

CASE STUDY: Croatia

BY ROBERT E. BOWEN, ANAMARIJA FRANKIC, AND MARY E. DAVIS

CROATIA AND COASTAL POPULATION

Croatia is a complex mix of coastline and 1,246 fringing islands. Many of these islands have full-time resident populations, while many others are visited regularly by recreational bathers in season. The Croatian coastline is home to 1.68 million people, which represents about 38 percent of the total national population (WRI, 2005). During the summer, an additional one million tourists visit the coast (MMTPR, 2005). In addition, the Adriatic Sea receives human and industrial waste from a resident watershed population of 15 million. Wastes from this watershed system make up approximately 35 percent of the total pollution load flowing into the Mediterranean (Kucpilic, 2005) (see Bowen et al., in press; Dewailly and Knap, this issue; Dewailly, this issue; Dufour and Wymer, this issue).

CONTAMINANT BURDENS IN CROATIAN SEAFOOD

The Adriatic Sea is located in the northeastern Mediterranean and is strongly influenced by the Po River watershed. It is characterized by low precipitation, high evaporation, low tidal action, low nutrient content, low suspended load, and low biological productivity. Several studies have addressed the question of contaminant burdens in commercially available fish in or near Croatian waters. Those studies argue that an initial focus on levels of mercury and polychlorinated biphenyls (PCBs) may be warranted (CIESM, 2004).

Mercury

Several papers concerning concentrations of mercury and methyl mercury in fish caught in the Adriatic and Mediterranean were published between 2000 and 2003. In Storelli and Marcotrigiano (2000, 2001), the total mercury in megrim (112 samples), common sole

(100 samples), striped mullet (312 samples), angler-fish (120 samples), and black-bellied angler (156 samples) caught in the South Adriatic Sea was measured. These species represent a mix of benthic (bottom-feeding) and pelagic (water-column feeding) fish. The benthic anglerfish species contained concentrations of mercury as high as 2.22 mg/kg, with means of 1.3 mg/kg for anglerfish and 0.7 mg/kg for black-bellied angler. A correlation between the size of fish and the concentration of methyl mercury was also observed in each species. Regulatory standards vary from country to country; however, 1.0 mg/kg is generally considered the trigger for management action.

Higher concentrations of methyl mercury were observed in bluefin tuna with a mean of 1.02 mg/kg for tuna (range, 0.07–4.26 mg/kg). Storelli et al. (2002) reported results for mercury/methyl mercury in tuna and sharks taken in the Adriatic Sea. The average concentration of mercury in spiked dogfish (*Squalus acanthias*) was 6.5 mg/kg—six times the common regulatory limit. In addition, mercury concentrations in commonly consumed fish in Croatia were examined in 2003. Hake (three samples) was found to contain mercury at an average concentration of 0.375 mg/kg. Anchovies, sardines, bogue, mackerel, and mussels all contained mercury at an average concentration of < 0.28 mg/kg (Juresa and Blanusa, 2003).

PCBs

A more limited set of recent studies has revealed levels of concern for PCBs in regional seafood. One study reports on the monitoring of chlorinated hydrocarbons in meat and fish in Croatia. Four hundred and sixty-six fatty-tissue samples of beef, pork, poultry, and fish were assayed between 1992 and 1996 for chlorinated hydrocarbons, including HCB, alpha-HCH, lindane, DDT and metabolites,

and total PCBs. Samples were divided into two groups: (1) meat and fish imported to Croatia and (2) meat from Croatian farms and fish from the Adriatic Sea. However, PCB levels in domestic fish were considerably higher (average 0.046 mg/kg) than in imported fish (0.006 mg/kg) (Kipic et al., 2002). Although these absolute numbers do not register an acute health concern, they do suggest levels of domestic product as holding comparatively higher amounts of PCBs than imported norms.

CROATIAN COASTAL TOURISM AND BATHING-WATER QUALITY

The Mediterranean is the world's number one tourist destination, generating one-third of global tourist revenues. Today, 63 percent of European tourists prefer the coast as a primary holiday destination. In Croatia, recent research suggests that overall tourism contributed 30 percent of total Gross Domestic Product (GDP) (US \$20.6 billion). In 2005, 10 million tourists visited Croatia, and recent government documents have established a goal to achieve 11 million by 2010 (MMTPR, 2005).

A significant risk vector for coastal tourists is direct contact at bathing beaches, with monitoring and beach closing as the dominant management tools. In Croatia, recent monitoring indicates promising results. Water-quality testing at beaches during 2003 and 2004 showed that 98 percent of samples complied with the standards set forth in the "Regulation on Bathing Water Quality Standards" (MZOPU, 2004). This regulation is based on the *European Council Directive 76/160/EEC Concerning the Quality of Bathing Water* (based on the "Annapolis Protocol"). Sea-water quality at beaches in Croatia has been monitored since 1988 (MZOPU, 2004).