An Investigation into Levels of Concentration, Seasonal Variations, and Source of Pesticide Toxicants in Some Species From Selected Bay Areas

Project MP-R-2

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ABSTRACT

Data presented in this paper indicate chronic pesticide levels present in oyster (Crassostrea virginica) tissue from all Texas bay areas sampled. Random samples of fish and bird tissue show the scope of contamination is much greater than first suspected. These data indicate only the degree and sequence of pollution in specific areas. The need is shown for (1) an intensified investigation of persistant pesticides present in streams entering the areas sampled and (2) the effects of chronic levels of pesticide toxicants on the marine environment

INTRODUCTION

Pesticide residue analyses on oyster tissue samples taken from selected Texas Bays have been performed monthly since July 1965. These analyses were performed to determine the extent of pesticide contamination, levels of contamination and season variations in concentration. Experimental data were examined to determine the possible sources of pesticide contamination.

Data gathered in 1965 by this writer indicated pesticide levels in oyster tissue from several Texas bays were of sufficient concentration to warrant further investigation. The purpose of this study is to investigate this pesticide pollution within some Texas bays.

MATERIALS AND METHODS

Oyster tissue samples were taken from Galveston, Matagorda, San Antonio, Aransas, and Corpus Christi Bay areas, and the lower Laguna Madre, including the Arroyo Colorado. Oysters were collected by dredge, tong, or hand from one station within a polluted area of a bay system; and other samples were taken some distance from known pollution. This was done in order to determine extent of pollution.

The twelve oysters in each sample were opened, drained, and ground to a smooth consistency in a blender. From this, 30.0 $\pm$ 5 grams of the oyster material were introduced into a clean jar. The sample was then chilled to a semi-frozen state, after which exactly three times the sample weight of dehydrating agent was added (approximately 10 per cent QUSO and 90 per cent Na_2SO_4--Baker 3898). This was mixed thoroughly with a spatula and then allowed to freeze. While solidly frozen each sample was ground to a free flowing powder. A duplicate of each sample was prepared from another 12 oysters taken concurrently. The duplicate was prepared exactly as the original and stored frozen in case the original was lost in handling before analysis.

Samples were wrapped in a double thickness of heavy-duty aluminum foil, sealed in polyethylene bags, and air mailed to the Bureau of Commercial Fisheries Gulf Breeze Laboratory where they were analyzed for the following chlorinated

Ieptachlor epoxide, Lindane, and Methoxychlor.

All samples were analyzed by 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 parts per million (ppm) approached the lower limit of accurate detection, and those values below this amount were reported as a trace (tr.).

The location of each sample station was determined by the availability of oysters in an area. At least one of these stations was chosen because of its proximity to the source of pollution. Data found experimentally in 1965 indicated areas of greater contamination, and when possible, these areas were sampled. Additional random samples were prepared where and when pollution was suspected.

For ease of handling data, the common or trade name of the various pesticides found and reported in this paper will be used. The compounds reported as DDT are a combination of DDT and its metabolites which are: DDT (o,p'+ p, p'; o, p'; p, p') dichlorodiphenyltrichloroethane, DDE dichlorodiphenyl, dichloroethylene, and DDD 1, 1-dichloro-2,2 bis (p-chlorophenyl) ethane. The chemical reported as Dieldrin is: not less than 85 per cent of 1, 2, 3, 4, 10, 10-hexa=chloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8a-octa=hydro-1, 4-endo-exo-5, 8-dimethanano = naphthalene. The chemical reported as Endrin is: 1, 2, 3, 4, 10, 10-hexachloro 6, 7-epoxy-1, 4, 4a, 5, 6, 7, , 8a-octahydro-1, 4-endo-endo-5, 8-dimethano-naphthalene. The chemical reported as Seven is: 1-naphthyl methylcarbamate. The chemical reported as Heptachlor epoxide is: 1, 4, 6, 7, 8, 8-heptachloro-2, 3-epoxy-3a, 4, , 7a-tetrahydro-4, 7-methanonindan.

