THE ABUNDANCE AND DISTRIBUTION OF MYSIDACEA IN THE SHALLOW WATERS OF GALVESTON ISLAND, TEXAS

A Dissertation

by

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ABSTRACT

The Abundance and Distribution of Mysidacea
in the Shallow Waters of Galveston Island,
Texas. (December 1976)

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The distributions, relative and seasonal abundances, and population structures of the species of mysids were sampled for 2 years in the various habitats in the shallow waters of Galveston Island, Texas. From February, 1971 through January, 1972, monthly collections were made and from February, 1973 through February, 1974 bimonthly collections were made with a beam trawl in the nearshore area. During the second year bimonthly samples were taken with an Ockelmann sledge along transects across Tucker Bayou and West Bay.

Mysidopsis almyra was the dominant species in the study, composing 82 per cent of the collections. The next 3 most abundant species were Mysidopsis bahia (10 per cent), Mysidopsis bigelowi (5 per cent), and Metamysidopsis swifti (4 per cent).

The ecological distributions of the mysids showed a pattern of habitat segregation among the species: Mysidopsis almyra occurred in lower salinity shallow waters of bayous and bays; Mysidopsis bahia in shallow bay waters of higher salinity; Mysidopsis bigelowi in deeper bay waters and offshore; Metamysidopsis swifti in seaside surf; and Brasilomysis castroi and Promysis atlantica in deeper offshore waters.

Microdistribution studies showed that *M. almyra* inhabits the layer of water just above the bottom during the day and night. As the tide ebbed, its numbers increased and as the tide flooded numbers decreased.

All mysid species displayed similar cycles of rapid reproduction and larger numbers during the summer months and slow reproduction and low numbers during the winter months. It was concluded that photoperiodicity and temperature were the major factors involved in these seasonal changes.

The largest gravid females of all species were collected in the winter months and were replaced by progressively smaller ones in the spring and summer. The number of eggs and young per brood was calculated to be a linear function of the volume (length^3) of female *M. almyra*, *M. bahia*, *M. bigelowi*, and *M. swifti*.

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TABLE OF CONTENTS

Page

INTRODUCTION 1

LITERATURE REVIEW 3

Species of Mysidacea reported from the Texas Coast ... 3

Seasonal abundance and population composition studies 4

Brood pouch studies 6

Temperature-salinity tolerance studies 8

Microdistribution 9

MATERIALS AND METHODS 15

Field study 15

Laboratory study 29

DESCRIPTION OF STUDY AREAS 34

Nearshore area 34

Tucker Bayou 39

West Bay 39

HYDROGRAPHIC DATA 40

Precipitation 40

Temperature 40

Salinity 46

RESULTS 52

Composition of Mysidacea in the Galveston Island area 52

Ecological distribution of Mysidacea among the study areas 52

TABLE OF CONTENTS - CONTINUED

Page

Composition of Mysidacea within each study area 57

Relationship between temperature and salinity and abundance of Mysidacea 72

Relationship between temperature and salinity and survival and behavior of Mysidacea 90

Microdistribution of Mysidacea 95

Seasonal distribution of Mysidacea 108

Relationship of length of Mysidacea to various environmental factors 122

Population studies of Mysidacea 127

DISCUSSION 148

Composition of Mysidacea in the Galveston Island area 148

Ecological distribution of Mysidacea among the study area 150

Composition of Mysidacea within each study area 152

Relationship between temperature and salinity and abundance of Mysidacea 157

Microdistribution of Mysidacea 162

Seasonal distribution of Mysidacea 165

Relationship of length of Mysidacea to various environmental factors 173

Population studies of Mysidacea 175

SUMMARY 180

LITERATURE CITED 184

APPENDIX 194

VITA 207

LIST OF TABLES

Table Page

1 Temperature (^{o}C) ranges and means for habitats and individual stations in the nearshore area in 1971-72 44

2 Temperature (^{o}C) ranges and means for habitats and individual stations in the nearshore areas in 1973-74 45

3 Salinity (ppt) ranges and means for habitats and individual stations in the nearshore area in 1971-72 49

4 Salinity (ppt) ranges and means for habitats and individual stations in the nearshore area in 1973-74 50

5 Total numbers and percentage composition of each mysid species from all study areas from Galveston Island in 1971-72 (year 1) and 1973-74 (year 2) 53

6 Number per tow of each mysid species collected from each study area of Galveston Island in 1971-72 and 1973-74 55

7 Per cent composition of the mysid species in each habitat of the nearshore area of Galveston Island in 1971-72 and 1973-74 58

8 Number per tow of the more common mysid species in each habitat of the nearshore area of Galveston Island 1971-72 and 1973-74 59

9 Number per tow of each mysid species at each station in each habitat of the nearshore area of Galveston Island 1971-72 and 1973-74 62

10 Incidence of occurrence of mysid species in different habitats of Galveston Island for 1971-72[a] and 1973-74[b] 64

11 Seasonal occurrence of the mysid species collected in Tucker Bayou 67

12 Seasonal occurrence of the mysid species collected at each station in West Bay 69

Page

Table

13 Mean number per tow of the developmental stages of *M. almyra*, *M. bahia*, and *M. swifti* at the different temperature groups in the nearshore area of Galveston Island in 1971-72 75

14 Mean number per tow of the developmental stages of *M. almyra*, *M. bahia*, and *M. swifti*, at the different temperature groups in the nearshore area of Galveston Island in 1973-74 76

15 Mean number per tow of each developmental stage of *M. almyra*, *M. bahia*, and *M. swifti* at the different salinity groups in the nearshore area of Galveston Island in 1971-72 78

16 Mean number per tow of each developmental stage of *M. almyra*, *M. bahia*, and *M. swifti* at the different salinity groups in the nearshore area of Galveston Island in 1973-74 79

17 Mean number per tow of *M. almyra*, *M. bahia*, and *M. bigelowi* at the different temperature groups in Tucker Bayou and West Bay 80

18 Mean number per tow of *M. almyra*, *M. bahia*, *M. bigelowi* at the different salinity groups in Tucker Bayou and West Bay 81

19 Mean number per tow of the developmental stages of *M. almyra*, *M. bahia*, and *M. bigelowi* at the different temperature groups in Tucker Bayou and West Bay 82

20 Mean number per tow of the developmental stages of *M. almyra*, *M. bahia*, and *M. bigelowi* at the different salinity groups in Tucker Bayou and West Bay 83

21 Number and per cent (in parentheses) of *M. almyra* surviving various temperature-salinity combinations for 10 days (15 mysids=100 per cent survival) 91

22 Number and per cent (in parentheses) of *M. swifti* surviving various temperature-salinity combinations for 10 days (10 mysids=100 per cent survival) 93

Page

Table

23 Vertical distribution of M. almyra with 0.94 m of the bottom determined by simultaneous collections of three 10 cm layers (32 cm apart) using a multiple level sampling device in Tucker Bayou during the first 27 hr sampling period 97

24 Vertical distribution of M. almyra within 0.95 m of the bottom determined by simultaneous collections of four 10 cm layers (18 cm apart) using a multiple level sampling device in Tucker Bayou during the second 27 hr period 98

25 Vertical distribution of developmental stages of M. almyra within 0.95 m of the bottom in Tucker Bayou during the second 27 hr period 99

26 Seasonal occurrences (number per tow) of each mysid species collected in the nearshore area of Galveston Island in 1971-72 109

27 Seasonal occurrence (number per tow) of each mysid species collected in each study area of Galveston Island in 1973-74 110

28 Seasonal occurrence (number per tow) by developmental stage of the more common mysid species collected in the nearshore area of Galveston Island in 1971-72 .. 112

29 Seasonal occurrence (number per tow) by developmental stage of the more common mysid species collected in the nearshore area of Galveston Island in 1973-74 114

30 Seasonal occurrence (number per tow) by developmental stage of M. almyra collected in Tucker Bayou in 1973-74 116

31 Seasonal occurrence (number per tow) by developmental stage of the more common mysid species collected in West Bay in 1973-74 118

32 Means lengths (mm) of mature females of M. almyra, M. bahia, and M. swifti at each station in the nearshore area for 1971-72 and 1973-74 123

33 Coefficients of correlation for various environmental factors concerning length of mature females of M. almyra, M. bahia, and M. swifti in the nearshore area in 1971-72 and 1973-74 131

Page

Table

34 Regression analysis equations showing relationship between number of eggs and young and volume (length^3) of the female in M. almyra, M. bahia, M. bigelowi, and M. swifti in each study area of Galveston Island in 1971-72 and 1973-74 133

35 Percentages of females and males of M. almyra, M. bahia, M. bigelowi, and M. swifti from each study area of Galveston Island in 1971-72 and 1973-74 134

36 Percentages of immatures and mature females of M. almyra, M. bahia, and M. swifti from the nearshore area of Galveston Island in 1971-72 and 1973-74 136

37 Observations and mean number of eggs and young per female of M. almyra, M. bahia, M. bigelowi, and M. swifti for each study area of Galveston Island in 1971-72 and 1973-74 138

38 Percentage composition of mysids collected in three studies along the Texas coast 149

39 Temperature values (^{o}C) for the stations in the nearshore area of Galveston Island in 1971-72 195

40 Temperature values (^{o}C) for the stations in the nearshore area of Galveston Island in 1973-74 197

41 Surface^{s} and bottom^{b} temperature values (^{o}C) for the stations of Tucker Bayou in 1973-74 199

42 Surface^{s} and bottom^{b} temperature values (^{o}C) for for the stations in West Bay in 1973-74 200

43 Salinity values (ppt) for the stations in the nearshore area of Galveston Island in 1971-72 201

44 Salinity values (ppt) for the stations in the nearshore area of Galveston Island in 1973-74 203

45 Surface^{s} and bottom^{b} salinity values (ppt) for the stations of Tucker Bayou in 1973-74 205

46 Surface^{s} and bottom^{b} salinity values (ppt) for the stations in West Bay in 1973-74 206

LIST OF FIGURES

Figure Page

1 Nearshore stations in the east portion of Galveston Island 16

2 Nearshore stations in the west portion of Galveston Island 17

3 Renfro beam trawl used in sampling nearshore stations (after Renfro 1963) 18

4 Stations and water depths along the Tucker Bayou transect 19

5 Stations and water depths along West Bay transect and location of Tucker Bayou 20

6 Ocklemann sledge used in sampling the Tucker Bayou and West Bay transects 21

7 Multilevel sampling device used in first 27 hr study 23

8 Multilevel sampling device used in second 27 hr study 24

9 Experimental apparatus for the study of mysids at reduced temperatures 32

10 Mean monthly rainfall for Galveston, Houston, and Anahuac from February, 1971-January, 1972, February, 1973-February, 1974 and from 1935-1974 41

11 Mean monthly temperature values for Galveston Island in 1971-72 and 1973-74 43

12 Mean monthly salinity values for Galveston Island in 1971-72 and 1973-74 48

13 Mean number per tow of mysids collected at each station in West Bay 71

14 Mean number per tow of M. almyra at the different temperature groups in the nearshore area of Galveston Island 73

LIST OF FIGURES - CONTINUED

Figure		Page
15	Mean number per tow of M. almyra at the different salinity groups in the nearshore area of Galveston Island	77
16	Mean number per tow of M. bahia at the different temperature groups in the nearshore area of Galveston Island	85
17	Mean number per tow of M. bahia at the different salinity groups in the nearshore area of Galveston Island	86
18	Mean number per tow of M. swifti at the different temperature groups in the nearshore area of Galveston Island	88
19	Mean number per tow of M. swifti at the different salinity groups in the nearshore area of Galveston Island	89
20	Numbers of M. almyra collected with multilevel sampling device during first 27 hr period and tidal cycle for that period	101
21	Numbers of M. almyra collected with multilevel sampling device during the second 27 hr period and tidal cycle for that period	102
22	Numbers of M. almyra collected each day during the 15 day sampling period	104
23	Daily tidal cycles during the 15 day study	105
24	Per cent frequency of each developmental stage of M. almyra collected during the second 27 hr study	106
25	Per cent frequency of each developmental stage of M. almyra collected during the 15 day study	107
26	Seasonal occurrence (number per tow) of M. almyra collected from the nearshore area of Galveston Island in 1971-72 and 1973-74	111
27	Seasonal occurrence (number per tow) of M. almyra collected in Tucker Bayou in 1973-74	113

LIST OF FIGURES - CONTINUED

Page

Figure

28 Seasonal occurrence (number per tow) of mysids collected in West Bay in 1973-74 117

29 Seasonal occurrence (number per tow) of *M. bahia* collected from the nearshore area of Galveston Island in 1971-72 and 1973-74 119

30 Seasonal occurrence (number per tow) of *M. swifti* collected from the nearshore area of Galveston Island in 1971-72 and 1973-74 121

31 Monthly mean lengths (± 1 standard error) of mature females of *M. almyra* collected from the nearshore area of Galveston Island in 1971-72 and 1973-74 124

32 Monthly mean length (± 1 standard error) of mature females of *M. bahia* collected from the nearshore Island in 1971-72 and 1973-74 125

33 Monthly mean lengths (± 1 standard error) of mature females of *M. swifti* collected from the nearshore area of Galveston Island in 1971-72 and 1973-74 .. 126

34 Mean lengths of mature females of *M. almyra* at the indicated temperature and salinity groups 128

35 Mean lengths of mature females of *M. bahia* at the indicated temperature and salinity groups 129

36 Mean lengths of mature females of *M. swifti* at the indicated temperature and salinity groups 130

37 Percentages of developmental stages of *M. almyra* for each month from the nearshore area of Galveston Island in 1972-73 and 1973-74 135

38 Mean number of eggs and young per gravid *M. almyra* for each month from the nearshore area of Galveston Island in 1971-72 and 1973-74 139

39 Seasonal variation in the mean number of eggs and young per female in a single size class of *M. almyra*, *M. bahia*, and *M. swifti* in the nearshore area of Galveston Island in 1971-72 and 1973-74 140

LIST OF FIGURES - CONTINUED

Page

Figure

40 Percentages of developmental stages of M. bahia for each month from the nearshore area of Galveston Island in 1971-72 and 1973-74 142

41 Mean number of eggs and young per gravid M. bahia for each month from the nearshore area of Galveston Island in 1971-72 and 1973-74 143

42 Percentages of developmental stages of M. swifti for each month from the nearshore area of Galveston Island in 1971-72 and 1973-74 145

43 Mean number of eggs and young per gravid M. swifti for each month from the nearshore area of Galveston Island in 1971-72 and 1973-74 147

44 Number per tow of M. bigelowi at each station in West Bay in June and August 1973 155

INTRODUCTION

The malacostracan order Mysidacea includes small, elongate, shrimp-like crustaceans which are called opossum shrimp because the females carry their developing young in a ventral brood pouch or marsupium. There are about 500 known species in the order Mysidacea. These are divided into two sub-orders, the Lophogastrida and Mysida. The Lophogastrida include marine deepwater species only, whereas most members of Mysida occur in shallow waters (200 m or less). The group is comprehensively discussed by Tattersall and Tattersall (1951). The seven species and 5 genera studied herein all belong to the family Mysidae.

Despite their abundance, mysids have received surprisingly little attention in bays and estuaries. They are poorly known for several reasons. First, mysids are small, relatively transparent organisms of little direct or apparent economic importance. Second, most collecting devices are not designed to catch them. Since they are hypopelagic, mysids are seldom taken in plankton nets, and because they are motile they are not often trapped in bottom samples.

There is an urgent need now for basic studies on marine invertebrates such as mysids which are poorly known since the widespread disturbance and rapid ongoing destruction of inshore waters is greatly reducing natural areas for study. Such studies in now relatively

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This paper follows the style of Contributions in Marine Science.

undisturbed areas are needed for a better understanding of natural ecosystem functioning, an understanding which would allow better monitoring of the effects man is and will be having on the inshore ecosystems.

The present study is concerned with the mysids in the shallow waters of Galveston Island. The study was undertaken with the following objectives in mind: to determine the distributions, relative and seasonal abundances, and population structures of the mysid species in the various habitats; to determine the relationship between abundance of the mysid species and various environmental factors; and to determine the microdistribution of the more common mysid species.

LITERATURE REVIEW

Species of Mysidacea Reported from the Texas Coast

There are only 10 papers in the literature reporting on 8 mysid species from the inshore Texas coast. The earliest reports are those of Copeland (1965) who listed *Mysis stenolepis* S. I. Smith at Aransas Pass Inlet, and Keith and Hulings (1965) who recorded it between Sabine Pass and Bolivar Point. In 1969 Molenock described *Mysidopsis bahia* Molenock from West Bay and Clear Lake. Solomon (1970) recorded *Bowmaniella dissimilis* (Coifmann) from Aransas Bay, Brazos estuary, and Colorado estuary, and *Mysidopsis bigelowi* W. M. Tattersall from Aransas Bay and Brazos estuary.

Conte and Parker (1971) reported *Bowmaniella brasiliensis* Bacescu, *Brasilomysis castroi* Bacescu, *Mysidopsis almyra* Bowman, *Mysidopsis bahia*, and *Taphromysis louisiana* Banner from Alligator and Oyster Lakes, 2 marsh embayments near West Bay. Mackin (1971) sampled several bays and estuaries along the Texas coast and found 7 mysid species. He found *M. almyra* in upper Galveston Bay, Clear Creek, Lavaca River, Lavaca Bay, Alazan Bay, and Baffin Bay. *M. bigelowi* was recorded from upper Galveston Bay, Clear Creek, and Lavaca Bay, and *M. bahia* was found in Alazan and Baffin Bays. *Bowmaniella brasiliensis* and *B. dissimilis* were listed from Lavaca and Baffin Bays; *Brasilomysis castroi* was taken in Lavaca Bay; and *Taphromysis louisiana* was collected in the Lavaca River.

The most recent reportings are from Kalke (1972), Schmidt (1972), and Williams (1972) who all sampled in upper Galveston Bay. All three authors found *M. almyra*; Williams also recorded *Bowmaniella dissimilis* and Kalke found *Taphromysis louisiana*.

Seasonal Abundance and Population Composition Studies

The only known seasonal abundance study on the Gulf coast in which large numbers of mysids were collected was done by Conte and Parker (1971). No population composition studies have been conducted on the Gulf coast.

Conte and Parker sampled Alligator and Oyster Lakes bi-weekly for a 2 year period. *Mysidopsis almyra* was the most abundant for the 5 mysid species collected. Specimens were collected year round with peaks in abundance from November through May and July through September. The abundance of *M. almyra* was greater in the colder months, November through May, than in the warmer months, July through September. Although specimens were collected in salinities ranging from 9 to 29 ppt, greater numbers were caught in Alligator Lake, with a mean salinity of 12.6 ppt, than Oyster Lake with a mean salinity of 17.0 ppt.

Mysidopsis bahia was reported in January, February, April, and July in Alligator Lake with a peak abundance of less than 50 specimens in early January. In Oyster Lake this species was collected from November through July with peak abundances in late December, early March, and early April. Greater numbers of *M. bahia* were collected in Oyster Lake than Alligator Lake.

Taphromysis louisiana was taken from November through March and in July with peak abundances of less than 50 per month in February and March in salinities ranging from 0-26 ppt. Only eight specimens of *Bowmaniella brasiliensis* were taken from December through February and in September and November in salinities ranging from 0-17 ppt. One specimen of *Brasilomysis castroi* was collected in December in a salinity of 22 ppt.

Hopkins (1965) studied the seasonal abundance and reproductive periods of mysids in the surface waters of Indian River Inlet, Delaware for a 2 year period. *Neomysis americana*, (S.I. Smith) the dominant species, was present throughout each year and was most abundant from April through September. Reproduction took place mainly in the warmer months and three major brood releases occurred (April-May, June, August). These brood releases probably produced three generations per year: two short-lived summer generations and a longer-lived winter generation. *Mysidopsis bigelowi*, the second most abundant species, was present throughout the year and was sporadically abundant from September through February. Gravid females were taken from April through November, but none were taken from waters cooler than 11 C.

Vorstman (1951) investigated the life cycle of *Neomysis vulgaris*, Thompson in Barnegat Pool north of Amsterdam in the Netherlands. He concluded that three generations were produced a year as a result of 3 major brood releases (April-May, July, August). The young produced by the August brood release overwintered and produced the first generation in the following year.

Mauchline (1965-1971) has done a voluminous amount of work in the cold waters off the west coast of Scotland. He divided his seasonal samples into several classes: (1) juveniles, (2) immature females, (3) immature males, (4) mature males, (5) females with eggs or young in marsupium, and (6) females with a marsupium from which young have emerged. From this information, he found that although most species reproduced throughout the year, there were periods of intensive breeding that resulted in the production of two to three generations per year. The population maxima most often occurred in the spring and summer. Mauchline, however (1971e) warned that seasonal maxima can be either real or apparent. "Real maxima are those caused by increases in the sizes of populations owing to active breeding and production of young. Apparent seasonal maxima of occurrence can be caused by a disaggregated population aggregating, or swarming, in a small sea area so that they are sampled more effectively than previously."

The only known seasonal study in warm temperate or tropical waters which has information concerning population composition was conducted by Goodbody (1965) in Kingston Harbor, Jamica. Monthly samples of Mysidium columbiae (Zimmer) were collected for 15 months and the percentage of the total number of adults carrying eggs or embryos was calculated. Eggs and embryos were carried by females at all seasons although the percentages varied from 18 to 67 per cent, being highest in late summer and autumn and lowest during winter.

Brood Pouch Studies

No brood size studies have been made on the Gulf coast, and brood size counts have been made for only 1 species found on the Texas coast. Wigley and Burns (1971) reported the lengths and brood sizes of 3 specimens of Mysis stenolepis taken off the coast of Massachusetts. The lengths and brood sizes were 25.0 mm, 25.5 mm, 25.0 mm and 144, 188, and 171 eggs or young, respectively.

In studying the life cycle of Neomysis vulgaris in Barnegat Pool

(Netherlands) Vorstman (1951) found in that mature winterstock females were larger and carried more eggs than the spring generation. The females of the spring generation, in turn, were larger and carried more eggs than the summer generation.

Jensen (1955) examined the relationship between body size and number of eggs of five species of European mysids, along with other malacostracans. He found that in the five mysid species the number of eggs per female was a linear function of the length of the female raised to the 3rd power. It appeared that the number of eggs in equally large specimens of the same species differed spatially and seasonally. Jensen concluded that "the quantity of eggs produced by a female as regards to the absolute number is determined by the external factors, whereas the relative number depends on the volume of the female in such a way, that the number of eggs becomes a linear function of the volume of the female."

Labat (1957) found that the ovigerous females of over-wintering populations of Paramysis nouveli Labat and P. bacescoi Labat in the regions of Roscoff, France were much larger in body size than those found in the summer. The winter broods of both species were larger than the summer broods.

Mauchline (1965, 1967) found that the number of eggs in any one size class of Praunus inermis (Rathke) and Schistomysis spiritus (Norman), collected from the West coast of Scotland, varied seasonally. In the brood pouches of gravid females of the same size, greater numbers of eggs were found during the summer, which is the period of most intensive breeding, than in the winter when breeding intensity was lowest.

Mauchline (1973) examined the broods of more than 20 species of British mysids and found that the volume of the egg, the number of eggs, and the volume of the brood increased with increasing size of epipelagic species. In bathypelagic species, the number of eggs did not increase with increasing size, although the other two relationships existed. Therefore, bathypelagic mysids produced fewer but larger eggs than epipelagic mysids. Mauchline found that all the gravid females he examined produced broods equal to about 10 per cent of their body volume.

Temperature-Salinity Tolerance Studies

The only known temperature-salinity tolerance study with mysids on the Gulf coast was done by Rhoads (1966) who tested the effect of 16 combinations of salinity (12, 19, 28, 36 ppt) and temperature (12, 17, 23, 28 C) on the survival, growth, and generation time of *Mysidopsis bahia*. She found that salinity alone was not a limiting factor in the survival or growth of this species although the combination of low temperature and low salinity resulted in no survival. The optimum temperature for survival was 17 C.

The best conditions for completion of a generation in the laboratory were between 17-23 C and 12-28 ppt. The generation time varied from 39 to 53 days for the entire range of test conditions. From seasonal hydrographic data in Galveston Bay, Rhoads projected that during five spring and fall months, conditions were optimum for growth and survival of *M. bahia*. She concluded that peak abundances in the population should occur at these times.

Cox (1974), who studied the effects of petroluem hydrocarbons on Mysidopsis almyra and Penaeus setiferus, did some preliminary work on the thermal resistance on the mysid species. If mysids held at 20 C were transferred to 34 C, death was immediate; at 33 C death occurred after 5.5 hours ± 45 minutes. Mysids survived for up to 10 hours at 32 C.

Microdistribution

Mysids are not randomly distributed horizontally or vertically in the water. This patchiness is a result of several factors including social behavior and horizontal and vertical migrations. No microdistribution studies have been conducted on the Gulf coast.

Vertical Distribution

Since Apstein (1906) first noted vertical migration of mysids, this phenomenon has been observed in shallow and deep water species (Russell 1925,1927,1928,1931; Fage 1932,1933; Waterman et al., 1939; Hulburt 1957; Beeton 1959; Herman 1963b; Pequegnat 1965; Clutter 1969). Most mysids remain on or just above the bottom during the day. The exact level occupied depends on the species (Clutter 1969). With the decrease of light at sunset, the mysids begin their ascent toward the surface. The extent of the rise also depends upon the species (Russell 1925,1927,1928,1931). At night the mysids usually distribute themselves throughout the water column and midnight sinking sometimes occurs (Herman 1963). With the advent of dawn, a dawn rise occurs at times, and the mysids descend to their daytime levels.

It is generally agreed that light intensity is the primary factor responsible for vertical migration (Russell 1925,1927,1928,1931; Fage

1932,19322; Hulburt 1957; Herman 1963b; Clutter 1969). Each species has an optimum light intensity at which it lives. Herman (1963a) observed that Neomysis americana seeks light having a wavelength of about 515 nm. He suggested that some organisms may try to follow light of an optimum intensity and at a certain wavelength (Herman 1963b).

In field studies on the vertical migration of Neomysis americana in Narraganset Bay, Herman (1963b) found that a dawn rise occurred from March through August but not from October through February. In the laboratory he found that if this species was kept in continuous darkness for 12 hours, it became photonegative. This condition lasted from 3 to 5 minutes at low light intensities. He suggested that whether or not N. americana undergoes a dawn rise depends upon the length of time spent in the dark during the night. If this time is less than 12 hours, the mysids are attracted to the dawn light and a dawn rise occurs. If this time is more than 12 hours the mysids are at first photonegative, and this condition is maintained by the increasing light intensity.

Fage (1932,1933) and Herman (1963b) found that mature mysids migrate vertically only during their breeding seasons. Nair (1939) observed that female Mesopodopsis orientalis always released its young at night, and other workers have suggested this to be true in other species (Tattersall and Tattersall 1951). Tattersall and Tattersall (1951) noted that if the young were released high in the water column, their chances of becoming widely distributed would be greatly increased.

Russell (1927) noted that young mysids usually occurred higher in the water column than adults. Herman (1963b) found that during vertical migration the young were the first to reach the surface and the last to leave. During the breeding season, however, the young had a tendency to occupy lower levels than they normally occupied the rest of the year.

Horizontal Distribution

Social behavior.--It is known that shallow water mysids swarm and school (Steven 1961; Clutter 1969; Mauchline 1971e). This patchiness results from the social interactions of mysids with each other.

Clutter (1967) found that mysids occurred in bathymetric zones roughly parallel with the shore off La Jolla, California. Within each zone the mysids occurred in large groups called shoals which ranged from a few meters to tens of meters across (Clutter 1969). The distribution of shoals within a zone was not correlated with temperature, salinity, light intensity, or substrate composition. The distribution was possibly related to the supply of food which was determined by the nearshore circulation system.

Clutter called smaller more integrated groups of mysids schools or swarms which were often constituent parts of shoals. Schools were polarized groupings of individuals swimming in the same direction; swarms implied cohesiveness but not parallel orientation. Schools or swarms were usually composed of individuals of the same age group.

Clutter found swarm or school formation was initiated during the day since light was the primary factor in establishing contact between individuals. Contact was maintained in darkness by body contact and perhaps chemical cues. At night, highly integrated schooling was reduced and some vertical spreading took place; however, the majority of the group remained near the bottom in approximately the same pattern as just before nightfall.

Clutter suggested some possible functions of social behavior: to maintain position within the habitat, to reduce predation, to increase the probability of copulation, and to contribute to population regulation. In reference to the last possible function, Clutter found an inverse relationship between field population size and percentage of gravid females. He suggested that crowding may reduce the reproductive rate and help control the population.

Horizontal migrations.--The horizontal movement of shallow water mysids is influenced by several factors: tidal conditions, currents, temperature changes, wave action, and maturity of individuals.

Percival (1929) investigated the estuarine fauna of the Tamar and Lynher Rivers in England and found that large numbers of mysids moved upstream before the rising tide. Tattersall and Tattersall (1951) suggested that daily migratory movements of this kind are probably common in estuarine waters where species such as *Neomysis integer*, *Praunus flexuosus*, and *Mesopodopsis slabberi* are found.

Elmhirst (1931,1932) observed that in Scotland *Schistomysis spiritus* and *Praunus flexuosus* migrated at night from below low water mark into sandy bays, moving with the rising tide. This movement was inhibited by bright moonlight. These species also migrated vertically at night and thus the overall movement combined horizontal with vertical movements.

According to Rice (1961), Liao (1951) found that in the shallow waters of Port Erin Bay, Isle of Man, S. spiritus moved to the water's edge each night and with each rising tide. It moved away from the water's edge during the day and at low tide. However, according to Mauchline (1967) Liao found the densest swarms of S. spiritus at low tides which coincided with dawn and dusk in Port Erin Bay, Isle of Man. He suggested that swarming was stimulated by low light intensities and the concentrating effect of the ebbing tide. Since I have not been able to see Liao (1951), the differences in interpretation of Liao's data can not be resolved. Mauchline (1967) found that in Scotland during high tide S. spiritus was spread out, but the ebb tide collected and concentrated them at low water mark. Clutter (1967) found that the population of Metamysidopsis elongata on the intercanyon shelf in the La Jolla bight in California shifted shoreward with the ebbing tide.

In a two year study of the distribution of Neomysis americana in the Delaware River estuary, Hulburt (1957) found that this species was much more abundant in the deep water than in the near-surface or shallow water. This estuary has a two-layered circulation with the fresher upper layer of water flowing over the more saline lower layer. The deep water has a net movement up-estuary and the upper layer down-estuary. The mysids stayed in the deeper layer and grew and reproduced as they moved upstream.

Temperature extremes can cause migration of mysids from shallow waters into the more stable deeper waters. Vorstman (1951) found that Neomysis vulgaris left the plankton and descended to the bottom when temperatures fell below 3 C in Barnegat Pool (Netherlands). Kinne (1955) found that N. vulgaria left the shallow waters of Kiel

Canal in the fall and moved to deeper waters when temperatures fell below 15 C.

Mauchline (1967,1971a) suggested that Schistomysis spiritus and Paramysis arenosa may move into deeper waters in the winter to avoid severe wave action, but did not mention temperature being a factor in the migration.

Mauchline (1970a) found that juvenile Schistomysis ornata were separated horizontally from the adults in Loch Etive. The adults occurred in deeper, cooler, and more saline water than the juveniles. As the juveniles matured they aggregated in the deeper areas to breed.

MATERIALS AND METHODS

Field Study

Seasonal Sampling

Mysid populations were sampled for 2 years in the shallow water surrounding Galveston Island. From February, 1971 through January, 1972 (year 1) monthly collections were made and from February, 1973 through February, 1974 (year 2) bimonthly collections were made at twenty-three stations along the West Bay nearshore area and the seaside beach in depths of 2 m or less (Figure 1 and 2). A 1.5 m beam trawl (Renfro 1963) with a .9 mm netting, and with a No. 1 mesh (.417 mm) plankton net with a removable bucket tied over the cod end of the net was used in making collections (Figure 3). The beam trawl was pulled by hand through the water for a distance of 30 m parallel to the shore line at each station. A 30 m rope attached to a marker was used to determine the length of each tow.

Besides the nearshore stations, sampling during 1973-1974 included a 4 station transect across the south end of Tucker Bayou (Figures 4 and 5) and a 7 station transect across West Bay (Figure 5). Both transects were perpendicular to the shore. The Tucker Bayou transect was just north of the public boat ramp and had stations which were approximately 60 m apart in water that ranged from .6m to 1.4 m deep. The West Bay transect was at the junction of Tucker Bayou and West Bay. The stations were 800 m apart in water from .9 m to 2.4 m deep. Collections were made using an Ockelmann sledge (Ockelmann 1964) with a mesh size of .220 mm (Figure 6). The sledge

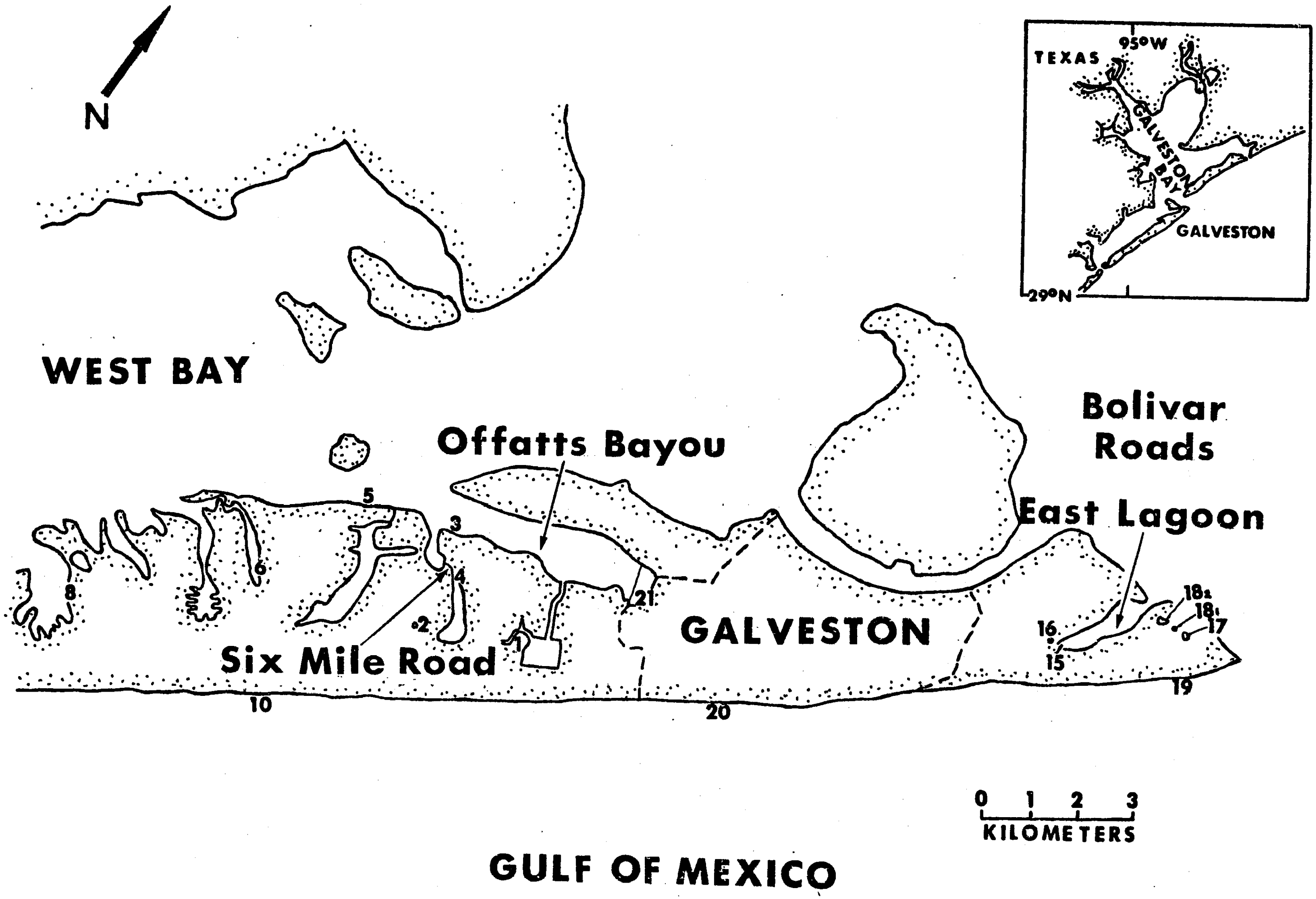

Figure 1. Nearshore stations in the east portion of Galveston Island.

