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Contaminants in Queen Conch (*Strombus gigas)* in Vieques, Puerto Rico

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ABSTRACT

Pollution has the potential to negatively alter coastal ecosystem health, including fisheries species, through direct impacts, food web effects and habitat degradation. Vieques is an island municipality of the Commonwealth of Puerto Rico, which lies off the east coast of the main island. In addition to normal pollution stressors associated with human activities, Vieques was also the site of a military bombing range from the 1940s until 2003. There is significant local concern about potential negative impacts of pollution from these and other activities on fisheries stocks, as well as seafood as a vector for toxic contaminants to enter the human food supply. In this study, queen conch (*Strombus gigas)* tissues were analyzed for a suite of contaminants: metals, the pesticide DDT (and its degradation products), and energetic compounds (associated with munitions) from three areas around the island. The magnitude of contamination found in queen conch was within the range of values reported in other studies in the Caribbean, suggesting that the levels of these selected contaminants present in conch in Vieques are not unusual for the region.

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1. Introduction

Current and historical land use has the potential to impact the ecological health of marine ecosystems. Land based sources of pollution, such as nutrients, sedimentation and toxics, can affect critical habitats, alter food webs (e.g. by reducing reproductive success and therefore abundance), and directly affect the health of marine organisms. In addition to affecting ecological health, pollution can impact harvested species, both in terms of altering the stocks of the species, and also in terms of toxin body burdens which may affect the safety of the seafood for human consumption.

Vieques is an island municipality of the Commonwealth of Puerto Rico (United States) that lies 11 km off the east coast of the main island (Fig. 1). It is 35 km long, is 7.2 km wide at its widest point, and is characterized by rolling hills with its highest point being Mount Pirata (301 m) on the western side of the island. There are numerous coastal lagoons and bays with varying degrees of connectivity to the ocean. Like mainland Puerto Rico, its climate is tropical (with temperatures ranging from 19° to 32 °C) with a dry season (December to April) and a rainy season (May to November). There are two towns on the island, Esperanza on the south coast and Isabel Segunda on the north coast (Fig. 1). The 2010 US Census reported the population of Vieques to be 9301 (US Census, 2010).

Previous work (Bauer et al., 2010) showed that the benthic habitat in the Vieques marine environment was a mix of turf algae, macroalgae, gorgonians, crustose/calcareous algae, hard coral, and sponges. Turf algae made up the highest percentage of the bottom area. As is the case in much of the Caribbean, hard coral cover was generally low. The fish community observed in the study consisted of 34 taxonomic families and 110 species, with wrasses and damselfishes being the most abundant, and surgeonfishes and parrotfishes accounting for the highest proportion of biomass. One of the major findings of this previous study was that Vieques is similar in terms of benthic cover, total fish abundance and biomass to other nearby locations in Southwest Puerto Rico, St. Croix and

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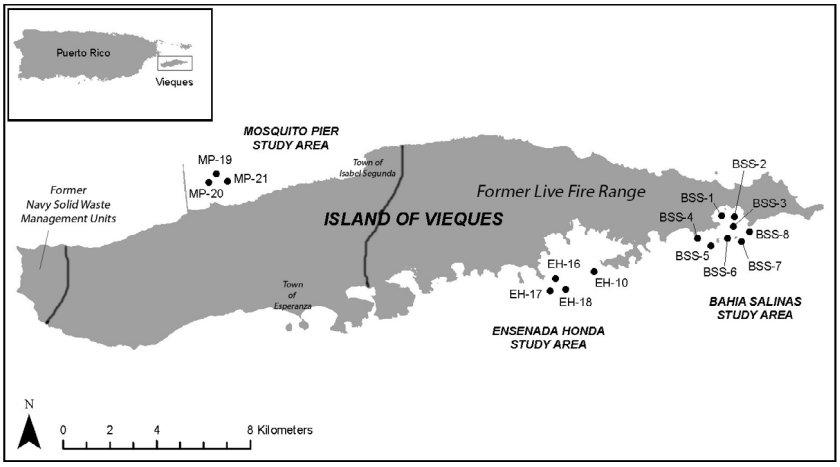

Fig. 1. Site map with labels. MP = Mosquito Pier, EH = Ensenada Honda, BSS = Bahia Salinas del Sur. Locations of former military activities are also shown, including live fire range on the eastern end of the island and waste disposal (including munitions) on the western end.

St. John in the US Virgin Islands (USVI). Longshore ocean currents generally move from east to west (Bauer et al., 2008).

