**DEVELOPMENT, PHYSIOLOGY AND ENVIRONMENT: A SYNTHESIS**

Section III: Developmental Challenges

Chapter 10: Case Study: THE 2010 GULF OIL SPILL

John P. Incardona and Nathaniel L. Scholz

Field and laboratory studies following the 1989 Exxon Valdez oil spill in Prince William Sound, Alaska, revealed new insights into the interactions between aquatic pollution and heart development in fish. The observation of cardiac-related defects in wild herring and salmon spawned near oiled shorelines led to more than two decades of research to characterize the developmental toxicity of crude oil and crude oil-derived compounds, especially polycyclic aromatic hydrocarbons (PAHs). By the time of the 2010 Deepwater Horizon incident, this mechanistic understanding had advanced to the point where potential impacts to the developing heart were a key focus for natural resource injury assessment activities focused on mahi mahi, tunas, and other species that spawn in the northern Gulf of Mexico. For both types of crude oil, subclasses of PAHs containing three aromatic rings, as well as complex mixtures, were found to have disruptive effects on cardiomyocyte physiology, blocking key ion channels involved in excitation-contraction (E-C) coupling. Disruption of E-C coupling by crude oil leads to rhythm and contractility defects at the whole-heart level, which concomitantly leads to abnormal development if exposure occurs during cardiac morphogenesis. Studies spanning a range of oil exposure concentrations have now identified a spectrum of developmental defects, from acute embryolarval heart failure and related secondary malformations to more subtle anatomical changes in outflow tract and ventricular structure, the latter leading to a permanent reduction of cardiorespiratory performance later in life. The state of the science now indicates that virtually all teleosts show a cardiotoxic response to crude oils. Moreover, nuanced differences in the nature of the cardiotoxicity across taxa is likely to be more influenced by species life history than by the geological origins of different oils. This is attributable to variations in the roles of specific macromolecular targets for PAHs in the hearts of fish with different swimming physiologies. Specifically, these targets include ion channels that control cardiomyocyte repolarization (e.g., rectifying potassium channels) and contraction (e.g., sarcoplasmic reticulum calcium channels). Overall, research on oil spills has shown how the early development and ecophysiology of fishes shapes their vulnerability to a global environmental threat.