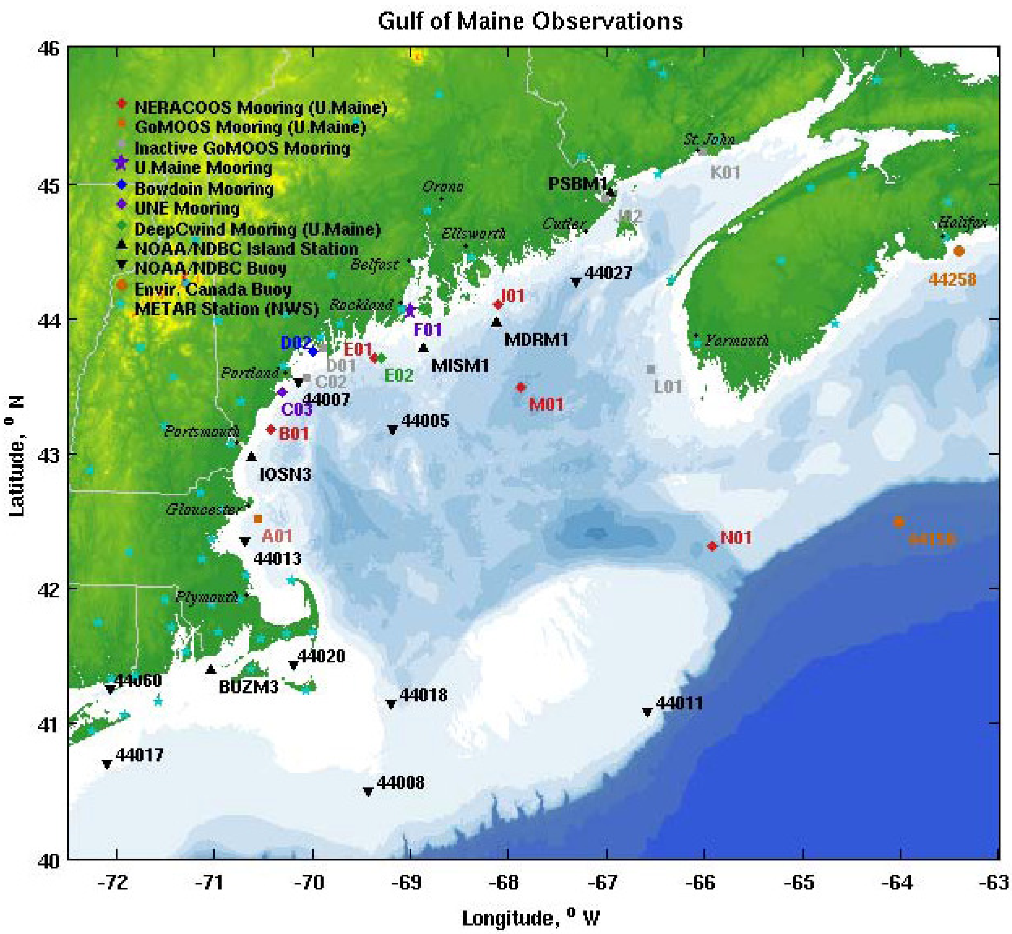
3.0 Gulf of Maine Resource Information

3.1 MET-OCEAN CONDITIONS

This section summarizes the University of Maine's (UMaine's) analysis of met-ocean data gathered for the GoM. Figure 3-1 shows the location of all buoys and other instrumented



sites in the GoM. Table 3-1 lists the sites analyzed as part of this study.

Figure 3-1: Observational buoy network in the Gulf of Maine

Observations in the GoM consist of the Northeastern Regional Association of Coastal Observing Systems (NERACOOS) buoys, Gulf of Maine Ocean Observing System

(GoMOOS) buoys, UMaine, Bowdoin, and University of New England (UNE) buoys, NOAA buoys and NOAA CMAN (land) stations, and Environment Canada buoys. Active NERACOOS and GoMOOS buoys are A01 (Massachusetts Bay), B01 (Western Maine Shelf), E01 (Central Maine Shelf), I01 (Eastern Maine Shelf), M01 (Jordan Basin), and N01 (Northeast Channel). Stations E02 and F01 are the UMaine DeepCwind and UMaine Penobscot Bay moorings. Bowdoin and UNE's moorings are respectively D02 (Lower Harpswell Sound) and C03 (East Saco Bay). NOAA buoys are given designated numbers as follows: 44005 (Gulf of Maine), 44007 (Portland), 44008 (Nantucket), 44011 (Georges Bank), 44013 (Boston), 44017
(Montauk Pt), 44018 (Cape Cod), 44020 (Nantucket Sound), and 44027 (Jonesport). NOAA CMAN (land) stations are given designated lettered names as follows: BUZM3 (Buzzards Bay), IOSN3 (Isle of Shoals), MDRM1 (Mt Desert Rock), MISM1 (Matinicus Rock), and PSBM1 (Eastport). In addition, Environment Canada buoys are given designated numbers and are as follows: 44258 (Halifax Harbor) and 44150 (LaHave Bank).

Table 3-1: Met-ocean data sites analyzed for the feasibility study

Name	Type	Latitude	Longitude	Location	Water Depth	# Years of Data
E01 Central Maine Shelf	NERACOOS Buoy	43°42.86'N	69°21.35'W	SSE of Port Clyde	100 m	9+
F01 Penobscot Bay	UMaine Buoy	44°3.25'N	68°59.87'W	Penobscot Bay	110 m	9+
44005 Gulf of Maine	NOAA Buoy	43°11.37'N	69°8.38'W	78NM East Of Portsmouth, NH	201 m	31+
44007 Portland	NOAA Buoy	43°31.88'N	70°8.65'W	12 NM Southeast of Portland, ME	24 m	27+
MISM1 Matinicus Rock	NOAA CMAN Station	43°47.0'N	68°51.3'W	Matinicus Rock, ME	0 m	25+

More information on the UMaine met-ocean buoys, data acquisition specifics, and data downloads is available at http://gyre.umeoce.maine.edu/buoyhome.php.

3.2 WIND DATA

UMaine has estimated the 8-minute average monthly and annual wind speeds at hub height using the data provided from the buoys in Table 3-1. Since the wind speeds were measured at reference heights different from the hub height, the wind speed was extrapolated to a hub height of 65 m using a power law approximation to the wind speed profile. Currently, there is no data available characterizing the surface to hub wind profile at these sites. The extrapolation was calculated using a power exponent of 0.14 as recommended in IEC 61400-3 Section 6.3, and changing this coefficient will have an effect on the reported wind speeds.

Please note that the exponent value used is commonly used for grassy fields (originally from the 'Kansas' experiments of the late 1960s) and may over-estimate wind speeds. Table 3-2 illustrates other power exponents used in calculating wind speeds at elevation as a function of surface roughness.

Table 3-2: Surface roughness lengths (z_0) and the wind shear exponent (α) (after Manwell et al. 2002; Gipe, 2004; Wizelius, 2007)

Terrain	Surface Roughness Length z_0 (m)	Wind Shear Exponent α
Ice, Smooth mud (BN 0)	0.00001	0.07
Snow on flat ground (BN 1)	0.0001	0.09
Calm sea (BN 2)	0.0002	0.09
Blown sea (BN 3)	0.0005	0.10
Coast with onshore winds (BN 4)	0.001	0.11
Rough snow-covered surface (BN 5)	0.002	0.12
Cut grass – "*Average conditions*"	0.007	0.14
Short-grass prairie	0.02	0.16
Crops, tall-grass prairie	0.05	0.19
Hedges	0.085	0.21
Scattered trees and hedges	0.15	0.24
Trees, hedges, a few buildings	0.3	0.29
Suburbs	0.4	0.31
Woodlands	1	0.43

Note: Relative to a reference height of 10 m (33 ft)

Unlike the other data sources, the land based MISM1 data actually reports the two-minute (2-min) average wind speed instead of an eight-minute (8-min) average. This has been corrected to an eight-minute (8-min) wind speed for comparison following guidelines in ISO 19901-1:2005. Table 3-3 shows the estimated eight-minute (8-min) average monthly wind speeds estimated at 65-meter (m) hub height. Note that the land-based measurements were adjusted from the two-minute (2-min) average wind speed using the ISO 19901-1:2005 methodology.

Table 3-3: Estimated 8-minute average monthly wind speed (m/s) (estimated) at 65 m height

Calendar Month	E01 (m/s)	F01 (m/s)	NOAA 44005 (m/s)	NOAA 44007 (m/s)	MISM1 (Land based)	
					2-min. average (m/s)	8-min. average (m/s) (adj. per ISO 19901-1: 2005)
January	11.4	10.0	12.5	10.1	11.6	11.2
February	11.1	9.5	12.1	9.7	11.0	10.6
March	10.3	9.2	11.1	9.1	10.3	9.9
April	8.1	7.5	9.3	7.9	8.9	8.5
May	7.1	6.7	7.5	6.8	7.9	7.6
June	5.9	5.5	7.0	6.2	7.8	7.5
July	5.4	4.7	6.6	5.6	7.1	6.9
August	5.5	4.9	6.9	5.8	7.0	6.7
September	6.7	6.3	7.9	6.8	7.6	7.3
October	9.0	8.4	9.9	8.5	9.5	9.2
November	10.5	9.5	11.0	9.4	10.8	10.4
December	11.9	10.2	12.4	10.2	11.5	11.1
Annual Avg.	**8.6**	**7.7**	**9.5**	**8.0**	**9.3**	**8.9**
Wind Measurement Height (m)	**4 m**	**4 m**	**5 m**	**5 m**	**22.6 m**	

3.3 WAVE DATA

UMaine examined the monthly average maximum significant wave heights and estimated the extreme significant wave heights for different return periods for the selected sites. Table 3-4 shows the calculated average monthly maximum significant wave heights. These values were obtained by taking the maximum significant wave height seen during a given month for each year and then taking the average.

Table 3-4: Average monthly maximum significant wave heights (m)

Month	E01 (m)	F01 (m)	NOAA 44005 (m)	NOAA 44007 (m)
January	4.6	2.6	5.8	4.2
February	5.0	2.7	5.9	4.3
March	4.8	2.4	5.3	4.0
April	4.8	2.5	4.6	3.9
May	3.7	2.1	3.6	2.9
June	2.9	1.6	3.3	2.3
July	2.3	1.3	2.6	1.8
August	2.2	1.2	3.0	2.2
September	2.9	1.6	3.8	2.6
October	5.1	2.7	4.8	3.7
November	5.8	3.1	5.2	4.1
December	5.8	2.9	6.4	4.7
Average	**4.2**	**2.2**	**4.5**	**3.4**

Table 3-5 lists the extreme significant wave heights at the buoys for different return periods. Extreme significant wave heights were estimated following IEC 61400-3 and ISO 19901-1: 2005 using the historical method. IEC 61400-3 states that maximum individual wave heights may be estimated as 1.86 times the extreme significant wave height assuming a Rayleigh distribution of wave heights and a three-hour (3-hr) storm.