RESULTS

Levels of Concentration:

Galveston Bay area -- Analysis of pesticide residue in samples taken from the Galveston Bay area revealed the presence (Table 1) of DDT and Dieldrin. The DDT residue levels ranged from .061 ppm to none. The peak concentration was in February. Residue was found in January, February, March, May, October, November, and December. Dieldrin was detected once in November at a concentration of .021 ppm.

Matagorda Bay area -- In the Matagorda and Lavaca Bay area DDT was the principal pesticide found. In concentration it ranged from .402 ppm to a trace. Peak concentration was in May, and October had the least amount detected. The only other pesticide found was Dieldrin which was found in May at a concentration of .013 ppm.

San Antonio Bay area -- The principal pesticide contamination found in this bay system was DDT. It was found during all months except August. The peak concentration was in May. The only other pesticide found was Dieldrin which was found once in March at a concentration of .017 ppm.

Aransas Bay area -- Some DDT contamination was found in samples each month of the year. The month of peak concentration was March. The month of lowest concentration was January. Dieldrin, the only other chemical detected in samples, was found once in December at a concentration of .011 ppm.

Corpus Christi Bay area -- DDT contamination found in samples ranged from a peak of .450 ppm in July to a low of a trace in December. Samples were not prepared all months of this study due to the scarcity of oysters. The only other pesticide detected was Dieldrin, it being found once in July at a concentration of .033 ppm.

Lower Laguna Madre area -- This is the area in which the greatest amount of pesticides was found. DDT, Dieldrin, and Endrin were all found during most of the study period. DDT concentrations ranged from none detected to .583 ppm. Dieldrin ranged from none detected to .046 ppm. Endrin ranged from none detected to .028 ppm. DDT concentration was highest in July and lowest in January and December. Dieldrin concentration was highest in June, and none was detected in October. The highest concentration of Endrin was found in July, and none was detected in April, September, and October.

Seasonal Variations:

DDT:

In all areas sampled, the high readings of DDT residue was during the period February through July, and the low concentrations ranged from June through December. Some overlap of levels appeared in June and July.

In the Galveston area, the high was in February and May. From June through September no residue was detected from the samples. A slight increase, or reappearance, occurred in November and December.

The Matagorda Bay area had a peak concentration in May, then receded to a low in October. In this area, unlike the Galveston area, concentrations were fairly high throughout most of the year, and considerably higher than in the Galveston area.

The San Antonio Bay area maintained a constant high level of contamination starting in January, reaching a peak in May, then showing a rapid decline. In August no contamination of this chemical was detected, and the level stayed low throughout the remainder of the year.

In the Aransas Bay area concentration levels started low at the beginning of the year, reached a high in March and declined to a low in September. The concentration slowly increased toward the end of the year. In this bay area, as in the San Antonio Bay area, DDT contamination was present in samples each month of the study.

Incomplete data were obtained from the Corpus Christi Bay area due to the scarcity of oysters for sample preparation. No samples were prepared in January, February, and June. In March, April, and December only 1 station was sampled. Of those samples examined, the highest concentration was in July, and the least amount was found in December.

The lower Laguna Madre samples contained the most DDT contamination of any area sampled. Although some other areas had one sample that contained as much or more contamination, the lower Laguna Madre samples had a sustained high degree of contamination. Concentrations increased progressively from January to July when a peak was reached. The low was in September and October.

)ieldrin:

In all areas sampled, except the lower Laguna Madre, Dieldrin contamina-:ion was detected only once. In the lower Laguna Madre it was found each nonth except October.

In the Galveston area it was found in November, in the Matagorda Bay ırea in May, in the San Antonio Bay area in March, in the Aransas Bay area ln December, and in the Corpus Christi Bay area in July.

The concentration level was found to be highest in the lower Laguna ʻadre in June.

ɪndrin:

The only other pesticide detected in oyster tissue samples was Endrin ınd it was found only in the lower Laguna Madre. This pesticide was found ɜach month except September and October. The peak concentration was in ʃuly.

ꞩource of Contamination:

All data (Table 1) indicate that the carriers of pesticide contamina-:ion are the rivers, streams, and drainage ditches that empty into the :espective bay areas being sampled. The stations near the discharge points)f these streams were more highly contaminated than those distant from these ꞩtreams.

