JOB REPORT

A. W. Moffett

Project No. MS-R-5 Date: June 23, 1964

Project Name: A Study of the Texas Shrimp Populations

Period Covered: January 1, 1963 through December 31, 1963 Job No.: 1

A Study of the Texas Bay Populations of Juvenile Shrimp, Penaeus aztecus, Penaeus setiferus, and Penaeus duorarum

Abstract:

Postlarvae were found entering Aransas Bay in appreciable numbers in the spring of 1963. Late post-larval and early juvenile stages of brown shrimp, Penaeus aztecus, were found in tertiary bays in April. White shrimp P. setiferus, were found in May and June. Brown shrimp grew about 0.8 mm per day, while, white shrimp grew about 1.1 mm per day. The first brown shrimp wave was relatively larger than minor waves that followed. In some bays the first white shrimp wave appeared to be smaller than later waves. Small brown shrimp were found moving through the inshore Gulf in large numbers in June and July. White shrimp reached a larger size in the bays and supported a large commercial bay fishery. Late fall waves of white shrimp left the bays at a smaller size (probably to escape low water temperatures).

Preliminary data indicate 1963 shrimp landings increased 25 per cent over 1962 landings.

Objective:

To analyse shrimp data collected during the year in nine bay areas along the Texas Coast and Gulf Area 20 and to prepare an annual coastal shrimp report.

Procedures:

Shrimp were sampled in estuarine areas and the inshore Gulf by state biologists stationed on the Texas coast from Sabine Lake to the Lower Laguna Madre.

Postlarval shrimps were sampled in Aransas Bay (Figure 1) with a 6-foot bar seine of 1 millimeter square mesh (a plankton net was attached to the cod-end), a beam trawl with a 1 by 3 foot opening (a 6 foot bag of 1 millimeter mesh was attached to the opening), and a meter plankton net. Bar-seine samples were collected by towing the net in a 471 foot arc on a sand flat east of Lydia Ann Channel. Beam trawl samples were collected by dragging the Aransas Ship Channel bottom each week for 6 minutes. The meter plankton net was used to collect "vertical" plankton samples in the Aransas Ship Channel. Adjusted cable lengths allowed the net to fish 2 minute intervals on bottom, at mid-depth and near the surface. Water volumes, passing through the net, were measured with flow meters.

Postlarval stations were to be sampled weekly, but weather, personnel changes and net damage hampered work. Compton and Bradley (1961-62) described postlarval samplers and collecting methods in detail. Specimens were identified to genus, counted and measured.

Bay systems on the upper coast are divided into tertiary, secondary and primary bays. This division is not clear in some sections on the lower coast, therefore, stations are defined by depth. The shallow (3 feet deep or less) mud and vegetated bottom areas are called tertiary. Areas 3 to 6 feet deep are secondary stations, while, primary stations are in deeper areas of major bays. (Figures 2 to 8).

Six-foot bar seines of 1/4 - inch bar mesh were used semi-monthly at tertiary stations. The seines were towed 500 feet to collect a sample. Secondary and primary stations were sampled semi-monthly with a 10-foot trawl of 1 1/4-inch stretched mesh with a 1/4-inch bar mesh liner. The duration of each drag was 15 minutes. When rough water or dense vegetation reduced trawling time, numbers of shrimp caught were equated to one 15 minute sample.

A 20 foot trawl was used to sample shrimp during the commercial bay shrimp season. The stretched mesh of the trawl was 1 1/2 inches. After sampling, a state biologist boarded a commercial trawler in the area and sampled the catch. That night a second shrimp trawl sample was taken from the same area. This sample was collected by dragging the trawl for 15 minutes.

Shrimp in the inshore Gulf off Port Aransas (Figure 9) were sampled weekly with a 42 foot flat trawl of 2-inch stretched mesh. The duration of each Gulf trawl was 30 minutes. Compton and Bradley (1961-62) described all materials and collecting methods used in the Gulf study.

Shrimp were identified and measured in total length (distance between tip of rostrum to end of telson) to the nearest millimeter. Sample weights were recorded in ounces, by species. Bottom water temperatures, salinities, wind velocity, wind direction and turbidity were recorded at sampling time.

Shrimp growth rates were determined by following the progression of modal lengths (Figures 10 through 24). These modes were selected from shrimp length-frequency distributions. Waves of shrimp were selected by inspection of average sample catch curves (Figures 10 through 24). This year bar-seine sampling time was reduced to 500 feet. Since it takes 5 minutes to cover this distance, sample sizes were adjusted to equal 15 minute time intervals used in the 1962 investigation. All shrimp sizes mentioned in the review of bay areas are modal lengths of the size distributions. Growth rates and sizes at departure from the bays are based on an assumption that all shrimp sizes present are equally vulnerable to the trawl.

Postlarval sampling began in February. Bay and Gulf sampling began in March and ended in December. This report discusses results during the second year (1963) of a six year program. All graphs were drawn to the scale used by Pullen (1961-62).

Findings:

Although brown shrimp (Penaeus aztecus) spawn in all seasons (Baxter, 1963) several waves of late postlarval and juvenile shrimp appear in the bay systems (Leary and Compton, 1959-60). Each wave probably represents periods of successful spawning during continuous spawning. The first or "spring" wave is usually large and important to the fishery (Leary and Compton 1959-60). Evidence of a buildup of postlarvae offshore in November was reported (Commercial Fisheries Review, 1963), but the importance of this to the fishery is not clear.

White shrimp postlarvae (P. setiferus) enter bays later in the spring.

This species spawns in the Gulf from 4 - 20 fathoms in depth (Rounsefell, 1963) and spawning near passes has been reported (Guest, 1958). Apparently spawning is continuous from March through Septmeber (Guest, 1958).

Postlarvae

Postlarval penaeid shrimps were found in appreciable numbers during the spring of 1962 and 1963 in Aransas Bay. The largest sample of the 1963 investigation was collected in April and contained 245 specimens (9-13 millimeters long). Number of Postlarvae and number of samples collected by month and gear since February 1962 are shown in Table 1.

Bay Investigation, Brown shrimp (Penaeus aztecus)

Sabine Lake: Data from this area were fragmentary because sampling began late. The shrimp caught in June probably represented remnants of a spring wave. A wave appeared in August at a modal length of 55 mm. These shrimp grew about 1.0 mm per day before leaving in early September at a length of 70 mm. After the September hurricane a small wave was detected; however, sample catches were too small to estimate growth (Figure 10).

Galveston Bay: The first of three shrimp waves was detected at tertiary stations in mid-April. Waves found in the summer and fall were much smaller (Figure 11). In the bay, the shrimp grew about 0.9 mm per day. Fall sample catches were small and growth of the last wave was not estimated.

The results of sampling are tabulated.

Wave Period in Bay	Modal length at detection (mm)	Modal length at departure (mm)	Growth mm/day
1. Mid - April - June	28	93	1.2
2. July - September	30	80	0.8
3. October - November	30	-	-

Most of each wave left, for the Gulf, before modal sizes exceeded 90 mm. Modes representing large shrimp in Figure 11 are based on few length measurements.

The catch per unit effort* reached a peak in early June. The average catch per unit effort was 12 per cent above 1962 data.

Matagorda Bay: Samples from this bay were indicative of a large year-class. Three waves and fragments of a possible fourth were found (Figure 12). The first, and largest, group was detected in early April. The average daily growth of shrimp was estimated at 0.9 mm per day. The sampling results are tabulated.

* Catch per unit effort is the average number of shrimp per sample in one semi-monthly sampling period.

Wave Period in Bay	Modal length at detection (mm)	Modal length at departure (mm)	Growth mm/day
1. April - June	25	90	1.0
2. June - August	25	100	0.8
3. August	30	-	-

The bulk of each wave moved Gulfward before shrimp were 100 mm long.

The catch per unit effort reached a peak in mid-April and remained at a high level through August. The average catch per unit effort was 67 per cent above 1962.

San Antonio Bay: A large wave of shrimp was found in mid-April; however, fluctuatuions in sample catches were slight and waves were difficult to separate (Figure 13). Apparently a small group appeared in September, by growth could not be traced. The average daily growth, based on samples from the first two waves, was about 0.65 mm per day. Sampling results are tabulated.

Wave Period in Bay	Modal length at detection (mm)	Modal length at departure (mm)	Growth mm/day
1. April - June	48	70	0.7
2. June - August	45	93	0.6
3. September	55	-	-

The catch per unit effort reached a peak in mid-May. The average catch per unit effort increased 37 per cent from 1962.

Aransas Bay: Four waves were identified. The first and largest was detected in April. A portion of the third wave appeared to remain longer in the bay and grow faster, since shrimp over 100 mm were taken in November (Figure 14). Indications of a late fall wave were found in November.

Wave Period in Bay	Modal length at detection (mm)	Modal length at departure (mm)	Growth mm/day
1. April - June	25	73	1.0
2. May - August	28	83	0.7
3. August - October	25	75	1.1
4. November	50	-	-

In the bay the average daily growth of shrimp was about 0.9 millimeters per day.

The catch per unit effort reached a peak in May. The average catch per unit effort was 67 per cent above 1962.

Inshore Gulf off Port Aransas: Brown shrimp were found passing through the inshore Gulf in large numbers in June and July. A peak in the sample catch curve appeared in June while 1962 samples reached a peak in May. (Figure 25). This suggests a possible later movement offshore in 1963. Modal sizes in June and July (Figure 26) were below the minimum legal size of 108 mm (65 tails per pound).

Corpus Christi Bay: Three waves of shrimp were identified. The first was large but later waves were small and determined by shrimp lengths instead of sample sizes (Figure 15). The overall average daily growth rate was about 0.8 mm. Results of sampling are tabulated.

Wave Period in Bay	Modal length at detection (mm)	Modal length at departure (mm)	Growth mm/day
1. April - May	60	88	0.6
2. June - August	48	80	1.1
3. September - November	48	-	-

The catch per unit effort reached a peak in early June. The average catch per unit effort decreased 37 per cent from 1962.

Upper Laguna Madre: Shrimp sampling indicated three waves (Figure 16).* Certain physical features of this area (mainly dense vegetation) prevented proper use of the bar-seine; therefore, shallow water stations were sampled with a 60-foot bag seine that caught larger shrimp. This created a problem when estimating growth and the following estimates are rough.

Wave Period in Bay	Modal length at detection (mm)	Modal length at departure (mm)	Growth mm/day
1. May - July	50	85	0.6
2. July - August	53	85	0.7
3. August	55	-	-

The bulk of each wave left the bay before they were 90 mm long. The catch per unit effort reached a peak in mid-July. The average catch per unit effort decreased 44 per cent from 1962.

Lower Laguna Madre: Fluctuations in shrimp sample catches indicated at least five waves. Pullen (1961-62) described the same number of waves.

In the bay, average shrimp growth was estimated at 0.75 mm per day. Results of sampling follow.

* The modal size of the second peak in Figure 16 was longer than preceding samples and was not considered a separate wave.

Wave Period in Bay	Modal length at detection (mm)	Modal length at departure (mm)	Growth mm/day
1. May - June	45	68	0.8
2. June - August	35	68	0.7
3. August - September	35	65	0.7
4. September - November	30	65	0.8
5. November	40	-	-

Most shrimp left for the Gulf before they were 70 mm long.

The catch per unit effort reached a peak in early May, and remained at a high level through mid-July. The average catch per unit effort decreased 53 per cent from 1962.

White Shrimp (setiferus)

Sabine Lake: Three shrimp waves were identified (Figure 17). The first and smallest group was detected in July. After Hurricane "Cindy" flooded the area a large wave appeared in October. This was followed by another large group in December. Results of sampling in January 1964 were negative. The last group left at a small size, probably, to escape low water temperatures.

The average shrimp growth was estimated at 0.9 mm per day. Results of sampling are tabulated.

Wave Period in Bay	Modal length at detection (mm)	Modal length at departure (mm)	Growth mm/day
1. July - August	78	127	1.1
2. October - November	60	85	0.5
3. December	63	-	-

Galveston Bay: The first of three shrimp waves was found at tertiary stations in June (Figure 18).

In the bay, the average shrimp grew about 1.0 mm per day.* An analysis of each wave is tabulated.

Wave Period in Bay	Modal length at detection (mm)	Modal length at departure (mm)	Growth mm/day
1. June - August	38	118	1.3
2. August - November	25	129	0.9
3. October - December	30	-	0.7

* A staining experiment to determine growth of white shrimp in Galveston Bay was conducted by the U. S. Bureau of Commercial Fisheries, Galveston, Texas in August, 1963 (Commercial Fisheries Review, 1963). To date results have not been published.

The catch per unit effort reached peaks in early August and November. The average catch per unit effort increased 15 per cent from 1962.

Matagorda Bay: The first white shrimp wave was detected in June. This was followed by larger waves in August and November (Figure 19).

The average growth of white shrimp was estimated at 1.1 mm per day. Results of sampling are tabulated.

Wave Period in Bay	Modal length at detection (mm)	Modal length at departure (mm)	Growth mm/day
1. June - August	43	105	1.0
2. August - October	28	105	1.0
3. November	35	-	1.3

The catch per unit effort reached peaks in mid-August and early November. The average catch per unit effort increased 76 per cent from 1962.

San Antonio Bay: White shrimp were found in the bay from June through November. The data, although weak, indicated two waves. The first was detected in June when shrimp were 48 mm long. A rough daily grow rate of 1.4 mm was calculated. A second group appeared in September and reached a peak of abundance in October (Figure 20). Sampling was incomplete; thus fall shrimp growth could not be traced.

The average catch per unit effort increased slightly from 1962.

Aransas Bay: White shrimp samples indicated three waves (Figure 21). The first group appeared in July and was followed by a second wave in September. A third wave appeared in late fall but catches were small and growth was not estimated.

Shrimp grew about 1.1 mm per day in the bay.

Wave Period in Bay	Modal length at detection (mm)	Modal length at departure (mm)	Growth mm/day
1. July - August	43	-	1.2
2. September - December	28	103	1.3
3. November	43	-	-

The catch per unit effort reached a peak in early July. The average catch per unit effort increased 20 per cent from 1962.

Inshore Gulf off Port Aransas: White shrimp were found in the inshore Gulf throughout the sampling period. The largest sample catches were in March and September (Figure 25). The modal length (Figure 26) were all over the legal minimum size of 112 mm (65 tails per pound). Shrimp sizes from the inshore Gulf in January are not shown, but fall waves apparently left the bays at a small size.

Corpus Christi: Although trawl catches were small, at least two distinct groups were present (Figure 23). A daily growth rate of 0.9 mm per day was estimated. Results are tabulated.

Wave Period in Bay	Modal length at detection (mm)	Modal length at departure (mm)	Growth
1. July - August	80	110	1.7
2. October - November	55	100	1.0

The catch per unit effort reached peaks in August and mid-November. The average catch per unit effort decreased 20 per cent from 1962.

Upper Laguna Madre: White shrimp were found in the upper Laguna Madre in July and August in salinities over 50 ppt. This area is not estuarine in the strict sense of the term (Rounsefell, 1963). Thus in 1962 Pullen (1961-62) assumed that white shrimp moved in from Corpus Christi Bay. The white shrimp size mode was 68 mm in July and 68-73 mm in August.

Lower Laguna Madre: White shrimp were present from June through November. There were two distinct waves (Figure 24). The first which grew about 1.3 mm per day appeared in June (35 mm) and left before August (90 mm). A second group appeared in the fall and grew about 1.2 mm per day.

The catch per unit effort reached a peak in mid-November. The average catch per unit effort dropped sharply from 1962.

Pink Shrimp (duorarum)

A few pink shrimp (P. duorarum) occur in all Texas bays. Guest (1958) states that pink shrimp are found in the bays in the fall and spring. Apparently this species increases in abundance in southern bays.

The separation of juvenile pink from brown shrimp still poses a taxonomic problem. In April large numbers of small grooved shrimp were reported from the Lower Laguna Madre. These may have been pink shrimp that left at a small size since the largest reported was 73 mm long. Numbers of pink shrimp caught in other bays were minor and did not merit further comment.

Commercial Sizes (Bay Fishery)

The objective of 20-foot trawl sampling was to determine sizes of shrimp caught commercially in the bays. The per cent length-frequency curves in Figure 27 are based on white shrimp length measurements from commercial and 20-foot trawl shrimp catches. Both samples were collected periodically in the same area and at the same time. The modes are well separated; thus 20-foot trawls catch smaller shrimp.

Sampling of commercial shrimp catches was limited in all bays but enough samples were collected from Galveston and Matagorda Bays for discussion. Fifty per cent of the total white shrimp sample was under 138 mm (about 36 tails per pound) from Galveston Bay and 128 mm (about 45 tails per pound) from Matagorda Bay (Figure 29). Five per cent of the Galveston Bay and 28 per cent of the Matagorda Bay shrimp sample was under legal minimum size (112 mm or 65 tails per pound).

Table 2 summarizes day-night 20-foot trawl samples. The day catch for both species was nearly double the night catch.

The Commercial Fishery

Shrimp landings at Texas ports increased about 25 per cent over 1962. Nearly 43 million pounds (as opposed to 35 million pounds in 1962) were reported, (Figures 26 and 30). Brown shrimp landings did not reach the production peaks of 1960 landings (Figure 29). These data are from the preliminary Gulf of Mexico Monthly Landings, Bureau of Commercial Fisheries, Market News Service reports.

The average pounds of white shrimp caught per day fished showed a general decrease from north to south along the Texas coast (Table 3). The average brown shrimp catch per day fished increased in late summer but dropped in the fall along the upper caost.

The commercial bay fishery produced over 4 million pounds of white shrimp and about 750,000 pounds of brown shrimp in 1963. The highest production period was August - September when over 3 million pounds of white shrimp were landed. Bay shrimp landings were donated by the Bureau of Commercial Fisheries, Galveston, Texas and are preliminary.

Discussion

St. Amant, et. al. (1963) offered evidence that brown shrimp postlarval growth accelerates when spring water temperatures reach 20°C. In most bays average water temperatures did not pass this point until April when small brown shrimp were detected.

Sample sizes (number of shrimp) declined sharply in December as water temperatures fell. The wave of small white shrimp present in Sabine Lake in December had disappeared by early January when water temperatures dropped to 11°C. Tabb, et. al. (1962) showed a pronounced reduction in pink shrimp sample catches during a cold spell in Florida. Temperatures seem to have a similar effect on shrimp populations in Texas.

The high salinity patterns of southern Texas bays probably were responsible, in some way, for the general decrease in the sample catch per unit effort along the lower coast from 1962. This was especially true for the Upper Laguna Madre where salinities over 60 ppt and in the Lower Laguna where salinities over 70 ppt were reported.

The brown shrimp sample curve (Figure 31) reached a peak earlier in 1963 than in 1961 and 1962. The white shrimp curve reached a peak in August and November (Figure 32). Neither curve approached the magnitude of 1960.

Small brown shrimp were found in most bays in April. The first wave in all bays appeared to be numerically larger than later waves. White shrimp were detected in nurseries in May and June. In most areas the first wave appeared to be composed of fewer shrimp than succeeding waves.

Average daily brown shrimp growth rates (areas combined) were estimated at 1.0 mm in 1960, 0.9 mm in 1961 and 0.8 mm in 1962 (Pullen 1961-62). The same investigator reported average daily white shrimp growth rates of 0.9 mm in 1960, 1.0 mm in 1961 and 1.1 mm in 1962. In 1963 the estimated daily growth rates were0.8 mm for brown shrimp and 1.1 mm for white shrimp.

Most brown shrimp left the bays before reaching a length of 100 mm. White shrimp reached a larger size in the bays but late fall waves apparently left at a small size.

One of several shrimp research objectives discussed by Kutkhun (1963) was ....to define the relationship between growth and natural mortality so as to predict the average size (or age) of shrimp at the moment population weight reaches a maximum, and thereby acquire the information needed to promote efficient resource utilization. When this information is available to the industry both bay and Gulf shrimp regulations may require adjustments.

The present shrimp bill (House Bill 109), passed in 1963, restricts commercial bay fishing in Texas to "major" bays. The photographs in Figure 33 illustrate the purpose of closing "minor" bays. The first photograph shows a shrimp sample collected on May 15, 1963 in Clear Lake (a "minor" bay). At this time brown shrimp pass through a rapid growth period. Most of these shrimp are under the legal minimum size of 108 mm. When these shrimp reach the primary or "major" bay a larger portion will be fishable size. The second photograph shows a Clear Lake shrimp sample collected on July 1, 1963. By this time Clear Lake served as habitat for both brown and white shrimp (all under minimum legal size). The shrimp sizes found in this "minor" bay offers evidence to support the close order.

The photographs of samples from Sabine Lake are shown to demonstrate rapid growth and change in white shrimp sizes over a short period (Figure 34).

