Economic Impact of the 2000 Red Tide on Galveston County, Texas
A Case Study

Prepared for

Texas Parks and Wildlife
State of Texas

by

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FINAL REPORT

TPWD No. 666226, FAMIS 403206

Tuesday, June 19th, 2001

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Executive Summary

The purpose of this case study was to estimate the economic impact of the 2000 Red Tide on Galveston, Texas. The study area was defined as Galveston county and its associated municipalities. Three activities were identified as important components of the Galveston economy that were most likely to be affected by a harmful algal bloom: tourism, commercial oyster harvests, and beach cleanup costs. A survey was created to assess the direct impacts of the 2000 Red Tide on businesses closely related to, or dependent on tourism. Oyster landings data was obtained along with dates and locations of state-mandated closures of shellfish harvesting areas in Galveston bays. Beach cleanup costs were obtained through interviews with agency representatives.

The 2000 Red Tide had an estimated minimum direct economic impact on Galveston county of $9.93 million, and a maximum direct economic impact of $11.5 million. Input-output analysis was used to calculate the total impact: the minimum total impact was $15.98 million and the total maximum impact was $18.45 million, approximately 0.12% of the total annual output of Galveston county. Employment impacts ranged between 367 and 425 jobs. Output and employment effects are probably temporary, persisting with the duration of the red tide. The majority of this impact was on businesses within the Food Stores sector (40% of the total estimated impact). Thirty five percent of the impact was on businesses in the lodging sector, and 25% was on businesses in the Miscellaneous Retail sector.

This report confirms that the 2000 Red Tide had palpable economic effects on the Galveston area. Business owners and customers alike voiced genuine concerns about the uncertainty of future red tide events on their health and livelihood. However, the seemingly random nature of red tide events in Texas, and Galveston in particular, combined with the existence of "halo effects" and masking variables, support caution when interpreting the results of this study. The analysis reported herein does not provide a statistical base from which impacts may be inferred. Hence, the results of this study should not be transferred to other areas of the coast that may have been affected by the red tide, or to future red tide events on the Texas coast.

The Economic Impact of the 2000 Red Tide on Galveston County, Texas
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1. Introduction

1.1 Purpose of Study

The purpose of this study was to estimate the economic impact of the 2000 Red Tide on the Galveston area. Red tide is the common name for the dinoflagellate *Karenia brevis* (formerly *Gymnodinium breve*, formerly *Ptychodiscus brevis*), an algal bloom that occurs sporadically along the Gulf coast, inland waterways, and bay systems. This microscopic organism exists at low concentrations along much of the Gulf coast throughout the year, and usually causes no problems. Outbreaks of red tide occur when the algae multiply rapidly, producing a bloom of growth that discolors the water with a reddish or brownish tint. Red tide is considered a harmful algal bloom (HAB) when in high enough concentrations to discolor the water, cause fish kills, respiratory irritation in humans (and other mammals), and temporarily contaminate shellfish.

Red tide is economically important, because it can affect a wide range of economic activities. Closure of oyster fisheries can result in lost income by commercial fishers. Discolored water, dead fish on beaches and in the water, and noxious gases directly emanating from algae may result in lost marine recreation opportunities such as tourism, recreational fishing, and swimming. Costs to clean dead fish from affected beaches and waters may also be a factor. Other costs might include monitoring and testing for the presence of red tide in the water, testing oyster meats for the presence of consequent toxins, medical costs from respiratory illness, neurotoxic shellfish poisoning NSP, and lost productivity in general.

1.2 Organization of Report

This report is divided into ten sections, the second of which follows hereafter and is an overview of harmful algal blooms. Then follows an overview of the 2000 Red Tide in Texas, a section explaining economic impact analysis, an overview of Galveston county, and a summary of the direct survey conducted there. Direct impact estimates are reported in sections seven and eight, followed by discussion, and finally conclusions.

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Acknowledgements

The authors are grateful to the following persons for their assistance in contributing to this research.

Lance Robinson, from the Texas Parks and Wildlife Department (Seabrook), provided recommendations for surveys, and oyster landings data. Kirk Wiles, from the Texas Department of Health (Austin), provided geographical and monitoring results for red tide events in Texas. Cindy Contreras from Texas Parks and Wildlife (Austin) acted as a patient coordinator, and provided recommendations concerning pertinent resource contacts.

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2. An Overview of Harmful Algal Blooms

2.1 Definition, Seasonality, and Range

Harmful algal blooms in the United States are caused by a variety of different single-celled marine algae or phytoplankton, including *G. breve, Alexandria spp., Aureococcus spp., Pfisteria piscicida,* and others (Focal Points, 1998). Major outbreaks in Texas have been caused by two species: *Ptychodiscus brevis* and *Gonyaulax monilata* (Red Tide, 1986). Two species are described as red tide agents for the Texas coast: *Alexandrium monilatum*, and *Gymnodinium breve* (Villareal, 1998). *G. breve* is only one of about 60 species of dinoflagellates known to cause red tide, and is only one of about 30 known to be toxic (Sulak, 1997). Red tides have been documented worldwide for thousands of years (Sea Stats, 2000), and a phenomenon that seems to be the red tide is recorded in the Bible (Red Tide, 1986). Concentrations of *G. breve* at or below one cell per ml is considered benign or background, while concentrations in excess of 100 cells per ml may kill fish (Sea Stats, 2000), and concentrations in the thousands of cells per ml are not uncommon (Steidinger & Joyce, 1973). At a concentration of 1000 cells per ml the water may turn brick red, or brownish in color (Texas Department of Health (TDH), 1997). During periods of intense blooms the concentration may be as high as 60,000 cells per ml (Torpey & Ingle, 1966). Bioconcentration is defined as a concentration below that which causes discoloration of the water (Beauchamp et al., 2001).

Red tides have been observed along most of the coastline of Florida and the coastal waters of Texas and Mexico. Blooms typically originate in deeper waters 30-40 nm from shore, occur most frequently in August through February, but have been documented in every month (Sea Stats, 2000). The first recorded bloom of red tide in Florida was in 1844. Blooms have recurred periodically off the west coast of Florida since then. (Tester, 1987). In the Gulf of Mexico, *Gymnodinium breve* blooms are usually seasonal, starting late in the summer or early fall and lasting three to four months. The most noticeable effects of red tides are dead fish, unpleasant odors, flies, and high bacterial counts (Steidinger & Joyce, 1973). In Texas, blooms tend to last a few days or weeks, or as long as several months, and tend to appear in August and September (Contreras, 1999; Red Tide, 1986).

2.2 Effect on Marine Life

Red tide produces as many as 10 different neurotoxins (Pierce, 1988) and hemolytic substances that can cause mass mortalities of marine animals, neurotoxic shellfish poisoning (NSP), and human respiratory irritation (ECOHAB, 1994). *G. breve* produces at least two major heat-stable, lipid-soluble toxins known as brevetoxins. These are neuromotor toxins (Steidinger & Joyce, 1973), and they cause inhibition of neuromuscular transmission in skeletal muscle. Fish sensitive to these toxins effectively "drown" in red tide waters when the toxin causes paralysis of the gills (Beauchamp et al., 2001). The preponderance of organisms in the water may lower the concentration of dissolved oxygen in the water (Steidinger, 1983), or the toxin itself may interfere with the

respiratory ability of fish by action upon the nervous system (TPW, 2001a), or both (Red Tide, 1986).

In the coastal and offshore waters of the Gulf of Mexico, scallops, surfclams, oysters, southern quahogs, coquinas, and many commercial and recreational species of fish have been found to contain or be adversely affected by *Gymnodinium breve* (Marine Biotoxins, 1982). Fish caught during red tides show no evidence of the toxin in their flesh and are safe to eat (Sea Stats, 2000). Red tide has been implicated as the causative agent for the death of sea birds, sea turtles, manatees, and dolphins (Marine Biotoxins, 1982). *Gymnodinium breve* is responsible for fish kills, and bird and manatee mortality in Florida from Pensacola to Jacksonville (Sutherland, 2000). *G. brevis* has little effect on shrimp and crabs. It does not kill oysters, clams, or mussels, even though shellfish accumulate the toxin in their tissue (Torpey & Ingle, 1966).

2.3 Effects on Humans

Red tides diminish the aesthetics of beaches, bays, and estuaries through problems with sight and smell. Other ways that red tides affect people include public health problems from puncture wounds by fish bones, ingestion of NSP-tainted bivalves resulting in neurotoxic shellfish poisoning, and inhalation of the neurotoxins, which causes severe respiratory irritation to residents and visitors (as well as other mammals) along areas experiencing air-borne toxins in marine aerosol (Pierce, 1998).

Background concentrations of the red tide organisms generally are not sufficient to result in toxic shellfish (Pierce, 1998). NSP contaminated shellfish are common during and after periods of red tides because molluscans filter algae as they feed and accumulate high concentrations of the toxin in their tissue. The toxin that accumulates in high concentrations in filter feeders can be dangerous for persons who eat the contaminated meat. Persons often develop Neurotoxic Shellfish Poisoning. There is very little published literature on the human health effects of NSP, although it is known to be a marine toxin-induced illness and with neorologic symptoms similar to Paralytic Shellfish Poisoning (PSP), and milder gastroenteritis than PSP (Fleming & Baden, 1998). It is not known to be fatal (TDH, 1997), but can cause nausea, dizziness, tingling sensations in the extremities, dilated pupils, and hot-cold reversals (Pierce, 1998). The symptoms usually disappear in several days (Red Tide, 1986).

Gymnodinium species possess an outer shell that is very fragile and easily disrupted by the vigorous mechanical action of the surf. On disruption, *Gymnodinium* organisms release cellular endotoxins into the surrounding water. Wind and surf action produce a fine aerosol that generally travels only a short distance from the beach. Thus, in areas with a great deal of surf action, airborne exposure to the toxins may be increased. Exposed individuals frequently report an acute but rapidly reversible syndrome consisting of conjunctival irritation, rhinorrhea, sneezing, cough, and (rarely) respiratory distress similar to an asthma attack. Persons swimming or wading in *G. breve* red tides may

experience eye and skin irritation accompanied by redness and itching (Beauchamp et al., 2001).

2.4 Economic Effects of HABs

Economic losses from toxic or noxious algal blooms have been documented for Maine, California, Washington, Alaska, North Carolina, Florida, New York, New Jersey, British Columbia, Korea, Phillipines, Western Samar, and Japan (Shumway, 1990). Currently almost every coastal state is threatened, in many cases over large geographic areas and by more than one harmful or toxic microalgal species (ECOHAB, 1994).

Red tide can result in economic losses due to commercial shellfish bed closures, consumer fear of purchasing any kind of seafood in red tide areas (*ie.*, the halo effect), lost marine recreational opportunities, increased monitoring and testing for the presence of toxins, increased medical costs, lost productivity, as well as beach cleanup costs, and reduced tourism.

Commercial fishing does not appear to be directly affected by red tides because most species that are killed are not considered economically important (Steidinger and Joyce, 1973). Red tides do not significantly reduce commercial landings, but do affect near-shore fishing, resulting in increased operating expenses for guide service operators, who must travel greater distances (Torpey and Ingle, 1966).

Dead fish are a noticeable consequence of red tides, and their presence can have a significant impact on economies dependent on tourism. Rotting carcasses of marine animals killed by the red tide is sufficiently noxious to result in diminished tourism (Torpey and Ingle, 1966; Steidinger and Joyce, 1973). Public uneasiness, dissemination of misinformation, and negative publicity subsequent to a red tide outbreak is probably more devastating economically than the bloom itself (Shumway, 1990).

Stories linking shellfish and contaminated waters can be blown out of proportion by rumors, and over-reactive proclamations that are intensified by press headlines. The resulting "halo effect" is similar to food scares caused by botulism poisoning, which frequently affects foods other than those directly concerned. For example, a shellfish ban along the New England coast in 1972 caused consumers to avoid wholesome and unaffected seafood products, including fish, lobsters, and scallops (Jensen, 1974). The halo effect caused by fish kills and shellfish closures results in cancellations of reservations and a reduction in seafood purchases (Tomas, 1999a).

LaCossitt reports various estimates of economic losses in Florida from the red tides in the early 50's. Clearwater Florida reported a loss of $3.75 million in 1953 to guide services, commercial fishers, and lodging. In 1954, Brandenton's $4 million commercial fishing industry was "practically out of business". Fort Meyers in 1954 had estimated losses of $500,000 because of cancelled [hotel] reservations (LaCossitt, 1954). Habas assessed the economic effects of the 1971 red tide on Florida businesses in a seven county area.

