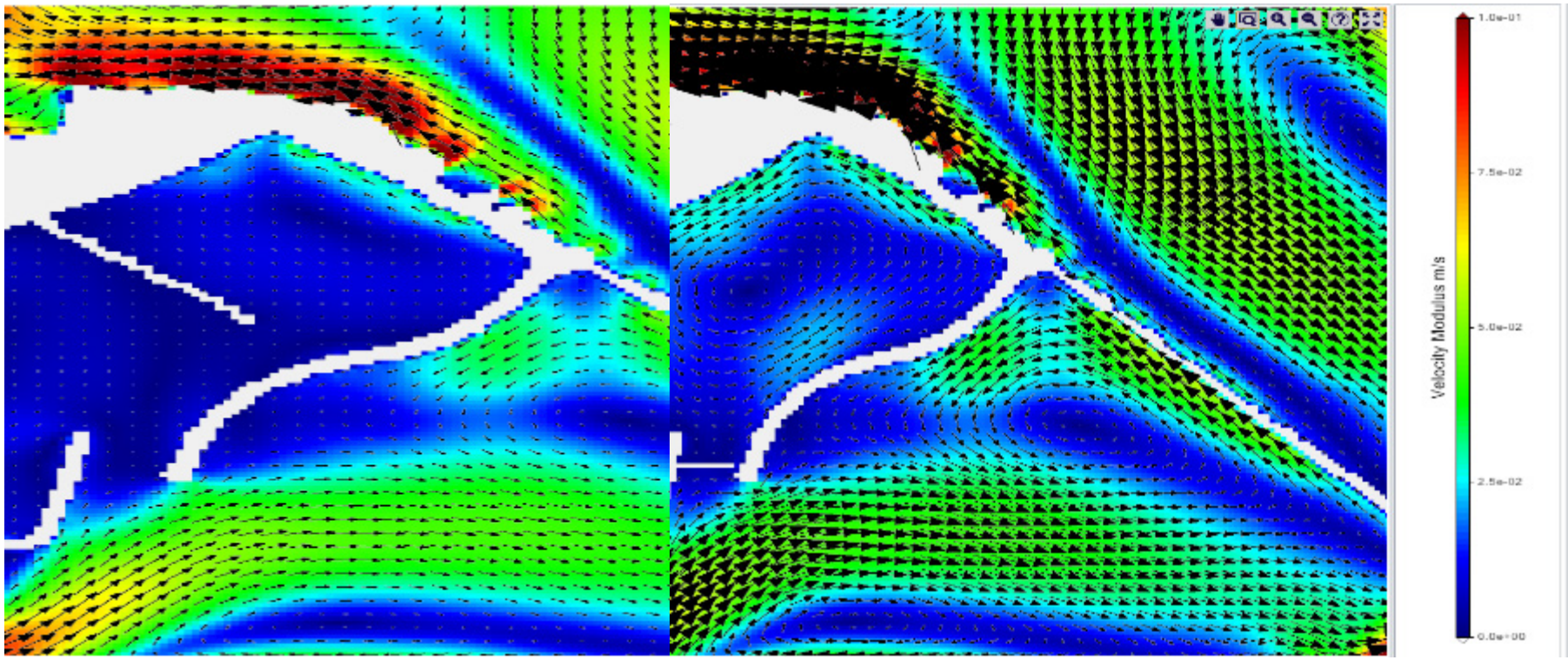
- Main Issues: Agitation, Current Circulation
- Alternatives:
  - A. Construct a bin wall under Pier "E" within the basin to hold the ice in place during the winter.
  - B. Place a gate across the marina entrance over the winter months to restrict flow and movement. - Permitting
  - C. Add a spur just inside the entrance to direct current flow toward the shoreline.
  - D. Open the northeast corner of the basin to allow more flow out of the basin therefore eliminating a gyre.
  - E. Extend the existing bin wall along the main navigation channel to divert river flow away from the marina entrance (possibly hard to permit due to navigation channel line) – Redefine Navigation Channel, Extensive Permitting
  - F. Deploy an ice boom during the winter months to hold ice in place. - Attempted in Past without Results.
  - G. Move all dockage to one side of the basin and secure. Protect from moving ice. – No Guarantee
  - H. Replace current dockage with new dockage more suitable to ice conditions. – Expensive, No Guarantee
  - I. Replace cross chain and anchor bracing. - Recommended
  - J. Potentially relocate entrance to Northeast corner.
  - K. De-Icer- Aerators
  - L. Public Design – "U" Shape Breakwater Extension
  - M. Public Design – "J" Shape Breakwater Extension