Data further show that discharge from some municipal areas contains ıs much contaminant as that from agricultural areas. For example, Station l (Table 2), located in Aransas Bay between the towns of Fulton and Rockport ınd remote from any drainage other than municipal areas, contained as much)r more contamination than did Station 2 samples which were taken from the ırea of drainage from the Mission and Aransas Rivers, this being an agri-:ultural area.

Other than isolated cases, agricultural and municipal drainage was the ꞩource of pesticide contamination in the selected Texas bay areas monitored.

At times, random samples were taken in areas of suspected contamina-:ion. One such sample, taken in the Calhoun County Barge Canal to Victoria ıt a point about 2 miles south of the Long Mott Turning Basin, had 1.249 ppm)f DDT residue (Table 3). This area is downstream from a large industrial :omplex and also adjacent to a vast agricultural area.

ʌnalysis of Fish Tissue:

In order to ascertain the spread of the pesticide contamination through :he food chain, random samples of fish tissue were analyzed. Two samples vere prepared from Guadalupe Bay (San Antonio Bay area), and one from the ʌrroyo Colorado. In the two Guadalupe Bay samples, whole body analysis vere made on striped mullet, Mugil cephalus. Menhaden, Brevoortia patronus, vere used in the Arroyo Colorado sample. A fish kill occurred in the Arroyo :olorado and some of the dead menhaden were used to prepare this sample.

In the first Guadalupe Bay sample prepared for analysis on October 10, 1966, analysis showed .083 ppm of DDT and .049 ppm of Dieldrin. The second sample, taken on November 30, 1966, had .064 ppm of DDT and .021 ppm of Dieldrin on analysis.

The sample from the Arroyo Colorado, prepared from whole bodies of the menhaden, revealed 1.520 ppm DDT, .045 ppm Dieldrin, and .028 ppm Endrin on analysis.

Data from these three samples showed enough pesticide residue present to warrant further investigation of fish tissue from known or suspected areas of pollution.

Analysis of Bird Tissue:

Samples of tissue from birds found dead in the general area of Corpus Christi, Texas, were analyzed for pesticide content.

On April 21, 1966, a dead blue heron (Ardea herodias) was found on or near the shore of the Cayo del Oso, south of Corpus Christi. When the liver of this bird was analyzed for pesticide content, .663 ppm of DDT was found. In this case DDT poisoning was believed to be the cause of death.

The Cayo del Oso is the site of the outfall of the Corpus Christi sewage and drainage system; however, some agricultural area also drains into this body of water.

On November 2, 1966, an immature pintail duck (Anas acuta) was found dead in the area of the Cayo del Oso. Upon analysis of fat tissue and the intestinal tract, it was found to contain .035 ppm DDT.

One dead grebe (Podicepes sp.) collected from Mustang Island on December 10, 1966, contained .672 ppm of DDT on analysis of fat tissue and the digestive tract. Another analysis of this type from a grebe found dead on Padre Island on December 10, 1966, showed a pesticide content of .842 ppm DDT and .026 ppm Heptachlor epoxide. Heptachlor epoxide was not found in other samples analyzed during this study.

DISCUSSION

The indirect effects of pesticide application are realized in the marine environment almost entirely due to movement after application. Geary (1967) stated that, to evaluate these indirect effects, it is necessary to know something about the distribution of pesticides in various elements of the environment and the changes in toxicity levels with time.

The distribution of pesticides within the marine environment depends upon such factors as solubility, suspendibility of the pesticide in water, the amount of rainfall on the area of original application, movement of a part of this application, and the movement of the water mass of the estuary. Other factors of importance are the chemical and physical changes of the pesticides in the presence of the biological environment.

Edwards (1966) noted the persistence of some chlorinated hydrocarbon pesticides in the soil. He stated the time for 95 per cent disappearance in years from date of application. Since DDT and Dieldrin are two of the pesticides most commonly found in the marine environment, they are of especial importance.