Using personal interviews and locally obtained secondary data, he estimated that the loss to the lodging sector , restaurants, and commercial fishing was $20 million over a 50 day period. A dinoflagellate bloom along the New England coast late in 1972 resulted in a sale and harvest ban of clams and mussels. The loss to fishermen was estimated to be one million dollars because of adverse publicity that depressed the market. Seafood product dealers reported business decreases from 25 to 50%, inability to sell lobsters, a 25% reduction in wholesale prices in national markets, and 50% reduction in wholesale sales to local seafood restaurants (Jensen, 1975).

The red tide of Florida in 1973-1974 resulted in a $15 million impact on a seven county region on the west coast. Losses included impacts on the tourist industry (primarily lodging), impacts on sportfishing and guide services, cleanup costs, and impacts on sales and construction of condominiums. (Habas and Gilbert, 1975).

The red tide outbreak in North Carolina waters in 1987 resulted in a direct loss of at least $500,000 from scallop losses, and $3.5 million to commercial fishermen, $1 million of which was due to market decline because of public fear. Bait and tackle shops and marinas reported reduced sales, and restaurants and seafood wholesalers reportedly laid off workers. The Small Business Administration denied the state's request for a red tide economic injury designation because the red tide outbreak did not qualify as a disaster (Impact, 1987).

Harmful algal blooms along the coast of Maine in 1980 resulted in economic losses exceeding $7 million because of recurrent costs associated with preventative shellfish programs (Shumay et al., 1988). Kahn developed a bioeconomic equilibrium model to estimate the economic impacts of annual algal blooms on the New York bay scallop fishery, and found that brown tide results in $2 million of lost landings per year.

Along the Gulf Coast, from Mexico to Florida and thence to the South Atlantic Bight, recurrent bloom events cause an economic loss of approximately $18-$24 million per episode and an associated halo effect that reduces consumer demand for all seafood products within and outside the affected region. Dead fish washed up on beaches, NSP - contaminated shellfish, and human respiratory problems affect the tourist industry, hotel/motel suppliers, commercial fisheries, and local governments for the expense of beach cleanup (ECOHAB, 1994).

In Texas, the biggest economic impact is presumed to be that on the commercial oyster industry (Red Tide, 1986). The halo effect compounds problems by making it difficult for commercial fishermen to sell their catch of wholesome fish to reluctant consumers. Tourism is the largest industry affected by red tide (Hollin, 1998). The bait fishing industry and city services can also be affected (Red Tide, 1986). Three sectors of the coastal economy that have been identified as adversely affected by outbreaks of red tide are commercial fishing, tourism, and prepared fish and seafood (Red Tide, 1998).

2.5 HABs in Texas

The bays of Texas are characterized by barrier island systems and salinities that are favorable to the persistence of *G. breve*. As a result, blooms that become established in one bay system are likely to move to adjoining bays. Detoxification of an area highly impacted by *G. breve* can take several months (TDH, 1997). The persistence of blooms in Texas bays is unusual compared to water bodies in other areas (*eg.*, Florida), and increases the likelihood of lengthy oyster fishery closures.

The earliest documented red tide in Texas was in 1935 (Table 2.1). However, more complete descriptions of red tide along the Texas Gulf coast are available for the outbreaks in 1986, 1996, and 1997. Red tides in each of these three years killed large numbers of fish. Mortality was predominately among schooling and filter feeders, including mullet, menhaden, and anchovies, but deaths were documented for 100 different species (McEachron et al., 1998). Slow moving, bottom dwelling fish are usually the first to be affected, although nearly all inshore and near-shore fish species are susceptible, depending upon the length and density of the bloom. Other affected species include redfish, rays, mackerel, grouper, trout, ladyfish, mudminnows, and eels (Red Tide, 1986).

Table 2.1. A Chronology of Red Tides in Texas

1935 – Fish kill off of Port Aransas - 2 million pounds
1955 – 2 million pounds of fish killed near Galveston
1974 – Probable red tide bloom kills fish 150 miles south of Brownsville
1986 – More than 22 million fish killed from Galveston to Brownsville
1987 – Bloom in Corpus Christi Bay.
1990 – Late winter bloom of red tide in the Brownsville ship channel.
1996 – Major fish kill along Texas coast (3-4 million fish, including 12000 mature red drum)
1997 – Major fish kill along Texas coast (20-22 million fish).

Source: Villareal, 1998; McEachron et al., 1998; Sea Stats, 2000; Sikes, 1997.

In 1986, the Texas oyster industry lost $3.7 million because of the red tide (Hollin, 1987). The red tide of 1996 persisted for 47 days beginning September 16th and the least impacted bays were closed to the harvest of shellfish for 77 days. Several bays were closed for 90 days, and large areas of oysters died during or after the impact of the bloom (TDH, 1997). The red tide of 1997 began in mid-September, resulted in fewer closures, and primarily affected recreational oyster harvesting along the lower coast of Texas. However, one commercially important bay was closed for nearly the whole of the season. It is thought that heavy rainfalls prior to the mid-September bloom shielded the upper coast from the intrusion of red tide there (TDH, 1998).

3. Overview of the 2000 Red Tide in Texas

The first reports of red tide in 2000 were late in June. Menhaden were reported dead and dying in Brazos Santiago Pass (near Port Isabell), where 49 cells/ml were counted in water samples. Within days, cell counts had increased at least three-fold and a small (4,000 sq. ft) bloom was observed in the pass. On South Padre Island, dead menhaden and respiratory irritation were also reported.

No other reports were received until mid-August when an estimated 50,000 dead fish over an 87,000 acre area, 10 to 15 nautical miles (nm) SSE of Sabine Pass was reported. Thousands were dead just 5 miles off the Sabine Pass jetties. By the end of the month, *G. breve* had been confirmed in water samples from the mouth of the San Bernard River, and in the Intracoastal Waterway at Surfside, and in West Galveston Bay (Appendix I). Discolored water and dead fish were reported at Bastrop Bayou, Playa Bagdad, from San Luis Pass to Surfside, in the mouth of the San Bernard, Quintana jetties, and numerous locations throughout the Freeport-Surfside coastal area, including Quintana Beach and San Luis Pass. (Contreras, 2001; TDH, 2001).

On September 1st, the Galveston County Health District issued a press release warning people about the harmful effects of the red tide. Within days the bloom moved into Lower Galveston Bay and the TDH closed three major areas of Galveston Bay to oyster harvesting. By mid-September the red tide bloom in Lower Galveston Bay had moved into East Galveston Bay and was confirmed by TDH. Fish kills were reported in the San Bernard river, Sargent Beach, Galveston Beach at 61st street, Galveston Island State Park, San Luis Pass and Park, the Gulf beach at Surfside and at the Surfside jetty, and at Quintana Beach. Coastal Fisheries staff estimated more than 1.5 million fish were dead. Approximately 250 dead fish were noted along a quarter mile section of the Surfside beach, but no respiratory irritation was observed (Appendix II).

Respiratory irritation was reported at Galveston Island State Park, and at the Gulf beach near Surfside jetty, and at Quintana beach. Before the end of the month the red tide had moved into bay systems along the lower coast, and was confirmed at Bolivar, Port O'Connor, San Jose Island, Cedar Bayou, Corpus Christi Bay, Oso Bay, Port Aransas jetties, East Galveston Bay near Rollover Pass, in Dickinson Bay, and Mesquite Bay, among others. Respiratory irritation was noted near Port Aransas, and the Galveston Beach Patrol reported persistent, daily red tide problems along Galveston beaches. Coastal fisheries estimate 10,983 dead fish in counts from three areas in Galveston bays.

By mid-October fish kills persisted in many places along the lower coast where the red tide had become established. Red tide and dead fish were reported in Aransas, Copano, Corpus Christi, San Antonio, and Redfish bays, and others. Respiratory irritation was reported at Padre Island, Surfside, Cedar Bayou, Port O'Connor, and Boca Chica Beach. The TDH found no cells in water samples from Galveston Bay proper, and began monitoring oyster tissues for the presence of toxin. Coast fisheries estimates of dead fish on San Jose Island exceeded 58,000. By the end of the month dead fish were observed in Nueces and Mesquite bays and reports from Mexico estimated 1.5 tons of dead fish in the

Matamoros-San Fernando area. On October 31st the TDH issued a press release warning that, even though November 1 was the opening day of the commercial oyster season, all Texas coastal waters were closed to the harvest of molluscan shellfish except parts of Galveston Bay.

In early November a bloom of red tide was confirmed in Tres Palacios Bay, and fish kills were noted in San Antonio Bay. The red tide persisted in East Matagorda, and Carancahua bays, but elsewhere along the coast there were no reports. By the middle of the month no blooms of red tide, respiratory irritation, or dead fish were being reported anywhere along the Texas coast. Most of Galveston Bay was re-opened to commercial oyster fishing by the end of the month. However, all areas from West Galveston Bay south to the Rio Grande remain closed.

West Galveston Bay was reopened in early December, and by late January the TDH had re-opened virtually all of the coastal waters. (Contreras, 2001; Evans, 2000; TDH, 2001)

4. Economic Effects of the 2000 Red Tide in Texas

4.1 A Case Study – Galveston, Texas

Previous studies of the economic impact of the red tide have varied widely in scope in methodology. Assessments have ranged from the level of impacts on single cities, entire states, to the entire eastern seaboard. The methods of analysis have ranged between the use of informal surveys to complex mathematical models. In many cases it seems that the level of information available in regard to the frequency, severity, and distribution of red tides has been inadequate to support any significant quantification of all the economic impacts. Even so, many estimates of economic damage have been reported. The difficulty of obtaining consistent data has been exacerbated by factors that mask the effects of the red tide, including weather, varied seasonal attractions, and other unidentified events that may significantly alter the economic equilibrium. The extent to which red tide events have affected the Texas economy has not been accurately determined in the past, and it is often difficult to prove that the red tide causes a direct dollar decline (Hollin, 1998).

The lack of consistent secondary data coupled with the apparent random nature of the occurrence of HABs along the Texas coast makes it difficult to quantify the impact of the 2000 Red Tide on Galveston area businesses and tourism. Given the difficulties associated with the unpredictability of the red tide in Texas (*cf.*, Florida which has had a red tide event in 23 of the past 25 years), it was decided that a reasonably accurate assessment of the economic impacts could only be made by approaching this analysis from the point-of-view of a case study. A case study would allow the focus to be on a specific period of time, and on a geographic area that was obviously affected by the red tide.

The analysis reported herein is a case study of the impact of the 2000 Red Tide on the Galveston economy during a four month period beginning September 1st. Three sectors of the economy were identified, and presumed to be most affected by the occurrence of a harmful algal bloom, and red tide in particular. These were commercial oyster fishing, tourism, and beach cleanup costs. After estimating the direct impacts to these three sectors, input-output analysis was used to estimate the total effects on the economy.

4.2 Input-Output Analysis

Input-output analysis is based on the idea that a change in one sector of the economy may have effects on other sectors of the economy. Multipliers are a product of input-output analysis and serve to quantify the level of effects in each sector as a result of an initial impact that changes the final demand in a specific sector. There are several different types of multipliers. Output multipliers estimate the change in total output (ie., business sales) by all sectors within a regional economy that results from a change in sales to final demand by one specific sector in the economy. Employment multipliers estimate the change in total employment (*ie.*, jobs) throughout the economy that results from a change in sales to final demand by a specific sector. Value Added multipliers essentially

estimate a change in Gross Regional Product (similar to GDP in the national economy) as a result of sales to final demand in a specific sector of the economy. Other multipliers may also be employed in the analysis process.

Direct effects are the initial impact. They represent the initial purchases for final use (*ie.*. final demand) from the affected economic sector. The sectors (or industries) that produce the goods required to meet this final demand by the affected sector must, in turn, purchase goods and services – these purchases are therefore called indirect purchases or indirect effects. As a result of indirect effects, changes in household income occur, and these induced effects must also be included when assessing the impact of the initial purchases on the economy. The sum of the direct impact, indirect, and induced effects provides a final estimate of the total impact.

4.3 Methodology and Data

A survey was created to assess the direct impacts of the 2000 Red Tide on area businesses. The impact of oyster closures was estimated using historical landings data from Texas Parks & Wildlife, and closure data from the Texas Department of Health. Estimates of beach cleanup costs were provided directly from representatives for the governmental organizations responsible for the cleanup.

An input-output model was developed for Galveston county. It was constructed with ImplanPro, a large computer algorithm consisting of a system of equations, each representing a sector of the economy and identifying the interrelationships among sectors (Olsen et al., 1993). It was originally developed by the USDA Forest Service to assist in land and resource management planning (MIG, 1999).

The version of Implan used in this study is based on price levels existing in 1997. Because inflation has occurred between 1997 and 2000, the final estimates of impacts were adjusted to a 2000 price level basis using the Consumer Price Index.