Recommendations for future work:

1. The use of postlarval samples as a index of abundance is complex. In Louisiana movements of postlarvae are cyclic and negative samples are collected as opposed to good catches a few days later (St. Amant, et. al., 1963). These workers believe that the decreased number of postlarvae in some samples apparently follow spring weather cycles of cold and warm fronts. They state: "Warm fronts accompanied by south winds increase the density and stimulate the movement of postlarvae". This indicates that postlarval sampling should be intensified (to correct for cyclic variations) and postlarval sample nets not supplying adequate data be dropped from future studies. The meter plankton net fishes at different depths and apparently provides the best samples.

2. Brown shrimp predictions are based mainly on spring samples of late postlarval (less than 25 mm long) and early juvenile stages. Intensified spring sampling would offer stronger data.

3. Shrimp sizes at departure from the bay to the Gulf are determined in some areas by very limited sampling. Although routine stations should be sampled, additional samples from primary bays would be of value. This may also detect possible differential shrimp growth within one bay system.

4. The 20-foot trawl catches are not representative of commercial catches. Sampling directly from the commercial catch should be expanded. This would also supply information on percentages discarded if catches are unsorted.

5. Sampling in the inshore Gulf should be expanded through December and January to determine sizes of white shrimp present.

Summary:

1. Postlarval penaids were sampled with a bar-seine, beam trawl and plankton net in Aransas Bay.

2. Juvenile shrimps were sampled with bar-seines and 10-foot trawls in nine major bay systems of Texas.

3. Inshore Gulf shrimp samples were collected with a 42-foot flat trawl.

4. The largest postlarval shrimp sample (245) was collected in April with a plankton net.

5. Growth was estimated by following the seasonal progression of modal sizes. The average growth of brown shrimp was 0.8 mm/day. White shrimp grew about 1.1 mm/day.

6. Undersized brown shrimp were found moving through the inshore Gulf in large numbers in June and July. White shrimp reached a larger size in bays and inshore Gulf waters and late fall "broods" left the bays at a small size.

7. Preliminary shrimp landings show a 25 per cent increase from 1962 landings.

8. Sampling indicated an increase in abundance on the upper coast and a decrease on the lower coast from 1962.

Alan W. Moffett
Project Leader

Prepared by: Alan W. Moffett
Marine Biologist

J. R. Stevens
Regional Supervisor

Approved by: Terrance K. Leary
Coordinator

Literature Cited

Baxter, K. N.
1963 Abundance of postlarval shrimp - One index of future shrimping success. Proc. Gulf Carib. Fish. Inst. (15th Annual Session).

Commercial Fish. Review
1963 Gulf Fishery Investigation. Comm. Fish Rev. 25 (12): 28.

Compton, Henry and Eddie Bradley
1961-62. A study of the post-larval penaeid shrimp entering Aransas Bay. Project Reports, Coastal Fisheries, Texas Game & Fish Comm. (Mimeographed).

_____
1961-62. Biological survey of the commercial shrimp and associated organisms of Area 20 in the Gulf of Mexico. Project Rpts., Coastal Fisheries, Tex. Game & Fish Comm. (Mimeographed).

Guest, W. C.
1958. The Texas Shrimp Fishery. Tex. Game Fish Comm., Bull. 36.

Kutkuhn, J. H.
1963 Expanded research on Gulf of Mexico shrimp. Proc. Gulf. Carb. Fish. Inst. (15th Annual Session).

Leary, Terrence and Henry Compton
1959-60 A study of the bay populations of juvenile shrimp Penaeus aztecus and Penaeus setiferus. Project Rpts., Marine Fisheries Division, Tex. Game & Fish Comm. (Mimeographed)

Pullen, Edward J.
1961-62 A study of the bay and Gulf populations of shrimp: Penaeus aztecus, Penaeus setiferus, and Penaeus duorarum. Projects Rpts., Coastal Fisheries, Tex. Game & Fish Comm. (Mimeographed)

Rounsefell, C.
1963 Realism in the management of estuaries. Alabama Marine Lab., Marine Resources Bull. (1).

St. Amant, L. S., K. C. Corkum, and J. G. Broom
1963 Studies on growth dynamics of the brown shrimp, Penaeus aztecus, in Louisiana waters. Proc. Gulf Carib. Fish. Inst. (15th Annual Session).

Tabb, D. C., David L. Dubow and Andrew E. Jones
1962 Studies in the biology of the pink shrimp, Penaeus duorarum Burkenrood, in Evergaldes National Park, Florida. Tech., Ser., Fla. State Board of Conserv. (37).

Figure 1. Postlarval Shrimp Stations (Aransas Bay Area)

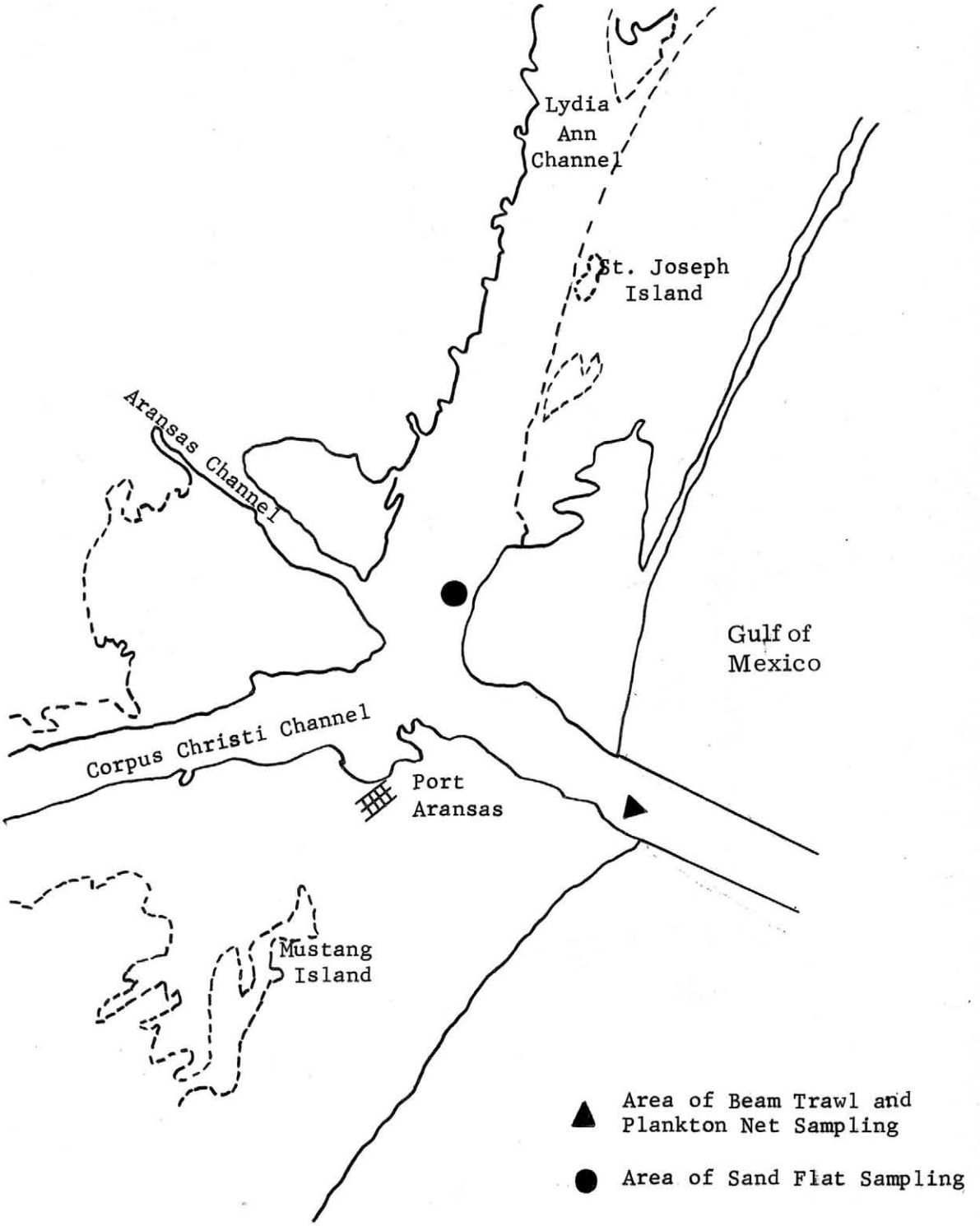


Figure 2. Map of Sabine Lake

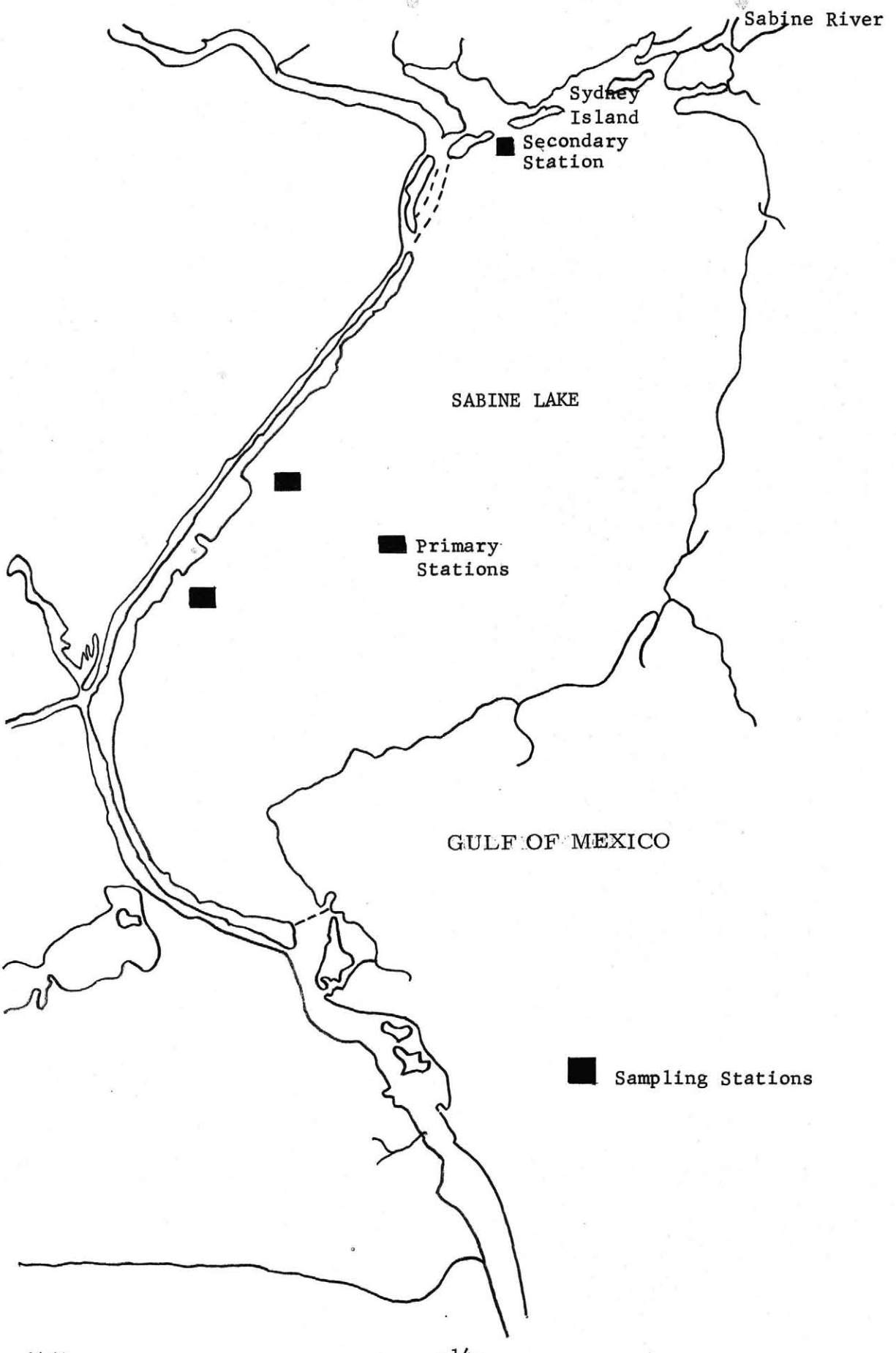
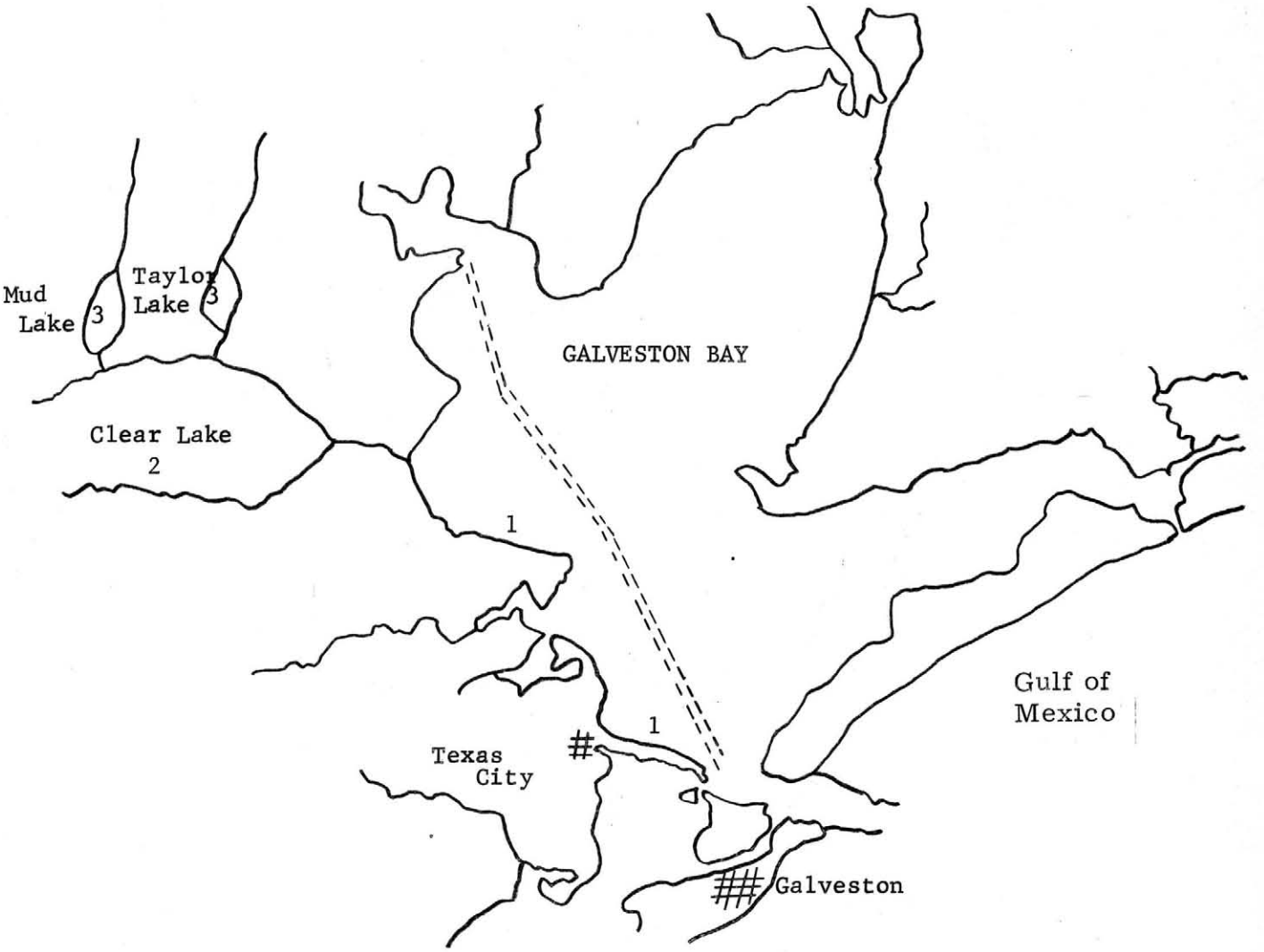


