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Exploration of the Windward Passage and Jamaica Channel: Tectonic Gateways to the Caribbean Sea

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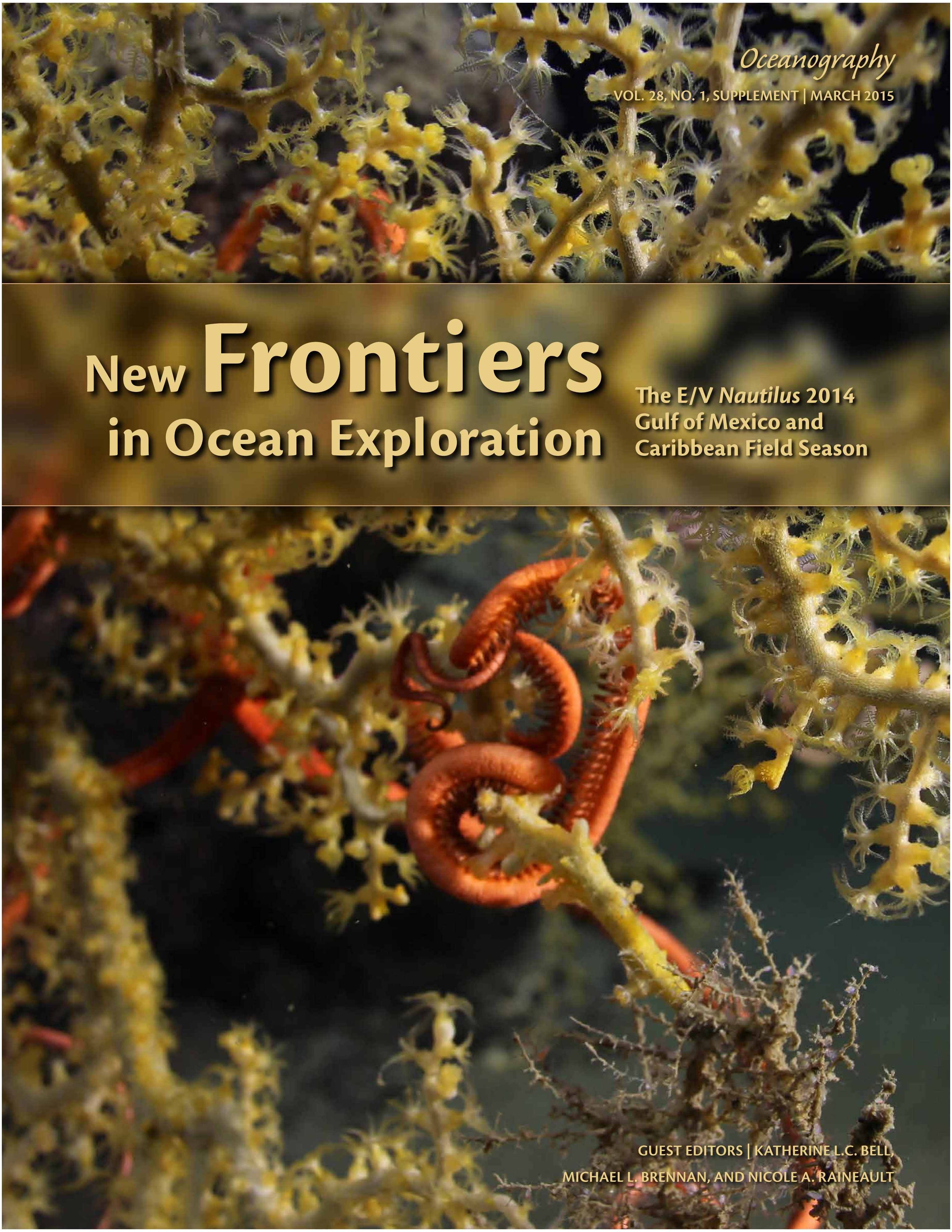
New Frontiers in Ocean Exploration

The E/V *Nautilus* 2014 Gulf of Mexico and Caribbean Field Season



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Exploration of the Windward Passage and Jamaica Channel: Tectonic Gateways to the Caribbean Sea

By Marie-Helene Cormier, Ruth Blake, Dwight Coleman, Kelly Guerrier, Nixon Saintilus, Jamie Wagner, and Steven Auscavitch

In August 2014, E/V *Nautilus* explored the region delimited by two deep straits of the northern Caribbean: the Windward Passage, which separates Cuba and Haiti, and the Jamaica Channel, which separates Jamaica and Haiti (Figure 1). Tectonically, the depth of each strait is controlled by a left-lateral transform fault: the Septentrional Fault and the Enriquillo-Plantain-Garden Fault (EPGF). Both faults slip at approximately 1 cm/yr and have produced large historical earthquakes. The Septentrional Fault last ruptured offshore Haiti in 1842, destroying the town of Cap Haitien. A previously unrecognized fault that abuts the EPGF system (now known as the Léogâne Fault) ruptured catastrophically in 2010 near Port-au-Prince, with devastating consequences, including a death toll of greater than 100,000. Tsunamis were associated with both earthquakes. Hydrographically, the Windward Passage is a major Caribbean "gateway," accommodating two-way water exchange between the North Atlantic Ocean and the Caribbean Sea. Thus, it is likely to be of key importance for deep-sea ecosystems.