5. Overview of Galveston Texas

5.1 County profile

Galveston county is situated in Texas about 60 miles south of Houston, and makes up the entire Galveston Metropolitan Statistical Area. In 1999 there were 15 cities and towns in the county, including Galveston and Texas City which made up more than 41% of the population. In 2000 the population of Galveston county was 250,158 persons, or 628.5 persons per square mile. The county's population ranked 14th in the state in 1997, and 35th in terms of per-capita income. The largest industries were state and local government, followed by nondurable good manufacturing. Retail sales in 1997 exceeded $1.78 billion (USCB, 2000).

5.2 Commercial Oyster Fishing

The commercial oyster season in Texas begins November 1st, and ends April 30th, with the exception of private leases, where there is no closed season. Oysters may be taken only from waters approved by the State Commissioner of Health (TPW, 2000a). Protocols for opening and closing bays are contained within the Contingency Plan for the Control of Marine Biotoxins (TDH, 1997). Areas impacted by cell counts greater than five cells per ml are immediately closed by the TDH to the harvest of molluscan shellfish. Active water sampling begins for the affected area until cell counts drop below five cells per ml. Then, active shellfish tissue sampling begins. When results indicate that no toxin is present in the tissue, the area is reopened to harvesting.

In 1997, Texas ranked second among all states along the Gulf of Mexico in terms of production of oysters, accounting for 20% (approximately 4.6 million pounds) of Gulf and about 11% of annual U.S. oyster industry production (Keithly and Diop, 2001). Galveston landings in 1997 accounted for about half of Texas landings, with 2.1 million pounds of oyster meat harvested from approved areas of West Galveston Bay, Upper Galveston Bay, Lower Galveston Bay, Trinity Bay, and East Galveston Bay.

Since 1990, annual oyster landings in Galveston waters have trended upward, averaging about 31.5% growth per year in quantity, and 21.8% per year in real value. The most productive bays are Lower Galveston Bay, and East Galveston Bay which account for 78% and 14% of quantity landings in the Galveston bay system, respectively. Upper Galveston Bay accounts for 7%, and Trinity and West Bay together make up about 1% of average annual landings.

The real value of annual landings closely mirrors the quantity of oysters landed, with Upper Galveston and East Bays accounting for 92% of annual real value landed on average since 1990. Oysters harvested from approved areas of Galveston bays make up 78% of annual harvests. This is because oysters are harvested from private leases when the regular season is closed (ie., May-August). The most important months for the

industry are November and December when 47% of the regular season oysters are harvested, 28% in November and 19% in December. Monthly harvests for January through April range from 11 to 15% of the annual regular season harvest.

5.3 Tourism

Galveston Island is less than an hour from Houston, Texas - the 4th largest city in America. It is close to two major airports, and is the 2nd largest cruise ship port in the nation. Total volume of visitation is estimated to be 17 million person-days in 1998-1999 (TDED, 2000). Eighty percent of visitors to Galveston come for leisure. Predominately they are on vacation (48%), or there to see a friend or relative, a special event, and/or for personal reasons (32%). The remaining 20% of visitors are engaged in business, primarily group meetings. Seventy eight percent of visitors to Galveston are Texans, nearly half of which originate from Houston. Visitors participate in a wide variety of activities, but mostly beach/waterfront activities (60%). Eleven percent engaged in outdoor sports, 27% in touring, 38% attended a cultural event, and 20% attended a non-cultural attraction (*eg.*, nightlife, theme park, sporting event).

The average expenditure per person per day was $93.50. Of this total, 27% was for food purchases, 21% for accommodation (about half of all visitors stayed in hotels and motels), 17% for transportation, and the balance was for entertainment and miscellaneous purchases (TDED, 2000).

5.4 Beach Management

Management of public beaches is dependent upon location within the county. The Galveston Parks Board of Trustees maintains beaches on Galveston Island, and is responsible for all beach cleanup. Along the Bolivar Peninsula the beaches have been maintained by the Galveston County Road Department since September 30, 2000. Prior to that time, the County Parks Department was responsible for beach cleanup.

6. Red Tide Economic Survey

6.1 Introduction

The purpose of the Red Tide Economic Survey (RTES) was to measure respondents' awareness and perception of the red tide that started late in the year of 2000 along the Texas Gulf Coast, and to assess the impact of the 2000 Red Tide on their normal business operations. Answers to each survey were made in confidence and combined with answers from other respondents to assess the overall impact of the 2000 Red Tide.

The study area for the survey was Galveston county. Prior to the beginning of the survey, businesses were identified as potential respondents: the focus was primarily on aquatic product dealers, specifically those that were considered "leaders" by Texas Parks & Wildlife. Other survey participants were identified arbitrarily during the course of the survey and included hotels, fishing piers, fresh seafood sales outlets, guide services, and other retail establishments that were obviously dependent upon tourism.

Respondents were asked to formulate their answers in regard to a four month period beginning September 1st, and ending December 31st, 2000. The survey consisted of 35 questions in six sections: Identification, Perception of the Event, Comparing the Red Tide, Availability of Information, Size of Business, and Final Comments. The format of the survey was personal interview, although some respondents, for whom the time was inconvenient, were allowed to return their survey by mail.

6.2 Summary Results

6.2.1 Section One – Respondent Characteristics

Thirty two of the 49 businesses asked to participate in the Red Tide Economic Survey completed and returned their survey for a response rate of 65%. Three of the respondents stated their business was located in Brazoria county, and their responses were not used. Most of the remaining 29 respondents stated that their primary business activity was "Bait and Tackle" (37.9%), which was expected given the initial identification of potential participants. Hotels accounted for 13.7% of the survey, fishing piers and fresh seafood sales accounted for another 13.7 percent. The remainder consisted of restaurants, sporting goods stores, guide services, and other retail or recreation related activities.

When asked if they engaged in other business activities, 58.6% responded yes. The other business activities were mostly bait and tackle, restaurant, or marina, but also included fresh seafood sales, commercial fishing, lodging, beer and wine sales, manufacturing, and marine-related activities. The average length of time the business had been open was 18 years. The minimum was 6 months and the maximum was 91 years. Only one business

operated on a seasonal basis – the remainder were open all year. The seasonal business was open only from April through October.

6.2.2 Section Two – Perception of the Red Tide Event

Every respondent answered yes when asked the question, "Are you aware that a significant red tide occurred along the Texas coast in 2000?" Most of the respondents were aware of the red tide in September (Figure 6.1). The media (*eg.*, radio, television, newspaper) was the source from which most respondents (41%) learned that a red tide event had occurred (Figure 6.2).

Figure 6.1. Percentage of respondents who first became aware of the 2000 Red Tide.

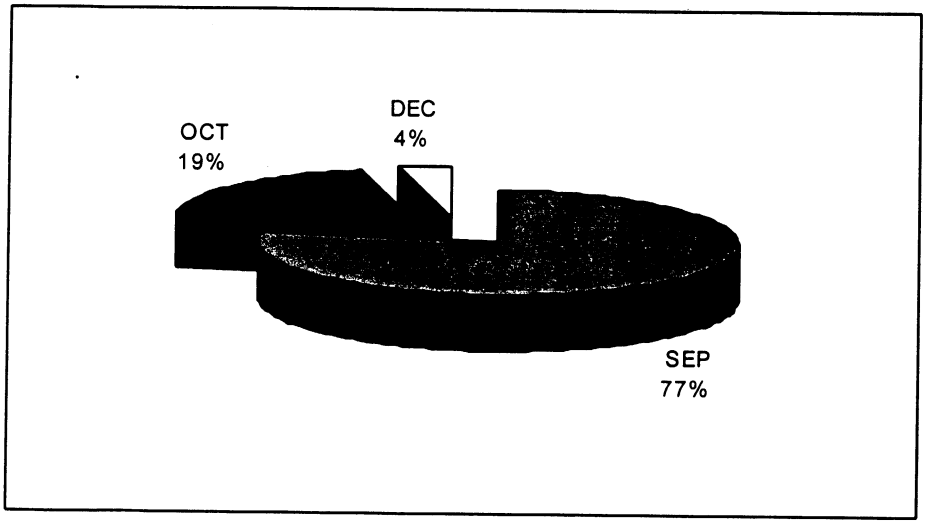
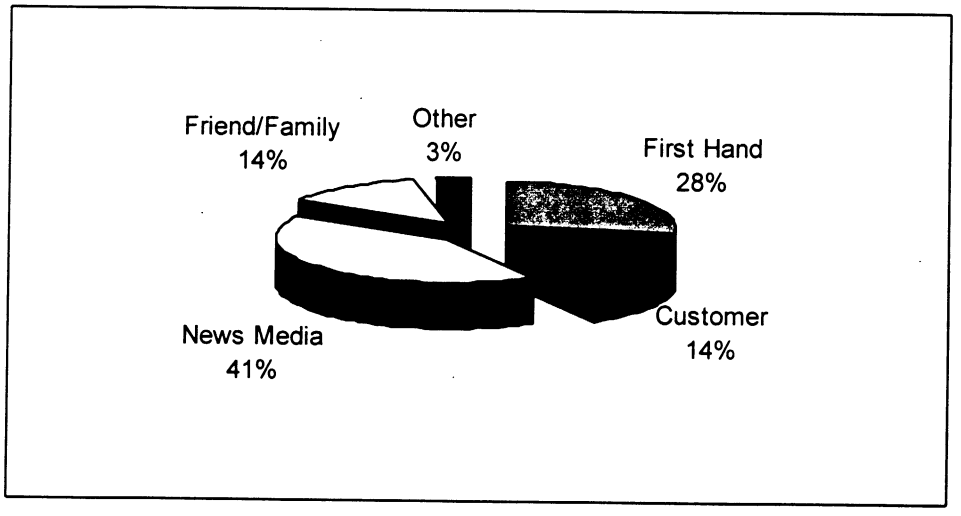


Figure 6.2. Percentage of respondents who first learned about the red tide from selected sources.



The impact of the 2000 Red Tide on business was reported to be mostly negative (59%), although some answered that it was positive (6%). Thirty five percent said that the 2000 Red Tide had no impact on the revenues or sale of their business in 2000 (Figure 6.3). The average overall impact was negative at 16.5%, but varied according to business sector (Table 6.1).

Figure 6.3. The impact of the red tide on the revenue or sales of respondents businesses.

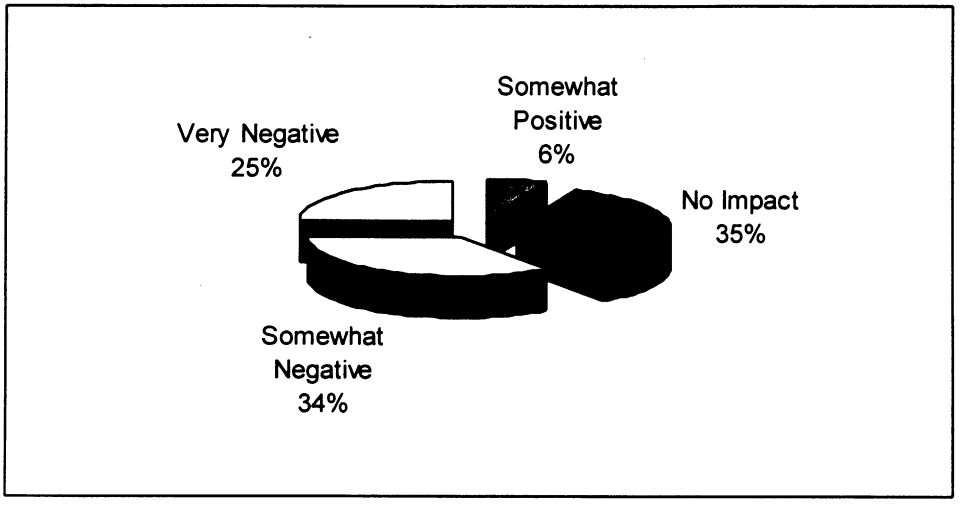


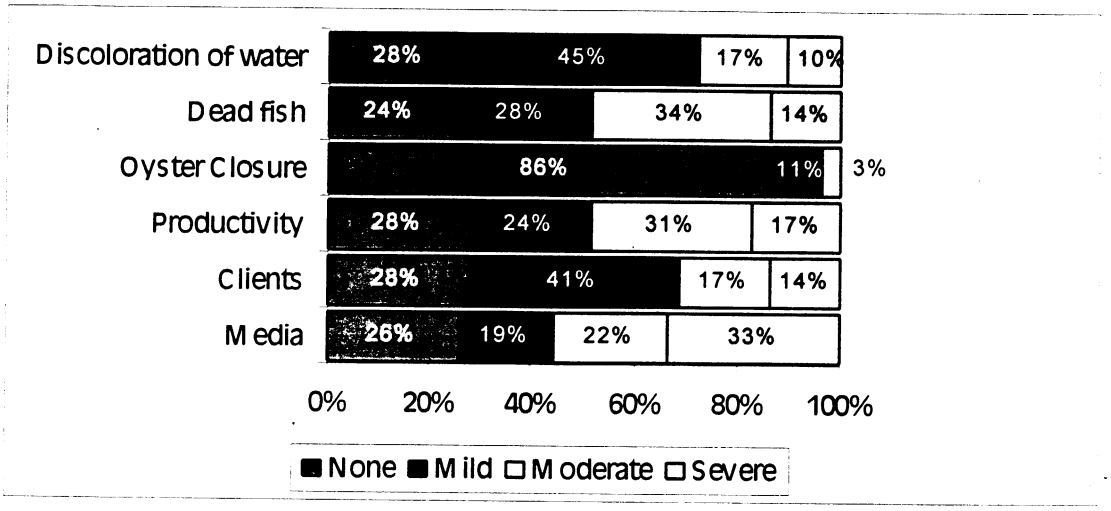
Table 6.1. Minimum, Average, and Maximum Reported Impacts of the 2000 Red Tide on Respondents' Business by Economic Sector in Galveston county.