Table 3-5: Extreme significant wave heights (m) and return periods (years)

Return Period (years)	E01 (m)	F01 (m)	NOAA 44005 (m)	NOAA 44007 (m)
1	7.1	3.5	7.4	6.0
5	8.3	4.2	8.9	7.3
10	8.8	4.5	9.6	7.9
25	9.5	4.9	10.5	8.7
50	10.0	5.2	11.1	9.3
100	10.5	5.5	11.8	9.9
500	11.6	6.3	13.3	11.3

Figure 3-2 shows the graph and data used to make the predictions of extreme wave heights using a Gumbel distribution for Buoy E01. The analysis for the other sites is included in Section 3.6.

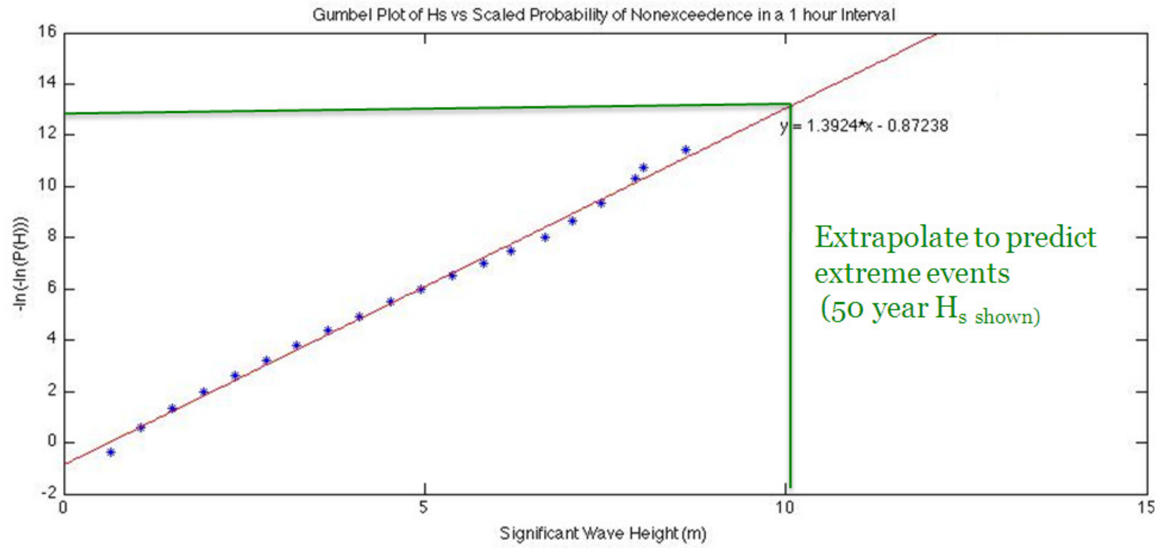


Figure 3-2: Example prediction of extreme significant wave heights (H_s) for Buoy E01 using a Gumbel distribution

3.4 MARINE GROWTH

Anecdotal evidence from the UMaine Physical Oceanography Group (PhOG) and two published studies were found as part of this research on the subject of marine growth. However, the information is not complete for an assessment for marine offshore structures. PhOG provided several pictures illustrating biological fouling of their buoys. Figure 3-3 to Figure 3-6 show some of the fouling and winter icing at the buoys. The general observations from the collection of these figures are as follows:

> *"The spring bloom (very active period of marine growth) usually starts in March or April of each year and then slows down by September/October (growth limited by light, temps, and nutrients). Buoys deployed in the fall and recovered in late winter/early spring typically do not have much growth. However, buoys deployed in the spring and recovered in the fall can have a large amount of fouling (approximately 6" has been seen). The type and amount varies by location and year, depending on currents, nutrients, light, etc."*

Figure 3-3: Buoy E01 summer bio-fouling (September 2006)

Figure 3-4: Buoy E01 summer bio-fouling close-up (September 2006)

Figure 3-5: Buoy E01 winter ice build-up (January 2004)

Figure 3-6: Buoy F01 early spring bio-fouling (April 2008)

UMaine also reviewed available scientific literature on the subject of marine fouling in the GoM. Two studies were found and the locations of the studies are shown in Figure 3-7.

The first study was completed at Pemaquid Point, Maine, in 1989 by Ojeda and Dearborn. The Pemaquid Point study reported that crustaceans, mollusks, and polychaetes were the most prominent, while green sea urchins (*Strongylocentrotus droebachiensis*) and horse mussels (*Modiolus modiolus*) were consistently the most important species in terms of biomass and density. Northern red chitons (*Tonicella rubra*), daisy brittle stars (*Ophiopholis aculeata*), Polychaetes, Northern sea stars (*Asterias vulgaris*), and limpets (*Tectura testudinalis*) were some of the most abundant macroinvertebrate taxa in the area. Various species of barnacles, worms, crustaceans, crabs, mollusks, shrimp, hydroids, bryozoa, and plants, including (*coralline*) algae, and kelp also make up a majority of the permanent marine life population (Ojeda and Dearborn, 1989).

In another study completed at Lamoine, Maine, in 1946 by Fuller et al., quantitative measurements were taken of marine growth on submerged panels. The results of this study for some of the species are summarized in Table 3-6. The thicknesses of the marine growth were not measured. Instead the number of species per square foot was recorded. Copies of the two journal articles referenced above are included in Appendix A.1 (Section 10.1.1).

Table 3-6: Attachment density of three common sedentary marine organisms at Lamoine, Maine, from 2 June – 25 September 1944 (Fuller et al., 1946)

Blue mussels (Mytilus edulis)			Barnacles (Balanus balanoides)			Worms (Spirorbis spirorbis)		
Depth (ft)	Dates	# organisms/ sq. ft/week	Depth (ft)	Dates	# organisms/ sq. ft./week	Depth (ft)	Dates	# organisms/ sq. ft./week
3	6/18 to 7/9	80	3	6/25 to 8/4	340	15	6/2 to 6/18	0.5
3	7/9 to 8/4	20000	15	6/25 to 7/23	500	15	6/18 to 7/9	12
3	8/20 to 9/3	2000	30	7/9 to 8/4	13400	15	7/9 to 8/4	0 – crowded out by Mytilus
3	9/3 to 9/17	130	NA			15	8/4 to 9/3	575

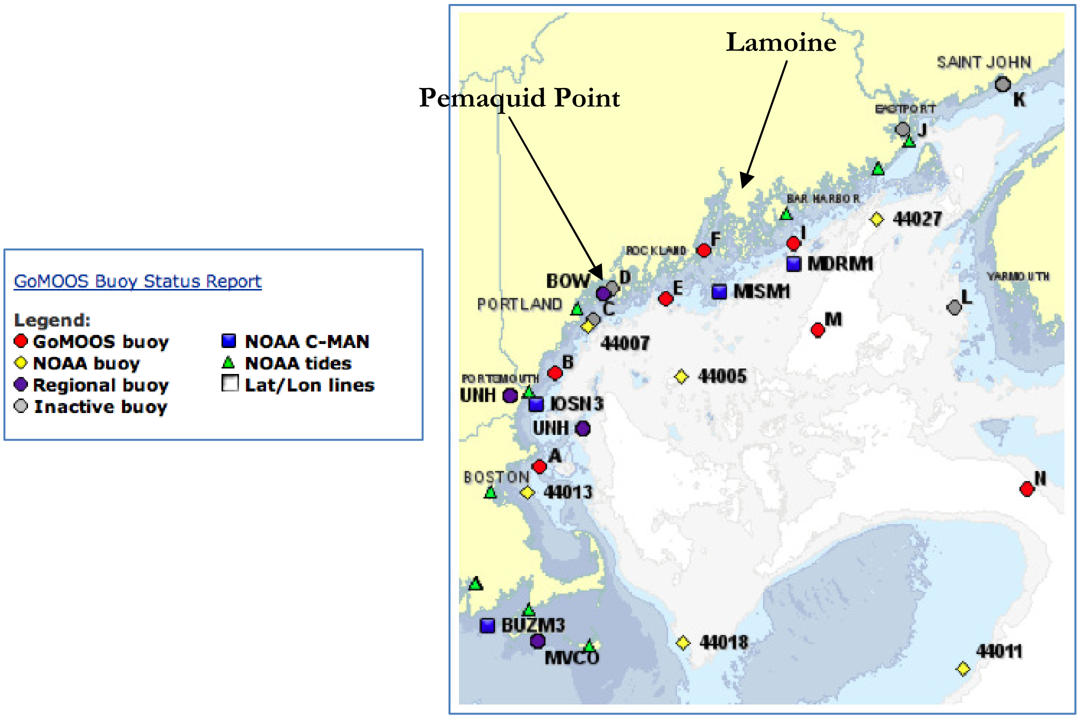


Figure 3-7: Locations of studies of marine growth in the Gulf of Maine

3.5 ICING

The following paragraphs summarize information obtained with regards to icing of marine structures in the GoM. No quantitative data for ice accumulation on offshore structures was found. The majority of the research found is for vessels and thus may predict larger ice thicknesses as compared to a non-moving floating platform.

The American Society of Civil Engineers (ASCE) "Minimum Design Loads for Buildings and Other Structures: ASCE 7-05" publishes design ice thicknesses for the United States. Following Figure 10-2 on p. 104 of this manual for the GoM, the 50-year mean recurrence interval uniform ice thickness due to freezing rain with concurrent 3-second gust speeds is reported as 25.4 mm. ASCE notes, "ice thickness on structures in exposed locations at elevations higher than the surrounding terrain and in valleys and gorges may exceed the mapped values," so the data provided by ASCE may not be completely accurate for our site. ASCE offers an alternative way to determine the 50-year ice thickness and concurrent wind speed, which involves using local meteorological data that is based on the same recurrence interval. This alternative procedure was completed as part of this study.

According to Godshall (1980), the probability of ice accumulating on the exposed, outer layers of ships at sea depends on the "formation of spray" as well as the temperature of the air and sea. The formation of spray is "dependent on direction of ship travel with respect to direction of wave travel and wave height." Godshall considered wind speed (related to wave height), and air and sea-surface temperature in estimating icing potential. Because ice accretion rate is also dependent on the shape of the surface, Godshall's estimates "refer to general icing conditions over a ship." Godshall's map is divided into one-degree squares of latitude and longitude. Table 3-7 reports values for a location near Buoy E01 in the GoM.

Table 3-7: Superstructure icing potential frequency (percent) at 43° – 44° N, 69° – 70° W, (Godshall, 1980)

Month	Light (1-3 cm/24 hr)	Moderate (4-6 cm/24 hr)	Severe (7-14 cm/24 hr)	Very Severe (≥ 15 cm/24 hr)
November	0	0	0	0
December	14.7	0.7	0	0
January	12.9	2.4	0	0
February	14.3	2.1	1.4	0
March	9.1	0	0	0
April	0.8	0	0	0

Note: no icing potential is expected during the other months of the year; all values are percentages.

