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Assessment of hydrodynamic impacts from tidal power lagoons in the Bay of Fundy

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ABSTRACT

The Bay of Fundy located in eastern Canada is home to some of the world's largest tides. Currently there is renewed interest in harnessing these very large tides for power generation in ways that avoid upsetting ecosystems, infrastructure and human activities that are presently well adapted to existing conditions. This paper investigates the hydrodynamic impacts due to tidal power lagoons, an approach to power generation that involves temporarily storing seawater behind a circular engineered dyke and generating power by gradually releasing the impounded seawater through conventional low-head hydroelectric turbines. This paper describes a study in which a two-dimensional, depth-averaged hydrodynamic model based on the TELEMAC modelling system was developed, calibrated, and applied to analyze, predict, and quantify the potential changes in tidal hydrodynamics (water levels, tide range, circulation patterns and tidal currents) throughout the Bay of Fundy and Gulf of Maine due to the presence of a single tidal lagoon and multiple lagoons operating at various locations in the upper Bay of Fundy. The sensitivity of the hydrodynamic impacts to changes in lagoon type, size, location, the number of lagoons, and their operating mode have also been investigated. The methods employed in this study and the main findings are presented and discussed herein. These results will help inform future decisions concerning development of the vast tidal energy resources in the Bay of Fundy.

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Introduction

The Bay of Fundy (BoF), located on the Atlantic coast of North America, between the Canadian provinces of Nova Scotia and New Brunswick, is renowned for its large amplitude tides, which are among the world's largest (Fig. 1). The Fundy tides are semi-diurnal; twice each day roughly 115 billion tonnes of seawater flow in and out of the 255 km long Bay. The tidal range near Burntcoat Head, located in Minas Basin, can exceed 16 m during spring tides. The natural geometry and bathymetry of the Bay of Fundy are the main factors responsible for producing these very large tides. The BoF, together with Gulf of Maine (GoM), forms a funnel with a natural period of approximately 13 h, close to the 12.42 h period of the M_2 tidal forcing. The large tides are a result of the near-resonant response of the BoF-GoM system to the M_2 tidal forcing [1]. Because of the large tidal range and the strong tidal currents that arise in certain locations, the Bay of Fundy has long been recognized as an ideal site for tidal energy projects.

In the early 1970s, a series of technical and economic assessments were performed to investigate the feasibility and environmental impacts of a potential large-scale tidal barrage in the Bay of Fundy [2]. From these studies, it has been shown that small changes in the geometry of the Bay, associated with the construction of a tidal barrage, could produce significant changes in tidal amplitudes as far away as Boston, USA. It was concluded that the development of a large-scale tidal barrage was considered potentially hazardous to the surrounding ecosystem, and the project was never implemented. Although a large-scale tidal barrage was not constructed, a smaller-scale tidal barrage was completed at Annapolis Royal, Nova Scotia. The Annapolis Royal tidal barrage, which began operations in 1984, remains one of three tidal power plants operating worldwide.

Tidal power lagoon concept

Presently, there is some interest in the idea of implementing tidal power lagoons in the upper Bay of Fundy. The tidal lagoon concept is a more recent approach to tidal power conversion that attempts to solve some of the environmental problems associated with tidal barrages. Rather than blocking off a section of the Bay with a barrage, the tidal lagoon concept involves constructing a circular impoundment structure (a rubble-mound or caisson-type dyke) and a power-house containing sluices and conventional low-head hydroelectric turbines, situated a mile or more offshore, in an area with shallow

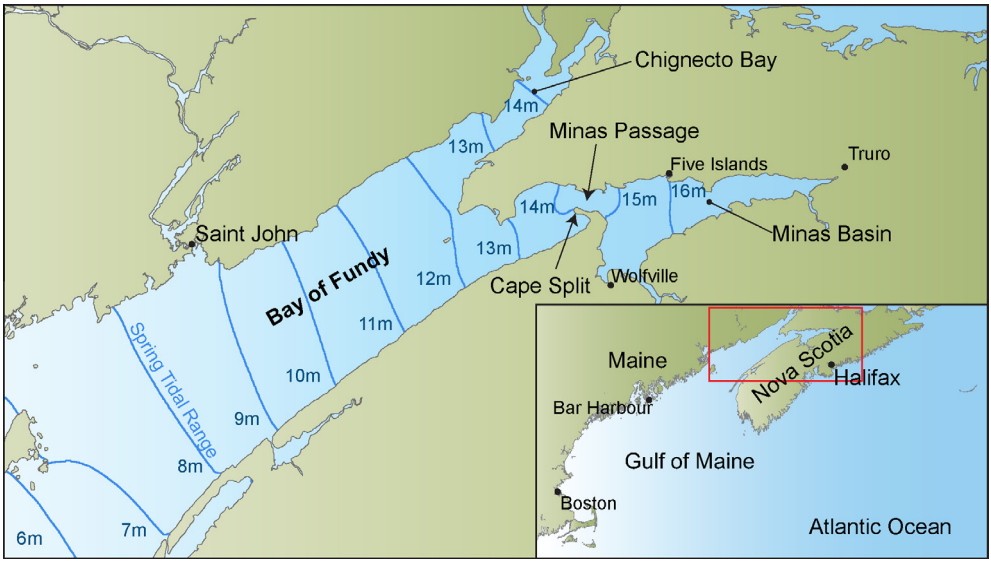

Fig. 1. Map of the Gulf of Maine and Bay of Fundy showing spring tide range.