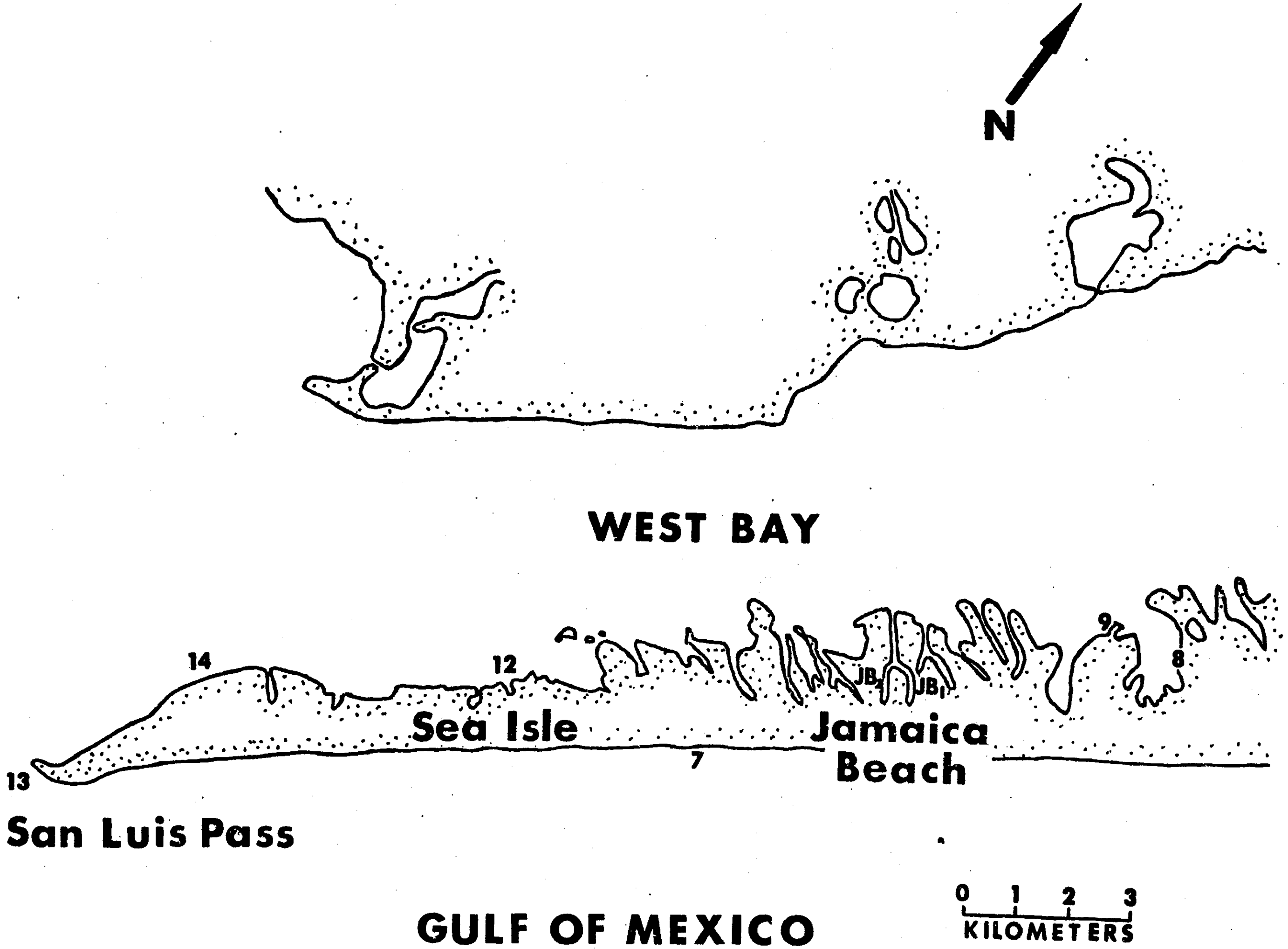

Figure 2. Nearshore stations in the west portion of Galveston Island.

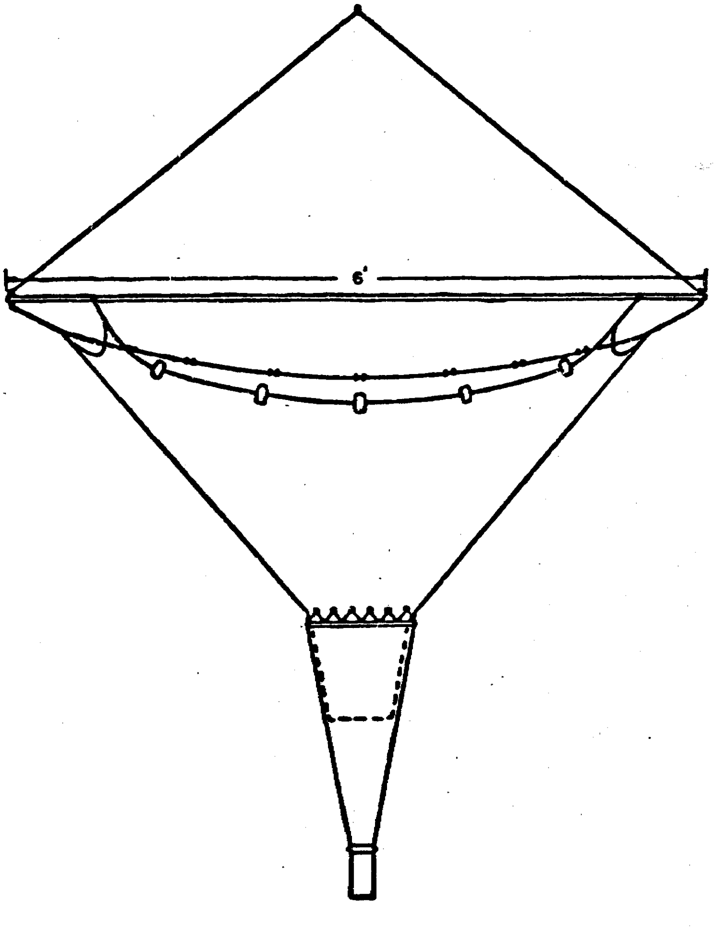

Figure 3. Renfro beam trawl used in sampling nearshore stations (after Renfro 1963).

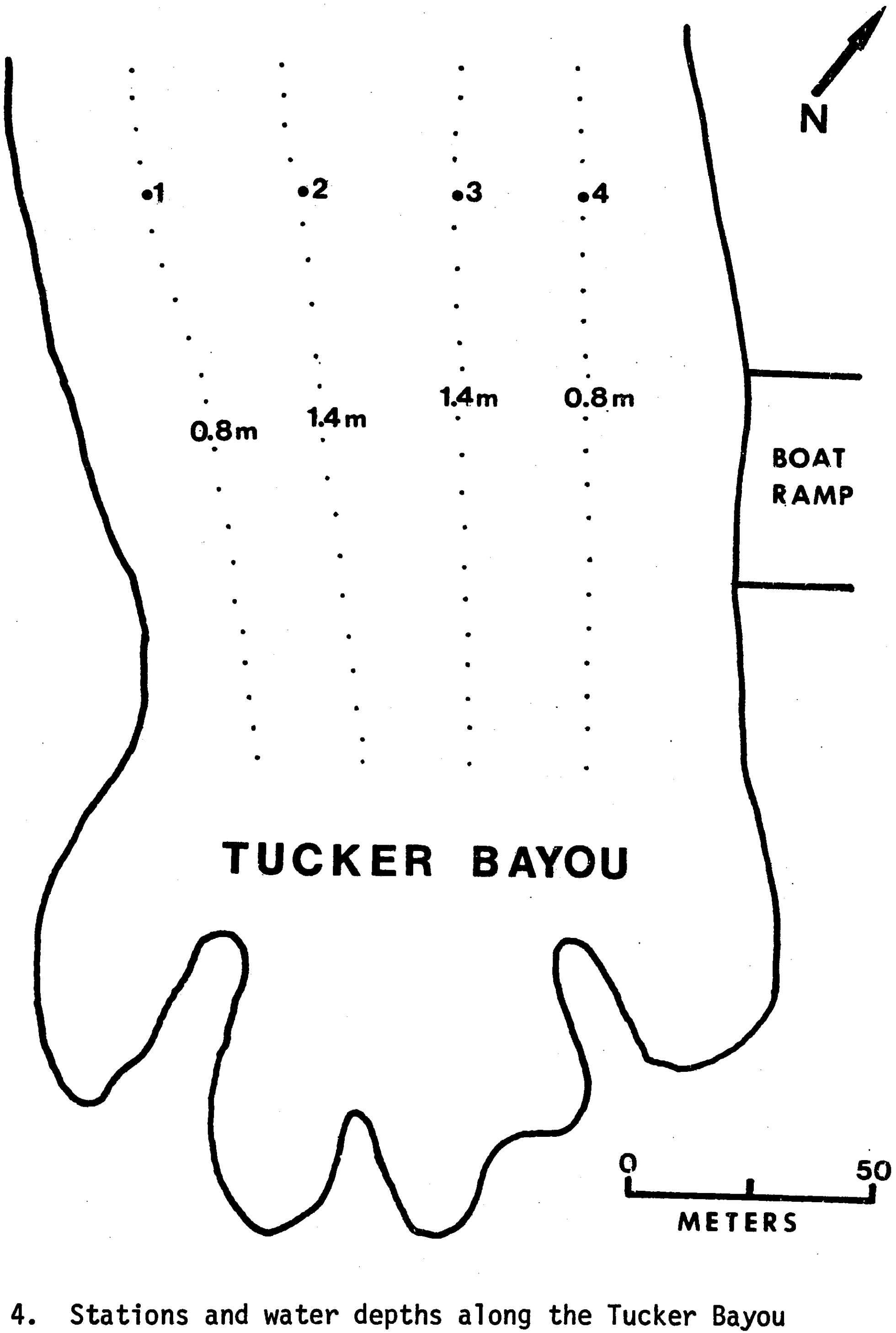

Figure 4. Stations and water depths along the Tucker Bayou transect.

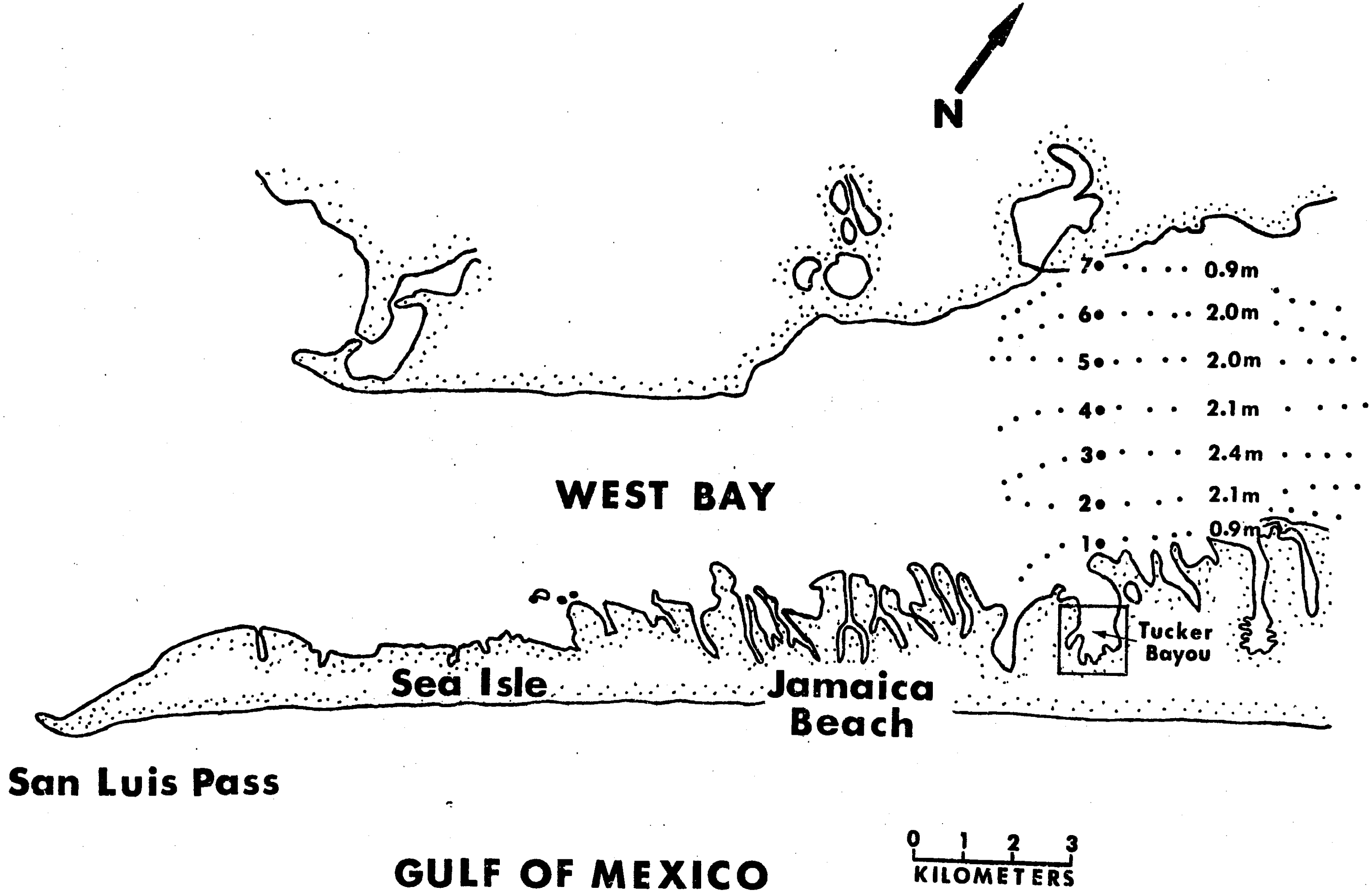

Figure 5. Stations and water depths along West Bay transect and location of Tucker Bayou.

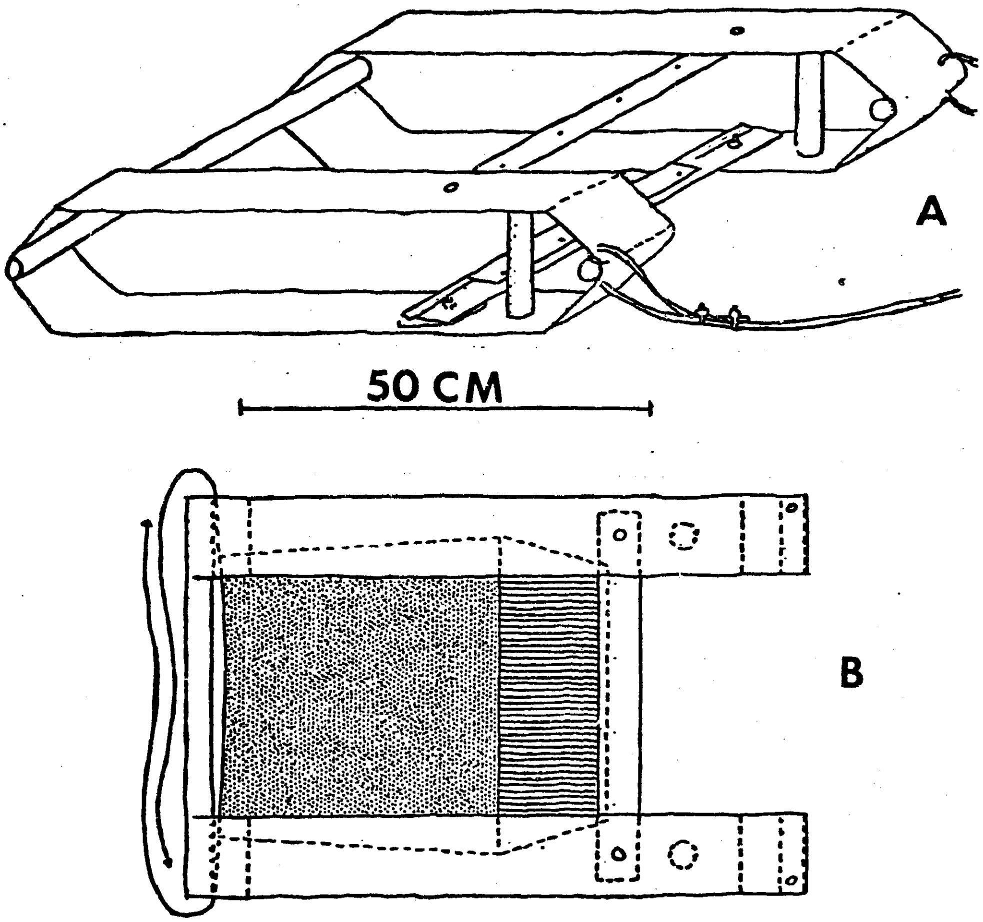

Figure 6. Ockelmann sledge used in sampling the Tucker Bayou and West Bay transects. A, lateral view, B, dorsal view with net (after Ockelmann 1964).

was pulled parallel to the shore line through the water by a 4.3 m motorized john boat at a constant speed of about 3.2 km per hour for 2 minutes. Samples from all areas were fixed in 10 percent buffered formalin in the field.

At each station the temperature, salinity, water depth, weather, wind, and nature of substrate were recorded. At the stations along the 2 transects, top and bottom water samples were taken for temperature and salinity measurements, but at the near shore stations only the surface temperature and salinity were measured. Water temperatures were measured with a field celsius thermometer. Salinities were determined with an Americal Optical Company TS (Total Solids) meter. Depths were measured with a calibrated pole or estimated to the nearest .15 m.

Intensive Short Term Sampling

During August, 1973 and May, 1974 3 intensive sampling studies were conducted - 2 for 27 hr each (August 4-5 and May 26-27) and 1 for 15 days (May 6-20). All studies took place at near-shore station 8 at Tucker Bayou.

For the 27 hour sampling studies, collections were made with the Ockelmann sledge which was modified to make a multilevel sampling device (Figures 7 and 8). This device was modeled after the multilevel net designed by Fager et al. (1966).

Using the Ockelmann sledge as a base, the main frame was made from 4 pieces of 3.5 cm doweling assembled with bolts and nuts. The bottom of each piece of doweling was attached to a 17.5 cm piece of 3.5 cm doweling that was fitted into a piece of tubing attached to

Figure 7. Multilevel sampling device used in first 27 hr study.

Figure 8. Multilevel sampling device used in second 27 hr study.

each corner of the sledge. The net frames were made of 1.9 cm^2 pieces of wood which were spaced on the upright pieces of doweling so that three nets could be towed simultaneously for the first study. The net frames were equally spaced for the second study so that 7 nets could be towed simultaneously. The nets were No. 1 plankton nets (.417 mm) which were .9 m long and equipped with detachable buckets on the cod ends. They were bolted to the net frames and had mouth openings of 10 cm by 33.5 cm.

During the first 27 hr study 3 nets, spaced 32 cm apart, were used. Therefore, 3 layers of water spaced 32 cm apart, each 10 cm by 33.5 cm, were sampled simultaneously within the zone extending from the bottom upward to 94 cm. During the second study, 4 nets spaced 18 cm apart, were used. The other dimensions were the same as described for the first study. For both studies collections were made every 3 hr for 27 hr. A 13.8 m nylon line connected to a 1.2 m bridle was attached to the front of the sledge. The multilevel sampler was placed at one end of the sampling area and the line was paid out in an arc to keep the sampler from disturbing the sampling area. The sledge was retrieved by hand for the 15 m distance. All drags were made parallel to the shore and in the same direction (north to south). Each successive drag was 2 m bayward of the one before it so that the same area of bottom was not covered twice.

After every sample, surface and bottom temperature and salinity readings were taken.

Light readings were taken with a Gossen Luna-Prometer and percent cloud cover was estimated. The exact level of the tide was measured by a yard stick placed in the sediment just below the intertidal zone. These tide measurements were later compared to measurements made by a tide recording gauge operated by the Corps of Engineers. The gauge was located at the bascule bridge on the railroad causeway between Galveston Island and the mainland.

For the 15-day sampling study a collection was made once a day for 15 consecutive days except for day 6. The samples were taken between 1330 and 1430 hr except for day 10 when the sample was taken at 1000 hr. The Ockelmann sledge with a No. 1 (.417 mm) plankton net attached was used. The same sampling procedure and tow length described for the 27 hr study was used. Approximately the same bottom area was covered each day.

After each collection the temperature, salinity, water depth, tide stage, light intensity, and percent cloud cover were recorded.

Laboratory Analysis

In the laboratory mysids were sorted from field collections and preserved in 70% ethanol. The larger samples were subsampled with the Folsom plankton splitter (McEwen, Johnson, and Folsom 1954; Longhurst and Seibert 1967). Only samples with 200 or more mysids were split. Identifications were made with a Vickers dissecting microscope using magnifications of 35X and 100X, and with a Swift compound microscope using magnifications of 100X and 400X.

The works most useful in identification were Tattersall's (1951) review of the Mysidacea of the United States National Museum and Brattegard's (1969,1970) investigations in the Bahamas and Florida. Other useful, shorter papers included mostly original descriptions

(Bacescu 1968a,1968b,1969; Bowman 1964; Clarke 1956; Molenock 1969; Tattersall, O.S. 1969; and Tattersall, W.M. 1923, 1926). Representatives of each species were sent to Dr. Thomas E. Bowman, Smithsonian Institution for veritifcation and identification.

Population Composition

Each sample was divided into the following population classes: 1) juveniles-secondary sexual characteristics not developed, 2) immature females-marsupium developing but no eggs or young present, 3) mature females-eggs or young in marsupium or stretched empty marsupium, 4) males-pleopods or genital appendage developing or developed. A satisfactory way to distinguish immature males from mature males in preserved samples was not found. Spermatozoa could be seen in squashed testes of live mysids, but not in testes of preserved mysids. Since the size at which mysids mature seems to vary with the season and presumably other factors it seems of dubious value to relate the sizes of live mature males to the preserved specimens.

All specimens in each population composition class from the second 27-hr study and the 15-day study were measured. Only mature females and females with stretched empty marsupia collected in the nearshore area during the 2 year seasonal sampling study were measured. The total length of each specimen was measured to the nearest 0.5 mm from the base of the eye-stalk to the posterior ends of the uropods, excluding the setae. A Wild M-5 dissecting microscope with a micrometer eyepiece was used.

Brood Pouch Size

The mature females from the seasonal sampling study were examined for marsupia filled with eggs or young. The eggs or young were removed from these individuals and counted; no counts were made if marsupia appeared to have lost eggs or embryos.

Sediment Analysis

Sediment samples were taken at the near shore stations on Galveston Island in March, 1972 by filling 150 ml jars with surface layers of sediment. Sediment samples were taken at the Tucker Bayou and West Bay transects in June, 1975, by scooping the sediment with jars at shallow stations and by using an Ekman grab at deeper stations.

In the laboratory sediment samples were air dried for about 2 weeks and then oven dried for 24 hr at 105 C. About 100 gm of each dehydrated sample were weighed, rehydrated, and allowed to soak until all hard lumps had disappeared. Then each sample was washed through a sieve series with 1000 µm, 500 µm, 250 µm, 120 µm, and 63 µm mesh openings (sieve numbers, 18, 35, 60, 120, 230 in the Standard Screen sizes). The sediments retained on each screen were washed into tared containers and oven dried. Sediment which passed through the 63 µm sieve was considered "mud" or silt and clay combined. Dried fractions were weighed and the dry weight of each fraction was expressed as a percentage of the weight of the whole sample. The weight of the mud was calculated by subtracting the combined screen fraction weights from the weight of the entire sample. Percentages obtained were used in comparing the sediment composition among the stations.

Laboratory Study

Temperature-Salinity Survival Studies

Specimens of Mysidopsis almyra and Metamysidopsis swifti were collected with a hand-drawn Ockelmann sledge from nearshore stations 8 and 7, respectively, in September, 1974. The ambient temperature and salinity ranged from 27-28 C and 26-28 ppt. The specimens were returned to the laboratory in aerated plastic buckets,and placed in 2 aerated 57 l all glass aquaria. They were held at 22 C and 23-24 ppt for 2 days before acclimation procedures began. Brine shrimp (Artemia salina) larvae were used as food.

Three temperatures (15,22,30 C) and 5 salinities (11,17,23,29, 35 ppt) which approximated the conditions found in the field during all seasons were used. Experimental solutions of different salinities were prepared with Instant Ocean (Aquarium Systems, Inc. Eastlake, Ohio). The 3 temperatures were maintained by the use of 2 incubators (22,30 C) and an environmental chamber (15 C).

Fifteen samples of between 15-20 specimens of mature and larger immature females were selected for each species from the holding tanks. Each sample was placed in a round 3 l glass aquarium in 2 l of aerated sea water at 23 ppt and 22 C. Salinities were decreased or increased stepwise at the rate of 2-4 ppt per 24 hr to the desired concentration by removing sea water and replacing it with an equal volume of distilled water or concentrated sea water. Four days were taken to complete salinity changes. At the end of the acclimation period, each group of organisms had been acclimated at the next lower or higher salinity for 24 hr prior to their arrival in the final test salinity, except for the samples at 23 ppt.

The 30 aquaria containing the 2 species were transferred to the 3 darkened temperature chambers at 22 C. The temperature was increased or decreased at the rate of 2-3C per 24 hr until the desired test temperature was reached in 3 days.

Twenty-four hours after the final temperature was reached, sufficient numbers of mysids were removed from the 30 aquaria to leave 15 Mysidopsis almyra in each of 15 aquaria and 10 Metamysidopsis swifti in each of 15 aquaria. The experiment was conducted for 10 days with observations at 12 hour intervals. During each observation dead individuals were removed and recorded.

During acclimation and the experiment, the mysids were fed brine shrimp daily. At this time any waste of uneaten food was removed. During the period water temperature and salinity never varied more than ±1.0C or ±1.0 ppt from the desired temperature or salinity. Distilled water was added during the experiment to balance salinity increases due to evaporation.

Burrowing Studies

Specimens of 3 species of mysids, Mysidopsis almyra, M. bahia, and Metamysidopsis swifti were collected from nearshore stations 8, 14 and 7, respectively, during October, 1974, with a hand-drawn Ockelmann sledge. During the collections, the water temperature ranged from 26 to 28°C and the salinity ranged from 27 to 29 ppt. The mysids were returned to the laboratory in aerated plastic buckets and placed in three 57 l all glass aquaria. They were held at about 23 C and 26 ppt for 2 to 5 days before use in experiments. Each aquarium was aerated and brine shrimp (Artemia salina) larvae were used as food.

Sediments to be used in the experiments were collected from the same 3 near shore stations by scooping up the top few mm of substrate with a 250 ml jar. Sediment from station 8 consisted of 90 per cent sand, 10 per cent silt and clay, and 1 per cent shell; sediment from station 14 was 93 per cent sand, 6 per cent silt and clay, and 1 per cent shell; and sediment from station 7 was composed of 76 per cent sand; 20 per cent shell, and 4 per cent silt and clay.

The experimental apparatus used was modeled after the one designed by Aldrich et al. (1968) (Figure 9). A small all glass tank (228 mm long, 228 mm high, and 60 mm wide) was used for all studies. For each study the tank contained about 240 ml of sediment (20 mm deep) and 720 ml of sea water (60 mm deep) prepared from Instant Ocean. The water temperature was reduced by circulating cold water through a 6 mm diameter glass tube partially immersed in the tank. Water for the cooling system was refrigerated by an ice bath in a styrofoam container and was continuously circulated by a submersible pump. The rate of cooling was controlled by varying the amount of glass tubing immersed in the water. Water and sediment temperatures were measured to the nearest 0.1 C with 2 mercury thermometers. The water temperature thermometer was suspended just above and the sediment temperature thermometer was placed just below the water-sediment interface.

Since burrowing is stimulated by light in some crustaceans (Fuss 1964, Fuss and Ogren 1966, Aldrich et al. 1968) the light was

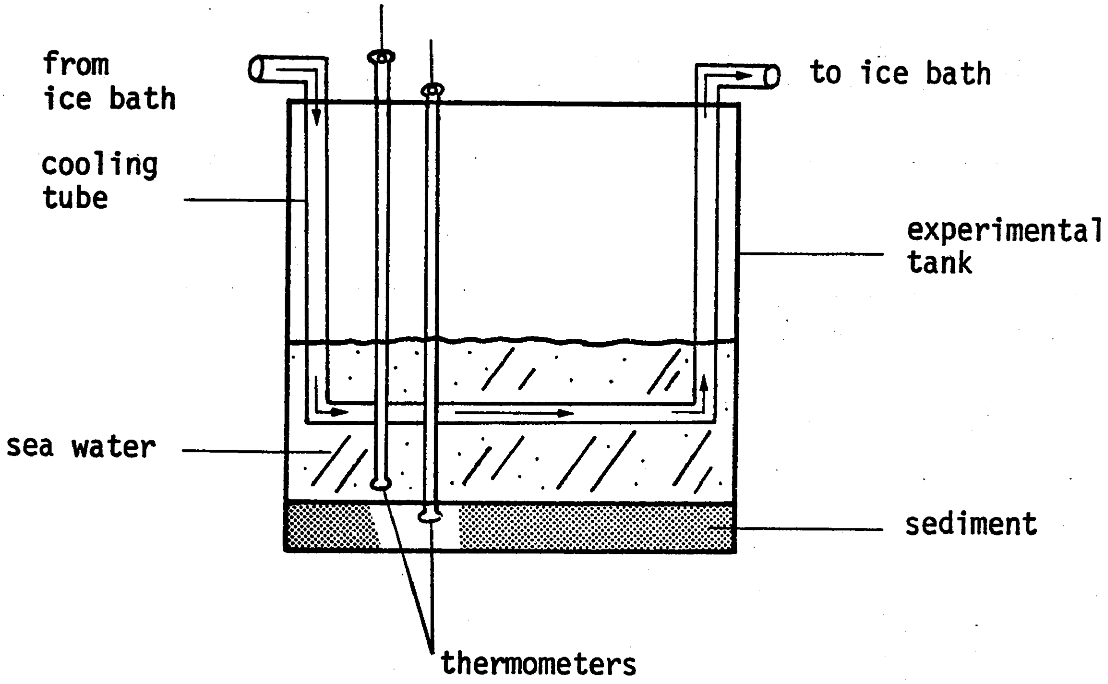

Figure 9. Experimental apparatus for the study of mysids at reduced temperatures.

reduced to the level produced by a 15 watt fluorescent bulb located 120 mm behind the tank. The bulb was covered with red cellophane so that only red light would be emitted. Herman (1963) has shown that Neomysis americana is less sensitive to red light than green, blue-green, or blue light.

Three experiments, 1 with each mysid species, were conducted. The salinity and initial temperature of each experiment were 26 ppt and 21.5-22.5 C. The procedures described were the same for all experiments. Three to 4 hours before each experiment 10 specimens were placed in the tank and the lighting was reduced to the experimental level. Observations were made during this pre-experimental control period to determine the behavior of the mysids in the absence of varying temperature. The water temperature was then dropped gradually at the rate of .06-.08 C per minute or 3.6 to 4.6 C per hr. Throughout the experiments the mysids were continually watched and temperature changes and observations were recorded every 5 minutes.

DESCRIPTION OF STUDY AREAS

Galveston Island is one of three sand barriers separating Galveston Bay from the Gulf of Mexico. It fronts West Bay, the southwest extension of the Galveston Bay system, and is cut off by two tidal passes, San Luis Pass on the west end, and Bolivar Roads on the east end (Lankford and Rogers 1969). The island is 46.4 km long and from .8 to 4.8 km wide (U.S. Coast and Geodetic Survey Chart 1282).

West Bay is 28.8 km long, from 3.2 to 6.4 km wide, and has an average depth of about 1.2 m (U.S. Coast and Geodetic Survey Chart 1282); along with East Bay it forms a coastwise lagoon about 88 km long (Lankford and Rogers 1969). Waters from the Gulf enter West Bay at its western end through San Luis Pass. Some tidal exchange also reaches West Bay through Bolivar Roads (Lankford and Rogers 1969). At the east end of West Bay, the passage to Galveston Bay is partially blocked by the Deer Islands and by the causeway between Galveston Island and the mainland (Galtsoff 1931).

Field studies were made in the nearshore area of Galveston Island (Figures 1 and 2) and along two transects - Tucker Bayou (Figure 4) and West Bay (Figure 5). The collecting sites visited for each area are discussed below.

Nearshore Area

The 23 stations collected during the study were found in the following habitats: seaside beach, open bay, muddy bayou, salt marsh, lagoon, temporary pond, brackish bayou, rocky clear bayou, bay grass bed, and bayou entrance.

Seaside Beach

Collections were made in the surf at the following five sites. The water averaged .9 to 1.2 m deep and was usually turbid. The bottom consisted of fine and medium sand and shell gravel.

Loran Tracking Station (19).--Site 19 was located opposite the Loran Tracking Station on the east end of the Island.

Marine Lab (20).--Site 20 was located opposite the Texas A&M Marine Laboratory just east of a rock groin.

Sunny Beach (10).--Collections were made about 0.8 km west of Eight Mile Road.

West Beach (7).--Site 7 was located 12 km east of San Luis Pass.

San Luis Pass (13).--Site 13 was located at the west end of the Island about .2 km south of San Luis Pass Bridge. Because of a strong tidal flow through the pass, sampling was difficult.

Open Bay

Six Mile Road (3).--Site 3 was located at the mouth of Offatts Bayou, at the northern end of Six Mile Road. The water was shallow and had a maximum measured depth of .6 m during the study. The bottom was composed of sand, silt, and clay. An oyster reef was located just east of this site.

Eight Mile Road (5).--Site 5 was located in West Bay at the northern end of Eight Mile Road just east of Andy's Fish Camp. The water averaged about .75 m in depth and the substrate consisted of shell and rock gravel, sand, silt, and clay. An oyster reef was located just east of this station.

Sea Isle (12).--Collections were made across the mouth of a small bayou just east of the Sea Isle housing development. The water was .6 to 19 m deep and the sediments consisted of sand, silt, and clay.

Muddy Bayou

Sydnor Bayou (*4*).--Site 4 was located at the north end of *Spartina*-lined Sydnor's Bayou which is just east of Six Mile Road. The water averaged about .6 m deep, and the sediments were composed of sand, silt, and clay.

Tucker Bayou (*8*).--Collections were made near the boat ramp on the southeast side of Tucker Bayou which is opposite 11 Mile Road. The depth of the water was .6 to .9 m and the sediments were composed of sand, silt, and clay.

Salt Marsh

Jamaica Beach 1 (JB_1).--Site JB_1 was located just east of the Jamaica Beach housing development in a *Spartina* marsh. The water depth varied from .15 to .75 m and the bottom consisted of sand, plant detritus, silt, and clay.

Jamaica Beach 2 (JB_2).--Collections were made just west of Jamaica Beach in a *Spartina* marsh. The water ranged from .15 to .75 m deep, and the bottom was composed of sand, plant detritus, silt, and clay.

Lagoon

East Lagoon (*15*).--Site 15 was located at the west end of East Lagoon which is at the east end of Galveston Island. The water depth varied from .15 to .9 m, and the substrate consisted of sand and shell gravel.

Temporary Ponds

Three of the 5 ponds sampled were located along Boddeker Drive at the east end of Galveston Island. Under normal conditions they were isolated from each other; but during extremely high tides during November, 1971 and April and October, 1973, they were connected. The shores of all three ponds were lined with *Spartina* grass.

Boddeker 1 (17).--This pond is about 30 m long and 15 m wide at its widest point. The water depth varied from .3 m along the shore to 1.5 m in the middle, the bottom was composed of fine sand.

Boddeker 2 (18_1).--This is the smallest of the three ponds and lies about 100 m north of site 17. It is about 15 m long and 10 m wide at its widest point. Its depth never exceeded .6 m. During June and July, 1971, the water was only .15 m deep, making sampling difficult. The sediments were composed of fine sand and silt.

Boddeker 3 (18_2).--This pond is about 100 m north of site 18_1 and is about twice as large as site 17. Its depth varied from .5 m along shore to more than 1.5 m in the middle. The sediments were composed of fine sand and silt. Collecting was not begun at this site until July, 1971 when it looked as if site 18_1 was going to dry up.

East Lagoon Pond (16).--Site 16 is a small pond located about 30 m from the end of East Lagoon. During high tides in November, 1971 and April, 1973 it became continuous with East Lagoon. Its depth varied from .3 m along the shore to 1.2 m in the middle. The substrate of site 16 consisted of sand, shell and rock gravel, and plant detritus.

Six Mile Road Pond (2).--This collecting site was a large pond located about .5 km from the junction of Six Mile Road and Stewart

Road. Its depth varied from .3 to 1.2 m and the bottom was composed of fine sand and silt and was covered with *Ruppia* during the warmer months of the year. During 1971-72 *Ruppia* was present from February through November except for July and August. During these months the pond nearly dried up and the water was extremely hot. During 1973-74 *Ruppia* was present from February through October. Shortly after my sampling was completed, station 2 was filled in during construction of the Galveston Municipal Golf Course.

Brackish Bayou (1).--Site 1 was located in Lake Madeline which is a partially enclosed body of water surrounded by homes. The lake leads to Offatts Bayou by way of a narrow canal. Another narrow canal leading from the northwest corner of the lake goes under Jones Drive. Site 1 was at this point. The water depth varied from .7 to 1.5 m and the bottom consisted of fine sand.

Rocky Clear Bayou (21).--Site 21 was located in Offatts Bayou which is a small embayment near the east end of West Bay. Collections were made just east of the south end of a causeway which extends across the bayou at its east end. The water averaged about 1.5 m deep along the shore, and was usually clear. The bottom was covered with large rocks and the sediments consisted of sand and shell gravel.

