Acc# 2126

A DETERMINATION OF SOURCE, AMOUNT, AND AREA OF PESTICIDE POLLUTION IN SOME TEXAS BAYS

Project MP-R-1
Job 1

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ABSTRACT

This study was initiated to determine the source, amount, and area of pesticide contamination within some Texas bays. The commercial oyster (Crassostrea virginica) was used as the indicator organism. Whole oysters were prepared for analysis by electron capture gas liquid chromatography. Analyses were made for the following chlorinated hydrocarbons: Aldrin, BHC, Dieldrin, DDD, DDE, DDT, Endrin, Heptachlor, Heptachlor epoxide, Lindane, and Methoxychlor.

The estimated crop land within each watershed being sampled was determined. Approximate pounds of each pesticide applied per year were determined to pinpoint areas of high application.

It was found that lower Laguna Madre oysters contained more pesticides than oysters from other areas and that the associated watershed had the highest rate of pesticide application per acre of cropland.

In the areas sampled, it appears that farm lands, rather than metropolitan areas, are the main source of pesticide pollution.

INTRODUCTION

With the increasing use of toxic chemical pesticides known to be resistant to degradation by biochemical and physical action and known to concentrate in living organisms, our knowledge must be broadened with respect to the effects these pesticides will have on the marine ecological systems and on human health when the edible forms are consumed.

Since the watersheds emptying into the oyster-growing bay areas receive enormous quantities of DDT as well as other pesticides, it is imperative that we know how much of this application actually reaches our bays.

Since the commercial oyster (Crassostrea virginica) is known to concentrate these toxic chemicals and store them within its body, it is being used as the indicator of pesticide presence. The present phase of this study has been established to: 1. Determine the source of the contaminants, 2. Determine the amount of contamination, and 3. Locate areas of greatest concentration of contamination. Future sampling methods may include the use of fish flesh and plankton.

The literature has been examined for similar work performed, and county agricultural agents have been contacted to collect pesticide application data as to kind and extent.

DESCRIPTION OF AREA

In each sample area, at least one station is located near a suspected area of contamination. Usually, this is near the mouth of a river or other drainage system, or near a town.

In the Galveston Bay area samples are taken from Beasley's Reef (Sample 1) in Trinity Bay and Hanna's Reef (Sample 2) in East Bay. The Palacios area is represented by samples from Tres Palacios Bay (Sample 1) and Lavaca Bay (Sample 2), each sample being taken near the mouth of a river. In the Seadrift area one sample is obtained from Nancy's Reef (Sample 1) in upper San Antonio Bay, and another sample is from Chicken Foot Reef (Sample 2) in extreme southwestern San Antonio Bay. In the Rockport area it has been difficult to find adequate sample stations due to the scarcity of oysters. However, stations were finally solidified in St. Charles Bay, near the mouth (Sample 2), and near Frondoleg Island (Sample 1) near Rockport. An adequate sample station has yet to be established in the Corpus Christi Bay area since this area is practically devoid of oysters. Temporary stations in Nueces (Sample 1) and Corpus Christi Bays (Sample 2) were used during this study. The lower Laguna Madre is sampled in the Arroyo Colorado at Arroyo City (Sample 1) and at Three Islands (Sample 2) in the Laguna Madre.

The estimation of land area having pesticide application within each watershed area has been determined from reports by county agricultural agents and Texas A. & M. University, Texas Agricultural Extension Service bulletins, or from various other publications (Figure 1).

MATERIALS AND METHODS

In order to determine the extent of pesticide contamination within each bay area, one sample station was established near the suspected areas of heaviest contamination, and another station was established in an area several miles away to determine the scope of contamination.

Pesticide Monitoring -- Oysters were collected by dredge, tong, or hand at each sample station. For each sample, twelve oysters were opened, drained, and ground to a smooth consistency in a blender. From this, 30.00 $\pm$ 5 grams were introduced into a clean, preserving jar. The sample was then chilled to a semi-frozen state after which exactly three times the sample weight of anhydrous Sodium Sulfate (Na_2So_4--Baker 3898) was added. This was mixed thoroughly and then allowed to freeze. While frozen, the sample was ground to a free flowing powder. A duplicate of each sample was prepared from another 12 oysters taken concurrently.

