STATUS AND TRENDS OF SELECTED LIVING RESOURCES IN THE GALVESTON BAY SYSTEM

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I. EXECUTIVE SUMMARY

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The Galveston Bay Estuary became a participant in the National Estuary Program (NEP) in October 1988. The goal of this program, sponsored by the U. S. Environmental Protection Agency, is to maintain estuaries in a healthy biological state while providing for other uses by developing a coordinated local, State and Federal management program.

The diverse uses of the Galveston Estuary inevitably pose potential threats to the survival of many estuarine species. The most urbanized areas of Texas lie within the Galveston Estuary drainage basin (Ditton et al. 1989). Approximately half of the nation's chemical production and a third of its petroleum industry are located in the Galveston Estuary area. Fifty-one percent of the wastewater discharge permits issued in 1987 by the Texas Water Commission were in the Galveston Estuary watershed. Yet in 1989, the Galveston Estuary produced 24-38 percent by weight of the Texas coastwide commercial harvest of finfish, shrimp, crab, and oysters (Johns 1990) and almost 40 percent of the recreational harvest (Green et al. 1991).

This report is part of the effort to characterize the ecosystem of the Galveston Estuary. Its purpose is to assess the relative health of the Galveston Estuary by evaluating the status and trends of several selected endemic species in order to identify potential problems, as indicated by significant declines in abundance, and to initiate the investigation of the probable causes of these declines.

The species studied were selected by members of the Galveston Bay National Estuary Program Scientific and Technical Advisory Committee. The list was assembled to include those groups fundamental to maintaining the Galveston Estuary ecosystem, and economically important taxa: commercially and ecologically important finfish and shellfish, locally breeding birds, alligators, plankton, and open bay and marsh benthos.

There were two phases to the project: the identification and examination of existing data sets containing information about target species, and the statistical analysis of those data sets with sufficient information to demonstrate temporal change.

SUMMARY OF RESULTS

Shellfish and finfish

Fish and shellfish trend analyses were done with Texas Parks and Wildlife Department Coastal Fisheries (CF) data collected during 1975 through 1990 (gill net), 1977 through 1990 (bag seine) and 1982 through 1990 (otter trawl). One data set for shrimp extended back to 1962. A complete listing of all species caught with these gear and catch per sample was compiled to summarize diversity information.

Of the fourteen different species that were analyzed, catch per unit effort (CPUE) showed a chronic decline only for blue crab and white shrimp. Blue crab young of the year (25-45 mm TW, total width) increased but there was a strong decreasing trend for juveniles and the life stage most valuable for reproduction, the first-time spawners. Adult crabs (>140 mm TW) also decreased in the later years of the analysis period. The decrease in large crabs in recent years may be a response to the dramatic increase in crab harvest since 1981. Young-of-the-year white shrimp (35-55 mm TL, total length) showed no trend. However, all larger white shrimp showed a marked decline in abundance. These decreases may be the result of overharvesting, loss of habitat, sublethal contamination by a chemical, or a combination of these. These two species are declining, and if there is no change in current population parameters, they may continue to decline.

Most species investigated showed different life stages to be a mixture of trends, including no trend at all (e.g. brown shrimp, southern flounder). For species that have high fecundity and live in an unstable environment, it is natural for the abundances of different age classes to be highly variable and for different trends to be exhibited simultaneously. Fish populations can be dominated by one or two age classes coming from highly successful spawns and subsequent excellent survival, so that a downward trend in later life stages, as members of this group die off, should not be alarming when compensating trends are found in the other life stages. Obviously, sustained declines in young of the year and first-time spawners should attract attention, especially if they occur simultaneously.

Red drum and spotted seatrout provided evidence supporting the hypothesis that some fish stocks were already in a state of reduced abundance during recent times. These species showed increasing trends for first-time spawners and remaining adults after regulations restricting their harvest were passed. The increases occurred in spite of three major freezes and a red tide outbreak in the area during the analysis period. Regulations that were recently passed to reduce the mortality of juvenile red drum and spotted seatrout included: the prohibition of commercial sale since 1981, the banning

of all nets in 1988, and the implementation of minimum and maximum sizes and daily bag and possession limits for recreational fishermen in 1982.