Economic Sector	MIN	AVG	MAX
Food Stores	25.0%	27.3%	29.5%
Misc. Retail	20.9%	22.5%	24.1%
Hotels and Lodging Places	12.0%	12.8%	13.6%
Amusement and Recreation Svcs.	0.0%	0.5%	1.0%

Respondents were asked to rate the impact of several characteristics of the red tide on the normal operations of their businesses (Figure 6.4). These characteristics were discoloration of water, dead fish on beaches or in water, closure of the oyster fishery by the TDH, respiratory distress effects on the productivity of their workforce, respiratory distress effects on the potential for clients to visit their business, and the media.

Discoloration of water impacted 78% of participants: 45% said the impact was mild, 17% said it was moderate, and 10% said it was severe. The remaining 28% said that it had no impact on their business. Dead fish had an impact on the normal operations of 76% of respondents. The closure of the oyster fishery by the TDH had the least impact. Eighty six percent of respondents said it had no impact on the normal operations of their business. However the potential loss of revenue to the oyster fisheries was estimated by a different method as reported in Section 7.2.

Figure 6.4. Percentage of respondents indicating the level of impact on their business for various characteristics of the red tide.

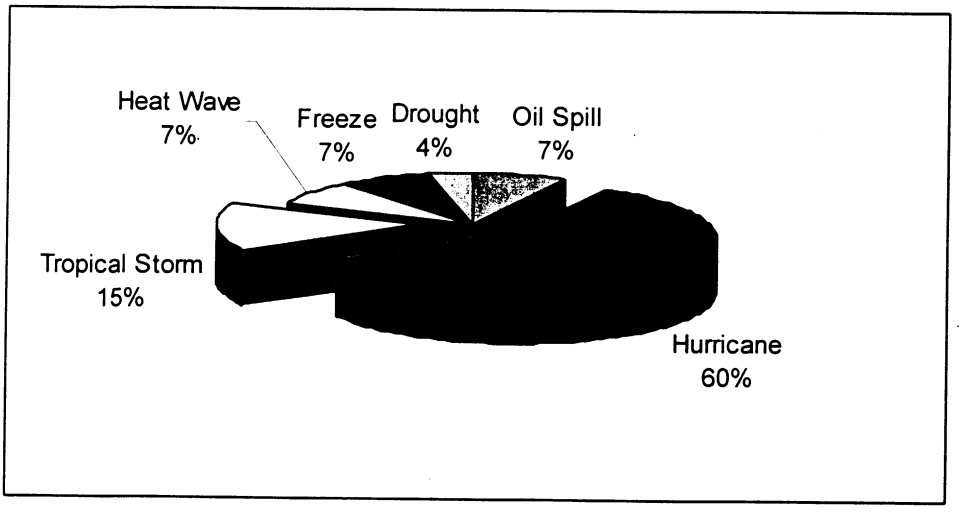


Two of businesses interviewed had to suspend operations during the four month period; one for less than a week in late September, and one for 7-8 weeks during the months of December and January.

6.2.3 Section Three – Comparing the Red Tide

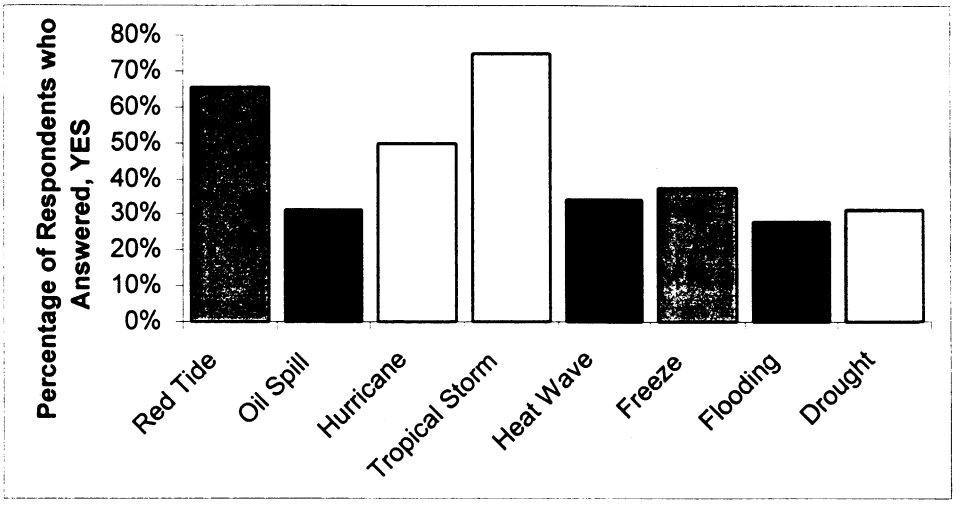
For a typical year, most respondents (60%) said that a hurricane is the greatest threat to the normal operations of their business (Figure 6.5).

Figure 6.5. Expected greatest threat to the normal operation of respondents' business in a typical year.



None of the participants indicated that a red tide was the greatest threat to their normal operations, although 65% indicated that a red tide had affected their normal operations in the past (Figure 6.6).

Figure 6.6. Fraction of respondents whose business has been affected by selected events in the past.



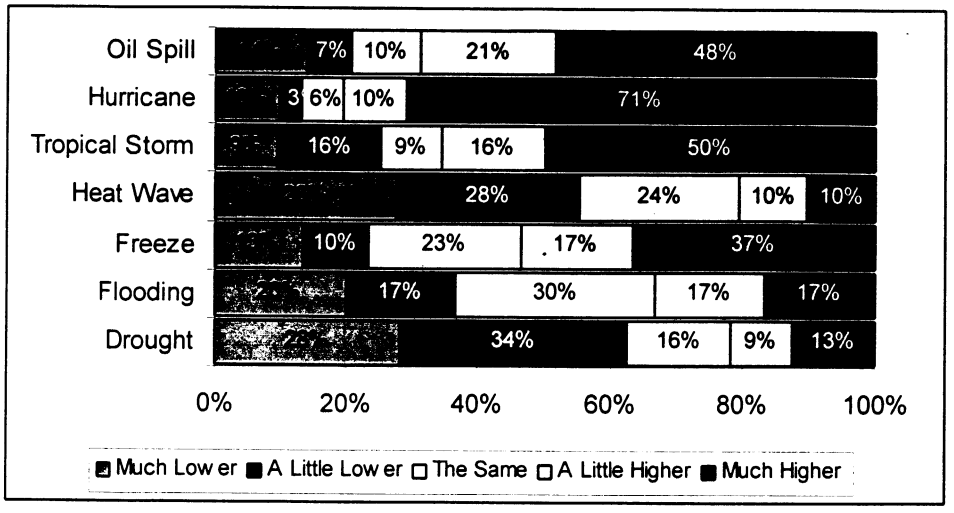
Participants were then asked to compare the impact of other events to the impact of the 2000 Red Tide on their business (Figure 6.7). Forty eight percent said that compared to the impact of the 2000 Red Tide, the impact of a major oil spill would be much higher. The impacts of hurricanes and tropical storms were also considered to be higher than the impact of the 2000 Red Tide. However, the impact of a drought, fresh water flooding, or an extended heat wave was considered to be much lower or the same as the impact of the 2000 Red Tide on their business.

When asked what they *thought* their customers most likely did if they avoided the area because of a red tide, 25% said they stayed at home, 25% that they visited another location along the coast, 25% that they visited a non-coastal area, and 16% that they postponed their visit to the same area until later in the year. Nine percent said they did not know.

6.2.4 Section Four – Availability of Information

Twenty two percent of respondents were aware that the State of Texas has a telephone number that provides updates to the public about the 2000 Red Tide, and 20% knew about the TP&W and/or TDH websites; 33% of those that knew about the websites had visited the TP&W website, and 17% had visited the TDH website, while the remainder didn't know which site they had visited.

Figure 6.7. Percent of respondents indicating the level of impact of selected events as compared to the 2000 Red Tide.



6.2.5 Section Five – Business Employment

In the businesses interviewed, the average number of employees was 21, but ranged between one and 350. The average for food stores was three, four for eating places, seven for miscellaneous retail, 93 for lodging, and seven for amusement and recreation services. Fourteen percent indicated that they had laid off employees. The range was one to two full-time employees for two to four months, and five part-time employees for three to six months.

6.2.6 Survey Comments

Participants were asked several times throughout the interview for comments on how the 2000 Red Tide affected their business, how other factors might have had a negative or positive impact, and final comments to conclude the interview. Typical comments were that (1) they received a lot of telephone calls from concerned customers, (2) they had to close early on some days, and (3) that it was "impossible" to keep fresh bait fish alive. Affected bay water was a concern because putting the toxin-tainted water in the bait tanks caused fish to die, or it just made it more difficult to catch bait. As a result, the red tide affected bait sales, slowed down business, and resulted in "fish-scared" customers, who decided not to go fishing.

Medical issues were mentioned, such as employees who, after being "finned" by fish, took longer to heal. Some store owners said that they had to call the beach patrol several times because people walking by the store were suffering from respiratory irritation.

Some businesses were in protected areas and were less affected by the red tide. This was the exception rather than the rule. "The loss of income to red tide was especially bad because it occurred during the busiest six months of the year for us", one participant said. Participants indicated that there were other factors that might have affected business. Most of these factors were negative, but some were positive.

This helped to identify potential *masking* variables. Masking variables are defined as the occurrence of some other event or factor at the same time as the red tide, that would have a similar (or contrary) effect on business as the red tide. Therefore, the effect of a masking variable would be difficult to separate from the effect of a red tide, and may "mask" some of its impacts.

Negative factors seemed to follow a general theme, the weather. Many complained of an early winter, colder than normal temperatures, northerly winds, and an unusually rainy November and December. This was preceded by heat that was "very high for that period", and a lack of rain. Other negative factors included school starting back in the Fall, a prolonged national election, the federal closure of the red snapper fishery on October 31st, fuel prices, low tides, and seaweed growing in Galveston Bay resulting in shrimp kills.

Some respondents were upbeat and indicated that they were in a new business and everyone was curious so they had no impact from red tide. Nice, warm weather was also cited as a positive factor. A captive audience was also a positive factor: "Most of our clients are corporate, therefore they would come here anyway." The termination of La Niña and the absence of hurricanes were also cited as positive to business.

Concluding comments could easily be grouped into several themes: health concerns, education, and the media. Some of the comments were; (1) "Everyone was sick because of the red tide", said one person, (2) "It made horses cough.", (3) "Red tide was really bad on everyone I knew", and (4) people "along the seawall had stinging eyes and respiratory problems".

Some offered a reason for the existence of the red tide. Heat, fecal-contaminated water, and industrial plant pollution were cited as the cause. Some stated that winds increased the problem, and that it was extremely localized. Others stated they didn't know what caused it, but would like to know - they wanted to know what caused it, why it killed fish, why it killed oysters, what areas were being affected, when it would happen in advance so they can adjust the number of employees, and how to prevent it. Some just want the information more easily available.

The third theme was the media. Not one of the participants who commented about the media had anything positive to say. "The media should make public statements of fact rather than 'media interpretation'", said one participant. They wanted "better media coverage", honest but not out of context. The "...news media are recreation's worst enemy", said one business owner who continued that the news media should call it like it is and not "blow things out of proportion", especially weather and recreation-related

events. Many seemed to feel that the red tide was a problem along certain areas of the beach, and that it did kill fish, but that the media had made it appear widespread and dangerous throughout the entire area.

7. Estimates of Direct Impacts

7.1 Estimates Based on the Red Tide Economic Survey

Implan uses data from more than 500 economic sectors. However, many of the sectors are composed of an aggregation of industries. For example, the Miscellaneous Retail sector in Implan is composed of all industries within Major Group 59 of the Standard Industrial Classification (SIC). This major group includes retail establishments, not elsewhere classified (SICM, 1987), including gift and novelty shops, souvenir shops, book stores, florists, direct sellers, *et cetera*.