These samples were sealed in the jars and air mailed to the Bureau of Commercial Fisheries, Biological Laboratory, Sabine Island, Gulf Breeze, Florida, where they were analyzed for the following chlorinated hydrocarbons: Aldrin, BHC, Dieldrin, DDD, DDE, DDT, Endrin, Heptachlor, Heptachlor epoxide, Lindane, and Methoxychlor.

All samples were analysed by electron capture gas liquid chromatography. Samples were usually injected into two columns of different polarity to identify a given compound. Sometimes additional methods were used to aid identification. Values below .010 ppm (parts per million) approach the lower limits of accuracy, and values below this amount were reported as a trace (TR).

Area and Rate of Application Determination -- The area draining into each bay being sampled is outlined in Figure 1. The counties, or portions of counties, within these areas were determined from observation of a map containing these political divisions. County agricultural agents were contacted to determine the amount of land in cultivation within each county. An estimation of the crop land within each county that lies within a specific drainage area was determined and used to project the total acreage under cultivation.

The rate of application of each pesticide was determined from data presented in Texas Agricultural Extension Service bulletins (Anonymous, 1965; and Newton, et al, 1966). In some cases two or more pesticides were applied as a combination in one application. By the use of information gained from these bulletins and discussions with county agents, a median rate of application was determined. In illustration: A mixture of Toxaphene and DDT might be applied at a rate of 1.75 pounds of DDT and 2.5 pounds of Toxaphene per acre. This mixture could be applied 2 times and then another mixture could be used to control another species of insect. From these various application combinations a minimum application rate was used to determine application over large areas of a watershed.

RESULTS

Pesticide Monitoring Data -- Samples taken in Galveston Bay and analyzed for pesticides reveal the presence (Table 1) of DDE and DDD in amounts ranging from a trace to .017 ppm. Concentrations of DDD in the oyster meat samples increased in November to .010 ppm in sample 1 and .011 ppm in sample 2. In December, sample 1 contained .011 ppm of DDE and .016 ppm DDD. Sample 2 had .017 ppm of DDD.

No other pesticides were found in the samples from the Galveston Bay area.

In the Palacios area (Tres Palacios Bay, Matagorda Bay, and Lavaca Bay) DDE ranged in concentration from a trace in September and October to a high of .093 ppm in December. The range of DDD was from none in September and October to .029 ppm in December. DDT was first found as a trace in samples in November and increased to .065 ppm in December. Other pesticides were not detected.

In the San Antonio Bay area only traces of DDE, DDD, and DDT were found in samples before November. In November, sample 1 contained .011 ppm of DDE and sample 2 contained .012 ppm of DDE. In December this increased to .025 ppm in sample 1. Other samples revealed a trace. Concentrations of DDT above a trace were not found prior to December when sample 1 contained .11 ppm.

The only other pesticide detected was Dieldrin, which was found in a concentration of .011 ppm in sample 1 in December.

In the Aransas Bay area (Aransas, Copano, and St. Charles Bays) DDE concentrations ranged from a trace in July, August, and October to a high of .21 ppm in sample 1 in September. In November, sample 1 contained .014 ppm and sample 2 contained .010 ppm of DDE. No samples were prepared for December.

In October .017 ppm of DDD were found in sample 1. Traces were found in August and September. No other pesticides were detected.

In the Corpus Christi - Nueces Bay area difficulty was encountered in obtaining a sufficient number of oysters to prepare samples. Samples analyzed in July had a trace of DDE, .017 ppm of DDD, and a trace of DDT. In September .011 ppm of DDE, .023 ppm of DDD, and a trace of DDT were found in sample 1.

Sample 2 had a trace of DDE. No further samples were prepared.

Samples were not prepared in the lower Laguna Madre in July and August. Sample 1 in September had a trace of DDE. Sample 2 had .17 ppm of DDE, .52 ppm of DDD, .020 ppm of DDT, and .018 ppm of Dieldrin.

In November sample 1 contained .055 ppm of DDE, .080 ppm of DDD, .017 ppm of DDT, .029 ppm of Dieldrin, and .032 ppm of Endrin. No sample was prepared from station 2.

