A Study of Texas Shrimp Populations
Project: MS-R-12 (1970)

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A Study of Commercial Shrimp Populations in Coastal Bays of Texas, 1970

ABSTRACT

In spring, samples were taken with bar-seines and trawls from Sabine Lake, Galveston Bay, Matagorda Bay, Aransas Bay and the Lower Laguna Madre to study brown shrimp (<u>Penaeus aztecus</u>) growth, movements, seasonal abundance trends and environmental needs. This shrimp was abundant in samples from Galveston Bay, Aransas Bay and the Lower Laguna Madre. Slow growth of juveniles during April in upper coastal bays was attributed to low temperature. Many, however, were 70 to 80 mm long by late May, because growth accelerated as bays warmed.

A direct correlation (r=0.918) between commercial brown shrimp production and sample size is demonstrated. The least-squares line equation is Y=12.67 + 0.21X.

The relationship between salinity and shrimp abundance is vague because other ecological factors vary with salinity. Apparently, salinities between 1 and, at least 30 ppt do not affect abundance.

Shrimp production in Texas for the period 1962-1970 is reviewed.

INTRODUCTION

Texas coastal ports receive 75 per cent of all shrimp landed at Gulf of Mexico and South Atlantic ports in the United States. Annually, the average Texas shrimp catch, 47.2 million pounds (worth $36.2 million) includes 73.3 per cent brown shrimp (<u>Penaeus aztecus</u>) 20.8 per cent white shrimp (Penaeus setiferus) and 5.9 per cent pink shrimp (<u>Penaeus duorarum</u>).

To manage this fishery, Parks and Wildlife Department personnel study shrimp growth rates, movements, seasonal abundance trends and habitat requirements (Leary and Compton, 1960; Compton, 1962; Pullen, 1963; Moffett, 1964, 1965, 1966, 1967, 1968, 1969). This report presents findings in 1970.

MATERIALS AND METHODS

Shrimp nursery areas were sampled with six foot bar seines (1/4 inch mesh webbing).[1] Stations in secondary and primary bays were sampled with ten foot trawls (1 1/4 inch mesh webbing, lines with 1/2 inch mesh webbing). A standard nursery area sample was the catch in one 500 foot tow. Sampling duration at each trawling station was 15 minutes. Incomplete samples (short tows) were equated to the standard.

Between April 1 and June 1, stations were occupied weekly in Galveston and Matagorda Bays and semi-monthly in Sabine Lake, Aransas Bay and the Lower Laguna Madre (Figure 1).

Shrimp in samples were identified, measured to the nearest millimeter (tip of rostrum to end of telson) and counted.

Water temperatures (°C), salinity (parts per thousand), wind direction, wind velocity and tidal data were recorded while sampling. Other climatological information was extracted from "Climatological Data" (1962-1970).

Commercial landing statistics were excerpted from "Shrimp Landings" (1962-1970).[2]

Shrimp growth rates were estimated by the method of Williams (1955) where growth was the difference between extreme shrimp sizes in periodic samples. Estimated brown shrimp "growth" rates from Sabine Lake and Matagorda Bay were unrealistic and were not used.

Analysis of Brown Shrimp Samples (April 1, 1970 to June 1, 1970)

Table 1 shows brown shrimp catch per unit-of-effort values (average number of shrimp per sample by date and bay type). Values from Galveston Bay, Aransas Bay and the Lower Laguna Madre were high; those from Sabine Lake and Matagorda Bay were relatively low.

Figure 2 shows the smoothed brown shrimp length-frequency distribution curves by date and bay type.[3] These distributions implied that shrimp growth rates were slow in Sabine Lake, Galveston Bay and Matagorda Bay when the average April air temperature was at a ten year low (16.1°C). In late April,

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[1] All mesh sizes are "stretch mesh".

[2] The 1969 and 1970 statistics are preliminary. All weights are on heads-off basis. All values are exvessel prices.

[3] Curves smoothed by a moving average of three to eliminate minor fluctuations.

as bays warmed, shrimp growth rates accelerated; thus many were emigration size (70 to 80 mm) in late May.

Sabine Lake

In early May 1970, brown shrimp were 43 to 58 mm long at a "secondary" bay station - Gulf States Canal - in the northern part of the estuary. Late in May, shrimp (still less than 78 mm long) were found at all sampled stations.

In spring 1969, the salinity range was 0.0 to 4.4 ppt and no brown shrimp were caught in samples (Moffett, 1969). Salinity values during the 1970 spring ranged from 0.5 to 7.2 ppt and brown shrimp were present in samples. Highest salinity values (both years) were at a station near Cameron Causeway in the southern part of the estuary.

Galveston Bay

On March 30, 13 postlarval brown shrimp, 19 to 23 mm long, were captured at a station sampled with a bar-seine in Moses Lake. By April 23, the young, 18 to 48 mm long, were present at stations sampled with trawls in Clear Lake and Upper Galveston Bay. They grew slowly in April; then fast in May. The average daily growth rate, April 1 to May 23, was 1.3 mm.

Values for catch per unit-of-effort, though relatively high, did not approach extreme high values calculated from 1967 shrimp data (Moffett, 1967).

Matagorda Bay

In mid-April, late stage postlarval and early stage juvenile brown shrimp, 23 to 33 mm long, were caught at sampled nursery areas. From April 23 to May 23, juveniles were available at stations sampled with trawls.

Aransas Bay

On April 1, brown shrimp were detected at sampled nursery area, 18-23 mm long, and at stations sampled with trawls, 48 to 58 mm long. Abundance peaked in samples on May 15 when the value for catch per unit-of-effort was 1,687 at primary bay stations.

On the average, brown shrimp grew 1.6 mm per day in April.

Lower Laguna Madre

Brown shrimp, 18 to 43 mm long, were present when sampling began on April 1. Shrimp, 18 to 83 mm long, were abundant in samples on April 15 at bar-seine stations and on May 15 at trawl stations.

Between April 1 and May 15, the average daily growth rate was 1.3 mm.

Analysis of White Shrimp Samples

Although over 12 million pounds of white shrimp were harvested in 1970, catch per unit-of-effort values (based on white shrimp samples from the Chocolate Bayou estuary in the Galveston Bay complex) were smaller than those calculated from 1968 data (Table 2). Therefore, I did not use these data to measure seasonal abundance trends. During 1968 and 1970, shrimp abundance in samples peaked in September and October. In 1969, abundance peaked in December.

A second white shrimp wave was not evident. Additional data were available, however from a special program begun in June 1969 to study the Chocolate Bayou estuary (Table 3). On December 8, 1970, a sample (5 minute drag) from the Chocolate Bay Channel and the Intracoastal Waterway intersection contained 1,748 shrimp, 50 to 90 mm long.