Survey response data was aggregated into the economic sectors in Implan that corresponded to the participant's primary business activity. Five sectors were identified: food stores, eating places, miscellaneous retail, hotels and lodging places, and amusement and recreation services (Table 7.1).

Table 7.1 Survey business to Implan sector bridge.

Examples of Survey Responses	Implan Description	Code
Fresh seafood sales	Food Stores	450
Restaurant	Eating Places	454
Bait & Tackle	Misc. Retail	455
Sporting goods store	Misc. Retail	455
Souvenir Shop	Misc. Retail	455
Gift Shop	Misc. Retail	455
Lodging	Lodging	463
Fishing camp	Lodging	463
Fishing pier	Amusement	488
Guide service	Amusement	488
Horse rental	Amusement	488

The average minimum and maximum lost business sales for each sector was calculated by averaging the minimum and maximum loss, respectively, as reported by respondents for each sector (Table 7.2). For example, in sector 463 there were five respondents. Two respondents indicated an impact in the range of 30-34%, and the remaining three said there was no impact. Hence, the average minimum direct impact was 12% (60% divided by 5), and the average maximum direct impact was 13.6%. The largest impacts were, in order; the Food Stores sector, followed by Miscellaneous Retail, Lodging, Amusement and Recreation Services, and Eating Places.

Sector output, which is a measure of business sales, was first adjusted for inflation. Then adjusted to reflect the output in each sector for the months of September through December (Table 7.3). Monthly distributions of output in each sector were not available in the Implan model. Therefore, proxy variables were used to estimate monthly outputs for each of the economic sectors. Monthly hotel receipts for 1996 were used to adjust the annual output of the Hotels and Lodging Places sector, and monthly gate receipts at Galveston State Park for 1997 were used to adjust the annual output for the other sectors.

Table 7.2 Estimated Percentage business loss in selected economic sectors due to the 2000 Red Tide.

Implan Code	Description	Average Minimum Loss	Average Maximum Loss
450	Food Stores	25.0%	29.5%
454	Eating Places	*	*
455	Misc. Retail	20.9%	24.1%
463	Lodging	12.0%	13.6%
488	Amusement	0.0%	1%

Using this method, output in the months of September through December were estimated to be 14.3% of annual output for food stores, eating places, miscellaneous retail, and amusement and recreation services. Output for hotels and lodging places during the last four months of the year was estimated to be 24.3% of annual output in that sector.

Table 7.3. Output of selected Implan sectors.

Implan Code	Description	Annual Output ($M 1997)	Annual Output ($M 2000)	Sep-Dec Output ($M 2000)
450	Food Stores	99.8	107.1	15.3
454	Eating Places	292.2	313.5	44.8
455	Misc. Retail	77.3	83.0	11.9
463	Lodging	110.4	118.5	28.8
488	Amusement Svcs.	10.5	11.3	1.6
Totals		590.2	633.4	102.4

Direct impacts were estimated by applying the average minimum and maximum sales loss percentages (Table 7.2) to the estimated September through December output (Table 7.3) for each sector. These results are presented in Table 7.4. For example, the average minimum impact in sector 450 was 25% of output in the months of September through December, or $3.8 million (0.25 times $15.3 million)

* Less than one percent.

Table 7.4. Estimated direct impacts by sector.

Implan Code	Description	Sep-Dec Output ($M)	Min ($M)	Max ($M)
450	Food Stores	15.3	3.8	4.5
454	Eating Places	44.8	< 0.1	< 0.1
455	Misc. Retail	11.9	2.5	2.9
463	Lodging	28.8	3.5	3.9
488	Amusement Svcs.	1.6	0	< 0.1
Total ($ million, adjusted for inflation)			9.8	11.3

The total estimated minimum direct impact attributed to the red tide is calculated as the sum of the minimum impacts in all five Implan sectors included in the study. The total estimated maximum direct impact was estimated by the same method. The total minimum and maximum direct impact was estimated to be $9.8 million and $11.3 million, respectively. This represents approximately 1.5 to 1.9% of the combined annual output of these five sectors (Table 7.3), or 9.6% to 11% of the $102.4 million output in September-December.

7.2 Estimated Impacts of Oyster Fisheries Closures

In the Galveston bay system there are seven areas classified by the TDH for the purpose of harvesting molluscan shellfish (Appendix III). They include North Approved Area (NAA) , Central Approved Area (CAA), East Approved Area (EAA), West Approved Area (WAA). They also include three conditionally approved areas: Conditionally Approved Areas One (CAA1), Two (CAA2), and Three (CAA3). All of these areas are normally opened at the beginning of the commercial oyster fishing season (regular season) on November 1st and closed April 30th. Closure of any of these areas during the normal season will alter harvesting and disrupt the oyster industry operations.

Prior to the opening day of the regular season five of these areas were closed by TDH due to the presence of red tide (Table 7.5). Two were reopened on or just before the opening day of regular season. Three were not reopened until after November 1st. NAA was closed for 24 days, WAA for 33 days, and CAA1 for 28 days. The remaining areas lost no days in the 2000 regular season.

Table 7.5. Galveston waters shellfish harvesting areas and closures in 2000.

Water Area	Regular Season	Closed	Opened	Lost Days Nov	Lost Days Dec	Lost Days Total
NAA	Nov 1 - Apr 30	4-Sep	24-Nov	24		24
CAA	Nov 1 - Apr 30	4-Sep	1-Nov			0
EAA	Nov 1 - Apr 30	4-Sep	1-Nov			0
WAA	Nov 1 - Apr 30	31-Aug	3-Dec	30	3	33
CAA1	Nov 1 - Apr 30	4-Sep	28-Nov	28		28
CAA2	Nov 1 - Apr 30		1-Nov			0
CAA3	Nov 1 - Apr 30		1-Nov			0

Source: Texas Department of Health.

Average monthly landings (Table 7.6) are based on historical landings data provided by TPWD (Appendix IV). Because of differences in the definition of areas by which data are reported, it was necessary to bridge the TPWD data to TDH shellfish classification areas. This was done by assuming NAA landings were 45% of Upper Galveston Bay landings, and that CAA1 landings were 23% and 14% of landings in Upper Galveston Bay and Lower Galveston Bay, respectively (Table 7.7).

Table 7.6 Average monthly landings (barrels) and real prices (2000 basis) in selected Galveston bay areas (1990-1999).

MONTH	Upper Galveston Bay (bbl)	Lower Galveston Bay (bbl)	.West Galveston Bay (bbl)	Price ($/bbl)	Value $
September	602	1965	0	$ 41.71	107,070
October	676	2750	0	$ 42.49	145,571
November	2366	20456	233	$ 39.21	903,987
December	2316	13031	96	$ 39.24	605,983

Estimated quantity losses of oyster harvests were 852 barrels for NAA, and 3,180 barrels for CAA1 in November. Losses for WAA (ie., West Bay) were estimated to be 233 barrels in November and about 9 barrels in December for a total of 241 barrels (Table 7.8).

Table 7.7 Estimated monthly landings (barrels) in 2000 for selected TDH Classification Areas in the Galveston bay system, 2000 regular season.

MONTH	NAA	CAA	WAA	CAA1
September	271	1684	0	414
October	304	2357	0	540
November	1065	17531	233	3408
December	1042	11168	96	2357

The average real price (2000 basis) for Galveston oysters was calculated at $39.21 per barrel in November, and $39.24 per barrel in December. Total direct losses to the oyster industry during the period of closures was $167,223 in November and $365 in December for total direct losses of $167,588 (Table 7.8).

Table 7.8 Estimated lost monthly landings in 2000 for selected TDH Classification Areas in the Galveston bay system (monetary values are in 1997 dollars).

MONTH	NAA (bbl)	WAA (bbl)	CAA1 (bbl)	Value ($)
September	0	0	0	
October	0	0	0	
November	851.8	233.0	3180.8	$167,223
December	0	9.3	0	$365
TOTAL	851.8	242.3	3180.8	$167,588

7.3 Beach Cleanup Costs

For the 2000 Red Tide event, beach cleanup costs were nil. The Galveston Parks Board of Trustees, which is responsible for beach cleanup, reported that the "red tide was not a problem in terms of cleanup", because they have to clean up the beaches anyway; they're "always out there". Hence, there was no extra effort required to clean the beaches of dead fish as a result of the 2000 Red Tide (Muller, 2001).

Galveston County Parks Department also reported no "impact of the red tide on beach cleanup" along Bolivar Peninsula (Lee, 2001). Galveston County Road and Bridge Department, which took over the management of beach cleanup along Bolivar Peninsula on October 1st, also reported that "there has been no impact on the Road Department regarding red tide cleanup" (Sonnenberg, 2001). However, all agencies queried did comment on an unrelated problem: seaweed. They said that seaweed was a recurring and persistent problem that often resulted in unforeseen costs.

8. Estimated Total Economic Impacts on Galveston County

8.1 Total Direct Impacts

One input-output model was created to model the Galveston county economy. Industry output, employment, employee compensation, and proprietor income are summarized by aggregate sector in Table 8.1. A more complete characterization that presents Other Property Income, Indirect Business Taxes, and Total Value Added can be found in Appendix V. Output, employment, and total value added multipliers by sector are presented in the tables of Appendix VI.

Table 8.1 Galveston county output, employment, compensation, and proprietor's income.

Code	Industry	Industry Output*	Employment	Employee * Compensation	Proprietor Income *
1	Ag and Forestry	27.997	1,260	8.239	6.852
25	Commercial Fishing	7.287	143	1.788	0.766
28	Mining	354.336	624	29.572	11.727
48	Construction	768.966	9,136	282.037	53.068
108	Food Processing	49.834	312	4.681	0.104
190	Manufacturing	6,508.911	7,803	550.272	148.603
433	Transportation	608.035	3,434	139.737	15.404
441	Communication	158.675	592	29.253	9.765
443	Utilities	253.242	531	30.490	29.898
447	Wholesale Trade	248.321	2,466	95.213	5.866
448	Taxed Retail	551.902	15,035	206.588	16.358
450	Retail, non-taxed	99.826	3,372	48.341	6.675
455	Misc Taxed Retail	77.348	3,037	27.918	12.414
456	F.I.R.E.	1,320.336	8,086	228.794	26.874
463	Hotels and Lodging	110.432	2,210	36.142	6.551
464	Services, taxed	312.058	7,774	86.957	30.055
474	Services, non-taxed	828.317	16,458	357.614	87.674
479	Services, partial-taxed	168.121	2,159	42.365	13.851
488	Amusement and Rec	10.525	398	2.781	0.982
510	Government Sectors	1,147.136	26,599	964.348	0.000
516	Non-Comparable Imports	3.603	0	0.000	0.000
	TOTAL	13,615.207	111,431	3,173.126	483.488

*Millions of dollars (base year 1997).

Two total impact scenarios were analyzed. These were; MINIMUM, with total direct impacts to tourism equal to $9.76 million, and MAXIMUM with total direct impacts to tourism equal to $11.31 million. Both impact scenarios were additionally supplemented by the estimated impact of $167,588 to the commercial fishing sector, which represents the economic loss because of TDH-imposed oyster fishery closures.

8.2 Impact on Output.

Output represents the sales of goods and services. The estimated minimum direct impact on output because of the red tide in Galveston county was 9.9 million dollars ($9.9M). The maximum was $11.5M. This direct impact represents a change in final demand (including losses to both the tourism industry and oyster industry) because of the red tide in 2000. Table 8.2 presents these direct impacts along with the indirect, induced and total impacts. The minimum and maximum estimated total impacts on the Galveston county economy were $15.98 million and $18.46 million, respectively.

Table 8.2. Estimated impact of the red tide on output.

	Direct	Indirect	Induced	Total
Minimum	$9.9M	$2.4M	$3.7M	$16.0M
Maximum	$11.5M	$2.7M	$4.3M	$18.45M

8.3 Impact on Employment.

Employment is defined here as the number of jobs at the "place of work". The direct impact represents an initial change in the number of jobs as a result of changes to final demand due to the red tide. Indirect employment impacts include job changes in sectors that supply inputs and services to the sector experiencing the direct impacts. The induced employment impact results from a change in household purchases. The total employment impact (direct+indirect+induced) was estimated at 367 to 426 jobs.

Table 8.3. Estimated impact of the red tide on employment.

	Direct	Indirect	Induced	Total
Minimum	299	22	46	367
Maximum	347	25	53	426

8.4 Impact on Value Added.

Value added consists of four components: employee compensation (ie., wage and salary payments as well as benefits including health and life insurance), proprietor income (ie., income reported on Federal Income Tax Form 1040C), other property income (ie., payments from interest, rents, royalties, dividends, and profits), and indirect business tax (ie., primarily excise and sales taxes, but not taxes on profit or income).

The estimated minimum total impact on value added because of the 2000 Red Tide was $10.75M (Table 8.4). The estimated maximum total impact on value added because of the red tide was $12.43 million.

