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Site selection of ocean current power generation from drifter measurements

Yu-Chia Chang [a, *], Peter C. Chu [b], Ruo-Shan Tseng [c]

[a] Department of Marine Biotechnology and Resources, National Sun Yat-sen University, Kaohsiung 80424, Taiwan
[b] Naval Ocean Analysis and Prediction Laboratory, Naval Postgraduate School, Monterey, CA 93943, USA
[c] Department of Oceanography, National Sun Yat-sen University, Kaohsiung 80424, Taiwan

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ABSTRACT

Site selection of ocean current power generation is usually based on numerical ocean calculation models. In this study however, the selection near the coast of East Asia is optimally from the Surface Velocity Program (SVP) data using the bin average method. Japan, Vietnam, Taiwan, and Philippines have suitable sites for the development of ocean current power generation. In these regions, the average current speeds reach 1.4, 1.2, 1.1, and 1.0 m s^{-1}, respectively. Vietnam has a better bottom topography to develop the current power generation. Taiwan and Philippines also have good conditions to build plants for generating ocean current power. Combined with the four factors of site selection (near coast, shallow seabed, stable flow velocity, and high flow speed), the waters near Vietnam is most suitable for the development of current power generation. Twelve suitable sites, located near coastlines of Vietnam, Japan, Taiwan, and Philippines, are identified for ocean current power generation. After the Kuroshio power plant being successfully operated in Taiwan, more current power plants can be built in these waters.

1. Introduction

Ocean current power is generated from the kinetic energy of ocean currents with less uncertainty than the wind, wave and solar power, and has the high load capacity resulting from the high density of fluid (seawater) [1–3]. Electric power generation from global ocean currents has enormous potential. In 2000, Blue Energy, Inc., estimated that global ocean currents have capacity over 450 GW and represent a market of approximately US$550 billion per annum (assuming purchase price per kWh = US$0.1395) [4]. However, it is noted that devices which extract power from a fluid's momentum (e.g. a tidal turbine or wind turbine) can realistically reach an efficiency up to 50% (the Betz limit is a bit higher, but not by a great deal).

There are many world-wide sites with tidal velocities of 2.5 m s^{-1} and greater. Countries with an exceptionally high resource include the UK, Italy, Philippines, and Japan [4]. But strong tidal currents only last for a short time period, and cannot provide a stable power supply. The strong Florida Current and Gulf Stream move close to the shore of the United States [5,6] in areas of high demand for power [4]. Earlier studies [7,8] indicated that the westward recirculations steadily increase the transport of the Gulf Stream from approximately 30 Sv (1 Sv = 10^6 m^3 s^{-1}) in the Florida Current to approximately 150 Sv at 55°W. The transport is around 20–30 Sv for the Kuroshio near Taiwan, and about 4–10 GW of ocean current power are generated with the flow velocity of 1 m s^{-1} [9].

In Taiwan, the Kuroshio power plant of 30 MW was planned between Taitung and Green Island (~121.43°E, 22.70°N, see Fig. 1) [9]. The estimated annual net income of power plant is 488.58 million NTD (new Taiwan dollar, 1 USD ~ 31 NTD). The payback period is only 6.2 years. The estimated power plant life is 20 years. Thus, the Kuroshio power plant in Taiwan will be operated successfully in the future. Questions arise: Are there other sites or locations in the East Asia suitable for the development of the (Kuroshio) current power generation? If yes, where are these sites? Ocean flow measurement data is an important factor in selecting the site of ocean current power generation. The purpose of this paper is to determine possible sites of current power plant for technical and economic feasibility, and to develop a complete map of strong currents in the East Asia using the Surface Velocity Program (SVP) drifter data of Global Drifter Program (GDP). The GDP is the principle component of the Global Surface Drifting Buoy

* Corresponding author. Fax: +886 7 5255033.
E-mail address: ycchang@staff.nsysu.edu.tw (Y.-C. Chang).