Relationship Between Commercial Brown Shrimp Production and Sample Catch Per Unit-of-Effort (1962-1970)

Figure 3 shows a strong direct correlation between brown shrimp sample catch per unit-of-effort data and annual commercial brown shrimp catches. Values for catch per unit-of-effort are the average number of shrimp per sample between April 15 and May 23 from Galveston Bay, Matagorda Bay, Aransas Bay and the Laguna Madre. Bar seine and trawl data were combined. I discarded eight samples collected on April 24, 1969, in the Aransas Bay system because the high catch per unit-of-effort value was not representative of brown shrimp population density. This was justified because these stations were resampled on April 28, 1969.

Importance of Salinity to Shrimp Abundance

The relationship between salinity and shrimp abundance is obscured because other ecological factors vary with salinity and shrimp abundance is difficult to measure. Zein-Eldrin and Aldrich (1965) report that postlarval shrimp at temperatures below 15°C demonstrate a decreased tolerance to low salinity, and that salinity per se has little effect on survival and growth, except at extreme temperatures. Copeland, Fruh and Moseley (1970) state; "........data collected by the Bureau of Commercial Fisheries, Texas Parks and Wildlife Department, Trusdale (1970), Trent (1966) and Parker (1970) reveals that both brown and white shrimp are virtually unaffected by salinity levels in upper bays; the shrimp apparently are equally abundant in salinities between about 1 and 30 ppt. This is true as long as adequate cover and food are available." Chapman (1966) however, reports that the largest number of young shrimp and generally smaller individuals are caught in upper bays near river mouths. This does not mean that they prefer low salinity but such areas serve as nurseries.

Brown Shrimp

Examination of data collected by Johnson (1970) reveals that salinity is a habitat requirement of young brown shrimp but they still appear to thrive at low salinity levels. Table 1 presents a comparison of the numbers of postlarval and juvenile brown shrimp in samples and salinity ranges from Trinity Bay during the 1969 and 1970 spring. In 1969, salinities were low (0.0 to 0.6 ppt) and brown shrimp were not caught. In 1970, salinities were higher (0.0 to 8.3 ppt) and the brown shrimp population was relatively high.

In Figure 4, annual rainfall in inches (upper coast) is plotted against brown shrimp landings in Texas. Rainfall was low (and salinity high) during spring 1967, the record brown shrimp production year. Baxter (1968), however, found strong relationship between average April air temperature at Galveston and time of peak abundance of juvenile shrimp in Galveston Bay. In 1967, the average April air temperature was high and the brown shrimp abundance peak was reached in early May. Generally the peak occurs later.

White Shrimp

Gunter and Hildebrand (1954) and Copeland (1966) demonstrate a relationship between white shrimp catch and rainfall fluctuations. Copeland (1966) reports: "An increase or decrease is followed by similar fluctuations in shrimp catch, generally after a two year delay." In Figure 4, evidence of a two year delay between "wet" years and high white shrimp production is apparent. Catches in 1964, 1968, 1969 and 1970 were high. Excluding the 1969 catch, these catches were made two years after a "wet" year. Apparently the 1969 catch increased because fishing pressure on white shrimp stocks were intensified to compensate for low brown shrimp catches (Moffett, 1969).

Commercial Production (1962-1970)

Tables 4, 5 and 6 present annual brown, white and pink shrimp catches in millions of pounds and exvessel prices at Texas ports, Gulf ports and South Atlantic ports. The 1970 shrimp statistics from Gulf and South Atlantic ports are not available.

Between 1961 and 1970, 424.5 million pounds of shrimp (brown, white and pink shrimp) were landed in Texas. This long-term catch included 311.3 million pounds of brown shrimp, 88.2 million pounds of white shrimp and 25.0 million pounds of pink shrimp. On the average, 34.6 million pounds of brown shrimp (worth $26.3 million) 9.8 million pounds of white shrimp (worth $7.2 million) and 2.8 million pounds of pink shrimp (worth $2.8 million) were landed annually.

Of all brown, white and pink shrimp landed between 1961 and 1971 at Gulf and South Atlantic ports in the United States, 75.67 per cent were landed in Texas. This included 85.44 per cent of all brown shrimp, 38.82 per cent of all white shrimp and 21.26 per cent of all pink shrimp.

In Texas the peak brown shrimp production year was 1967 when 55.5 million pounds were landed (Figure 3). White shrimp catches were high in 1964 (12.0 million pounds), 1968 (12.5 million pounds), 1969 (12.0 million pounds) and 1970 (12.4 million pounds). Most pink shrimp were caught off the Campeche Banks, Mexico and off the Dry Tortugas, South Florida; then transported to Texas.

Commercial Production (1970)

In 1970, brown shrimp production, 39.1 million pounds, was better than the average (Table 7). The industry suffered in August, however, when Hurricane "Celia" moved onshore in the Corpus Christi Bay area. Unfortunately, 26 Gulf trawlers were sunk, 28 had major hull damage, 32 were beached and 25 small trawlers were damaged. Fleet and harbor facility damage in the Aransas Bay area was in excess of $3.0 million. Regardless, August was the peak brown shrimp production month, 7.9 million pounds.

White shrimp production, 12.4 million pounds, peaked in October when 3.0 million pounds were landed. Large catches made in May (1.3 million pounds) near Gulf passes were partly responsible for the successful yield.

DISCUSSION

The shrimp program, now limited to sampling during April and May, in Sabine Lake, Matagorda Bay, Aransas Bay and the Lower Laguna Madre, is designed to study the large "commercial" brown shrimp brood which utilizes bays in late winter and spring. Unfortunately, data are not available from San Antonio and Corpus Christi Bays. Data on late brown shrimp broods and white shrimp year classes are also lacking. I could not use data, from another study of a small estuary in the Galveston Bay system, as an index of white shrimp growth and year-class density.

In early spring, slow brown shrimp growth rates are common along the upper coast, since there is a relationship between growth and temperature. Postlarval growth and survival rates are low when temperatures are below 18°C (St. Amant, Broom and Ford, 1966). Growth becomes rapid at 20°C. If the young are undersize in April, growth accelerates as bays warm in May and they usually reach emigration size (about 70 to 80 mm) by late May.

In April 1967, when bay water temperatures were high brown shrimp grew rapidly and the Gulf emigration started in late April or early May. In addition to temperature, relative high bay salinities and crowding (due to high abundance) may have been responsible for the early emigration. Since this project began in 1959, I have not found evidence of late brown shrimp emigration, regardless of shrimp size or bay ecology.

The determination of the importance of salinity to penaeid shrimps poses a problem. Extreme salinity levels, probably less than 1 and well over 30.0 ppt, are detrimental. From examination of data I find that young white shrimp do not flourish when salinities are relatively high e.g., the Upper Laguna Madre. Often they appear to favor low salinity sites in some estuaries, e.g., the Arroyo Colorado in the Lower Laguna Madre.