Figure 3. Galveston Bay Station Locations



1. Primary Stations
2. Secondary Stations
3. Tertiary Stations

Figure 4. Matagorda Bay Station Locations

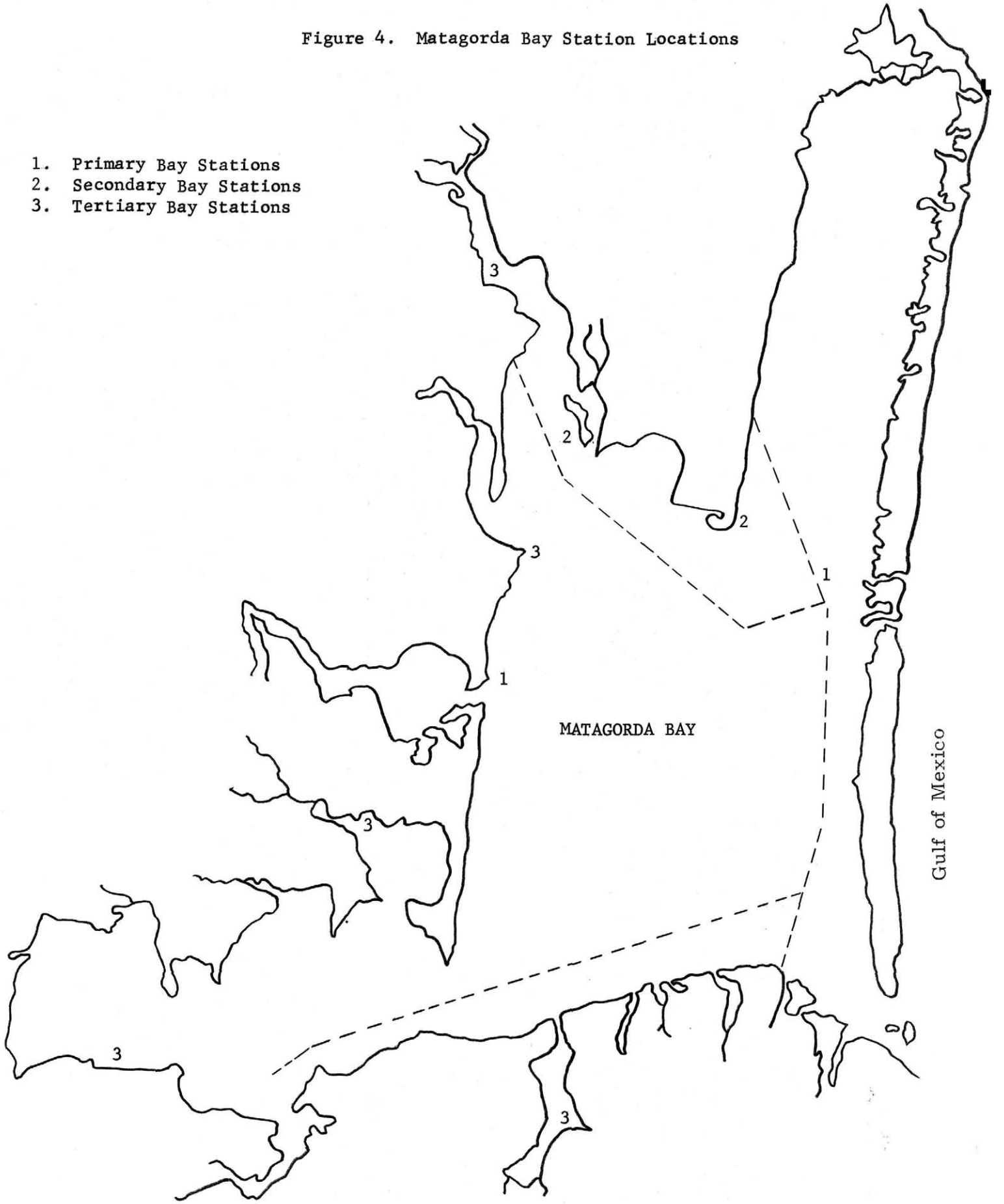


Figure 5. San Antonio Bay Station Locations

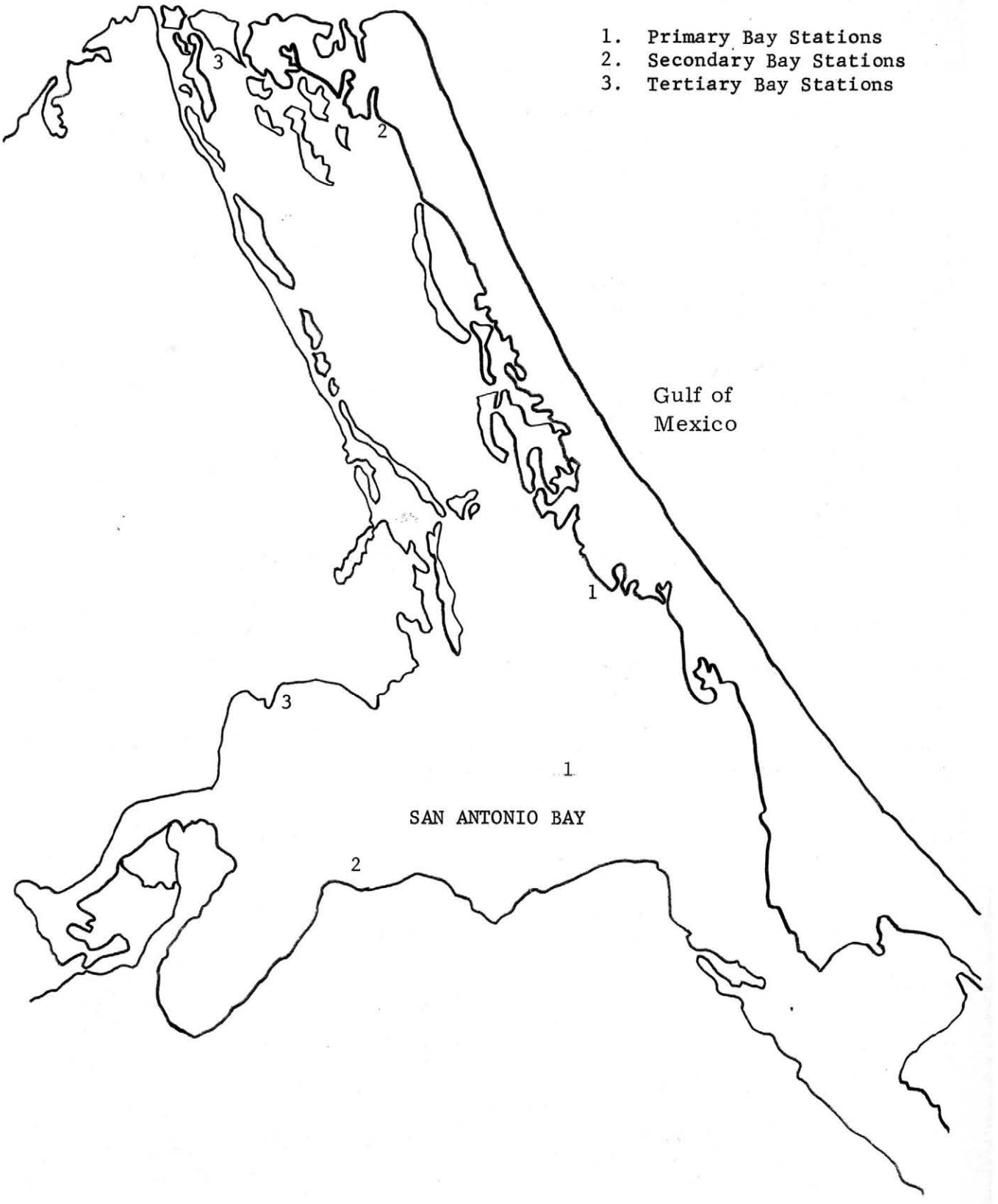


Figure 6. Aransas Bay Station Locations

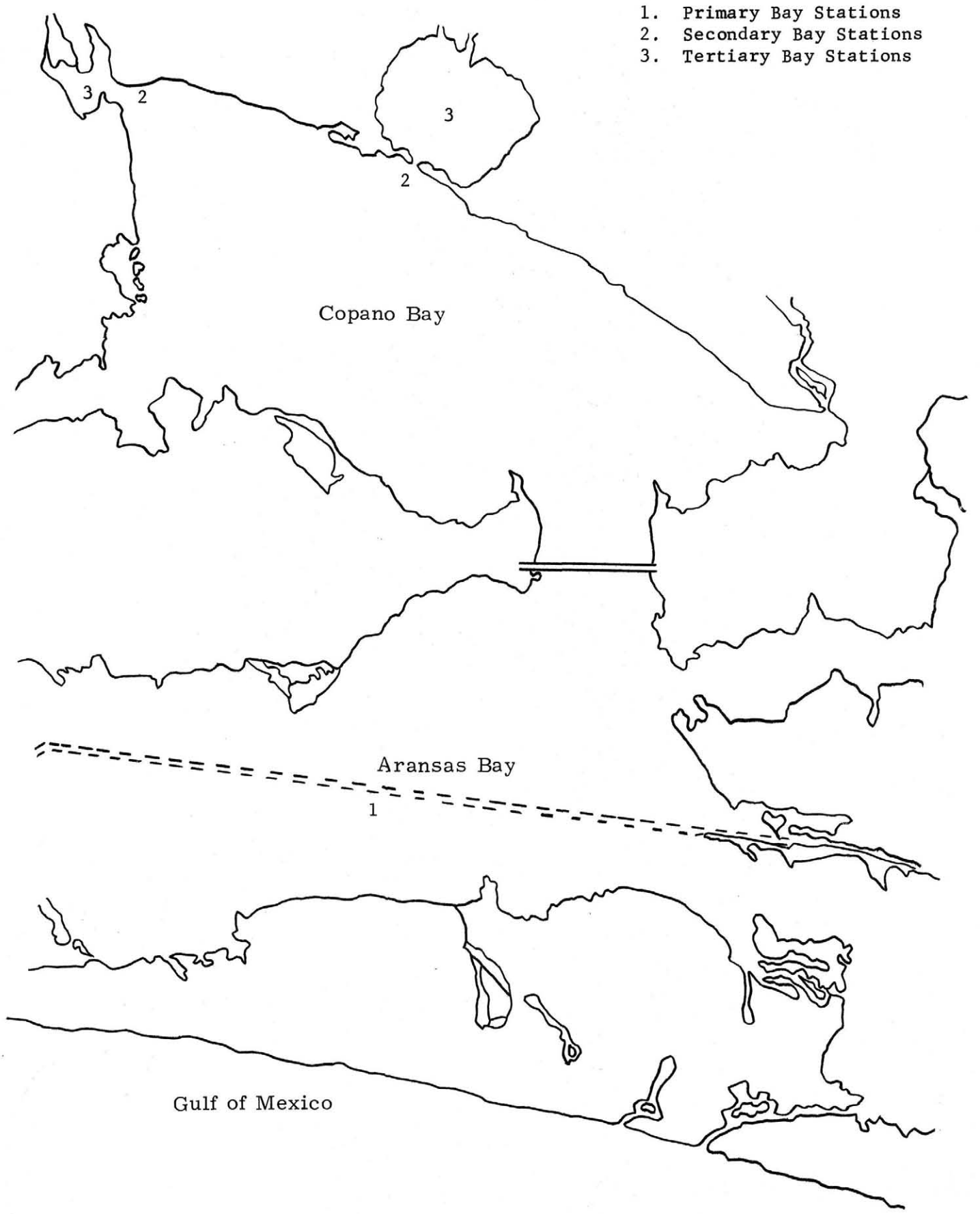


Figure 7. Corpus Christi Bay Station Locations

1. Primary Bay Stations
2. Secondary Bay Stations
3. Tertiary Bay Stations

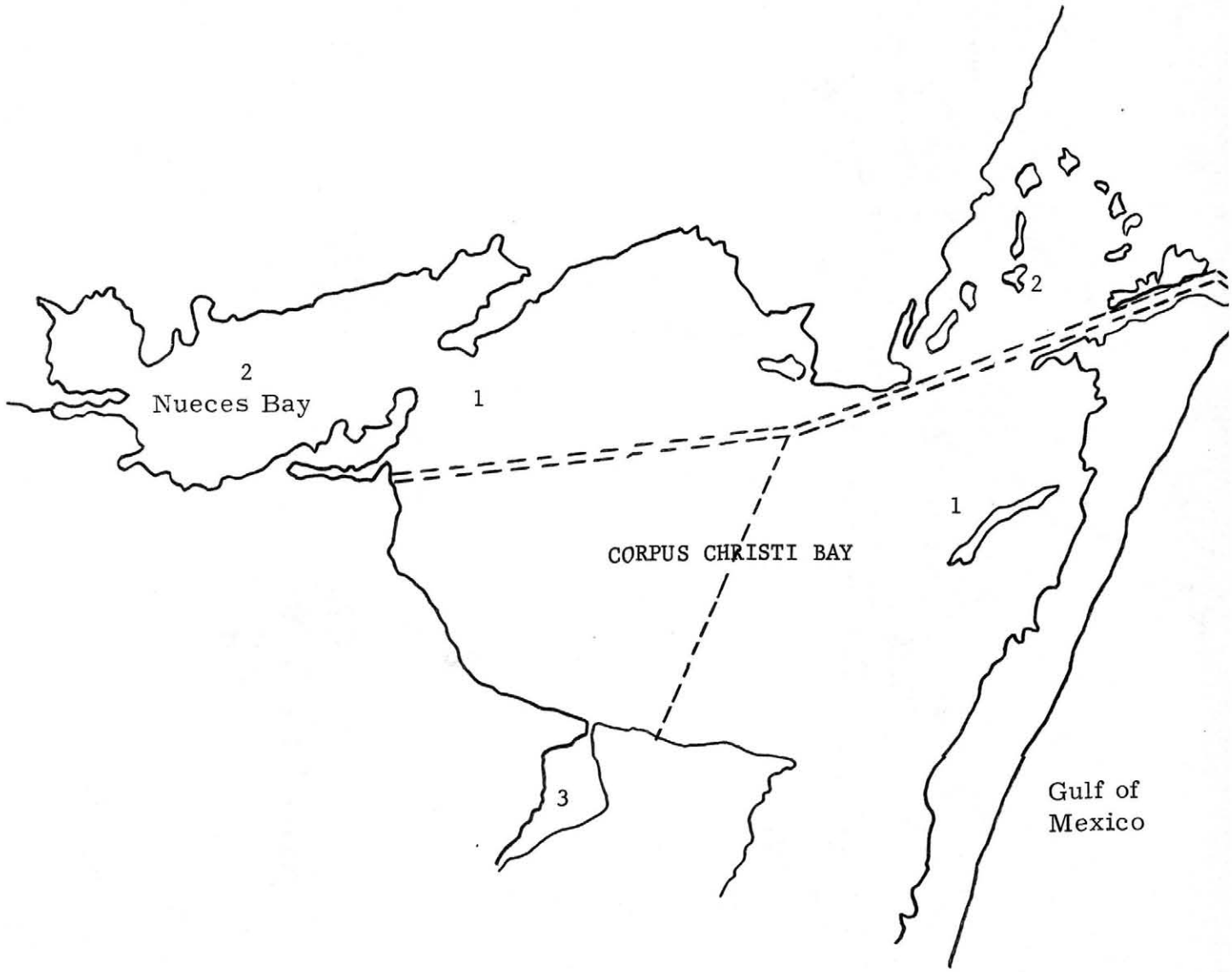


Figure 8. Map of Laguna Madre

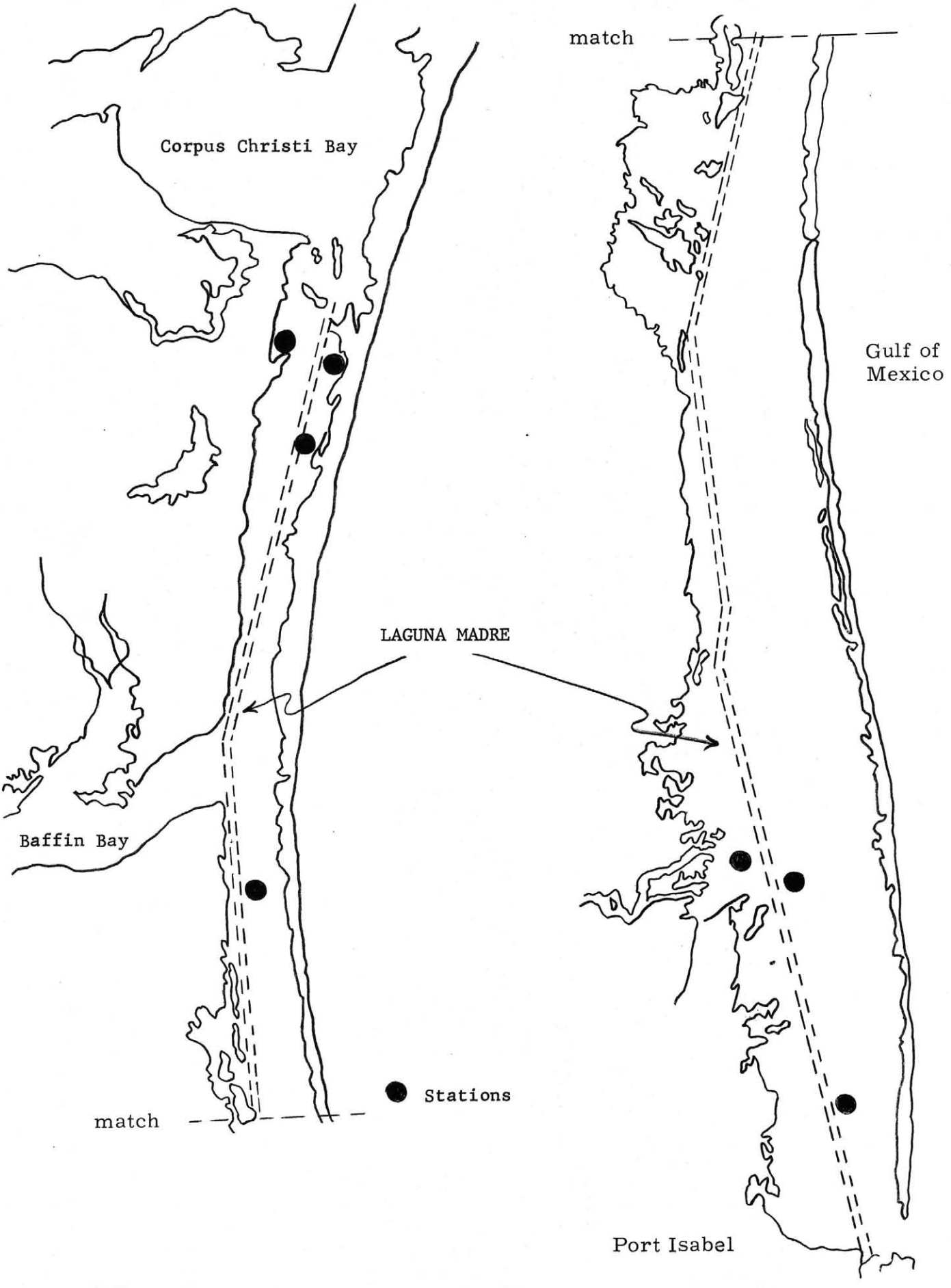


Figure 9. Map of inshore Gulf sampling area of Port Aransas

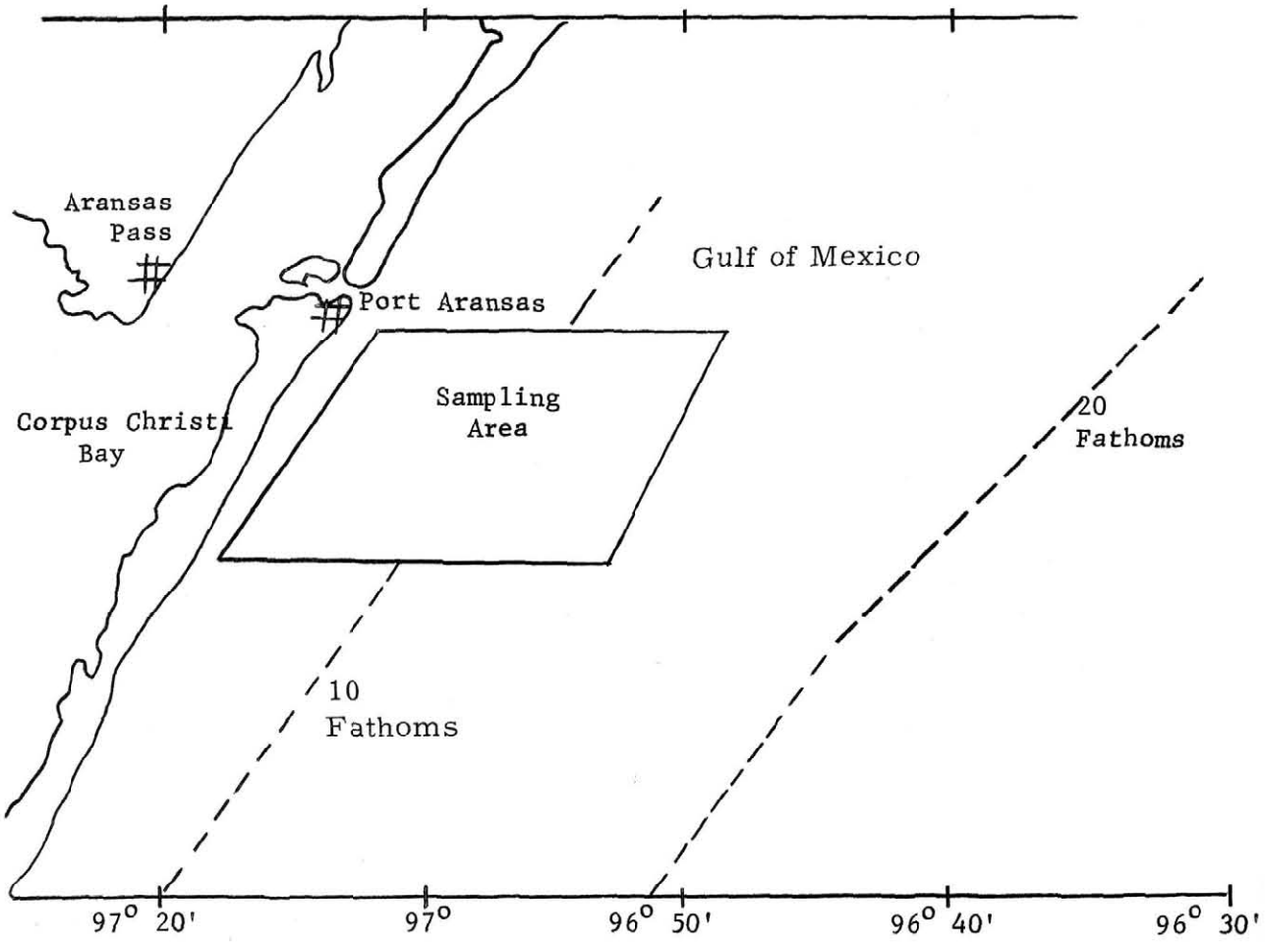


Figure 10. Average number of brown shrimp per sample (top) Bottom: Progression of modes from brown shrimp size distribution.

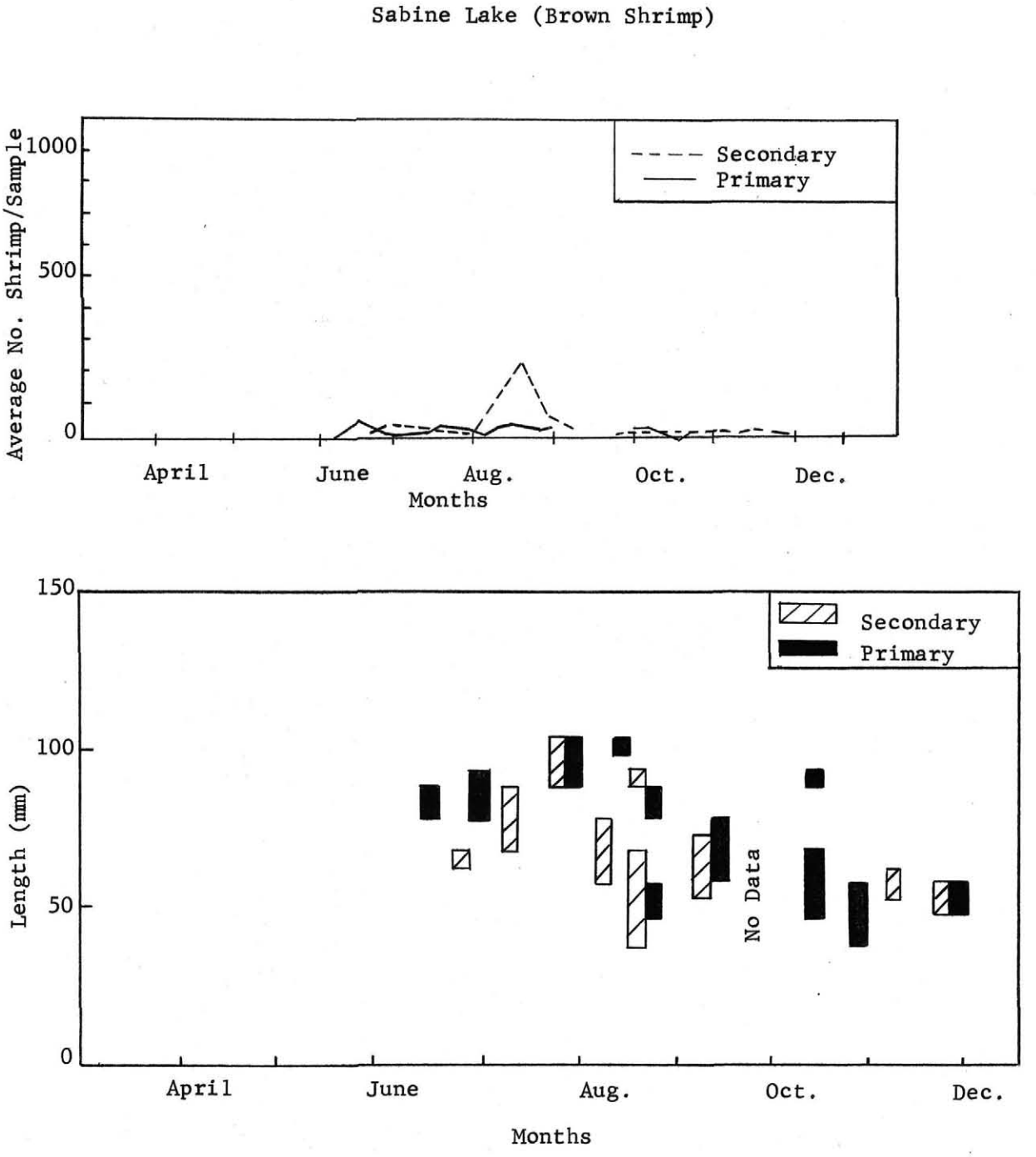


Figure 11. Average number of brown shrimp per sample (top). Progression of modes from brown shrimp size distributions (bottom).