NOAA researchers developed a general formula to predict vessel icing at near-freezing sea surface temperatures in Alaskan waters (Overland, 1990). The icing rate depends on the following: wind speed (V_a [m/s]), air temperature (T_a [°C]), sea (surface) temperature (T_s [°C]), and freezing point of seawater (T_f [°C]) with a predictor (PR) given as follows:

$$PR = \frac{V_a\left(T_f - T_a\right)}{1 + 0.4\left(T_s - T_f\right)}$$

The icing rate can be determined using Table 3-8.

Table 3-8: Ice accumulation for vessels (Overland et al., 1986)

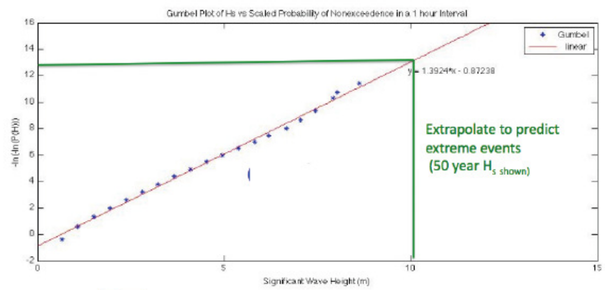
PR (m°C/s)	< 20.6	20.6 < PR < 45.2	PR > 45.2	PR > 70.0
Description	light	moderate	heavy	extreme
Ice Accumulation (cm/hr)	< 0.7	0.7-2.0	>2.0	NA

3.6 EXTREME VALUE ANALYSIS OF WAVE DATA

Extreme wave height predictions for each of the buoy locations are summarized in Table 3-9 to Table 3-12.

Table 3-9: Extreme wave height prediction for Buoy E01

- Per IEC 61400-3/ oil and gas standard ISO 19901-1:2005, extreme events are to be calculated using one of two methods
  - **Historical method (method used here)**
  - Deductive method



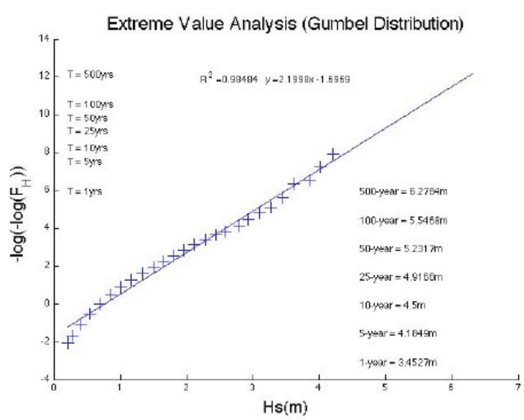
H_{max} =1.86xH_s (m)

"X" year wave	Probability of Non-occurrence in one year	Sig. Wave Height, H_s (m)	Max Individual Wave Height (1.86*H_s) (m)
1	37.0%	7.1	13.2
5	80.0%	8.3	15.4
10	90.0%	8.8	16.4
25	96.0%	9.5	17.7
50	98.0%	10.0	18.6
100	99.0%	10.5	19.5
500	99.8%	11.6	21.6

Compares very well with study by:
Panchang, V.G, Pearce, B.R., and Puri K.K. "Hindcast estimates of extreme wave conditions in the Gulf of Maine". Applied Ocean Research, 1990, Vol. 12, No.1 p. 43.

Table 3-10: Extreme wave height prediction for Buoy F01

- Per IEC 61400-3/ oil and gas standard ISO 19901-1:2005, extreme events are to be calculated using one of two methods
  - **Historical method (method used here)**
  - Deductive method

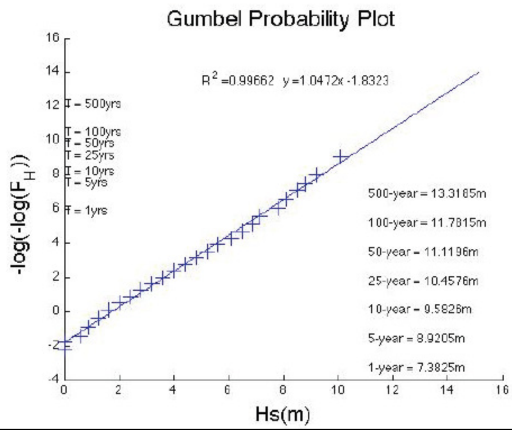


"X" Year Wave	Probability of Occurrence in One Year	Sig. Wave Height, H_s (m)	Max Individual Wave Height (1.86*H_s) (m)
1	37.0%	3.5	6.4
5	80.0%	4.2	7.8
10	90.0%	4.5	8.4
25	96.0%	4.9	9.1
50	98.0%	5.2	9.7
100	99.0%	5.5	10.3
500	99.8%	6.3	11.7

H_{max} =1.86xH_s (m)

Table 3-11: Extreme wave height prediction for NDBC Buoy 44005

- Per IEC 61400-3/ oil and gas standard ISO 19901-1:2005, extreme events are to be calculated using one of two methods
  - **Historical method (method used here)**
  - Deductive method

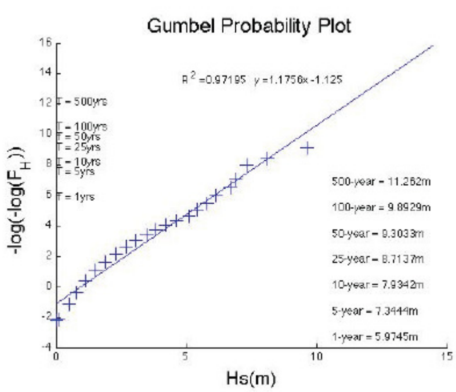


"X" Year Wave	Probability of Occurrence in One Year	Sig. Wave Height, H_s (m)	Max Individual Wave Height ($1.86*H_s$) (m)
1	63.0%	7.4	13.7
5	20.0%	8.9	16.6
10	10.0%	9.6	17.8
25	4.0%	10.5	19.5
50	2.0%	11.1	20.7
100	1.0%	11.8	21.9
500	0.2%	13.3	24.8

$H_{max} = 1.86 x H_s$ (m)

Table 3-12: Extreme wave height prediction for NDBC Buoy 44007

- Per IEC 61400-3/ oil and gas standard ISO 19901-1:2005, extreme events are to be calculated using one of two methods
  - **Historical method (method used here)**
  - Deductive method



"X" Year Wave	Probability of Occurrence in One Year	Sig. Wave Height, H_s (m)	Max Individual Wave Height ($1.86*H_s$) (m)
1	63.0%	6.0	11.1
5	20.0%	7.3	13.7
10	10.0%	7.9	14.8
25	4.0%	8.7	16.2
50	2.0%	9.3	17.3
100	1.0%	9.9	18.4
500	0.2%	11.3	20.9

$H_{max} = 1.86 x H_s$ (m)

3.7 BATHYMETRY DATA

The bathymetry data used for this study includes ocean floor contours of the GoM, supplying essential information regarding the underwater topography and water depths. Bathymetry information for this study was obtained primarily from two sources: (1) Digital bathymetry contours for the GoM provided by the United States Geological Survey (USGS), Coastal and Marine Geology Program (CMGP), as part of their studies of the sea floor geology in the GoM and along the New England Shelf; and (2) a field hydrographic survey of a discrete portion of the GoM completed by James W. Sewall Company (Sewall). Descriptions of both data sources follow.

USGS Digital Bathymetry Contours (GOM15CTR): USGS bathymetry data is based on surveys and soundings from at least eight separate sources, supplying data at various resolutions. The resulting dataset is a compilation by Roworth and Signell (1998) of the highest resolution data available throughout the GoM, blended to produce an accurate representation of sea floor topography measured from consistent vertical and horizontal data. The geographic extents of the data span from south of the Cape Cod area to Nova Scotia in the north. This bathymetry data from USGS is available as layers for Geographic Information System (GIS) software at 30-arcsecond (1 km) and 15-arcsecond (0.5 km) resolutions. The 15-arcsecond resolution data was used as the basis of this study due to its detail.

USGS bathymetry water depths are measured in meters from the mean sea level (MSL) datum. In a positive upward coordinate system, these depths are given as negative numbers from MSL. Depths range from zero (0) meters (m) to 5,200 meters (m). The horizontal datum used is the World Geodetic System 1984 (WGS84). The data is presented in 1-meter vertical bins and is not to be used for navigation purposes.
Figure 3-8 shows the 15-arcsecond grid bathymetry data for the GoM.

Hydrographic Survey: Sewall performed a field hydrographic survey to provide detail of the bathymetry at a critical depth location within Penobscot Bay. The area surveyed is along a shipping lane that has the potential to be used as tow out route for assembling turbine equipment. Available bathymetric data from USGS did not provide sufficient accuracy or resolution to evaluate the current channel depth and changes in channel morphology.

The survey took place on 18 – 19 August 2010 and was performed by Sewall professional surveyors using a contracted vessel and captain. The area surveyed measures approximately 1.75 miles by 1.75 miles and is bounded generally between 43º58'00"N and 44º00'00"N, and 68º58'00"W and 69º00'00"W. The survey vessel was outfitted with a Trimble Pathfinder ProXH GPS receiver and Horizon DS50 digital depth sounder, both linked to a data collector, and measurements were taken each second. The vessel traveled in a methodical fashion, with roughly 200 ft between travel passes (see Figure 3-9). The resulting data was then adjusted for tidal fluctuations using a control survey of a known tidal benchmark (Rockland, Maine #8415490) during the same time as the vessel survey. See Table 3-13 for tidal statistics for the Rockland, Maine benchmark. A vertical datum of Mean Lower Low Water (MLLW) was used and depths are shown in meters. Geographic coordinates were recorded in decimal degrees, and then projected to UTM NAD83 coordinates, measured in meters. Depth measurements are accurate to ± 2%, which based on the depths measured in this survey, translates to accuracy of ± 1.2 to 2 meters (m).