According to Marr (1952), the catch per unit-of-effort data, used frequently in this report, does not measure relative abundance, but rather relative apparent abundance. He defines apparent abundance as that fraction of the population which is available. These data do, however, measure relative changes from season to season. Though the catch per unit-of-effort data and annual brown shrimp catch statistics demonstrated a direct correlation, I found no correlation between white shrimp data and commercial production. I think a relationship exists but is obscure by the common occurrence of late shrimp waves which may or may not contribute to commercial production.

Since 1965, brown and white shrimp catches have, generally, increased. This upward trend has been accompanied by increased fishing pressure. Since 1965, numerous trawlers with greater cruising range, greater carrying capacity and highly efficient fishing gear have been added to the Texas fleet. The present rate of fishing does not appear to be detrimental. Researchers, however, are studying the effects of long-term changes in fishing intensity on shrimp stocks.

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Table 1: Values of brown shrimp catch per unit-of-effort based on biological samples (1968-1970)

Date		Tertiary Bays 1968	Tertiary Bays 1969	Tertiary Bays 1970	Secondary Bays 1968	Secondary Bays 1969	Secondary Bays 1970	Primary Bays 1968	Primary Bays 1969	Primary Bays 1970
					Sabine Lake					
May	1	-	-	-	36	0	33	56	0	1
	15	-	-	-	108	0	123	660	0	40
					Galveston Bay					
Apr.	1	5	0	4	0	0	0	0	0	0
	8	18	18	33	0	0	0	0	0	0
	15	15	76	132	0	1	0	0	0	0
	23	69	49	165	3	0	18	0	1	42
May	1	65	117	327	3	2	51	4	1	3
	8	71	303	310	13	29	84	147	7	40
	15	402	114	151	27	11	68	109	8	30
	23	70	145	426	32	43	309	23	9	71
					Matagorda Bay					
Apr.	1	3	0	0	-	0	0	0	0	0
	8	11	18	0	0	0	0	0	0	0
	15	63	11	4	6	16	0	0	3	0
	23	70	49	22	16	10	33	4	2	124
May	1	107	10	130	22	148	101	34	49	34
	8	175	90	81	-	132	-	-	23	-
	15	40	63	78	222	11	63	133	23	71
	23	14	-	7	69	19	55	121	47	19
					Aransas Bay					
Apr.	1	6	4	27	6	2	1	0	2	31
	8	0	77	-	0	2	-	0	4	-
	15	-	233	153	-	8	140	-	6	20
	23	19	1,007	-	19	4	-	0	16	-
May	1	16	316	263	16	13	146	10	38	379
	8	-	284	-	-	72	-	-	473	-
	15	69	392	518	69	199	474	190	792	1,687
	23	156	-	-	156	-	-	300	-	-
					Lower Laguna Madre					
Apr.	1	137	124	27	112	19	10			
	15	259	823	113	63	128	190			
May	1	43	195	63	527	8	693			
	15	71	271	86	617	247	984			

Table 2: Number of brown and white shrimp at two stations in Chocolate Bay (1968-1970)

Brown Shrimp

Month	Number Shrimp 1968	1969	1970	Salinity 1968	1969	1970	Temperature 1968	1969	1970
				Nymph Point					
March	0	0	0	11.1	7.2	14.4	15.0	22.0	17.0
April	24	21	21	1.1	0.0	8.9	23.0	26.0	23.0
May	56	45	12	1.1	0.0	14.9	27.0	26.0	22.0
June	89	8	20	9.4	16.1	10.0	27.5	23.0	27.0
July	0	2	26	3.3	17.8	8.9	29.0	29.5	25.5
				Monsanto Channel					
March	0	0	0	21.1	11.1	6.7	15.0	15.0	17.0
April	2	2	0	8.9	1.1	4.4	24.0	26.0	20.0
May	85	147	203	1.1	6.7	7.2	26.5	26.0	21.0
June	557	438	121	13.3	15.5	9.4	30.0	30.0	26.0
July	1	303	39	13.9	28.9	14.4	30.0	30.5	25.0

White Shrimp

Month	Number Shrimp 1968	1969	1970	Salinity 1968	1969	1970	Temperature 1968	1969	1970
				Nymph Point					
May	0	0	0	1.1	0.0	14.9	27.0	26.0	22.0
June	41	15	0	9.4	16.1	10.0	27.5	33.0	27.0
July	2	5	0	3.3	17.8	8.9	29.0	29.5	25.5
August	3	0	0	9.4	16.7	15.5	30.0	30.0	30.0
September	17	18	21	8.9	15.5	8.9	26.0	32.0	26.5
October	825	321	25	13.3	9.9	7.7	22.0	28.0	21.0
November	12	0	-	11.1	17.2	-	22.0	18.0	-
December	0	10	1	14.0	13.3	15.5	17.0	12.0	-
				Monsanto Channel					
May	0	0	0	1.1	6.7	4.4	26.5	26.0	20.0
June	4	0	1	13.3	15.5	9.4	30.0	30.0	26.0
July	148	0	149	13.9	28.9	14.4	30.0	30.5	25.0
August	1,026	81	740	15.5	33.3	18.9	29.0	30.0	29.0
September	1,234	0	606	14.4	29.4	14.4	27.0	29.5	30.5
October	624	183	4	12.0	15.5	0.0	22.0	28.0	20.5
November	6,201	48	81	20.0	26.0	16.6	21.0	18.0	20.5
December	132	2,457	36	22.8	26.6	17.8	12.0	14.0	17.5

Table 3: Average number of shrimp based on data collected in the Chocolate Bay/Bayou study (from Project No. CE-2-1)

	CHOCOLATE BAY AREA		HALL'S LAKE AREA	
Month	Brown Shrimp	White Shrimp	Brown Shrimp	White Shrimp
June 1969	103	64	ND	ND
July	13	90	11	99
August	4	89	0	148
September	0	171	0	0
October	1	121	0	230
November	24	167	0	121
December	1	118	0	0
January 1970	0	0	0	0
February	0	1	0	0
March	23*	4	6	0
April	1	7	22	0
May	130	1	116	0
June	116	23	30	38
July	85	10	0	192
August	5	91	7	59
September	1	87	1	45
October	0	70	0	64
November	0	73	0	24
December	0	180	0	0

* Postlarvae

Table 4: Relation between brown shrimp sample size and salinity, Trinity Bay, Texas (1969-1970).