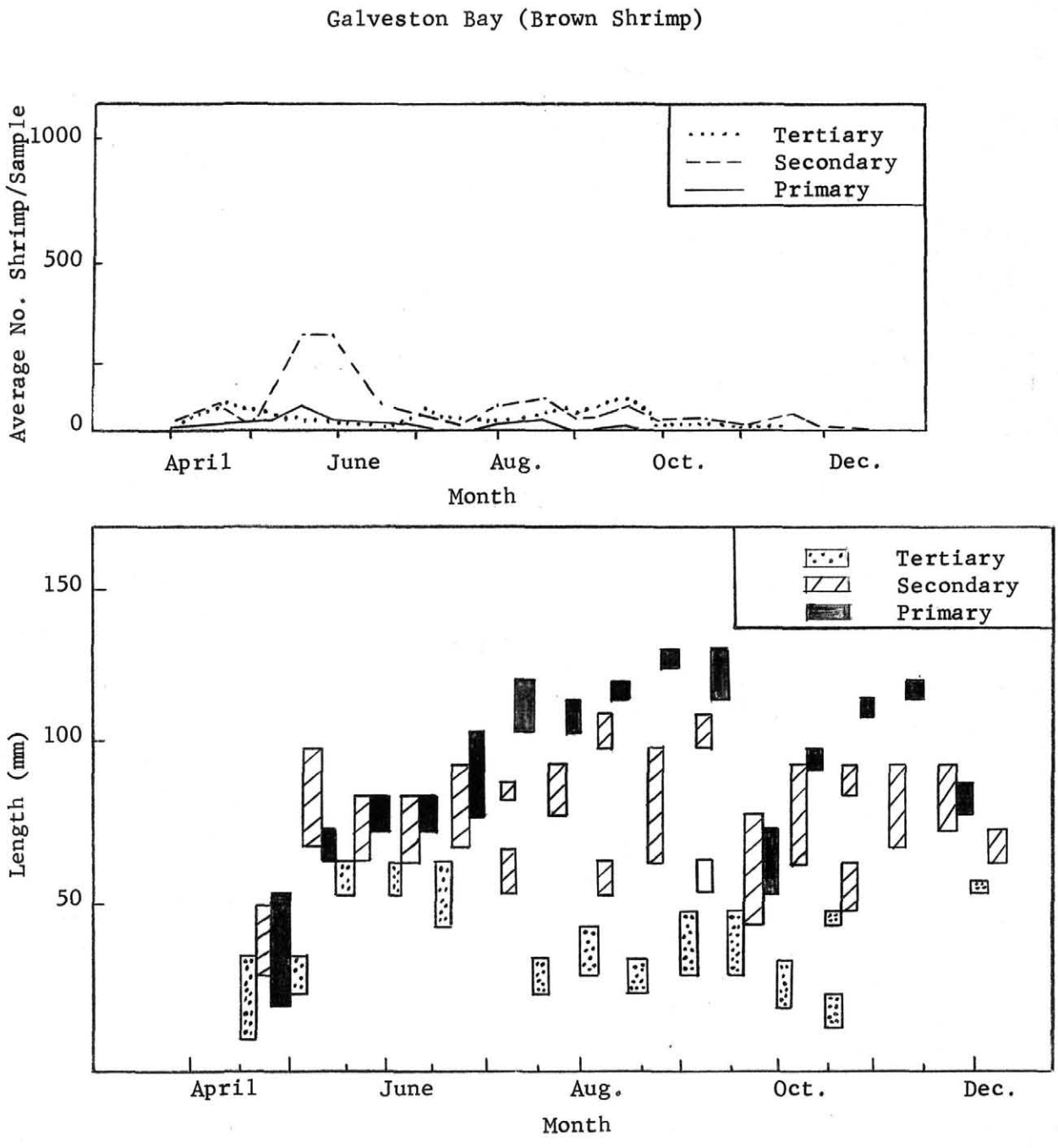


Figure 12. Average number of brown shrimp per sample (top). Progression of mades from brown shrimp size distributions (bottom).

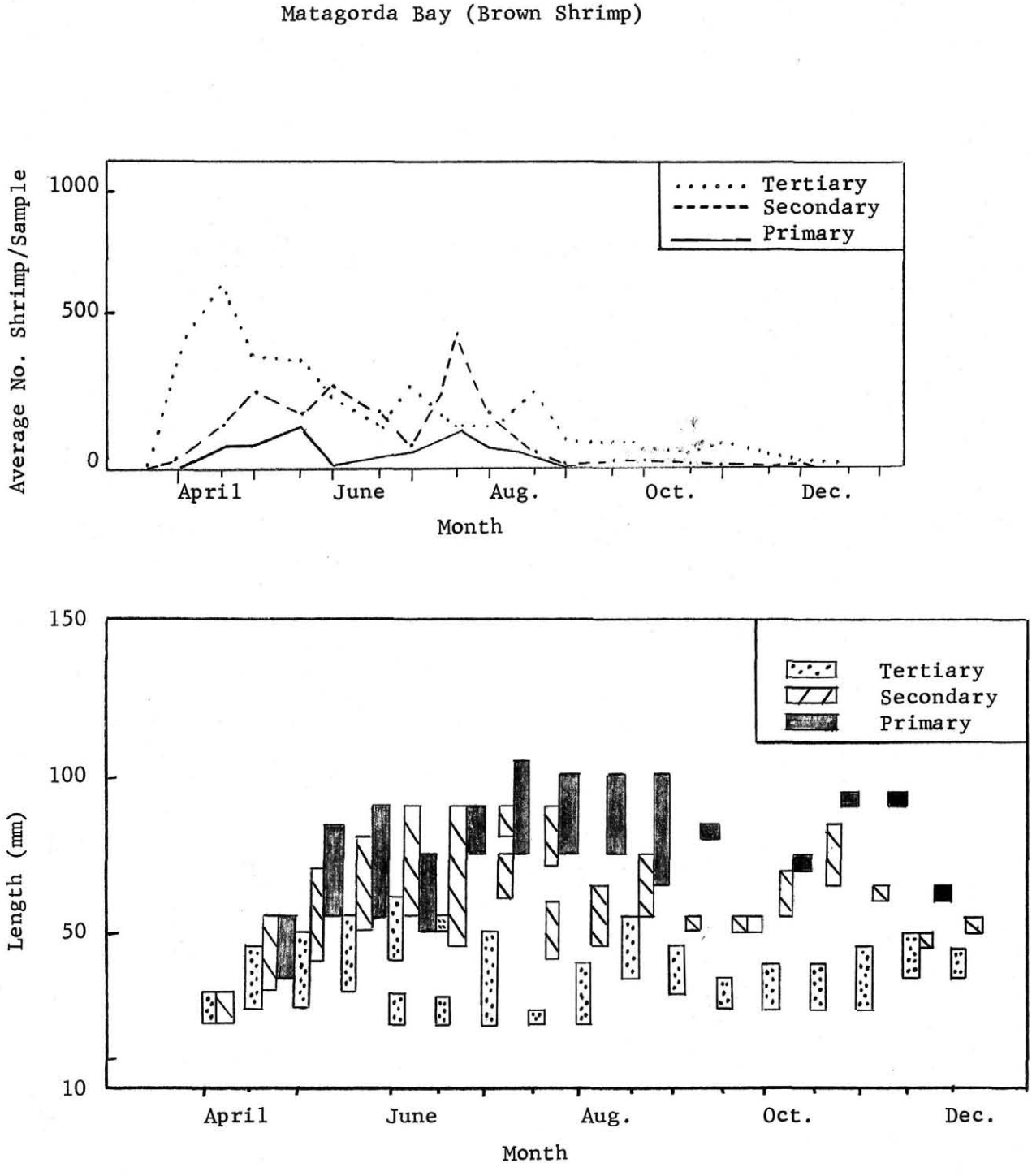


Figure 13. Average no. brown shrimp per sample (top). Progression of modes from brown shrimp size distribution (bottom).

San Antonio Bay (Brown Shrimp)

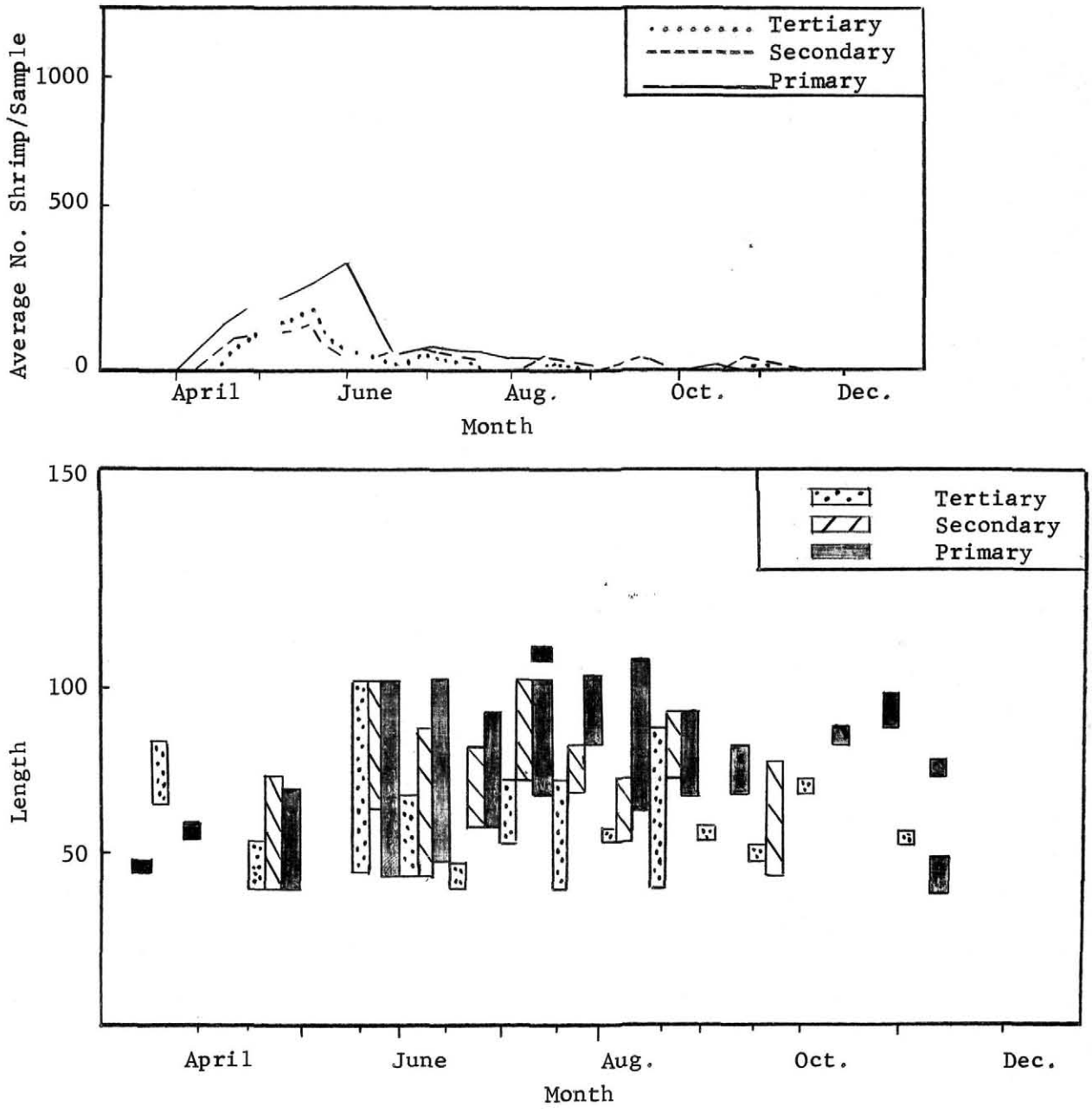
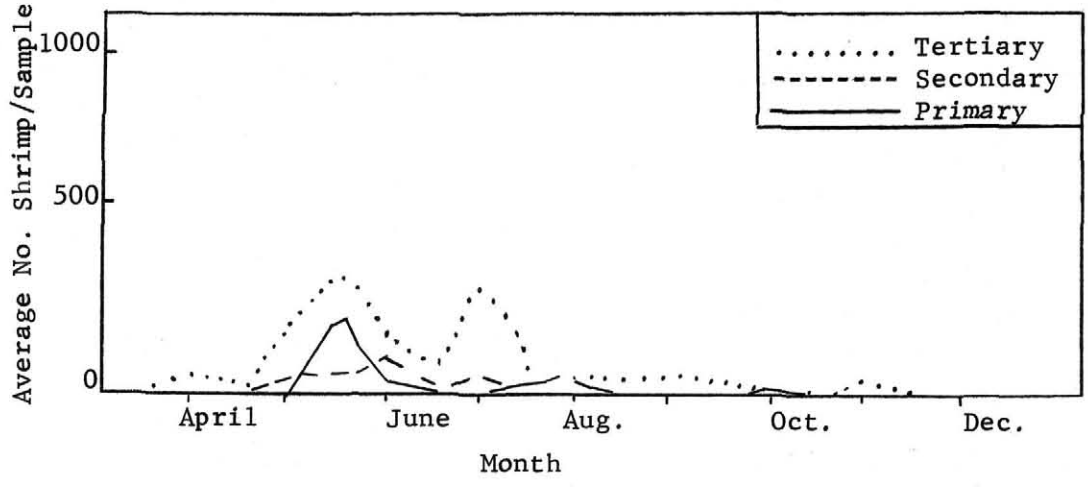


Figure 14. Average number of brown shrimp per sample (top). Progression of modes from brown shrimp size distributions (bottom).

Aransas Bay (Brown Shrimp)



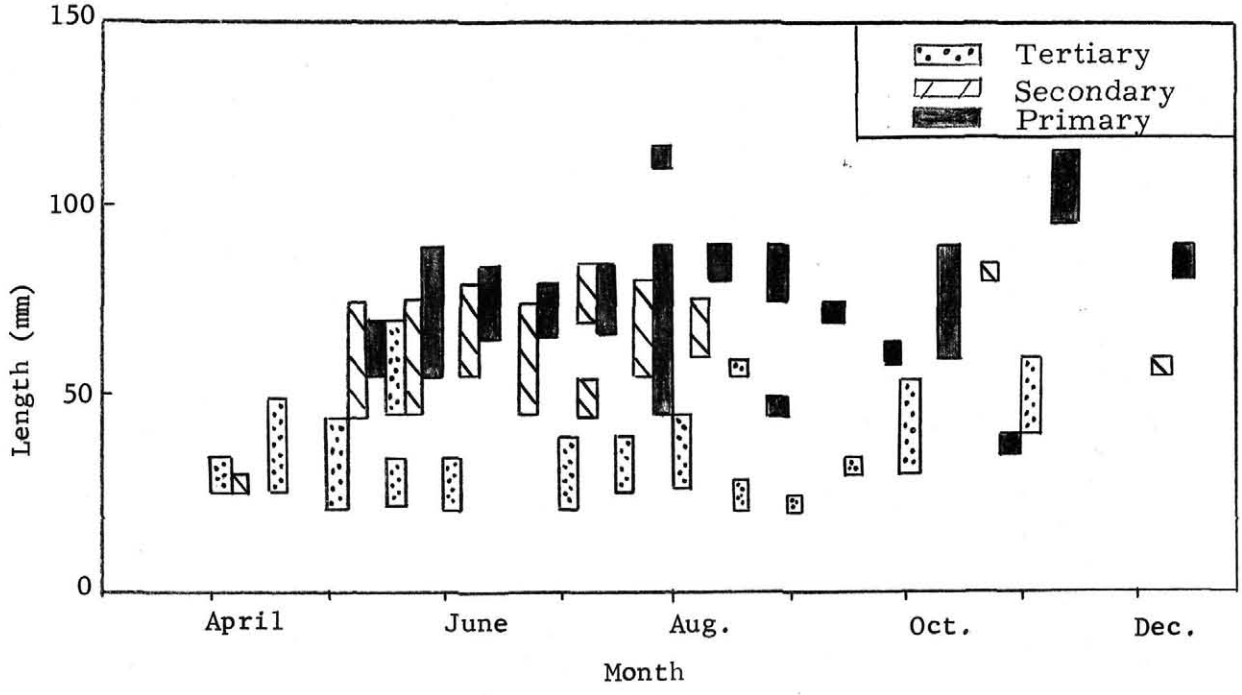
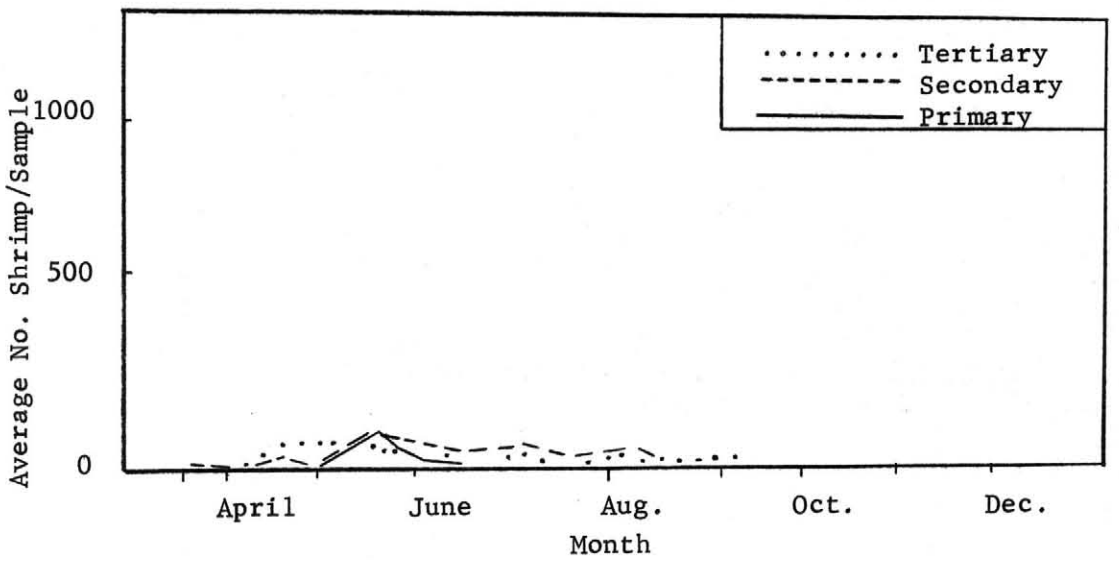


Figure 15: Average number of shrimp per sample (top). Progression of modes from shrimp size distributions (bottom).