Table 3-13: Tidal statistics for Rockland, Maine (based on NOAA National Ocean Service benchmark tables)

TIDAL STATISTICS	Rockland (8415490)	
	(m)	(ft)
Highest Observed Water Level	4.319	14.17
Mean Higher High Water (MHHW)	3.223	10.57
Mean High Water (MHW)	3.100	10.17
North American Vertical Datum 1988 (NAVD88)	1.751	5.74
Mean Sea Level (MSL)	1.624	5.33
Mean Tide Level (MTL)	1.609	5.28
Mean Low Water (MLW)	0.119	0.39
Mean Lower Low Water (MLLW)	0	0
Lowest Observed Water Level	-0.795	-2.61

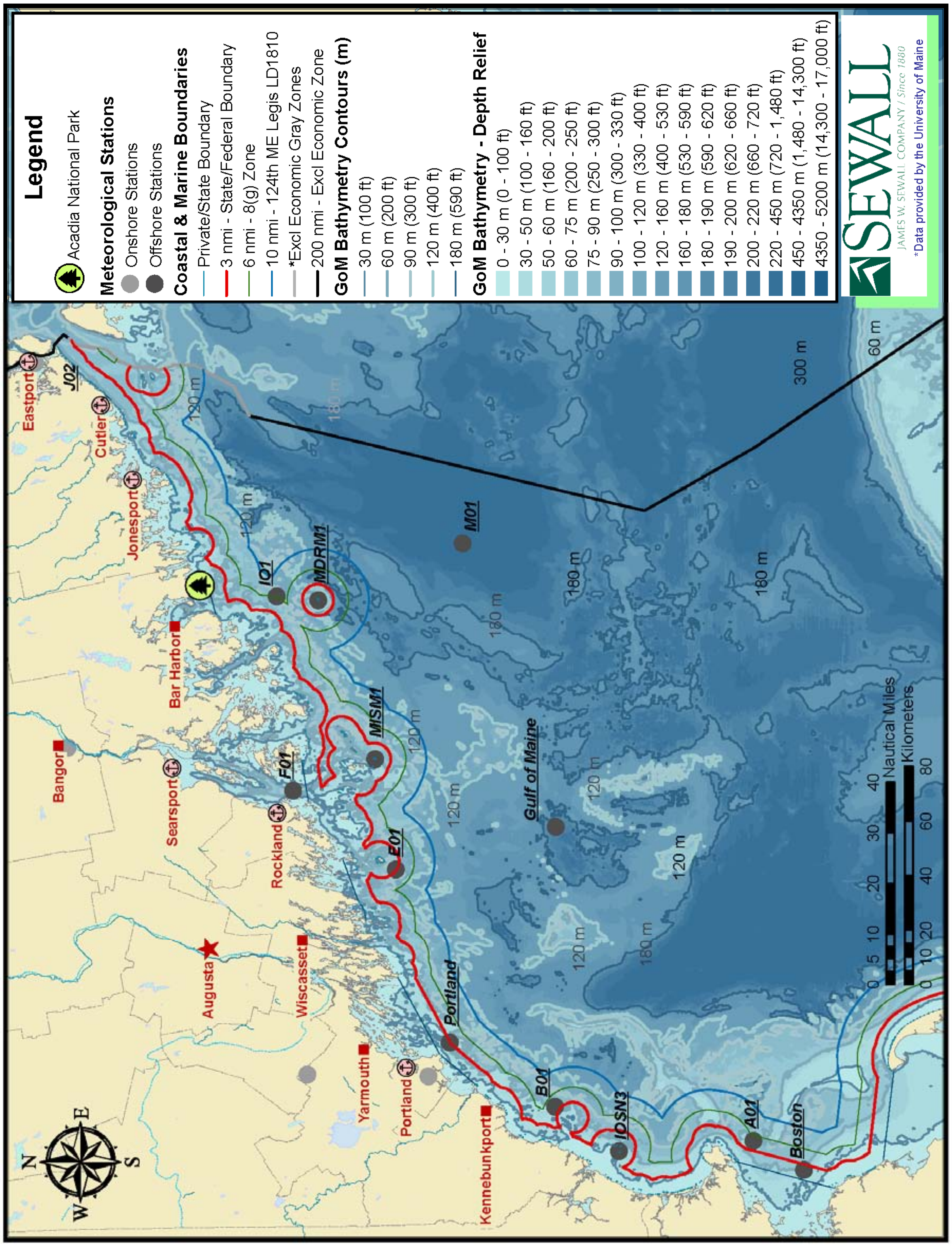


Figure 3-8: Gulf of Maine bathymetry and marine boundaries

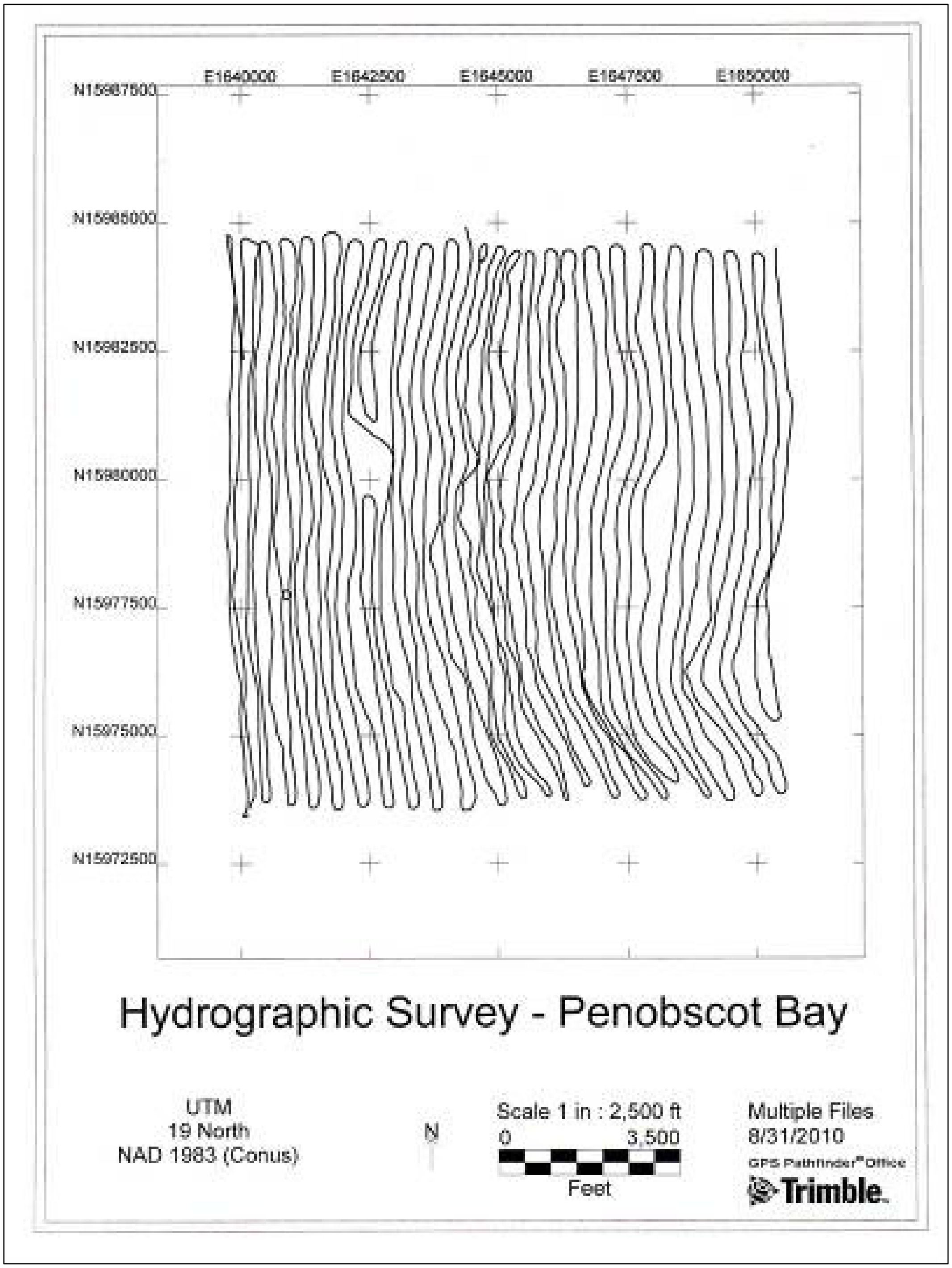


Figure 3-9: Hydrographic survey vessel track (August 2010)

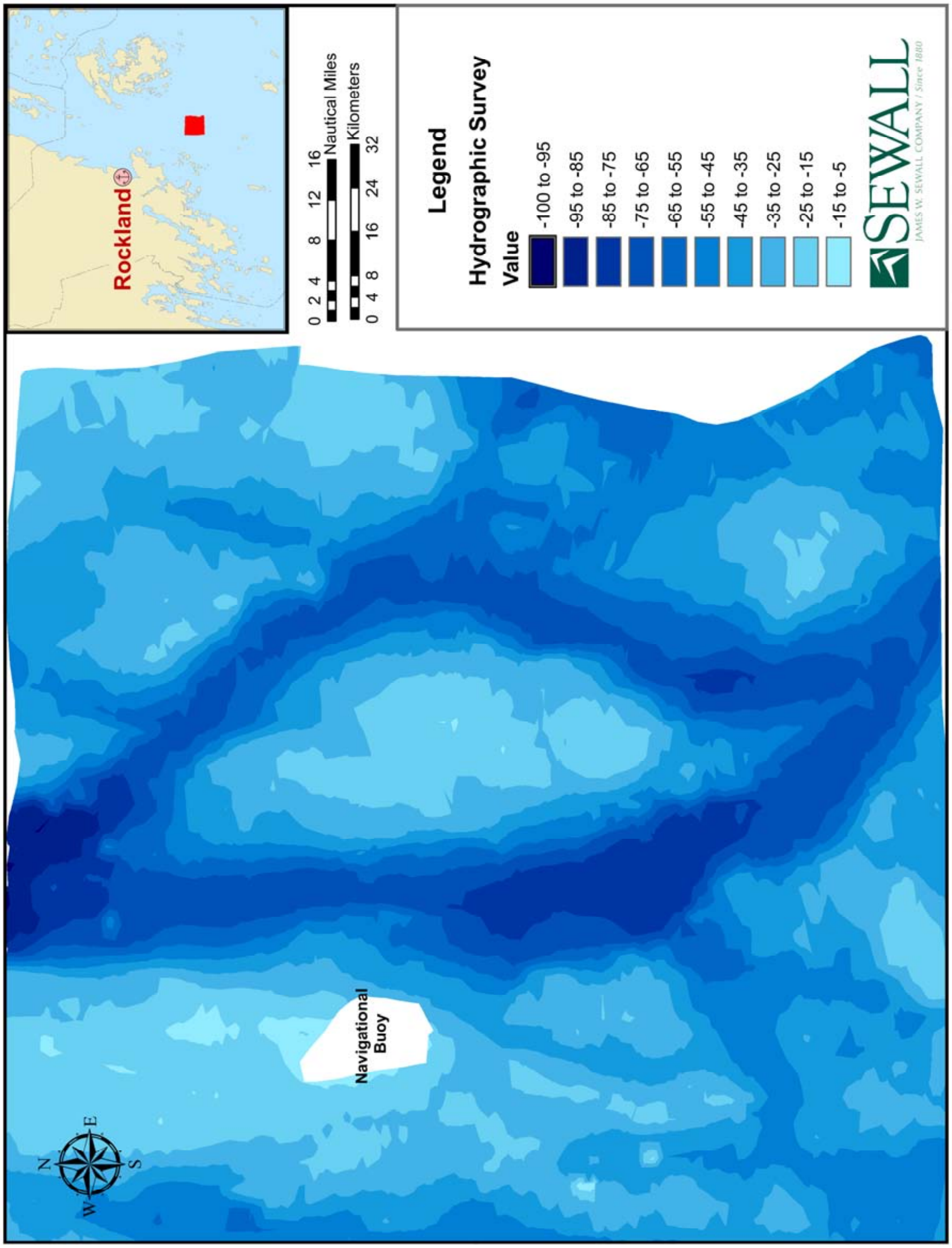


Figure 3-10: Measured depths (m) from August 2010 hydrographic survey

3.8 MARINE GEOLOGY OF THE MAINE INNER CONTINENTAL SHELF

The geology of the Maine inner continental shelf is controlled by three factors:

1) bedrock composition and structure;
2) glacial deposits; and
3) modern processes including changing sea level.