SPRING, 1969			SPRING, 1970		
Date Sampled	Number Caught	Salinity Range (ppt)	Date Sampled	Number Caught	Salinity Range (ppt)
April, 14	0	0.0-0.0	April, 17	205	0.0-1.7
May, 2	0	0.0-0.0	May, 4	102	1.7-5.6
May, 16	0	0.0-0.0	May, 15	165	0.0-8.3
June, 5	0	0.0-0.0	June, 4	287	2.2-5.6
June, 6	0	0.0-0.6	June, 15	260	2.2-6.6

After Johnson, 1970

Table 5: Brown shrimp landings (mill. of pounds) and value (mill. of dollars)

	TEXAS LANDINGS		GULF LANDINGS		SOUTH ATLANTIC		TOTAL LANDINGS	
Year	Lbs.	Value	Lbs.	Value	Lbs.	Value	Lbs.	Value
1962	24.5	19.7	41.4	30.0	7.2	4.8	48.6	33.7
1963	31.3	19.3	56.0	29.1	4.7	2.4	60.7	31.6
1964	25.9	16.7	42.2	23.6	4.4	2.6	46.6	26.2
1965	34.3	22.2	62.4	35.5	5.0	2.9	67.5	38.5
1966	33.9	30.3	64.0	48.2	7.2	5.9	71.2	54.1
1967	55.5	39.3	100.9	60.6	4.9	3.0	105.9	63.9
1968	37.0	33.1	78.9	56.8	3.7	3.3	82.6	60.1
1969	29.8	29.5	65.8	51.1	6.0	5.6	71.0	56.4
1970	39.1	37.0	-*	-	-	-	-	-

* No data

Table 6: White shrimp landings (mill. of pounds) and value (mill. of dollars)

	TEXAS LANDINGS		GULF LANDINGS		SOUTH ATLANTIC		TOTAL LANDINGS	
Year	Lbs.	Value	Lbs.	Value	Lbs.	Value	Lbs.	Value
1962	7.0	4.9	23.1	14.7	7.9	5.6	31.0	20.3
1963	8.9	4.8	47.1	19.9	4.7	2.6	51.8	22.5
1964	12.0	7.1	44.0	24.2	5.3	3.4	49.2	27.6
1965	9.2	5.7	33.6	19.1	10.6	6.7	44.2	25.8
1966	7.8	6.3	29.9	21.5	5.9	4.7	35.9	26.2
1967	6.4	5.0	24.9	18.4	7.1	5.3	32.0	23.7
1968	12.5	10.1	30.9	24.9	11.0	10.0	41.9	34.9
1969	12.0	10.8	43.6	36.3	11.0	10.2	55.7	46.5
1970	12.4	10.5	-	-	-	-	-	-

Table 7: Pink shrimp (mill. of pounds) and value (mill. of dollars)

	TEXAS LANDINGS		GULF LANDINGS		SOUTH ATLANTIC		TOTAL LANDINGS	
Year	Lbs.	Value	Lbs.	Value	Lbs.	Value	Lbs.	Value
1962	3.0	2.4	22.1	16.4	1.4	0.8	23.5	17.2
1963	3.4	2.5	24.1	14.4	0.3	0.2	24.5	14.6
1964	3.5	2.2	26.8	14.7	1.2	0.6	28.0	15.4
1965	4.6	3.3	26.2	16.1	1.0	0.5	27.2	16.6
1966	1.9	1.7	18.3	13.0	0.3	0.2	18.7	13.2
1967	2.2	2.0	15.3	11.5	1.0	0.5	16.3	12.1
1968	2.7	2.5	17.6	14.0	0.8	0.6	18.5	14.5
1969	2.3	2.8	15.2	13.2	1.1	0.8	16.2	14.0
1970	1.4	1.5	-	-	-	-	-	-

Table 8: Monthly shrimp landings at Texas ports, 1970*

	No. of Pounds		
Month	Brown Shrimp	White Shrimp	Pink Shrimp
January	1,180,626	182,669	65,431
February	1,307,033	76,669	437,058
March	1,270,246	380,066	408,967
April	1,296,529	421,877	293,652
May	1,342,164	1,344,828	105,091
June	2,965,492	65,817	976,797
July	6,847,211	694,033	18,034
August	7,944,042	1,444,911	-
September	6,697,678	2,226,521	-
October	4,040,300	3,005,000	700
November	3,341,900	1,293,800	-
December	3,218,600	360,000	28,200

*Preliminary data

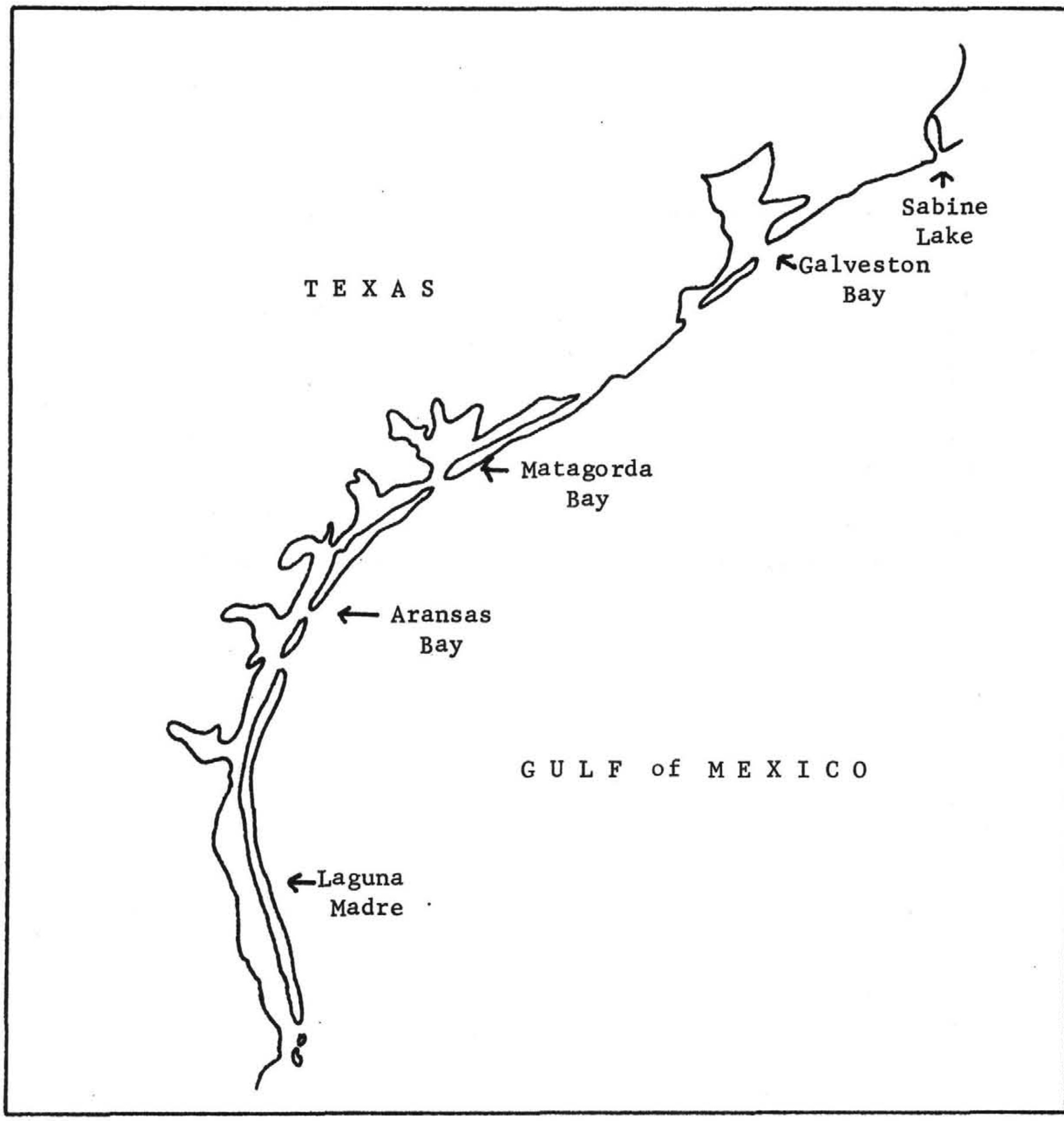


Figure 1: Position of bays sampled on Texas Coast

Figure 2: Brown shrimp length-frequency distribution based on biological samples (1970)