Corpus Christi (Brown Shrimp)



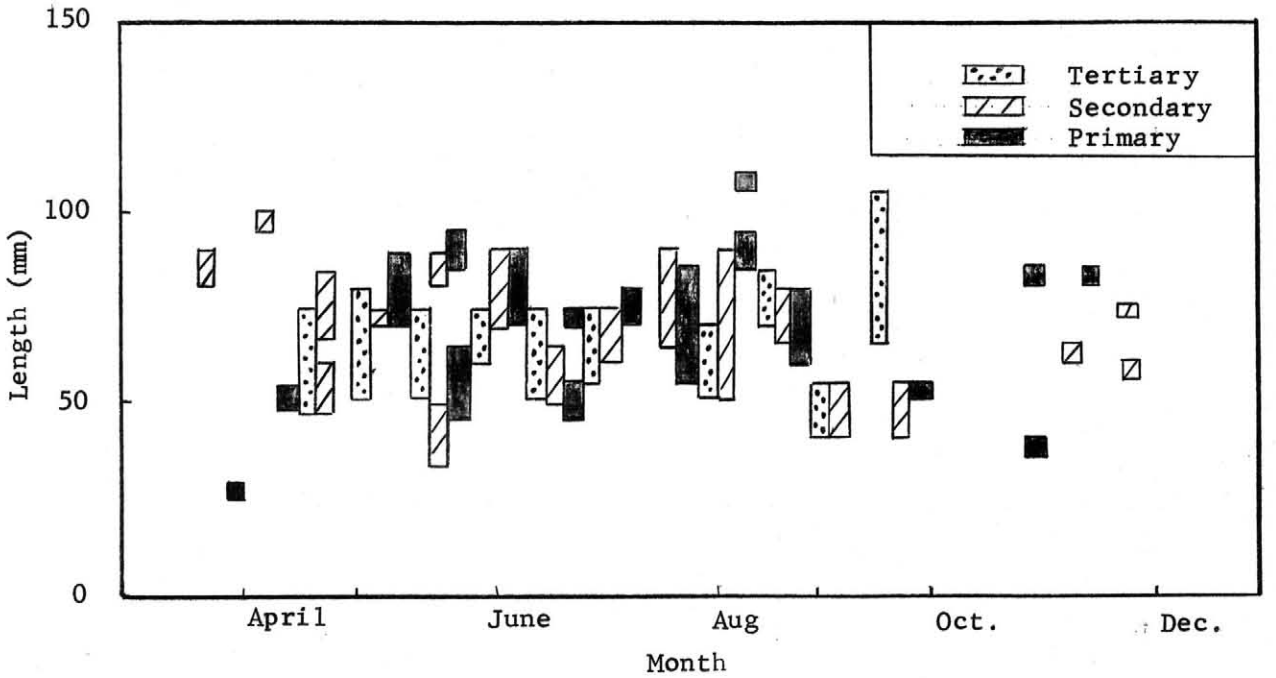
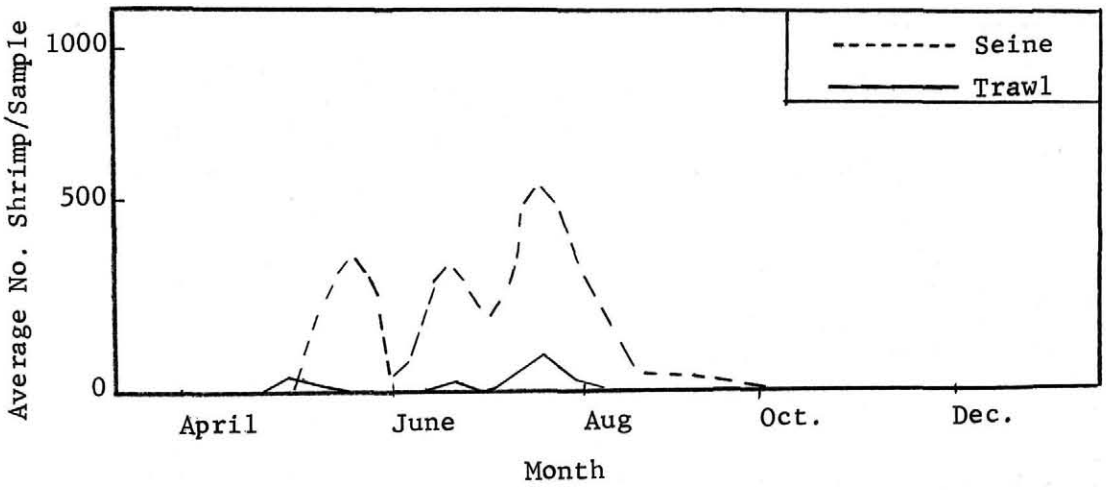


Figure 16. Average number of shrimp per sample (top). Progression of modes from shrimp size distributions (bottom).

Upper Laguna Madre (Brown Shrimp)



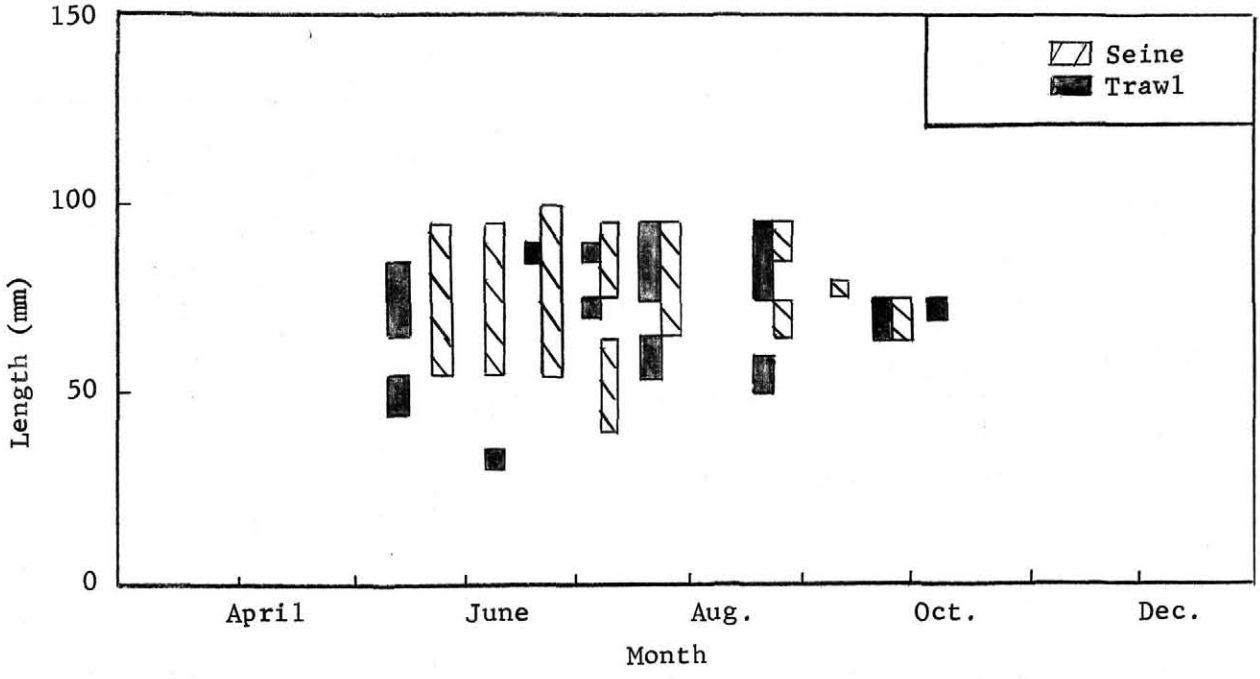
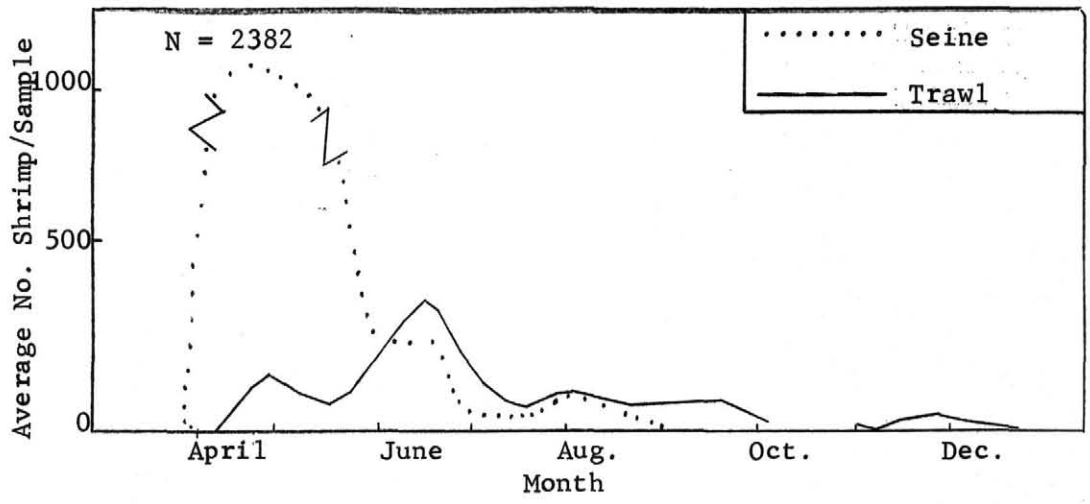


Figure 17. Average number of shrimp per sample (top). Progression of modes from shrimp size distributions (bottom).

Lower Laguna Madre (Brown Shrimp)



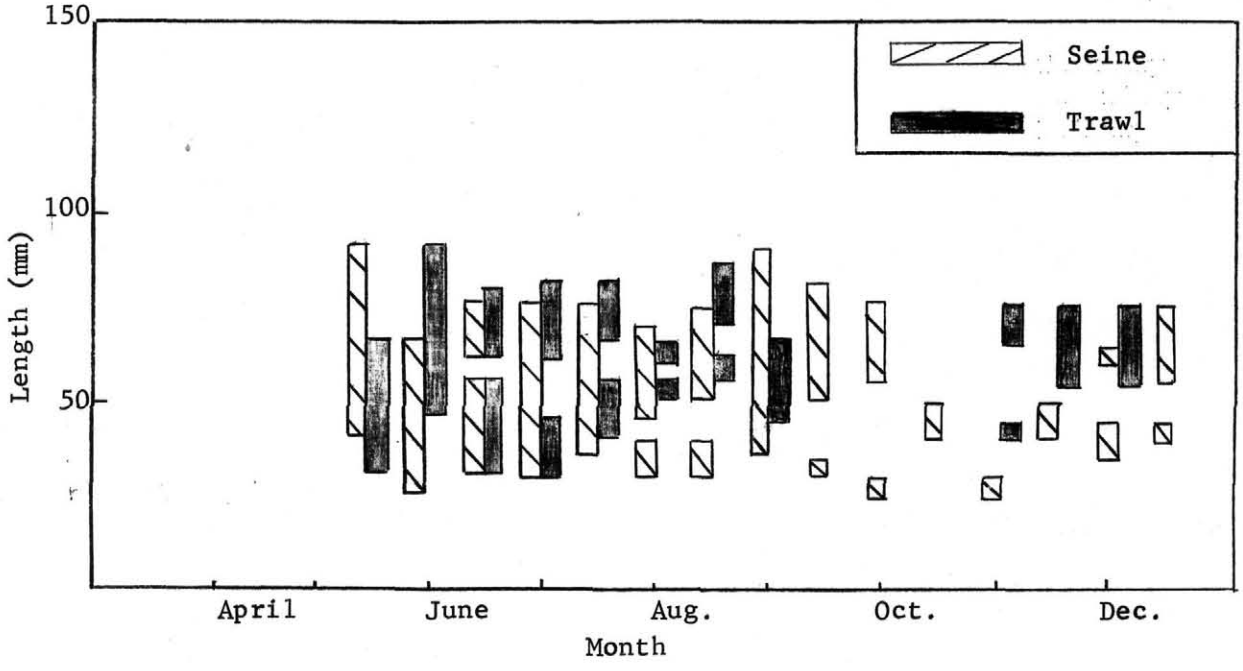


Figure 18. Average number of white shrimp per sample (top). Progression of modes from shrimp size distributions (bottom).

Sabine Lake (White Shrimp)

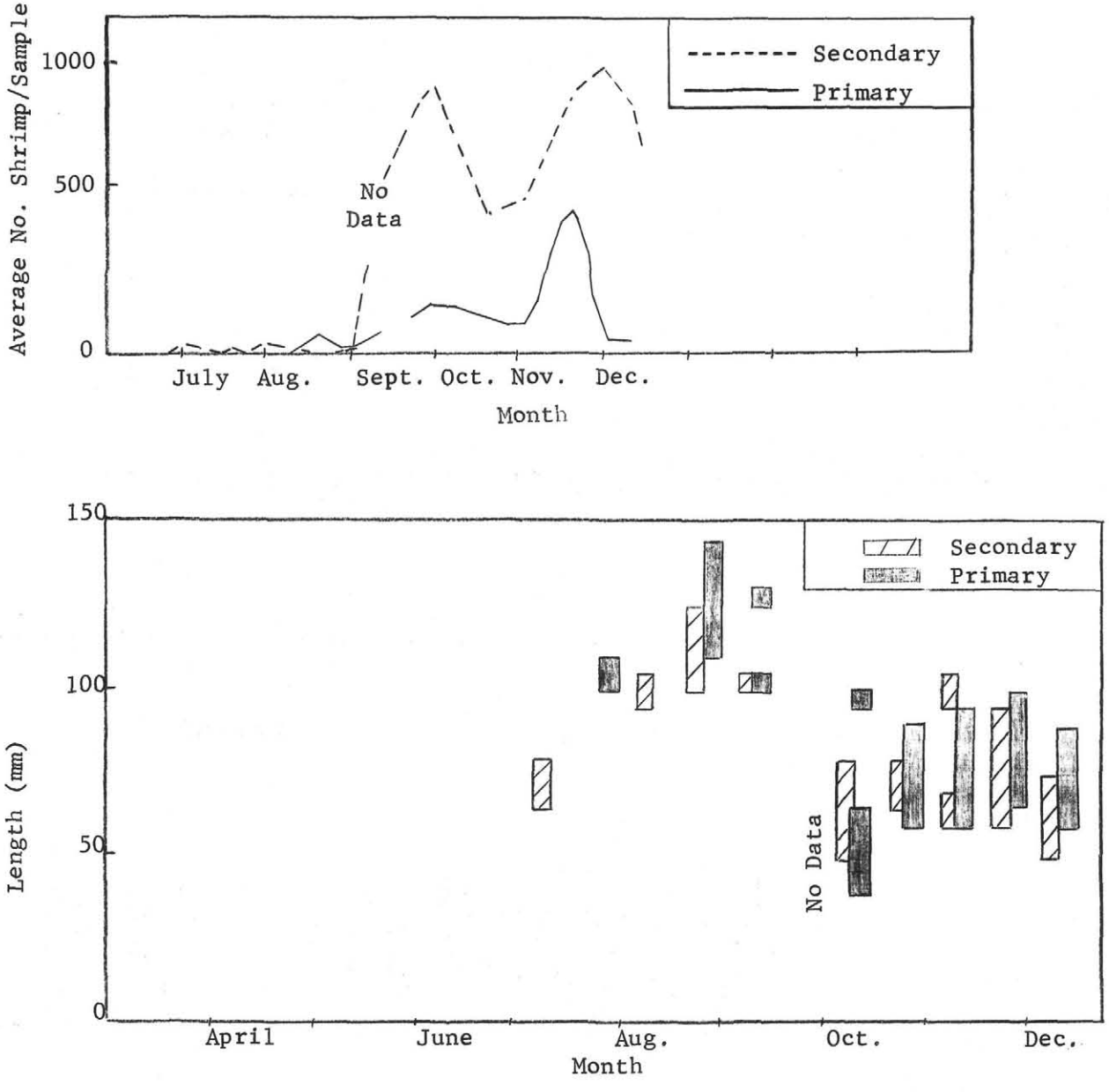


Figure 19. Average number of shrimp per sample (top). Progression of modes from shrimp size distributions (bottom).

Galveston Bay (White Shrimp)

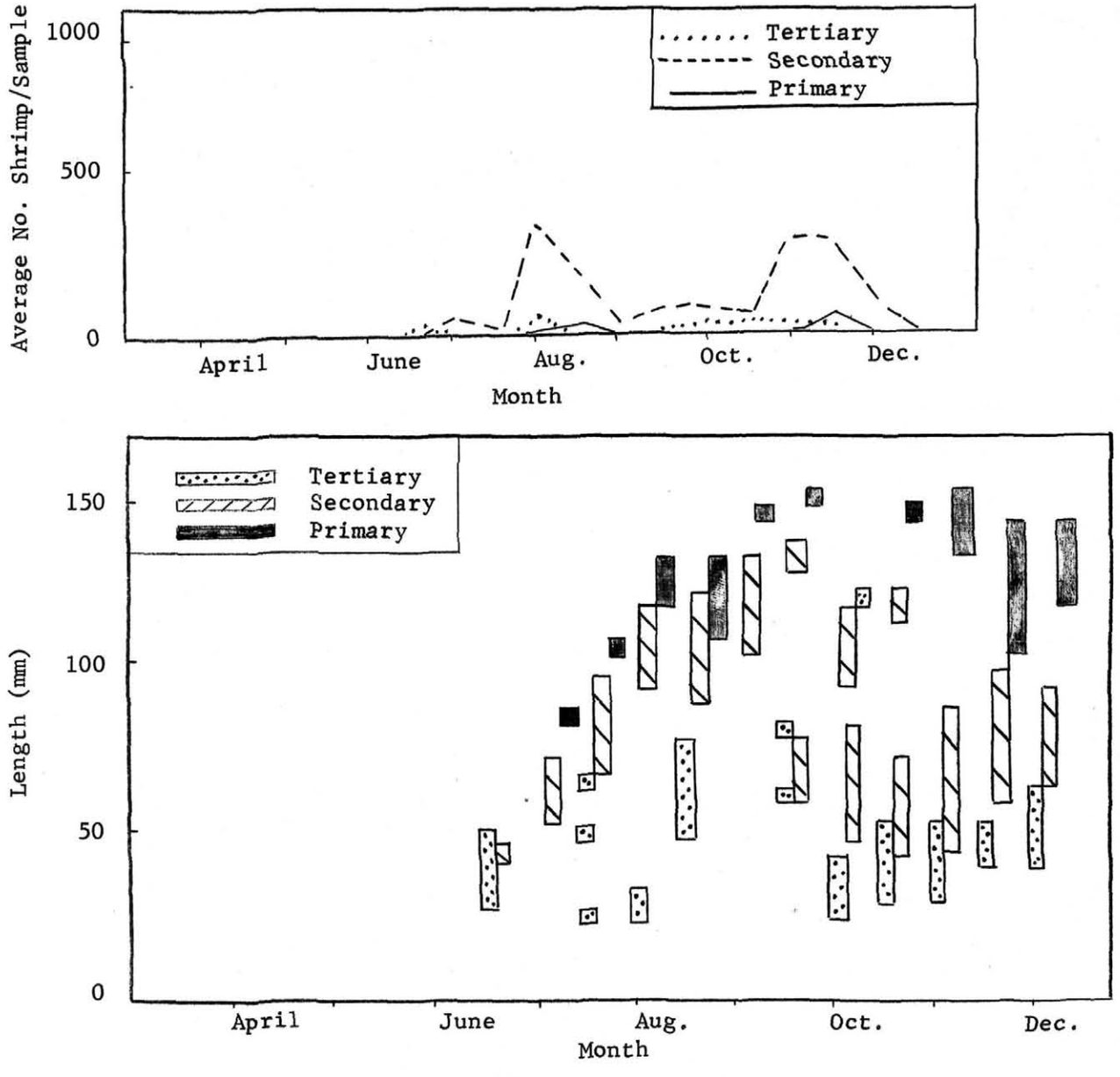


Figure 20. Average number of shrimp per sample (top). Progression of modes from shrimp size distributions (bottom).