The bedrock consists of many distinct terrains of differing ages, compositions and structures (van Stall et al., 2009). These have undergone differential erosion for hundreds of millions of years so that rocks resistant to erosion (intrusive or "granitic" rocks) remain as islands, peninsulas and shoals, while those rocks more readily eroded underlie bays and deeper basins. As a rule, the topography of the coastal zone is a reasonable guide to what the adjacent seafloor is like (Kelley et al., 1998). Off the central coast, shoals continue seaward of the many peninsulas of the region with deeper basins seaward of estuaries. Shallow, highly irregular seafloor surrounds granitic islands, and paleo-fault zones are often linear bays or basins.

Glaciers sculptured weak rocks and accentuated their topographic/bathymetric expression. They also deposited material over the bedrock. The main glacial deposits include till and fine-grained glacial-marine sediments (i.e., glacial-marine mud). Till is a mixture of many rock types and sizes and occurs as patchy deposits of widely varying thickness (0-30 m) and in elongate moraines that once paralleled the ice margin (Kelley et al., 1998; 2008). Glacial-marine muddy sediment is the most common deposit in the GoM. It is often highly laminated with alternating mud and sand layers and is rock flour that blanketed the landscape seaward of melting glaciers.

Sea level changed profoundly because of deglaciation. As the ice melted back, its weight depressed the land and marine waters accompanied ice retreat and accommodated deposition of the glacial-marine muddy sediment. Once the ice melted, the land rebounded and the shoreline fell to -60 m depth around 12.5 ka (Kelley et al., 2010). Since then, sea level has risen at an irregular rate to the present time.

The changes in sea level allowed sediment deposition from rivers well out onto the present continental shelf (Kelley et al., 2003; Belknap et al., 2005). The passage of the shoreline across glacial deposits also led to their erosion and re-deposition of their sediment as beaches, tidal flats and other deposits. The time/depth interval between 11.5 ka and 7.5ka/ 25 m and 15 m (respectively) was one of very slow sea-level rise and, hence, relatively complete erosion of glacial sediment along with extensive deposition of the reworked sediment (Kelley et al., 2010). Abundant shallow water deposits also accumulated on the shelf at that time/depth and are occasionally associated with early human remains.

The surficial sediment distribution resulting from the complex bedrock and glacial history is very heterogeneous and complex. Kelley et al. (1998) suggested that on the basis of almost 2,000 bottom samples and more than 5,000 km of seismic reflection and side scan sonar profiles a simplified description of the shelf involves only 6 map units defined by bathymetry and surficial sediment. This is illustrated in Figure 3-11 for the inner continental shelf in central Maine.

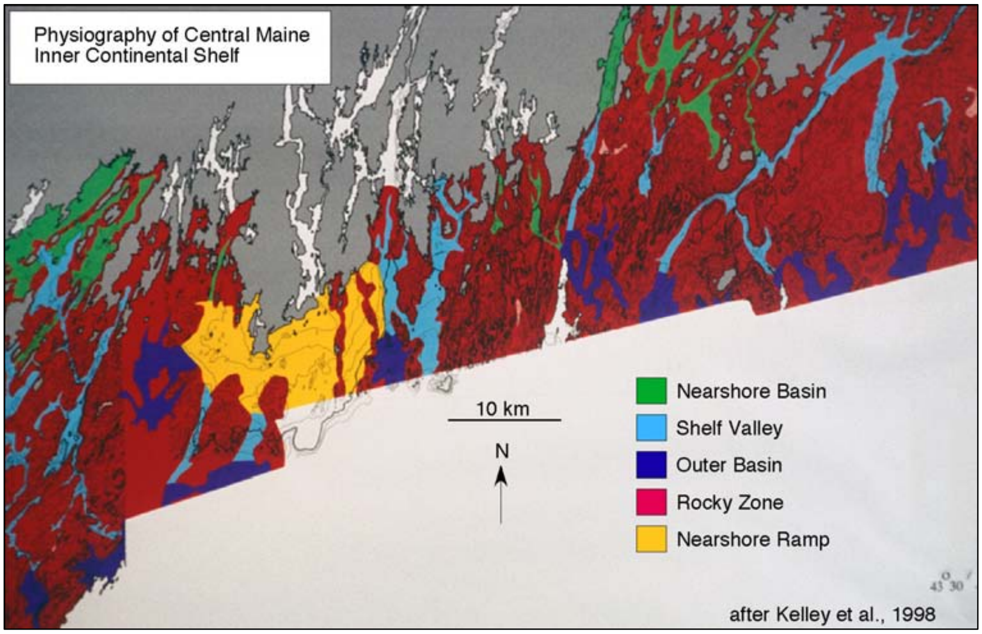


Figure 3-11: Central Maine inner continental shelf physical geology (after Kelley et al., 1998)

1. **Nearshore Ramps** occur seaward of large beaches and often represent the remains of deltas from a time of lower-than-present sea level. The seafloor is composed of well-sorted sand and gravel and bathymetric contours are widely spaced and subparallel to one another. Bedrock occurs randomly through these areas, which are largely in the southern half of Maine. The surficial sand deposit is wedge shaped, commonly thickening to as much as 5 m near land.
2. **Nearshore Basins** are muddy areas seaward of the numerous tidal flats and bluffs of glacial-marine sediment found north of Portland. The seafloor tends to be relatively flat and the mud deposits can be more than 50 m thick. Bedrock crops out within the basins and typically follows the trend of rock ridges on land.
3. **Rocky Zones** are generally shallow areas (< 50 m water depth) underlain by exposed bedrock or coarse-grained glacial deposits (moraines). They comprise almost 50% of the inner shelf and represent locations where younger sediment was eroded as sea level passed over the shelf twice (falling and then rising). They are common seaward of peninsulas and surrounding islands, but occur in all depths of

water. Bathymetric relief in excess of 5 m occurs commonly over short horizontal distances in Rocky Zones. Gravel is the most common sediment type in these areas.

4. **Shelf Valleys** are elongate bathymetric depressions that typically extend seaward from Nearshore Basins into the deeper GoM. Their origin is unclear, but they occur seaward of every embayment in Maine. They are sometimes filled in and only recognized on seismic reflection profiles, but often are steep-sided and possess up to 50 m of relief cut into bedrock in some places. They are commonly floored by sand and gravel.

5. **Outer Basins** occur seaward of the 40-m isobath and are relatively flat regions covered with mud. Many Shelf Valleys terminate in Outer Basins, which may represent the depositional sink of the Valley systems. Rock and gravel can occur in the Outer Basins, but mud is dominant in these quiet, deep water areas that experience little wave activity or erosion.

6. **Hard-Bottom Plains** (not shown in Figure 3-11) are only found in the most eastern part of the inner shelf, but they occur at all water depths. These are bathymetrically flat areas with gravel up to boulder size strewn across the seafloor. Their eroded appearance and occurrence near the opening of the Bay of Fundy suggest that tidal currents eroded and formed the Hard-Bottom Plains.

3.9 MARINE GEOHAZARDS

A geohazard is a geological state related to present or past geological conditions and/or processes that represent, or have the potential to develop, a situation leading to damage or uncontrolled risk (Offshore Geohazards, 2010). Offshore geohazards such as submarine landslides, gas build-up and earthquakes have the potential to impart unnecessary risk to offshore infrastructure if inadequately assessed, mitigated and managed. In the GoM, geologic features having the potential to result in geohazards are related to gassy seafloor sediments and earthquakes.

3.9.1 Seafloor Gas

A systematic side-scan sonar, seismic reflection, and bathymetric geophysical mapping program covering more than 1,900 square miles has identified biogenic natural gas in more than 120 square miles of the western GoM's nearshore, muddy embayments (typically less than 300 ft of water depth) and within the deep basins of the GoM (Rogers et al., 2006; Uchupi and Bolmer, 2008). Gas, where found offshore of Maine, is typically in thickly deposited modern mud and does not occur in quantities economical for energy capture. While the presence of gas is not fully understood, it is most likely the result of decomposing organics that were deposited when sea level was much lower than present.

The presence of gas is not identifiable by imaging the seafloor or bathymetric data, however seismic reflection surveys and an experienced interpreter can identify if it is likely present or not. The one case where evidence of gas at the seafloor occurs is from pockmarks. Pockmarks are massive seafloor depressions associated with fluid (e.g., gas or water) escape (Figure 3-12). Where formed, pockmarks significantly alter the seabed and form fields of numerous (hundreds to thousands) hemispherical depressions that can be up to hundreds of meters in diameter and tens of meters deep (Rogers et al., 2006). Brothers et al. (2010) discuss hypotheses surrounding pockmark formation in the muddy embayments of Maine, and conclude they most likely form "episodically with changes in environmental conditions such as changes in ocean temperature, storm- or tsunami-related sea-level changes, or by physical vibration from earthquakes or other sources." Little evidence is reported for recent formation and activity.

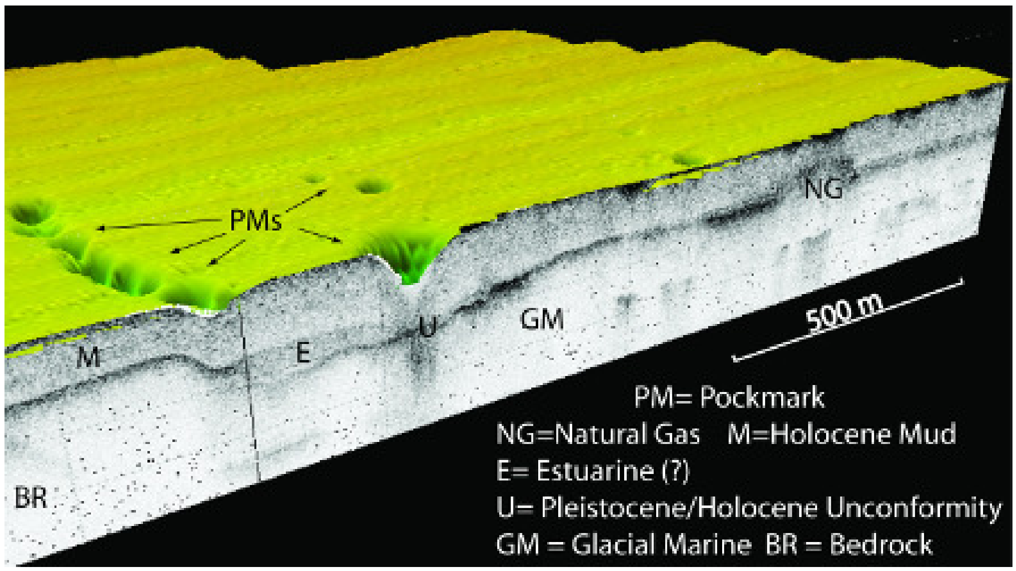


Figure 3-12: Combined bathymetric and seismic reflection data illustrating seafloor sediment layering and the pockmark surface features (Andrews et al., 2010)

Pockmarks have been observed regularly in regions surrounding gas deposits in Maine's inner continental shelf regions (Brothers et al., 2010). Regions where gassy sediment and pockmarks associated with gassy sediment have been identified are shown in Figure 3-13, which include Penobscot, Blue Hill and Passamaquoddy Bays as well as other locations.