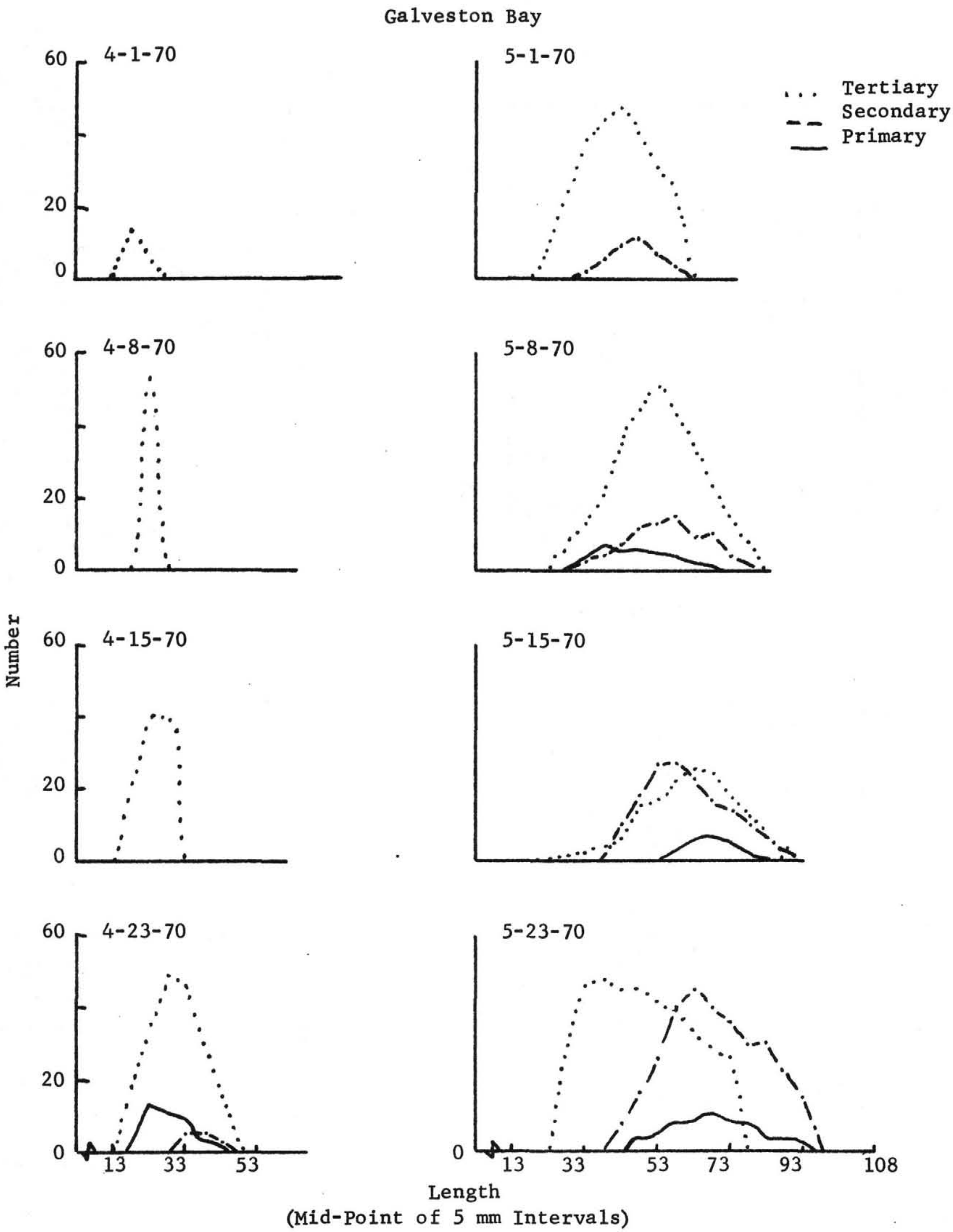


Figure 2: Cont.