The specific objectives of expedition NA050 were to follow the traces of the Septentrional Fault and the EPGF and detect signs of recent tectonic activity and landslides, characterize the water column, observe the benthic ecosystems, and inventory potential cold seeps. We also set out to explore the slopes surrounding Navassa Island, a small, uninhabited island managed by the US Fish and Wildlife Service as a National Wildlife Refuge. Because of the protected status of this island, a unique and pristine mesophotic ecosystem was expected in its vicinity. Navassa is located only 20 km north of the EPGF, but its structural and tectonic relation to that plate boundary is unclear.

Altogether, eight *Hercules* ROV dives were carried out in water depths ranging from 2,300 m to 200 m. The Septentrional Fault is clearly visible in the *Hercules* video imagery as impressively steep escarpments, or in places, as a series of thin slivers of rocks aligned subparallel to plate motion (Figure 2). South of Navassa Island, we explored the headscarp and a 4 km wide landslide debris field. Its age remains unclear, making it difficult to correlate it to a particular earthquake event. At the base of the steep northern slope of Navassa Island, we observed lava flows draping over sediment (Figure 3), which may have been emplaced as part of the Caribbean Plateau or as part of the volcanic arc that migrated eastward through the area—suggesting that Navassa likely grew as a coral atoll over a volcanic substrate. We also explored the length of a small canyon that had been folded and whose walls were colonized by a diversity of corals and other benthic animals. While we anticipated discovering some fluid seeps along the transform fault, as has been reported elsewhere in similar tectonic settings, we did not. This is not surprising because seeps typically affect only small areas of the seafloor, can be ephemeral, and are often discovered serendipitously.

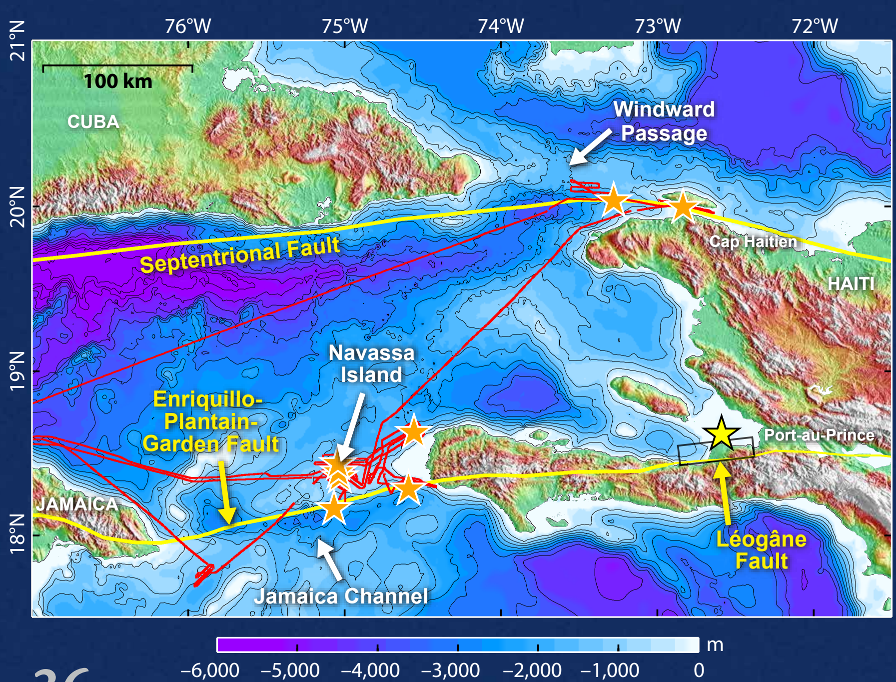

FIGURE 1. Map of the Windward Passage and Jamaica Channel regions, showing the location of the islands of Cuba, Jamaica, and Haiti, along with the two major strike-slip fault systems, the Septentrional Fault to the north and the Enriquillo Plantain-Garden-Fault to the south (yellow lines). The location of the 2010 Port-au-Prince earthquake is indicated by a yellow star, and the black box approximately outlines the associated rupture area on the Léogâne Fault. The red lines indicate the ship tracks and the orange stars the dive locations.