Preliminary Concepts

Numerical Modeling

Bin Wall

Gate Across Entrance

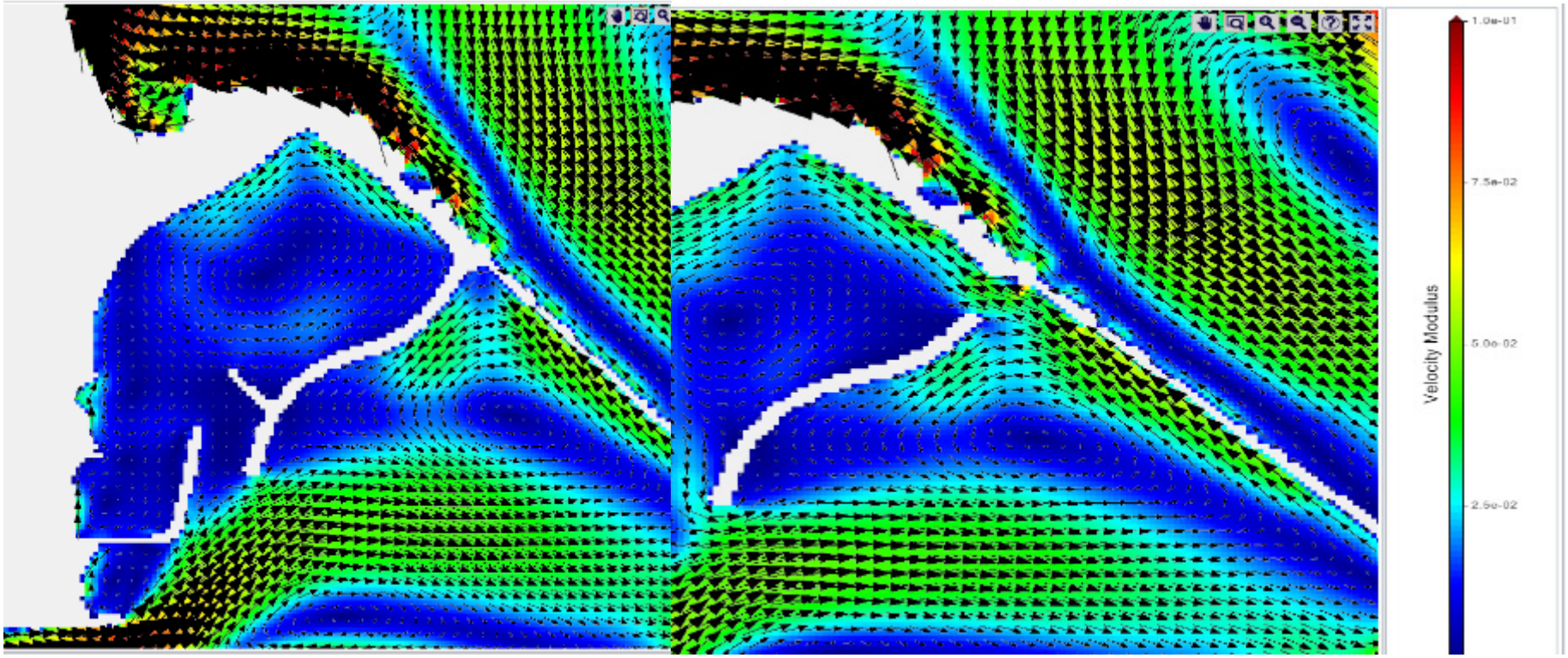


Preliminary Concepts

Numerical Modeling

Entrance Spur

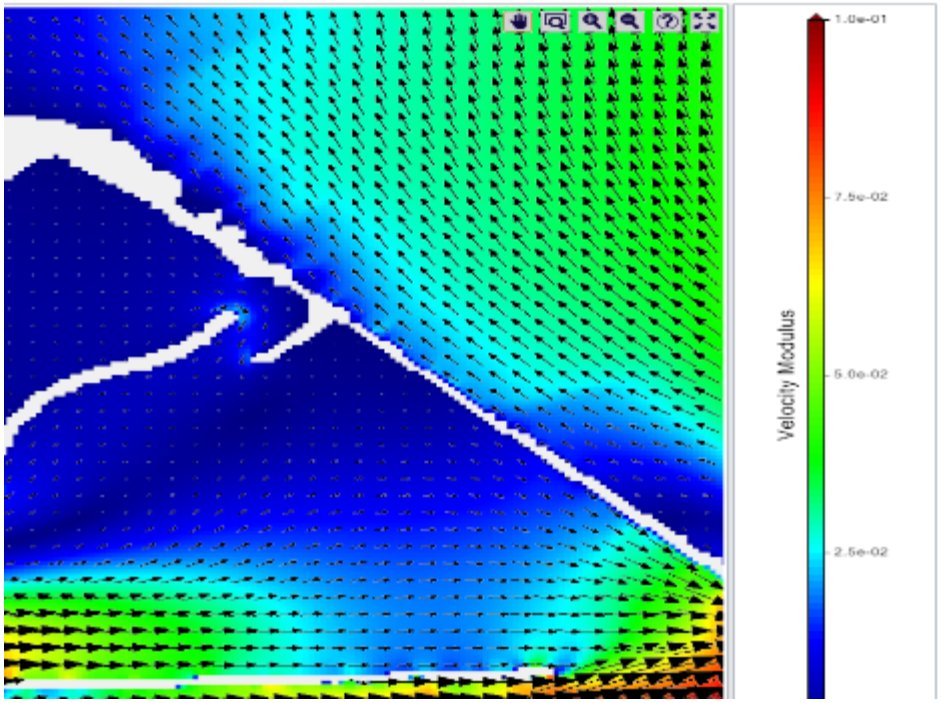
North Opening



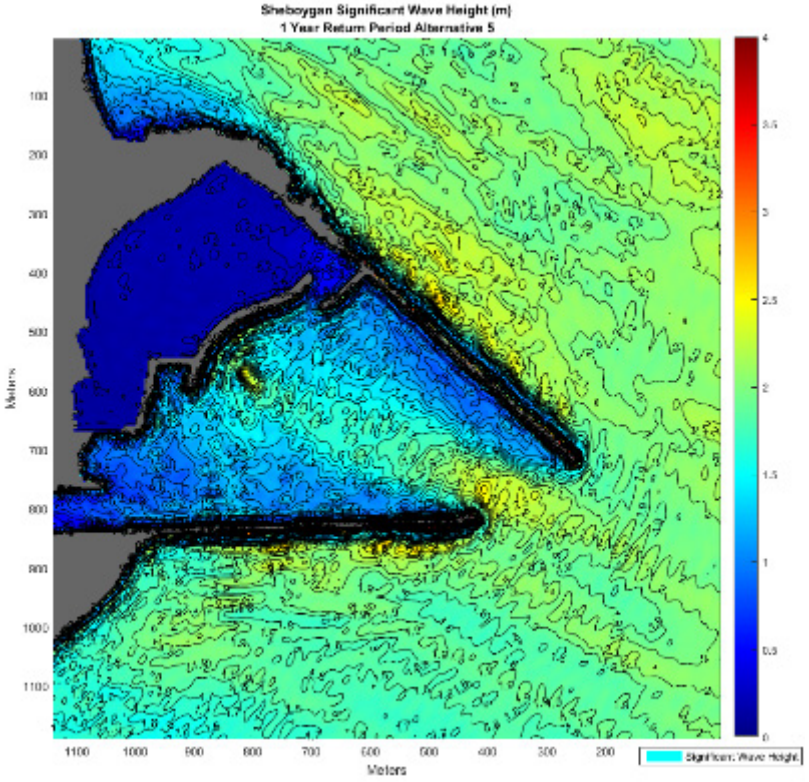