Bay Grass Bed (14).--Site 14 was located about 1.6 m from the west end of Galveston Island at West Bay Fishing Camp. *Spartina* grass lined the shore and a large bed of *Diplanthera* began about 30 m into the open bay. The sea grass was present during both years of sampling from June through Oct.-Nov. Collections were made in the sea grass bed where the water never exceeded .5 m deep and sediment was fine sand.

Bayou Entrance (9).--Site 9 was at the north end of Twelve Mile Road in Pirate's Cove housing development near the junction of a small bayou and West Bay. The shore was steep and covered with loose bricks and rocks. The water was .9 to 1.2 m deep, and the substrate consisted of brick, rock gravel, and sand.

Tucker Bayou

Tucker Bayou is a long winding bayou that leaves the south side of West Bay opposite 11 Mile Road. The 4-station transect (Figure 4) was made at the south end of the bayou which is about 120 m wide and lined with *Spartina*. The average water depth of each station is shown in Figure 4. The sediment of station 1 was composed mostly of fine sand and a small amount of mud, while station 2 was about half fine sand and half mud. The bottoms of stations 3 and 4 were largely fine sand with a moderate amount of mud.

West Bay

A transect consisting of 7 stations was made across West Bay on a line from just east of the junction of West Bay and Tucker Bayou to a point just east of Green's Lake (Figure 5). The width of West Bay at this point was 4.8 km, and the average depth of each station is shown in Figure 4. The sediments of stations 2,3,4, and 5 were composed of large amounts of fine sand and moderate amounts of mud. Stations 1 and 7 were mostly fine sand, and station 6 was fairly equal amounts of shell, fine sand, and mud since it was on an oyster bed.

HYDROGRAPHIC DATA

Precipitation

In the Galveston Bay system and surrounding areas, a 39 year period (1935-1974), the average yearly rainfall, about 122 cm, has been well distributed throughout the year. The lowest precipitation usually occurs in spring, followed by a steady rise in summer, to a peak in September (Figure 10). Precipitation in the Galveston Bay area during year 1 totaled 108.5 cm and was below average 8 of 12 months; from February through July little rainfall occurred. This dry period was followed by a peak of above average rainfall in August-September, a sharp drop in October, and another peak in December (Figure 10). In contrast, rainfall during year 2 totaled 182.3 cm and was above average 7 of 13 months. Three large peaks occurred in April, June, and September-October with a smaller peak the following January (Figure 10).

Temperature

Several hydrographic studies indicate that the water temperature in the Galveston Bay system undergoes a fairly regular yearly cycle (Hedgepeth 1953; Martinez 1970; Kalke 1972). Peak temperatures of around 30 C occur from June through September, followed by a decline to around 10 C in December. Temperatures remain low until March when the water begins warming, reaching a peak in June.

The monthly water temperature data for each station in each study area each year are presented in Tables 39 through 42 in the Appendix. The mean water temperature for the near shore area for the 2 year

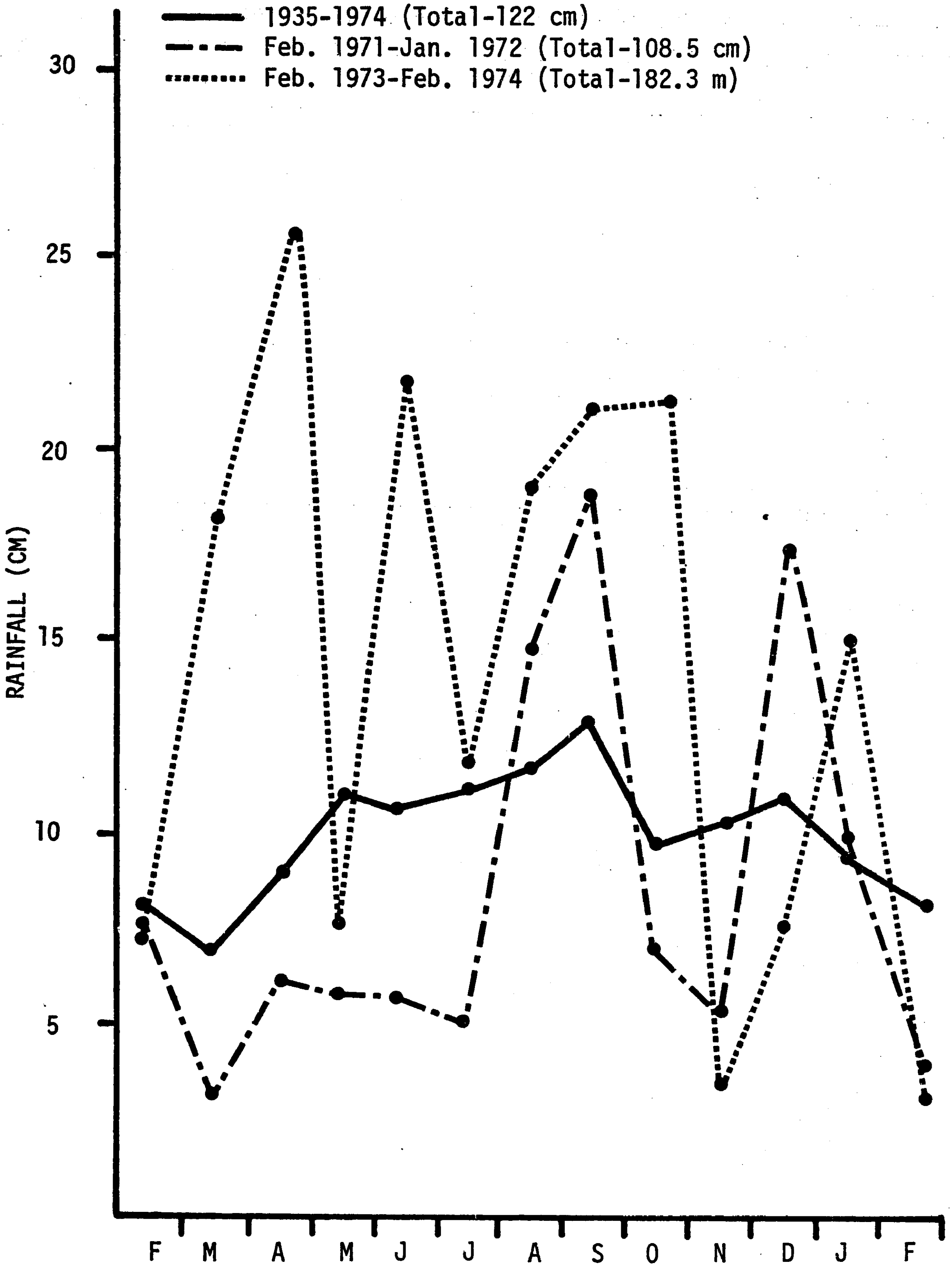

Figure 10. Mean monthly rainfall for Galveston, Houston, and Anahuac from February 1971-January, 1972, February, 1973-February, 1974 and from 1935-1974. (U.S. Department of Commerce 1968, 1971-74,1974a,1974b).

sampling period was 23.9 C (year 1 - 24.1 C; year 2 - 23.7 C).

From around 20 C in February, 1971 the average monthly temperature declined slightly in March, rose to above 30 C in June, and leveled off through August (Figure 11). It dropped to a low of around 15 C in November, and rose slightly the last two months of year 1. During year 2 the mean monthly temperature rose from 8.5 C in February, to a peak of over 30 C in June-August and declined to around 20 C the following February.

Table 1 gives the temperature means and ranges for the habitats and stations of the near shore area in year 1. Little difference existed between the means and ranges of the habitats and stations. The greatest difference in the mean temperature of the stations was only 2.3 C - station 21 (22.9 C) and station 8 (25.2 C).

Table 2 gives the temperature means and ranges for the habitats and stations of the near shore area in year 2. The greatest difference in the mean temperature of the stations was 3.6 C - station 21 (22.0 C) and station JB_2 (25.6 C).

The mean temperature for the Tucker Bayou transect was 23.4 C. The seasonal changes in water temperature were similar to the cycle described for the near shore area in 1973-1974 (Figure 11). Surface and bottom temperatures were taken 4 of the 6 sampling trips. In all cases the surface temperature was equal to or greater than the bottom temperature of the same station. During the cooler months the mean bottom temperature never varied more than 0.5 C from the mean surface temperatures. During June and August the mean bottom temperatures were 1-1.25 C less than the mean surface temperatures.

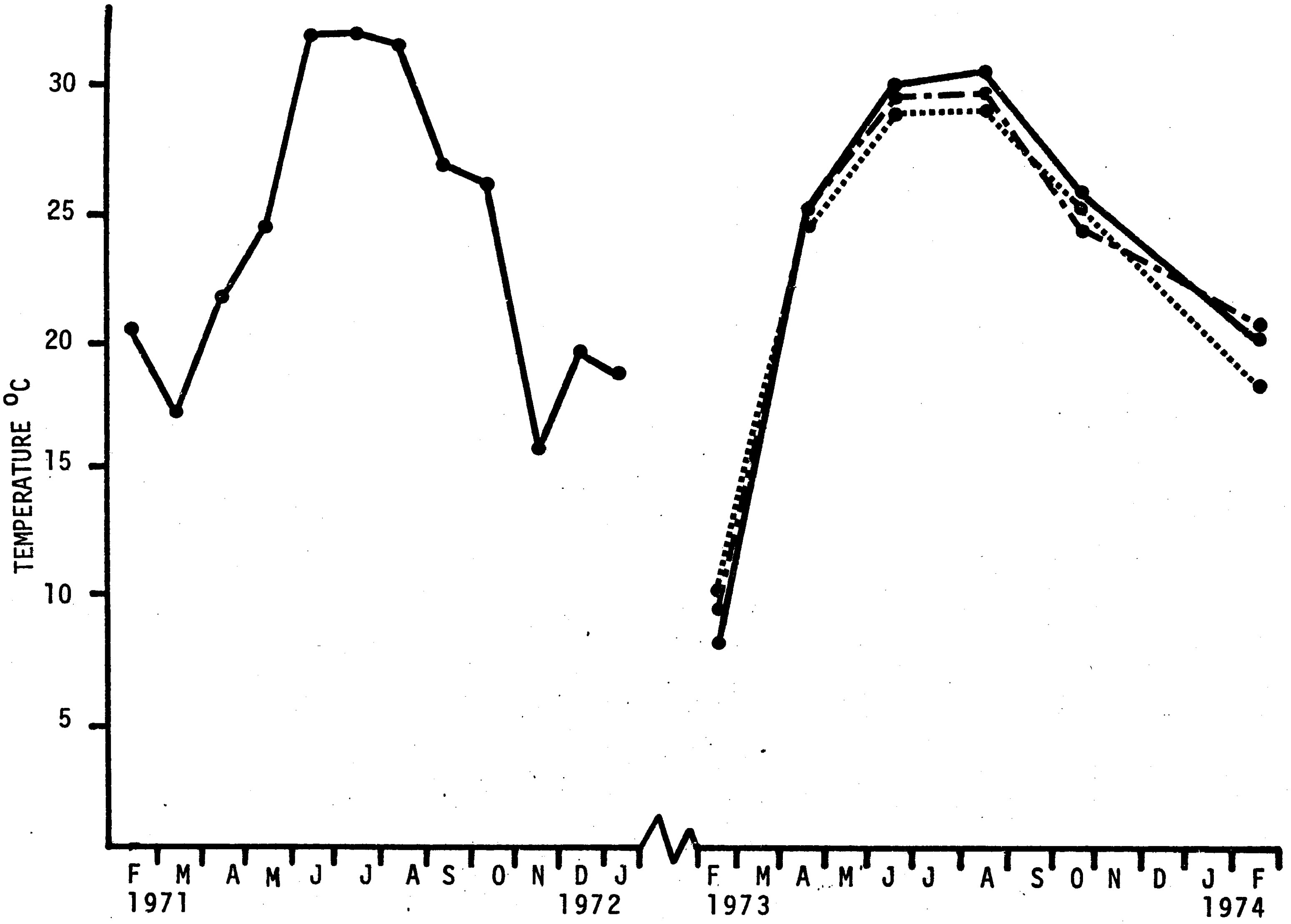

Figure 11. Mean monthly temperature values for Galveston Island in 1971-72 and 1973-74. Nearshore area (——), Tucker Bayou (— · —), West Bay (········).

Table 1. Temperature (^{o}C) ranges and means for habitats and individual stations in the nearshore area in 1971-72.

Habitats and Stations	Maximum	Minimum	Mean
Seaside Beach	33.0	15.0	23.5
19	32.0	15.6	22.9
20	33.0	15.6	22.9
10	33.0	15.0	23.9
7	33.0	16.0	23.9
13	33.0	15.0	23.7
Open Bay	35.5	17.0	24.4
3	35.5	17.0	24.2
5	34.0	17.0	24.1
12	35.0	12.0	25.0
Muddy Bayou	36.0	16.0	24.8
4	36.0	16.0	24.2
6	36.0	17.0	25.0
8	36.0	16.5	25.2
Salt Marsh	36.0	11.0	24.8
JB_1	36.0	11.0	24.5
JB_2	36.0	16.0	25.1
Temporary Ponds	37.0	13.0	24.2
2	37.0	16.0	24.2
16	35.0	13.0	24.3
17	35.0	14.0	23.5
18_1	37.0	14.0	24.8
18_2	35.0	14.0	24.4
Lagoon - 15	33.0	13.0	23.3
Brackish Bayou - 1	32.0	11.0	23.1
Rocky Clear Bayou - 21	32.0	14.0	22.9
Bay Grass Bed - 14	35.0	14.0	25.0
Bayou Entrance - 9	36.0	16.0	24.7

Table 2. Temperature (^{o}C) ranges and means for habitats and individual stations in the nearshore area in 1973-74.

Habitats and Stations	Maximum	Minimum	Mean
Seaside Beach	32.0	9.5	23.4
19	32.0	9.5	23.8
20	31.0	9.5	22.8
10	31.0	10.0	22.8
7	31.0	10.0	23.8
13	31.0	10.0	23.8
Open Bay	31.5	9.5	23.5
3	31.5	9.5	22.5
5	31.0	11.0	23.9
12	31.0	10.0	24.2
Muddy Bayou	32.0	8.0	24.0
4	32.0	9.5	23.2
6	32.0	8.0	24.3
8	31.5	8.5	24.5
Salt Marsh	32.0	10.0	25.0
JB_1	31.0	10.0	24.4
JB_2	32.0	11.0	25.6
Temporary Ponds	34.5	5.0	24.1
2	34.5	8.0	24.5
16	32.0	6.5	23.8
17	33.0	5.0	23.8
18_1	32.0	6.5	24.2
18_2	33.5	6.0	24.1
Lagoon - 15	31.0	5.5	23.3
Brackish Bayou - 1	30.0	7.0	22.7
Rocky Clear Bayou - 21	30.0	7.0	22.0
Bay Grass Bed - 14	31.0	10.0	24.7
Bayou Entrance - 9	30.0	9.0	23.6

For the sampling period the greatest difference in the mean temperatures of the stations was only 0.4 C (Table 41).

The mean temperature of the West Bay transect was 22.6 C. The seasonal changes in temperature were similar to the other two study areas sampled in year 2 (Figure 11). Surface and bottom temperatures were taken 4 of the 6 sampling trips, and little difference existed between the two zones. During August and February, 1974 the mean bottom temperature was 0.3-0.5 C less than the mean surface temperature. The greatest difference in the mean surface temperatures of the stations for the year was 1 C (Table 42).

Salinity

As indicated by hydrographic data, the salinity pattern in the Galveston Bay system does not follow a predictable yearly cycle (Hofstetter 1959; Martinez 1966, 1968, 1970; Harper 1970). This is because rainfall is not uniform from year to year. Freshwater runoff from the Trinity River and tidal influx through Bolivar Roads are the two main influences on the salinity patterns of the bay system (Hofstetter 1959). West Bay is the most saline area in the bay system since it is farthest away from the Trinity River discharge, and is influenced by two tidal passes. The average annual salinity range of West Bay is 11-34 ppt (Hofstetter 1959; Stevens 1963).

The monthly salinity data for each station in each study area each year are presented in Tables 43 through 46 in the Appendix. The mean salinity for the near-shore area for the 2 year sampling period was 22.7 ppt (year 1 - 25.5 ppt; year 2 - 17.4 ppt). From 25.4 ppt in February, 1971 the mean monthly salinity dipped slightly and then rose to a peak of over 34 ppt in July (Figure 12). It declined sharply to about 20 ppt in September due to heavy rains. Moderate rains continued through the remainder of year 1, and after a slight rise in October the salinity declined steadily to a low of 19 ppt in January. During year 2 the mean monthly salinity declined from 19 ppt in February to a low of 12.7 ppt in June. It rose to 20.7 ppt in August and fell slightly to 18.6 ppt in February, 1974.

Table 3 gives the salinity means and ranges for the habitats and stations of the year 1 nearshore area. The habitats with the highest and lowest mean salinities were station 14 (28.3 ppt) and station 1 (17.5 ppt), respectively. The other habitats varied only 4 ppt (23.6-27.6 ppt) in mean salinity. The salinity range of most stations was 12-20 ppt; however, stations 1 and 2 had ranges of 36 and 30 ppt, respectively due to low salinities there. A salinity gradient extended along the bayside of Galveston Island with the salinity increasing toward the west end.

Table 4 gives the salinity means and ranges for the habitats and stations of the year 2 near shore area. The only habitat with a mean salinity exceeding 20 ppt was Seaside Beach (21.6 ppt). The habitats with the lowest mean salinities were station 1 (11.6 ppt) and Temporary Brackish Pond (13.9 ppt). The difference between the mean salinities of all other habitats was 4.1 ppt (15.2-19.3 ppt). The least salinity range was 5.9 ppt at station 21, the greatest was 18 ppt at stations 12 and 19.

The mean salinity for the Tucker Bayou transect was 18.1 ppt. The seasonal pattern was similar to the pattern of the nearshore area (Figure 12). No difference existed between the surface and

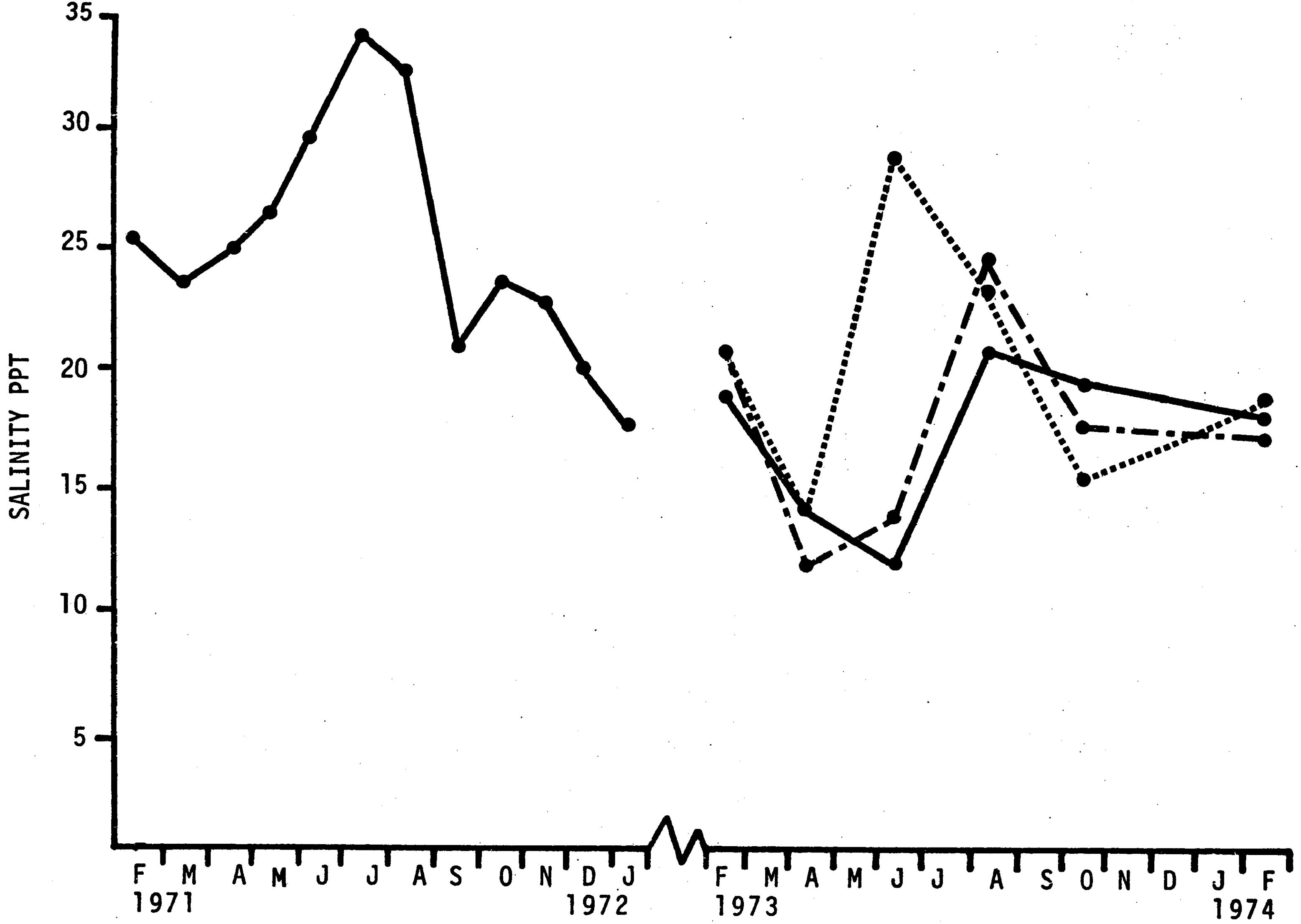

Figure 12. Mean monthly salinity values for Galveston Island in 1971-72 and 1973-74. Nearshore area (———), Tucker Bayou (— · —), West Bay (········).

Table 3. Salinity (ppt) ranges and means for habitats and individual stations in the nearshore area in 1971-72.

Habitats and Stations	Maximum	Minimum	Mean
Seaside Beach	35.10	21.60	27.6
19	34.56	22.68	27.4
20	34.02	21.60	27.2
10	35.10	22.68	27.6
7	35.10	23.22	27.9
13	34.56	23.76	27.8
Open Bay	34.56	21.06	25.9
3	32.40	18.36	25.4
5	33.48	18.36	25.6
12	34.56	21.06	26.8
Muddy Bayou	34.56	17.80	25.8
4	32.40	18.36	25.1
6	34.56	17.80	26.2
8	34.56	18.36	26.1
Salt Marsh	37.8	19.44	27.0
JB_1	37.8	19.44	26.7
JB_2	36.7	19.44	27.2
Temporary Ponds	39.96	4.32	23.6
2	39.96	4.32	13.1
16	36.72	12.42	26.4
17	36.72	19.44	26.5
18_1	39.96	19.44	27.3
18_2	34.56	18.36	24.9
Lagoon - 15	32.40	18.36	25.1
Brackish Bayou - 1	31.32	1.33	17.5
Rocky Clear Bayou - 21	32.40	12.96	23.9
Bay Grass Bed - 14	34.56	22.68	28.3
Bayou Entrance - 9	35.64	18.36	26.5

Table 4. Salinity (ppt) ranges and means for habitats and individual stations in the nearshore area in 1973-74.

Habitats and Stations	Maximum	Minimum	Mean
Seaside Beach	30.0	12.0	21.6
19	30.0	12.0	21.0
20	28.0	14.0	21.9
10	27.0	14.5	21.7
7	26.0	15.0	21.3
13	26.0	15.0	22.0
Open Bay	28.0	9.0	17.3
3	21.0	9.0	16.0
5	21.1	9.0	16.7
12	28.0	10.0	19.2
Muddy Bayou	25.0	12.0	17.3
4	19.0	12.0	17.0
6	22.0	12.0	16.5
8	25.0	13.0	18.3
Salt Marsh	26.0	12.0	19.3
JB_1	25.0	12.0	-
JB_2	26.0	12.0	19.3
Temporary Ponds	25.0	2.0	13.9
2	13.5	2.0	7.1
16	25.0	15.0	18.6
17	21.0	10.0	16.0
18_1	20.5	10.0	14.8
18_2	19.0	10.0	13.2
Lagoon - 15	19.0	9.0	15.2
Brackish Bayou - 1	18.0	1.1	11.6
Rocky Clear Bayou - 21	21.0	15.1	17.2
Bay Grass Bed - 14	25.0	15.0	-
Bayou Entrance - 9	24.0	12.0	17.9

bottom salinities or the mean salinities of the stations (Table 45).

The mean salinity for the West Bay Transect was 20.3 ppt. The seasonal salinity pattern for West Bay was somewhat different from the other two study areas sampled in 1973-1974 (Figure 12). From about 20 ppt in February, 1973 the salinity dropped to a low of 13.8 ppt in April and then rose sharply to nearly 30 ppt in June. It declined to around 16 ppt in October and rose slightly the following February. The salinity in West Bay seemed to react more quickly to precipitation changes than the salinities in the more shallow water areas. Little difference existed between the surface and bottom salinities of any of the stations. The greatest difference between the mean salinities of the stations was 0.8 ppt (Table 46). At times there was a slight salinity gradient along the stations, with the lower salinities occurring toward the mainland.

RESULTS

Composition of Mysidacea in the Galveston Island Area

A total of 7 species of mysid were collected during the two year sampling period. Table 5 gives total number and percentage composition of each species found in the study and in each study area. *Mysidopsis almyra* was the dominant species found throughout the study, composing nearly 82 per cent of the mysids collected. The next 3 most abundant species were *Mysidopsis bahia*, *Mysidopsis bigelowi*, and *Metamysidopsis swifti*. Only 68 specimens of *Bowmaniella* spp. were collected; however, this may not represent a true evaluation of their abundance, since I have observed specimens of this genus burrowing into the sediment in the laboratory. The specimens collected were either *B. brasiliensis* or *B. dissimilis*. These two species can be distinguished from one another only by differences in the copulatory organ of the third pleopod of mature males. The single mature male collected was *B. brasiliensis*. *Brasilomysis castroi* and *Promysis atlantica* are offshore species and probably wandered into or were carried into the bay with inflow of offshore waters.

Ecological Distribution of Mysidacea Among the Study Areas

The distribution of the mysid species in the study areas and a comparison of the study areas are presented when possible. Because of differences in sampling gear and sampling conditions not all study areas can be quantitatively compared. Nearshore area years 1 and 2 can be compared as can the 2 transects; however, the nearshore area can not be quantitatively compared with the two transects. The number

Table 5. Total numbers and percentage composition of each mysid species from all study areas from Galveston Island in 1971-72 (year 1) and 1973-74 (year 2).

Study area/ Species	Nearshore year 1		Nearshore year 2		Tucker Bayou		West Bay		Entire Study	
	Total No.	%	Total No.	%	Total No.	%	Total No.	%	Total No.	%
Mysidopsis almyra	39,524	65.5	65,710	94	46,052	99.6	5,132	33.8	156,418	81.6
Mysidopsis bahia	15,969	26.4	2,167	3	36	<0.1	402	2.6	18,574	9.7
Mysidopsis bigelowi	89	<1	0	0	154	<1	9,583	63.2	9,826	5.0
Metamysidopsis swifti	4,765	7.9	1,941	3	0	0	9	<0.1	7,144	3.7
Bowmaniella spp.	19	<0.1	0	0	1	<0.1	48	<1	68	<0.1
Brasilomysis castroi	5	<0.1	0	0	0	0	0	0	5	<0.1
Promysis atlantica	4	<0.1	0	0	0		0	0	4	<0.1
Total	60,375	100	69,818	100	46,243	100	15,174	100	191,610	100
Number of tows	265		137		24		42			
Sampling gear	Beam trawl		Beam trawl		Ockelmann sledge		Ockelmann sledge			

per tow of each mysid species in each study area is presented in Table 6.

Mysidopsis almyra

Mysidopsis almyra ranked first in numbers in every study area, except West Bay where it made up one-third of the mysids and ranked second behind M. bigelowi. It was virtually the only species found in Tucker Bayou, where it composed 99 per cent of the collections. In the nearshore area in 1971-1972 M. almyra composed 65.5 per cent of the population and was 2.5 times more abundant than M. bahia, the second most common mysid. In the same area in 1973-1974 M. almyra made up 94 per cent of the population and was over 30 times more abundant than M. bahia.

Mysidopsis bahia

Mysidopsis bahia was most numerous in the nearshore area where it ranked second in abundance both years; however, it was much more numerous in year 1 than year 2. It ranked third in abundance in West Bay, making up 2.6 per cent of the collection. Only 36 specimens (<0.1 per cent) were taken in Tucker Bayou.

Mysidopsis bigelowi

Mysidopsis bigelowi was numerous only in West Bay where it ranked first in abundance and composed 63.2 per cent of the mysids taken. It made up less than 1 per cent of the collections in Tucker Bayou and nearshore area year 1, and no M. bigelowi were found in the nearshore area in year 2.

Table 6. Number per tow of each mysid species collected from each study area of Galveston Island in 1971-72 and 1973-74.

Study area/ Species	Nearshore-year 1 No/Tow	Nearshore-year 2 No/Tow	Tucker Bayou No/Tow	West Bay No/Tow
Mysidopsis almyra	149	480	1,919	122
Mysidopsis bahia	60	16	2	10
Metamysidopsis swift	18	14	0	<1
Mysidopsis bigelowi	<1	0	6	228
Bowmaniella spp.	<1	0	<1	1
Brasilomysis castroi	<1	0	0	0
Promysis atlantica	<1	0	0	0
Total	228	510	1,927	361

Metamysidopsis swifti

Metamysidopsis swifti was collected in large numbers only in the nearshore area where it composed 7.9 and 3 per cent of the total population in years 1 and 2. Only 9 specimens were found in West Bay and none were collected in Tucker Bayou.

Bowmaniella spp.

Bowmaniella spp. were not numerous in any study area, but were found most frequently in West Bay and the nearshore area in year 1.

Brasilomysis castroi

For the entire study only 5 specimens of *B. castroi* were collected and all were found in year 1 in the nearshore area.

Promysis atlantica

All 4 *P. atlantica* collected during the study were found in year 1 in the nearshore area.

Nearshore Area, Year 1 vs. Year 2

All 7 species reported in the study were found in year 1 but only the 3 most abundant of these species were found in year 2. However, only half as many samples were taken the second year as the first. A quantitative comparison of the 2 years shows that more than twice as many individuals per tow were taken in year 2 as in year 1 (510 to 228). *M. almyra* was more than 3 times as numerous per tow in year 2 as in year 1; however, *M. bahia* was only one-fourth as abundant per tow in the second year as the first. The number per tow of *M. swifti* was approximately the same both years, being slightly more abundant the first year than the second.

Tucker Bayou vs. West Bay

The same species were collected in both areas with the exception of _M. swifti_, which was found only in West Bay. Over 5 times as many mysids per tow were taken in Eckert Bayou as West Bay (1,927 to 361). _M. almyra_ was nearly 16 times more abundant per tow in Tucker Bayou than in West Bay; however, _M. bigelowi_ and _M. bahia_ were about 36 and 6 times as numerous per tow in West Bay as in Tucker Bayou. _Bowmaniella_ spp. was about 3 times as abundant per tow in West Bay as Tucker Bayou, although few specimens were collected in either area.

Composition of Mysidacea within each Study Area

The distribution of the mysid species within each study area is examined. In the nearshore area, the various habitats are compared and in Tucker Bayou and West Bay the individual stations are compared.

Nearshore Area

All 7 species collected during the study were found in the seaside beach habitat, followed by 6 species from the open bay and 5 species from the bay grass bed (Table 7). At least 3 species were found in each habitat type. Table 8 shows that for the 2 year period the largest numbers of mysids were collected in the bayou entrance (1338/tow) and muddy bayou (942/tow), followed by brackish bayou (415/tow), salt marsh (306/tow), and temporary brackish pond (243/tow). The most diverse habitats yielded low numbers of mysids - open bay (135/tow), seaside beach (79/tow), and bay grass bed (45/tow). The fewest mysids were collected in the rocky clear bayou (5/tow) and the lagoon (2/tow). The numbers per tow of the mysid species collected

Table 7. Per cent composition of the mysid species in each habitat of the nearshore area of Galveston Island in 1971-72 and 1973-74.

Species/Habitat	Station No	*Mysidopsis almyra*	*Mysidopsis bahia*	*Mysidopsis bigelowi*	*Metamysidopsis swifti*	*Bowmaniella spp*	*Promysis atlantica*	*Brasilomysis castroi*
Seaside Beach	7,10,13 19,20	10.4	<1	<1	88.8	<1	<0.1	<0.1
Open Bay	3,5,12	57.6	42.1	0	<1	<1	<0.1	<0.1
Muddy Bayou	4,6,8	90.6	9.0	<0.1	<1	0	0	0
Salt Marsh	JB$_1$,JB$_2$	95.8	3.7	<1	0	0	0	<0.1
Lagoon	15	22.2	11.1	0	66.7	0	0	0
Temporary Pond	2,16,17,18$_1$, 18$_2$	99.6	<0.1	0	<1	0	0	0
Brackish Bayou	1	96.9	2.6	0	<1	<.01	0	0
Rocky Clear Bayou	21	6.7	1.1	0	92.2	0	0	0
Bay Grass Bed	14	8.0	91.4	0	0	<1	<0.1	<.01
Bayou Entrance	9	70.1	29.8	0	<0.1	<.01	0	0

Table 8. Number per tow of the more common mysid species in each habitat of the nearshore area of Galveston Island 1971-72 and 1973-74.

Habitat/	Seaside Beach			Open Bay			Muddy Bayou			Salt Marsh		
Species	Year 1	Year 2	Entire Study	Year 1	Year 2	Entire Study	Year 1	Year 2	Entire Study	Year 1	Year 2	Entire Study
Mysidopsis almyra	11	2	8	15	203	78	536	1487	853	142	571	293
Mysidopsis bahia	<1	<0.1	<1	69	33	57	122	12	85	6	21	11
Mysidopsis bigelow	<1	0	<1	0	0	0	<1	0	<0.1	3	0	2
Metamysidopsis swifti	78	55	70	0	<1	<1	<1	11	4	0	0	0
Bowmaniella spp.	<0.1	<1	<0.1	<1	<1	<1	0	0	0	0	0	0
TOTAL	90	57	79	84	237	135	658	1510	942	151	591	306

	Temporary Pond			Lagoon			Brackish Bayou			Rocky Clear Bayou		
Species	Year 1	Year 2	Entire Study	Year 1	Year 1	Entire Study	Year 1	Year 2	Entire Study	Year 1	Year 2	Entire Study
Mysidopsis almyra	123	457	242	<0.1	<1	<1	601	37	402	<1	<1	<1
Mysidopsis bahia	<1	<0.1	<1	0	<1	<1	16	0	11	0	<1	<0.1
Mysidopsis bigelowi	0	0	0	0	0	0	0	0	0	0	0	0
Metamysidopsis swifti	1	<1	<1	<1	2	1	0	6	2	3	8	5
Bowmaniella spp.	0	0	0	0	0	0	0.1	0	0.1	0	0	0
TOTAL	124	457	243	<1	3.	2	618	43	415	4	9	5

Table 8 - (Continued)

Species	Bay Grass Bed			Bayou Entrance		
	Year 1	Year 2	Entire Study	Year 1	Year 2	Entire Study
Mysidopsis almyra	<1	10	4	208	2400	938
Mysidopsis bahia	5	119	41	561	<1	399
Mysidopsis bigelowi	0	0	0	0	0	0
Metamysidopsis swifti	0	0	0	<1	0	<1
Bowmaniella spp.	<0.1	0	<0.1	<0.1	0	<0.1
TOTAL	6	129	45	769	2401	1338

at each station and each habitat type, and their incidence of occurrence for the 2 year study are given in Tables 8, 9 and 10.

Mysidopsis almyra.--Over the 2 year study M. almyra was the most abundant mysid collected in the temporary pond, muddy bayou, brackish bayou, salt marsh, bayou entrance, and open bay habitats, comprising over 90 per cent of the mysids collected in all but the last 2 of these habitats (Table 7). It ranked second in numbers in the other 4 habitats. M. almyra was most abundant in the bayou entrance (938/tow) and muddy bayou (853/tow) habitats.

Much larger numbers per tow were found in year 2 than year 1 in most habitats. In year 1 M. almyra ranked second in abundance in the open bay habitat, comprising only 18 per cent (15/tow) of the population. In year 2 it was first in abundance and composed 86 per cent (203/tow) of the mysids collected. M. almyra was second in abundance in the bayou entrance habitat in year 1 making up 27 per cent (208/tow) of the population. In year 2 it comprised 97 per cent (2400/tow) of the mysids collected. M. almyra was from 2 to 12 times more abundant in year 2 than year 1 in the muddy bayou, salt marsh, temporary pond, bay grass bed, and lagoon. It was more numerous per tow the first year than the second in only 2 habitats - seaside beach and brackish bayou.

Mysidopsis bahia.--Over the 2 year study M. bahia was the numerically dominant mysid at only 1 habitat - bay grass bed. In the Diplanthera bed it made up 91 per cent of the mysids collected, but yielded only 41 individuals per tow. Although it ranked second in abundance in 5 other habitats, M. bahia was collected in large

Table 9. Number per tow of each mysid species at each station in each habitat of the nearshore area of Galveston Island in 1971-72 and 1973-74.