Area and Rate of Application Data -- Acreage estimates for each drainage system varies from 790,358 acres draining into the Galveston Bay area to 207,357 acres draining into the Aransas--Copano Bay area (Table 2 and Figure 1).

The crops grown vary with the climatic and environmental conditions found in each watershed (Table 2). In the Galveston, Palacios, and Seadrift areas the crops grown are cotton, sorghum, and rice. In the Rockport and Corpus Christi areas the crops grown are cotton and sorghum. The crops grown in the lower Laguna Madre drainage area are more diversified and include cotton, sorghum, citrus fruits, and vegetables.

The actual acreage under cultivation in the Arroyo Colorado-Laguna Atascosa drainage area that empties into the lower Laguna Madre is much less than the acreage appearing in the data in table 2. This is due to much double and even triple cropping in this sub-tropical area of the lower Laguna Madre. This area has a very large application of pesticides each year.

Rate of application for DDT, both in mixture and alone, amounts to approximately 1.75 pounds per acre per application on cotton. It is normally applied twice at this rate. It is applied on vegetable crops at the rate of 1.5 pounds per acre for applications.

Dieldrin is normally used as a seed treatment on rice at the rate of 5 pounds per acre and on vegetables at the rate of .4 pounds per acre for 4 applications.

The only application of Endrin was on vegetables. The rate of application is .4 pounds per acre for 4 applications.

Toxaphene is the most widely used and the most heavily applied of all the pesticides studied. It is applied to cotton 4 times (normally) at the rate of 2.5 pounds per acre. On sorghum it is applied 4 times at the rate of 2 pounds per acre. On vegetables it is applied 4 times at the rate of 1.5 pounds per acre. On rice the application is 4 times at the rate of 2 pounds per acre.

Sevin is applied to cotton, rice, and vegetables. On cotton it is applied at a rate of 2 pounds per acre for 4 applications. Rice has an application of Sevin at a rate of 1.25 pounds per acre for 3 applications. Vegetables receive Sevin at a rate of .35 pounds per acre for 4 applications.

Parathion is used on cotton, sorghum, and vegetables. On both cotton and sorghum the rate of application is .25 pounds per acre for 4 applications. On vegetables it is applied at a rate of .35 pounds per acre for 4 applications.

The number of times pesticides are applied to a crop must, by necessity, be an arbitrary number since needs will vary so widely. These data presented are intended only as a guide to indicate areas of greatest pesticide use. An examination of Table 2 and 3 indicates that the data does represent these areas effectively.

DISCUSSION

Pesticides are chemicals toxic to certain target animals, and any chemical capable of controlling or killing one form of animal life is usually capable of harming other forms of life as well. This fact is the basis for this and numerous other studies. The hazard of a pesticide varies with its toxicity and persistence. This hazard might be slight or very great indeed. The manner of application and the area in which applied become important considerations in assessing the hazard to wildlife, as well as to man.

Loosanoff (1959) found that the larvae of the common oyster, Crassostrea virginica, are strongly affected by the presence of DDT in sea water. With a concentration of 1.0 ppm in sea water, the larvae died in 4 days, and in a concentration of 1.0 part in 40 million parts of sea water, the larvae did not grow well.

Davis (1961) found that Endrin and Dieldrin, as well as Toxaphene, affected the growth and survival of oyster eggs. He stated further that if one pound of any pesticide were in solution and distributed evenly over an acre of water 1 foot deep, the concentration would be .37 ppm. If the water were 16 feet deep, for example, the concentration would be .023 ppm. In the case of DDT this concentration would be enough to reduce the growth of oyster larvae by 40 per cent and their survival by 20 per cent.

Oysters concentrate pesticides possibly 50 to 60 thousand times above the sea water concentration. Using this as a guide, the data presented in Table 1 would indicate present levels in bay water are below those found to affect growth and survival.

Since the total environment must be considered in any comprehensive study of the effects of pesticides, we should not be led to the conclusion that the concentrations below toxic level are not harmful. The long-term effects could possibly inhibit phytoplankton blooms and thus cause changes in oyster growth through the food chain. For example, Spector (1956) found that carbamate compounds (Sevin) were found to suppress cytoplasmic division, which allows for a low "safe" concentration of these compounds.