Historical data for brown shrimp collected during 1963-1968 and 1972-1980 were analyzed for total catch (all size classes for the months April through November) and for first-time spawners (85-110 mm TL) for the months May through August. No clear trend was noted for the years 1963-1968 in either group. However, the data showed a small increase in CPUE from 1972 through 1980 in both groups. This trend was strongly influenced by high catches during 1980.

In the CF data, both young of the year (30-55 mm TL) caught by bag seine and first-time spawners (85-110 mm TL) caught by trawl showed great year-to-year variation without any significant annual trend. The annual CPUE was highest during 1987 for both bag seine and trawl catches. Mean annual CPUE in bag seine and trawl catches appear to be correlated (1983 through 1990).

Grass shrimp declined in abundance from 1983 through 1987, but have been increasing through 1990 (the most recent year analyzed). Only one size group was analyzed because only adult grass shrimp were caught.

Juvenile Atlantic croaker caught by bag seine decreased slightly in abundance while mature croaker in both trawl and gill net catches increased. Young of the year (30-50 mm) increased in abundance from 1977 to 1983, then decreased through 1989. Croaker near the age to spawn for the first time (115-135 mm) caught by trawl showed a linear increase from 1983 through 1990. Mature croaker (230-275 mm) captured by gill net also increased linearly from 1975 through 1989.

Three size classes of bay anchovy (15-34 mm, 35-54 mm, and >55 mm) caught by bag seine all decreased in abundance from 1978 to 1990, with peak catches in 1981-1983. The same size classes caught by trawl had a nonlinear trend showing an increase from 1983 to 1990. However, the differences between the gear types may be an artifact of the different study periods, because both show slight increases during a common period of record (1984 through 1990).

Young-of-the-year black drum (55-85 mm) decreased in abundance from 1978 through 1990, while first-time spawners (300-400 mm) and remaining adults (>400 mm) increased.

The CPUE for young-of-the-year (20-30 mm) Gulf menhaden peaked in 1980, then declined through 1989. First-time spawners (100-120 mm) showed a non-linear trend, with maximum catch rates in the winter of 1985-86. The 1990 CPUE was slightly higher than those for 1983. Remaining adults peaked in 1977 but showed no long-term trend.

Young-of-the-year pinfish (40-60 mm) in bag seine catches peaked in 1984-85 and declined after 1985. Both juvenile (80-109 mm) and first-time spawning pinfish (110-140 mm) in trawl catches showed an upward trend in abundance.

Young-of-the-year sand seatrout (35-55 mm) caught by bag seine increased in abundance from 1978 through 1984, then generally decreased from 1984 until 1988, with high catches in 1982-84 and 1989. Juveniles (65-85 mm) caught by trawl increased in abundance from 1983 to 1990 though first-time spawners (140-160 mm) showed no annual trend during the same period. Remaining adults ($>=160$ mm) caught by gill net decreased in abundance from 1975 to 1989.

There was no significant trend in CPUE for either young-of-the-year (20-45 mm) or adult (>250 mm) southern flounder in this study.

Young-of-the-year striped mullet (20-40 mm) did not show a simple annual trend; peak CPUE occurred in 1981 and 1987. First-time spawners (230-275 mm) increased from 1983 to 1990, with peaks in the winters of 1985-86 and 1989-90. Age IV adults (275-314 mm) decreased from 1975 to 1979, then maintained fairly constant levels through 1990, while Age V+ adults (>314 mm) exhibited no quantifiable trend during the same period.

Birds

Bird trend analyses were mainly accomplished using data from the Shorebird Survey of Bolivar Flats (SSBF), Christmas Bird Count (CBC), Texas Colonial Waterbird Survey (TCWS), Mid-Winter Waterfowl Transects (MWWT), Mid-Winter Cruise Counts (MWCC), and North American Breeding Bird Survey (NABBS).