The range for DDT was 4-30 years with an average of 10 years. In the case of Dieldrin, the range was 5-25 years, with the average being 8 years. Much of this retention of pesticides in soils over long periods of time is closely related to rainfall.

Since most of the persistant pesticides are insoluable, or nearly so, in water, the moisture content of the soil determines, to a great extent, the amount adsorbed. Harris and Lichtenstein (1961) demonstrated that insecticides are strongly adsorbed on dry soils. Even in these dry soils nearly 100 per cent of insecticides are in the top 6 inches of soil. pproximately 85 per cent of this amount is found in the top 2 inches of the soil. Very little leaching occurs to carry this load deeper into the soil.

Probably most of the pesticides reaching the drainage system of the various bay areas would come from soils having a high moisture content at the time of application, and then receiving additional large amounts of rainfall to erode away this thin surface area containing the largest mount of the pesticides present. This pesticide would dissolve into the water, remain as suspended particles, or remain attached to soil particles n suspension.

Lichtenstein et al (1966) stated the most frequent pollution of water n rivers and ponds with pesticides possibly occur through the transport f soil particles to which pesticidal residues are absorbed by rainfalls nd flooding.

He went on to state the degree to which water was contaminated was lso dependent on the insecticidal concentration in the soil which esulted from the original application dose and the specific properties f a given toxicant in the soil.

Since a great amount of the pesticides moved from the site of appli- ation by rainfall and the subsequent runoff would be trapped en route to he bays, it appears quite likely that the greater amount of that portion eaching the bays was originally applied within a few miles of the coastal reas being sampled.

A good example of this supposition may be seen in data reported by hildress (1965) as to the estimated amount of pesticides applies to pecific drainage areas. For example, the area draining into Galveston ay had an estimated pesticide application of over 14 million pounds per ear, yet this bay area had less pesticides found in oyster tissue examined han did the Palacios area where less than 4 1/2 million pounds were esti- ated to have been applied per year. In the Galveston Bay drainage most f the agricultural lands are a considerable distance from the bay area ampled, while in the Palacios area the drainage area is small and near he bay area being sampled.

Other sources of pesticide pollution in the marine environment are hose applied directly to coastal marshes to control mosquitos or that mount that might be blown from aircraft spraying adjacent to bays.

Those pesticides entering the marine environment are of particular ignificance to the fishing industry, both commercial and sport. Anonymous 1966) states that ten marine animal groups make up 80 per cent of the 381.2 million U. S. Fishery. Of these ten, five spend important parts f their lives in estuarine waters, where they are vunerable to the pesticide pollution that may occur. The five are shrimp, mollusks, Pacific salmon, crabs, and menhaden. Of these five, only the Pacific salmon is not a part of the Texas fishery.

Once toxicants, in the form of pesticides, enter the estuarine systems the logical sequence of passage is from the water to plankton. The next step in this sequence is ingestation by some of the plankton feeders such as oysters and menhaden.

Butler (1966) reported that, in the case of DDT pollution, only when data on residues were at hand and they could estimate the time of initial pollution of the water, were they able to identify the source of the DDT.

He went on to state that DDT residues may be fatal to predators at different tropic levels depending on the amount ingested at one time. It is probable that higher death rates and significant losses in productivity exist undetected in estuarine fauna contaminated with DDT.

Most data reported from laboratory studies are for a specific toxicant affecting a certain species. The usual test involves the death or paralysis of half of the test animals in 24 or 48 hours, this period at times being extended to 96 hours.

These tests reveal that some pesticides in fantastically small amounts kill shrimp and crabs. One part per billion (ppb) of DDT in sea water will kill blue crabs in 8 days. In laboratory tests 0.3 to 0.4 ppb of Endrin killed or immobilized commercial brown (Penaeus aztecus) and pink (P. duorarum) shrimp. In the estuaries where only the fittest survive, immobilization means almost immediate death.

Oysters have stored DDT where the concentration was as low as 10 parts per trillion. Concentration above the levels present in water has been noted as being up to 70,000 times greater. The oyster, unlike some other species, will eliminate the pesticide when the pollution ceases or when they are removed to clean water.