Other species adversly affected by pesticides are shrimp and crabs. Butler (1963) found that Penaeus setiferus, the commercial white shrimp, was extremely sensitive to DDT. DDT levels of .001 ppm and above are extremely toxic to them and for tests to check accumulation, a concentration of .0005 ppm was selected. After 72 hours considerable mortality occurred and the surviving shrimp were analyzed. Paper chromatography analysis revealed .14 ppm of DDT in whole body samples.

Other researchers working with the blue crab, Callinectes sapidus, found that 1.0 ppb (parts per billion) of DDT in sea water killed blue crabs in 8 days.

Since analysis data presented here reveals that several of the pesticides commonly used are present in oysters and that these pesticides are applied to several thousand acres of land within each watershed, the next logical step is to determine the actual amounts present in the bay water.

Water analysis data from the lower Laguna Madre, the San Antonio Bay system and Tres Palacios Bay, would be especially valuable since these areas all show high levels of concentration in analysis of whole oysters. The watersheds of these same areas have a large acreage of cultivated land receiving pesticide application. This would seem to point out areas of greatest agricultural activity as contributing most to the pesticide contamination.

Data from this survey is as yet too sketchy to indicate any appreciable amounts of pesticides originating with cosmopolitan areas. No doubt they do contribute, but to what extent, is not known. Mosquito control applications are another source that should be carefully scrutinized.

ACKNOWLEDGEMENTS

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FIGURE 1: Watersheds of Some Texas Bays

