A review of the preference-avoidance responses of fishes to aquatic contaminants

By

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I. Introduction

The use of behavioral endpoints in environmental hazard and impact assessment has become a major field of study in recent years. Although behavior has always been accepted as an important aspect of animal survival and ecology, toxicological research over the past two decades has concentrated primarily on lethality, growth, and reproductive success. Behavioral toxicology has lagged in areas of impact assessment for several reasons: (1) difficulties in objectively quantifying behavioral endpoints, (2) variability associated with the endpoint, (3) lack of standardized testing procedures which would provide more comparable data, and (4) difficulties in extrapolating to field situations the ecological significance of effects observed in the laboratory. These problems certainly are not unique to ethological testing but have proven to be obstacles to its success as an impact assessment tool.

As an assessment tool, the study of behavior must be limited to those observations which can be objectively and rapidly quantified. These criteria effectively reduce the infinite range of behaviors for study, so that behavioral bioassays for aquatic organisms have developed along four principal lines of inquiry: (1) locomotor responses, primarily preference-avoidance reactions and activity changes; (2) ventilatory responses, primarily opercular movements and coughs; (3) predator-prey interactions; and (4) toxicant-induced changes in conditioned behavior. Although a myriad of behavioral patterns are essential to the survival of a species, we chose to focus on the preference-avoidance reactions in this review because of the apparent ecological and economic significance of this behavior. Effective concentrations are reported for the other three categories, however, when these data are available. For a complete review of behavioral toxicology in fishes, as measured by changes in conditioned responses, see Marcucella and Abramson (1978).

In this review we discuss a broad range of chemical contaminants by comparing concentrations causing preference and/or avoidance with concentrations eliciting other behavioral changes, biochemical or physiological alterations, and acute and chronic toxicity. Although previous reviews have been presented on various aspects of behavioral responses of fishes and invertebrates to aquatic contaminants (Anderson 1971, Sutterlin 1974, Scherer 1977, Maciorowski *et al.* 1977, Larrick *et al.* 1978, Cherry and Cairns 1982, Cairns and van der Schalie 1981), no review to date has been found which systematically evaluates the relative sensitivities of the diverse testing methods.

II. Methods and definitions of terms

A wide variety of experimental techniques, ranging from highly automated computer-interfaced systems to those using human observation, have been used to quantify behavioral responses. For preference-avoidance reactions, the experimental chambers generally fall into two categories: (1) steep-gradient chambers provide the organism with distinct choices between water treated to a given con-