Several groups of birds showed similar trends across independent data bases, thereby providing corroborative support for the results. However, the results from these different data bases were not always consistent. The CBC showed an increase in populations of some waterfowl and colonial waterbirds while the TCWS and the MWT showed decreases. The two possible explanations for these discrepancies are (1) both trends are accurate but represent different populations of birds (i.e., breeding and wintering), or (2) trends from one data base are not accurate. Data on the ranges of birds in North America (Root 1988) indicate that coastal southeastern Texas receives an influx of colonial waterbirds during the winter season. The migration status of breeding colonial waterbirds in the Galveston Estuary area is less well known and there is no indication that breeding populations are made up of resident birds. Therefore, apparently conflicting trends for the TCWS and the CBC may actually reflect real trends for two distinct populations. The case for waterfowl is less clear because both data sets were basically collected during the winter period, though different months were sampled by the surveys. Given that the MWT has a more systematic design than does the CBC, the principal investigator's opinion is that the MWT more accurately reflects population trends.

Also, the Bolivar Flats Shore Bird Survey (SSBF) only permits the evaluation of trends in the use of Bolivar Flats, and is not a robust data base that can be used to evaluate trends on the Galveston Estuary as a whole. The numbers of black-bellied plovers, willets, sanderlings and western sandpipers increased based on both the SSBF and the

CBC, but American avocets and dunlins showed no change based on the SSBF, while both species increased based on the CBC. In this case the CBC is probably a more accurate indicator of regional population trends.

A decrease in total numbers for some species was reflected by a decline in numbers per colony. Based on the TCWS, snowy egrets, roseate spoonbills, and black skimmers showed a decrease in both the total number of birds and the average number of birds per colony. However, mathematical models describing the trend in the number of colonies containing these species indicated no change over time. Snowy egrets and roseate spoonbills increased in numbers based on the CBC. Numbers of black skimmers did not change based on the CBC.

Tricolored herons showed a decrease in the total number of birds observed per year, an increase in the number of colonies containing these birds, and a non-linear decrease in the average number of birds per colony based on the TCWS. Tricolored herons showed no change in numbers based on the CBC.

Olivaceous cormorants increased in total numbers and in the number of colonies based on the TCWS. There was no indication that the mean number of birds per colony was changing. Numbers of birds seen on the CBC increased; however, the increase varied among years and count-areas, indicating that birds moved around or nesting success was highly variable.

Numbers of colonies of black-crowned night-herons and Forster's terns increased, but it was not possible to describe changes in total birds or mean colony sizes based on the TCWS. Numbers of both species increased based on the CBC.

The number of colonies containing nesting great egrets showed a non-linear increase and the mean number of birds per colony decreased based on the TCWS. There was no change in the total number of individuals based on the TCWS, but CBC data showed an increase.

The number of American coots did not change significantly based on the Mid-Winter Waterfowl Transects (MWWT) and the CBC.

The numbers of green-winged teal, northern shovelers, and American wigeons have not changed over the sampling period based on both the MWWT and the CBC. However, counts varied depending on year and count-area for northern shovelers using the CBC, and between year and transect for American wigeons based on the MWWT. Again, this might indicate birds are changing their use of different areas depending on local conditions.

Mallards and gadwalls showed no change in numbers based on the MWWT. Models based on the CBC indicated that mallards are increasing linearly and gadwalls are increasing non-linearly.

Numbers of mottled ducks and northern pintails decreased based on the MWWT. In contrast, numbers of mottled ducks increased linearly and numbers of northern pintails increased non-linearly based on the CBC.

Blue-winged teal showed a non-linear decrease based on the MWWT. This species increased linearly based on the CBC.

Scaups, ruddy ducks, bufflehead, and wood ducks increased linearly and ring-necked ducks increased non-linearly based on the CBC.

Numbers of canvasbacks and fulvous whistling-ducks did not vary significantly based on the CBC.

Numbers of red-winged blackbirds did not change significantly over the sampling period based on the NABBS. No models were developed to adequately describe the variation in counts of great-tailed grackles and boat-tailed grackles among years based on the NABBS.