Matagorda Bay (White Shrimp)

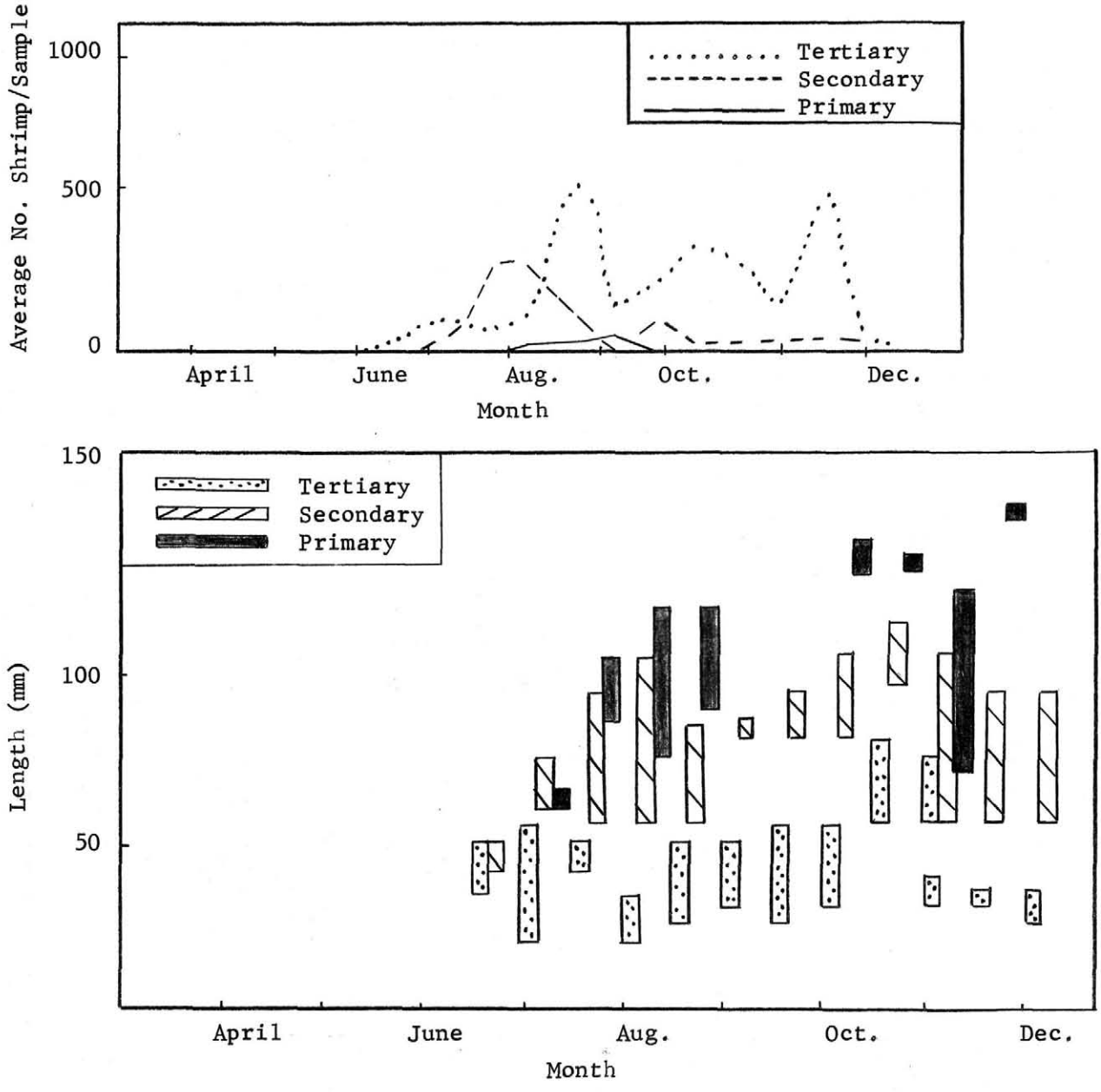


Figure 21. Average number of shrimp per sample (top) Progression of modes from shrimp size distribution (bottom).

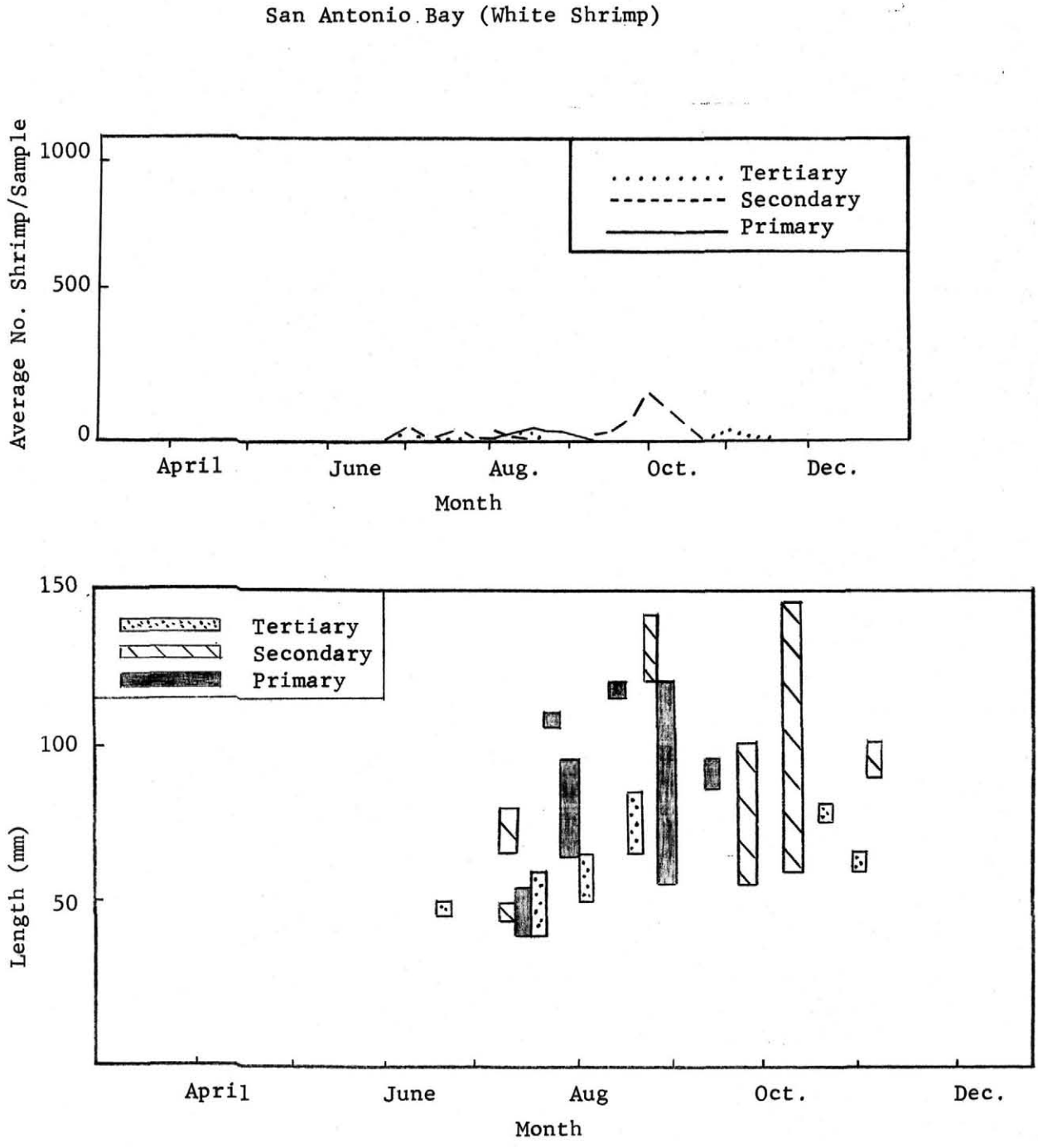


Figure 22. Average number of shrimp per sample (top) Progression of modes from shrimp size distribution (bottom).

Aransas Bay (White Shrimp)

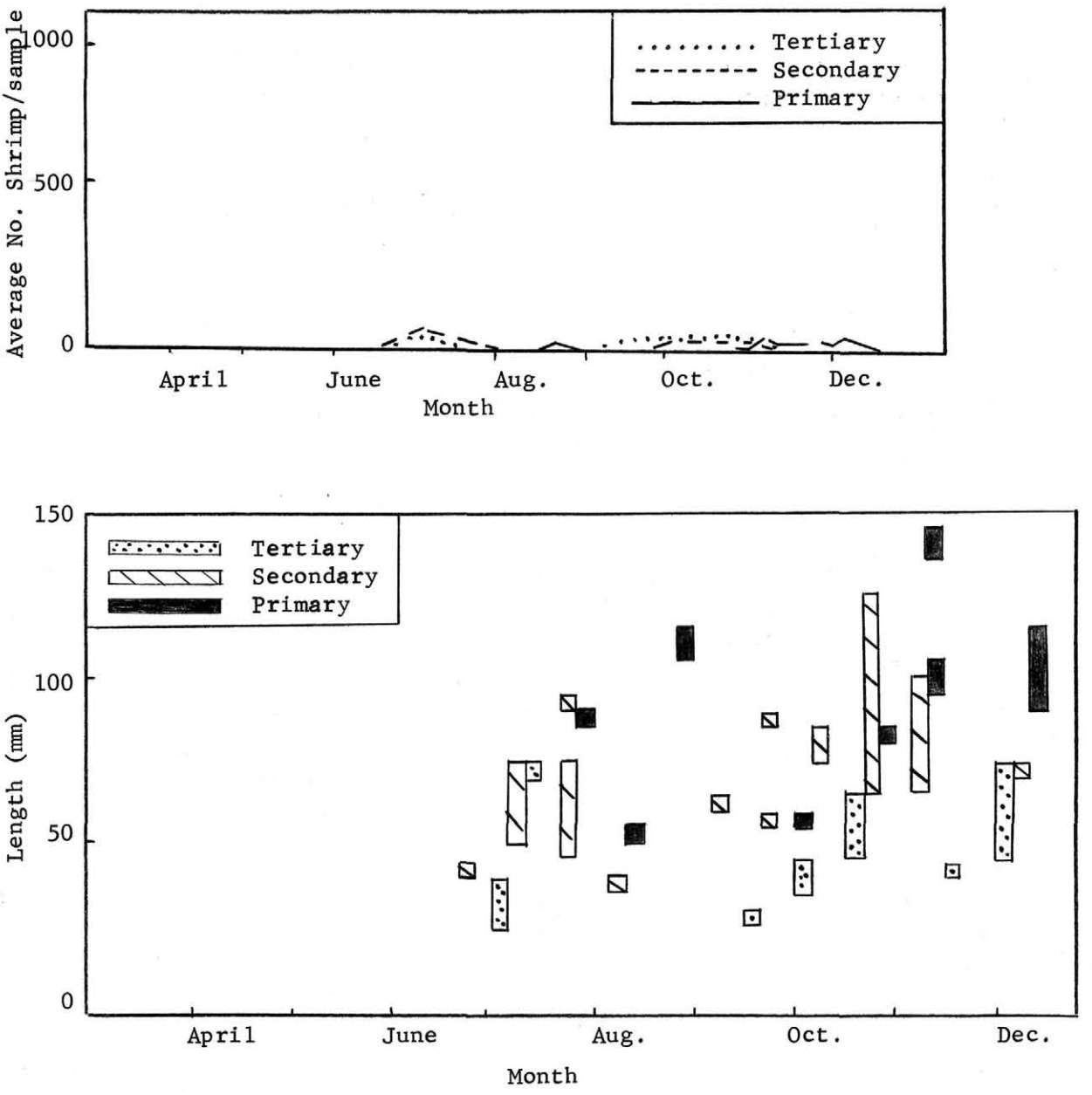


Figure 23. Average number of shrimp per sample (top)
Progression of modes from shrimp size
distribution (bottom)

Corpus Christi Bay (White Shrimp)

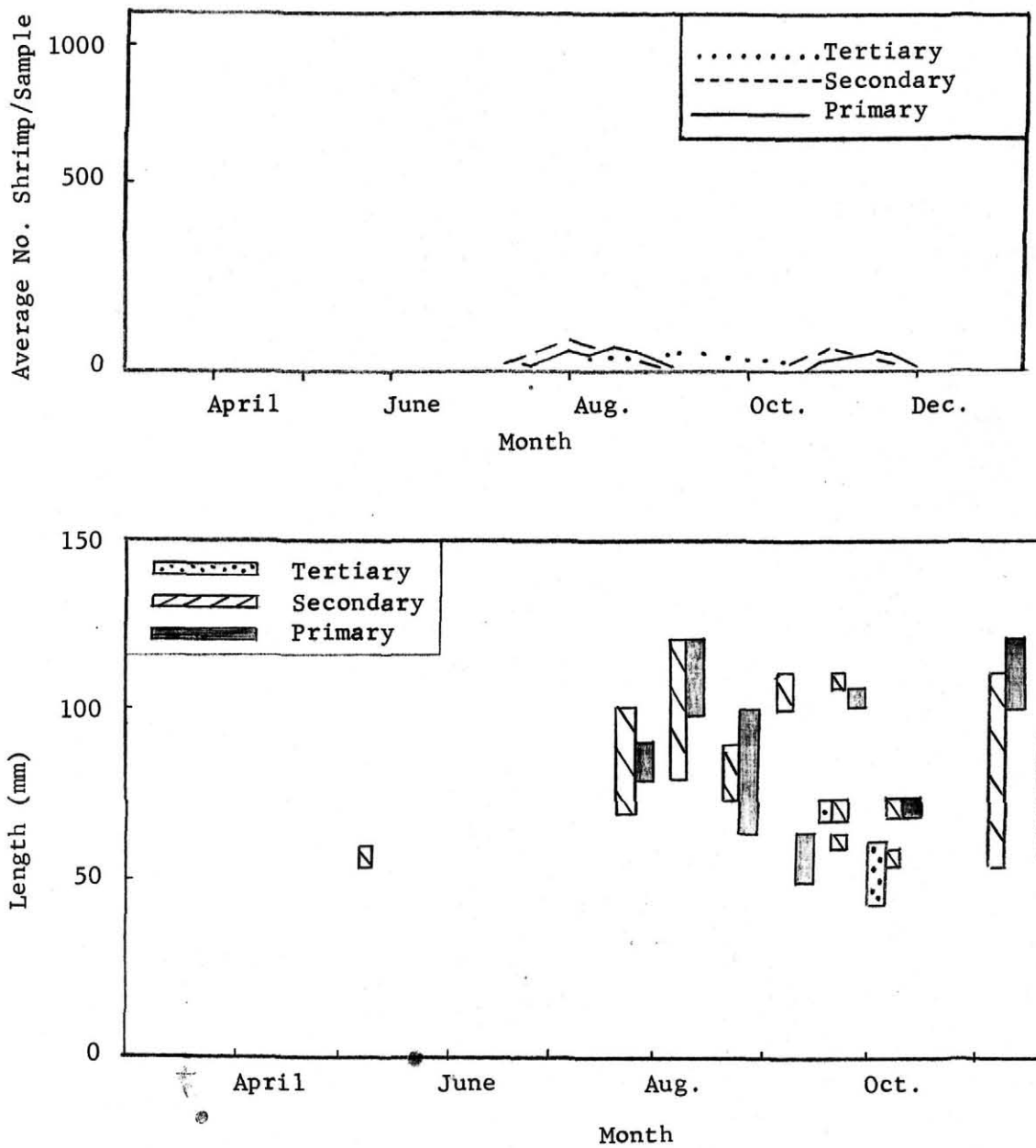
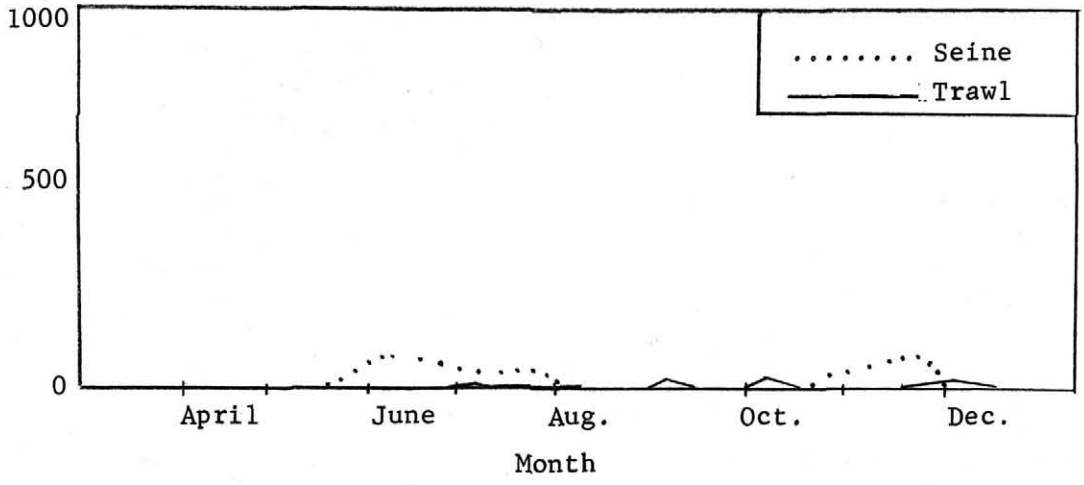


Figure 24. Monthly average number of shrimp per sample (top) Progression of modes from shrimp size distribution (bottom).

Lower Laguna Madre (White Shrimp)



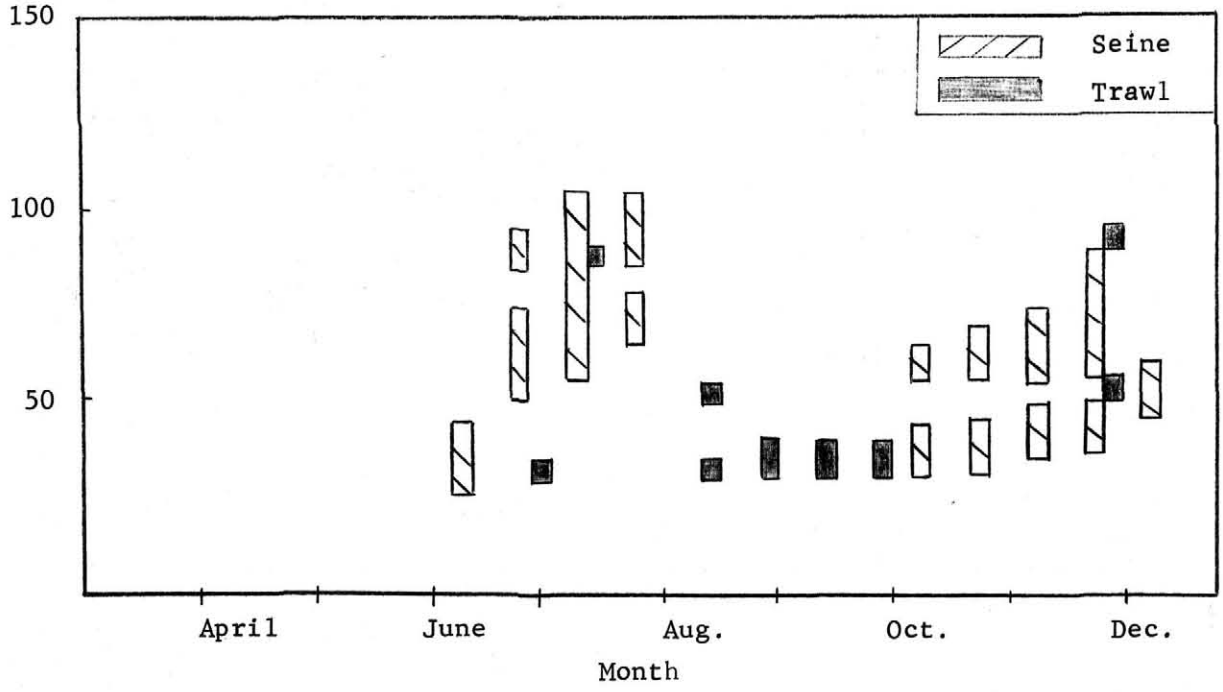


Figure 25. Monthly average number of shrimp per sample based on 42-foot trawl data collected in the inshore gulf (1960-1963).

