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A Review of Histopathological Effects of Selected Contaminants on Some Marine Organisms

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Histological assessment of the effects of environmental pollutants on marine organisms includes consideration of trends which develop that may link a closely related group of compounds to a representative tissue or organ response. Definition of such a relationship could benefit adjudication of water pollution controversies and, thus, the enforcement of public water pollution laws.

Evidence based on numerous histological evaluations suggests two frequent responses to toxic materials which may represent trends: 1) petroleum hydrocarbon exposures often cause anomalies which involve or are closely associated with the vascular system of many organisms, and 2) that some neurosensory organs in finfishes are extremely sensitive to an array of toxic materials. Although the nature of lesions usually differs with the type of toxic substance encountered, olfactory organs appear to be particularly sensitive. In addition, neurosensory tissue sensitivity in at least two species of finfish has been affected by adverse water quality.

VASCULAR RESPONSES

Petroleum hydrocarbon studies have indicated that the primary response of selected vertebrates and invertebrates often involves some element of the vascular system. Specifically, Atlantic silversides, *Menidia menidia*, responded to waste motor oil with changes in cellular integrity of atrial valves and other vascular anomalies (Gardner et al., 1975). Waste motor oil and crude oil have induced extensive alterations in the pseudobranch, a highly vascular organ, in some marine fishes (Gardner, 1975; Gardner et al., 1975). Crude oil, in addition, induced necrosis of ventricular myocardium in Atlantic silversides (Gardner, 1975). Both water soluble and insoluble fractions of crude oil also induced various lesions in Atlantic silversides. Dilation and congestion of submucosal vasculature in olfactory organs occur with exposure to the water insoluble fraction (Gardner, 1975).

Effects of waste motor oil and of #2 fuel oil on oysters, *Crassostrea virginica*, and scallops, *Aequipecten irridians*, at the cellular level indicate that these petroleum products may commonly induce lesions in the heart and promote amebocytic inclusions of afferent vessels (Gardner et al., 1975).

Lesions induced by petroleum hydrocarbons in tissues other than those of the circulatory system include necrosis of oyster mantle; cellular alteration associated with the food groove of the scallop (Gardner et al., 1975); and deterioration of epidermal cells of lobster, *Homarus americanus*, carapace. Concentrations of 1 ppm #2 fuel oil also impair chemoreception in lobsters, although lesions could not be linked to abnormal behavior (Gardner, unpubl. observations).

In addition to the preceding histopathological effects of petroleum exposure, long-term studies have been initiated in an attempt to induce neoplasia in the soft-shell clam, *Mya arenaria*. The purpose of these studies is to provide insight into the etiology of gonadal tumors found in clams collected from various locations in the State of Maine. Circumstantial evidence links tumors found in clams in Maine to accidental spillage of jet and #2 fuel oil.

NEUROSENSORY RESPONSES

Neurosensory organs have demonstrated a sensitivity to petroleum hydrocarbons, some heavy metals, pulp mill waste, and possibly pesticides (Eisler and Gardner, 1973; Gardner, 1975; Gardner and LaRoche, 1973; Gardner et al., 1975; U.S. Environmental Protection Agency, 1972).

Whole crude oil and water soluble and insoluble fractions of crude oil each elicit different cellular responses in olfactory organs of Atlantic silversides. Water soluble components elicit epithelial metaplasia. Water insoluble components induce dilation and congestion of submucosal vasculature. Whole crude oil induces a marked hyperplastic response (Gardner, 1975).

Some heavy metals induce lesions in olfactory organs and other organs associated with the lateral line of fishes. Copper, mercury, and silver are known to induce such lesions in some species (Gardner, 1975; Gardner and LaRoche, 1973). Generally, lesions induced in sensory organs are characteristic of the metal and are distinguishable from each other. Other metals, of which cadmium is one, are not known to elicit lesions in sensory organs (Gardner and Yevich, 1970). However, cadmium and low levels of copper together elicit a synergistic effect which promotes a renal lesion characteristic of cadmium exposures, as well as lesions in sensory organs that are characteristic of copper toxicity (Eisler and Gardner, 1973).

Neurosensory responses of finfishes

similar to those caused by petroleum and heavy metal exposure have also been observed in the mummichog, *Fundulus heteroclitus*, following exposure to the pesticide methoxychlor, and in Atlantic salmon, *Salmo salar*, exposed to a pulp mill waste (Gardner, 1975; U.S. Environmental Protection Agency, 1972).

Atlantic salmon olfactory senses were impaired by severe cellular damage following exposure to a range of pulp mill waste concentrations in experimental bioassays. Concurrent with laboratory bioassays, Atlantic salmon were exposed in situ to pulp mill waste. Results of in situ studies at locations from the point of discharge to 8 miles downstream from the point source proved similar to laboratory results.

Menhaden examined from three New England coastal areas had lesions associated with internal ear, lateral line, and olfactory organs. Though etiology of these lesions remains unknown, all three collection points were found to have high levels of copper in the water column (Gardner, unpubl. observations; Gardner et al., 1975). Comparability of laboratory and field study results with Atlantic salmon and field observations of menhaden, *Brevoortia tyrannus*, gives credence to histological findings with other species.

LITERATURE CITED

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NOAA/NMFS Developments

Inhibition of Proteolysis in Pacific Hake Fillets

To date, U.S. processors have used the Atlantic whiting, *Merluccius bilinearis*, and species of hake imported from South America and South Africa, for much of the production of fish sticks and portions. As a result of the Fishery Conservation and Management Act of 1976, U.S. fishermen and processors have shown an interest in using the Pacific hake, *Merluccius productus*, for domestic markets and possibly for export.

The Utilization Research Division of the Northwest and Alaska Fisheries Center (NWAFC), NMFS, NOAA, Seattle, Wash., has been examining the quality characteristics of the Pacific hake to solve any technological problems that might present themselves as barriers to the full utilization of this resource by U.S. industry. On occasion, the Pacific hake develops an undesirably soft texture of the flesh that must be overcome before the resource meets all the quality requirements of the U.S. consumer. When a change in Pacific hake texture occurs, it is due to the presence of an enzyme (a protease) that is capable of breaking the chemical bonds of the muscle fibers that give any flesh food its characteristic texture. When the protease is present, it is capable of breaking bonds at nearly any temperature above freezing, but it does this most rapidly at temperatures just a bit lower than those that destroy the enzyme itself. During such conventional cooking processes as baking, broiling, and pan-frying, temperatures are reached that enhance the action of the protease and continue for a time before reaching the level that will destroy the protease. Several methods of preventing this textural change have been tried (i.e., very rapid cooking, sonication, and the use of chemicals to inactivate the enzyme, all of which have the potential for inactivating the enzyme before it damages the muscle. Recent laboratory tests by Ruth Miller, research chemist, in the Utilization Research Division, have demonstrated that two common oxidizing agents, hydrogen peroxide and potassium bromate, are effective in inactivating the enzyme. Even when used in concentrations of less than 0.5 percent, either of these additives achieves nearly complete inhibition of the enzymes. Hydrogen peroxide appears to be the reagent of choice because it is rapidly decomposed into water and oxygen, leaving no undesirable residue. The effectiveness of hydrogen peroxide can be enhanced by the simple expedient of changing the pH of the fillet. These parameters and rapid application techniques are being developed at the NWAFC.

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