Alligators

Night-counts of alligators from 1971-1984 indicated a non-linear increase in numbers with the lowest counts occurring in the late 1970s. Satisfactory models could not be developed to explain the variation in numbers of nests from 1979 through 1983; however, no trends were evident using night-counts of alligators during this same period.

Benthos

Data in existing literature were examined in order to characterize bottom-dwelling communities.

Marsh benthos (bottom-dwelling animals)

Marine worms dominated the community of submerged soil-dwelling animals living in brackish waters in the delta marshes of Trinity Bay. Brackish-water clams were also abundant in subtidal habitats adjacent to delta marshes. Small crustaceans (e.g. amphipods), abundant elsewhere, were nearly absent from the delta. Animals living in submerged soils attained their highest densities and greatest variability in the mid-salinity marshes of Moses Lake and Smith Point. Benthic densities in the higher-salinity marshes of West Bay and Christmas Bay were intermediate to those in the deltas and in the Moses Lake and Smith Point region.

Open water benthos

Marine worms, mollusks, and crustaceans were usually the dominant animals found in and on open-bay submerged soils. Typically, one or two species were numerically dominant and these dominant species were generally one or two orders of magnitude

more abundant than other species. Therefore, they controlled the overall abundance trends of the assemblage.

Benthic assemblages generally exhibited a pattern of spring peak abundance and low fall abundance, but a few studies documented a second peak in the fall. Spring peak abundances generally occurred between February and May and the fall low generally occurred during October-November. Freshwater flood conditions can temporarily alter this normal seasonal pattern. These bottom-dwelling animals can be good indicators of salinity, but there are not enough data among the studies reviewed to document long-term changes in salinity patterns.

There appears to be an abundance gradient in the Galveston Estuary in which numbers of individuals increase from the Trinity Bay-Upper Galveston Bay region to the Lower Galveston Bay-West Bay region. This is the reverse of the pattern found in the San Antonio Estuary, and may reflect the more southerly location and overall higher salinity of the San Antonio Estuary. There also appears to be a gradient in which abundances decrease from the Galveston Estuary southward to the San Antonio Estuary.

Plankton

Existing literature was used to characterize plankton (small microscopic plants and animals incapable of swimming against tides or currents).

Phytoplankton (plants)

There are few detailed studies of the dynamics of the diverse phytoplankton of the Galveston Estuary. Several studies have examined phytoplankton species diversity in Galveston, but did not provide information on the species identified (Hohn 1959; Copeland and Bechtel 1971). One investigator (Strong 1971) found several species of diatoms to be most common at different times and locations. These studies have reported that diatoms and a green alga (Chlorella sp.) were dominant during the cold months, and several different species were dominant during other times of the year. They found species diversity was lower at the low salinity sampling stations than at the high salinity sampling stations, though the abundance of dominant species was not found to correlate precisely with temperature or salinity conditions. Generally, high cell numbers were more common in waters of lower salinity (0 to 15 ppt) than in waters of higher salinity (16 to 33 ppt).

It is difficult to draw conclusions about long term trends in phytoplankton biomass from the limited data sets available. There was some evidence for an increase in maximum chlorophyll levels, indicating a higher density of green algae: the maximum chlorophyll concentration measured by Zein-Eldin (1961) in the late 1950s was ca. 45 mg m^{-3}, but during the 1970s Mullins (1979) found a concentration of ca 70 mg m^{-3}.

Zooplankton (animals)

The dominant species of zooplankton in the Galveston Estuary were copepods, larval marine worms and larval barnacles (McAden 1977). Even less information is available about the spatial and temporal distribution of zooplankton than for the phytoplankton because fewer studies have been done. In the main study reviewed in this investigation the three stations sampled were in the intake canal and discharge canals of the Robinson Generating Station. No clear seasonal pattern in the abundance of any of the dominant species was found.