Habitat/		Seaside Beach					Open Bay			Muddy Bayou			Salt Marsh	
Species	Year	19	20	10	7	13	3	5	12	4	6	8	JB	11
Mysidopsis almyra	1	54	<1	<1	2	<0.1	30	9	7	227	490	891	177	98
	2	10	<1	0	<1	0	117	23	468	16	2721	1724	272	870
Mysidopsis bahia	1	0	<0.1	<1	<1	<1	98	58	50	24	211	129	9	3
	2	0	0	0	0	<1	40	30	29	2	3	31	5	36
Mysidopsis bigelowi	1	<1	0	<1	1	0	0	0	0	0	<1	0	<1	9
	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Metamysidopsis swifti	1	66	10	49	260	3	0	0	0	0	0	1	0	0
	2	45	34	30	157	8	0	1	0	0	0	32	0	0
Bowmaniella spp	1	<1	0	<0.1	0	<0.1	<0.1	<1	0	0	0	0	0	0
	2	<1	<1	1	0	0	<1	<1	0	0	0	0	0	0
Promysis atlantica	1	0	0	0	0	<0.1	0	<0.1	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Basilomysis castroi	1	0	0	0	0	<0.1	0	<1	0	0	0	0	<0.1	0
	2	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9 - (Continued)

Habitat/ Species	Year	Temporary Pond					Lagoon	Brackish Bayou	Rocky Clear Bayou	Bay Grass Bed	Bayou Entrance
		2	16	17	18_1	18_2	15	1	21	14	9
Mysidopsis almyra	1	27	48	460	3	23	<0.1	601	<1	<1	208
	2	33	<1	722	952	577	<1	37	<1	10	2400
Mysidopsis bahia	1	<1	<1	<1	<0.1	<1	0	16	0	5	561
	2	0	<1	0	0	0	<1	0	<1	119	77
Mysidopsis bigelowi	1	0	0	0	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0	0	0	0
Metamysidopsis swifti	1	<0.1	0	0	5	0	<1	0	3	0	<1
	2	<1	<1	0	0	0	2	6	8	0	0
Bowmaneilla spp	1	0	0	0	0	0	<0.1	<0.1	0	<0.1	<0.1
	2	0	0	0	0	0	0	0	0	0	0
Promysis atlantica	1	0	0	0	0	0	0	0	0	<1	0
	2	0	0	0	0	0	0	0	0	0	0
Brasilomysis castroi	1	0	0	0	0	0	0	0	0	<0.1	0
	2	0	0	0	0	0	0	0	0	0	0

Table 10. Incidence of occurrence of mysid species in different habitats of Galveston Island for 1971-72[a] and 1973-74[b].

Habitat/ Species	Seaside Beach		Open Bay		Muddy Bayou		Salt Marsh		Temporary Pond		Lagoon		Brackish Bayou		Rocky Clear Bayou		Bay Grass Bed		Bayou Entrance	
Collections Made	[a]60	[b]30	36	18	36	18	22	12	54	30	12	6	11	6	11	6	11	5	12	6
Mysidopsis almyra	9	5	20	11	30	16	19	12	30	22	1	1	11	5	1	1	3	2	11	5
Mysidopsis bahia	4	1	29	10	21	10	15	6	10	1	0	1	4	0	0	1	6	4	10	4
Mysidopsis bigelowi	5	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Metamysidopsis swifti	48	17	0	1	1	1	0	0	2	3	1	2	0	2	3	3	0	0	1	0
Bowmaniella spp	4	4	3	2	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0
Promysis atlantica	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Brasilomysis castroi	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0

numbers only in the bayou entrance (399/tow), muddy bayou (85/tow), and open bay (78/tow) habitats.

In most habitats M. bahia was more numerous per tow in year 1 than in year 2. In year 1 it ranked first in abundance in the open bay habitat, making up 82 per cent (69/tow) of the population. In year 2 it was second in abundance, but comprised only 14 per cent (33/tow) of the mysids collected. M. bahia was the most abundant mysid collected in the bayou entrance habitat in year 1 comprising 73 per cent (561/tow) of the collections. However, in year 2 it made up only 3 per cent (0.5/tow) of the mysids collected. Although it ranked second in abundance in the muddy bayou, temporary pond, and brackish bayou habitats both years, M. bahia was at least 10 times more abundant per tow in these habitats in year 1 than in year 2. It was more numerous per tow the second year than the first in only 2 habitats - bay grass bed and salt marsh.

Metamysidopsis swifti.--Although M. swifti was collected in every habitat but the salt marsh and bay grass bed, it was more numerous and most often collected at the seaside beach habitat. Over the 2 year sampling period about 94 per cent of M. swifti collected from the nearshore area came from this habitat. It was by far the most common mysid found at the seaside beach, outnumbering the second most numerous mysid, M. almyra nearly 9 to 1. M. swifti was observed in 65 of 90 collections made at this habitat.

Although it was not numerous in any other habitat, M. swifti was the dominant mysid collected in the rocky clear bayou and the lagoon. In the first habitat it was found in 6 of 17 collections and composed 83 of the 90 specimens taken over the 2 year period. Of the 27 mysids collected in the lagoon, 18 were _M_. _swifti_. In all other habitats, this species was observed in only 11 of 277 collections.

Mysidopsis bigelowi.--Eighty-nine specimens of _M_. _bigelowi_ were collected in 3 habitats in 1971-72 only. In the salt marsh 56 individuals were taken in 3 of 34 collections. At the seaside beach 28 _M_. _bigelowi_ were taken and 5 individuals were collected in the muddy bayou habitat.

Bowmaniella spp.--Twenty four of the 27 specimens of _Bowmaniella_ spp. collected over the 2 year study were found at the seaside beach (12) and the open bay (12) habitats. One individual each was collected in the brackish bayou, bay grass bed, and bayou entrance.

Brasilomysis castroi.--Of the 5 _B_. _castroi_ collected, 2 were found in the open bay, and 1 each in the seaside beach, salt marsh, and bay grass bed.

Promysis atlantica.--Of the 4 individuals taken, 2 were collected in the bay grass bed, and 1 each in the seaside beach and open bay.

Tucker Bayou

The 4 stations in the Tucker Bayou transect differed little in water depth. Their sediment composition was about the same except for station 2 which had a much greater mud content than the other 3 stations. Table 11 shows the seasonal occurrence for each mysid species at each station in Tucker Bayou.

Mysidopsis almyra.--_M_. _almyra_ composed more than 99 per cent of the mysids collected and was the most abundant species observed in each of the 24 samples. When the distribution of organisms among

Table 11. Seasonal occurrence of the mysid species collected in Tucker Bayou.

Month/ Station-Species	Feb. 1973	April	June	August	October	Feb. 1974	Mean no per tow
1							
Mysidopsis almyra	39	478	1224	672	3776	934	1,187.2
Mysidopsis bahia	0	6	0	8	0	4	3.0
Mysidopsis bigelowi	0	0	0	0	0	0	-
Bowmaniella spp.	0	0	0	0	0	2	0.3
2							
Mysidopsis almyra	166	116	1096	576	896	158	509.7
Mysidopsis bahia	0	0	0	4	0	0	0.7
Mysidopsis bigelowi	0	0	0	52	4	4	9.3
Bowmaniella spp.	0	0	0	0	0	0	0
3							
Mysidopsis almyra	266	147	2008	11,520	472	470	2,480.5
Mysidopsis bahia	0	0	0	0	2	0	.3
Mysidopsis bigelowi	0	0	0	96	2	0	16.3
Bowmaniella spp.	0	0	0	0	0	0	0
4							
Mysidopsis almyra	457	157	342	7,768	11,424	890	3,506.3
Mysidopsis bahia	0	0	0	0	0	4	.7
Mysidopsis bigelowi	0	0	0	0	0	0	0
Bowmaniella spp.	0	0	0	0	0	0	0

the 4 stations was compared with temperature, salinity, and tide stage no consistant pattern appeared; however, station 2 usually had lowest numbers of _M. almyra_. It averaged about 500 specimens per tow which was less than 1/2 the number per tow of the next lowest station. Stations 3 and 4 had the most specimens per tow, but each of these stations had 1 tow of more than 11,000 _M. almyra_ which accounted for more than 1/2 of their total numbers for the year.

Mysidopsis bahia.--Only 28 specimens were collected during the year. However, 22 of these were collected in the most shallow stations 1 and 4.

Mysidopsis bigelowi.--All 154 specimens collected came from the 2 deeper stations, 2 and 3.

Bowmaniella spp.--Two specimens were observed at station 1.

West Bay

The distribution of the more abundant mysid species in West Bay was related to water depth. Table 12 and Figure 13 show that _Mysidopsis almyra_ inhabited the shallow waters of less than 1 m while _M. bigelowi_ was collected mainly in the deeper water of 2 m or more.

Mysidopsis almyra.--_M. almyra_ was most abundant at shallow water stations 1 and 7. Its numbers decreased toward the middle of West Bay until less than 2.5 individuals per tow were found at stations 3 and 4.

Mysidopsis bahia.--Low numbers of _M. bahia_ were fairly evenly distributed throughout the stations. Although no depth was definitely preferred, larger numbers were more often collected in shallow than deeper waters.

Table 12. Seasonal occurrence of the mysid species collected at each station in West Bay.

Months/ Station-Species	Feb	April	June	August	October	Feb	Mean no per tow
1							
Mysidopsis almyra	2	4	30	384	261	17	116
Mysidopsis bahia	0	15	30	64	13	4	21
Mysidopsis bigelowi	0	0	0	1936	0	0	323
Metamysidopsis swifti	0	0	0	0	0	0	0
Bowmaniella spp.	0	1	0	0	0	2	<1
2							
Mysidopsis almyra	1	0	1	16	26	46	15
Mysidopsis bahia	3	1	1	16	5	14	7
Mysidopsis bigelowi	0	0	91	2152	100	0	391
Metamysidopsis swifti	0	0	0	0	0	0	0
Bowmaniella spp.	0	0	5	0	0	0	<1
3							
Mysidopsis almyra	0	0	0	0	5	9	2
Mysidopsis bahia	0	10	5	24	4	1	7
Mysidopsis bigelowi	1	6	178	2584	152	2	487
Metamysidopsis swifti	0	0	0	0	0	0	0
Bowmaniella spp.	0	0	1	0	0	0	<1
4							
Mysidopsis almyra	0	1	0	6	2	0	2
Mysidopsis bahia	4	3	2	20	5	2	6
Mysidopsis bigelowi	3	7	79	584	111	0	131
Metamysidopsis swifti	0	0	0	0	0	0	0
Bowmaniella spp.	0	0	0	0	0	0	0

Table 12 - (Continued)

Months/ Station-Species	Feb	April	June	August	October	Feb	Mean no per tow
5							
Mysidopsis almyra	0	0	4	3	48	0	9
Mysidopsis bahia	0	9	12	12	20	13	11
Mysidopsis bigelowi	0	0	22	358	457	1	140
Metamysidopsis swifti	0	0	0	0	1	0	<1
Bowmaniella spp.	0	0	0	0	0	0	0
6							
Mysidopsis almyra	0	0	5	156	84	21	44
Mysidopsis bahia	0	1	0	24	6	7	6
Mysidopsis bigelowi	0	3	3	528	76	0	102
Metamysidopsis swifti	0	0	0	0	0	0	0
Bowmaniella spp.	0	0	0	0	0	0	0
7							
Mysidopsis almyra	2	8	0	48	3848	94	667
Mysidopsis bahia	0	5	5	3	34	14	10
Mysidopsis bigelowi	0	0	3	59	80	0	24
Metamysidopsis swifti	0	0	0	0	8	0	1
Bowmaniella spp.	1	5	5	4	24	0	7

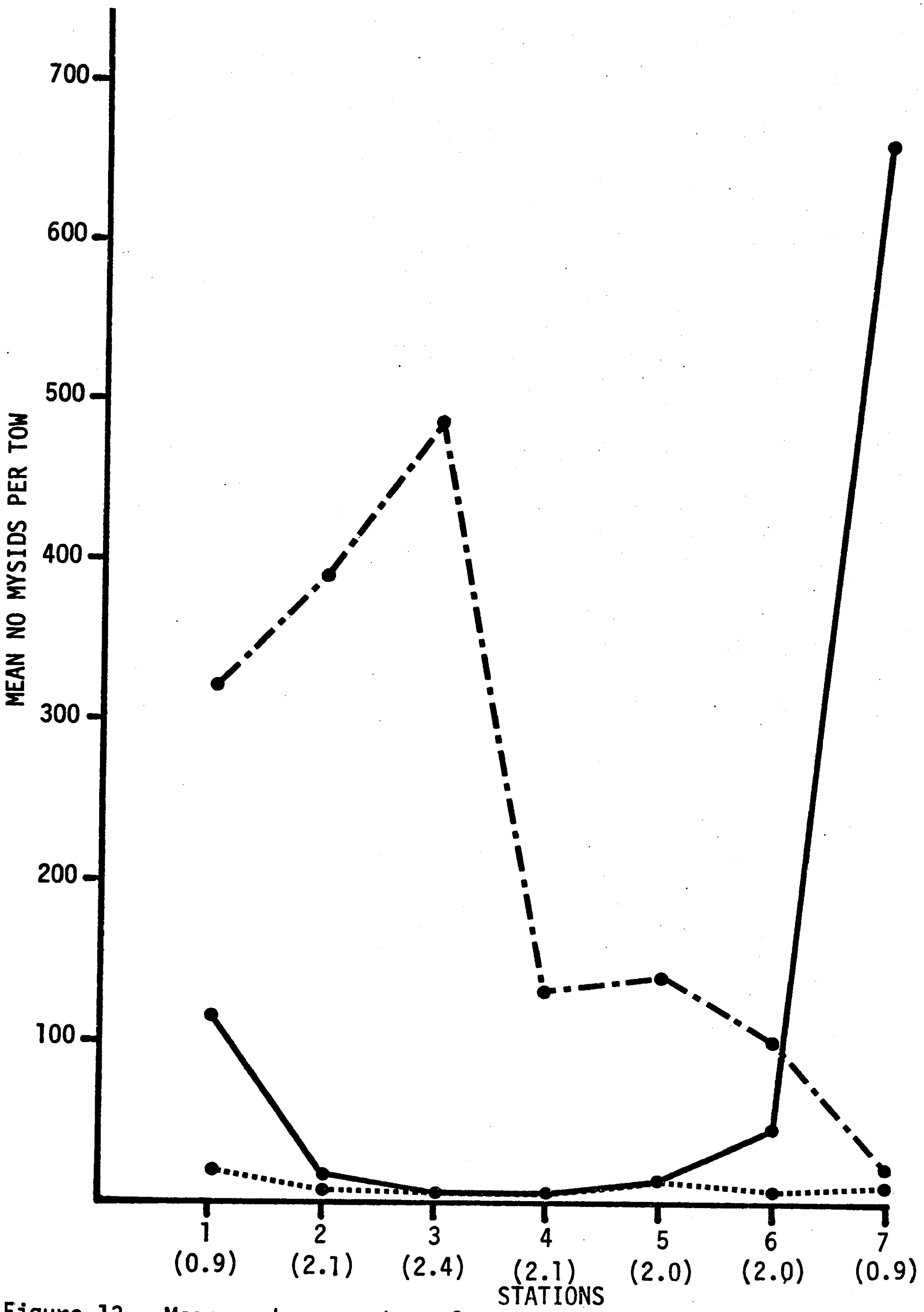

Figure 13. Mean number per tow of mysids collected at each station in West Bay. M. almyra (———), M. bahia (·········), M. bigelowi (— · —). The mean depth (m) of each station is given below each station number.

Mysidopsis bigelowi.--M. bigelowi was the numerically dominant mysid at all stations but 7. Its greatest numbers occurred at the deepest station, 3, where it averaged 487 individuals per tow. M. bigelowi was found in 25 of 30 collections in the deeper water stations 2-6. It was found only 4 of 12 times at stations 1 and 7. The only time it was found at station 1, 1936 individuals were collected in August. This single large collection accounted for M. bigelowi being the most numerous mysid at station 1.

Metamysidopsis swifti.--Nine specimens of M. swifti were collected at stations 5 and 7 in October.

Bowmaniella spp.--Although collected in low numbers Bowmaniella spp. seemed to prefer the shallower areas of West Bay. Of the 48 individuals found, 42 came from stations 1 and 7.

Relationships Between Temperature and Salinity and Abundance of Mysidacea

The temperatures and salinities recorded in all study areas over the two year sampling period were divided into the following groups: 0-10, 10-20, 20-30, 30+. The relationships between these groups and total numbers and numbers of developmental stages of Mysidopsis almyra, M. bahia, M. bigelowi, and Metamysidopsis swifti are given.

Mysidopsis almyra

Nearshore Area

For the 2 year sampling period , the number per tow of M. almyra increased with increasing temperatures (Figure 14). By far the greatest numbers occurred in temperatures exceeding 20 C. Year 2

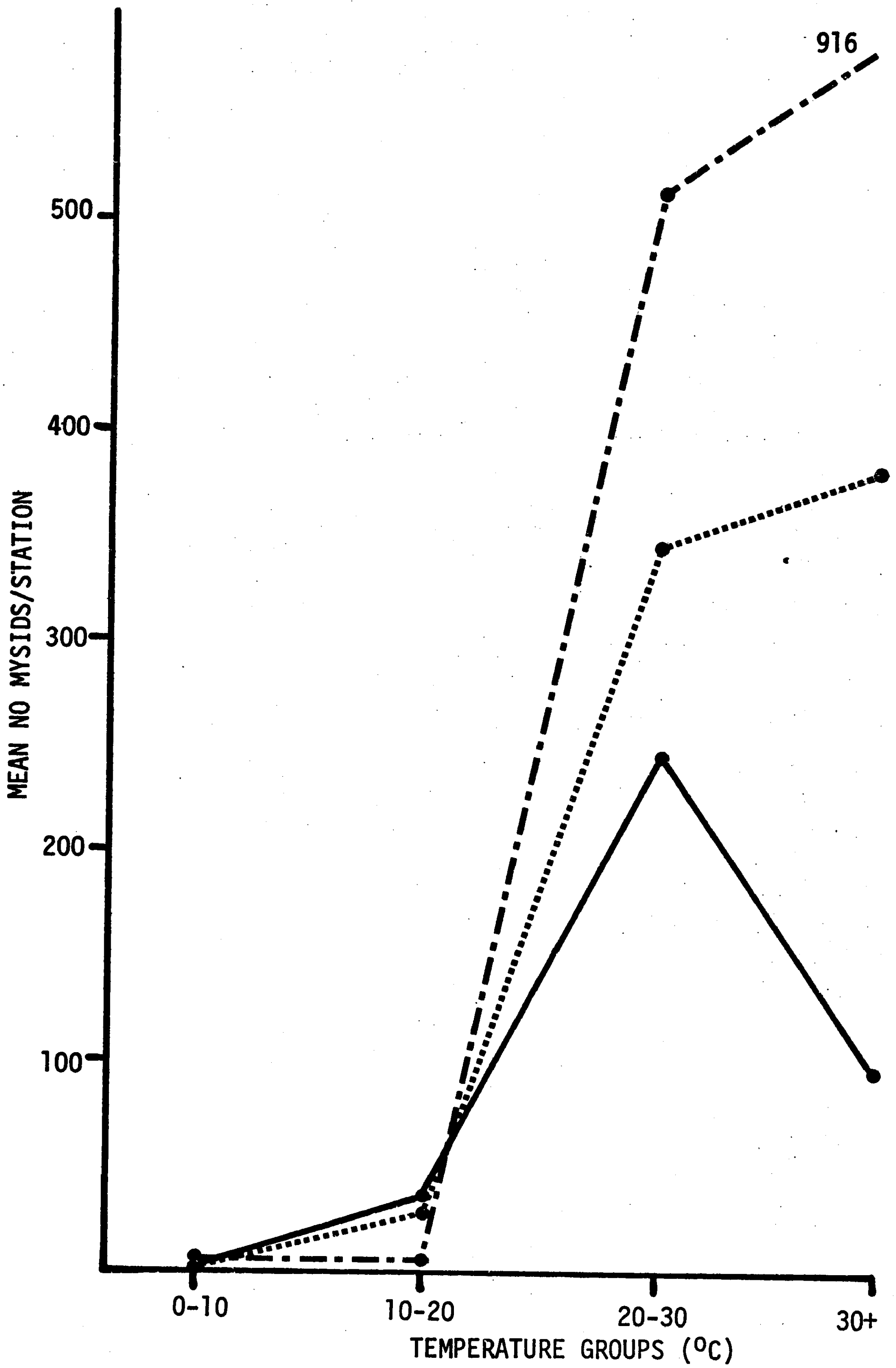

Figure 14. Mean number per tow of M. almyra at the different temperature groups in the nearshore area of Galveston Island. 1971-72(———), 1973-74(— · —), 1971-72 and 1973-74 (·········).

followed this pattern; however, in year 1 the largest numbers were collected in temperatures ranging from 20-30 C.

Generally, the developmental stages of M. almyra showed the same relationship with temperature as the whole population in each of the 2 years. By far the greatest numbers per tow of all stages except juveniles were collected in temperatures of 20-30 C in year 1 (Table 13). Juveniles increased gradually with increasing temperature. The largest numbers of all stages in year 2 were also found in temperatures exceeding 20 C (Table 14).

Figure 15 shows that over the entire study the greatest numbers of M. almyra were collected in salinities ranging from 10-30 ppt with the peak at 10-20 ppt. During year 1 the largest abundances were found in salinities over 20 ppt, with the peak occurring at 20-30 ppt. In year 2 numbers increased with increasing salinities to 30 ppt.

Table 15 shows an increase in numbers of all developmental stages with increasing salinity to 30 ppt, with the sharpest rise occurring at the 20-30 ppt group in year 1. In salinities over 30 ppt, there was a small decrease in numbers of all stages except mature females which rose slightly. During year 2 numbers of all developmental stages except mature females showed the same relationship with salinity as the entire population (Table 16). Numbers of mature females peaked at 10-20 ppt and declined thereafter.

Tucker Bayou

Numbers of M. almyra increased with increasing temperature and salinity (Tables 17 and 18). Tables 19 and 20 show that the developmental stages followed this same trend; however, the number of

Table 13. Mean number per tow of the developmental stages of _M. almyra_, M. _bahia_, and _M. swifti_ at the different temperature groups in the nearshore area of Galveston Island in 1971-72.

Temp. groups (°C)/ Species	10-20	20-30	30+
Mysidopsis almyra			
Juveniles	1.5	6.6	9.9
Immature females	17.0	111.0	42.5
Mature females	5.2	29.0	13.0
Males	10.2	101.0	30.9
Mysidopsis bahia			
Juveniles	0.2	1.0	10.2
Immature females	1.0	17.0	61.0
Mature females	0.2	9.0	31.0
Males	1.0	19.0	82.0
Metamysidopsis swifti			
Juveniles	0.3	0.5	0
Immature females	3.8	8.3	0
Mature females	4.9	16.5	0.1
Males	4.0	4.7	0.2

Table 14. Mean number per tow of the developmental stages of M. almyra, M. bahia, and M. swifti at the different temperature groups in the nearshore area of Galveston Island in 1973-74.

Temp. groups (°C)/ Species	0-10	10-20	20-30	30+
Mysidopsis almyra				
Juveniles	0.5	0	33.0	41.0
Immature females	1.0	2.0	179.0	308.0
Mature females	2.0	2.0	106.0	155.0
Males	1.3	2.0	197.0	412.0
Mysidopsis bahia				
Juveniles	0	0	0.2	0.3
Immature females	0.2	0	4.8	4.7
Mature females	0.3	0	6.7	3.4
Males	0	0	8.8	10.0
Metamysidopsis swifti				
Juveniles	0	0	0.1	0.9
Immature females	0	3.4	3.1	1.5
Mature females	0	6.3	7.8	8.8
Males	0	5.4	7.6	3.0

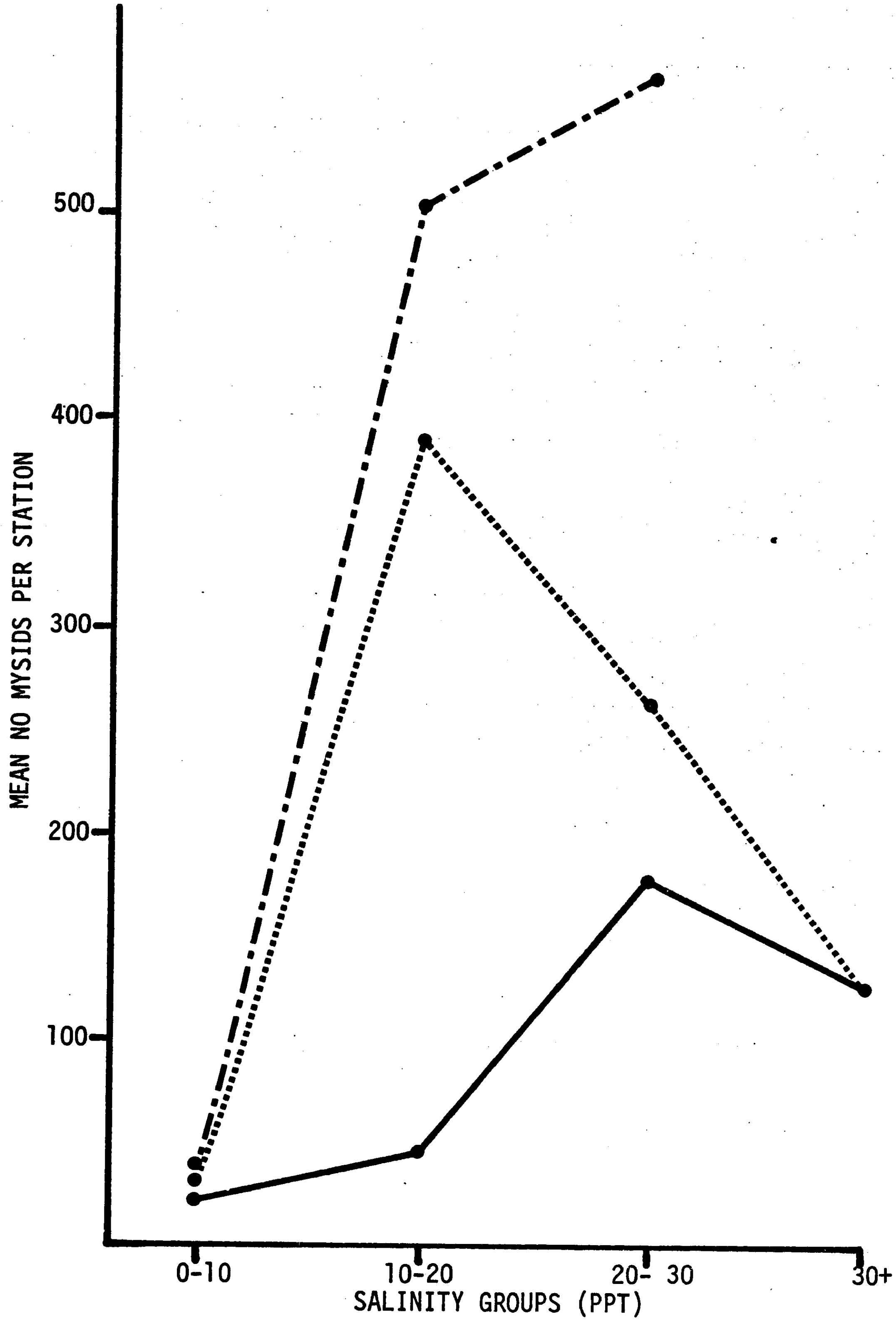

Figure 15. Mean number per tow of M. almyra at the different salinity groups in the nearshore area of Galveston Island. 1971-72 (——), 1973-74 (— - —), 1971-72 and 1973-74 (·········).

Table 15. Mean number per tow of each developmental stage of *M. almyra*, *M. bahia*, and *M. swifti* at the different salinity groups in the nearshore area of Galveston Island in 1971-72.

Salinity groups (ppt)/ Species	0-10	10-20	20-30	30+
Mysidopsis almyra				
Juveniles	.5	2.0	6.8	4.7
Immature females	13.0	20.0	81.9	52.8
Mature females	2.0	7.0	17.5	20.1
Males	6.6	17.0	70	48.4
Mysidopsis bahia				
Juveniles	0	0	1.3	7.0
Immature females	1.6	0.1	15.4	48.0
Mature females	4.8	0.1	7.7	25.0
Males	4.4	0.3	17.5	66.0
Metamysidopsis swifti				
Juveniles	0	0	0.4	1.0
Immature females	0	0.1	7.7	1.0
Mature females	0	0.1	14.5	0.9
Males	0.1	0.1	5.0	1.3

Table 16. Mean number per tow of each developmental stage of *M. alymra*, *M. bahia*, and *M. swifti* at the different salinity groups in the nearshore area of Galveston Island in 1973-74.

Salinity groups (ppt)/ Species	0-10	10-20	20-30
Mysidopsis almyra			
Juveniles	1.0	27.3	37.0
Immature females	13.4	160.0	236.0
Mature females	11.5	117.0	75.0
Males	14.9	200.0	264.0
Mysidopsis bahia			
Juveniles	0	0	0.5
Immature females	0.1	1.7	9.1
Mature females	0	2.7	9.9
Males	0.1	3.9	16.1
Metamysidopsis swifti			
Juveniles	0	0	0.6
Immature females	0	0.4	7.0
Mature females	0.6	2.8	17.0
Males	0.2	2.0	13.9

Table 17. Mean number per tow of _M. almyra_, _M. bahia_, and _M. bigelowi_ at the different temperature groups in Tucker Bayou and West Bay.

Temp. groups (°C)/ Study area-Species	0-10	10-20	20-30	30+
Tucker Bayou				
Mysidopsis almyra	230.5	-	1670	3134
West Bay				
Mysidopsis almyra	0.6	26.3	178.0	-
Mysidopsis bahia	1.0	7.9	12.3	-
Mysidopsis bigelowi	0.6	0.5	342.0	-

Table 18. Mean number per tow of M. almyra, M. bahia, and M. bigelowi at the different salinity groups in Tucker Bayou and West Bay.

Salinity groups (ppt)/ Study area-Species	10-20	20-30
Tucker Bayou		
Mysidopsis almyra	1539.0	2677.0
West Bay		
Mysidopsis almyra	213.0	33.0
Mysidopsis bahia	8.8	10.7
Mysidopsis bigelowi	47.0	409.0

Table 19. Mean number per tow of the developmental stages of _M. almyra_, _M. bahia_, and _M. bigelowi_ at the different temperature groups in Tucker Bayou and West Bay.

Temp. groups (°C)/ Study area-Species	0-10	10-20	20-30	30+
Tucker Bayou				
Mysidopsis almyra				
Juveniles	99.0	-	584.0	902.0
Immature females	17.0	-	416.0	631.0
Mature females	54.0	-	223.0	462.0
Males	61.0	-	447.0	114.0
West Bay				
Mysidopsis almyra				
Juveniles	0	10.7	80.0	-
Immature females	0.1	3.9	38.0	-
Mature females	0.4	5.7	13.0	-
Males	0.1	6.0	47.0	-
Mysidopsis bahia				
Juveniles	0	2.0	2.0	-
Immature females	0.4	1.1	3.4	-
Mature females	0.3	1.4	2.6	-
Males	.3	3.0	4.4	-
Mysidopsis bigelowi				
Juveniles	0	0	29.0	-
Immature females	0.3	0	64.0	-
Mature females	0.1	0.2	106.0	-
Males	0.1	0.3	143.0	-

Table 20. Mean number per tow of the developmental stages of *M. almyra*, *M. bahia*, and *M. bigelowi* at the different salinity groups in Tucker Bayou and West Bay.

Salinity groups (ppt)/ Study area-Species	10-20	20-30
Tucker Bayou		
Mysidopsis almyra		
Juveniles	602.0	624.0
Immature females	360.0	544.0
Mature females	189.0	445.0
Males	388.0	1064.0
West Bay		
Mysidopsis almyra		
Juveniles	103.0	7.0
Immature females	44.0	7.0
Mature females	12.0	7.0
Males	53.0	13.0
Mysidopsis bahia		
Juveniles	1.8	1.6
Immature females	2.4	2.7
Mature females	1.2	2.8
Males	3.3	3.7
Mysidopsis bigelowi		
Juveniles	4.3	34.0
Immature females	12.5	72.0
Mature females	11.1	131.0
Males	19.2	172.0

juveniles was about about the same over all salinities.

West Bay

The numbers of M. almyra were greatest at temperatures over 20 C and salinities between 10-20 ppt (Tables 17 and 18). This same relationship with temperature and salinity was shown for all developmental stages (Tables 19 and 20).

Mysidopsis bahia

Nearshore Area

Low numbers per tow of M. bahia were collected in temperatures of less than 20 C during both years. Above 20 C numbers increased with increasing temperatures in year 1 (Figure 16). By far the largest numbers were found in temperatures over 30 C. During year 2 the numbers of M. bahia increased at 20-30 C and then leveled off.

During year 1 the developmental stages showed the same relationship to temperature as the entire population (Table 20). Few juveniles were found at any temperatures during year 2 (Table 14). The mature females peaked at 20-30 C and decreased at higher temperatures. The numbers of the other developmental stages increased at 20-30 C and leveled off.

Few M. bahia were taken in salinities below 20 ppt over the 2 year period (Figure 17). In salinities over 20 ppt numbers increased with increasing salinity during both years. Tables 3 and 4 show that the developmental stages exhibited the same relationship to salinity as the entire population.

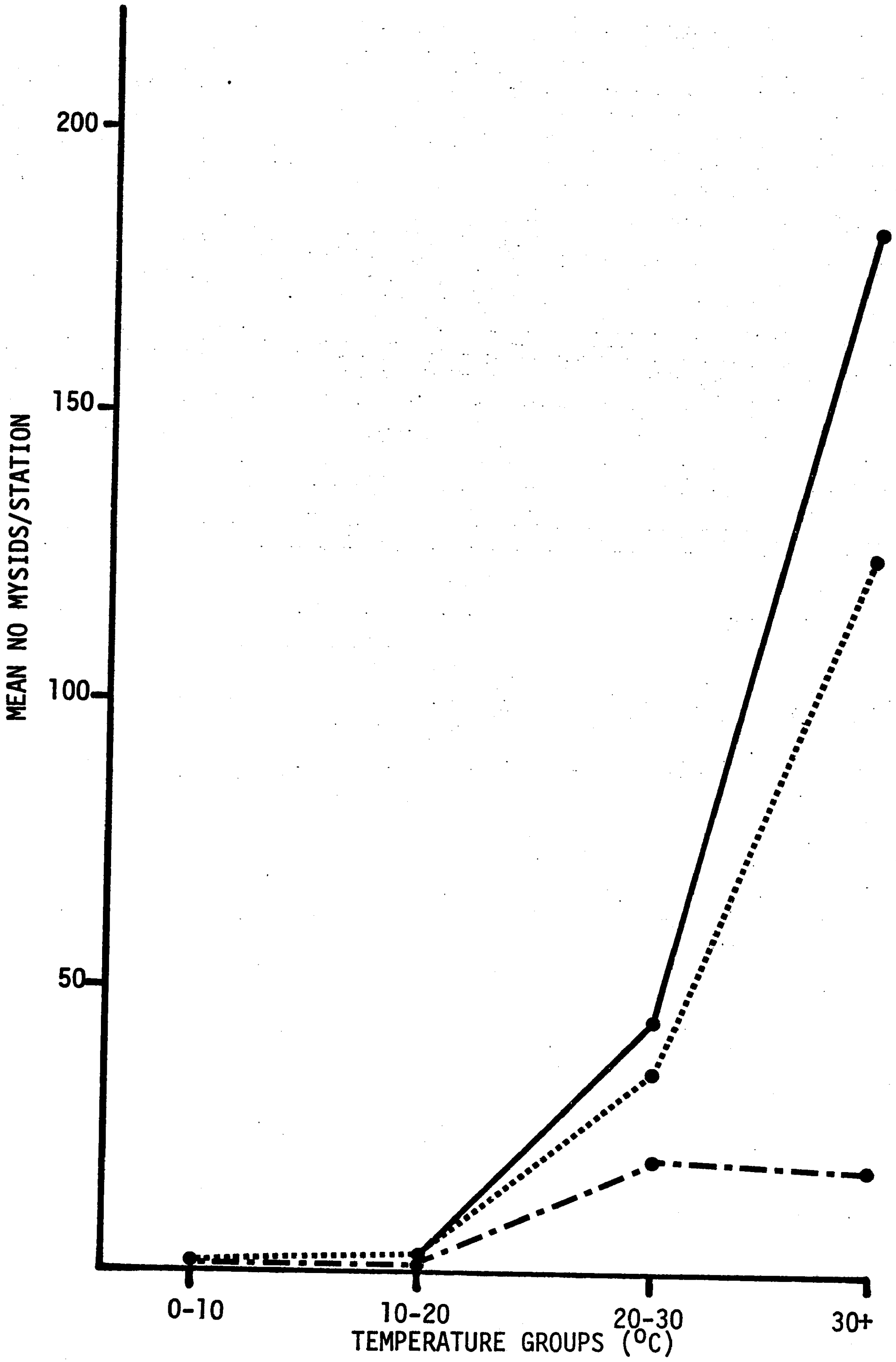

Figure 16. Mean number per tow of M. bahia at the different temperature groups in the nearshore area of Galveston Island. 1971-72 (———), 1973-74 (— - —), 1971-72 and 1973-74 (········).