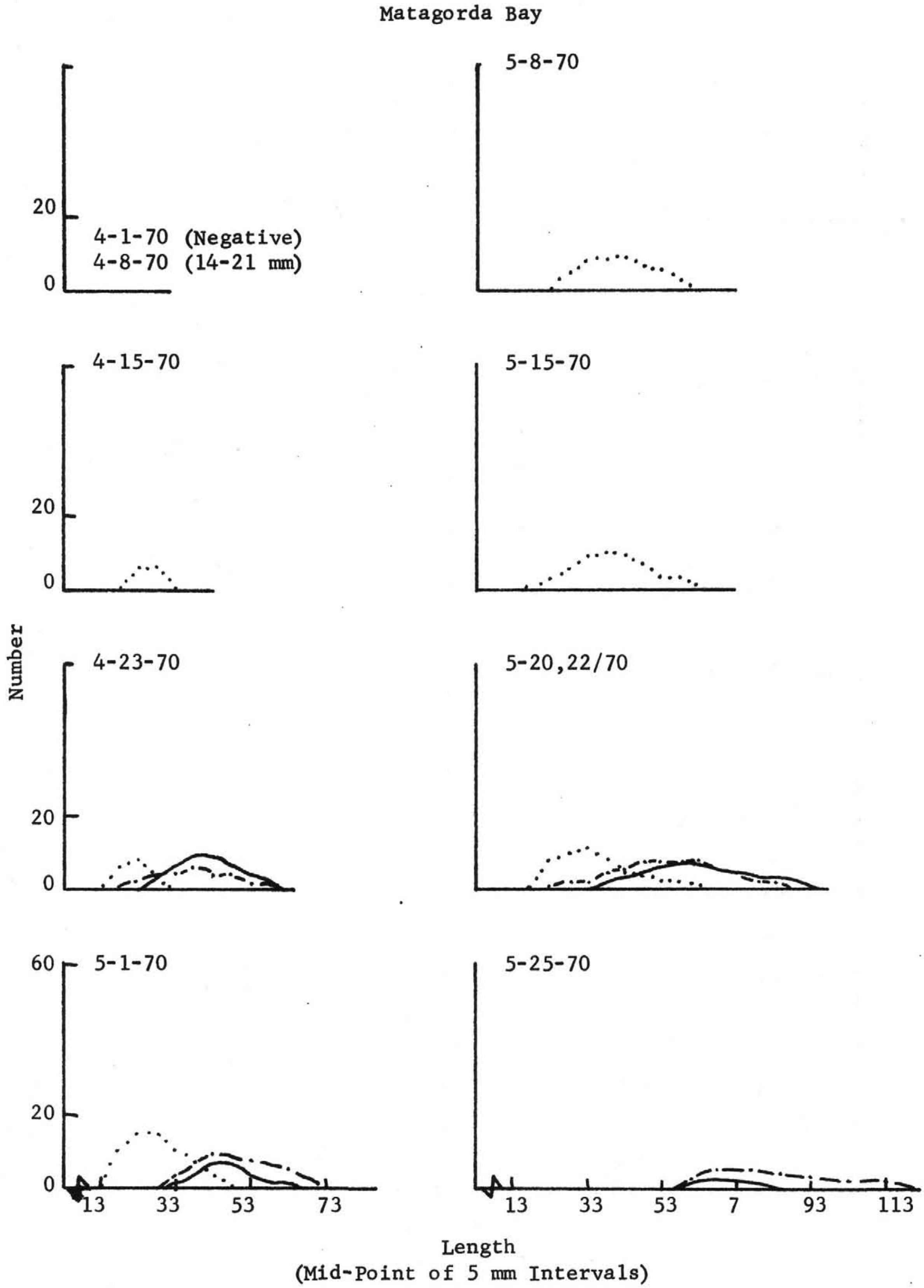
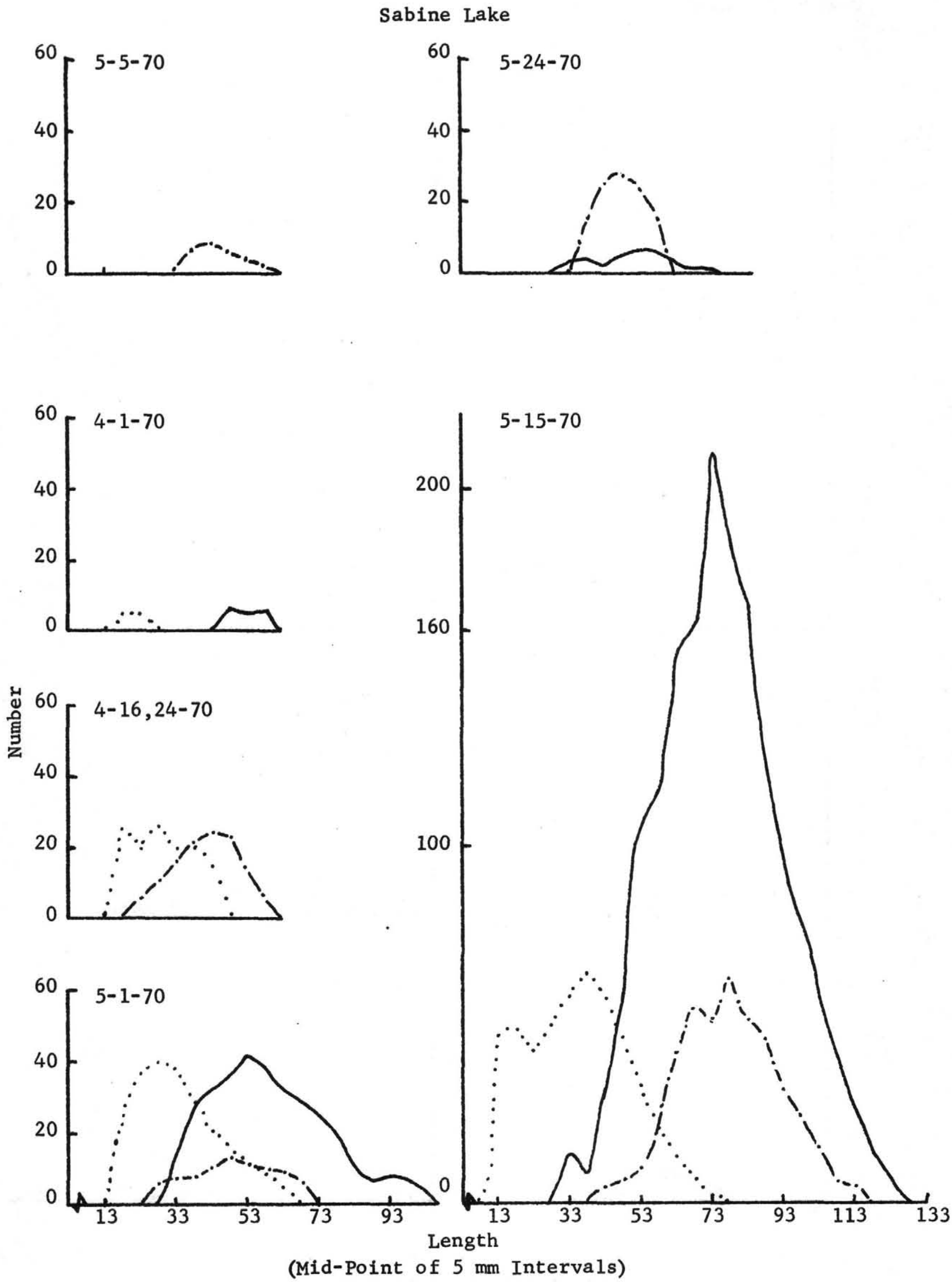


Figure 2: Cont.