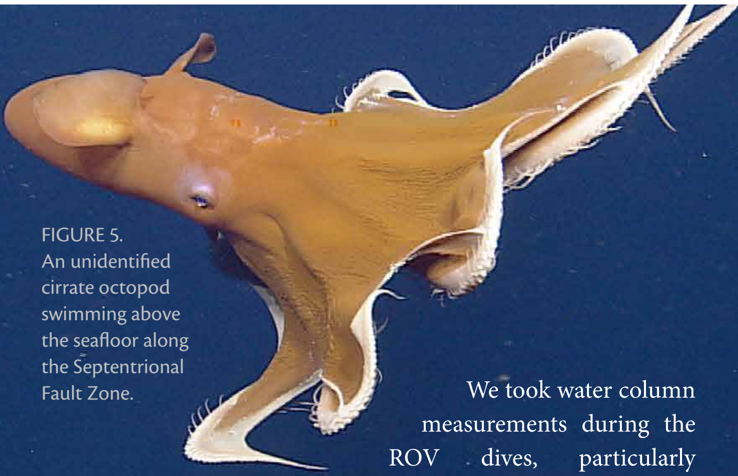

FIGURE 5. An unidentified cirrate octopod swimming above the seafloor along the Septentrional Fault Zone.

FIGURE 2. Highly tectonized seafloor within the damage zone of the Septentrional Fault.

We took water column measurements during the ROV dives, particularly along the deepest parts of the Windward Passage and Jamaica Channel. We used the CTD and Niskin bottles mounted on the ROV to obtain information on water column properties and to sample different water masses within the Windward Passage proper, along the convergence zone between Atlantic and Caribbean waters, and within and outside of Jamaica Channel. We also obtained vertical profile samples of the water column to study regeneration of dissolved phosphate from sinking organic matter ("marine snow") using PO_4 stable oxygen isotope compositions. Two mini-autonomous plume recorders (MAPRs) clamped onto the ROV cable measured and logged the presence of suspended particulate matter, oxidation-reduction potential, pressure, and temperature. The data did not reveal anomalous measurements that might have indicated hydrothermal plume activity or fluid seeps along the fault systems.

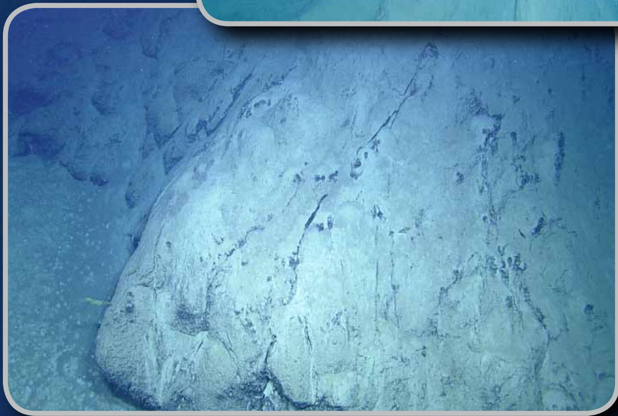

FIGURE 3. A lava flow covered with a thin veneer of sediment exposed at the base of the steep northern slope of Navassa Island.

Some physical properties of water circulation through the Windward Passage and Jamaica Channel were examined during the cruise. Two drifters developed and deployed by the students involved in the Ocean Exploration Trust's Honors Research Program (see page 22 for details) floated with the ocean currents, and their positions were tracked with a GPS receiver. The information collected was regularly transmitted to a shore-based server, allowing the students to record drifter speed and location over time. Both drifters recorded data for several months and revealed an interesting pattern of eddy activity and an overall surface flow through both channels directed westward toward the Yucatán.

FIGURE 4. An unidentified red-orange brisingid sea star observed in a submarine canyon northwest of the Tiburon Peninsula.

This *Nautilus* expedition provided the first observations of animal life on the deep seafloor of the Windward Passage and Jamaica Channel, as well as the deep slopes of Navassa Island and Hispaniola. During our exploration of the region, we encountered diverse seafloor communities. Hard-bottom slopes of Navassa Island and Hispaniola, below ~200 m, were frequently covered in clusters of sponges and cold-water corals. Rocky walls and escarpments in this area hosted a diverse assemblage of corals, including solitary and colonial stony corals, primnoid and bamboo octocorals, and black corals, as well as their numerous invertebrate and fish associates. Fauna were notably sparser on soft sediment patches at the bases of slopes and escarpments, and consisted primarily of sea cucumbers, crinoids, asteroid sea stars, and occasional sea pens (Figure 4). In addition, there were a few observations of pelagic fauna, particularly the cirrate or "dumbo" octopods (Figure 5) and large chains of siphonophores. Biogeographic questions remained to be answered as to the relationship of these faunas with those of adjacent ocean basins in the Caribbean Sea, Gulf of Mexico, and western Atlantic Ocean.