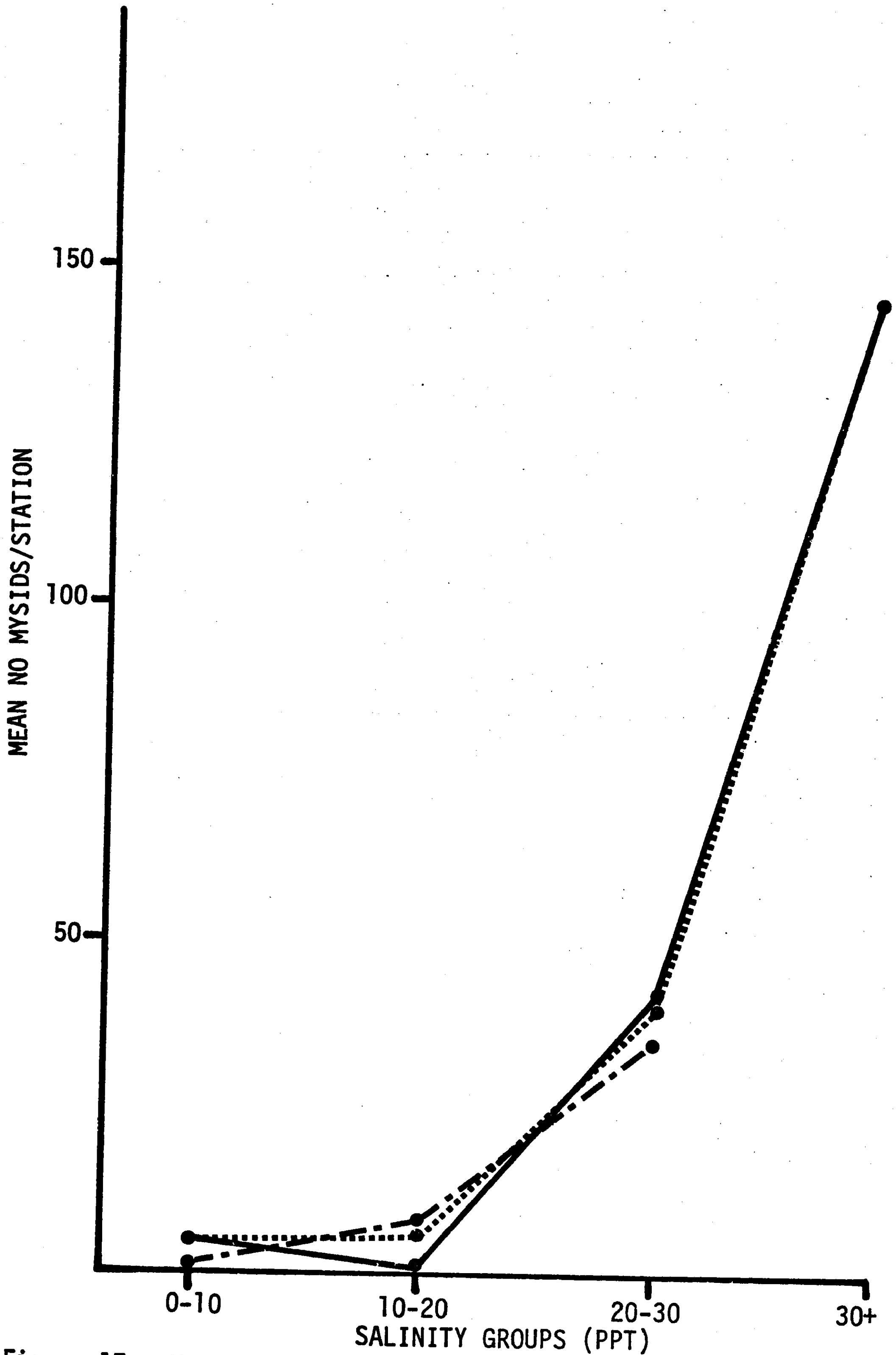

Figure 17. Mean number per tow of *M. bahia* at the different salinity groups in the nearshore area of Galveston Island. 1971-72 (———), 1973-74 (— · —), 1971-72 and 1973-74 (········).

Only 36 M. bahia were found in this area. Most specimens were taken in temperatures of 20-30 C and salinities of 15-25 ppt.

West Bay

The numbers of M. bahia collected in West Bay increased with increasing temperature and salinity (Tables 17 and 18). Generally the developmental stages followed this pattern (Tables 19 and 20).

Metamysidopsis swifti

Nearshore Area

The largest numbers per tow of M. swifti were found between 10 and 30 C with the peak occurring at 20-30 C both years (Figure 18). Although the numbers decreased at temperatures exceeding 30 C both years, the drop was much more drastic the first year than the second.

During year 1 the developmental stages of M. swifti showed the same relationship to temperature as the entire population (Table 13). Table 14 shows that during year 2 the numbers of mature females increased and the numbers of immature females decreased with increasing temperature.

Low numbers of M. swifti were collected in salinities of less than 20 ppt during both years (Figure 19). The largest numbers were found in the 20-30 ppt range both years, and in year 1 a sharp decrease occurred in salinities over 30 ppt.

The relationship between salinity and numbers of developmental stages was the same as for the entire population during both years (Tables 15 and 16).

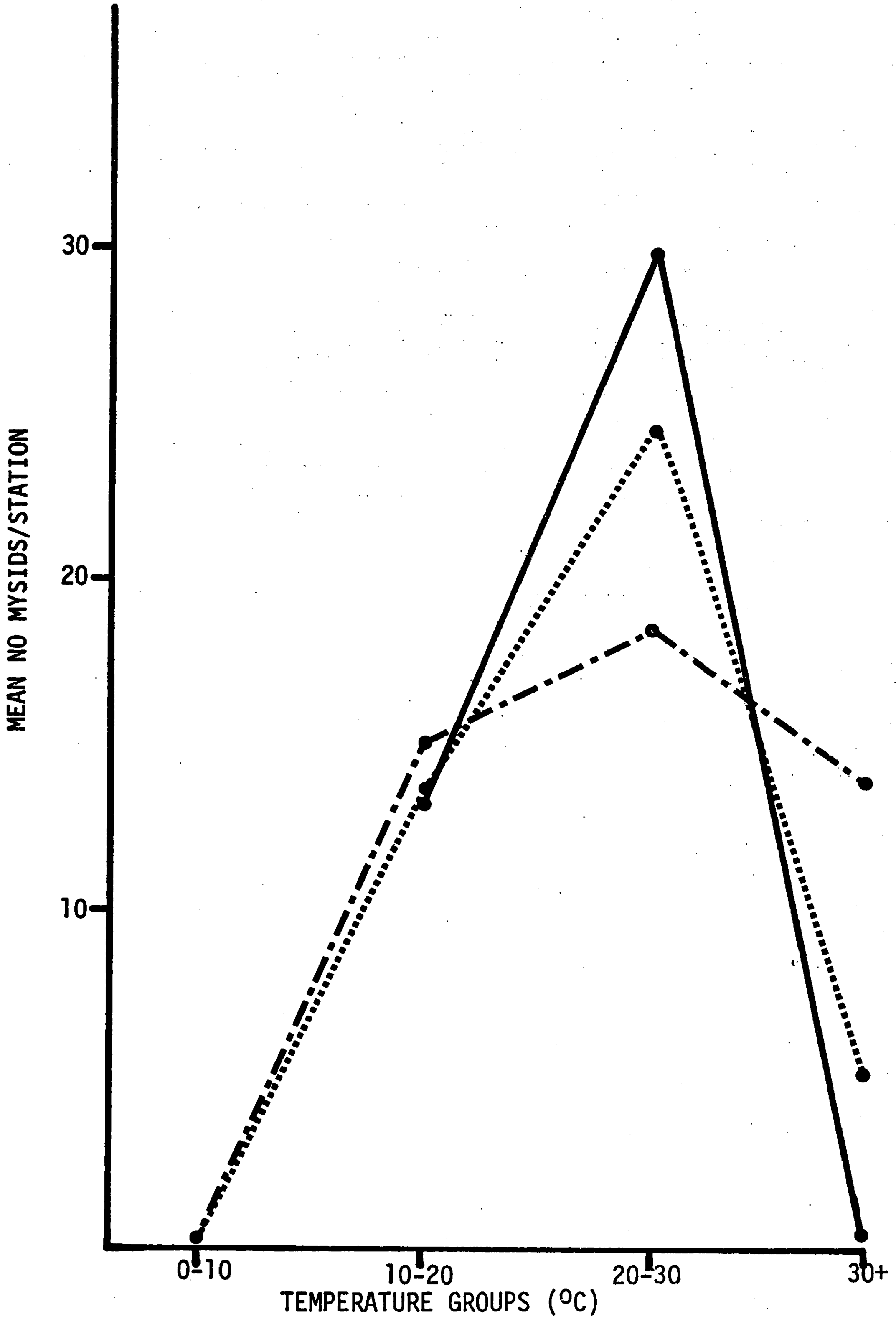

Figure 18. Mean number per tow of M. swifti at the different temperature groups in the nearshore area of Galveston Island. 1971-72 (———), 1973-74 (—·—), 1971-72 and 1973-74 (········).

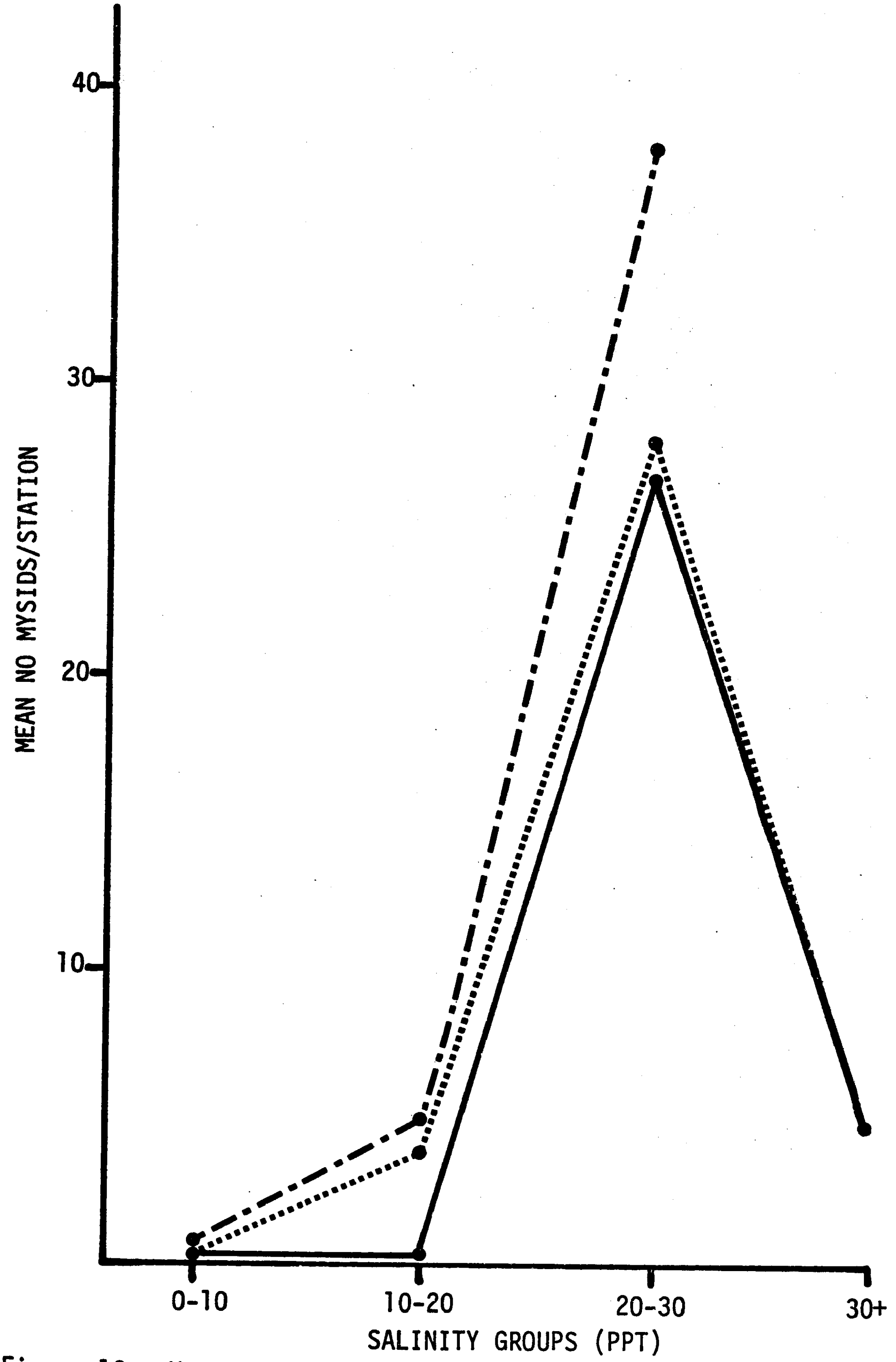

Figure 19. Mean number per tow of M. swifti at the different salinity groups in the nearshore area of Galveston Island. 1971-72 (———), 1973-74 (— - —), 1971-72 and 1973-74 (·········).

Tucker Bayou

No specimens were taken during the sampling period.

West Bay

Nine *M. swifti* were collected at 25.5 C and 15 ppt.

Mysidopsis bigelowi

Nearshore Area

During year 1, 77 of the 89 specimens collected were taken in temperatures of 25-30 C and salinities exceeding 20 ppt. No *M. bigelowi* was found in year 2.

Tucker Bayou

About 150 *M. bigelowi* were collected at 30 C and 25 ppt.

West Bay

M. bigelowi was found in large numbers only in the highest temperature and salinity groups - 20-30 C and 20-30 ppt (Tables 17 and 18). The developmental stages showed this same relationship with temperature and salinity (Tables 19 and 20).

Relationship Between Temperature and Salinity and Survival and Behavior of Mysidacea

Survival Studies

Mysidopsis almyra

M. almyra survived the 10-day period at low-moderate temperatures (15-22 C) with little mortality (5 per cent) (Table 21); however, held

Table 21. Number and per cent (in parentheses) of *M. almyra* surviving various temperature-salinity combinations for 10 days (15 mysids = 100 per cent survival).

	Salinity (ppt)					
Temperature (^oC)	11	17	23	29	35	Total
15	14(93)	14(93)	15(100)	14(93)	13(87)	70(93)
22	14(93)	15(100)	14(93)	15(100)	15(100)	73(97)
30	8(53)	11(73)	13(87)	10(67)	9(60)	51(68)
Total	36(80)	40(89)	42(93)	39(87)	37(82)	

at 30 C they had a high mortality rate (32 per cent). Although survival was high at all salinities, it was best between 17-29 ppt. At 11 and 35 ppt the mortality rate increased slightly.

The effects of temperature-salinity interaction on survival indicated that temperatures from 15-22 C and salinities from 17-29 ppt were best suited for the survival of *M. almyra*. At high temperatures (30 C) survival at all salinities was reduced, and was lowest at the low and high salinities (11, 35 ppt).

An analysis of variance indicated that only temperature had a statistically significant effect on the survival of *M. almyra* ($p < .001$). Duncan's Multiple Range Test, at the 5 per cent probability level, showed that the survival rates of mysids at 15 and 22 C were significantly higher than those at 30 C.

Metamysidopsis swifti.--The survival of *M. swifti* decreased with increasing temperature (Table 22). The mortality rates were fairly low for low-moderate temperatures (15-22 C) but increased sharply at 30 C. The survival of *M. swifti* increased with increasing salinity. The mortality rate was negligible at high salinities (29-35 ppt), increased slightly at moderate salinities (17-23 ppt), and increased drastically at the lowest salinity (11 ppt).

Temperature-salinity interactions indicated that temperatures of 15-22 C and salinities of 17-35 ppt were optimum for the survival of *M. swifti*. Low salinities (11 ppt) at all temperatures, and medium salinities (17 ppt) at high temperatures (30 C) showed lowest survival.

Table 22. Number and per cent (in parentheses) of *M. swifti* surviving various temperature-salinity combinations for 10 days (10 mysids = 100 per cent survival).

	Salinity (ppt)					
Temperature (°C)	11	17	23	29	35	Total
15	3(30)	10(100)	10(100)	10(100)	10(100)	43(86)
22	2(20)	8(80)	8(80)	10(100)	10(100)	38(76)
30	0(0)	2(20)	6(60)	8(80)	9(90)	25(50)
Total	5(17)	20(67)	24(80)	28(93)	29(97)	

An analysis of variance showed that both temperature and salinity have a statistically significant effect on the survival of M. swifti ($p < .01$). Duncan's Multiple Range Test indicated that the survival of M. swifti at 15 and 22 C was significantly higher than at 30 C. Survival of mysids at 17, 23, 29, and 35 ppt was significantly higher than at 11 ppt, and survival at 29 and 35 ppt was significantly higher thatn at 17 ppt.

Behavioral Reactions

This section is devoted to observations made during the survival studies and the experiment on burrowing. Since mysids in the survival studies were kept in enclosed incubators or environmental chambers, few observations could be made. The only observations made concerned the activity of mysids in relation to temperature. As the temperature increased, activity increased - the mysids at 30 C moved almost continually while the ones at 15 C moved little, spending most of their time resting on the bottom.

The burrowing experiment was designed to determine whether M. almyra, M. bahia, and M. swifti burrowed into the sediment in response to lowered temperatures. During both sampling years, low numbers of the 3 species were collected during the winter months and burrowing is a possible explanation for this finding.

During the pre-experimental control period, the 3 species swam almost continuously and aimlessly just above the sediment, stopping occasionally to sift through it. As experimental water temperatures were lowered from the initial levels (22-22.5 C), some successive behavioral stages were noticed in the mysid species. The first stage was an increase in activity occurring at 17-18 C in M. almyra, but not in the other two species. At 14.5-16 C a decrease in activity was noted in all 3 species. A further reduction of temperature to 12-13 C caused a complete cessation of activity in M. almyra and M. bahia; they rested on the substrate. No loss of equilibrium was noted in these 2 species although the temperature was lowered to 10 C. At 10-12 C M. swifti exhibited two types of behavior. Some individuals swam to the surface, floated to the bottom right side up or up-side down, lay on the substrate for a few seconds, and then swam back to the surface. Other individuals simply lost their equilibrium and rested on the bottom. At no time during the experiment did individuals of the 3 mysid species attempt to burrow.

Microdistribution of Mysidacea

In the nearshore seasonal sampling program which was on a monthly (year 1) and bimonthly (year 2) basis, the assumption was made that in the shallow water areas the same population of mysids was being sampled each collecting trip. An intensive sampling program was designed to see if, and to what extent, vertical or horizontal movements occurred in all, or part of, the mysid population over short time periods in a typical bayou. The results of this short term study could help determine the accuracy of the nearshore seasonal sampling program.

Mysidopsis almyra was the only species taken in the 27 hr and 15 day studies. This indicates that there was probably no replacement of one species with another between monthly sampling trips in the shallow water bayou habitats.

Vertical Distribution

Both 27 hr studies showed that M. almyra inhabited the layer of water just above the bottom during the day and night. During the first study more than 90 per cent of the population was found within 42 cm of the bottom in 9 of the 10 samples taken (Table 23). During the second study more than 95 per cent of the population was found within 28 cm of the bottom in every sample taken (Table 24). During the day virtually no mysids were found in the upper water columns in either study. At night the population spread upward slightly but in only 1 collection did this movement account for an appreciable percentage of the entire population.

Table 25 gives the vertical distribution of M. almyra by developmental stages for each sample collected during the second 27 hr study. Only the 3 samples taken from 2130-0330 had individuals at all 4 levels. For statistical analysis these samples were combined and only the immature females and mature females at the 4 levels were totaled. A chi-square test of independence indicated that the level of water sampled had a statistically significant effect on the ratio of immature females to mature females ($X^2 = 41.4$, $P < .005$). Immature females outnumbered mature females by nearly 4 to 1 at the lowest level (1). At the other 3 levels the ratio was about 1:1.

Horizontal Distribution

A large difference existed in the total numbers of M. almyra taken in the 10 samples of each of the two 27 hr studies (Tables 23 and 24). The pattern of population change and the tidal cycles of the two 27 hr periods were closely related (Figures 20 and 21).

Table 23. Vertical distribution of *M. almyra* within 0.94 m of the bottom determined by simultaneous collections of three 10 cm layers (32 cm apart) using a multiple level sampling device in Tucker Bayou during the first 27 hr sampling period.

Time (CST)	Total no. per sample	per cent of total no. per sample		
		Water Column (cm above bottom)		
		0-10	42-52	84-94
0930	105	99.1	.9	0
1230	215	99.5	.5	0
1530	3298	99.7	.1	.2
1830	7386	99.9	<.1	0
(sunset) 2009				
2130	2407	94.7	4.5	.8
0030	491	67.4	27.9	4.7
0330	807	90.1	7.2	2.7
0630	165	95.2	0	4.8
(sunrise) 0642				
0930	1138	100	0	0
1230	296	99.7	0	.3

Table 24. Vertical distribution of <u>M. almyra</u> within 0.95 m of the bottom determined by simultaneous collections of four 10 cm layers (18 cm apart) using a multiple level sampling device in Tucker Bayou during the second 27 hr period.

Time (CST)	Total no. per sample	per cent of total no. per sample			
		Water column (cm above bottom)			
		0-10	28-38	56-66	84-94
0930	244	99	1	0	0
1230	360	100	0	0	0
1530	720	100	0	0	0
1830	624	100	0	0	0
(sunset) 2011					
2130	2661	97.3	1.4	1	.3
0030	1644	96.8	2.0	.9	.3
0330	3276	95.4	3.0	.9	.7
(sunrise) 0622					
0630	5384	99.9	.1	0	0
0930	1988	100	0	0	0
1230	280	100	0	0	0

Table 25. Vertical distribution of developmental stages of M. almyra within 0.95 m of the bottom in Tucker Bayou during the second 27 hr period.

Time	Layer of water column*	Juveniles	Immature Females	Mature Females	Males
0930	1	51	78	34	79
	2	1	1	0	0
	3	0	0	0	0
	4	0	0	0	0
1230	1	111	95	47	107
	2	0	0	0	0
	3	0	0	0	0
	4	0	0	0	0
1530	1	254	242	44	180
	2	0	0	0	0
	3	0	0	0	0
	4	0	0	0	0
1830	1	118	226	54	226
	2	0	0	0	0
	3	0	0	0	0
	4	0	0	0	0
2130	1	824	932	184	648
	2	10	7	7	12
	3	5	7	9	5
	4	4	4	3	0
0030	1	416	492	180	504
	2	18	2	8	5
	3	10	2	2	0
	4	3	0	2	0
0330	1	1480	852	252	540
	2	24	20	13	43
	3	14	11	4	0
	4	8	7	5	3
0630	1	1888	1560	632	1304
	2	0	0	1	1
	3	0	0	0	0
	4	0	0	0	0

Table 25 - (Continued)

Time	Layer of water column*	Juveniles	Immature Females	Mature Females	Males
0930	1	476	572	352	588
	2	0	0	0	0
	3	0	0	0	0
	4	0	0	0	0
1230	1	85	133	17	45
	2	0	0	0	0
	3	0	0	0	0
	4	0	0	0	0

* Layer 1, 0-10 cm above bottom; 2,28-38 cm; 3,56-66 cm; 4,84-94 cm.

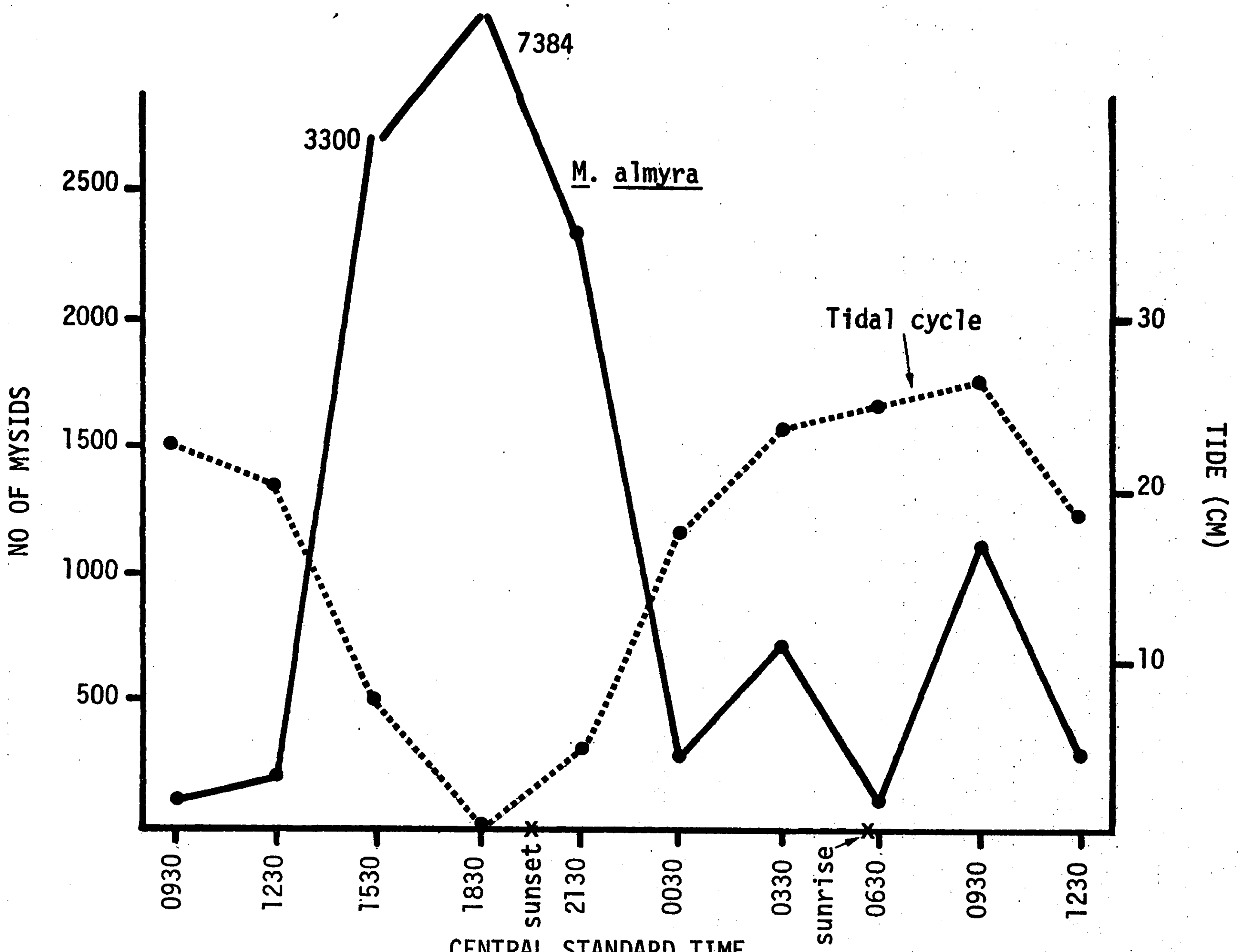

Figure 20. Numbers of M. almyra collected with multilevel sampling device during first 27 hr period and tidal cycle for that period.

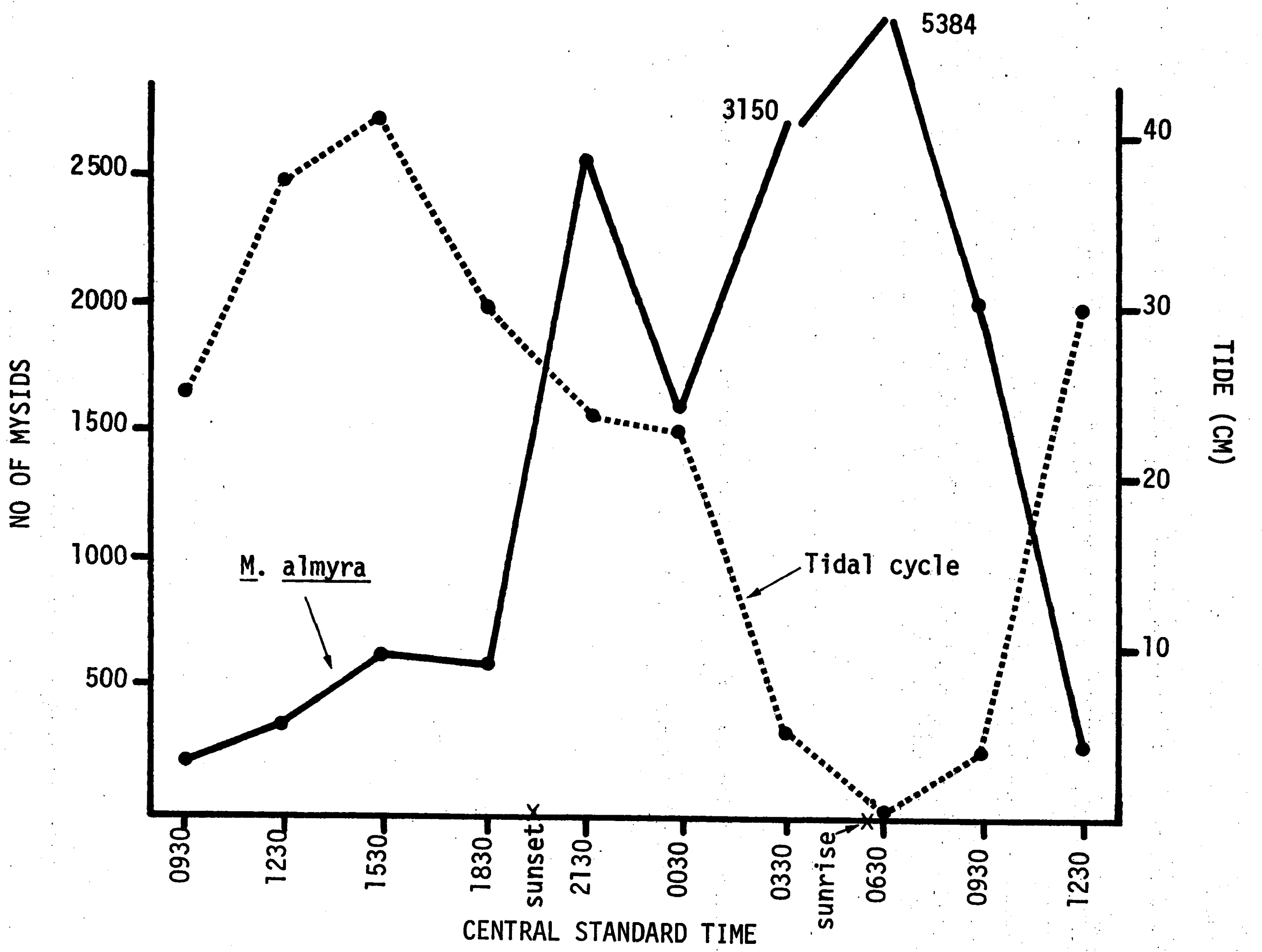

Figure 21. Number of M. almyra collected with multilevel sampling device during the second 27 hr period and the tidal cycle for that period.

In most cases as the tide ebbed, numbers of *M. almyra* increased and as the tide flooded numbers decreased. The largest numbers of mysids were found at low tide in both studies. The relationship between numbers and high tide was not as clear, but the numbers usually decreased or remained fairly low at this tidal stage.

The numbers of *M. almyra* collected during the 15 day sampling period are given in Figure 22. Although erratic, the numbers found the first 9 days totaled at least 1,500 individuals per tow and the mean for the period was 2,600 per tow. On day 10 a large drop in numbers occurred and the mean for the last 6 days was 434 individuals per tow. Figure 23 shows the daily tidal cycles for the 15 day period. During the first 9 days most of the collections were made after the start of the ebb tide. Most of the collections for the last 6 days were made at high tide. The inverse relationship between numbers and tidal cycle suggested by the 27 hr studies could serve as a possible explanation of differences in numbers found in the 15 day study. In any case while preliminary the results warrent further study.

The population composition of each collection of the second 27 hr study and the 15 day study are given in Figures 24 and 25. For both studies no consistant pattern for any developmental stage was evident. The population structures of the 2 populations were essentially the same. The percentages of juveniles and immature females varied from 60-64.3 per cent, the males ranged from 25-32.4 per cent, and the gravid females and females with stretched marsupia ranged from 7.6-10.8 per cent.

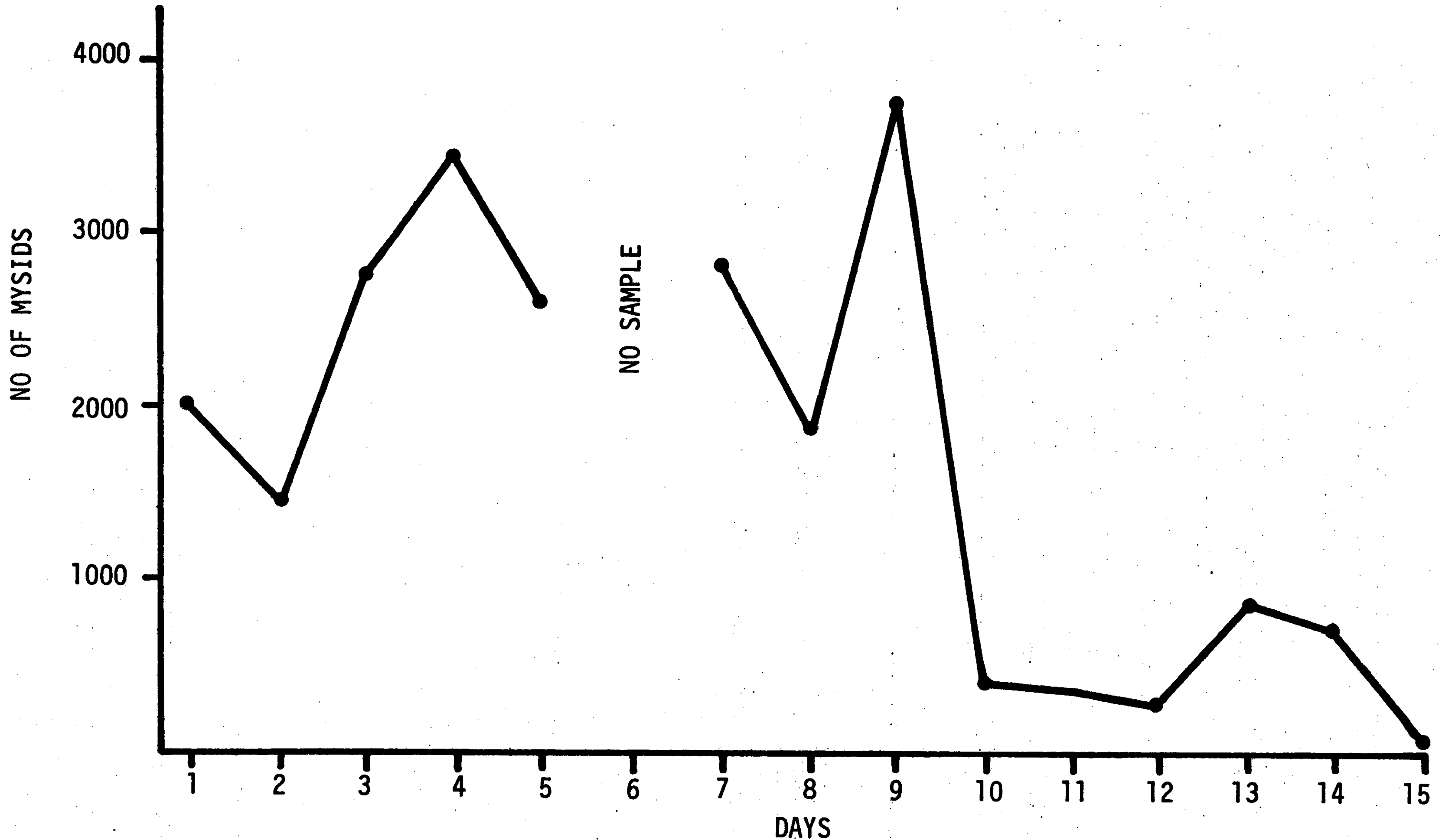

Figure 22. Numbers of *M. almyra* collected each day during the 15 day sampling period.