Much of the existing offshore geohazards knowledge is for water depths less than 100 m, corresponding to the area of extensive study of Maine's inner continental shelf geology. This is shallower than most of the area relevant for floating offshore wind development. Small pockets of gassy sediments, likely from organic matter decomposition, have been identified as far offshore as southwest of Monhegan Island, more than ten (10) miles from the mainland.

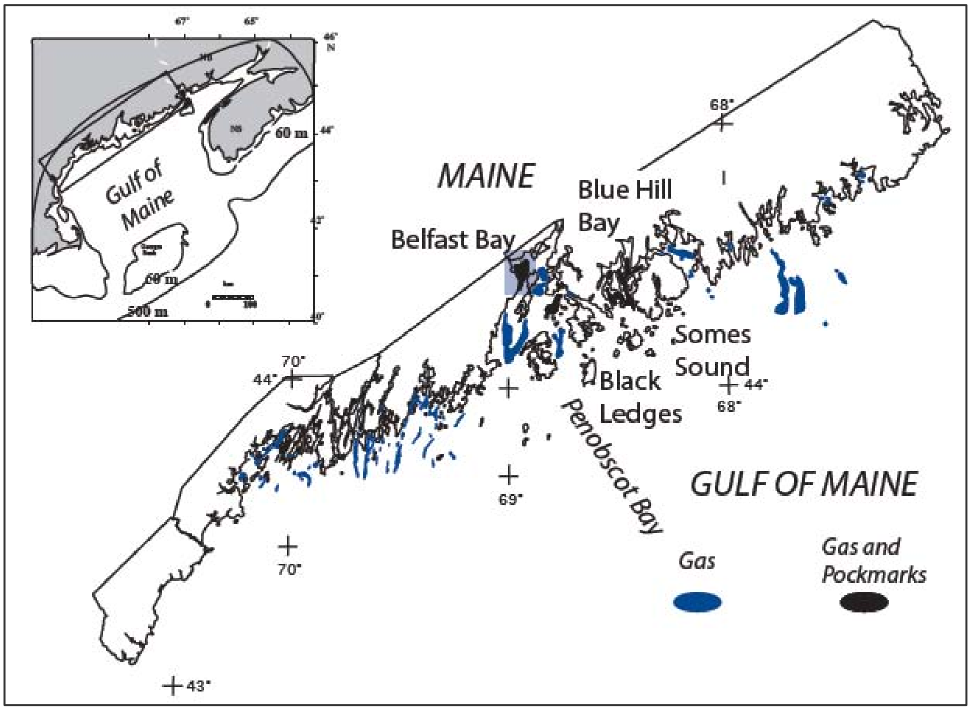


Figure 3-13: Maine shoreline with natural gas fields where gas only is shaded blue and black represents gas and pockmarks (Brothers et al., 2010, modified following Rogers et al., 2006)

What does the presence of gas mean for development? Marine sediments containing gas are often more compressible and have weaker strengths than non-gassy sediments, which is dependent on gas pressure and past and present sediment loading (Sills and Gonzalez, 2001). Gas also has the potential to migrate along the interface of structural elements in the seafloor, thereby compromising or eliminating their ability to withstand loading. Avoidance of gas is optimal. However, there are numerous examples in offshore oil and gas development of successful mitigation and management of the effects of seafloor gas at development sites upon discovery, both pre- and post-construction.

Identification of the presence of seafloor gas will be possible through geophysics surveys conducted as part of any routine site investigations required for offshore development. It is unlikely that deepwater development tens of miles from Maine's coast will encounter significant amounts of seafloor gas, due to the limited impact of sea level changes and low rates of organic material deposition. The most significant impact it is likely to have for development along the inner continental shelf relates to locating pipelines or cables. Pockmark fields have a highly variable seafloor, which may require meandering cable/pipe routes or leave lengths of cable/pipe unsupported.

3.9.2 Earthquakes

The Maine Geological Survey has cataloged most of the recorded earthquakes that have occurred between 1814 and 2002 (Berry and Loiselle, 2003). Additionally, earthquake monitoring in the New England states is performed by the Weston Observatory at Boston College, as well as the United States Geological Survey (USGS). In the last century, earthquakes with Richter scale magnitudes as great as 4.9 have occurred on land and offshore, with a recent 2006 event near Bar Harbor, Maine, with a Richter magnitude of 4.2.

Maine is located within the North American plate and experiences "intraplate" earthquakes, not plate boundary earthquakes like those that occur in California, which cannot be correlated with known faults. Generally, Maine earthquakes seem to break on a different fault every time, many of which are unmapped (Berry and Loiselle, 2003). Mapped faults in Maine have not been found to demonstrate recurring movement that leads to earthquakes. The impact of this geohazard is likely minimal. Routinely, offshore development projects include seismic risk analyses that would mitigate concern for this geohazard.

3.10 SURFICIAL SEDIMENTS

The uppermost layer of sediment along the ocean floor is referred to as surficial sediment, and provides critical information for any structure that may rest on or be embedded in the seabed, including anchoring systems. The surficial sediment data used in this study includes location, description and texture of samples that have been collected by numerous marine sampling programs. Textural and descriptive data may include grain-size analyses, silt or clay content, and lithology of rock samples encountered.

This feasibility study uses the following sources for surficial sediment information: USGS East Coast Sediment Texture Database; USGS Continental Margin Mapping (CONMAP) sediments grain size distribution for the United States East Coast Continental Margin; USGS BARNHARDT: Maine Inner Continental Shelf Sediment Data; and Maine Geological Survey (MGS) Surficial Geology of the Maine Inner Continental Shelf map series. These data sources are further described in the subsections below. A brief summary of the datasets may be found in Table 3-14.

Table 3-14: Surficial sediment dataset summary

Name	Description	Horizontal Datum	Vertical Datum	Accuracy
USGS East Coast Sediment Texture Database	Location of sediment samples throughout the world – mostly in Atlantic Continental Margin (US). Texture data available for some samples. GIS points layer.	NAD27, decimal degrees	Unadjusted water depth at time of sample, meters	Horizontal accuracy varies
USGS CONMAP	Maps of sediment classifications based on grain size distributions. GIS polygon layer.	NAD83, decimal degrees	NA, no elevation information	Boundaries inferred, use for general trends not small scale analysis
USGS BARNHARDT	Sediment sample data from the northwestern Gulf of Maine inner continental shelf. GIS points layer.	NAD27, decimal degrees	Water depth, meters	Horizontal accuracy varies from ±10 m to ±100 m
MGS Surficial Geology of the Maine Inner Continental Shelf	Map series showing generalized surficial geology areas along the Maine inner continental shelf. Digital static maps (pdf).	NAD27, decimal degrees	NOS Bathymetric Maps (datum not explicitly noted)	Horizontal accuracy varies from ±10 m to ±100 m

3.10.1 USGS East Coast Sediment Texture Database (ECSTB2005)

The USGS East Coast Sediment Texture Database (ECSTDB2005) includes information on the location, the description, and the texture regarding all sediment samples that were processed at the USGS Woods Hole Coastal and Marine Science Center (WHSC) Sediment Laboratory through November 2004. Samples are located from around the world, but are mostly concentrated in the Atlantic Continental Margin of the United States. This GIS data was derived from an Excel spreadsheet containing the accumulated results of surficial sediment analyses, and converted into a points layer for use in GIS software.

The horizontal datum is the North American Datum 1927 (NAD27), measured in decimal degrees; however due to different systems, datums and navigational equipment, positional accuracy of the samples in this dataset varies. Vertical depths of water overlying sediment samples are available for individual samples, measured in meters; depths have not been adjusted for tides and were measured at time of sampling. Top and bottom depths of the sample, measured from sea floor surface, are reported in centimeters.

3.10.2 USGS Continental Margin Mapping Sediment Grain-Size (CONMAPSG)

CONMAPSG is the USGS Continental Margin Mapping (CONMAP) program focusing on mapping sediment grain size distributions for the U.S. East Coast Continental Margin, analyzed at WHSC from 1962 to 2005, and is presented in a graphical form. Sediments were classified using the Wentworth (1929) grain-size scale and the Shepard (1954) scheme of sediment classification. Some grain-size categories were combined due to the paucity of some sediment textures, while empty regions of the maps indicate areas where data was insufficient to infer sediment type. Graphical data include broad-scale boundaries of sediment classifications, based on grain size distribution, for dominant sediments along the East Coast Continental Margin of the United States, extending from just south of Florida to Nova Scotia. The horizontal datum is the North American Datum 1983 (NAD83), measured in decimal degrees. There is no vertical data associated with this dataset. The data was published in 2005 in GIS shapefile format.

Maps depicted from this data should be used as a general overview of textural trends in sediment, as they do not accurately reflect small-scale sediment distributions or sea-floor variability. Boundaries between sediment types should be viewed as inferred and not absolute, as actual boundaries may be highly irregular or gradational. USGS also used bathymetric data to provide additional support for probable sediment type transitions.

3.10.3 USGS Maine Inner Continental Shelf Sediment Data (BARNHARDT)

Localized to the inner continental shelf in the northwestern GoM along the coast of the State of Maine, the BARNHARDT dataset is a compilation of data collected by UMaine, produced in connection with the Maine Geological Survey, and published by USGS in 2003. It consists of information for over 1,700 sediment samples, including grain size data, locations, and textural classifications. Data was used to create a points layer for use in GIS software.

The horizontal datum is NAD27, measured in decimal degrees. Horizontal positional accuracy of the data varies from +/-10 m to +/-100 m, due to the use of various navigation apparatuses, and is not differentiated on the individual sample locations. Water depths are recorded in meters for individual samples; however a vertical datum is not specified.

3.10.4 Maine Geological Survey Surficial Geology of the Maine Inner Continental Shelf

The surficial geology map series of the Maine inner continental shelf was produced by Maine Geological Survey (MGS) in 1996 (Barnhardt et al., 1996) and depicts generalized mapping of dominant surficial geology. Sediment sample locations and oceanic features, such as identified shipwrecks, are noted on the map series. The maps also include short descriptions of the sediment types and their general locations. This map set is complimented by The Seafloor Revealed (Kelley et al., 1998), a book that describes surveys and data analysis leading to the understanding of surficial and stratigraphic geology of the inner continental shelf of Maine. Copies of these maps may be found in Appendix A.3 (Section 10.1.2) or at

the following web address:
http://www.maine.gov/doc/nrimc/mgs/pubs/online/ics/ics.htm/ .