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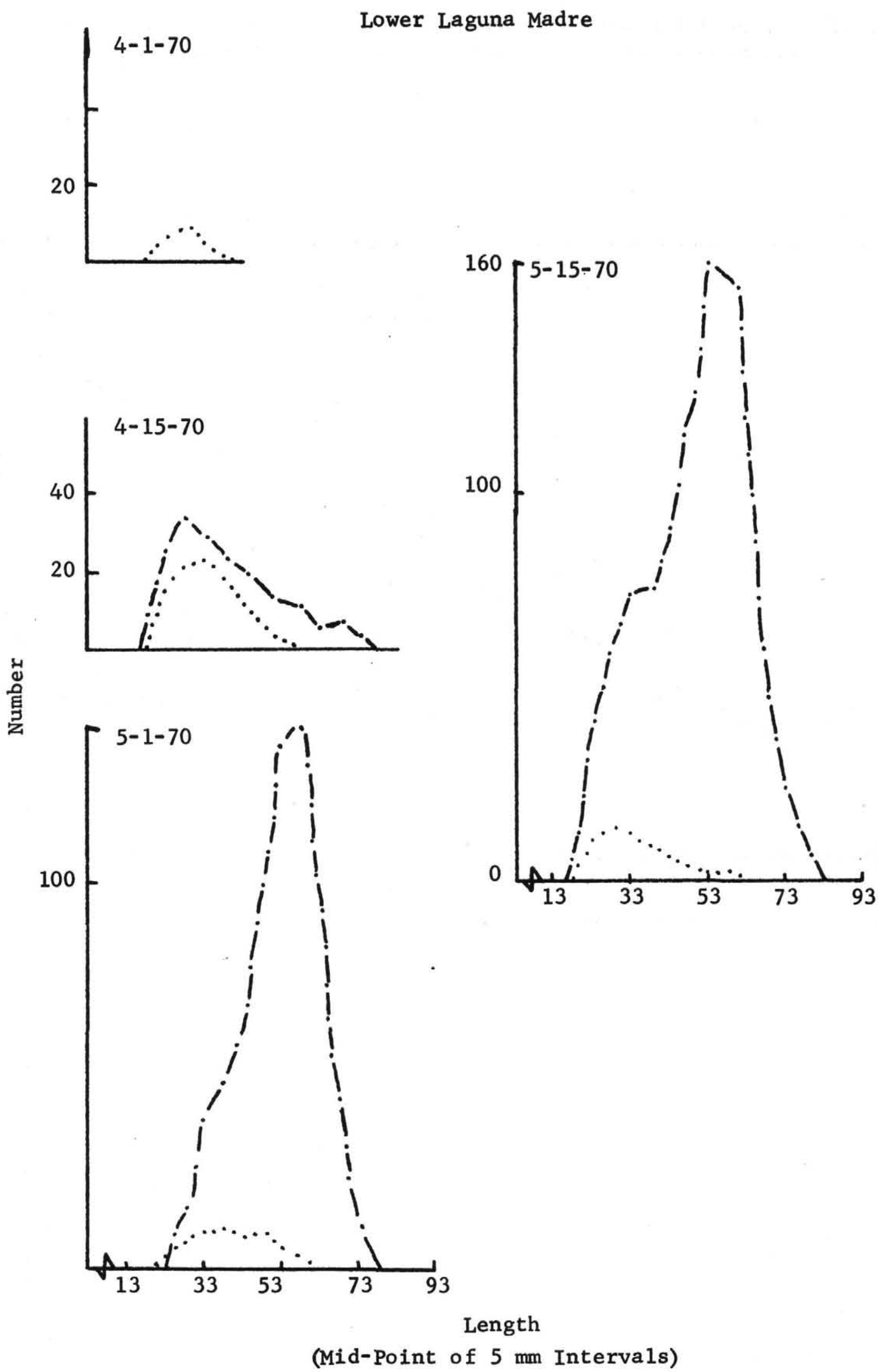


Figure 3: The relation between annual brown shrimp catches (mill. of pounds) and sample catch (per unit-of-effort), 1962-1970

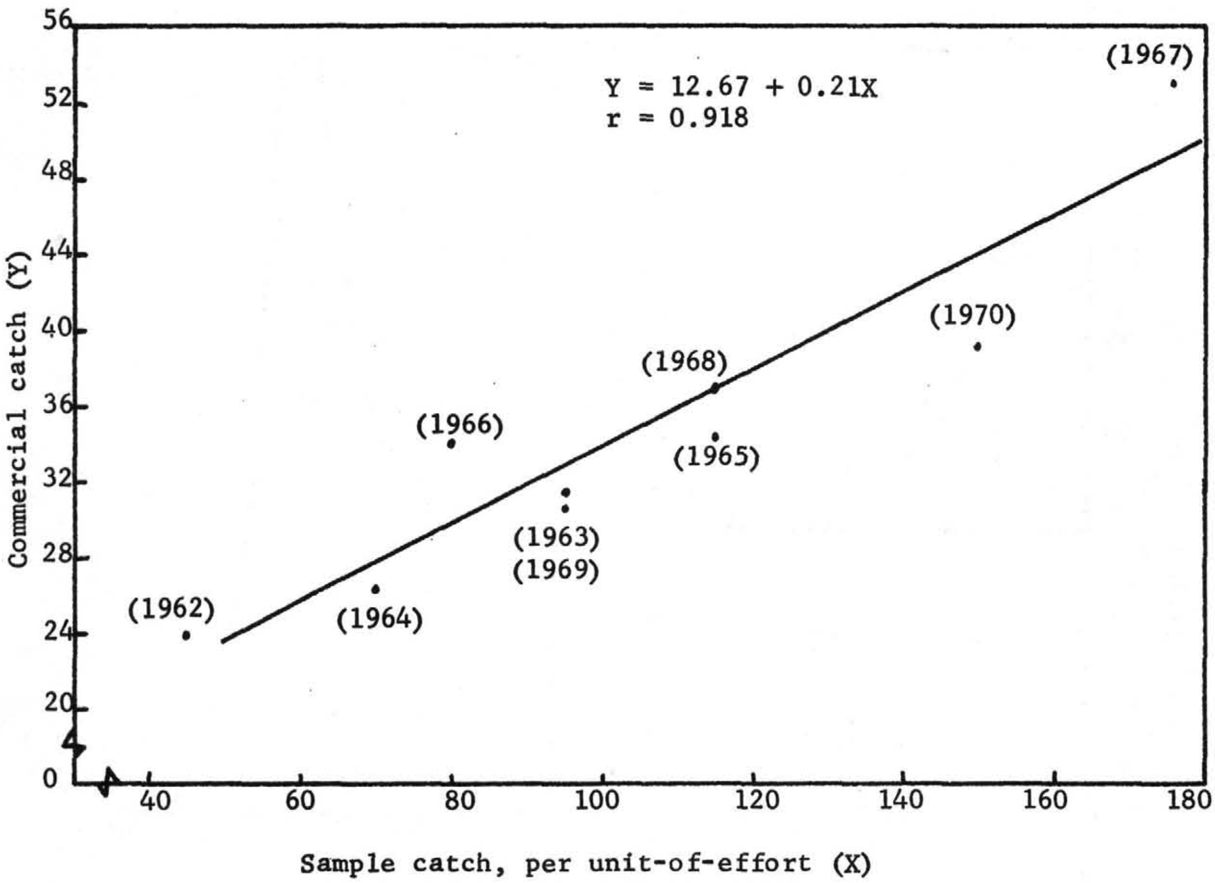
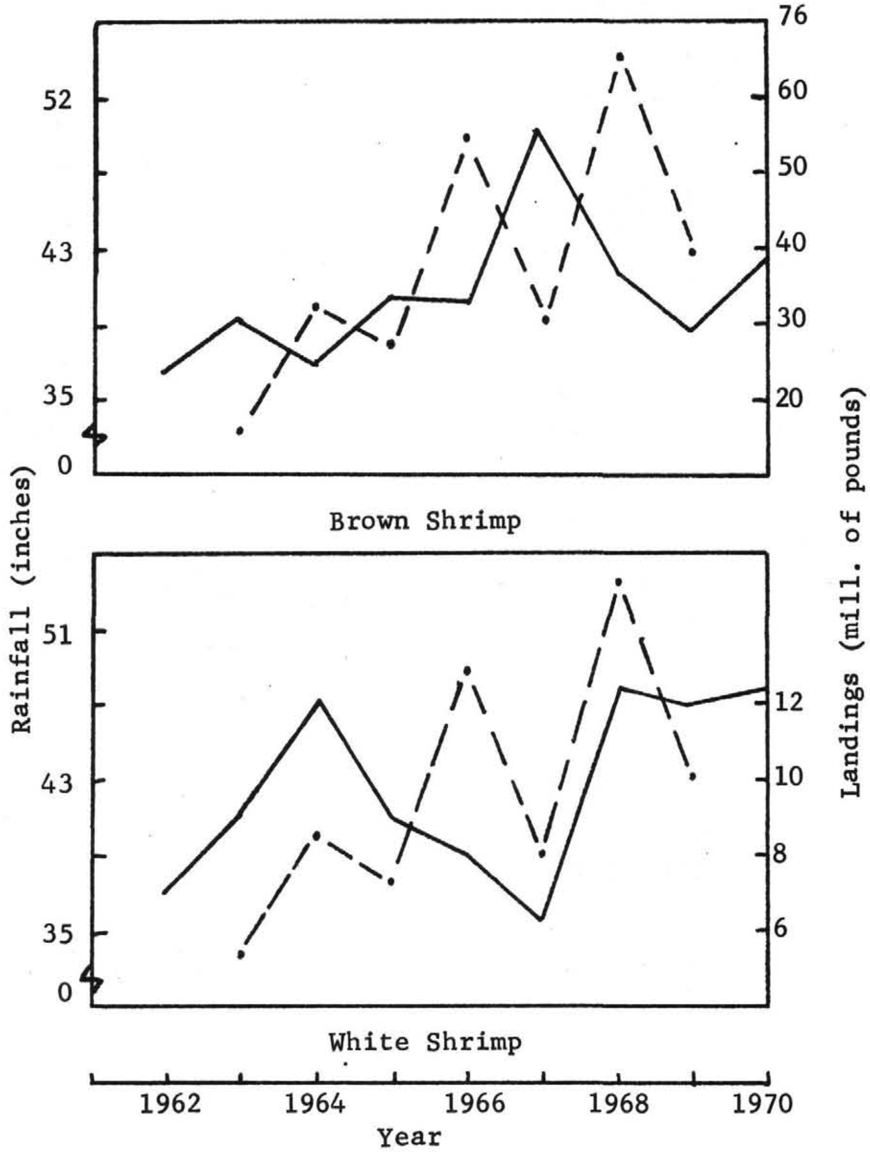