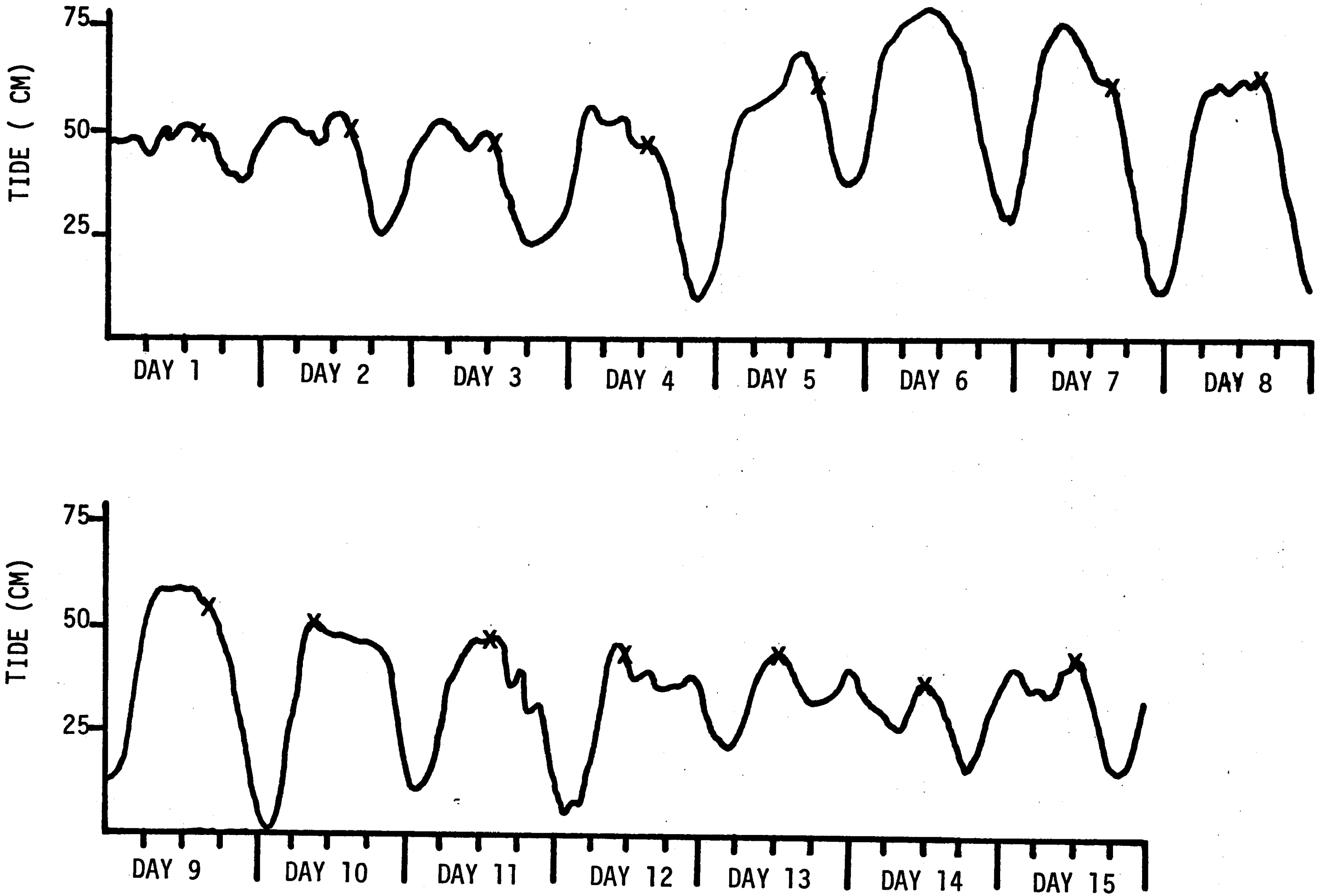

Figure 23. Daily tidal cycles during the 15 day study. X denotes time when sample was taken each day.

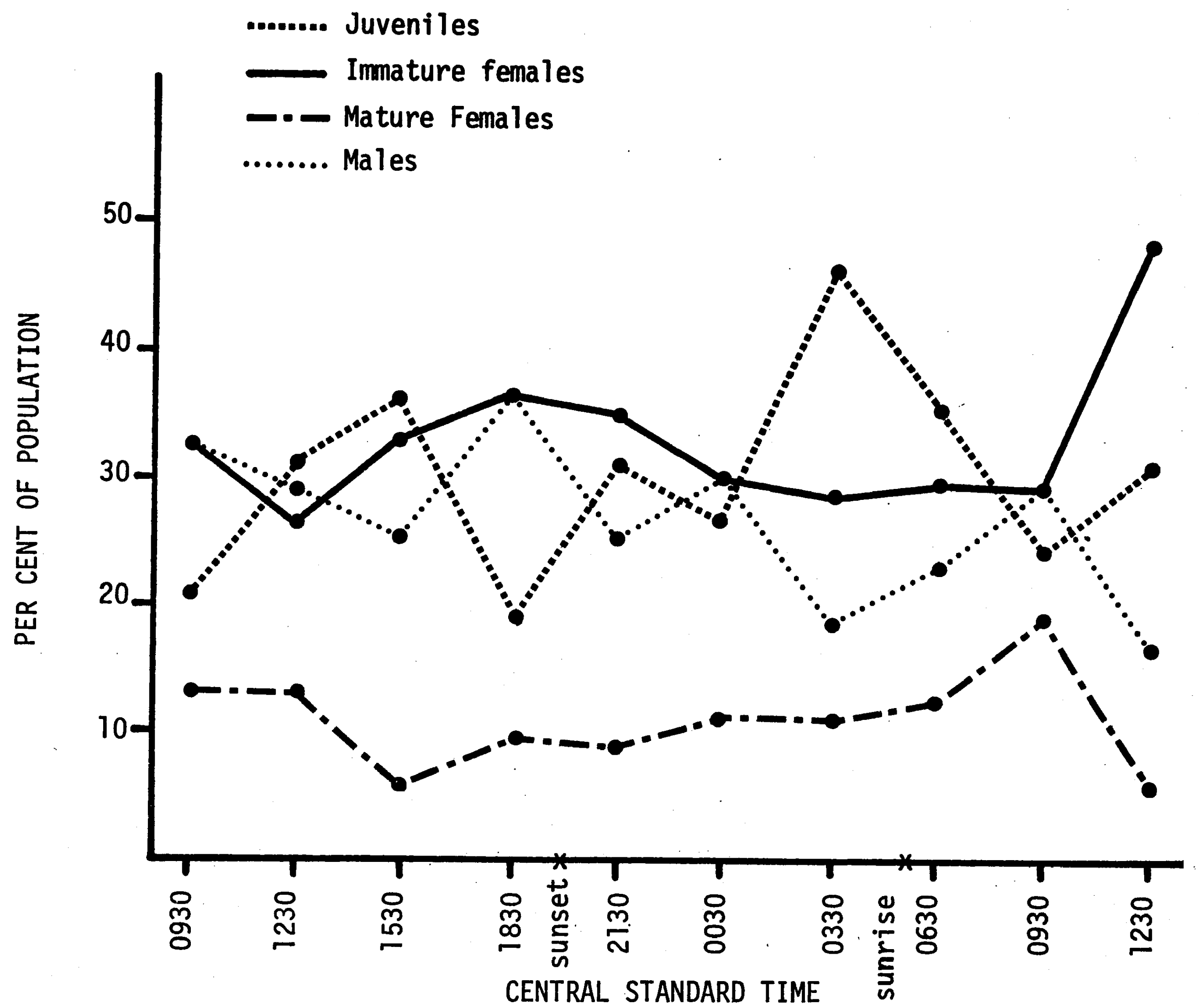

Figure 24. Per cent frequency of each developmental stage of M. almyra collected during the second 27 hr study.

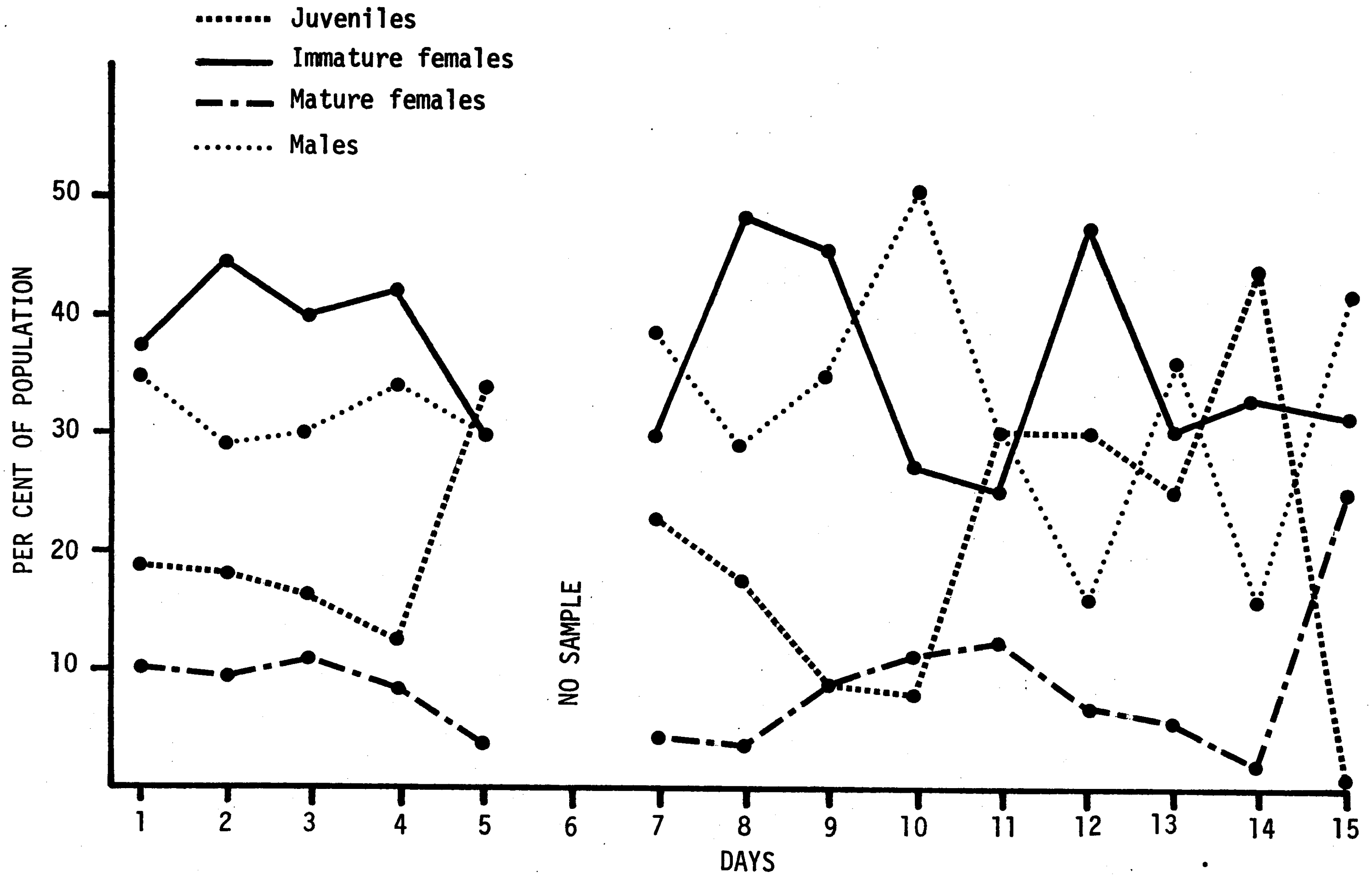

Figure 25. Per cent frequency of each developmental stage of M. almyra collected during the 15 day study.

Seasonal Distribution of Mysidacea

The seasonal distribution of the mysid species in all study areas was generally the same each year. In the cooler months (November-April) mysids were found in fairly low numbers. As the temperature increased, their numbers rose until a peak was reached in July-October. Tables 26 and 27 give the seasonal distribution of the species of mysids in each study area over the two year period.

Mysidopsis almyra

M. almyra was present in all seasons in all study areas during the two year sampling period. During year 1 few specimens were observed in February, but starting in March the numbers of this species rose steadily until a peak was reached in June and July. The population abruptly declined in August and suddenly rose to its greatest abundance in September, then dropped fairly steadily to a low level in January (Figure 26).

All developmental stages of M. almyra, except mature females, followed the same seasonal pattern as the entire population during year 1 (Table 28). After a peak in October, the mature females declined steadily for the remainder of the study. All other stages peaked again in December before falling drastically in January.

From the nearshore area in year 2, M. almyra rose from low numbers in February and April to extremely high levels in August and October. Fairly high numbers were maintained the following February (Figure 26). A similar seasonal pattern appeared in the Tucker Bayou transect (Figure 27). Again, extremely large numbers of M. almyra were collected in August-October. Tables 29

Table 26. Seasonal occurrence (number per tow) of each mysid species collected in the nearshore area of Galveston Island in 1971-72.

Months/Species	Feb 1971	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan 1972	Total
Mysidopsis almyra	8	27	35	141	281	307	13	479	211	90	119	6	149
Mysidopsis bahia	<1	<1	12	134	365	104	<1	23	65	7	22	<1	60
Mysidopsis bigelowi	<1	0	<1	0	0	0	0	3	<1	0	<1	0	<1
Metamysidopsis swifti	<1	<1	29	45	11	<1	<1	73	4	2	29	16	18
Bowmaniella spp.	0	<1	0	0	0	0	0	<1	<1	0	<1	<1	<1
Bowmaniella brasiliensis	0	0	0	0	0	0	0	0	0	0	0	<1	<1
Brasilomysis castroi	0	0	0	0	<1	0	<1	0	0	0	0	0	<1
Promysis atlantica	0	0	<1	0	<1	0	0	0	0	0	0	0	<1

Table 27. Seasonal occurrence (number per tow) of each mysid species in each study area of Galveston Island in 1973-74.

Months/Species-study areas	Feb 1973	April	July	Aug	Oct	Feb 1974	Total
Mysidopsis almyra							
Nearshore	5	7	242	1187	1131	294	480
Tucker Bayou	232	225	1168	5,134	4,142	613	1919
West Bay	<1	2	6	93	611	26	122
Mysidopsis bahia							
Nearshore	<1	<1	4	3	50	9	16
Tucker Bayou	0	2	0	3	3	2	2
West Bay	1	5	8	23	12	8	10
Mysidopsis bigelowi							
Nearshore	0	0	0	0	0	0	0
Tucker Bayou	0	0	0	37	2	0	6
West Bay	<1	2	55	1171	139	<1	228
Metamysidopsis swifti							
Nearshore	0	0	5	27	45	8	14
Tucker Bayou	0	0	0	0	0	0	0
West Bay	0	0	0	0	1	0	<1
Bowmaniella spp.							
Nearshore	0	0	0	0	0	0	0
Tucker Bayou	0	0	0	0	0	<1	<1
West Bay	<1	<1	2	<1	3	<1	1

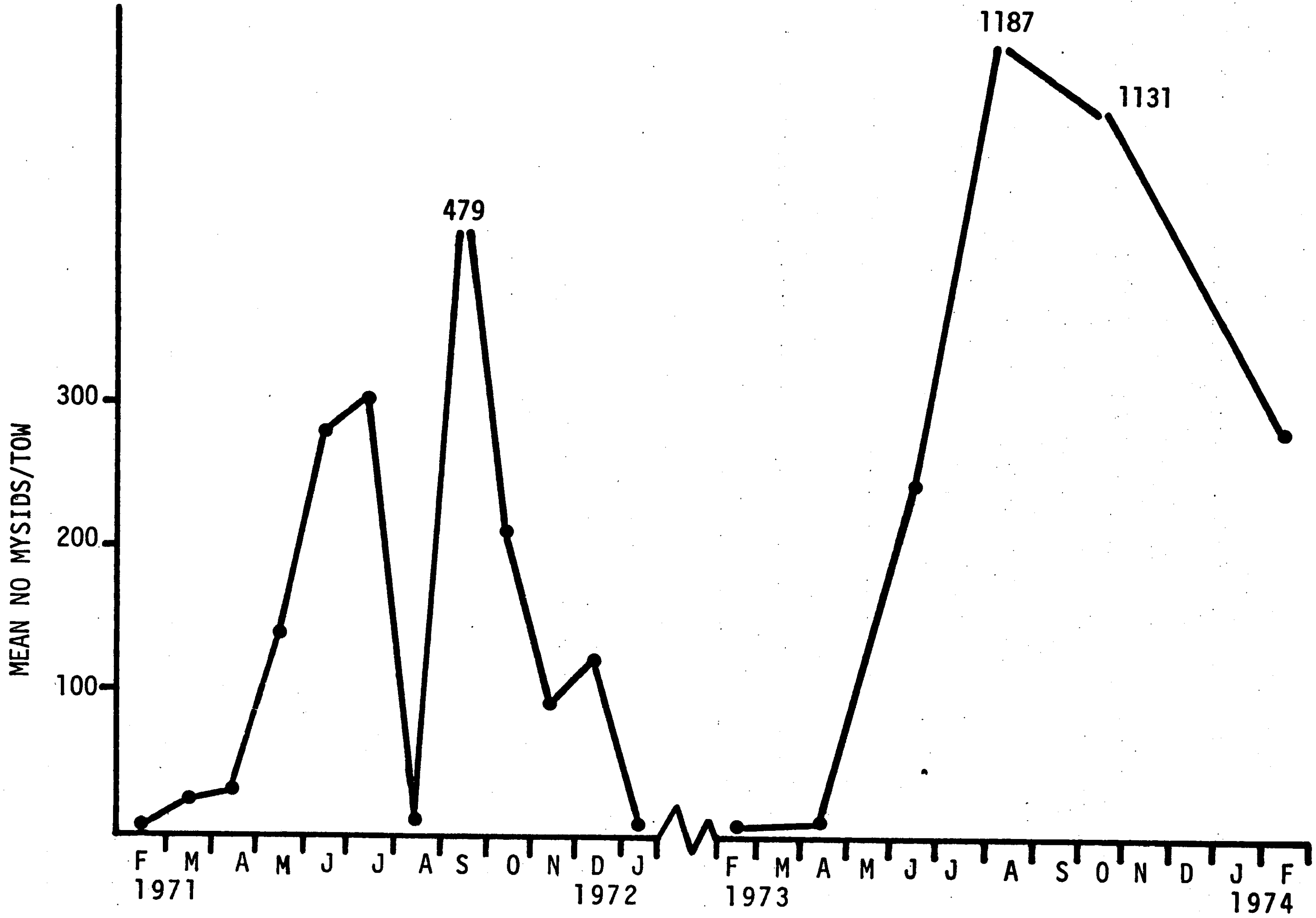

Figure 26. Seasonal occurrence (number per tow) of M. almyra collected from the nearshore area of Galveston Island in 1971-72 and 1973-74.

Table 28. Seasonal occurrence (number per tow) by developmental stage of the more common mysid species collected in the nearshore area of Galveston Island in 1971-72.

Month/ Species-stage	Feb. 1971	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan 1972
Mysidopsis almyra												
Juveniles	1	<1	<1	6	14	8	1	23	1	4	5	<1
Immature females	3	5	24	45	106	145	4	225	77	50	61	3
Mature females	1	7	2	24	55	30	2	35	45	14	11	<1
Males	3	14	9	66	106	124	5	197	88	22	41	2
Mysidopsis bahia												
Juveniles	<1	0	<1	3	21	4	0	<1	<1	<1	<1	<1
Immature females	<1	<1	6	17	114	17	<1	4	20	3	12	<1
Mature females	<1	0	2	56	62	35	<1	8	18	<1	1	<1
Males	<1	<1	4	58	150	48	<1	11	27	3	8	<1
Metamysidopsis swifti												
Juveniles	0	0	<1	0	3	0	0	0	<1	0	1	<1
Immature females	<1	0	2	2	3	<1	<1	9	1	<1	8	6
Mature females	<1	<1	23	42	2	<1	<1	48	1	1	14	3
Males	<1	<1	5	2	4	<1	<1	16	1	1	7	7

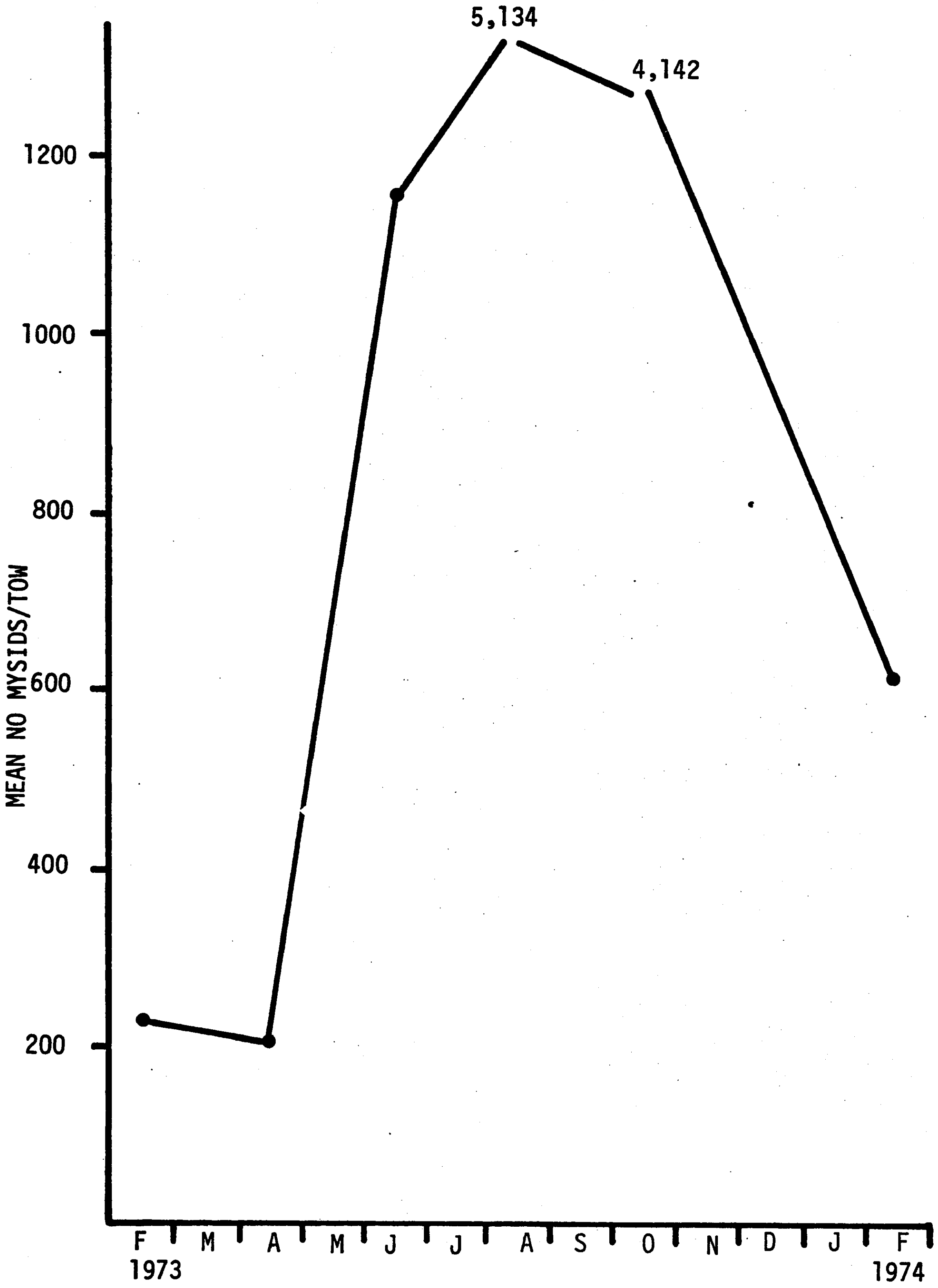

Figure 27. Seasonal occurrence (number per tow) of _M_. _almyra_ collected in Tucker Bayou in 1973-74.

Table 29. Seasonal occurrence (number per tow) by developmental stage of the more common mysid species collected in the nearshore area of Galveston Island in 1973-74.

Month/ Species-Stage	Feb 1973	April	June	Aug	Oct	Feb 1974
Mysidopsis almyra						
Juveniles	<1	<1	14	55	65	25
Immature females	1	3	61	400	442	75
Mature females	2	1	58	196	206	111
Males	1	3	109	537	414	107
Mysidopsis bahia						
Juveniles	0	0	0	<1	<1	<1
Immature females	<1	0	<1	8	24	<1
Mature females	<1	0	1	6	14	5
Males	0	<1	3	17	20	3
Metamysidopsis swifti						
Juvenile	0	0	0	1	<1	0
Immature females	0	0	0	2	10	2
Mature females	0	0	4	16	17	3
Males	0	0	1	8	20	3

and 30 show that the different developmental stages followed the same general seasonal pattern as the entire populations sampled in the nearshore area and Tucker Bayou.

In the West Bay area, the numbers of _M. almyra_ stayed low February-July, rose to a peak in October, and then dropped to below 200 the following February (Figure 28). The different developmental stages followed this same seasonal pattern (Table 31).

Mysidopsis bahia

M. bahia was found throughout all seasons in all study areas both years, although it occurred in low numbers in Tucker Bayou and West Bay. In the nearshore area in 1971-1972, _M. bahia_ was present in low numbers in February-March, but starting in April rose to a peak in June. The population declined to a low level in August, rose to a second smaller peak in October and declined to only 10 specimens in January (Figure 29). All developmental stages, except juveniles, followed the same seasonal pattern as the whole population. Virtually no juveniles were collected except during May-July and November (Table 28).

From the nearshore area in 1973-1974 _M. bahia_ occurred in low numbers during February-April, rose to a peak in October and declined to less than 200 specimens the following February (Figure 29). A total of 36 _M. bahia_ were collected in April, August, October, and February in Tucker Bayou with the highest numbers occurring the middle 2 months. In West Bay few _M. bahia_ were found in February and April; they rose to a peak of less than 200 in August and declined to around 50 in February, 1974 (Figure 28). In all study areas in

Table 30. Seasonal occurrence (number per tow) by developmental stage of _M_. _almyra_ collected in Tucker Bayou in 1973-74.

Month/ Species/stage	Feb 1973	April	June	Aug	Oct	Feb 1974
Mysidopsis almyra						
Juveniles	99	84	654	1150	1278	392
Immature females	17	42	192	1070	1073	134
Mature females	54	37	88	836	596	36
Males	61	70	212	2067	1199	71

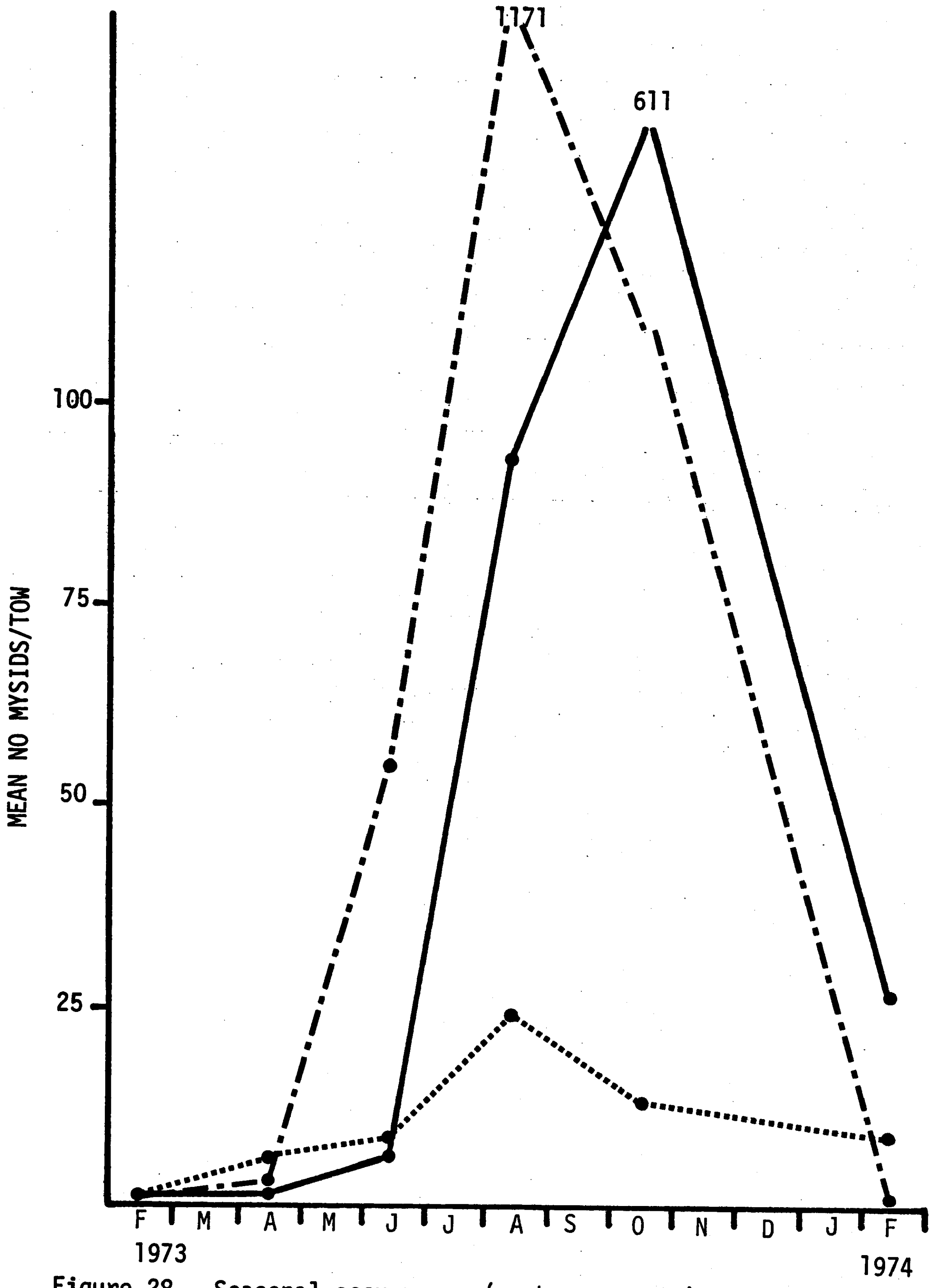

Figure 28. Seasonal occurrence (number per tow) of mysids collected in West Bay in 1973-74. M. almyra (——), M. bahia (········), M. bigelowi (—·—).

Table 31. Seasonal occurrence (number per tow) by developmental stage of the more common mysid species collected in West Bay in 1973-74.

Month/ Species-stage	Feb 1973	April	June	August	Oct	Feb 1974
Mysidopsis almyra						
Juveniles	0	<1	3	17	299	11
Immature females	<1	<1	1	20	129	4
Mature females	<1	<1	<1	19	31	6
Males	<1	<1	1	37	151	6
Mysidopsis bahia						
Juveniles	0	1	2	3	2	2
Immature females	<1	2	2	6	4	1
Mature females	<1	<1	2	6	2	1
Males	<1	3	3	8	4	3
Mysidopsis bigelowi						
Juveniles	0	<1	6	97	13	0
Immature females	<1	<1	12	204	37	0
Mature females	<1	<1	15	378	33	<1
Males	<1	<1	22	494	57	<1

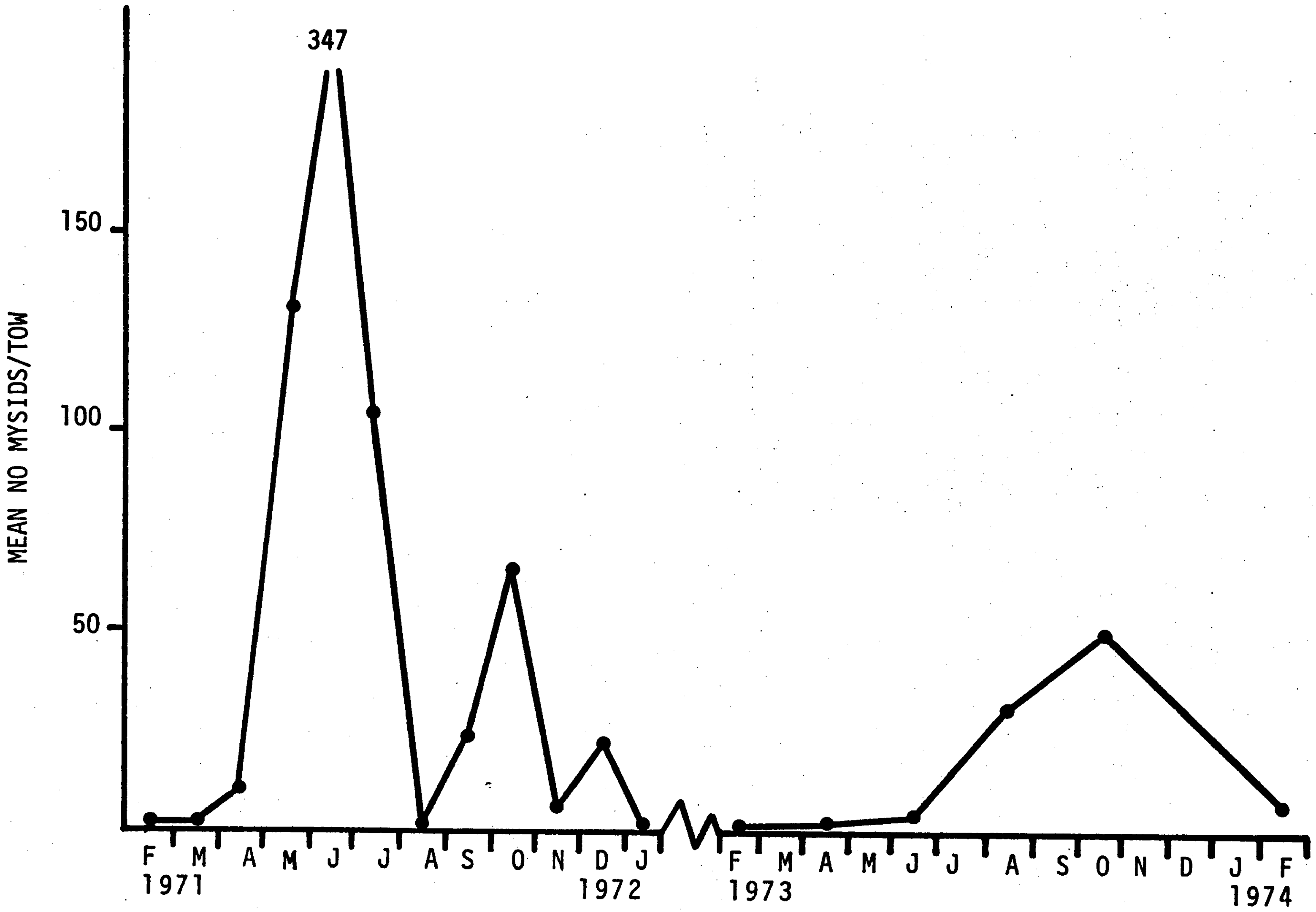

Figure 29. Seasonal occurrence (number per tow) of M. bahia collected from the nearshore area of Galveston Island in 1971-72 and 1973-1974.

1973-1974, the developmental stages followed the same seasonal patterns as the entire populations (Tables 29, 30, and 31).

Metamysidopsis swifti

M. swifti was collected almost exclusively in the nearshore area. No specimens were collected in Tucker Bayou, and only 9 were collected in October in West Bay. During the first year in the nearshore area, M. swifti was observed in low numbers except for peaks in April, May, September, December, and January (Figure 30). Table 28 shows that juveniles were the only developmental stage which differed from the general seasonal pattern of the whole population. They were present in low numbers throughout the sampling period except for a small peak in June.

During year 2 in the nearshore area no M. swifti were collected in February and April, but starting in June the population rose steadily to a peak of over 1000 in October and dropped to less than 200 specimens the following February (Figure 30). The developmental stages followed the same seasonal pattern as the whole population (Table 29).

Mysidopsis bigelowi

M. bigelowi was found infrequently in the nearshore area and Tucker Bayou. In year 1 only 89 specimens were collected, with 69 occurring in September. No M. bigelowi were collected in the nearshore area in year 2. Most of the 154 specimens collected in Tucker Bayou were taken in August. This species was abundant in West Bay from July through October, with the greatest number coming in August (Figure 28).