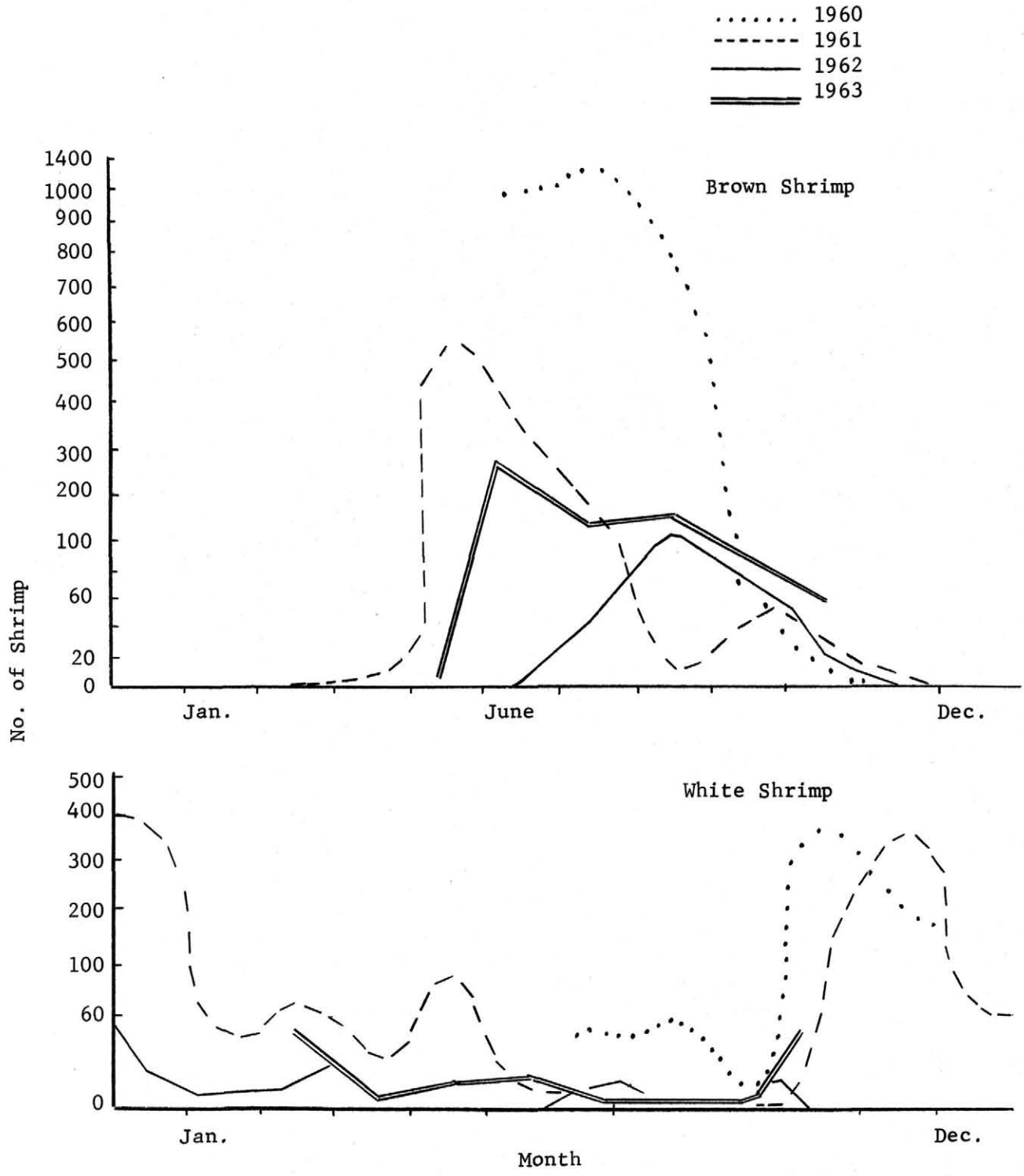


Figure 26. Monthly pregression of modes based on shrimp samples from the inshore Gulf. White blocks represent white shrimp. Shaded areas represent brown shrimp.

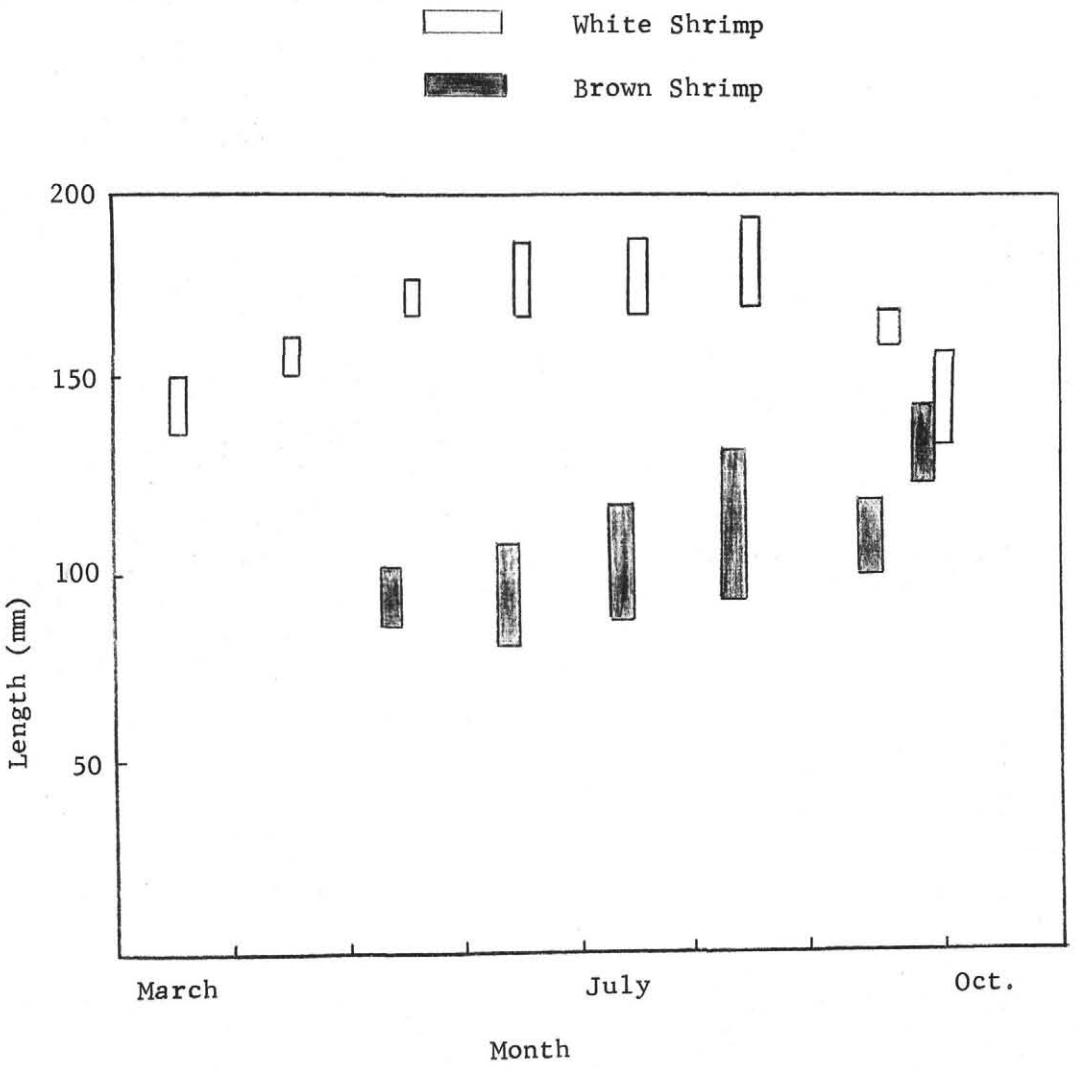


Figure 27. Length frequency distributions based on 20-foot trawl and commercial white shrimp sample (Galveston Bay 1963).

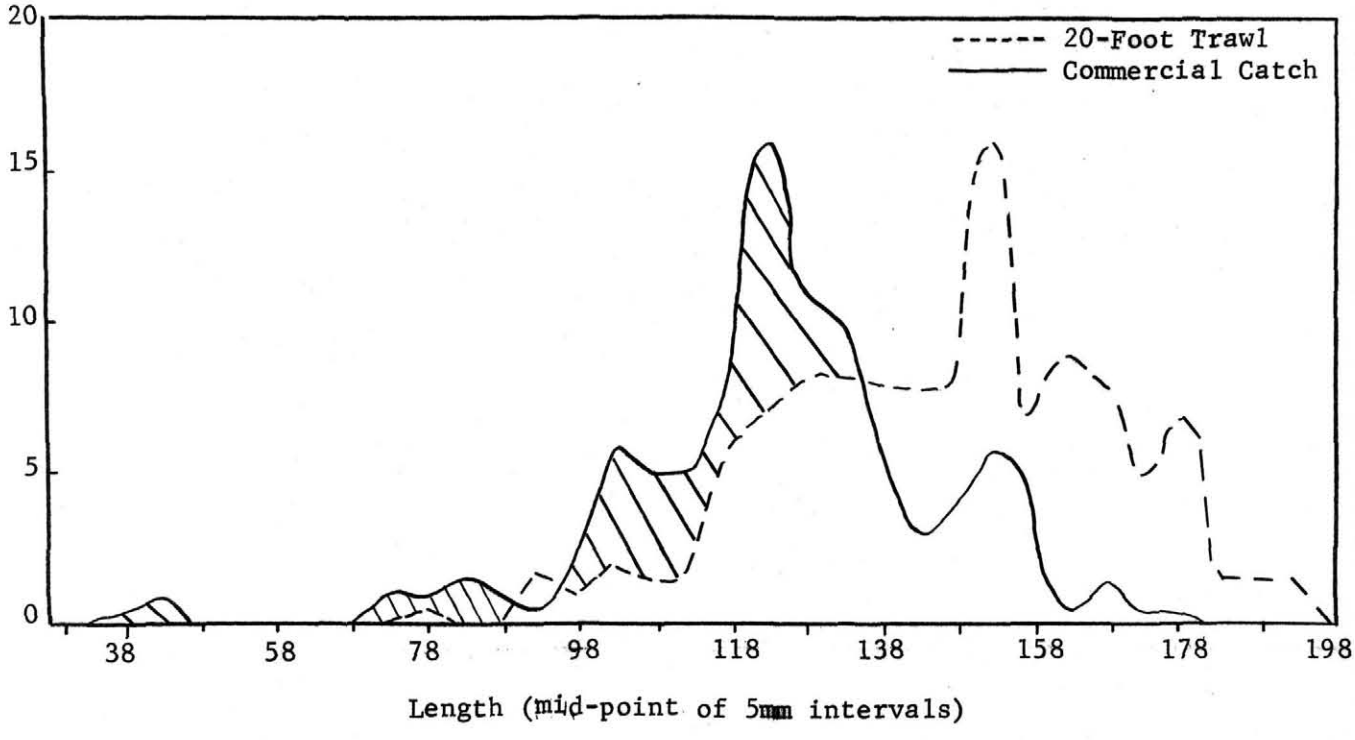


Figure 28. Cumulative - distribution of white shrimp measurements from unsorted commercial trawl samples (1963).

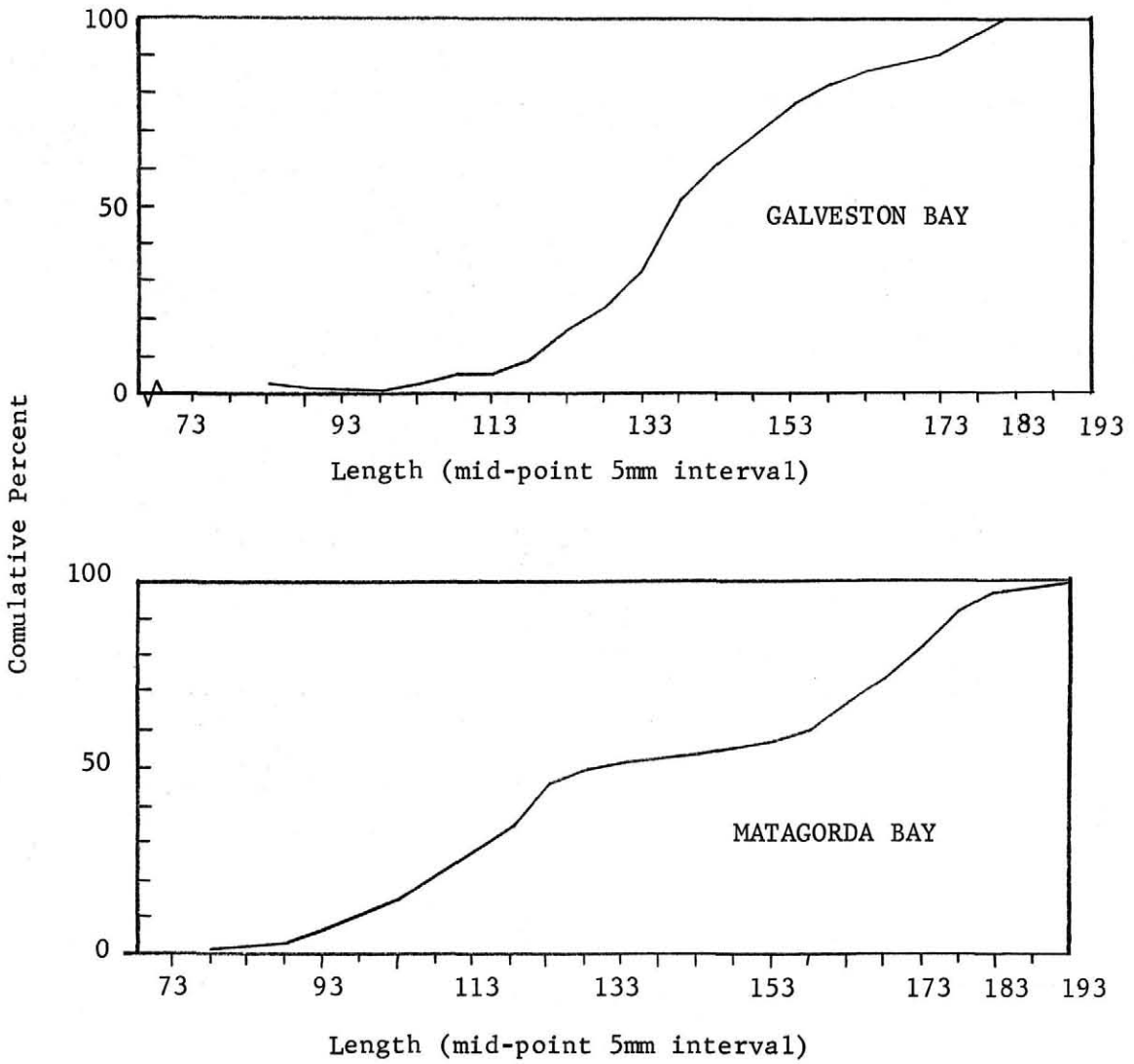


Figure 29. Monthly brown shrimp landings (1960-63).

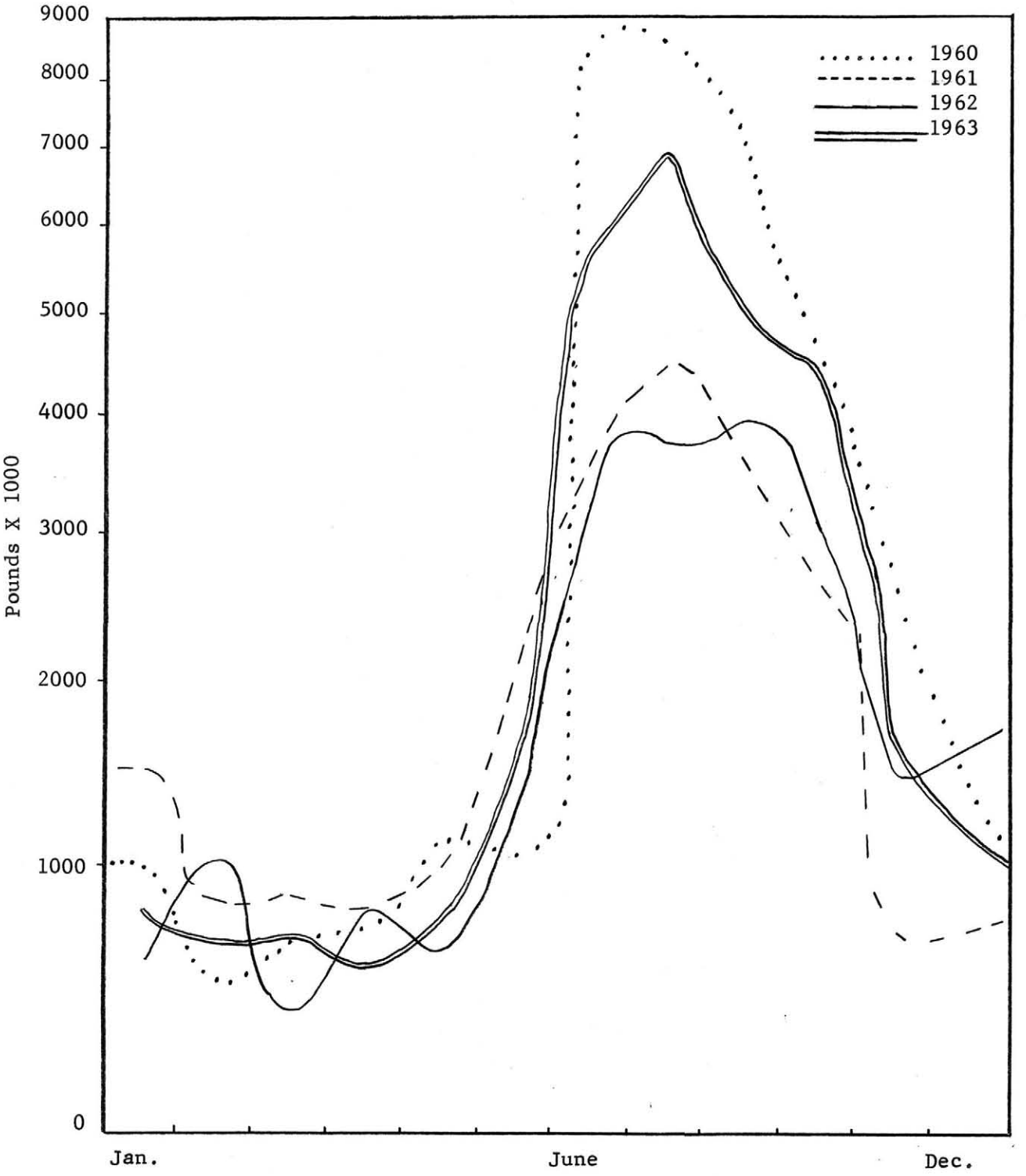
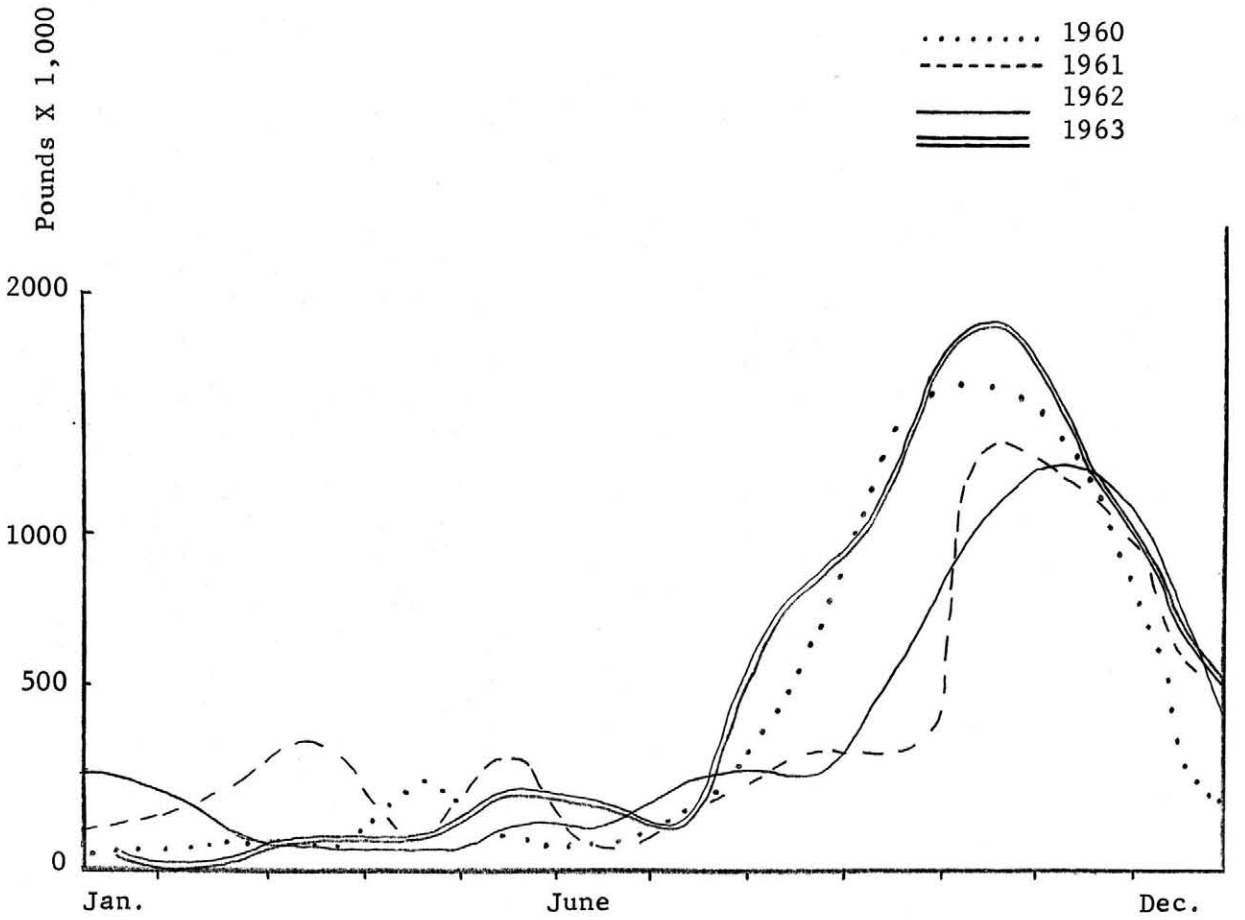


Figure 30. Monthly white shrimp landings (1960-63).