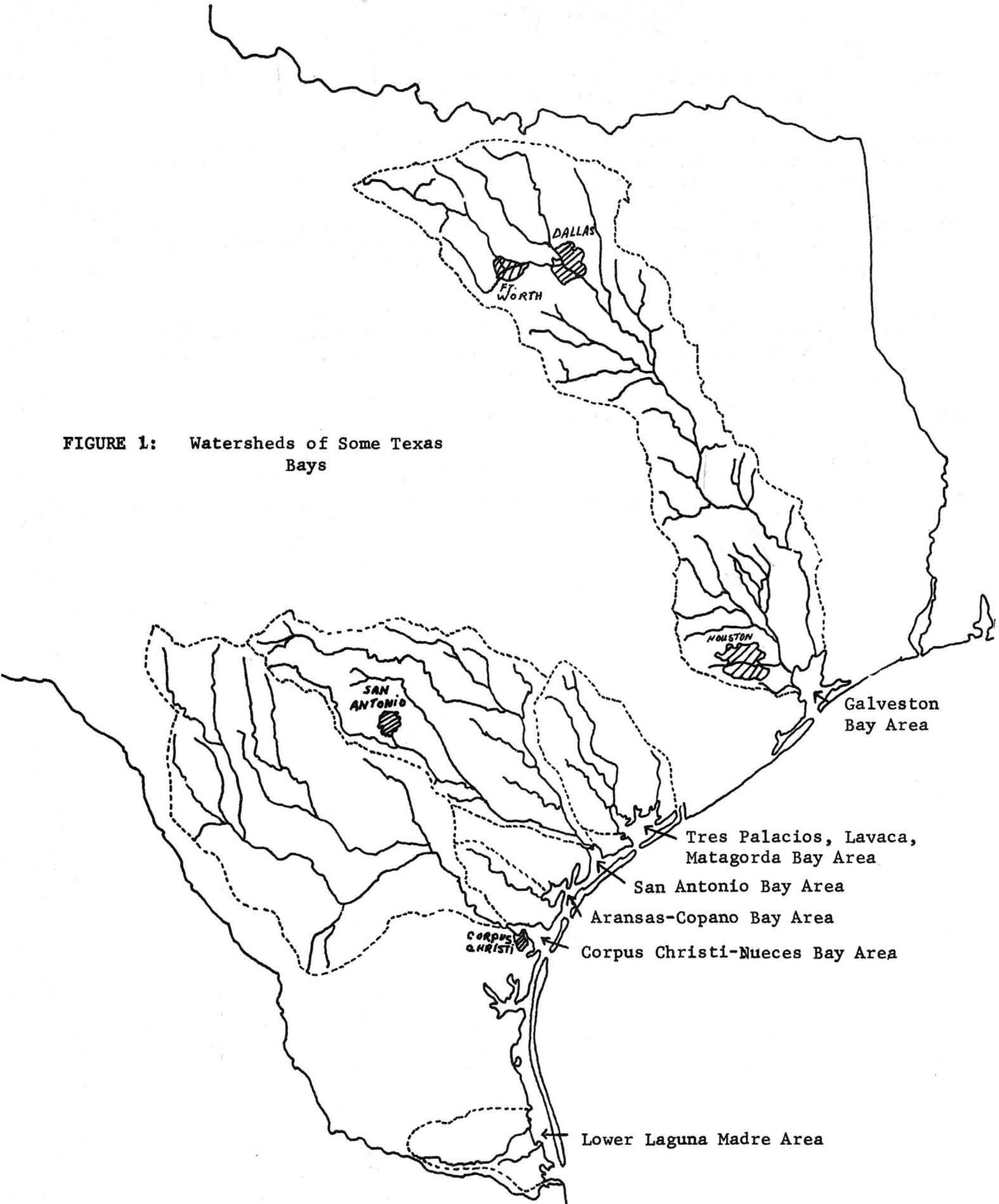

TABLE 1: Pesticide monitoring analysis data

Chemical found-parts per million

Area & Date		DDE A	DDE B	DDD A	DDD B	DDT A	DDT B	DIELDRIN A	DIELDRIN B	ENDRIN A	ENDRIN B
<u>Galveston</u>:											
July	1	TR	TR	TR	TR	--	--	--	--	--	--
	2	NR	--	NR	--	NR	--	NR	--	NR	--
August	1	--	NR	--	NR	--	NR	--	NR	--	NR
	2	TR	NR	--	NR	--	NR	--	NR	--	NR
September	1	TR	NR	--	NR	--	NR	--	NR	--	NR
	2	TR	NR	--	NR	--	NR	--	NR	--	NR
October	1	TR	NR	TR	NR	--	NR	--	NR	--	NR
	2	NSP	NR	NSP	NR	NSP	NR	NSP	NR	NSP	NR
November	1	TR	NR	.010	NR	--	NR	--	NR	--	NR
	2	TR	NR	.011	NR	--	NR	--	NR	--	NR
December	1	.011	NR	.016	NR	--	NR	--	NR	--	NR
	2	TR	NR	.017	NR	--	NR	--	NR	--	NR
<u>Palacios</u>:											
July	1	.011	.011	TR	TR	--	--	--	--	--	--
	2	.011	.034	TR	.010	--	--	--	--	--	--
August	1	.011	NR	TR	NR	--	NR	--	NR	--	NR
	2	TR	NR	--	NR	--	NR	--	NR	--	NR
September	1	TR	NR	--	NR	--	NR	--	NR	--	NR
	2	--	NR	--	NR	--	NR	--	NR	--	NR
October	1	TR	NR	--	NR	--	NR	--	NR	--	NR
	2	TR	NR	--	NR	--	NR	--	NR	--	NR
November	1	.021	NR	TR	NR	TR	NR	--	NR	--	NR
	2	.013	NR	TR	NR	TR	NR	--	NR	--	NR
December	1	.093	NR	.029	NR	.065	NR	--	NR	--	NR
	2	.022	NR	TR	NR	.010	NR	--	NR	--	NR
<u>San Antonio</u>:											
July	1	TR	TR	TR	TR	--	--	--	--	--	--
	2	--	--	--	--	--	--	--	--	--	--
August	1	TR	NR	TR	NR	TR	NR	--	NR	--	NR
	2	TR	NR	--	NR	--	NR	--	NR	--	NR
September	1	TR	NR	TR	NR	--	NR	--	NR	--	NR
	2	TR	NR	TR	NR	TR	NR	--	NR	--	NR
October	1	TR	NR	TR	NR	TR	NR	--	NR	--	NR
	2	TR	NR	TR	NR	TR	NR	--	NR	--	NR
November	1	.011	NR	TR	NR	TR	NR	--	NR	--	NR
	2	.012	NR	.010	NR	.016	NR	--	NR	--	NR
December	1	.030	NR	.025	NR	.016	NR	.011	NR	--	NR
	2	.017	NR	TR	NR	TR	NR	--	NR	--	NR