Preliminary Concepts

Numerical Modeling

Northeast Entrance - Currents



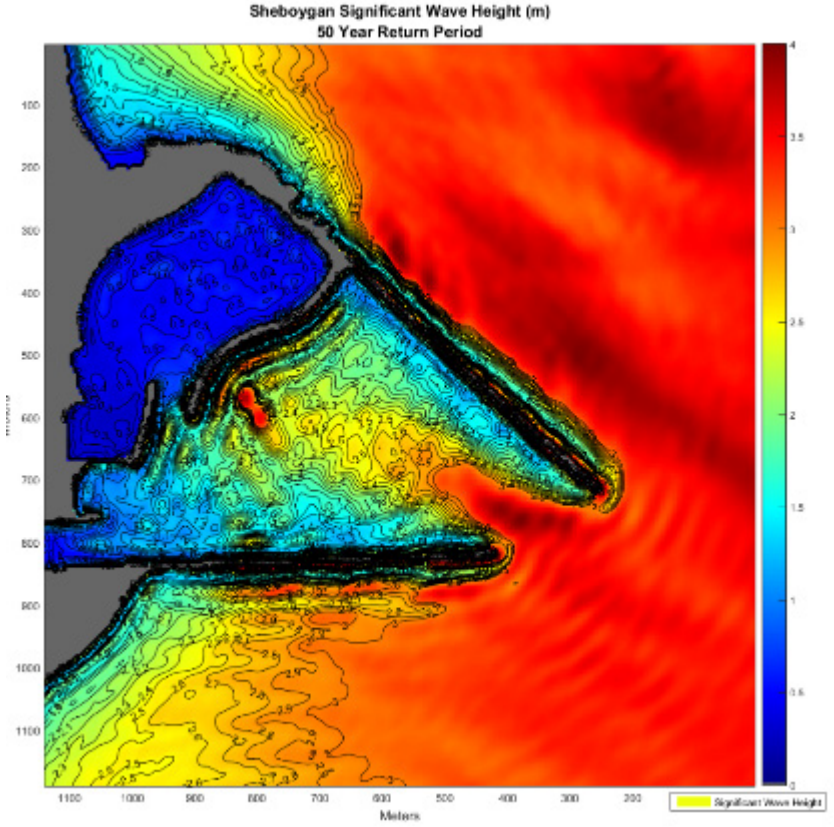
Northeast Entrance - Agitation



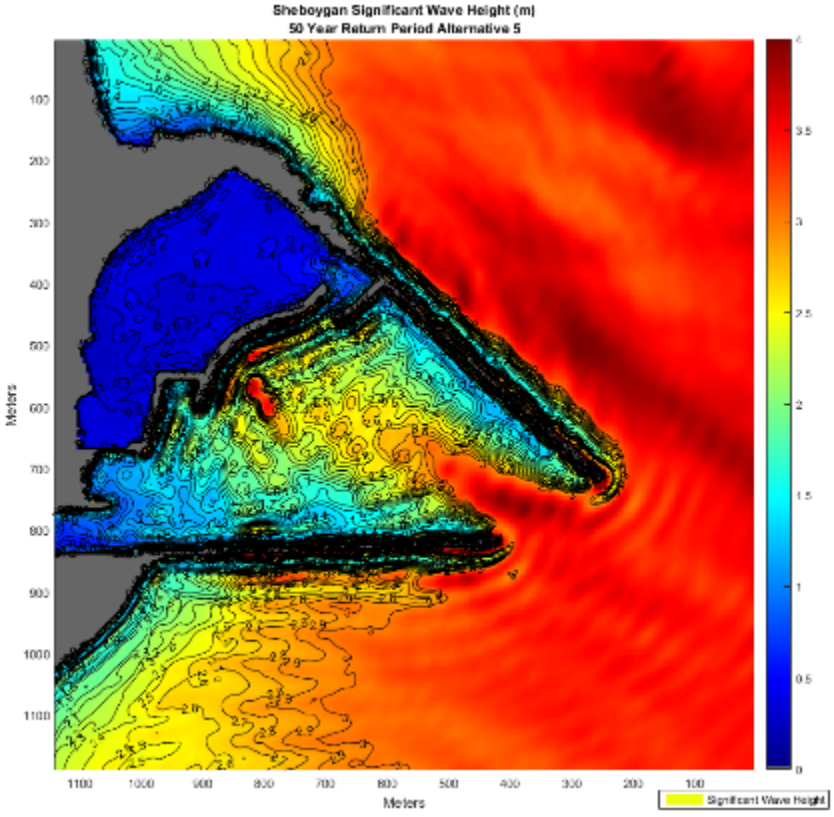
Preliminary Concepts

Numerical Modeling