The maps are based on seismic reflection and side-scan sonar geophysical data, bottom samples, National Ocean Service (NOS) provisional bathymetric maps, published nautical charts, and are supplemented with bottom photographs and direct observations from submersibles. The map series are available publicly only as digital static maps. Basic bathymetric contours are shown on these maps, however it is noted that these contours may not be reliably accurate for navigation due to digitization methods and potential interpretation errors. Accurate bathymetry data used for this feasibility study is described in Section 3.7 of this report.

The maps use a horizontal datum of NAD27. Horizontal accuracy varies from +/-10 m to +/-100 m, due to differences of equipment and navigation. The vertical datum is based on NOS bathymetric maps and not explicitly noted.

3.11 OFFSHORE WIND ENERGY GEOGRAPHIC INFORMATION SYSTEM DATA STATUS AND UPDATES

The Offshore Wind Energy Geographic Information System (OWEGIS) was created and developed by Dr. Susan Elston at UMaine and was implemented and refined through a partnership between UMaine and Sewall. This partnership combined the scientific expertise and resource capabilities of UMaine with Sewall's understanding of state and federal permitting regulations, wind energy development, and Geographic Information System (GIS) expertise. This public-private collaboration produced a comprehensive, integrated ecosystem-based information system for use in siting, planning and permitting offshore wind energy in the GoM. OWEGIS was created with the intent to collect, analyze, and graphically display information to assist in planning, permitting, and development of offshore wind energy in the Gulf of Maine in a transparent manner. ***N.B.* The information contained in OWEGIS reflects the current state of knowledge and should not be considered the final authority on continuously evolving data, data sources, or on-going scientific studies and it does not reflect any position within or external to the University of Maine.**

Areas encompassed by the OWEGIS system include coastal and marine areas from Nantucket, Massachusetts to the Bay of Fundy. OWEGIS was used to leverage the power of GIS technology and geospatial data analysis for the purpose of resource assessment and site selection. The assessment and site selection process consisted of identifying key assessment criteria across various stakeholders in evaluating regions of interest for offshore wind development.

OWEGIS was designed to be a flexible geospatial database system that could easily accommodate continuously evolving spatial and temporal data as well as be easily modified to address stakeholder needs. The comprehensive multi-faceted OWEGIS information system currently has over 450 data layers derived from public and private sources, including traditional GIS data, discrete observational data, and value-added data. For clarity, these layers have been subdivided into five principle areas by theme: (1) physical characteristics/physical environment, (2) coastal restrictions and marine hazards, (3) human activity impacts, (4) infrastructure and commercial uses, and (5) legal, technical, and permitting boundaries. The human activity constraints are further subdivided into three equally important areas: (3a) coastal economic and extractive resource uses, (3b) cultural and aesthetic qualities, and (3c) ecological-environmental impacts and wildlife (see OWEGIS reference information in Appendix A.4). The guiding principle for selection of pertinent assessment criteria and data layers was identifying the key state and federal legislation affecting the use and management of submerged lands and the outer continental shelf (see Appendix A.4). Incorporation of this broad range of data into OWEGIS allows for a comprehensive evaluation of the potential impacts of a variety of human activities in and upon coastal and marine environments. This evaluation is critical to conservation planning efforts in line with traditional, new and expanding human uses, which will facilitate ecosystem sustainability.

OWEGIS information used in assisting the State and UMaine in the resource analysis of offshore wind energy in Maine is summarized in Table 3-15 below and can be found listed in the *UMoffshorewind energy_GIS_mar19.pdf* document at the Maine State Planning Office (SPO) website under the Ocean Energy Task Force – Environmental Issues subcommittee: http://www.maine.gov/spo/specialprojects/OETF.

An example of using OWEGIS as a public outreach and transparent siting tool is shown in Table 3-15 and was developed by the consensus of active participants during the public OETF subcommittee #1 meeting held on March 17, 2009. Researchers, developers, consultants, state agency personnel, and the interested public attended this subcommittee meeting to decide collaboratively how best to rate the individual layers of information in OWEGIS, critical data gaps, and criteria necessary for its use in the development of offshore wind projects in the GoM.

The outcome of the March 17, 2009, subcommittee meeting provides one approach to classifying complex overlapping multi-faceted data in a consistent fashion. For another approach to the same complex overlapping multi-faceted data, please see "The Creation of a Multidisciplinary, Criteria-Oriented Review and Selection Process for Deepwater Wind Test Facilities in Maine State Waters" developed by the State Planning Office (SPO). The resultant work of the SPO criteria review with non-proprietary data supplied by UMaine from OWEGIS is now part of the Maine Coastal Atlas.

Table 3-15 provides a brief description of the data collected and integrated into OWEGIS through March 2009. Additionally, it identifies data in various stages of acquisition and integration, as well as supplemental information necessary to improve OWEGIS.

Table 3-15: OWEGIS Data Content and Status (October 2008 to March 2009)

Gulf of Maine Offshore Wind Energy Development Initiative

THE UNIVERSITY OF MAINE

Topic: ***Updated Content of the Gulf of Maine Offshore Wind Energy Geographic Information System (OWEGIS) – DRAFT****

Date: *April 22, 2009*

Authors: *Dr. Susan A. Elston, Dr. Melissa M. Landon, Dr. Habib J. Dagher (University of Maine), & Matthew E. Nixon (State Planning Office)*

The Offshore Wind Energy Geographic Information System (*OWEGIS*) was created with the intent to collect, analyze, and display graphical information to assist in planning, permitting, and the development of offshore wind energy in the Gulf of Maine. This document provides a brief description of the data collected and integrated into the Gulf of Maine *OWEGIS* to date. Additionally, it identifies data in various stages of acquisition and integration, as well as supplemental information necessary to improve *OWEGIS*. ***N.B.* This information reflects current state of knowledge and should not be considered the final authority on continuously evolving data, data sources, or on-going scientific studies.**

A. Rating Criteria for Offshore Wind Turbine Site Locations Minimizing Conflict – Weights by Filter Order & Geometry Type
Weights by Filter Order - Arabic Numerals: 1 – 3 respectively for first order filtering to third order filtering for siting considerations
1 – first order resource assessment filtering for siting considerations (e.g., physical criteria – winds, water depth, infrastructure, marine hazards)
2 – second order resource assessment filtering for siting considerations (e.g., additional physical criteria – land use, public planning information)
3 – third order resource assessment filtering for siting considerations (e.g., site specific conditions – local and regional feature assessment)

Weights by Geometry Type - Upper Case Letters: A – C for go/no go conditions, range conditions, site specific conditions
A – Go/No go conditions for siting (e.g., shipping channels or unexploded ordinances)
B – Range conditions (e.g., bathymetry, wind power class – technology dependent, etc.)
C – Site specific conditions (e.g., endangered/threatened/depleted species, shellfish industry, etc.)

Assessment Criteria for Offshore Wind Turbine Regions of Interest were divided into four general categories with "telescoping" as follows:

Resource Availability – Physical Characteristics (Level 1)
Human Activity Constraints – Coastal Economic & Extractive Resource Uses (Level 2)
Human Activity Constraints – Cultural & Aesthetic Features (Level 2)
Human Activity Constraints – Environmental Impacts & Wildlife (Level 2)
Industrial Needs – Infrastructure & Commercial Uses (Level 3)
Legal & Permitting Boundaries (Level 4)

Coastal economic & extractive resource uses, environmental impacts & wildlife, and cultural & aesthetic features are treated equal. OWEGIS layers were developed in reference to MMS' Proposed Rule 30 CFR Parts 250, 285, & 290 & the Multipurpose Marine Cadastre OCS Mapping Initiative.

Table 3-15 continued

B. OWEGIS Current Content

Items in gray indicate data in acquisition/integration and/or data sources that can only be viewed for proprietary reasons and/or have limited data sharing agreements. Items marked by * indicate data are multi-dimensional and are listed under more than one category.

PHYSICAL CHARACTERISTICS

1 Gulf of Maine Wind Resource

- 1 B Analysis/interpretation of comprehensive wind data collected from the Gulf of Maine buoy network by Dr. Susan A. Elston, including wind speeds and classes for elevations of 50 m and 100 m above mean sea level.
  - January 2009 analysis includes 11 data stations within 3 nautical miles and 13 stations within 6 nautical miles of the coast, with a total of 40 data stations within U.S. and International Atlantic Ocean waters.
  - An additional 16 verifiable sites will be included for subsequent analyses of the wind resource.
- 1 B U.S. DOE National Renewable Energy Laboratory (NREL)/AWS Truewind Gulf of Maine wind resource at 50 & 100m.
- 1 B LANDSAT satellite imagery for the Gulf of Maine from USGS Global Viewer (to be incorporated)
- 2 B/C Scatterometer winds providing spatial fields of wind vectors over the entire Gulf of Maine (consideration by Andy Thomas)
- 3 C Historical Atlantic hurricane tracks*

2 Bathymetry and Topography

- 1 B Selected contour intervals – 20 fathoms (40 meters), 30 fathoms (60 meters), 50 fathoms (90 meters), 100 fathoms (180 meters), 200 fathoms (400 meters) – designating regions of bathymetric change*
- 1 C Continental shelf survey (ICS) bottom photographs (older data – low resolution data)
- 1 C Integrated continental shelf surveys (ICS) surveys
- 1 C Seismic fault lines in the coastal zone and uplands*
- 2 B Geologic depth profiles of marine soils, bedrock, and gas deposits at discrete locations from Maine Geological Society survey tracks: locations shown in *OWEGIS*, with actual profiles available from UMaine Marine Geologists Joseph Kelley and Daniel Belknap.
- 2 B Gulf of Maine bathymetry (ocean depths)
- 2 B Maine 20 m topography (for assistance in characterizing on-shore wind resource)
- 2 B/C Coastal Navigation Charts (Resolution: 1:24,000 for Greater Portland; Bar Harbor; Casco Bay; 1:80,000 – 1:120,000 elsewhere in the Gulf of Maine Region)
- 2 C Surficial soils (low resolution data)
- 3 A Inter-continental shelf (ICS) surficial soils and methane gas locations from the Maine Geological Survey (data in acquisition)
- 3 C Inter-continental shelf bathymetric survey tracks and bathymetry from Maine Geological Survey

INFRASTRUCTURE & COMMERCIAL USES

3 Transportation Infrastructure

- 1 C Maine airports (*Maine airports showing a 5 nautical mile radius buffer zone around them*)
- 1 C Coastal airports (*Coastal Maine airports within 10 nautical miles of the coastline showing a 5 nautical mile radius buffer zone*)
- 1 C Heliports and Med-Flight/Life-Flight landing locations (data in acquisition)
- 1 C Air tours in Coastal Maine (Trenton, MDI/Acadia region)
- 1 C Alternative Fuel Stations (data in acquisition)*
- 1 C Navigable waterways (data in acquisition)*
- 1 C Army Corps of Engineers Ports (data in acquisition)*
- 2 C National Railway Network (data in acquisition)*
- 2 C Ferry routes
- 2 C Rail lines*

