International Journal of Marine Energy 10 (2015) 97–112

Contents lists available at ScienceDirect

International Journal of Marine Energy

journal homepage: www.elsevier.com/locate/ijome

Evaluating current power availability for energy conversion along the Southern Brazilian Shelf

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A R T I C L E I N F O

Article history:
Received 25 April 2014
Revised 29 December 2014
Accepted 5 January 2015
Available online 10 January 2015

Keywords:
Coastal current
Energy potential
Seasonality
TELEMAC3D
Finite element method

A B S T R A C T

The continuous growth of the worlds population increases the demand and competition for energy, leading to an immense struggle to obtain non-renewable energy sources. As a result, new technologies are being developed, and global policies concerning the generation of renewable and clean energy have strengthened. Several methods of power conversion have been developed over the years, such as the water current turbine-based power converter, which demonstrates a high power generation capacity. The coastal current system of the Southern Brazilian Shelf exhibits synoptic and seasonal variability, which hinders the unidirectional conversion of power. Helical turbines, which are capable of generating power multidirectionally, are recommended. Using a 2-year simulation from the TELEMAC3D model coupled with the energy conversion module, two regions within the study area with high potential for exploiting energy from marine currents were identified. The most viable region for the installation of current converters reaches an average power production of approximately 10 kW/day and an integrated value of 3.5 MW/year. Seasonal analysis revealed that the most energetic periods in both regions occurred during the spring. The highest levels of power generation were found at intervals of 16 days and exhibited high correlations with the passage of meteorological fronts within the study region.

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http://dx.doi.org/10.1016/j.ijome.2015.01.003
2214-1669/

1. Introduction

The oceans are an important and infinite source of renewable energy [1]. Such energy can be obtained from waves, tide oscillations or tidal currents, ocean thermal energy (OTEC), the osmotic gradient and ocean currents. Two ways to obtain energy from the currents are through potential energy (variations in the sea level) and kinetic energy (ocean currents and their water masses). In general, the technique is defined as undersea wind power. According to [2], the energy from river and estuary flow, tidal currents and other artificial water channels is considered a viable source of renewable energy.

The Canadian Hydrology Center (CHC) conducted a survey of the available marine energy in the Canadian coastal region [3]. This study demonstrated that the average electrical power at 190 study points would constitute approximately 63% of Canadian energy demand. A similar study was carried out by Hall et al. [4] for the United States, where the authors identified regions with the highest potential for hydropower. Defne [5] investigated the energy potential of waves and tidal currents along the southeastern coast of the United States and identified a power conversion that ranged between 1.0 and 3.0 MW/year. Additionally, EPRI documented 16 TWh/year (4.4 GW/year) in Alaska and 0.6 TWh/year (166 MW/year) in Puget Sound [6–11].

In Brazil, approximately 80% of the population lives within 200 km of the coastline [12]. However, maps of the Brazilian coastal region that convey the usability of hydrokinetic turbines, which convert energetic power into electricity, have not been developed. Marques et al. [13] conducted studies concerning the influence of hydrokinetic turbines installed along the Southern Brazilian Shelf (SBS) and identified possible changes to the areas natural hydrodynamic and morphodynamic characteristics. The results of this study are promising with respect to the use of coastal currents to obtain electrical energy; an integrated value of approximately 5 GW/year was obtained using 6 axial converters.

The SBS, located between 28°S and 35°S (Fig. 1a), has a slightly rugged shoreline that is oriented northeast-southwest. The bathymetry of this region is quite smooth, with a higher slope and shelf break located near the 180 m isobath [14]. The Patos Lagoon has a drainage basin of approximately 201.000 km^2. Its principal tributaries are the Jacu and Taquari rivers, which converge in the Patos Lagoon through the Guaíba River. At the end of autumn and the beginning of spring, the maximum river flows usually occur, with an annual average discharge rate near 2000 m^3/s [13].

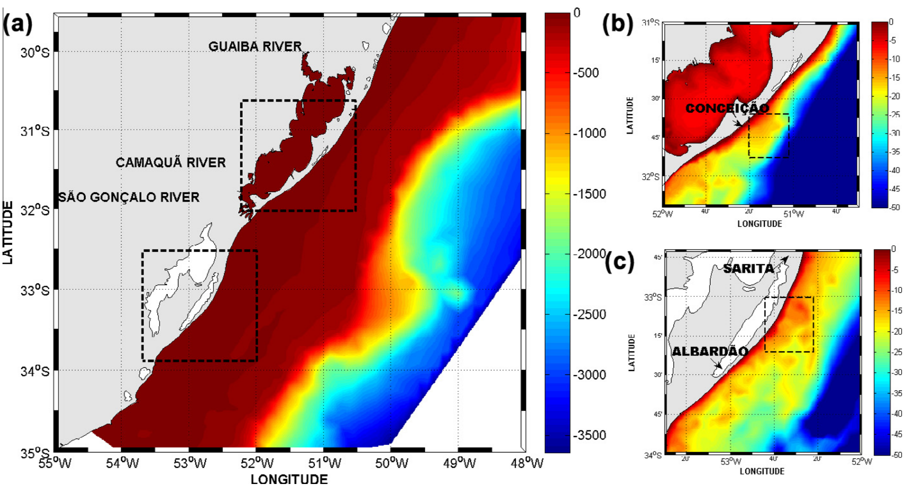

Fig. 1. The study area. (a) The northern and southern study regions of the Southern Brazilian Shelf, which has a depth of approximately −3500 m, are outlined with the dashed squares. (b) The northern region is depicted with the locations of the Solidão and Conceição lighthouses. (c) The southern region is located to the south of the Sarita lighthouse and to the north of the Albardão lighthouse.