Table 8.4. Estimated impact of the red tide on value added.

	Direct	Indirect	Induced	Total
Minimum	$7.47M	$1.23M	$2.06M	$10.75M
Maximum	$8.64M	$1.4M	$2.38M	$12.43M

8.4 Summary.

The change to final demand as a result of the 2000 Red Tide represents the direct impact on Galveston county. The direct impact was used to estimate the impacts on total output, employment and value added, including indirect, and induced effects.

Minimum direct impacts were estimated at $9.9 million in sales, 299 jobs, and a $7.5 million change in total value added. The maximum direct impacts were $11.5 million in sales, 347 jobs, and $8.64 million in total value added.

Minimum total impacts were estimated at $16.0M in sales, 367 jobs, and a $10.75M change in total value added. The maximum total impacts were $18.45M in sales, 426 jobs, and $12.4M in total value added.

Direct and total impacts on output, employment, and total value added are summarized in Table 8.4, and in detail for each sector of the economy in Appendices VII and VIII.

Table 8.4 Summary of direct and total impacts.

	Output		**Employment**		**Total Value Added**	
	Direct	**Total**	**Direct**	**Total**	**Direct**	**Total**
Minimum	$9.9M	$16.0M	299	367	$7.5M	$10.7M
Maximum	$11.5M	$18.5M	347	426	$8.6M	$12.4M

9. Limitations to the Study

9.1 The problem with analyzing red tide events in Texas.

Red tide events in Texas occur sporadically, and persist for unpredictable lengths of time, depending upon factors such as the location, weather, and salinity (factors that may depend on each other). The seeming randomness of these events, as well as the unpredictable nature of their severity, distribution, and persistence makes it all but impossible to predict the duration, location, severity, or longevity of HABs. For these reasons alone it is difficult to accurately and consistently assess any damages due to outbreaks of these organisms. The analysis is made only more difficult by factors that mask the effects of the red tide. For example, visitors and fishermen may avoid an area of the coast because of the red tide, but they may be just as likely to avoid the same area if the weather is unfavorable. In cases such as these it is difficult to separate the two in order to determine which factor is resulting in avoidance. Indeed it is quite likely that two (or more) factors interact in such a way as to complement or cancel each other resulting in higher or lower impacts than either factor alone. The difficulty does not lie with the statistical analysis, however, but rather the lack of consistently obtained, accurate data at the local level where (and when) the red tide occurs.

Although consistent landings data is available to estimate losses to the commercial fishing sector as a result of closed oyster harvesting areas, it must be noted that oysters are captive prey and not usually harmed by red tide. There is certainly an immediate loss of revenue when a shellfish harvesting area is closed, but what happens when it is reopened? The long term effect may very well "net out" because delayed harvesting should result in the harvest of larger oysters. The initial reduction in supply may prove to be an advantage by raising economic rents when the larger oysters are sold, if larger oysters command a higher unit price when compared to the sale of smaller oysters. The delay in itself may reduce marginal costs in the longer run.

Halo effects have been documented elsewhere, and in Texas recent studies have examined the impact of labeling oysters. California, in 1991, passed a law requiring oysters from the Gulf of Mexico when sold in that state to be labeled with a warning. The result was the depression of market prices for Gulf oysters even when the product was guaranteed to be as wholesome as oysters from the West coast or Chesapeake Bay (Diop and Keithly, 2001; Keithly and Diop, 2001). The red tide may have another, similar effect that results in market aversion not only of oysters but of all commercial seafood products taken from Texas coastal waters. This halo effect was not examined in this paper, but several survey respondents suggested that customers were avoiding seafood, and oysters especially, and generally were avoiding the coast as well. These are indicators that a halo effect was in existence at the time.

9.2 Transferability of Results

Because this is a case study, the results of this analysis apply only to Galveston county during a single four-month period beginning September 1st, 2000. The results here can not be transferred easily to other counties or regions for several reasons; (1) Survey data was obtained from, and analyzed for respondents in Galveston county – demographics, income, demand for tourism, and employment will necessarily vary from one area to another, (2) Oyster landings data is based only on landings from Galveston bays – losses in landings from other bay systems will affect other regions differently than Galveston county for many of the same reasons (*ie.*, differences in demographics, income, employment, *etc.*), (3) The red tide may have been more or less persistent along other portions of the lower coast, and its severity may differ from that in Galveston bays, and, (4) The duration and severity of the red tide that occurred in September – December, 2000 in Galveston may not be the same in the future.

9.3 Confounding Responses

According to the Galveston Convention and Visitors Bureau (GCVB), the 2000 Red Tide had no effect on tourism or visitation based on hotel occupancy. Bed and Breakfasts, hotels, motels, and condo occupancy was up 5.6% from the previous year, and occupancy at flagship hotels was up more than 11%. A spokesman for the GCVB said that it would have been worse if "beaches had been closed, but since they weren't it had no effect." (Bellinger, 2001). This would appear to be in direct conflict with our estimate of impacts to the hotel industry of between $3.2 and $3.6 million. The GCVB however relies on voluntary reporting by participating lodging establishments, some of whom only sporadically report. Even so, our estimates represent approximately a 2.7% annual impact on the Lodging sector in Galveston county, a value small enough to be offset by positive impacts during months previous to the onset of the 2000 Red Tide (during the months of January through August hotels receipts typically exceed 75% of the annual total).

10. Conclusions

The purpose of this case study was to estimate the economic impact of the 2000 Red Tide on Galveston, Texas. The study area was defined as Galveston county and its associated municipalities. Economic sectors were identified as potentially affected based on a review of literature, consultation with state and local governmental agencies, and personal observations. Tourism-related sectors, commercial shellfishing , and beach cleanup costs were identified as the three most likely areas of the economy to be affected.

These economic areas are important because they each appear to be directly affected by the occurrence of the red tide, economic data is likely to be available for each activity in

terms of time and scope, and each activity is interconnected with other important sectors in the economy. Estimates of direct impacts were from several sources. These included; (1) a survey that targeted aquatic product dealers, and other businesses related to recreation and tourism, (2) losses based on the duration of closed shellfish harvesting areas, and (3) interviews with agents responsible for beach cleanup efforts.

It was estimated that the 2000 Red Tide had a direct economic impact on Galveston county of at least $9.9 million, and as much as $11.5 million. After including interactions within the local economy, the range of economic impacts increased from between $16.0 million to $18.45 million, approximately 0.12% of the total annual output of the county. In terms of employment this represents between 367 and 425 lost jobs. These effects are probably temporary, persisting with the duration of the red tide.

Caution is urged when interpreting the results of this study, because the primary difficulty of analyzing the effects of red tides in Texas is the random nature of the occurrence of red tide events in general

Additionally, factors unrelated to the red tide may serve to "mask" its effects. The closure of oyster fisheries results in obvious losses of revenues in the short term, but may "net out" over time, and may even have a net positive effect because of reduced marginal costs. There is adequate reason to believe the 2000 Red Tide resulted in halo effects, which are especially insidious and difficult to quantify. Nevertheless, the effects of the 2000 Red Tide were felt in the Galveston area. Business owners and customers alike voiced genuine concerns about the uncertainty of future red tide events on their health and livelihood.

APPENDIX I. Chronology of 2000 Oyster Fishery Closures in Galveston Waters.

- **31 August**

Red Tide bloom in West Galveston Bay. Galveston County Health District issues a press release warning residents and visitors.

- **3 September**

Red tide bloom moves into Galveston Bay proper.

- **4 September**

Oyster fisheries closed: Central Approved Area (CA), East Approved Area (EA), Conditionally Approved Area 1 (CAA1).

- **10-11 October**

No cells found in water samples in Galveston Bay proper. Oyster tissue tested for presence of toxin in CA, EA, and CAA1.

- **17 October**

Oyster tissue tested for presence of toxin in North Approved Area (NA), Conditionally Approved Area 2 (CAA2), and Conditionally Approved Area 3 (CAA3).

- **26 October**

CA and EA reopened. CAA1 remains closed.

- **31 October**

Texas Department of Health issues a press release: "All Texas coastal waters closed except for parts of Galveston Bay".

- **1 November**

Opening Day of Regular Commercial Oyster Season for NA, EA, CA, CAA1, CAA2, and CAA3. NA, West Bay, and CAA1 remain closed.

- **24 November**

NA reopened.

- **28 November**

CAA1 reopened.

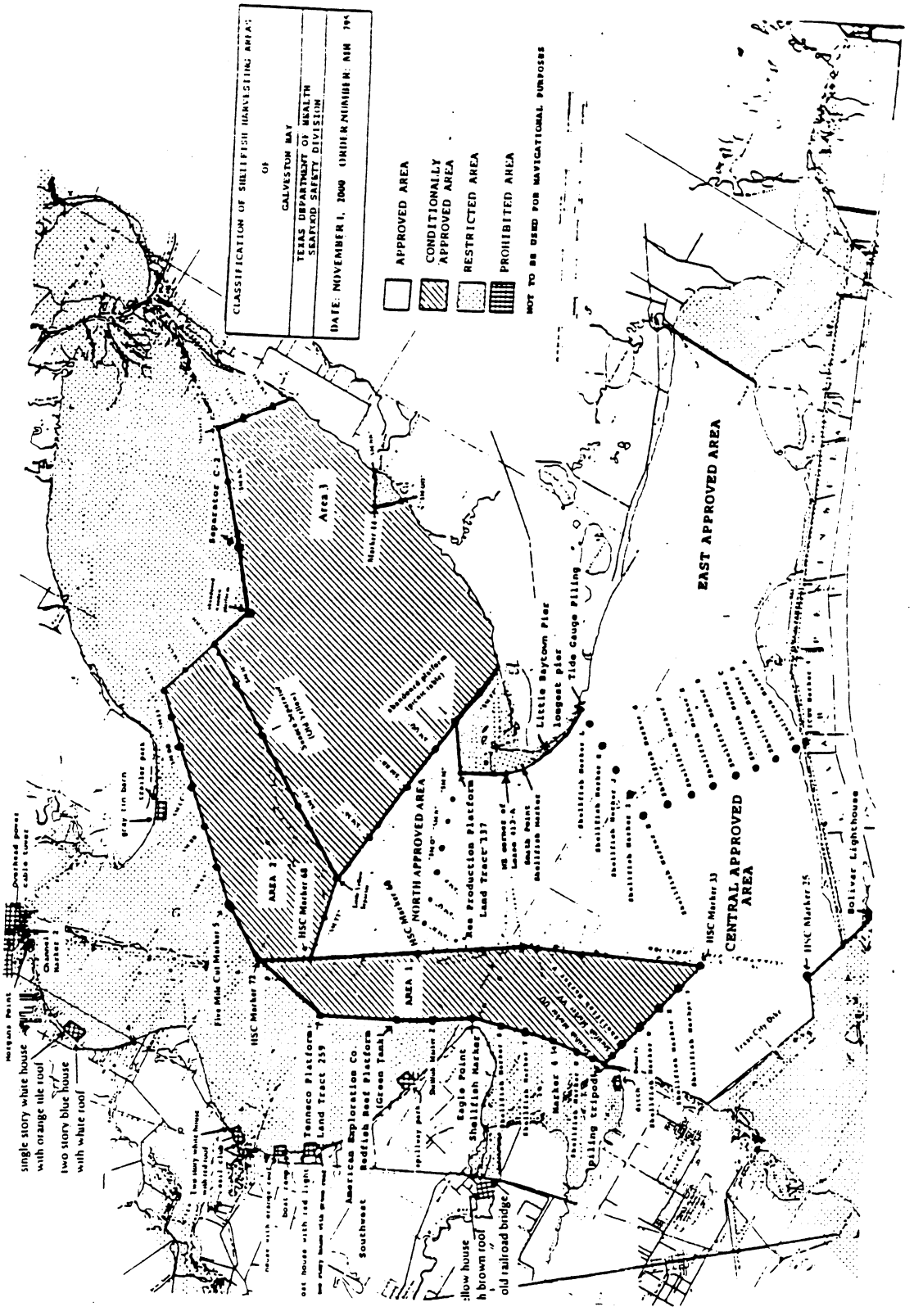
- **3 December**

West Bay reopened.