Existing Entrance - Agitation



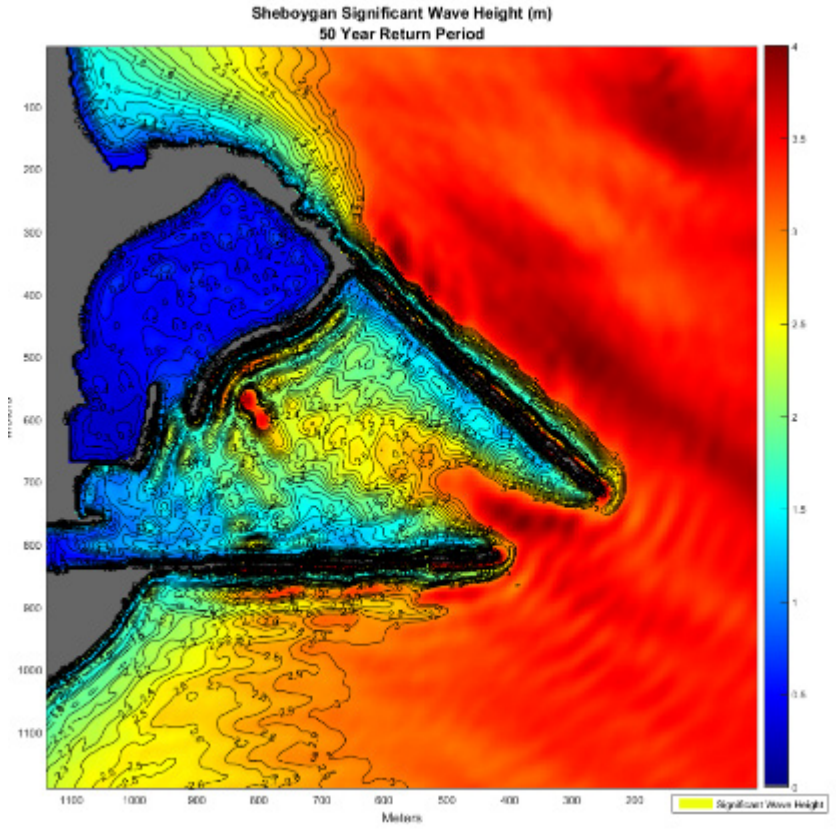
Northeast Entrance - Agitation



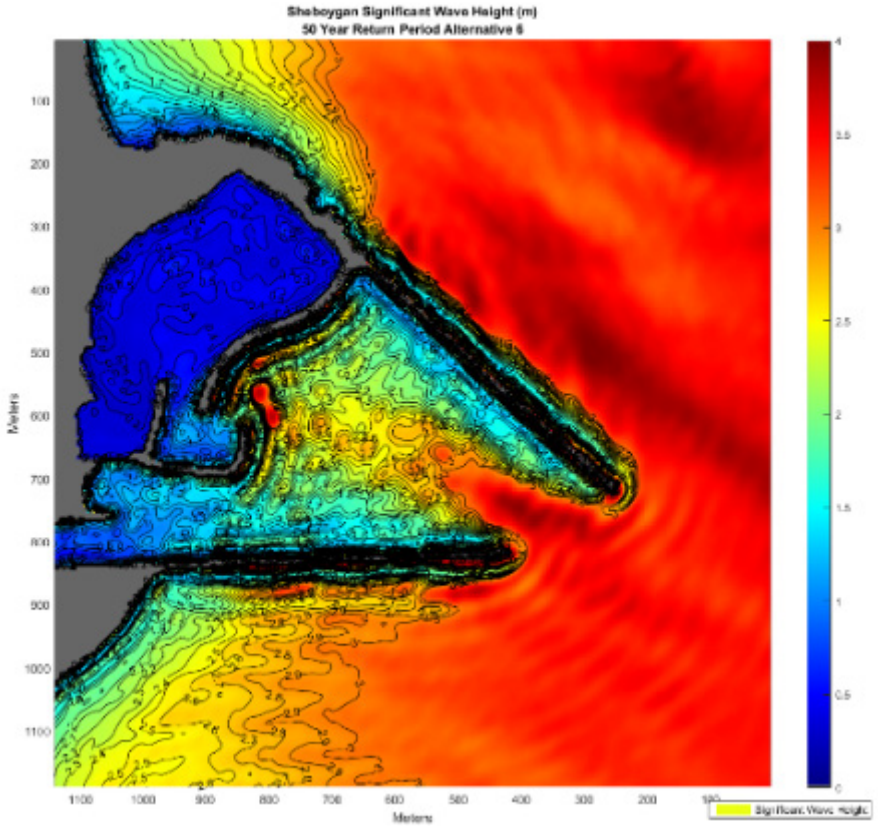
Preliminary Concepts

Numerical Modeling

Existing Entrance - Agitation



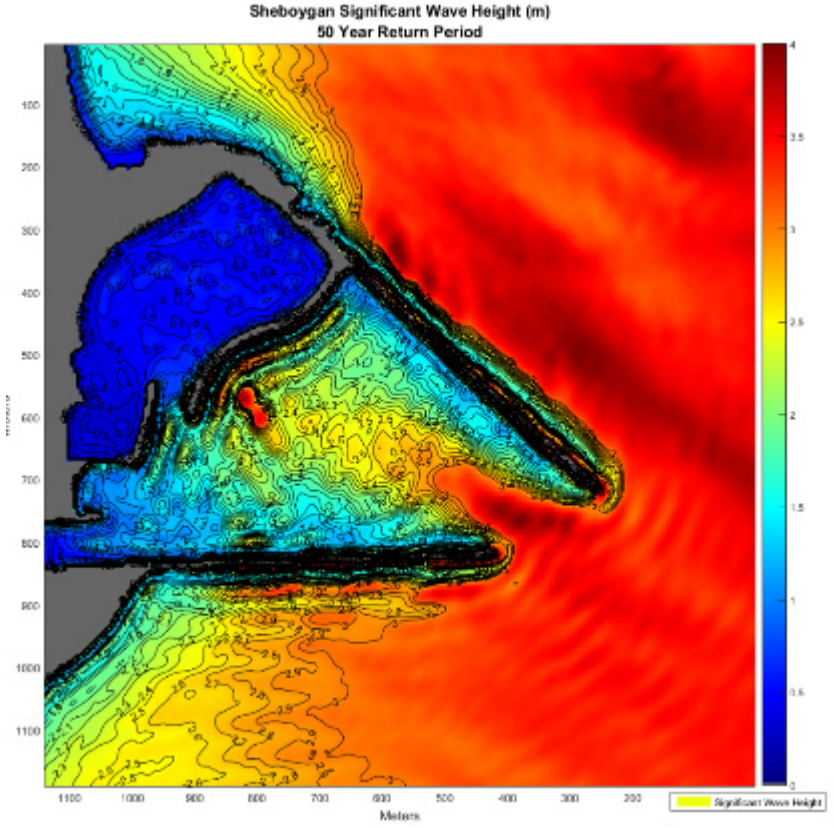