When fish are exposed to pesticide pollution through ingestion of contaminated food, most is stored in the body fat. In times of privation or stress the amount released from the body fat may be enough to cause death.

Possibly of even more importance to the marine fisheries of Texas are the sublethal concentrations of pesticides in the estuarine environment. Davis (1961) found that 2.5 ppm of carbamate (Sevin) inhibited the development of eggs and growth of larvae of the clam (Venus mercenaria), and 1.0 ppm of Sevin inhibited the development of eggs of the oyster. However, since Sevin breaks down at 20° Centigrade at the rate of 20 per cent per day to 1-naphthol, it is not a threat to these species.

Lowe (1965) reported blue crabs (Callinectes sapidus) appeared normal in concentrations of DDT of .25 ppb, but could survive only a few days when the water contained DDT in excess of .50 ppb.

Butler (1966) stated that the growth response to pesticides in general is not predictable and that each chemical must be tested individually. Often the lowest concentrations of the organochlorine tested, .0001 ppm, were frequently deleterious to oysters.

Butler (1966) demonstrated that DDT and its metabolites localized in the gametes of sexually mature oysters. The sequel to this work was the culturing of larvae resulting from contaminated gametes. Fertilization and cleavage proceeded normally, but all cultures were lost within 48 hours. The probability of larval cultures containing body burdens of 20-30 ppm of DDT producing oyster populations appears to be nil. Earlier work has shown 100 per cent mortality of larval cultures exposed to 1.0 ppm of DDT for 6 days.

He continued to explain that body residues are not helpful in the interpretation of any single factor such as length of exposure or exposure concentration. These data are somewhat instructive as to the degree and sequence of pollution in specific areas.

Data from other areas of research indicate the effects on fish are similar in that they affect the reproductive cycle. Holden (1964) stated that chronic toxicity results in the accumulation of residues in all organs and tissues. Amounts sublethal to the adult female may endanger the progeny after accumulation in the ova, resulting in egg or fry mortality. Reaction to external stimuli may also be affected.

Experimental data presented here reveal that the most persistant of the pesticides, namely DDT, Dieldrin, and Endrin, are present in sufficient quantities to cause some concern about chronic exposure. Data collected have not shown concentrations considered lethal, except possibly in the case of some of the birds examined.

Work performed by other researchers indicates much intensified investigation needs to be done in Texas estuaries to determine the levels of the persistant pesticides present, not only in oyster tissue, but in fish, plankton, and especially in the water of streams entering these estuaries. At the same time, studies of the effects of chronic levels of these toxicants on the marine species need to be initiated.

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Table 1: Pesticide monitoring analysis data

Area & Date		Chemical (parts per million) in oyster tissue DDT*	Dieldrin	Endrin
Galveston:				
January	1	.029	---	---
	2	.051	---	---
February	1	.061	---	---
	2	.045	---	---
March	1	.045	---	---
	2	.043	---	---
April	1	NSP	NSP	NSP
	2	NSP	NSP	NSP
May	1	.044	---	---
	2	.051	---	---
June	1	---	---	---
	2	---	---	---
July	1	---	---	---
	2	---	---	---
August	1	---	---	---
	2	---	---	---
September	1	---	---	---
	2	---	---	---
October	1	tr.	---	---
	2	---	---	---
November	1	.024	.012	---
	2	tr.	---	---
December	1	.024	---	---
	2	.012	---	---
Palacios:				
January	1	.056	---	---
	2	.157	---	---
February	1	.167	---	---
	2	.075	---	---
March	1	.374	---	---
	2	.043	---	---
April	1	.131	---	---
	2	.099	---	---
May	1	.402	.013	---
	2	.097	---	---
June	1	.081	---	---
	2	.193	---	---
July	1	.304	---	---
	2	.055	---	---
August	1	.126	---	---
	2	.037	---	---
September	1	.021	---	---
	2	.017	---	---
October	1	.011	---	---
	2	tr.	---	---
November	1	.023	---	---
	2	tr.	---	---