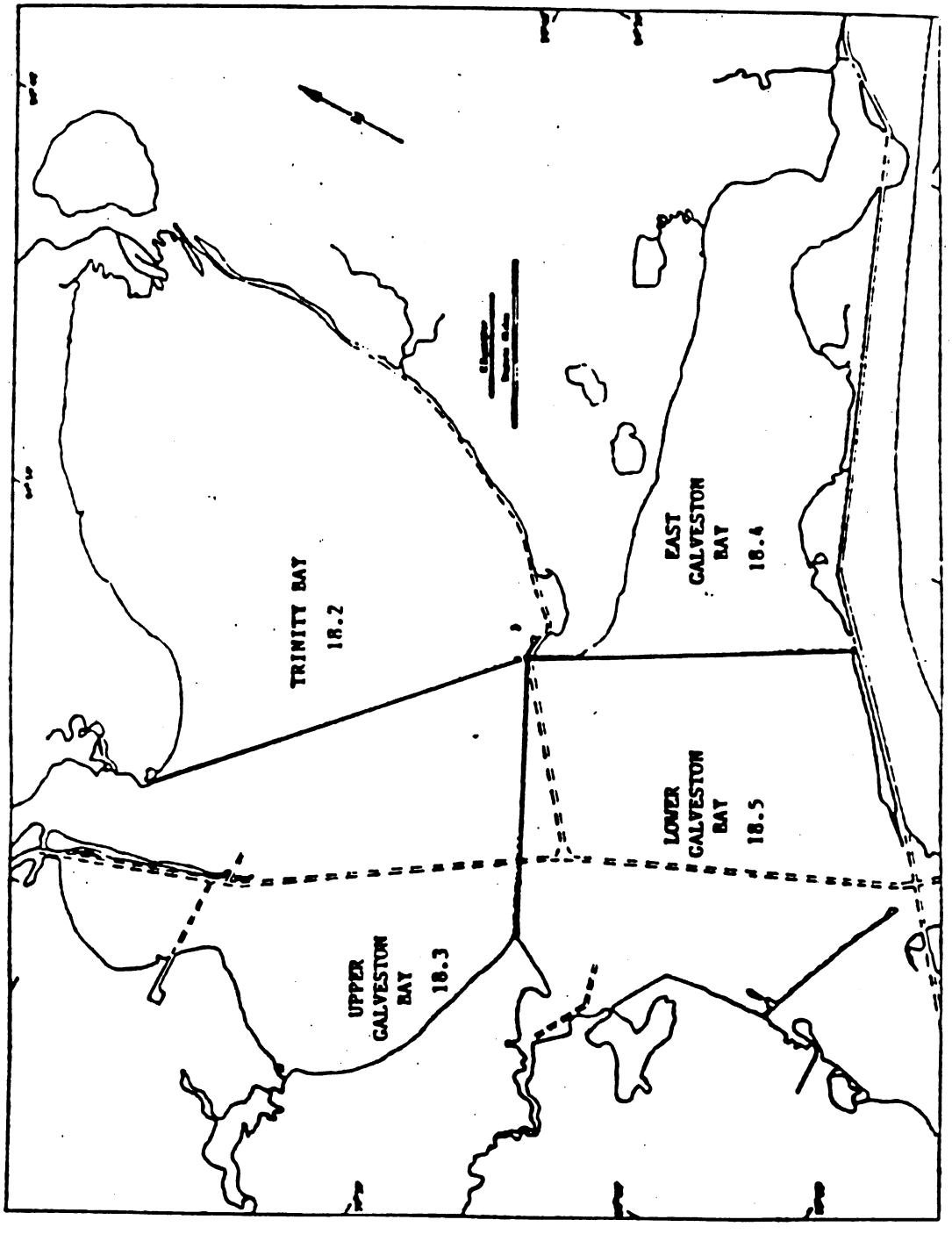
APPENDIX II. Labor Day Weekend 2000 – Personal Observations.

Cindy Contreras from Texas Parks and Wildlife confirmed on August 31 that the best place to observe the effects of this red tide event would be near San Luis Pass, along the beach west towards Surfside, and the Quintana jetties in Freeport. I talked with Christine Hopkins of the Galveston Visitors and Convention Bureau on September 1. She told me that there would be a concert at Galveston East Beach on September 2, and that she was also in communication with Parks and Wildlife and the Texas Department of Health, and that she was concerned that the red tide could affect the turnout to this highly publicized event. When asked about the red tide on Saturday September 2, a hotel manager in Freeport indicated that he did not know about the red tide, was nearly fully booked with confirmed reservations, and was unconcerned about its potential effects. A casual interview with several recreational fishermen in Freeport resulted in the conclusion that fishing was fair to poor. Sub-par fishing conditions were attributed mostly to a predominate westerly wind, which had rapidly reduced the visibility of the water and was creating a strong beach current. A visual survey of the beach from Surfside to San Luis Pass confirmed the presence of dead fish. Most of the dead fish had been washed up to the high tide line during the early morning hours, and consisted almost entirely of menhaden and hard-head catfish. I counted 250 carcasses along a quarter-mile section of the beach about 6 miles east of Surfside. At San Luis Pass there were as many as 13 dead fish every 10 feet and the odor was more noticeable. The presence of dead fish did not deter the many fishermen present at San Luis Pass who were actively camping and fishing. When queried, some restaurant owners indicated that business was a little slower than expected, but that it was still a busy and profitable weekend. Traffic along the Galveston sea wall was very congested on Saturday and Sunday, and the concert at East Beach was unaffected by the red tide according to staff members at the Galveston Visitors Bureau. Tourism appeared unaffected in Galveston due to the Red Tide. The weather seemed a more significant factor, as a heat wave pushed temperatures to all-time record levels for the city of Galveston. Christine Hopkins would later verify that the concert at Galveston was successful, and that at no time did the red tide affect tourism in Galveston, but that heat may have kept some beach goers at home. At a beach-house leasing office in Surfside, employees said that reports of red tide typically results in clients making reservations at the last minute, and that this was currently not a problem. The threat of hurricanes, they added, seemed to result in similar behavior. The Mayor of Surfside told me that this year was "not that bad". The popular beach areas close to Surfside he said were cleaned of dead fish before the crowds arrived, and although there seemed to be fewer people when compared to the Spring Break holiday, he attributed the lower turnouts to the heat, and said that any adverse effects on tourism by the red tide were less than that caused by the heat wave. The highest concentration of dead fish that I observed was near the Quintana beach jetties. Carcasses were piled to nearly a foot high along the beach areas next to the west jetty, and the smell was odious. It appeared that the area might have been a dumping ground for beach-cleanup crews, but this was not confirmed. The high concentration may have been due to currents around the jetty, or a higher concentration of red tide in the previous days. Fishers upon the jetty were actively fishing, and seemed unaffected by the heat or the smell, although both factors were lessened to a degree near the end of the jetty where they were congregated. (Evans, 2000).

APPENDIX III. Classification of TDH Shellfish Harvesting Areas



APPENDIX IV. Classification of Oyster Landings Areas.



APPENDIX V. Galveston County Output, Value Added and Employment in 1997.

Implan Code	Industry	Industry Output*	Employment	Employee Compensation*	Proprietor Income*	Other Property Income*	Indirect Business Tax*	Total Value Added*
1	Ag and Forestry	27.997	1,260	8.239	6.852	6.393	1.020	22.504
25	Commercial Fishing	7.287	143	1.788	0.766	3.887	0.185	6.627
28	Mining	354.336	624	29.572	11.727	137.395	17.643	196.337
48	Construction	768.966	9,136	282.037	53.068	22.763	9.648	367.516
108	Food Food Processing	49.834	312	4.681	0.104	1.626	0.610	7.020
190	Manufacturing	6,508.911	7,803	550.272	148.603	680.635	154.080	1,533.589
433	Transportation	608.035	3,434	139.737	15.404	69.791	16.626	241.557
441	Communication	158.675	592	29.253	9.765	45.417	10.542	94.978
443	Utilities	253.242	531	30.490	29.898	107.591	33.345	201.323
447	Wholesale Trade	248.321	2,466	95.213	5.866	35.082	37.705	173.866
448	Taxed Retail	551.902	15,035	206.588	16.358	57.574	61.516	342.036
450	Retail, non-taxed	99.826	3,372	48.341	6.675	13.337	16.177	84.530
455	Misc Taxed Retail	77.348	3,037	27.918	12.414	10.300	12.494	63.126
456	FIRE	1,320.336	8,086	228.794	26.874	577.878	123.188	956.733
463	Hotels and Lodging	110.432	2,210	36.142	6.551	15.867	6.893	65.454
464	Services, taxed	312.058	7,774	86.957	30.055	30.928	14.558	162.497
474	Services, non-taxed	828.317	16,458	357.614	87.674	27.601	5.241	478.130
479	Services, partial-taxed	168.121	2,159	42.365	13.851	19.632	6.425	82.273
488	Amusement and Rec	10.525	398	2.781	0.982	1.984	0.430	6.177
510	Government Sectors	1,147.136	26,599	964.348	0.000	114.279	0.000	1,078.626
516	Non-Comparable Imports	3.603	0	0.000	0.000	3.621	0.000	3.621
	TOTAL	13,615.207	111,431	3,173.126	483.488	1,983.578	528.328	6,168.521

*Millions of dollars

APPENDIX VI. Galveston County Multipliers.

Table VI.1 Output Multipliers for Galveston County

Implan	Description	Effects			Multipliers		
		Direct	Indirect	Induced	Total	Type I*	Type SAM*
1	Ag and Forestry	1.0000	0.1285	0.3751	1.5037	1.1285	1.503665
25	Commercial Fishing	1.0000	0.0920	0.2432	1.3352	1.0920	1.335242
28	Mining	1.0000	0.3951	0.1409	1.5360	1.3951	1.535969
48	Construction	1.0000	0.6208	0.3760	1.9968	1.6208	1.996755
108	Food Food Processing	1.0000	0.5428	0.1656	1.7084	1.5428	1.708380
190	Manufacturing	1.0000	0.9091	0.1960	2.1051	1.9091	2.105105
433	Transportation	1.0000	0.6270	0.2861	1.9131	1.6270	1.913139
441	Communication	1.0000	0.3673	0.2344	1.6016	1.3673	1.601643
443	Utilities	1.0000	0.1570	0.1827	1.3398	1.1570	1.339784
447	Wholesale Trade	1.0000	0.2846	0.3278	1.6124	1.2846	1.612403
448	Taxed Retail	1.0000	0.2962	0.3287	1.6249	1.2962	1.624885
450	Retail, non-taxed	1.0000	0.1545	0.3927	1.5471	1.1545	1.547133
455	Misc Taxed Retail	1.0000	0.1854	0.3816	1.5669	1.1854	1.566931
456	FIRE	1.0000	0.2455	0.1839	1.4295	1.2455	1.429477
463	Hotels and Lodging	1.0000	0.3783	0.3416	1.7199	1.3783	1.719939
464	Services, taxed	1.0000	0.4962	0.3509	1.8471	1.4962	1.847150
474	Services, non-taxed	1.0000	0.3896	0.4431	1.8327	1.3896	1.832739
479	Services, partial-taxed	1.0000	0.6073	0.3102	1.9175	1.6073	1.917511
488	Amusement and Rec	1.0000	0.4073	0.3219	1.7292	1.4073	1.729153
510	Government Sectors	1.0000	0.0613	0.5573	1.6186	1.0613	1.618559
516	Non-Comparable Imports	1.0000	0.0000	0.0000	1.0000	1.0000	1.000000

*Type I=(Direct + Indirect)/Direct

** Type SAM =(Direct + Indirect Page #

APPENDIX VI. Galveston County Multipliers.

Table VI.2 Employment Multipliers for Galveston County

Implan	Description	Effects				Multipliers	
		Direct	Indirect	Induced	Total	Type I*	Type SAM*
1	Ag and Forestry	45.0048	1.4623	4.5901	51.0573	1.0325	1.134485
25	Commercial Fishing	19.6320	0.6324	2.9705	23.2349	1.0322	1.183520
28	Mining	1.7614	2.3157	1.7686	5.8457	2.3147	3.318844
48	Construction	11.8810	3.9915	4.6534	20.5259	1.3360	1.727627
108	Food Food Processing	6.2558	5.8527	2.1184	14.2268	1.9356	2.274180
190	Manufacturing	1.1989	4.1467	2.5190	7.8645	4.4588	6.559858
433	Transportation	5.6484	4.4475	3.6188	13.7147	1.7874	2.428057
441	Communication	3.7296	3.3300	2.9141	9.9737	1.8928	2.674189
443	Utilities	2.0986	0.8306	2.2654	5.1946	1.3958	2.475279
447	Wholesale Trade	9.9307	2.6118	4.1011	16.6436	1.2630	1.675976
448	Taxed Retail	27.2421	2.8805	4.1210	34.2436	1.1057	1.257010
450	Retail, non-taxed	33.7836	1.4865	4.8543	40.1245	1.0440	1.187690
455	Misc Taxed Retail	39.2641	1.7838	4.7309	45.7788	1.0454	1.165918
456	FIRE	6.1242	2.2609	2.3453	10.7303	1.3692	1.752125
463	Hotels and Lodging	20.0167	3.4388	4.3338	27.7893	1.1718	1.388308
464	Services, taxed	24.9130	4.9003	4.4356	34.2488	1.1967	1.374739
474	Services, non-taxed	19.8689	3.6446	5.5724	29.0859	1.1834	1.463890
479	Services, partial-taxed	12.8414	3.1799	3.9047	19.9259	1.2476	1.551700
488	Amusement and Rec	37.8147	4.0888	4.0553	45.9588	1.1081	1.215369
510	Government Sectors	23.1872	0.4310	6.8196	30.4378	1.0186	1.312700
516	Non-Comparable Imports	0.0000	0.0000	0.0000	0.0000	0.0000	0.000000

*Type I=(Direct + Indirect)/Direct

** Type SAM =(Direct + Indirect + Induced)/Direct

APPENDIX VI. Galveston County Multipliers.

