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Wave Climatology in Coastal Maine for Aquaculture and Other Applications

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Abstract Wind waves represent a significant hydrodynamic factor affecting many oceanographic studies such as sediment transport, design of structures, etc. In coastal Maine, wave information is needed, among other applications, for aquaculture-related activities. As few data sources exist, a question that confronts scientists pertains to the magnitudes of typical and extreme wave conditions at various times. To address this, numerical modeling was performed for a period of six and a half years (7/99–12/05) on a continuous basis by coupling National Oceanic and Atmospheric Administration's outer ocean predictions to two coastal, high-resolution, regional domain grids encompassing the Penobscot Bay and Machias Bay regions where aquaculture activity is prevalent and expanding. As the modeling involves uncertainties because of bathymetric and wind field representations, their effect on the results was explored. It was found that although the uncertainties could create inaccuracies in real-time forecasts, their effect on the development of climatogies was minimal. Average modeled significant wave heights are found to vary between 0.6 and 1.5 m in the sub-domains. The maximum conditions are of the order of 6.5 m in the outer parts of the sub-domains and occurred in September and December. Estimated wave-induced bottom velocities were found in many areas to be in excess of the published estimates of resuspension thresholds for net-pen wastes. Estimates of "extreme" wave conditions, corresponding to a recurrence interval of 30 years (representing the nominal design life of the cage), were found to vary between 2 and 7 m in the modeled areas. Detailed contour maps have been developed for site-specific characterization of the wave climate.

Keywords Maine · Wave climate · Hindcasting · Models · Wave statistics · SWAN

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Introduction

Surface waves constitute possibly the most energetic element of the physical oceanography affecting the coastal waters near Maine's 3,500-mile-long coastline. Waves create turbulent effects that are orders of magnitude larger than baroclinic and barotropic currents; obviously, the estimation of wave conditions is important for many oceanographic studies. For example, in the context of sediment transport/coastal engineering, the paucity of reliable wave information appears to have adversely affected the estimation of long-shore sediment transport and the related jetty designs at Camp Ellis (Saco) and Wells Beach (Kelly and Anderson 2000). While there are other areas such as marine operations and maritime safety that also need wave information, the primary motivation for the work described here pertains to the needs of the aquaculture industry.

Aquaculture activities in Maine involve structures like salmon cages and mussel rafts of various designs (Hartstein 2005; DeCew et al. 2005; Lee and Wang 2005), and ocean waves can have a significant effect on the behavior of the structures and the overall aquaculture operation. In some cases (e.g., Toothacher Bay, Maine), Panchang et al. (1997) concluded that waves play the dominant role in cleansing the bay of settled net-pen wastes (excess fish food and fecal matter) by inducing resuspension and subsequent transport. On the other hand, large waves as well as low frequency swell (i.e., resonance, as noted by Frederikkson et al. 2003)