ıle 1: Continued

꞉a & Date		Chemical (parts per million) in oyster tissue		
		DDT*	Dieldrin	Endrin
꞉acios:				
꞉ember	1	.026	---	---
	2	.011	---	---
ı Antonio Bay:				
ıuary	1	.069	---	---
	2	.013	---	---
ıruary	1	.073	---	---
	2	.013	---	---
·ch	1	.077	.017	---
	2	.014	---	---
·il	1	.052	---	---
	2	.033	---	---
'	1	.078	---	---
	2	.034	---	---
ıe	1	.064	---	---
	2	tr.	---	---
.y	1	.026	---	---
	2	---	---	---
;ust	1	---	---	---
	2	---	---	---
ıtember	1	tr.	---	---
	2	---	---	---
꞉ober	1	.013	---	---
	2	tr.	---	---
'ember	1	.015	---	---
	2	.015	---	---
꞉ember	1	.033	---	---
	2	.010	---	---
ınsas Bay:				
ıuary	1	.011	---	---
	2	.012	---	---
ıruary	1	.061	---	---
	2	tr.	---	---
꞉ch	1	.077	---	---
	2	.011	---	---
꞉il	1	.016	---	---
	2	NSP	NSP	NSP
'	1	.073	---	---
	2	.011	---	---
ıe	1	.045	---	---
	2	---	---	---
.y	1	.030	---	---
	2	---	---	---
;ust	1	.033	---	---
	2	---	---	---
ıtember	1	.020	---	---
	2	---	---	---
꞉ober	1	.053	---	---
	2	tr.	---	---

Table 1: Continued

Area & Date		Chemical (parts per million) in oyster tissue DDT*	Dieldrin	Endrin
November	1	.057	---	---
	2	tr.	---	---
December	1	.058	---	---
	2	.015	.011	---
Corpus Christi Bay:				
January	1	NSP	NSP	NSP
	2	NSP	NSP	NSP
February	1	NSP	NSP	NSP
	2	NSP	NSP	NSP
March	1	.076	---	---
	2	NSP	NSP	NSP
April	1	.039	---	---
	2	NSP	NSP	NSP
May	1	.072	---	---
	2	.066	---	---
June	1	NSP	NSP	NSP
	2	NSP	NSP	NSP
July	1	.450	.033	---
	2	.057	---	---
August	1	.038	---	---
	2	.030	---	---
September	1	.034	---	---
	2	tr.	---	---
October	1	tr.	---	---
	2	.011	---	---
November	1	.012	---	---
	2	tr.	---	---
December	1	NSP	NSP	NSP
	2	tr.	---	---
Lower Laguna Madre:				
January	1	.160	.034	.019
	2	---	---	---
February	1	.279	.023	.017
	2	---	---	---
March	1	.267	.024	.014
	2	---	---	---
April	1	.144	.018	---
	2	---	---	---
May	1	.191	.016	.022
	2	.057	---	---
June	1	.401	.030	.023
	2	tr.	.046	---
July	1	.583	.045	.028
	2	tr.	---	---
August	1	.387	.027	.013
	2	.013	---	---
September	1	.155	.014	---
	2	---	---	---

Table 1: Continued

Area & Date		Chemical (parts per million) in oyster tissue DDT*	Dieldrin	Endrin
Lower Laguna Madre:				
October	1	.012	---	---
	2	.012	---	---
November	1	.249	.018	.014
	2	---	---	---
December	1	.133	.020	.012
	2	tr.	---	---

NSP - No Sample Prepared
--- Sample prepared and examined, but no pesticides found.
tr. - Trace (less than .010 ppm)

DESCRIPTION OF AREAS

Galveston -- Galveston, Trinity, and East Bays
Palacios -- Tres Palacios, Matagorda, and Lavaca Bays
San Antonio Bay -- San Antonio and Guadalupe Bays
Aransas Bay -- Aransas, Copano, and St. Charles Bays
Corpus Christi Bay -- Corpus Christi, Nueces, Oso, and Redfish Bays
Laguna Madre -- Lower Laguna Madre

* DDT, as reported here, includes DDT and its two metabolites, DDD and DDE.

