

II. INTRODUCTION

The study documented by this report is part of the effort to characterize the ecosystem of the Galveston Bay estuarine system (including Galveston, Trinity, West, East, Christmas, Bastrop, and several other minor bays; hereafter referred to as the Galveston Estuary). Its purpose is to substantiate potential problems, as indicated by significant declines in species abundances, to evaluate the possible causes of the declines, to call attention to critical missing data, and to recommend possible management solutions or additional research.

This report represents the second part of a two-year project. The first phase concentrated on trend analyses for selected economically and ecologically important species: fourteen species of finfish and shellfish, eight species of birds, and alligators. Available data were summarized for open bay benthos, marsh benthos, and plankton. Oysters were studied elsewhere (Powell 1993). Results of the first phase of the study were published as "Status and Trends of Selected Living Resources in the Galveston Bay System" (Loeffler and Walton 1992).

Green (in Loeffler and Walton 1992) concluded that the overall health of the Galveston Estuary appears to be fair to good. Certain species, however, showed declining trends that were cause for concern: white shrimp and blue crab among fisheries species, certain colonial waterbirds (snowy egrets, roseate spoonbills, tricolored herons, and black skimmers), and some species of waterfowl (northern pintail, blue-winged teal, and mottled ducks).

The present report draws on the results of the first, and specifically focuses on underlying causes in addition to the documentation of trends. Factors that affect entire segments of the biota are discussed in Chapters III and IV. Chapters V, VI, and VII focus on those species that showed declines.

MATERIALS AND METHODS

Biological data sets

The standardized, fishery-independent Resource Monitoring Program conducted by the Fisheries and Wildlife Division of the Texas Parks and Wildlife Department (TPWD) provided most of the data used for aquatic species (the CF data set; Dailey et al. 1991). Details for sampling procedures are described in the TPWD Marine Resource Monitoring Operations Manual which is updated annually. Of the three gear types mentioned in this report, gill nets have been used in the Galveston Estuary since 1975-76, bag seines since 1977-78, and otter trawls since 1982-83.

Data for white and brown shrimp were collected by TPWD from 1963 through 1980 and transcribed onto computer files by the National Marine Fisheries Service (the

TPWD/NMFS data set). The data were taken using different methods from the CF data set but were useful for comparison, as discussed by Osborn et al. (1992). Historical trends for white shrimp are presented in Chapter V.

Recent years of commercial landings data for white shrimp were provided by the National Marine Fisheries Service. Landings data for blue crab came from the Texas Parks and Wildlife Department's Fisheries and Wildlife Division (Campbell et al. 1992). Recent and historical landings data, collected from Annual Reports of the Texas Parks and Wildlife Department and its ancestral agencies (the Texas Game, Fish and Oyster Commission and the Texas Game and Fish Commission), were described by Osborn (1992).

Of the data sets for birds, the most important to this report is the Texas Colonial Waterbird Survey, conducted annually during two weeks of the summer nesting season (Slack 1978, Texas Colonial Waterbird Society 1982, Martin 1989, Lange in review). Also mentioned are: the Mid-winter Waterfowl Transects, conducted from the air by the Texas Parks and Wildlife Department in cooperation with the U.S. Fish and Wildlife Service (Haskins 1990); Christmas Bird Counts, day-long tallies collected by a variety of means, sponsored by the National Audubon Society (Butcher 1990); and Shorebird Surveys of Bolivar Flats, conducted by the U.S. Fish and Wildlife Service. The data sets are described in greater detail by Slack et al. (in Loeffler and Walton 1992).

Several State and Federal agencies provided environmental data. These are described further in Chapter IV.

Statistical analysis

Numerical methods used with fisheries species follow those detailed in Osborn et al. (1992). Fisheries data permit the calculation of a Catch Per Unit Effort (CPUE), defined as the number of individuals caught per 0.03 hectare net area in the case of bag seine, or as per ten minutes net towing in the case of trawl. For aquatic species the results of trend analyses are shown as annual fitted values plus and minus the standard error, plotted with mean annual observed CPUE. Analysis of Deviance (ANODE) tables are presented in Appendix 1.

Size ranges and seasons used for the analysis of fisheries species in this report were chosen using the same reasoning described by Osborn et al. (1992): a size range was selected to represent the life stage of interest, and the data were confined to those months when individuals of that size are most abundant, to minimize zero catches and provide the best representation of geographic distribution. Data collected in 1991 became available during the course of this study and were included in analyses where possible.

Correlations between CPUE and environmental variables, described in Chapter III, were calculated using PROC CORR and PROC REG in SAS (PC Version 6.04). Only simple linear correlations are presented in Tables 1-3.

Work accomplished by Slack and others subsequent to the first phase of this project (1992) used detrended correspondence analysis, following the methodology of Spendelov et al. (1989), to recognize statistically significant within-community (structural) changes in assemblages of colonial waterbirds (Gawlik et al. 1992). Results of the analysis are discussed in Chapter VI.

For many phenomena that are reasonably expected to affect living resources, there were no data available of a duration, spatial coverage, and resolution comparable to that used to show population trends. For example, there is no routine monitoring for toxic organic compounds in the Galveston Bay System (Stanley 1989); expensive analytical procedures are used only for short-term studies or when there is reason to suspect a problem. Many "probable causes" are consequently not supported by a rigorous long-term correlation analysis. Because a cause is not ideally documented, however, does not mean it is not important. These situations are discussed in Chapter IV.

Species workshops

This study was initiated as a series of meetings with the purpose of assembling a group of experts to review the data. The participants in these meetings came from state and federal agencies, universities, conservation organizations, and private industry. The general approach during the workshops was similar: a presentation of the available data, a review of life history information from the literature, and a series of leading questions to guide discussion.

In all cases we attempted to address the following questions: What are the biases of data collection and analysis? What is the probability that the observed trends are artifacts rather than real biological phenomena? What is the probable temporal extent of the trends? Are the trends driven by a particular part of the Galveston Estuary? Are the trends unique to the Galveston Estuary or part of a larger phenomenon? Can the data be related to environmental factors, natural or human-induced? What are the possible consequences if the decline were to continue? And of course, what are the probable causes and possible remedies for the decline? The results of these discussions and follow-up studies were the foundations for Chapters V, VI, and VII.