Table VI.3 Total Value Added Multipliers for Galveston County

Implan	Description	Effects				Multipliers	
		Direct	Indirect	Induced	Total	Type I*	Type SAM*
1	Ag and Forestry	0.8038	0.0626	0.2074	1.0737	1.0778	1.335808
25	Commercial Fishing	0.9094	0.0372	0.1342	1.0809	1.0410	1.188569
28	Mining	0.5541	0.1856	0.0795	0.8192	1.3349	1.478457
48	Construction	0.4779	0.2319	0.2097	0.9195	1.4851	1.923950
108	Food Food Processing	0.1409	0.2423	0.0949	0.4780	2.7200	3.393510
190	Manufacturing	0.2356	0.3245	0.1128	0.6729	2.3771	2.855776
433	Transportation	0.3973	0.2658	0.1628	0.8259	1.6691	2.078795
441	Communication	0.5986	0.1754	0.1315	0.9055	1.2931	1.512716
443	Utilities	0.7950	0.0791	0.1021	0.9761	1.0994	1.227837
447	Wholesale Trade	0.7002	0.1315	0.1845	1.0161	1.1878	1.451269
448	Taxed Retail	0.6197	0.1505	0.1852	0.9555	1.2429	1.541721
450	Retail, non-taxed	0.8468	0.0776	0.2188	1.1432	1.0917	1.350066
455	Misc Taxed Retail	0.8161	0.0932	0.2131	1.1224	1.1141	1.375281
456	FIRE	0.7246	0.1398	0.1051	0.9695	1.1930	1.337970
463	Hotels and Lodging	0.5927	0.1977	0.1943	0.9848	1.3336	1.661483
464	Services, taxed	0.5207	0.2269	0.1991	0.9467	1.4358	1.818110
474	Services, non-taxed	0.5772	0.1862	0.2503	1.0137	1.3226	1.756222
479	Services, partial-taxed	0.4894	0.2286	0.1755	0.8934	1.4671	1.825634
488	Amusement and Rec	0.5869	0.1973	0.1821	0.9663	1.3361	1.646441
510	Government Sectors	0.9403	0.0268	0.3080	1.2751	1.0285	1.356069
516	Non-Comparable Imports	1.0048	0.0000	0.0000	1.0048	1.0000	1.000000

*Type I=(Direct + Indirect)/Direct

** Type SAM =(Direct + Indirect + Induced)/Direct

APPENDIX VII. Minimum Impacts.

Table VII.1 Minimum Impact on Output by Aggregate Sector in Galveston County

Implan	Industry	Direct	Indirect	Induced	Total
1	Ag and Forestry	0	6,367	10,589	16,956
25	Commercial Fishing	167,588	390	1,964	169,942
28	Mining	0	26,111	31,925	58,036
48	Construction	0	109,336	45,347	154,683
108	Food Food Processing	0	987	9,038	10,025
190	Manufacturing	0	631,167	856,617	1,487,784
433	Transportation	0	143,212	127,417	270,629
441	Communication	0	91,741	78,633	170,374
443	Utilities	0	126,277	105,108	231,385
447	Wholesale Trade	0	29,226	68,493	97,719
448	Taxed Retail	0	27,777	427,027	454,804
450	Retail, non-taxed	3,829,000	4,998	77,427	3,911,425
455	Misc Taxed Retail	2,485,000	3,954	65,088	2,554,042
456	FIRE	0	556,139	819,619	1,375,758
463	Hotels and Lodging	3,451,000	40,070	36,927	3,527,997
464	Services, taxed	0	300,172	142,506	442,679
474	Services, non-taxed	0	239,843	506,270	746,113
479	Services, partial-taxed	0	35,064	64,666	99,730
488	Amusement and Rec	0	4	10,253	10,257
510	Government Sectors	0	298	185,412	185,710
516	Non-Comparable Imports	0	0	1,026	1,026
25001	Foreign Trade	0	0	0	0
28001	Domestic Trade	0	0	0	0
	Total	9,932,588	2,373,134	3,671,352	15,977,074

APPENDIX VII. Minimum Impacts.

Table VII.2 Minimum Impact on Employment by Aggregate Sector in Galveston Coun

Implan	Industry	Direct	Indirect	Induced	Total
1	Ag and Forestry	0.0	0.3	0.5	0.8
25	Commercial Fishing	3.3	0.0	0.0	3.3
28	Mining	0.0	0.0	0.1	0.1
48	Construction	0.0	1.3	0.5	1.8
108	Food Food Processing	0.0	0.0	0.1	0.1
190	Manufacturing	0.0	0.8	1.0	1.8
433	Transportation	0.0	0.8	0.7	1.5
441	Communication	0.0	0.3	0.3	0.6
443	Utilities	0.0	0.3	0.2	0.5
447	Wholesale Trade	0.0	0.3	0.7	1.0
448	Taxed Retail	0.0	0.8	11.6	12.4
450	Retail, non-taxed	129.4	0.2	2.6	132.1
455	Misc Taxed Retail	97.6	0.2	2.6	100.3
456	FIRE	0.0	3.4	5.0	8.4
463	Hotels and Lodging	69.1	0.8	0.7	70.6
464	Services, taxed	0.0	7.5	3.6	11.0
474	Services, non-taxed	0.0	4.8	10.1	14.8
479	Services, partial-taxed	0.0	0.5	0.8	1.3
488	Amusement and Rec	0.0	0.0	0.4	0.4
510	Government Sectors	0.0	0.0	4.3	4.3
516	Non-Comparable Imports	0.0	0.0	0.0	0.0
25001	Foreign Trade	0.0	0.0	0.0	0.0
28001	Domestic Trade	0.0	0.0	0.0	0.0
	Total	299.3	22.1	45.8	367.2

APPENDIX VII. Minimum Impacts.

Table VII.3 Minimum Impact on Total Value Added by Aggregate Sector in Galvest

Implan	Industry	Direct	Indirect	Induced	Total
1	Ag and Forestry	0	5,118	8,511	13,629
25	Commercial Fishing	152,403	355	1,786	154,543
28	Mining	0	14,468	17,690	32,158
48	Construction	0	52,255	21,673	73,928
108	Food Food Processing	0	139	1,273	1,412
190	Manufacturing	0	148,712	201,831	350,543
433	Transportation	0	56,895	50,620	107,514
441	Communication	0	54,913	47,068	101,981
443	Utilities	0	100,388	83,559	183,948
447	Wholesale Trade	0	20,463	47,956	68,420
448	Taxed Retail	0	17,215	264,646	281,860
450	Retail, non-taxed	3,242,285	4,232	65,563	3,312,079
455	Misc Taxed Retail	2,028,091	3,227	53,121	2,084,438
456	FIRE	0	402,986	593,907	996,893
463	Hotels and Lodging	2,045,433	23,750	21,887	2,091,070
464	Services, taxed	0	156,308	74,207	230,515
474	Services, non-taxed	0	138,445	292,235	430,679
479	Services, partial-taxed	0	17,159	31,646	48,805
488	Amusement and Rec	0	2	6,017	6,020
510	Government Sectors	0	280	174,339	174,619
516	Non-Comparable Imports	0	0	1,031	1,031
25001	Foreign Trade	0	0	0	0
28001	Domestic Trade	0	0	0	0
	Total	7,468,211	1,217,310	2,060,564	10,746,084

APPENDIX VIII. Maximum Impacts.

Table VIII.1 Maximum Impact on Output by Aggregate Sector in Galveston County

Implan	Industry	Direct	Indirect	Induced	Total
1	Ag and Forestry	0	7,316	12,255	19,571
25	Commercial Fishing	167,588	434	2,273	170,295
28	Mining	0	30,042	36,948	66,989
48	Construction	0	125,013	52,475	177,488
108	Food Food Processing	0	1,123	10,460	11,583
190	Manufacturing	0	727,336	991,418	1,718,754
433	Transportation	0	163,470	147,465	310,934
441	Communication	0	105,673	91,009	196,682
443	Utilities	0	144,829	121,650	266,479
447	Wholesale Trade	0	33,591	79,272	112,863
448	Taxed Retail	0	31,993	494,233	526,226
450	Retail, non-taxed	4,518,000	5,769	89,614	4,613,383
455	Misc Taxed Retail	2,863,000	4,564	75,333	2,942,897
456	FIRE	0	639,537	948,607	1,588,144
463	Hotels and Lodging	3,911,000	46,104	42,737	3,999,841
464	Services, taxed	0	347,067	164,932	511,999
474	Services, non-taxed	0	275,611	585,948	861,559
479	Services, partial-taxed	0	40,375	74,842	115,217
488	Amusement and Rec	16,000	5	11,866	27,871
510	Government Sectors	0	329	213,897	214,226
516	Non-Comparable Imports	0	0	1,185	1,185
25001	Foreign Trade	0	0	0	0
28001	Domestic Trade	0	0	0	0
	Total	11,475,588	2,730,178	4,248,421	18,454,187

APPENDIX VIII. Maximum Impacts.

Table VIII.2 Maximum Impact on Employment by Aggregate Sector in Galveston County

Implan	Industry	Direct	Indirect	Induced	Total
1	Ag and Forestry	0.0	0.3	0.6	0.9
25	Commercial Fishing	3.3	0.0	0.0	3.3
28	Mining	0.0	0.1	0.1	0.1
48	Construction	0.0	1.5	0.6	2.1
108	Food Food Processing	0.0	0.0	0.1	0.1
190	Manufacturing	0.0	0.9	1.2	2.1
433	Transportation	0.0	0.9	0.8	1.8
441	Communication	0.0	0.4	0.3	0.7
443	Utilities	0.0	0.3	0.3	0.6
447	Wholesale Trade	0.0	0.3	0.8	1.1
448	Taxed Retail	0.0	0.9	13.5	14.3
450	Retail, non-taxed	152.6	0.2	3.0	155.9
455	Misc Taxed Retail	112.4	0.2	3.0	115.6
456	FIRE	0.0	3.9	5.8	9.7
463	Hotels and Lodging	78.3	0.9	0.9	80.1
464	Services, taxed	0.0	8.6	4.1	12.8
474	Services, non-taxed	0.0	5.5	11.6	17.1
479	Services, partial-taxed	0.0	0.5	1.0	1.5
488	Amusement and Rec	0.6	0.0	0.4	1.1
510	Government Sectors	0.0	0.0	5.0	5.0
516	Non-Comparable Imports	0.0	0.0	0.0	0.0
25001	Foreign Trade	0.0	0.0	0.0	0.0
28001	Domestic Trade	0.0	0.0	0.0	0.0
	Total	347.2	25.4	53.0	425.7

APPENDIX VIII. Maximum Impacts.

Table VIII.3 Maximum Impact on Total Value Added by Aggregate Sector in Galveston County

Implan	Industry	Direct	Indirect	Induced	Total
1	Ag and Forestry	0	5,881	9,851	15,731
25	Commercial Fishing	152,403	394	2,067	154,864
28	Mining	0	16,646	20,473	37,119
48	Construction	0	59,748	25,080	84,828
108	Food Food Processing	0	158	1,474	1,632
190	Manufacturing	0	171,370	233,592	404,962
433	Transportation	0	64,942	58,584	123,527
441	Communication	0	63,253	54,475	117,728
443	Utilities	0	115,137	96,710	211,847
447	Wholesale Trade	0	23,519	55,504	79,023
448	Taxed Retail	0	19,827	306,297	326,124
450	Retail, non-taxed	3,825,710	4,885	75,883	3,906,477
455	Misc Taxed Retail	2,336,589	3,724	61,482	2,401,795
456	FIRE	0	463,417	687,373	1,150,790
463	Hotels and Lodging	2,318,079	27,326	25,331	2,370,735
464	Services, taxed	0	180,727	85,885	266,612
474	Services, non-taxed	0	159,091	338,227	497,318
479	Services, partial-taxed	0	19,758	36,626	56,384
488	Amusement and Rec	9,390	3	6,964	16,357
510	Government Sectors	0	309	201,123	201,432
516	Non-Comparable Imports	0	0	1,191	1,191
25001	Foreign Trade	0	0	0	0
28001	Domestic Trade	0	0	0	0
	Total	8,642,170	1,400,117	2,384,188	12,426,474

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