



The Guajira upwelling system

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Abstract

The coastal upwelled waters of the Guajira coast, the most northerly peninsula of South America, were studied on the basis of historical data bases, remotely sensed data, and three oceanographic cruises. The Guajira Peninsula is the locus of particularly strong upwelling because it protrudes into the Caribbean Low-Level Wind Jet and its west coast parallels the direction of the strongest winds. The year-round upwelling varies with the wind forcing: strongest in December–March and July, and weakest in the October–November rainy season. The east–west temperature, salinity and density front that delimits the upwelling lies over the shelf edge in the east of the peninsula but separates from the south–westward trending topography to the west. A coastal westward surface jet geostrophically adjusted to the upwelling flows along the front, and an eastward sub-surface counterflow is trapped against the Guajira continental slope. The undercurrent shoals toward the western limit of the upwelling, Santa Marta, beyond which point it extends to the surface. Some of the westward jet re-circulates inshore with the counterflow but part continues directly west to form an upwelling filament. Much of the mesoscale variation is associated with upwelling filaments, which expel cooler, chlorophyll-rich coastal upwelling waters westward and northward into the Caribbean Sea. Freshwater plumes from the Magdalena and Orinoco rivers influence the area strongly, and outflow from Lake Maracaibo interacts directly with upwelled waters off Guajira. Another important factor is the Aeolian input of dust from the Guajira desert by episodes of offshore winds.

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1. Introduction

The Guajira Region, the northernmost tip of South America, comprises the area between the Peninsulas of Guajira and Paraguaná, which protrude into the Central Caribbean beyond 12°N. This flat and desertic region, only a few

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hundred metres in elevation, extends up to 600 km from Puerto Cumarebo, at 69°W in Venezuela, to the Sierra Nevada de Santa Marta, at 74°W in Colombia (Fig. 1a). The two peninsulas enclose the Gulf of Venezuela, at the mouth of Lake Maracaibo, the location of major oil exploitation.

The persistent and intense Caribbean Low-Level Jet (LLJ) of the North Trade Winds blows almost parallel to the Guajira coast to produce a coastal upwelling recognised in a number of

studies (e.g. Wust, 1963; Gordon, 1967; Fajardo, 1979; Andrade, 2000). Recently, satellite observations of ocean colour (Muller-Karger et al., 1989; Andrade, 1995) have revealed the highly variable interaction between the continental shelf upwelling regime and the offshore Caribbean Basin regime. The boundary between the cool, nutrient-rich upwelled waters and the warmer, nutrient-poor offshore waters is irregular and often contorted into long, narrow, offshore-flowing streamers or

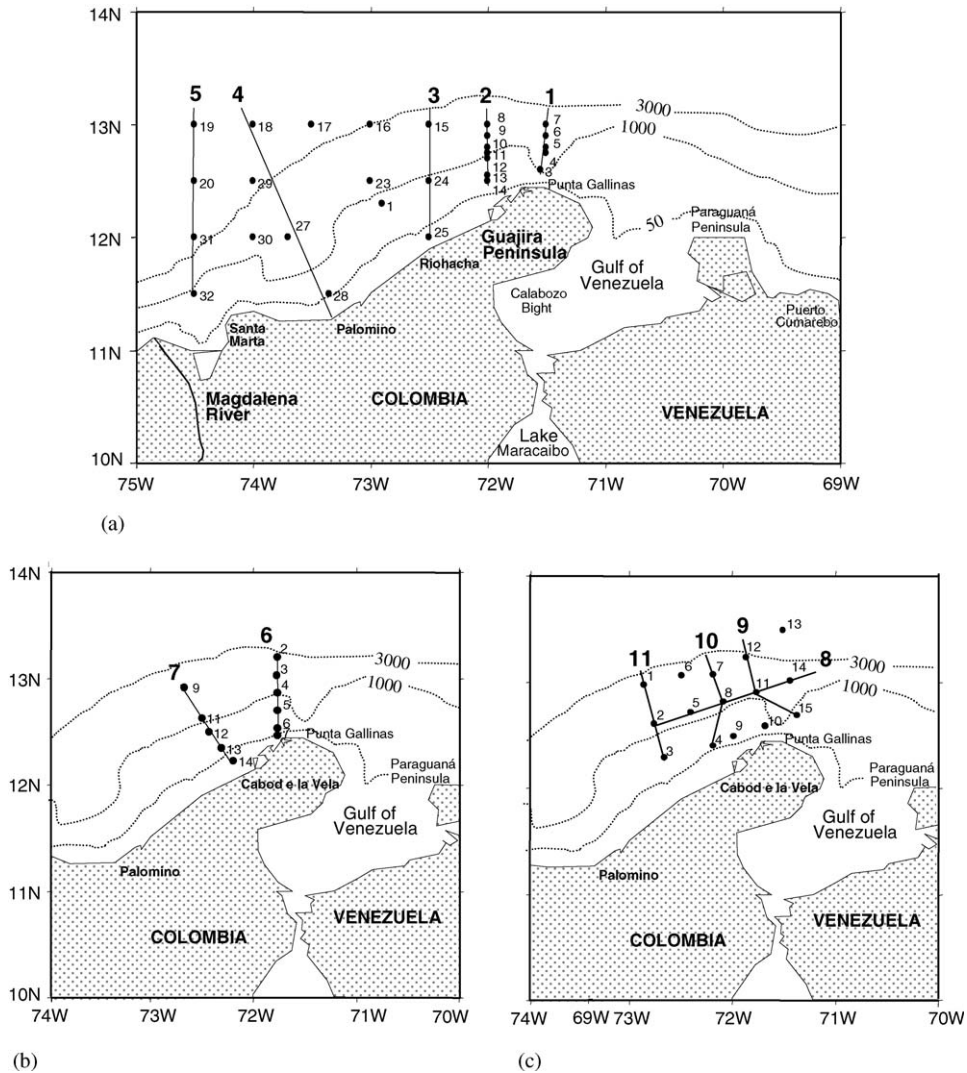


Fig. 1. Geographical location of CTD stations made during (a) April 1994, (b) February 1998, and (c) November 1998.

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