Number 31. Monthly average number of brown shrimp per sample (1960-1963). Average sample sizes were determined for 1st of the month samples then added to the same value for mid-month samples. The resulting totals were plotted (Pullen 1961-62).

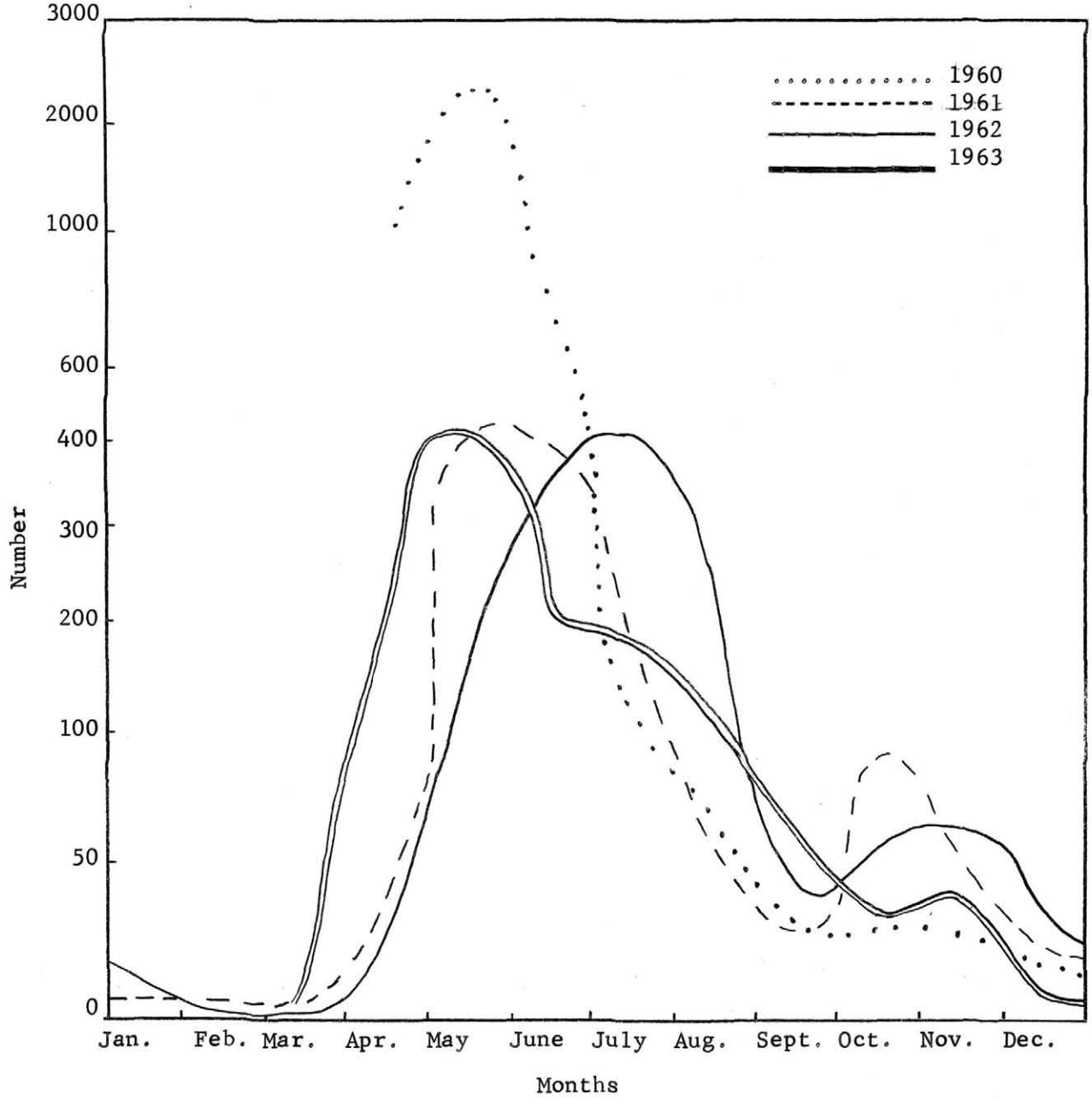
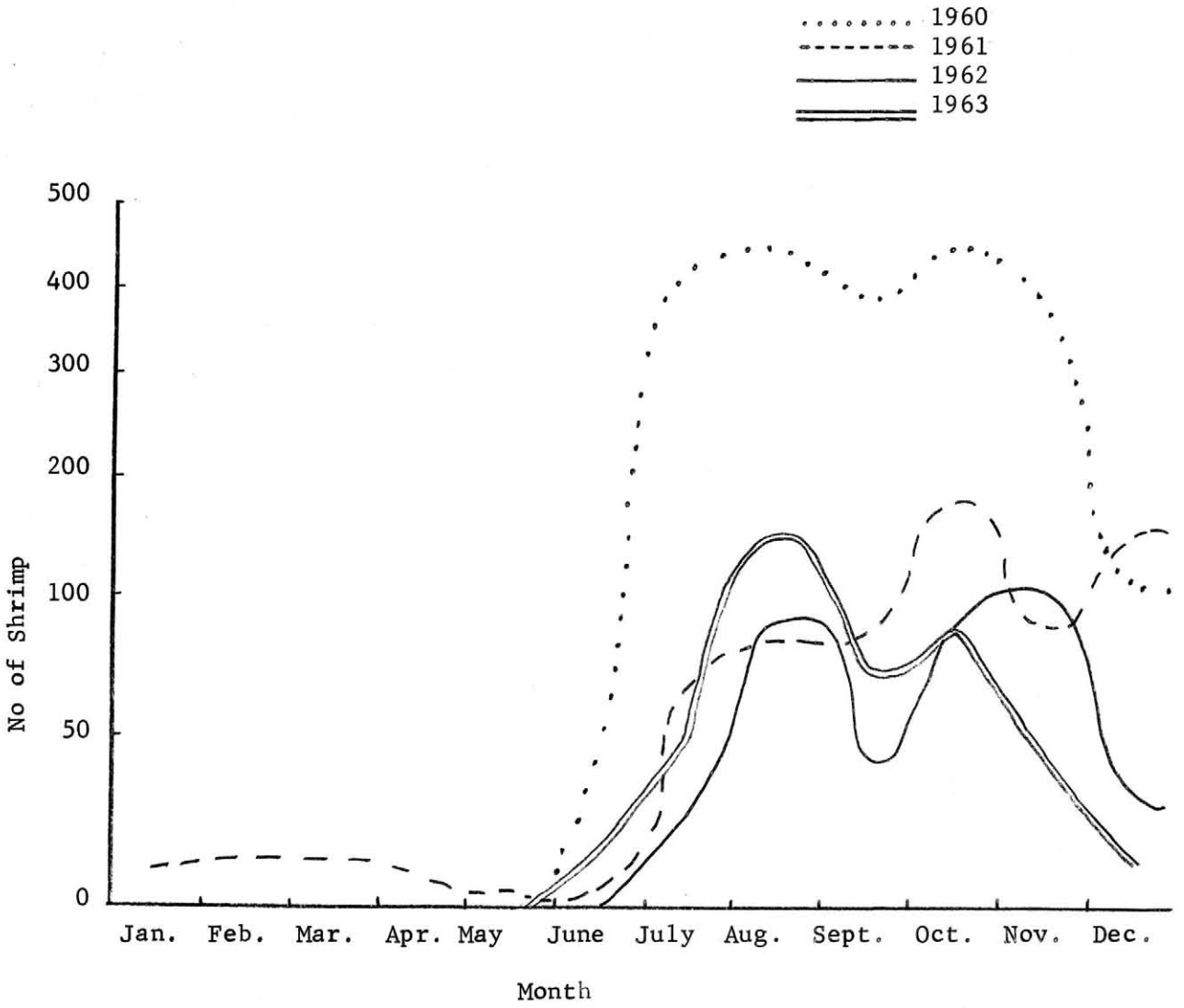


Figure 32. Monthly average number of white shrimp per sample (1960-1963). For explanation see title of Figure 31.



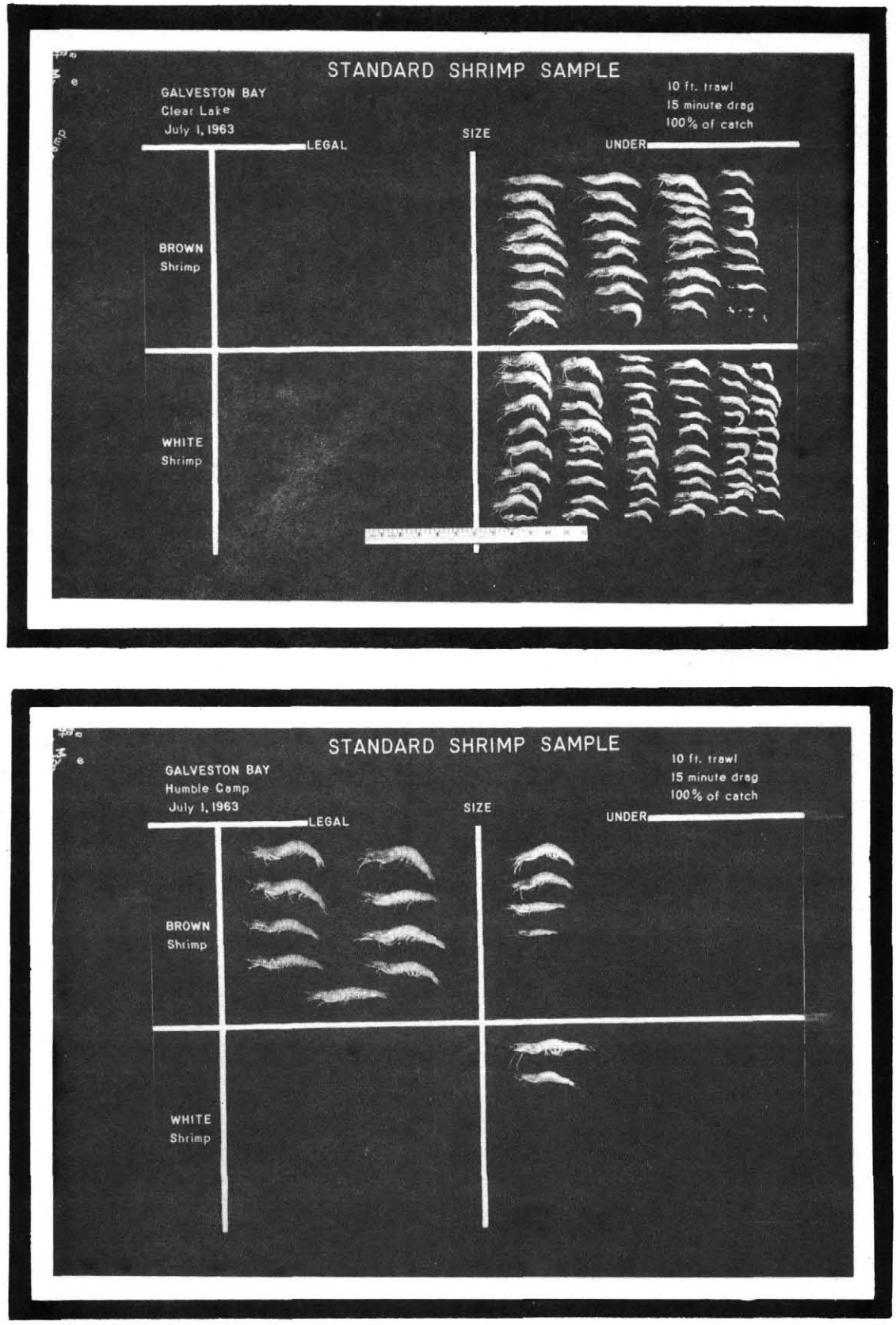


Figure 33. Sizes of shrimp caught in samples from a minor bay (top) and a major bay (bottom) on July 1, 1963.

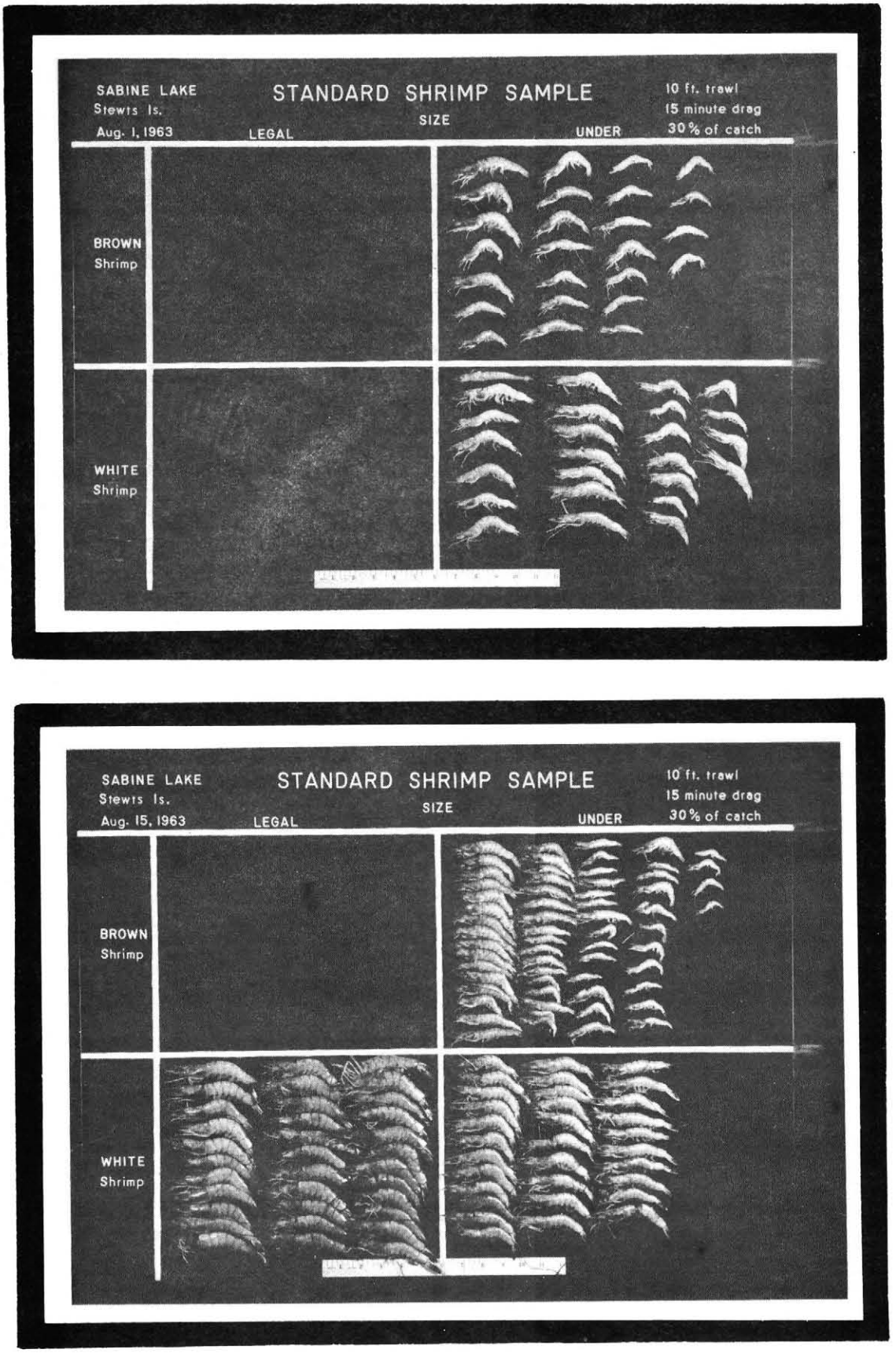


Figure 34. Sizes of shrimp caught in samples from Sabine Lake on August 1, 1963 and on August 15, 1963.

Table I. Summary of postlarval samples (Aransas Bay 1962-63)

Month	Type of Net	No. Samples 1962	No. Samples 1963	No. Postlarvae 1962	No. Postlarvae 1963
Jan.	Plankton net	0	1	-	0
Feb.	Plankton net	0	1	-	0
	Beam trawl	1	2	72	6
	Bar seine	0	3	-	0
Mar.	Plankton net	0	0	-	9
	Beam trawl	1	2	140	28
	Bar seine	2	4	165	22
Apr.	Plankton net	0	3	-	414
	Beam trawl	2	3	9	23
	Bar seine	1	4	0	11
May	Plankton net	0	2	-	11
	Beam trawl	3	2	30	30
	Bar seine	2	4	3	0
June	Plankton net	0	3	-	90
	Beam trawl	0	3	-	2
	Bar seine	0	3	-	1
July	Plankton net	0	0	-	-
	Beam trawl	0	0	-	-
	Bar seine	2	2	-	-
Aug.	Plankton net	0	0	1	0
	Beam trawl	0	0	-	-
	Bar seine	0	4	-	0
Sept.	Plankton net	2	0	24	-
	Beam trawl	1	0	0	-
	Bar seine	1	2	0	0
Oct.	Plankton net	1	5	3	0
	Beam trawl	2	4	9	0
	Bar seine	1	0	1	-
Nov.	Plankton net	1	3	80	0
	Beam trawl	1	1	5	0
	Bar seine	0	0	-	-
	TOTAL	24	64	542	647

Table 2. Numbers of shrimp caught in 20-foot trawl samples (1963).

Area	Aug. 15 Day	Aug. 15 Night	Sept. 1 Day	Sept. 1 Night	Sept. 15 Day	Sept. 15 Night	Oct. 1 Day	Oct. 1 Night	Oct. 15 Day	Oct. 15 Night	Nov. 1 Day	Nov. 1 Night	Total Day	Total Night
BROWN SHRIMP														
Galveston Bay	109	9	4	26	138	27	10	38	28	12	6	4	295	116
Matagorda Bay	47	10	36	28	* -	-	14	15	1	11	-	-	98	64
Aransas Bay	47	23	19	10	-	-	-	-	6	0	-	-	72	33
Total	203	42	59	64	138	27	24	53	35	23	6	4	465	213
WHITE SHRIMP														
Galveston Bay	130	15	4	26	23	9	25	14	23	1	38	7	243	73
Matagorda Bay	118	90	356	177	-	-	13	24	13	76	-	-	500	376
Aransas Bay	65	16	19	7	-	-	-	-	3	0	-	-	87	23
Total	313	121	379	210	23	9	38	38	39	77	38	7	830	462

* No Data

Table 3. Average catch (pounds) per days fishing effort *(1960-1963).

White Shrimp	Statistical Area: Galveston				Matagorda & San Antonio				Aransas & Corpus Christi				Laguna Madre			
Month	1960	1961	1962	1963	1960	1961	1962	1963	1960	1961	1962	1963	1960	1961	1962	1963
J	0	256	113	0	9	136	154	16	6	85	111	0	0	29	218	0
F	10	4	14	3	1	213	75	3	0	36	63	0	0	130	75	0
M	291	251	154	228	22	248	140	200	4	249	23	7	0	105	33	0
A	365	90	33	168	157	81	22	93	34	51	52	0	0	33	29	0
M	83	69	54	112	46	99	44	48	14	166	83	84	1	78	46	6
J	51	23	30	7	21	19	8	4	2	8	4	31	1	3	0	0
J	34	35	61	29	35	31	56	15	3	16	6	0	1	8	1	0
A	57	10	13	10	28	25	59	8	3	2	0	0	1	5	0	1
S	263	256	118		134	71	63		24	3	0	-	1	2	0	-
O	398	465	455		171	355	38		35	274	3	-	0	28	0	-
N	549	388	476		301	397	236		150	526	68	-	22	71	1	-
D	267	226	19		291	315	27		72	333	0	-	43	153	0	-
Brown Shrimp																
Month																
J	602	205	383	413	508	290	366	365	364	380	374	404	390	450	229	430
F	578	279	480	343	445	247	345	323	298	326	330	297	276	337	242	294
M	112	136	181	233	515	196	115	119	361	180	301	174	275	321	285	165
A	23	256	279	46	246	282	212	183	244	323	51	261	320	292	276	225
M	276	247	178	138	295	287	184	237	333	250	138	205	364	357	215	343
J	237	291	415	838	254	407	327	554	307	797	509	520	278	732	372	250
J	1,520	460	355	829	1,460	516	371	828	1,358	662	597	979	1,145	599	605	967
A	1,019	550	448	786	1,060	524	411	763	1,064	571	578	775	970	535	516	698
S	643	217	556	-	753	483	583	-	870	484	657	-	818	711	643	-
O	414	55	203	-	659	207	516	-	749	235	479	-	782	667	590	-
N	195	138	120	-	399	138	357	-	519	9	405	-	700	362	559	-
D	209	261	495	-	244	156	521	-	450	158	546	-	556	283	591	-

* Source: Gulf coast shrimp data. United States Department of the Interia, Bureau of Comm. Fish., Washington 25, D. C. (1960-1963).