4 Utility and Development Infrastructure

- 1 C Electrical infrastructure (*power plants, substations, 115 kV and 345 kV transmission lines*) – current infrastructure
- 1 C Electrical infrastructure (power plants, substations, 115 kV and 345 kV transmission lines) – current infrastructure (proprietary)
- 1 C Electrical infrastructure (power plants, substations, 115 kV and 345 kV transmission lines) – approved plans (data requested)
- 1 C Electrical infrastructure (power plants, substations, 115 kV and 345 kV transmission lines) – submitted plans (data requested)
- 1 C Pipeline and cable infrastructure (data requested from management body)
- 1 C Military Bases and Installations (data in acquisition)
- 1 C Navigable waterways (data in acquisition)*
- 1 C Army Corps of Engineers Ports (data in acquisition)*
- 2 C National Railway Network (data in acquisition)*
- 2 C Rail lines*
- 2 C Hospitals

5 Coastal Restrictions & Marine Hazards

- 1 A Dragging prohibited zones
- 1 A Dumping and spoil grounds, explosives dumping grounds, areas of unexploded ordinance(s).
- 1 A Military zones
- 1 A Right whale restrictions (critical habitat, foaling grounds, recommended avoidance routes)
- 1 A Shipping lanes (harbor approach, traffic separation)
- 1 C Seismic fault lines in the coastal zone and uplands*
- 2 C Obstructions (movable physical hazards, buoys, etc.)

Table 3-15 continued

- 2 B Lobster and fish trap area* - general regions classified by NOAA Coast Survey – distinct data from local and regional information
- 2 B Coastal shellfish collection regions* - general regions classified by Maine – distinct data from local and regional information
- 2 B Worm crop harvest regions* - general regions classified suitable for harvesting – distinct data from local and regional information
- 3 C Historical Atlantic hurricane tracks*

CULTURAL & AESTHETIC FEATURES

6 **Native Lands and Cultural/Historical Features (including Landscapes & Seascapes)**

- 1 A National Park Service Data* (to be incorporated)
- 1 A State Park Data* (verify have most up-to-date version)
- 1 C Maine Coastal Island Registry*
- 1 C Fishing charter vessel and operations locations
- 1 C Maine portion of the Appalachian Trail
- 1 C Maine special protection rivers, Maine's Finest Lakes, Wildlands Lakes
- 1 C Maine Wind Jammer Association estimated use range (SPO)
- 1 C National Historic Register Sites (SPO)
- 1 C Native lands
- 1 C Whale watching charter vessel locations
- 2 C Sunken vessels, ship wrecks, light houses, and sea archeology sites

ENVIRONEMENTAL IMPACTS & WILDLIFE

7 **Habitat and Wildlife (Terrestrial, Coastal, and Marine)**

- 1 A/C Marine sanctuaries*
- 1 B Selected contour intervals – 20 fathoms (40 meters), 30 fathoms (60 meters), 50 fathoms (90 meters), 100 fathoms (180 meters), 200 fathoms (400 meters) – designating regions of bathymetric change*
- 1 B Bats – some digitally available migration route and tracking survey routes
- 1 B Breeding bird – locations/routes where surveys were conducted
- 1 B Environmental Vulnerability Index Maps (Maine Oil Spill Hazard Mitigation Maps)*
- 1 B Migratory marine mammals – sightings of threatened, endangered, and depleted species (dolphins: bottlenose, spinner; turtles: green, leatherback, loggerhead; whales: fin back, humpback, minke, sei, and northern right)
- 1 C Anadromous fish year-class counts of salmon per location
- 1 C Essential Aquatic Habitats (eelgrass, freshwater wetlands)
- 1 C Essential avian habitats (bald eagle nests; coastal seabird nesting; piping plover, least tern, roseate tern areas; inland waterfowl and wading bird areas)
- 1 B Maine and New Hampshire National Marine Fisheries Service Trawl Data
- 2 B National Marine Fisheries Service Trawl Data

- 2 B Northeast Resources
  - 2 B Essential fish habitat – as per the Code of Federal Regulations (50CFR 648.81)
  - 2 B New England Multispecies closures (year-round and seasonal closures for scallops and other species)
  - 2 B Gulf of Maine Dynamic Area Management Zones (DAMS) for Right Whales (yearly, seasonal, and real time closures)
  - 2 B Regulated mesh area (regulated fishing zones)

COASTAL ECONOMIC & EXTRACTIVE RESOURCE USES

8 **Coastal Economic Regions (Marine and Terrestrial)**

- 1 B Selected contour intervals – 20 fathoms (40 meters), 30 fathoms (60 meters), 50 fathoms (90 meters), 100 fathoms (180 meters), 200 fathoms (400 meters) – designating regions of bathymetric change*
- 1 B Environmental Vulnerability Index Maps (Maine Oil Spill Hazard Mitigation Maps)*
- 1 B Local and regional Lobster and fish trap areas* (data in acquisition)
- 1 B Local and regional Coastal shellfish collection regions* (data in acquisition)
- 1 B Local and regional Worm crop harvest regions* (data in acquisition)
- 2 B Lobster and fish trap area* - general regions classified by NOAA Coast Survey – distinct data from local and regional information
- 2 B Coastal shellfish collection regions* - general regions classified by Maine – distinct data from local and regional information
- 2 B Worm crop harvest regions* - general regions classified suitable for harvesting – distinct data from local and regional information

LEGAL & PERMITTING BOUNDARIES

9 **Boundaries/Municipalities/Population**

- 1 A National Park Service Data*
- 1 A State Park Data*
- 1 C Maine Coastal Island Registry*
- 1 A/C Marine sanctuaries*
- 1 B Selected contour intervals – 20 fathoms (40 meters), 30 fathoms (60 meters), 50 fathoms (90 meters), 100 fathoms (180 meters), 200 fathoms (400 meters) – designating regions of bathymetric change*
- 1 C Coastal state and federal marine boundaries
  (*private, state, federal "8(g)" revenue-sharing, territorial sea, contiguous zone, economic exclusive zone*)
- 1 C Outer Continental Shelf (OCS) Lease Blocks (data acquired, to be incorporated)
- 1 C State easements and right of way access (roads, transmission lines, pipelines, rail)
- 1 C State, New England States, and International boundaries
- 2 C Tax parcels (i.e., LURC vs. non-LURC divisions)
- 3 C 2000 Maine State Census Data
- 3 C Maine towns

Table 3-15 continued

C. Areas of *OWEGIS* Needing Further Development or Data Integration

- Supplemental migration routes and tracking survey data (digital GIS, tabulated, or proxy) for the following:
  - ECON 1 B Ground fish and fisheries resource zone information
  - ENVR 1 B Protected mammals (right whales, etc.) and/or delisted species
  - ENVR 1 B Updates to salmon essential habitat, newly designated closure areas for Atlantic Salmon fishing rights
  - ENVR 1 B Birds and Bats (tracking methods: radar, satellite, or radio-tagged)
- CLTR 1 C Additional Native population information regarding cultural/historical resources and wind power development
- CLTR 2 C Onshore historical or archeological sites (for permitting), recreational trails, additional recreational resources
- ENVR 1 C Areas of Special Significance
- ENVR 1 B Maine Seaweed and Kelp Harvesting Areas
- ENVR 2 B Land use change information – changes in land use with time over the last 20 and 50 years for development purposes
- INFR 1 C Additional power infrastructure information
- INFR 1 C Med-flight information and coastal hospitals with helicopter landing facilities
- LEGL 1 A Comprehensive Maine State permitting agencies and requirements for offshore energy development
- LEGL 2 C All relevant public and marine policy, management, and planning information
- Potential Additional Sources of New Information
  - CLTR 2 C Maine Island Trails Association
  - ECON 1 C Cobscook Bay Resource Center
  - ECON 1 C Penobscot East Resource Center
  - ECON 1 B Island Institute
  - ENVR 1 C University of Southern Maine Census on Marine Life
  - ENVR 2 B Northwest Atlantic Marine Alliance

D. Bibliography of digital information collected and integrated into *OWEGIS*

- Automated Wreck and Obstruction Information System (AWOIS)
- Bangor Hydro (BHE)
- Maine Department of Environmental Protection (ME-DEP)
- Environment Canada (envCanada)
- Federal Emergency Management Agency (FEMA)
- Federal Geographic Data Committee (FGDC)
- Island Institute
- Maine Department of Conservation (DoC)
- Maine Department of Marine Resources (DMR)
- Maine Office of GIS (MEgis)

INFRASTRUCTURE & COMMERCIAL USES

3 Transportation Infrastructure

- 1 C Maine airports (*Maine airports showing a 5 nautical mile radius buffer zone around them*)
- 1 C Coastal airports (*Coastal Maine airports within 10 nautical miles of the coastline showing a 5 nautical mile radius buffer zone*)
- 1 C Heliports and Med-Flight/Life-Flight landing locations (data in acquisition)
- 1 C Air tours in Coastal Maine (Trenton, MDI/Acadia region)
- 1 C Alternative Fuel Stations (data in acquisition)*
- 1 C Navigable waterways (data in acquisition)*
- 1 C Army Corps of Engineers Ports (data in acquisition)*
- 2 C National Railway Network (data in acquisition)*
- 2 C Ferry routes
- 2 C Rail lines*

4 Utility and Development Infrastructure

- 1 C Electrical infrastructure (*power plants, substations, 115 kV and 345 kV transmission lines*) – current infrastructure
- 1 C Electrical infrastructure (power plants, substations, 115 kV and 345 kV transmission lines) – current infrastructure (proprietary)
- 1 C Electrical infrastructure (power plants, substations, 115 kV and 345 kV transmission lines) – approved plans (data requested)
- 1 C Electrical infrastructure (power plants, substations, 115 kV and 345 kV transmission lines) – submitted plans (data requested)
- 1 C Pipeline and cable infrastructure (data requested from management body)
- 1 C Military Bases and Installations (data in acquisition)
- 1 C Navigable waterways (data in acquisition)*
- 1 C Army Corps of Engineers Ports (data in acquisition)*
- 2 C National Railway Network (data in acquisition)*
- 2 C Rail lines*
- 2 C Hospitals

5 Coastal Restrictions & Marine Hazards

- 1 A Dragging prohibited zones
- 1 A Dumping and spoil grounds, explosives dumping grounds, areas of unexploded ordinance(s).
- 1 A Military zones
- 1 A Right whale restrictions (critical habitat, foaling grounds, recommended avoidance routes)
- 1 A Shipping lanes (harbor approach, traffic separation)
- 1 C Seismic fault lines in the coastal zone and uplands*
- 2 C Obstructions (movable physical hazards, buoys, etc.)