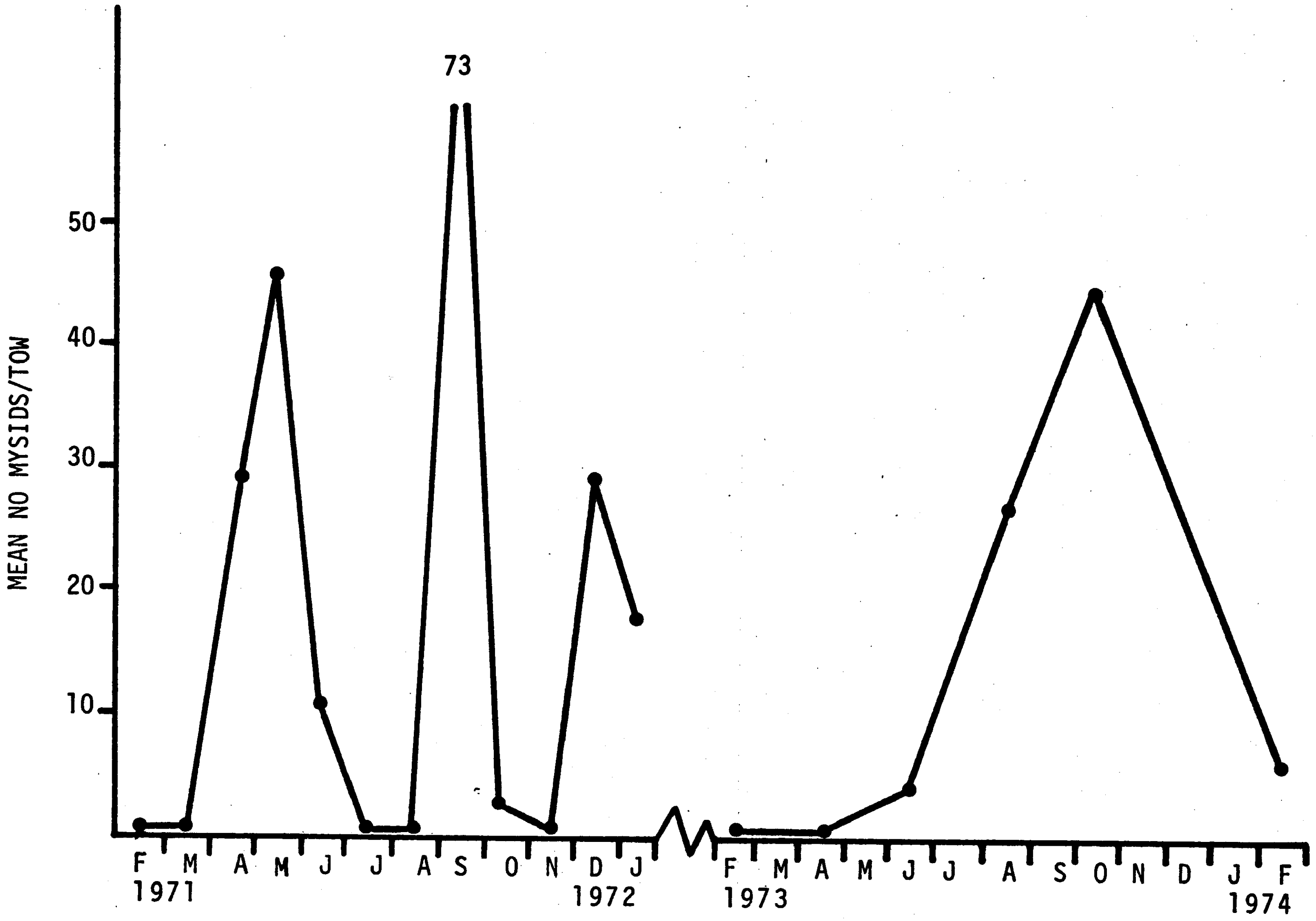

Figure 30. Seasonal occurrence (number per tow) of *M. swifti* collected from the nearshore area of Galveston Island in 1971-72 and 1973-74.

Bowmaniella spp. and B. brasiliensis

Only 68 specimens were collected during the entire study. In the nearshore area in year 1, 18 Bowmaniella spp. and 1 B. brasiliensis were found, mostly during the cooler months. No specimens were collected in this area in year 2. Only 1 specimen was found in February, 1974 in Tucker Bayou. Bowmaniella spp. was taken during all sampling periods in West Bay, with the largest numbers occurring in July and October.

Brasilomysis castroi

Five B. castroi were collected in the nearshore area in year 1 in June and August.

Promysis atlantica

Four P. atlantica were taken in the nearshore area in year 1 in April and June.

Relationship of Length of Mysidacea to Various Environmental Factors

Only mature females of Mysidopsis almyra, Mysidopsis bahia, and Metamysidopsis swifti collected in the nearshore area both years were measured. Table 32 shows that M. almyra had the greatest mean length, 6.0 mm, followed by M. bahia, 5.6 mm, and M. swifti, 5.1 mm.

All 3 species showed the same seasonal pattern of length change (Figures 31, 32, 33). The largest mature females were collected during the winter months, but were replaced by progressively smaller gravid females in the spring and summer. In the fall increasingly large mature females were found.

Table 32. Means lengths (mm) of mature females of *M. almyra*, *M. bahia*, and *M. swifti* at each station in the nearshore area for 1971-72 and 1973-74.

Species/ Stations	*M. almyra*		*M. bahia*		*M. swifti*	
	No.	mean Length	No.	mean Length	No.	mean Length
1	126	6.0	21	6.1	19	4.9
2	121	6.1				
3	57	5.5	62	5.2		
4	33	5.9	22	5.6		
5	17	5.4	83	5.5	3	5.8
6	275	5.7	37	5.6		
7	1	6.3			432	5.0
8	99	6.0	44	5.0	14	5.0
9	201	6.3	196	5.8	1	4.8
10	1	7.8	2	5.6	276	5.3
JB$_1$	114	5.4	9	5.4		
JB$_2$	161	5.6	20	4.8		
12	45	5.8	62	5.8		
13					23	5.1
14	6	5.6	69	6.1		
15					5	5.2
16	25	5.7	2	5.8		
17	178	6.8				
18$_1$	118	6.4			23	5.8
18$_2$	123	6.0	2	5.1		
19	21	6.2			206	5.2
20	1	5.3			158	5.0
21	1	7.8			50	5.0
Total	1724	6.0	631	5.6	1180	5.1

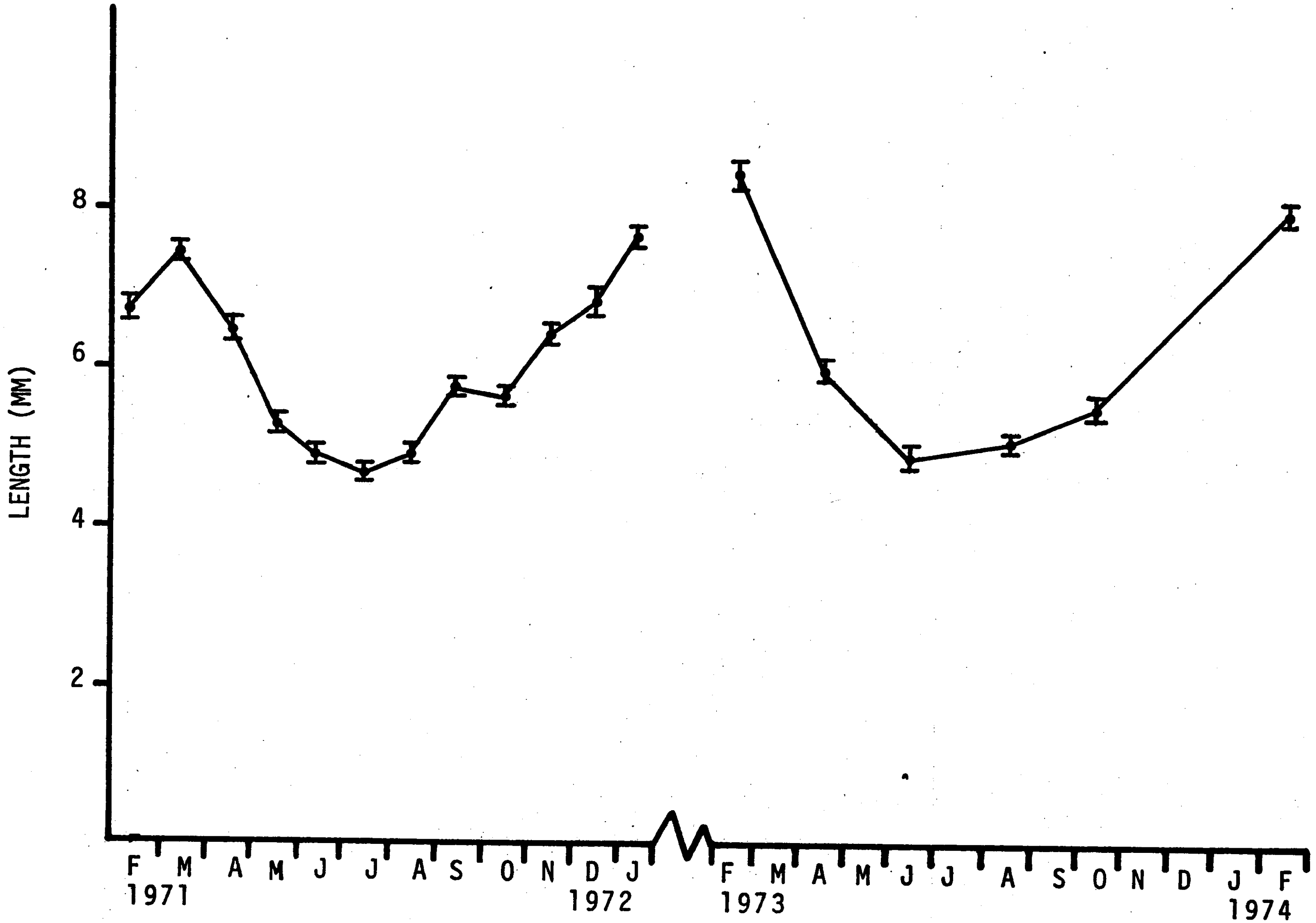

Figure 31. Monthly mean lengths (±1 standard error) of mature females of M. almyra collected from the nearshore area of Galveston Island in 1971-72 and 1973-74.

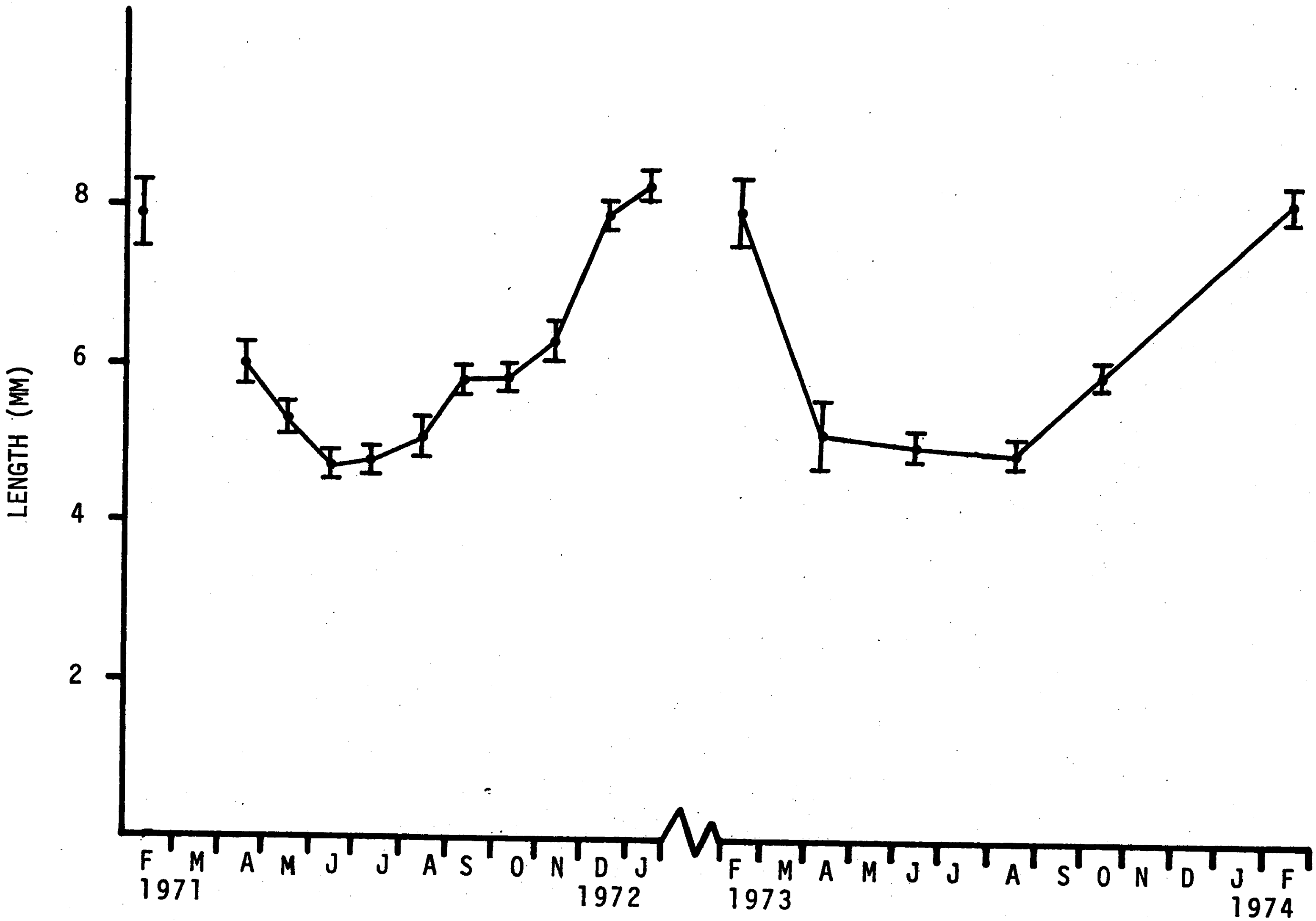

Figure 32. Monthly mean length (±1 standard error) of mature females of M. bahia collected from the nearshore area of Galveston Island in 1971-72 and 1973-74.

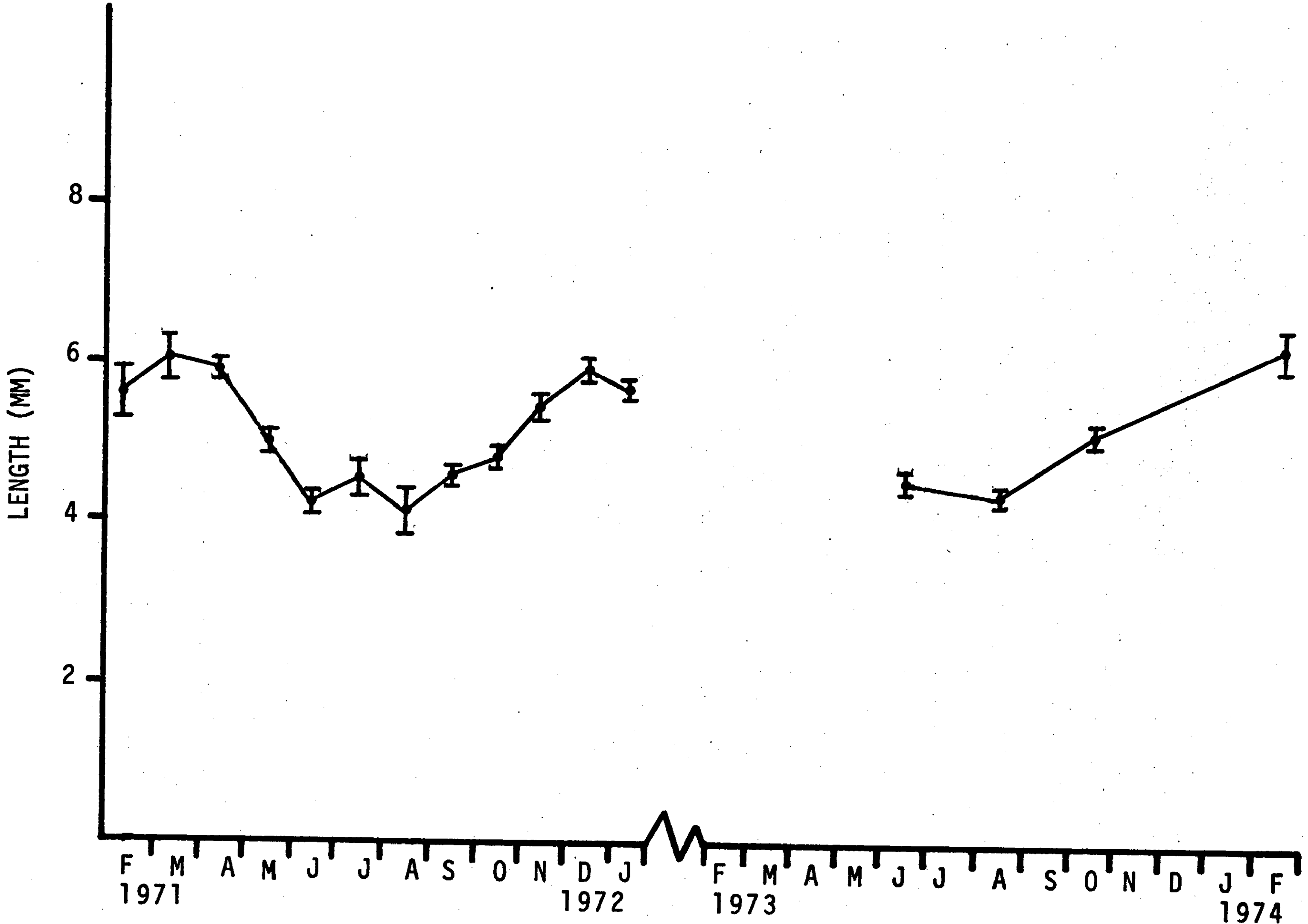

Figure 33. Monthly mean length (±1 standard error) of mature females of M. swifti collected from the nearshore area of Galveston Island in 1971-72 and 1973-74.

As expected the mean lengths of the mature females of all 3 species were inversely proportional to the temperatures in which they were collected (Figures 34, 35, 36). In salinities above 10 ppt the mean lengths of mature females of M. almyra and M. bahia increased with increasing salinities (Figures 34 and 35). No consistent relationship between length and salinity was found with M. swifti (Figure 36).

Table 32 shows that the mean lengths of mature females of all 3 species differed little from station to station.

Coefficients of correlation were calculated for the relationship between length and 4 environmental factors for mature females of the 3 mysid species (Table 33). For all species the highest coefficient of correlation was recorded for length vs. month followed by temperature, salinity, and station for M. almyra and M. swifti.

However, salinity had a higher coefficient of correlation than temperature for M. bahia, and there was a much greater difference between the coefficients of month and temperature than in the other 2 species.

Population Studies of Mysidacea

While the present study was not designed to determine the population dynamics of any mysid species, enough information was available to obtain an outline of the population structures of 3 of the more numerous species: Mysidopsis almyra, Mysidopsis bahia, and Metamysidopsis swifti. The purpose of this section was to examine the seasonal and overall population structure and egg production of these 3 species. Data from the nearshore area, years 1 and 2,

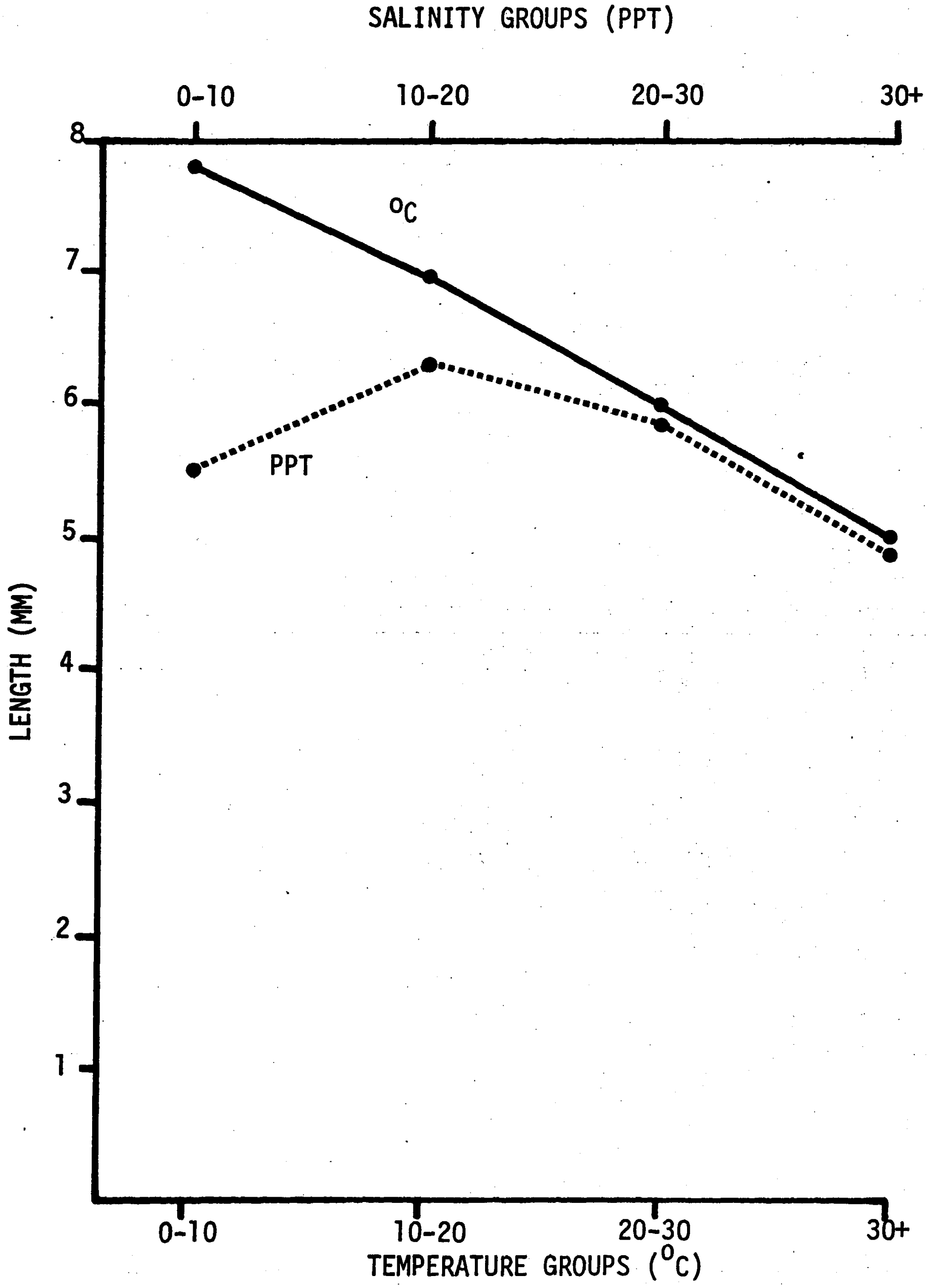

Figure 34. Mean lengths of mature females of M. almyra at the indicated temperature and salinity groups.

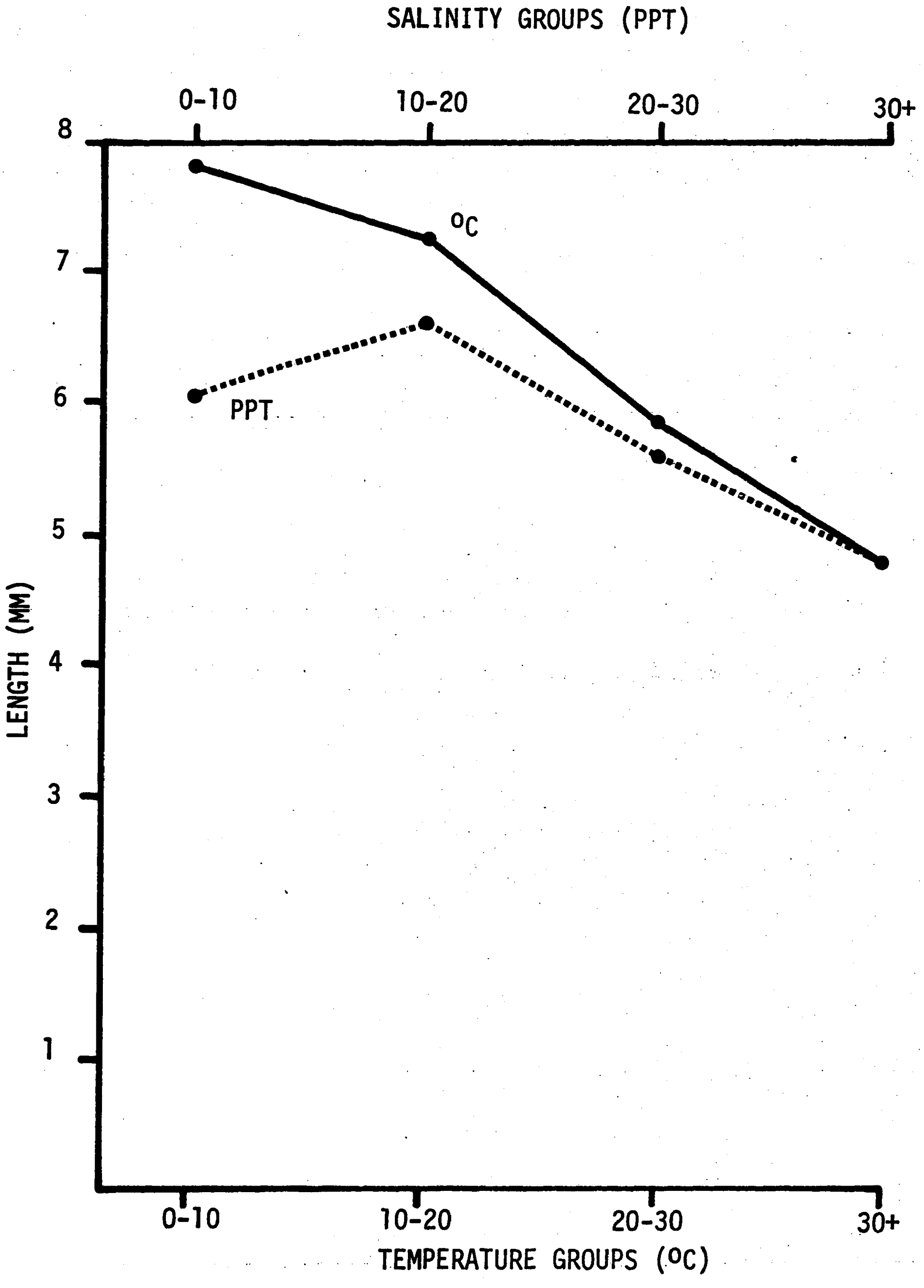

Figure 35. Mean lengths of mature females of *M. bahia* at the indicated temperature and salinity groups.

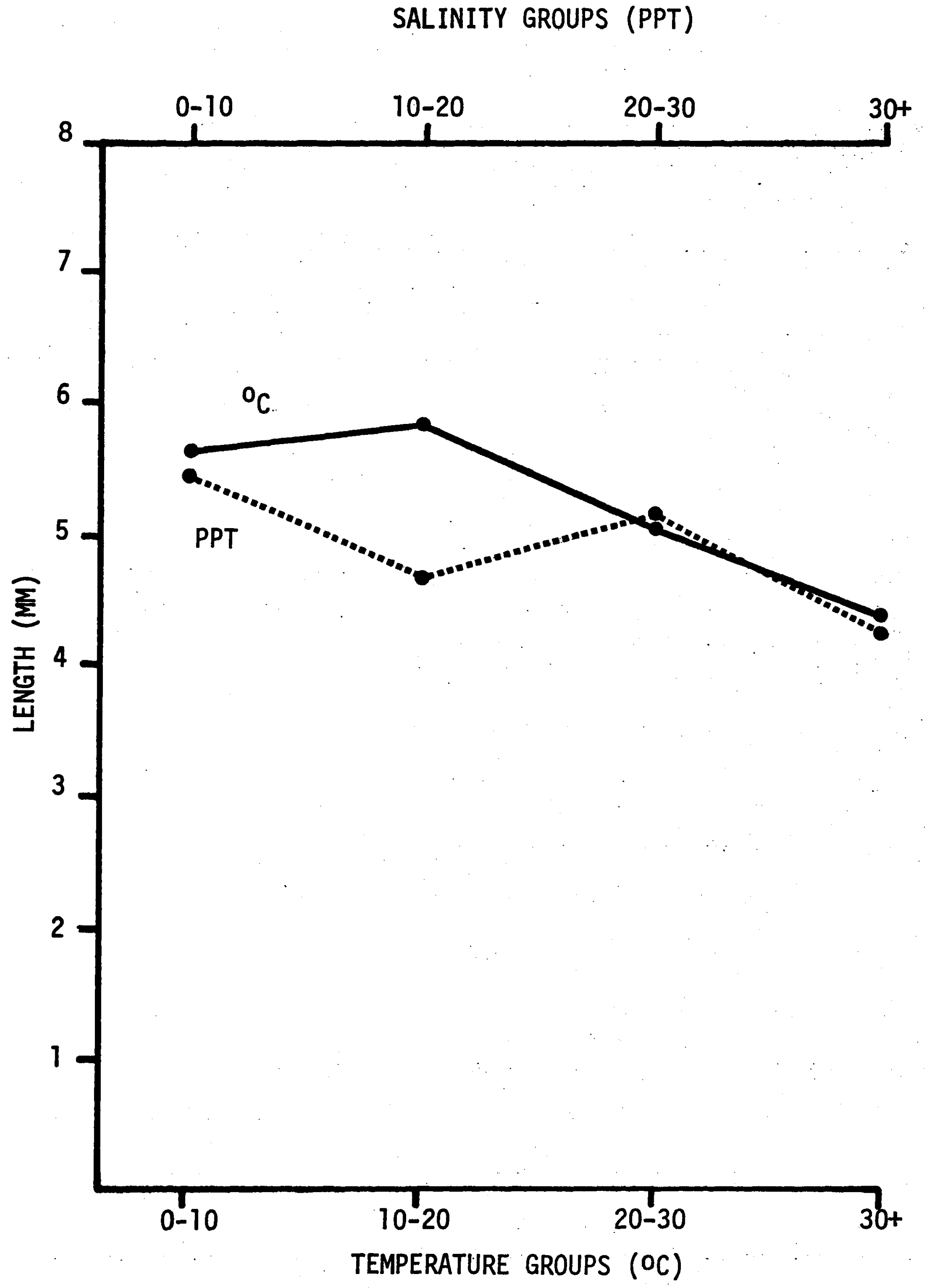

Figure 36. Mean lengths of mature females of M. swifti at the indicated temperature and salinity groups.

Table 33. Coefficients of correlation for various environmental factors concerning length of mature females of *M. almyra*, *M. bahia*, and *M. swifti* in the nearshore area in 1971-72 and 1973-74.

Species -factors	r-value
Mysidopsis almyra	
Length vs. month	0.9219
Length vs. temperature	0.8835
Length vs. salinity	0.6971
Length vs. station	0.3489
Mysidopsis bahia	
Length vs. month	0.9037
Length vs. temperature	0.6674
Length vs. salinity	0.7345
Length vs. station	0.3225
Metamysidopsis swifti	
Length vs. month	0.8342
Length vs. temperature	0.7844
Length vs. salinity	0.6202
Length vs. station	0.1385

were used for all species. When juveniles and immature females were combined they were referred to as immatures.

The number of eggs and young per brood was calculated to be a linear function of the volume (length^3) of the female for the 3 species in all areas in which they were abundant during both years. The formulae of the regression lines are given in Table 34.

<u>Mysidopsis almyra</u>

For the entire study there was a ratio of 56.4 per cent females to 43.6 per cent males (Table 35). In every study area females outnumbered males with the greatest percentage difference occurring in the nearshore area in year 1 (59.1 to 40.9). Figure 37 shows that females outnumbered males in every month, except one, in the nearshore area, both years. During the warmer months when total numbers were high, the percentages of the two sexes were close together and the ratio stayed fairly constant. During the cooler months when total numbers were low, females tended to dominate more and the degree of dominance fluctuated.

Over the 2 year period immatures were 2.5 times as abundant as mature females (Table 36). The ratio was 3.6 to 1 in 1971-72 and 2 to 1 in 1973-74. Although no clear seasonal pattern developed, the ratio tended to increase in the cooler months of year 1; however, this ratio reversed the second year.

Mature females with eggs and young were collected every month indicating that reproduction occurred during all seasons. They composed 13 and 19 per cent of total population in years 1 and 2. Little seasonal fluctuation occurred during the first year. During

Table 34. Regression analysis equations showing relationship between number of eggs and young and volume (length^3) of the female in *M. almyra*, *M. bahia*, and *M. bigelowi*, and *M. swifti* in each study area of Galveston Island in 1971-72 and 1973-74.

Species/Study area	*M. almyra*	*M. bahia*	*M. bigelowi*	*M. swifti*
Near-shore, year 1	$y = -875.8+3.6x$	$y = -495.1+2.71x$	-	$y = -112.48+6.53x$
Near-shore, year 2	$y = -561.3+2.02x$	$y = -555.3+2.2x$	-	$y = -247.6+2.08x$
Tucker Bayou	$y = -285.1+1.12x$	-	-	-
West Bay	$y = -958.1+2.51x$	-	$y=-267.4+1.95x$	-

Table 35. Percentages of females and males of *M. almyra*, *M. bahia*, *M. bigelowi*, and *M. swifti* from each study area of Galveston Island in 1971-72 and 1973-74.

Species/Study area	*M. almyra*		*M. bahia*		*M. bigelowi*		*M. swifti*	
	Females	Males	Females	Males	Females	Males	Females	Males
Nearshore, year 1	59.1	40.9	55.0	45.0	-	-	79.7	20.3
Nearshore, year 2	56.6	43.4	54.1	45.9	-	-	63.1	36.9
Tucker Bayou	53.1	46.9	-	-	-	-	-	-
West Bay	52.0	48.0	56.7	43.3	54.3	45.7	-	-
Total	56.4	43.6	54.9	45.1	54.3	45.7	74.8	25.2

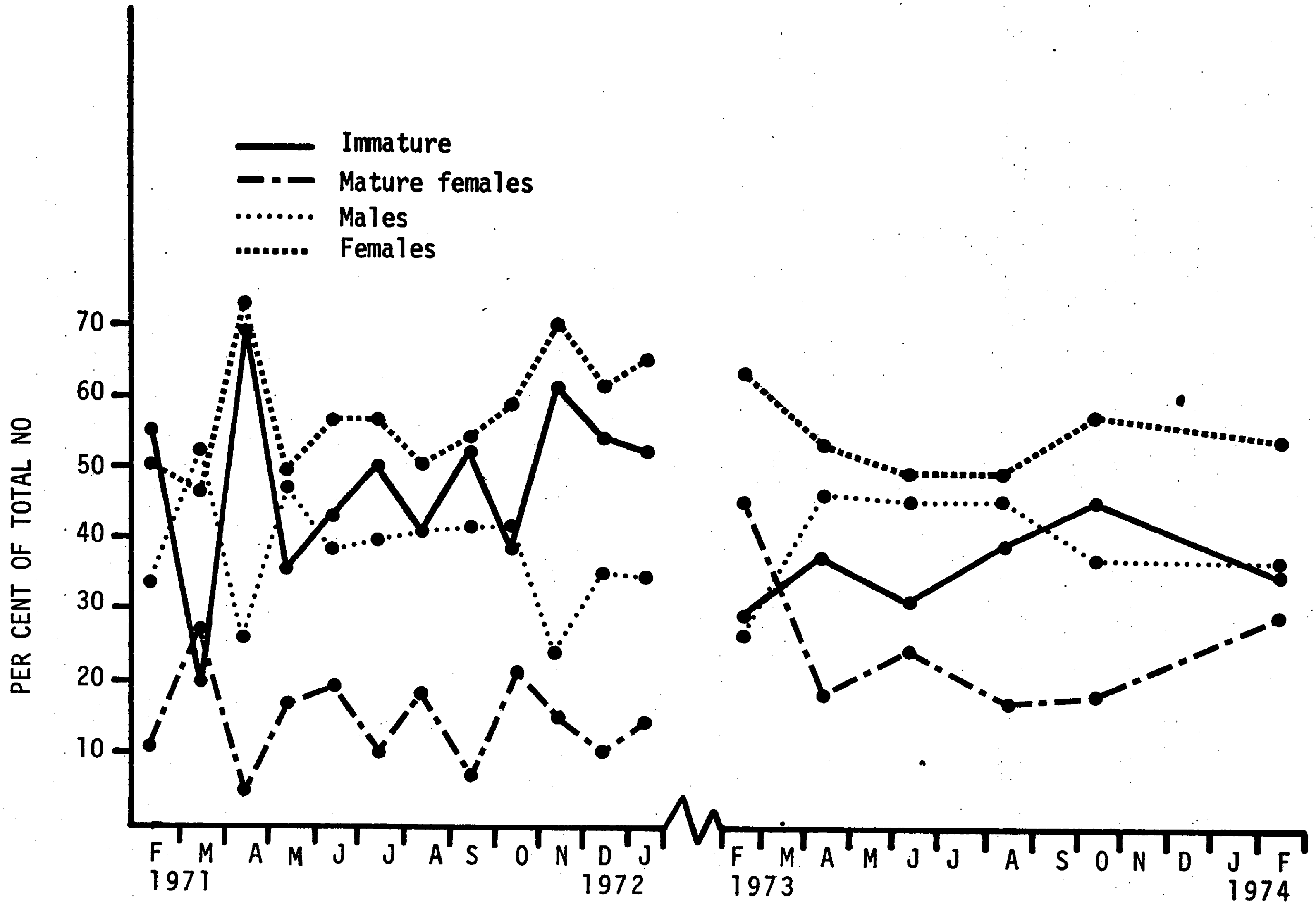

Figure 37. Percentages of developmental stages of M. almyra for each month from the nearshore area of Galveston Island in 1971-72 and 1973-74.

Table 36. Percentages of immatures* and mature females of _M. almyra_, _M. bahia_, and _M. swifti_ from the nearshore area of Galveston Island in 1971-72 and 1973-74.

Species/Study area	_M. almyra_		_M. bahia_		_M. swifti_	
	Immatures	Mature Females	Immatures	Mature Females	Immatures	Mature Females
Nearshore, year 1	47.0	13.0	31.0	25.7	16.5	63.6
Nearshore, year 2	40.0	19.0	25.6	29.0	17.0	46.4
Total	42.7	16.9	30.5	26.1	16.6	58.6

* juvenile and immature females

the second year the largest proportions of mature females occurred in the winter months when total numbers were lowest.