CONCLUSIONS

A primary problem identified by the GBNEP was concern over recent losses or alteration of living resources. Specific habitats named by the GBNEP to be investigated were wetlands, sea grasses, oyster reefs, and shallow bay bottom; other animal populations were not directly mentioned except as a priority problem identified as fisheries resource depletion. This study relates more to the goal of the GBNEP by beginning to develop a measuring stick for assessing the health of the Galveston Estuary. This was done by estimating the recent abundance of several populations living in or adjacent to the Galveston Estuary, and comparing them to past abundances.

Using the concept that biodiversity and ecological processes can be used to measure ecosystem health leads to the conclusion that the overall health of the Galveston Estuary System appears to be fair to good. This conclusion was based on the observation that there was not a wholesale decline in species population abundances and that a large number of species were present in all trophic levels, indicating that energy and material transport within and between trophic levels was occurring more or less naturally. However, apparent long term declines indicated in striped bass, green turtle, and diamondback terrapin populations and recent declines in white shrimp, blue crab, mottled ducks, northern pintail, blue winged teal, and all colonial water birds except olivaceous cormorants, provides ample reason for concern. This coupled with the knowledge that there have been major losses of wetlands and possibly oyster reef, that pressure for development along estuarine shoreline continues, and that the total harvest of animals that depend on the estuary has increased by 2000 percent during the last 100 years (including offshore harvest of shrimp and menhaden), provides reason to question whether the health of the Galveston Estuary can be maintained.

There were some significant increases in populations, namely in American alligators, red drum, spotted seatrout, Atlantic croaker, black-bellied plovers, willets, sanderlings, western sandpipers and olivaceous cormorants. Although not a subject of this study the brown pelican population also has increased. These provide evidence that the ecosystem is still operating and that rehabilitation programs can have an effect.

Although it was directed that this study not examine population trends of brown pelicans, reddish egrets, and piping plovers, these species were recorded in several data bases and could be analyzed in future studies.

Comparisons of data in available literature on phytoplankton, zooplankton and benthic populations indicated that primary production has been high and that the respective assemblages were reasonably healthy in recent years. These diagnoses were made with caution and with the knowledge that very few of the sampling stations were located in the vicinity of point discharges or major industrial complexes. Depressed benthic assemblages were found around brine separator platforms, and it is probable that similarly depressed fauna may be found at other localities throughout the bay and along the bay margin. Assemblages in the center of the bay appear to be normal for the prevailing salinity regime.

All the conclusions in this study regarding trends were made with the knowledge that data sets generally suffered from one or more of the following: sampling periods were short relative to population dynamics, spatial or temporal representation was poor, effort was not known, and sample sizes were small. Other data are available but have not all been synthesized and recorded in useable form. Nevertheless, the record was adequate to support the conclusions drawn and to provide information for improving future monitoring programs.

RECOMMENDATIONS

All the principal investigators made recommendations for specific sampling programs to monitor species or species groups. In these cases where ongoing monitoring programs were established, specific recommendations were made to improve those programs. Most of these recommendations were aimed directly at developing methods to estimate the abundance of populations and to recognize change in abundances through time. There was less attention paid to the question of which monitoring programs would be most important in assessing the overall health of the Galveston Estuary.

We recommend that the GBNEP create a committee with the assigned task of designing an integrated sampling program that could be used to track short-lived organisms (phyto- or zooplankton) as measures of ambient estuarine quality and longer-lived organisms (larger shellfish and fishes) as measures of trends in estuarine quality. This committee would have the primary goal of refining a definition of estuarine health for the Galveston Estuary and how the data from the proposed sampling program would successfully measure this health. This would require that careful thought be given to the way the estuarine ecosystem works. The committee must also recognize where and how sampling could be done that would not only address the question of population abundances but also why they are changing and whether humans have any control over the changes. Is the biggest threat the loss of habitat, toxicity, predation or disease, a decline in the food supply because it has been affected by the preceding, overharvesting, or a combination of the above? The value of the Galveston Estuary requires this monitoring effort to assure its wildlife communities are not lost and economics require this effort to be reasonable and efficient.