Table 1: Continued

Aransas:

July	1	TR	TR	TR	TR	--	--	--	--	--	--
	2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
August	1	TR	TR	TR	TR	--	--	--	--	--	--
	2	TR	TR	TR	TR	--	--	--	--	--	--
September	1	.021	NR	TR	NR	--	NR	--	NR	--	NR
	2	--	NR	--	NR	--	NR	--	NR	--	NR
October	1	TR	NR	.017	NR	--	NR	--	NR	--	NR
	2	TR	NR	TR	NR	--	NR	--	NR	--	NR
November	1	.014	NR	--	NR	--	NR	--	NR	--	NR
	2	.010	NR	--	NR	--	NR	--	NR	--	NR
December	1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Corpus Christi:

July	1	TR	TR	.017	.012	TR	TR	--	--	--	--
	2	NSP	NSP	NSP	NSP	NSP	NSP	NSP	NSP	NSP	NSP
August	1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
September	1	.011	NR	.023	NR	TR	NR	--	NR	--	NR
	2	TR	NR	--	NR	--	NR	--	NR	--	NR
October	1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
November	1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
December	1	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
	2	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR

Laguna Madre:

July	1	NR	NSP	NR	NSP	NR	NSP	NR	NSP	NR	NSP
	2	NSP	NSP	NSP	NSP	NSP	NSP	NSP	NSP	NSP	NSP
August	1	NSP	NSP	NSP	NSP	NSP	NSP	NSP	NSP	NSP	NSP
	2	NSP	NR	NSP	NR	NSP	NR	NSP	NR	NSP	NR
September	1	TR	NR	--	NR	--	NR	--	NR	--	NR
	2	0.17	NR	0.52	NR	.020	NR	.019	NR	--	NR
October	1	.024	NR	.033	NR	TR	NR	TR	NR	--	NR
	2	TR	NR	--	NR	--	NR	--	NR	--	NR
November	1	.055	NR	.080	NR	.017	NR	.029	NR	.032	NR
	2	--	NR	--	NR	--	NR	--	NR	--	NR
December	1	.064	NR	.080	NR	.016	NR	.034	NR	.019	NR
	2	--	NR	--	NR	--	NR	--	NR	--	NR

NR---No report received
NSP---No sample prepared
--Sample prepared and examined, but no pesticides found.
TR---Trace

DESCRIPTION OF AREAS
Galveston--Galveston, Trinity, and East Bays
Palacios--Tres Palacios, Matagorda, and Lavaca Bays
San Antonio--San Antonio Bay
Aransas-Aransas, Copano and St. Charles Bays
Corpus Christi--Corpus Christi and Nueces Bays
Laguna Madre--lower Laguna Madre

TABLE 2: Estimated Acres of Agricultural Land Having Pesticide Application

Area	Cotton	Sorghum	Rice	Citrus	Vegetables
Galveston	471,253	230,518	88,587	-0-	-0-
Palacios	97,412	106,279	76,125	-0-	-0-
Seadrift	114,750	239,775	2,682	-0-	-0-
Rockport	68,757	138,600	-0-	-0-	-0-
Corpus Christi	108,932	321,070	-0-	-0-	-0-
lower Laguna Madre	197,052	147,875	-0-	28,663	246,723
Total Average	1,058,156	1,184,117	167,394	28,663	246,723

TABLE 3: Estimated Pounds of Pesticides Applied

AREAS

	Galveston	Palacios	Seadrift	Rockport	Corpus Christi	Laguna Madre
DDT	1,649,386	340,942	401,625	240,650	381,262	2,110,020
Dieldrin	442,935	380,625	13,410	-0-	-0-	378,757
Endrin	-0-	-0-	-0-	-0-	-0-	378,757
Toxaphene	7,265,370	2,433,644	3,087,156	1,796,370	3,657,880	4,573,858
Sevin	4,102,225	1,064,764	928,058	550,056	871,456	3,251,956
Parathion	701,771	203,691	354,525	207,357	430,022	676,339
Totals	14,161,687	4,423,666	4,784,774	2,794,433	5,340,620	11,369,687