"U" Breakwater Extension- Agitation



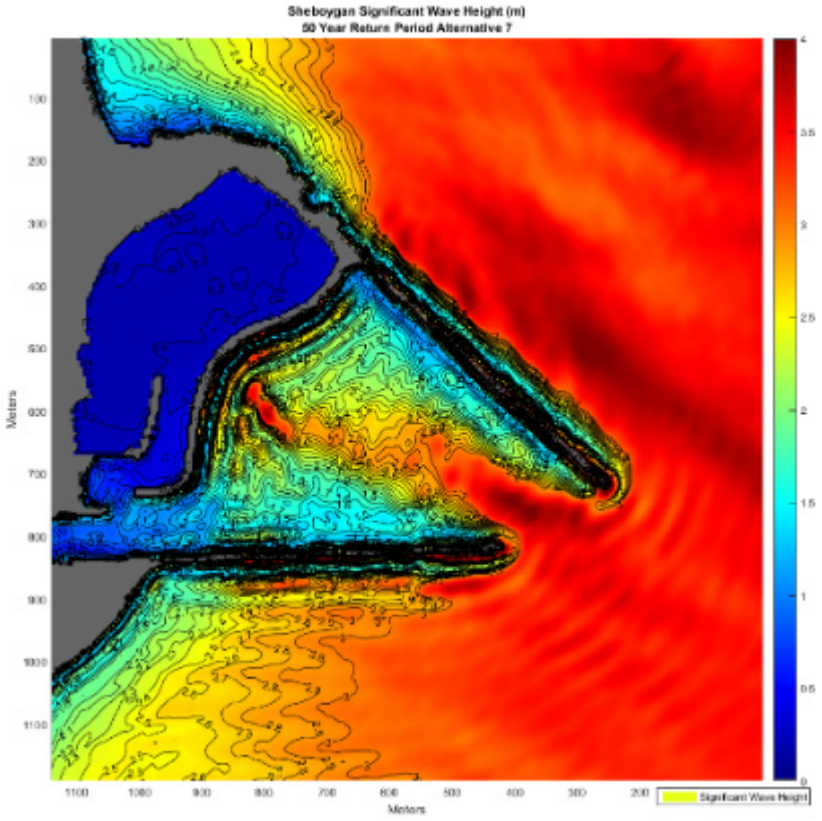
Preliminary Concepts

Numerical Modeling

Existing Entrance - Agitation

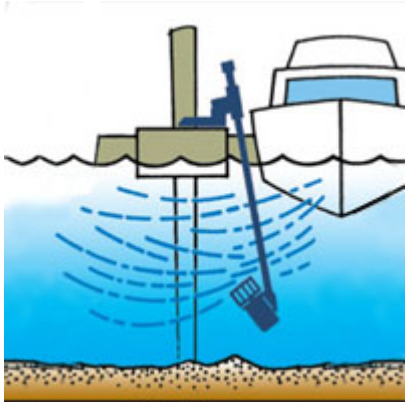


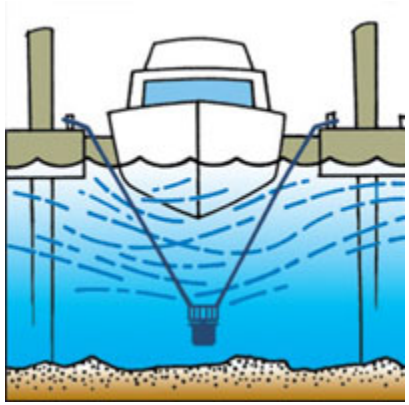
"J" Breakwater Extension- Agitation



Preliminary Concepts

De-Icer- Aerators





Cost Estimate

Mitigation Technique	Cost	Notes
New Breakwater, per linear foot	$4,000	*assumes 16ft depth
Rehab Breakwater, per linear foot	$2,700	*assumes 16ft depth
De-Icer, Dock Mounts	$46,750	*assumes 50 units

- Equivalent Breakwater to De-Icer Cost:
  - New Breakwater = 11.6 ft
  - Rehab Breakwater = 17.3 ft

- Kasco Marine recommends only 28 units for the basin. Cost: $26,180
- Considerations:
  - Installation/Removal
  - Storing
  - Electricity
  - Replacements