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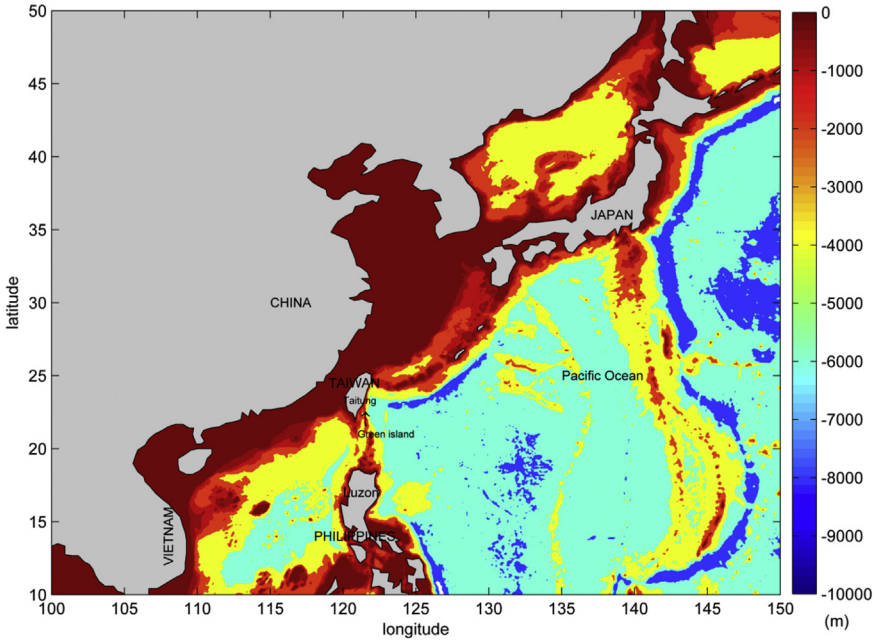

Fig. 1. Geography and bottom topography of the East Asia.

Array, a branch of the NOAA Global Ocean Observing System (GOOS) and a scientific project of the Data Buoy Cooperation Panel (DBCP).

2. Data and method

The NOAA Drifter Data Assembly Center (DAC) provides quality controlled data for velocity measurements. Upper ocean current velocities every 6 h can be obtained from the website: http://www.aoml.noaa.gov/phod/dac/dacdata.php (Accessed 25 Nov 2014). A total of 1883 drifters in the northwestern Pacific (10°–50°N, 100°–150°E) during 1985–2009 are used for this study (see Fig. 2). There are 1,029,889 six-hourly velocity observations of SVP drifters in the study area. All drifters had a holey-sock drogue centered at a nominal depth of 15 m. The 6 hourly velocities are obtained via 12 h centered differencing of the kriged positions [10]. The estimated accuracy of the velocity measurements using SVP drifters is 0.01 m s^{-1} with surface winds of 10 m s^{-1} [11].

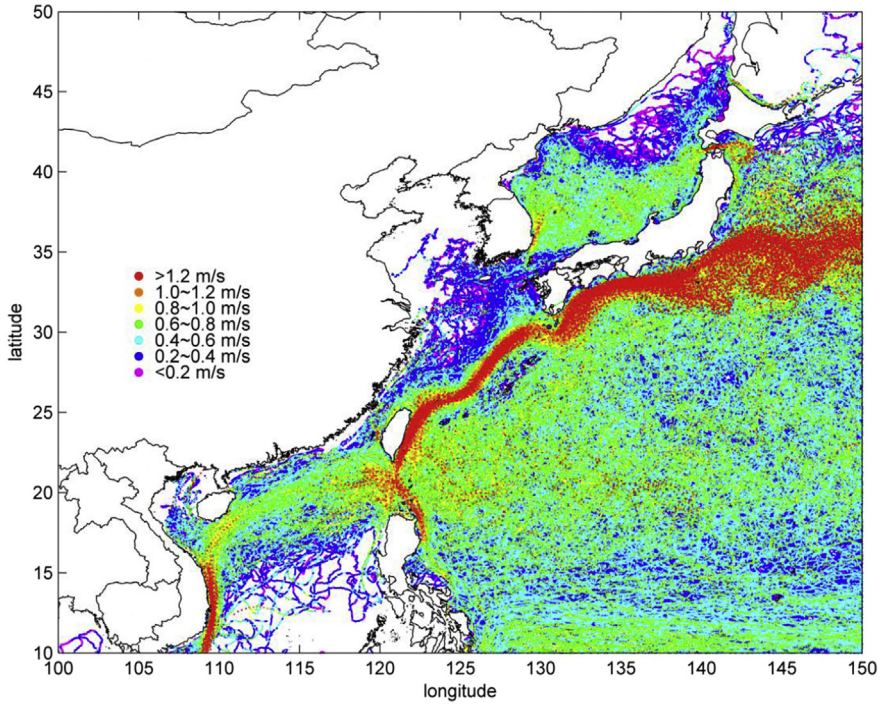

Fig. 2. Locations of drifters with color-coded in accordance with their 6-hourly instantaneous speed.