Figure 4: Relation of shrimp landings (mill. of pounds) and rainfall in Texas; solid line represents commercial landings; broken line represents rainfall (upper coast)



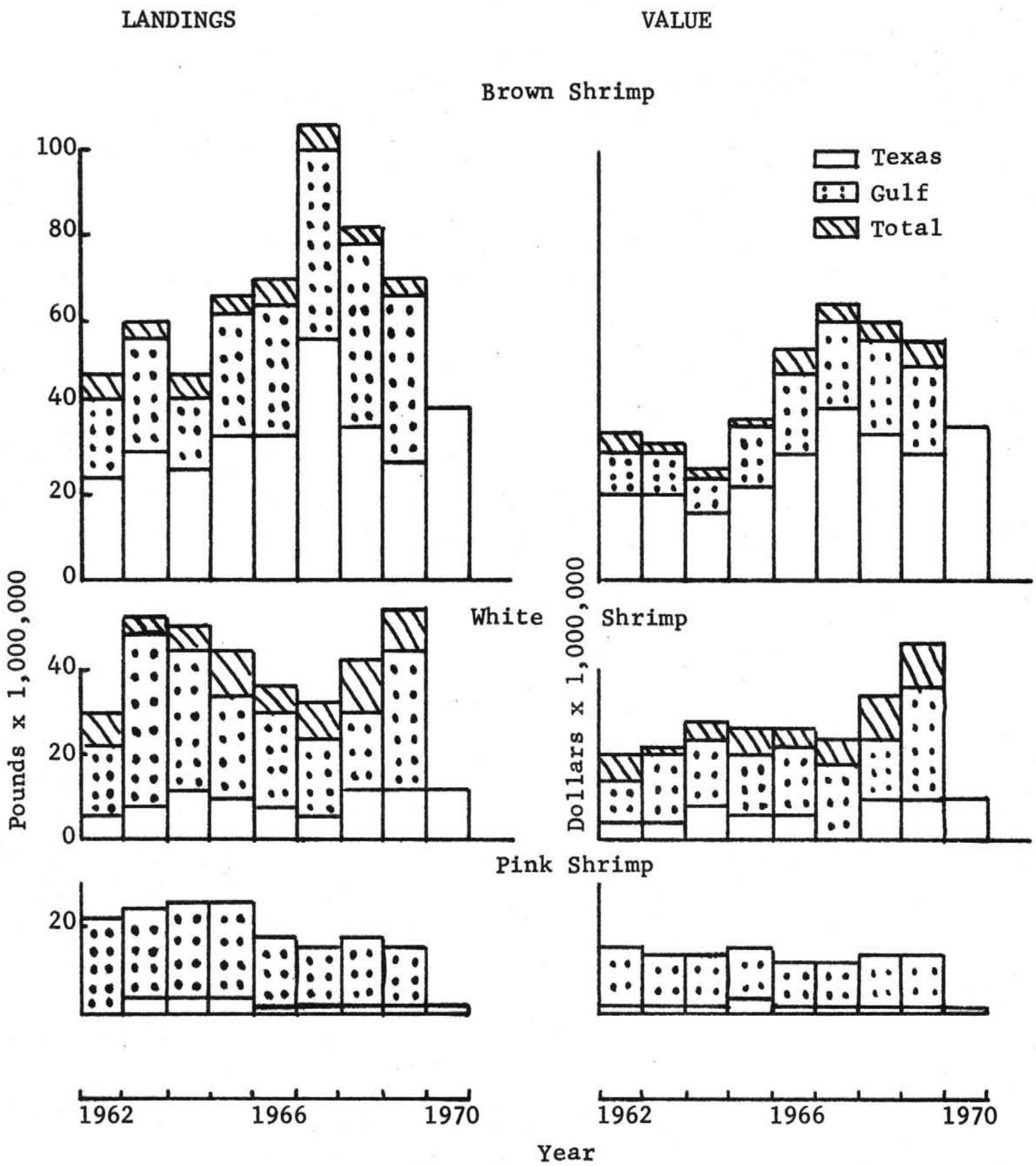


Figure 5: Comparison of shrimp landings and exvessel prices at Texas ports, Gulf ports and total landings (1962-1970)