Vieques has a varied and unusual land use history. Spanish colonists cleared much of the land for sugar cane production in the mid-1800s, and the sugar industry prospered into the early 1900s. Puerto Rico, including Vieques, became part of the United States in 1898 following the Spanish-American War. In the 1940s, the United States annexed approximately two-thirds of the land on Vieques for use by the Navy as a base and training facility. This included ammunition storage and disposal on the west end of the island and live fire training activities on the east end of the island, including air, sea, and maneuver warfare, air-to-ground bombing, amphibious landings, and artillery training operations (DON, 1979, 1986, 2001; GMI, 2003; CH2M HILL, 2004; GMI, 2005). Naval activities ceased in 2003 as controversy over the Navy's presence in Vieques escalated. In 2003, the Navy transferred most of this land to the Department of the Interior's Fish and Wildlife Service to create the Vieques National Wildlife Refuge. Public access to some of these lands is restricted due to safety concerns related to unexploded ordnance. In 2005, the former Navy areas of Vieques were designated as a "Superfund" site under the Comprehensive Environmental Response, Compensation, and Liability Act, requiring environmental investigation and cleanup by the Navy. Cleanup activities are expected to continue through at least 2025.

Reported high cancer rates on the island (ATSDR, 2013) have led to widespread speculation that the marine environment is polluted from historical land uses and that seafood might be a vector for human exposure. More recently it has been hypothesized that contaminants have led to a decline in the Vieques fishery (Caribbean Business, 2013). A previous study (Pait et al., 2010) found relatively low levels of contaminants in marine surface sediments, with the exception of chromium (elevated at one site on the northeastern side of the island) and DDT (elevated at four sites on the southeastern side of the island).

In order to assess the hypothesis that contaminants are entering the marine food web at deleterious levels, this study reports contaminant concentrations in queen conch (*Strombus gigas*) collected from three areas around Vieques. Conch was suggested by local fishermen as an important species, and their habitat and feeding mechanisms are well suited to examining contamination. Queen conch are large marine soft bodied gastropod mollusks with a hard calcium carbonate shell. They are found throughout the tropical western Atlantic (Martin, 1995), generally in waters between 5 and 20 m, with their depth range is limited primarily by food sources (Sterrer, 1986). The habitat includes coral reefs, rocky shores, seagrass beds and patchy sand flats (Randall, 1964). Queen conch feed on algal plant material (e.g. Thalassia), epiphytes and benthic algae, may ingest sediment particles during this process (Randall, 1964). Conch can live up to 30 years (McCarthy, 2008) and reach up to 30 cm in length (Randall, 1964). Individuals reach sexual maturity at 3–4 years of age (McCarthy, 2008) and are especially susceptible to predation as juveniles, i.e. prior to shell formation (Appeldoorn, 2013). Queen conch have relatively small home ranges (mean of 6 ha, Glazer et al., 2003). This small home range, in combination with its benthic habitat, make conch well suited for contaminant studies. Conch is an important food source across the Caribbean. Pollution has been shown to negatively impact queen conch populations in the Caribbean (Glazer et al., 2008; Spade et al., 2010).

Previous studies (Apeti et al., 2014; Rizo et al., 2010) have quantified contaminants in queen conch, and others (Glazer et al., 2008) have correlated the presence of contaminants (metals, PAHs, PCBs, DDT) with conch reproductive health. The conch tissues were analyzed for a suite of munitions-related (energetic) compounds, metals and DDT and its breakdown products.

2. Materials and methods

2.1. Sampling design

In April of 2014, scientists from NOAA and the Puerto Rico Department of Natural and Environmental Resources (DNER) consulted with the local fishing community to determine fishing areas of concern near the island. Federal resource managers and environmental regulators (US Fish and Wildlife Service and US Environmental Protection Agency) also were consulted. Two areas on the south shore of the island were identified as being of concern: Ensenada Honda and Bahia Salinas del Sur (Fig. 1). Bahia Salinas del Sur is located adjacent to the former Live Impact Area (LIA), where most of the live bombing exercises occurred. Ensenada Honda, while not in the LIA, is adjacent to, and downstream from (based on the prevailing longshore current) the restricted area were military activities occurred. Additionally, the fishermen identified an area on the north shore, near Mosquito Pier (Fig. 1), as an area relatively less impacted by pollution. While this "unimpacted" site is not a true control, it is useful for comparative purposes, as it is far less likely to have been affected by military activities. The benthic habitat of all three sampling areas contained a mix of coral reefs, seagrass beds and unconsolidated sediments. Within the two larger sampling areas (Ensenada Honda and Bahia Salinas del Sur), the sampling area was geographically divided into three sub-areas

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