Table 2: Station locations

Area	Station	Description
Galveston Bay area	#1	Todd's Dump
	#2	Beasley's Reef or Frenchy's Reef
Palacios area	#1	Tres Palacios Bay
	#2	Lavaca Bay (mouth of Lavaca River)
San Antonio Bay area	#1	Nancy's Reef (north part of bay)
	#2	Chicken Foot Reef (SW part of bay)
Aransas Bay area	#1	Frondeleg Island (Key Allegro)
	#2	St. Charles Bay (mouth)
Corpus Christi Bay	#1	Causeway Reef (between Nueces & C. C. Bay)
	#2	Steadman Reef (Redfish Bay)
lower Laguna Madre	#1	Arroyo City (Arroyo Colorado)
	#2	Three Islands (in Laguna Madre)

Table 3: Random Samples

Oyster

Location	Date	Pesticide found - ppm DDT	Dieldrin	Endrin
Calhoun County Barge Canal to Victoria-2 miles south of Long Mott Turning Basin	2-7-66	1.249	---	---

Fish

Location	Date	Species	Pesticide found - ppm DDT	Dieldrin	Endrin
Guadalupe Bay	10-10-66	Striped Mullet	.083	.049	---
Arroyo Colorado	10-21-66	Menhaden	1.520	.045	.028
Guadalupe Bay	11-30-66	Striped Mullet	.064	.021	---

Birds

Location	Date	Species	Pesticide found - ppm DDT	Dieldrin	Endrin
Cayo del Oso	4-21-66	Blue Heron	.663	---	---
Cayo del Oso	11-2-66	Pintail Duck	.035	---	---
Mustang Island	12-10-66	Grebes	.672	---	---
Padre Island	12-10-66	Grebes	.842 .026 Heptachlor epoxide	---	---

ppm - Parts per million

LITERATURE CITED

Anonymous 1966. Fish, Wildlife, and Pesticides. U. S. Dept. of the Interior, Fish and Wildlife Service. Bulletin 1966 0-796-260.

Butler, Philip A. 1966. Pesticides in the Marine Environment. Journal of Applied Ecology. 3 (Suppl.), 253-259, June 1966.

Butler, Philip A. 1966. The Problem of Pesticides in Estuaries. Bureau of Commercial Fisheries, U. S. Dept. of the Interior. Gulf Breeze, Florida.

Butler, Philip A. 1966. Fixation of DDT In Estuaries. Reprinted from Transactions of the Thirty-First North American Wildlife and Natural Resources Conference, March 14, 15, 16, 1966. Published by the Wildlife Management Institute, Wire Building, Washington, D. C. 184-189.

Childress, U. R. 1965. A Determination of Source, Amount, and Area of Pesticide Pollution In Some Texas Bays. Texas Parks and Wildlife Department, Coastal Fisheries 1965 Project Reports. Project MP-R-1, Job 1, pp 245-255.

Davis, H. C. 1961. Effects of Some Pesticides on Eggs and Larvae of Oysters (Crassostrea virginica) and clams (Venus mercenaria). Comm. Fish. Rev. 23 (12): 8-23.

Edwards, C. A. 1966. Insecticide Residues in Soils. Residue Rev. 13, 83-132. 1966.

Geary, John M. 1967. Pesticides Monitoring Journal-Introduction. June 1967, Vol. 1, No. 1.

Harris, C. R. and E. P. Lichtenstein 1961. Factors Affecting the Volatilization of Insecticides from Soils. J. Econ. Entomol. 54, 1038 (1961).

Holden, A. V. 1964. Contamination of Fresh Water by Persistant Insecticides and Their Effects on Fish. Proceedings of the Association of Applied Biologists. Oct. 1964 55, 332-335.

Lichenstein, E. P., Schulz, K. R., Skrentny, R. F., and Tsukano, Y. 1966. Toxicity and Fate of Insecticide Residues in Water. Archives of Environmental Health, February 1966. Vol. 12, pp 199-212.

Lowe, Jack I. 1965. Chronic Exposure of Blue Crabs (Callinectes sapidus), to Sublethal Concentrations of DDT. Ecology, Vol. 46, No. 6, pp 899-900.