The number of eggs and young per brood varied from 3 to 42 during the 2 year study and averaged 10.3 the first year and 9.7 the second year (Table 37). The seasonal pattern of mean number of eggs and young per female (Figure 38) followed closely the seasonal length pattern of gravid females (Figure 31). This was to be expected since mean number of eggs and young per female and length were closely related. No clear correlation was found between seasonal production of eggs and young and seasonal variation in percentages of gravid females.

Figure 39 shows the seasonal variation in the number of eggs and young per female in a single size class. Since the lengths of gravid females varied substantially seasonally there was only one size class of M. almyra which covered all seasons. Within the 5.5-6.5 mm range, the mean number of eggs and young per female reached peaks in the spring and late summer and declined in the early summer, fall, and winter.

Mysidopsis bahia

The females of M. bahia outnumbered the males over the entire study, 54.9 per cent to 45.1 per cent (Table 35). Females were more numerous in every study area with the greatest percentage difference occurring in West Bay (56.7 to 43.3). Percentages of developmental stages for 6 months of the two year period were not included in Figure 40 since the total numbers collected in each of the 6 months were less than 20. During year 1 in the nearshore area the female/male ratio followed the same pattern that was described for the females

Table 37. Observations and mean number of eggs and young per female of *M. almyra*, *M. bahia*, *M. bigelowi*, and *M. swifti* for each study area of Galveston Island in 1971-72 and 1973-74.

Species/Study area	*M. almyra*		*M. bahia*		*M. bigelowi*		*M. swifti*	
	Observ.	Mean	Observ.	Mean	Observ.	Mean	Observ.	Mean
Near-shore, year 1	366	10.3	174	8.6			199	15.5
Near-shore, year 2	465	9.7	87	10.8			159	9.0
Tucker Bayou	177	8.1						
West Bay	43	12.7	10	16.8	65	7.5		

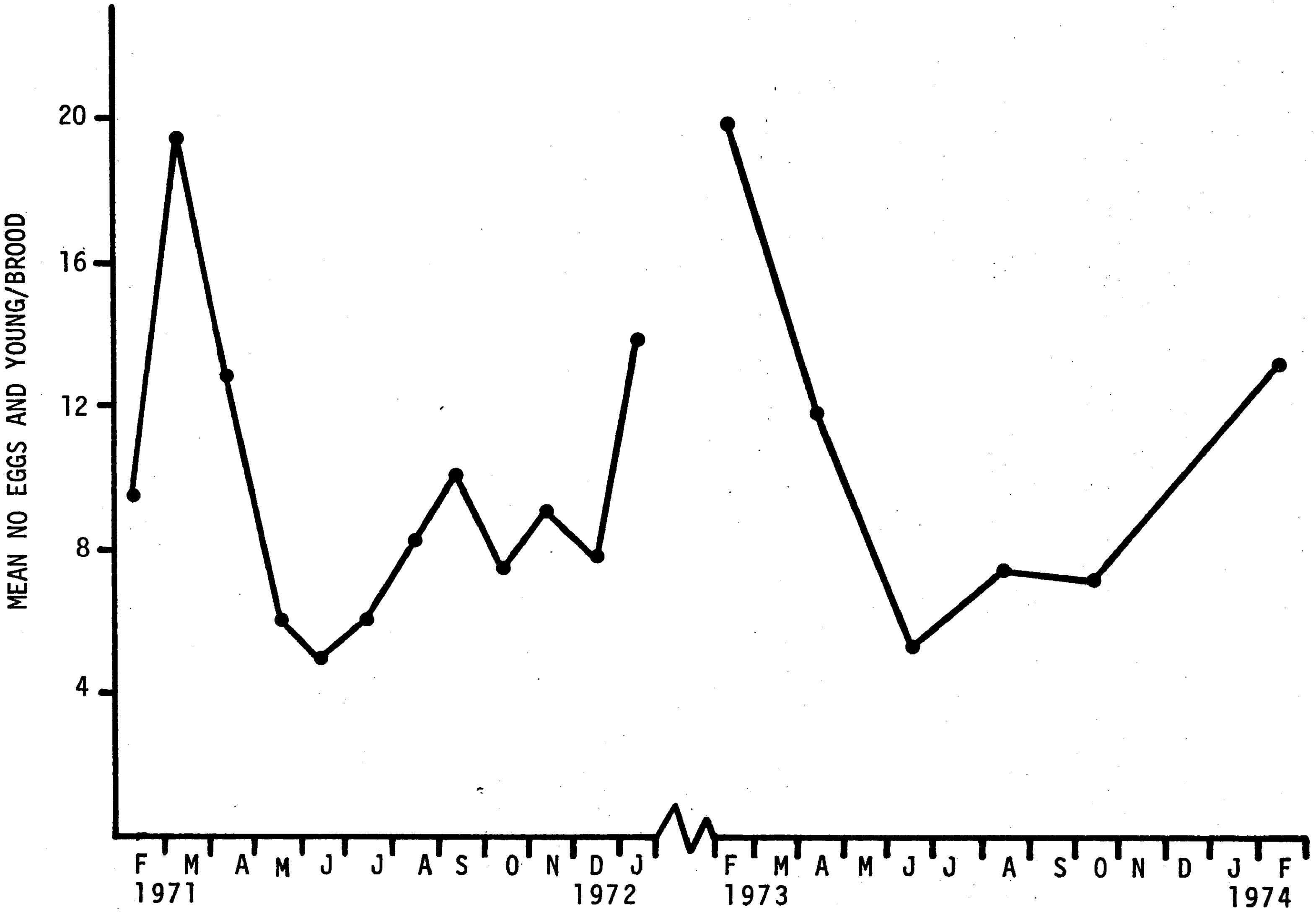

Figure 38. Mean number of eggs and young per gravid M. almyra for each month from the nearshore area of Galveston Island in 1971-72 and 1973-74.

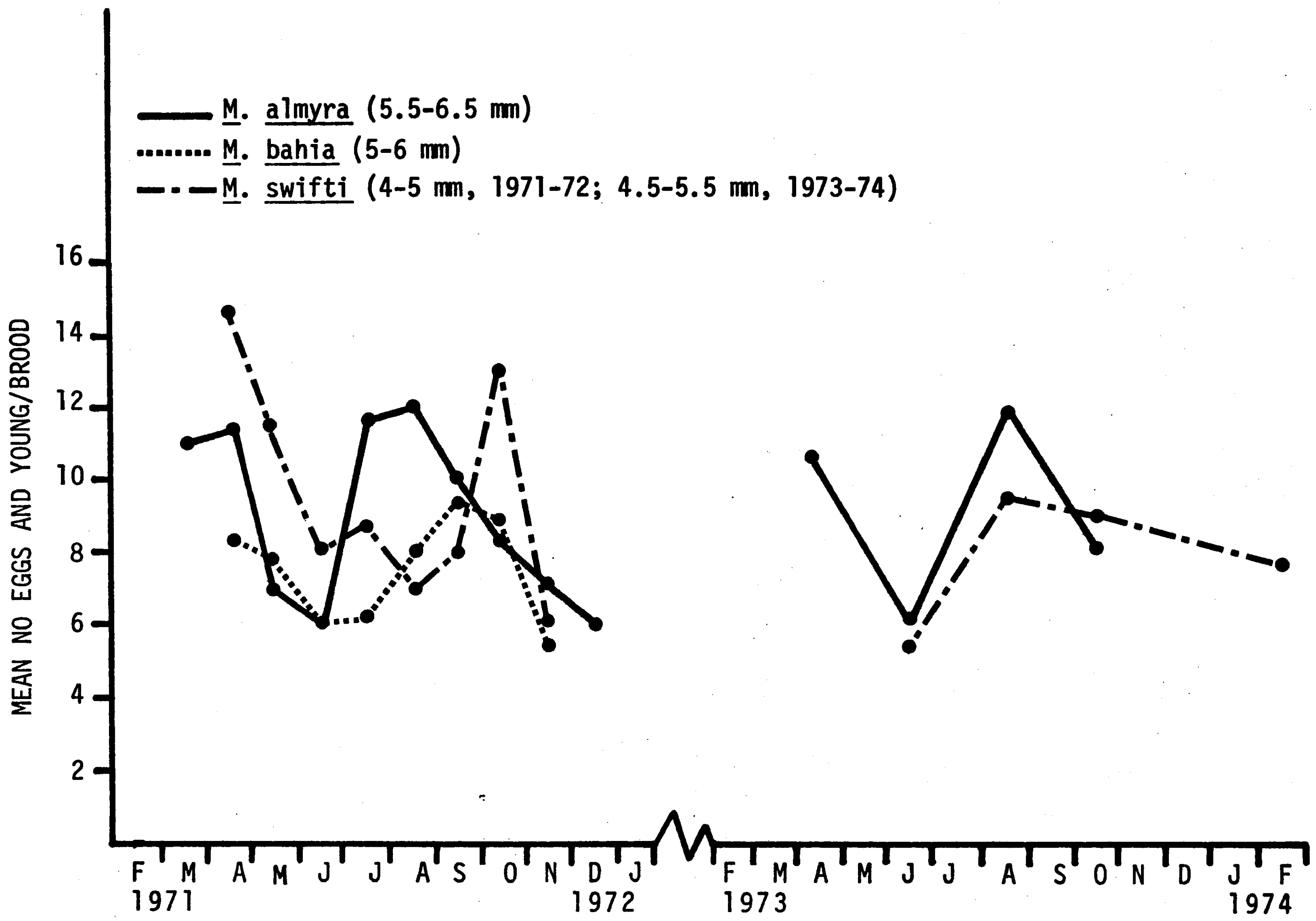

Figure 39. Seasonal variation in the mean number of eggs and young per female in a single size class of *M. almyra*, *M. bahia*, and *M. swifti* in the nearshore area of Galveston Island in 1971-72 and 1973-74.

and males of M. almyra (Figure 40). In the second year the same pattern existed except males were dominant in the warmer months and the sexes were reversed in the fall and winter.

Table 36 shows that the percentages of immatures and mature females were about equal for the two year study. The first year the immatures were dominant and the second year the mature females dominated. During the first year the immatures dominated the mature females during the colder months. This ratio fluctuated in the spring and reversed during most of the summer. During year 2 this ratio was approximately 1:1 except in February, 1974 when the mature females outnumbered the immatures 10:1.

Gravid females were collected in all but 2 months. In these 2 months a total of 7 M. bahia were found. The proportion of gravid females was highest in the warmer months and lowest during the colder months the first year. The second year this trend was reversed.

The number of eggs and young per brood varied from 3 to 24 for the entire study and averaged 8.6 and 10.8 in years 1 and 2, respectively (Table 37). Seasonally, the mean number of eggs and young per brood was highest in the colder months when the gravid females were largest and lowest in the warmer months when the gravid females were smallest (Figure 41). No clear correlation appeared between seasonal production of eggs and young and seasonal variation in percentages of gravid females for year 1. There was a tendency toward an inverse relationship in the colder months. During year 2 a direct relationship occurred so that peak production of eggs and young coincided with months when highest percentages of gravid females appeared.

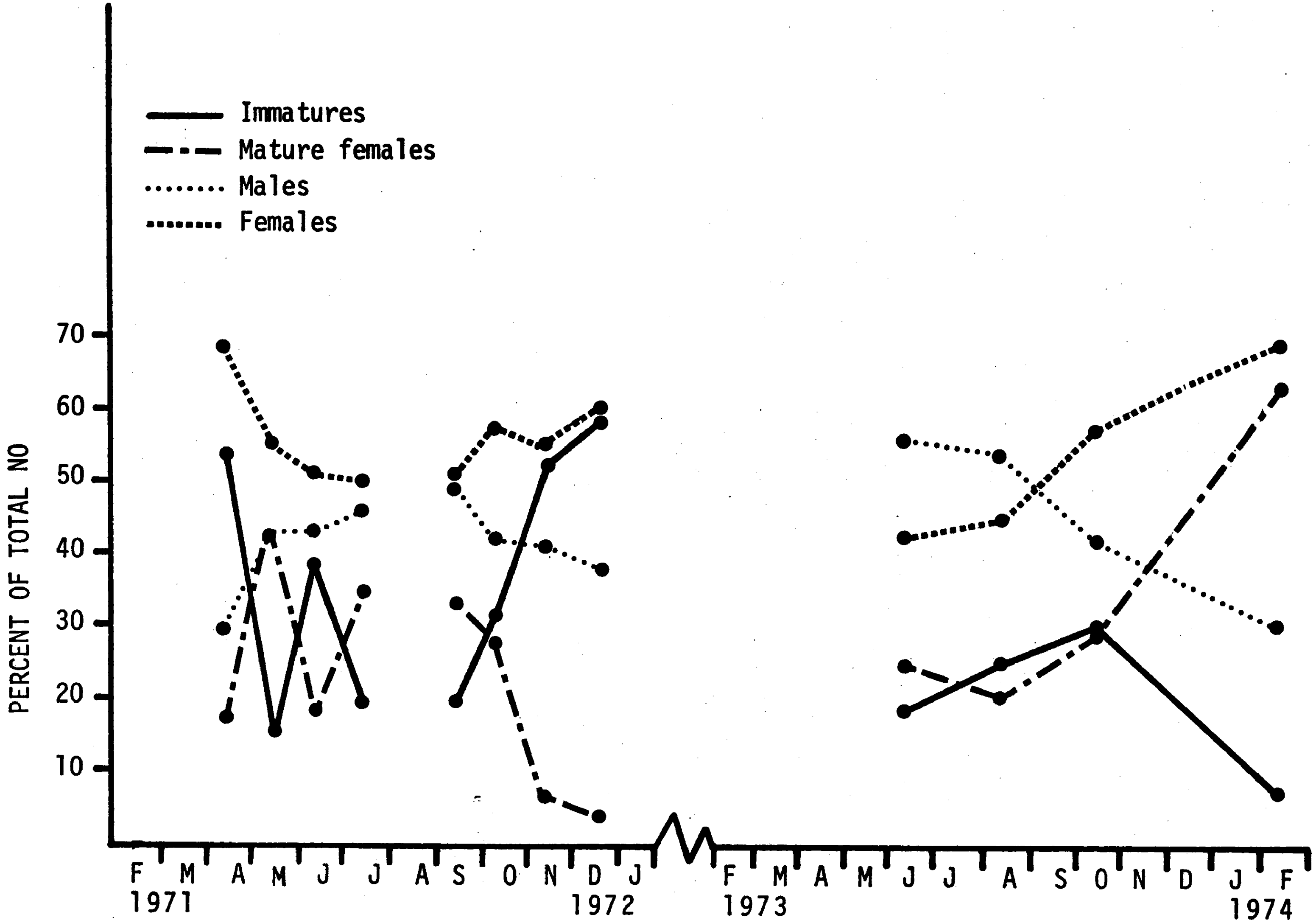

Figure 40. Percentages of developmental stages of M. bahia for each month from the nearshore area of Galveston Island in 1971-72 and 1973-74.

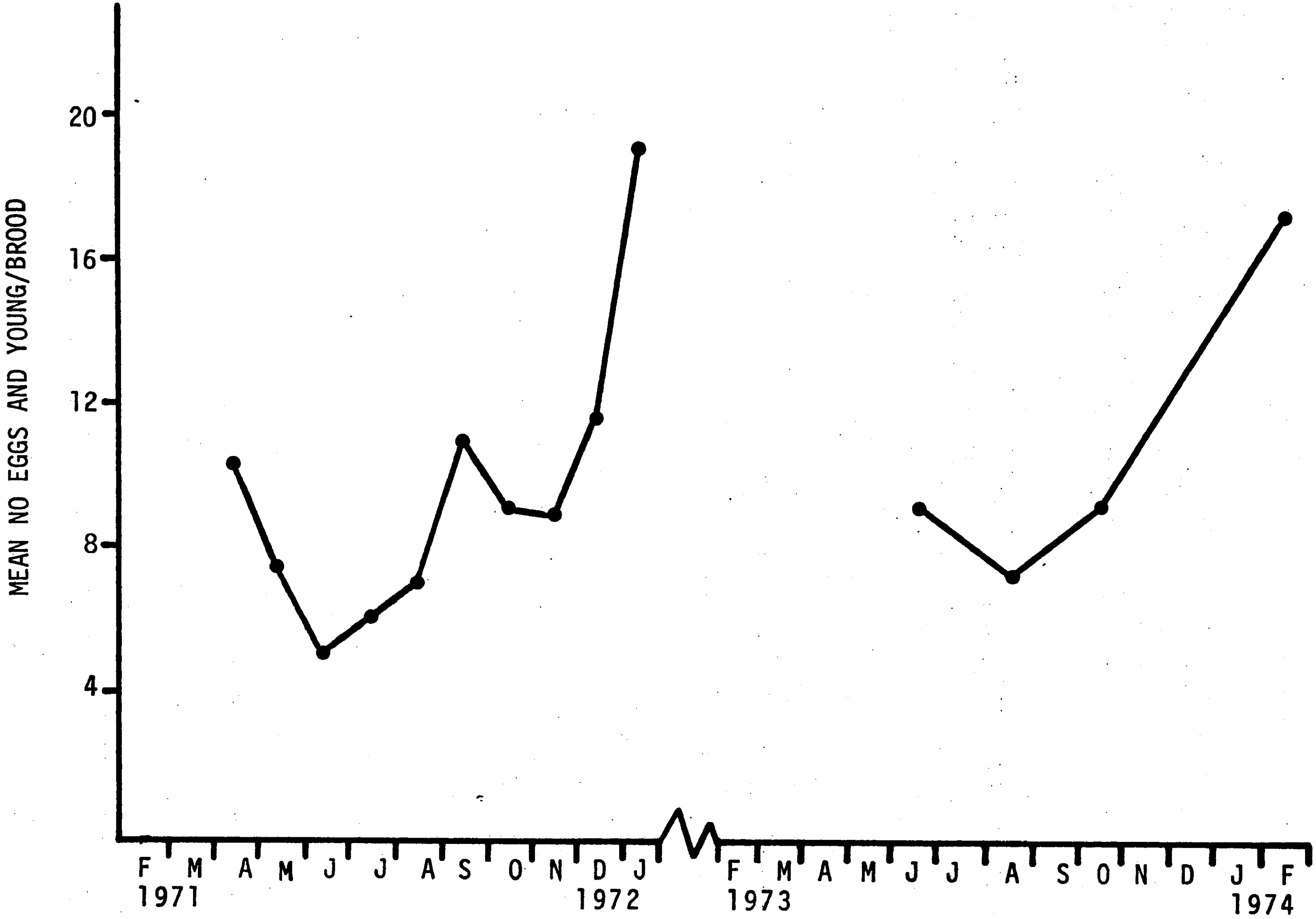

Figure 41. Mean number of eggs and young per gravid M. bahia for each month from the near-shore area of Galveston Island in 1971-72 and 1973-74.

The number of eggs and young per female in the 5-6 mm size class followed the same general seasonal pattern as that of M. almyra (Figure 27); however, the main peak was reached in fall rather than the late summer. No size class could be traced seasonally during year 2.

Metamysidopsis swifti

The dominance of females over males in M. swifti was greater than in any other species. For the entire study the ratio of females to males was 3 to 1 with the greatest difference occurring in the nearshore area in year 1, 79.7 per cent females to 20.3 per cent males (Table 35). Figure 42 shows that the percentages of females far outnumbered males in all but the 3 summer months in year 1. During year 2 the ratio of females to males was greatest in the summer and least in the fall and winter.

Mature females outnumbered the immatures in every month but 1, and were 3.5 times more abundant over the 2 year period; however, the seasonal pattern was erratic. During year 1 the ratio was low in the spring and fall and 1:1 in the winter. In the summer the immatures were 2.7 times as abundant as the mature females. During year 2 mature females were 6 times as abundant as immatures in the summer and about twice as abundant in the fall and winter.

The gravid females of M. swifti composed a greater per cent of the population than gravid females of any other species, 59 per cent. Seasonally, in year 1 the proportion of gravid females was greatest in the spring and fall when total numbers were highest. Proportions of gravid females were greatest in the summer of year 2 although percentages remained high in the fall and winter.

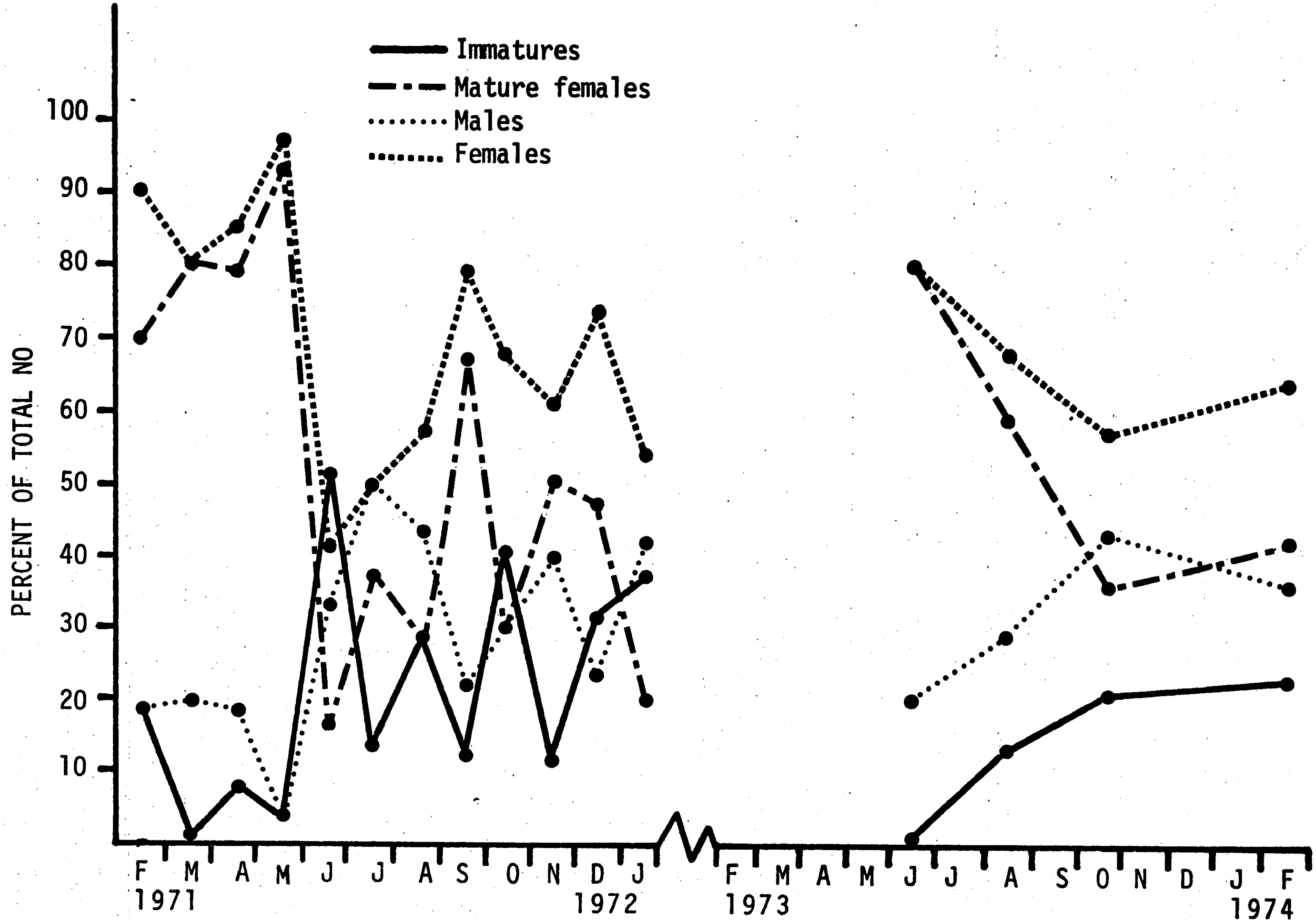

Figure 42. Percentage of developmental stages of M. swifti for each month from the nearshore area of Galveston Island in 1971-72 and 1973-74.

The mean number of eggs and young per brood for year's 1 and 2 was 15.5 and 9.0, respectively (Table 37) and ranged from 3 to 42. The seasonal pattern of mean number of eggs and young per brood (Figure 43) was the same as the seasonal length pattern of gravid females (Figure 33). Little correlation was found between seasonal percentages of gravid females and seasonal production of eggs and young.

Figure 39 shows that the seasonal variation in number of eggs and young per brood in the size classes, 4-5 and 4.5-5.5 mm followed the same general pattern as _M_. _almyra_ and _M_. _bahia_. This pattern also correlated roughly with the seasonal variation in total numbers of _M_. _swifti_.

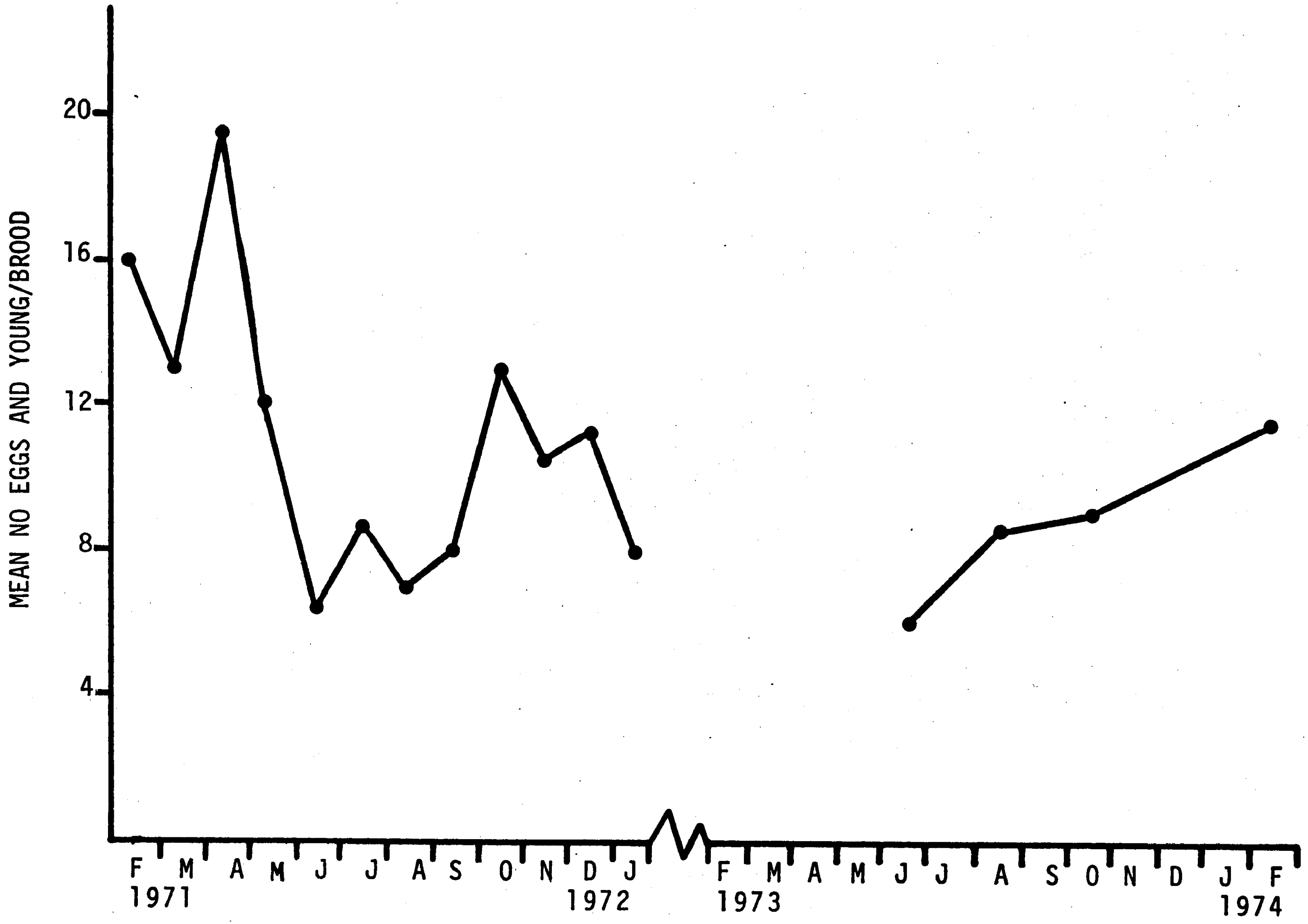

Figure 43. Mean number of eggs and young per gravid M. swifti for each month from the nearshore area of Galveston Island in 1971-72 and 1973-74.

DISCUSSION

Composition of Mysidacea in the Galveston Island Area

Of the 7 species of mysid collected in the present study 5 have been reported previously from the Texas coast. *Promysis atlantica* and *Metamysidopsis swifti*, surprisingly considering its abundance, represent new records for Texas. *M. swifti* has been reported from the Gulf coasts of Florida (Bacescu 1969; Brattegard 1970) and Mexico (Price 1975), and the Caribbean coasts of Colombia (Brattegard 1974a), and Panama (Brattegard 1974b). The distribution of *P. atlantica* ranges from Brazil to North Carolina (Clarke 1956). In the Gulf it is known from the northern Florida coast (Hopkins 1966) and the Louisiana coast (Clarke 1956).

Mysidopsis almyra is the dominant mysid in the inshore waters of the Texas coast. Table 38 shows that this species composed more than 95 per cent of the mysids collected in Conte and Parker's study of Alligator and Oyster Lakes (1971). Mackin's (1971) data indicated that *M. almyra* made up 93 per cent of the mysids he collected in 10 bays and estuaries along the Texas coast.

Mysidopsis bahia and *Mysidopsis bigelowi* are the next 2 most abundant species on the Texas coast according to the 3 studies shown in Table 38. Although *Metamysidopsis swifti* composed 4 per cent of the mysids taken in the present study, it was not found in the other 2 studies. This species inhabits nearly exclusively the seaside beach habitat, an area not sampled in Conte and Parker's or Mackin's studies.

Table 38. Percentage composition of mysids collected in three studies along the Texas coast.

Study/Species	Present study	Conte and Parker 1971	Mackin 1971
Mysidopsis almyra	82	96	93
Mysidopsis bahia	10	3	<1
Mysidopsis bigelowi	5	0	3
Metamysidopsis swifti	4	0	0
Bowmaniella spp.	<0.1	0	<1
Bowmaniella brasiliensis	<0.1	<0.1	<1
Bowmaniella dissimilis	0	0	<1
Brasilomysis castroi	<0.1	<0.1	<1
Promysis atlantica	<0.1	0	0
Taphromysis louisiana	0	<1	<0.1

Few specimens of the species of Bowmaniella were found in the above 3 studies; however, the sampling gear used was not designed to collect burrowing organisms. Few specimens of Brasilomysis castroi and Promysis atlantica were taken in the 3 studies. These two offshore species evidently do not maintain resident populations in Texas bays and estuaries. Taphromysis louisianae is a fresh to brackish water mysid (Conte 1972) that was not collected in the present study. Evidently the high salinity of West Bay and the absence of rivers entering this area of the Galveston Bay system prevented the entrance of T. louisianae into these waters. Conte and Parker collected less than 100 specimens in their extensive study, and Mackin found only 3 specimens in the Lavaca River. I have found large numbers of T. louisianae in the fresh and brackish water marsh areas north of Matagorda Bay (Price unpublished).

Ecological Distribution of Mysidacea Among the Study Areas

Mysidopsis almyra and Mysidopsis bahia were the dominant mysids in the extremely shallow waters (1.4 m or less) of the nearshore area and Tucker Bayou. These 2 species were also dominant in Conte and Parker's study (1971) in which collections were made in depths of 2 m or less.

In the deeper waters of West Bay Mysidopsis bigelowi was numerically dominant, although M. almyra was common in the shallower areas. Similarly M. bigelowi because of its depth preference was not collected in Conte and Parker's study (1971). In Mackin's study (1971) it was collected only in the deeper waters of Galveston and the

Lavaca-Matagorda Bay area. In the latter area, *M. almyra* was found only in shallower waters. A population of *M. bigelowi* also was discovered offshore of Galveston Island (Price unpublished). The distribution of this species may be similar to that of *Neomysis americana* which maintained a population in the deeper waters of the estuary of the Delaware River as well as in the offshore waters (Hulburt 1957). Its abundance in the estuary was due to reproduction there and entrainment of offshore populations.

The greater number of mysids collected in the nearshore area in year 2, as compared to year 1, was due to the tremendous numbers of *M. almyra* present during the second year. The increase of *M. almyra* and the decrease of *M. bahia* from year 1 to year 2 was related to the lower salinity experienced the second year (mean-17.4 ppt) then the first (mean-25.5 ppt). Apparently, *M. almyra* preferred inshore waters of lower salinity and *M. bahia* preferred higher salinity waters. Conte and Parker (1971) came to this conclusion when they collected greater numbers of *M. almyra* in Alligator Lake, with a mean salinity of 12.6 ppt, than in Oyster Lake, with a mean salinity of 17.0 ppt. Greater numbers of *M. bahia* were found in Oyster Lake than Alligator Lake. The relationship between salinity and these 2 species is discussed more thoroughly later.

The greater abundance of mysids in Tucker Bayou than West Bay was to be expected since the most productive part of an estuary is the intertidal and adjacent shallow water zones (Odum 1971). Detritus, the major food of inshore mysids (Odum and Heald 1972), was much more abundant in the bayou area than the deeper waters of the open bay. The dominance of *M. almyra* in Tucker Bayou and *M. bigelowi* in West Bay is a reflection of the different water depths in these areas. *M. bigelowi*, as mentioned previously, is dominant in deeper water. *M. bahia* was more abundant in West Bay than Tucker Bayou because of its ecological preference for open bay areas to bayous.

In summary, the generalized ecological distributions of the mysids show a classic pattern of ecotopic or habitat segregation among the species: *Taphromysis louisianae* occurs in fresh to brackish waters; *Mysidopsis almyra* in lower salinity shallow waters; *Mysidopsis bahia* in shallow bay waters of higher salinity; *Mysidopsis bigelowi* in deeper bay waters including offshore; *Metamysidopsis swifti* in seaside surf; *Brasilomysis castroi* and *Promysis atlantica* in deeper offshore waters; *Bowmaniella* is a burrowing species in contrast to the others which are hypopelagic in habit. It is noteworthy that the 3 species of the genus *Mysidopsis* form an ecological group as well, dominating and exploiting differently the estuarine ecosystem of the Texas Gulf coast. The seaside surf and freshwater species, inhabitng physiologically very different habitats, are also generically distinct. However, the situation is more complex since the species co-occur extensively as discussed in the next section.

Composition of Mysidacea Within Each Study Site

Although mysids are often treated as plankton, the inshore species do not drift passively with the currents. They are able to maintain themselves close to the bottom and seek out and remain in particular habitats.

Mysidopsis almyra and *Mysidopsis bahia* were found predominately in the nearshore areas of the bays and bayous. They lived sympatrically in the different habitats of this area. During year 1, when salinities were high, *M. almyra* was the dominant mysid only in the bayou-salt marsh habitats, and *M. bahia* was numerically dominant in the open bay habitats. During year 2 in overall lowered salinities, *M. almyra* was by far the most numerous mysid collected in the bayou-salt marsh and open bay habitats with the exception of the bay grass bed. My interpretation of this pattern is that *M. bahia* could sustain reasonably large populations in the higher salinities in most bayou-salt marsh habitats and could maintain a competitive advantage over *M. almyra* in open bay habitats. In lowered salinities this competitive advantage was eliminated. During year 2 the bay grass bed clearly served as a refuge for the *M. bahia* population. Perhaps the protection and food afforded by grass beds permitted *M. bahia* to survive there. A number of grass beds exist in West Bay (D.V. Aldrich, personal communication). Therefore a fairly sizeable population of *M. bahia* could be supported during unfavorable salinity conditions. In such reservoirs *M. bahia* would avoid competitive elimination by *M. almyra* and expand into the bay when favorable salinity conditions returned.

Metamysidopsis swifti was found in large numbers only in the seaside beach habitat. Its total distribution offshore is not known although a series of samples taken at depths of 9.2-12.2 m yielded no specimens of *M. swifti*. Clutter (1967) found that 5 species of hypopelagic mysids and 4 species of benthic mysids lived in bathymetric zones roughly parallel to the beach from the surf area to a depth of 17 m on the open coast off La Jolla, California. *Metamysidopsis elongata* occurred from a depth of about 2 m to about 10 m below mean lower low water. All the hypopelagic species inhabited different zones except for one species which was found sporatically in the *M. elongata* zone. It is possible that zonation of this kind occurs offshore of Galveston Island with *M. swifti*, *Mysidopsis bigelowi*, *Promysis atlantica*, and *Brasilomysis castroi*, but the collection data available does not permit such an analysis.

M. bigelowi maintained a population offshore of Galveston Island and in the deeper waters of West Bay during the warmer months. It was collected in the shallower waters of West Bay only during August, the month in which this species reached its peak in numbers. Figure 44 shows the normal distribution of *M. bigelowi* in June and its expanded distribution in August. Clutter (1963) found that large populations of *Metamysidopsis elongata* were more dispersed than smaller ones. Perhaps the intraspecific competition for space during August caused *M. bigelowi* to enter shallower areas than it normally inhabits.

In the nearshore area the 3 habitats in which species diversity was the greatest were probably no more diverse than any other habitat studied with the possible exception of the bay grass bed. Of the 7 species recorded in the seaside beach samples all but *M. swifti* and possibly *Bowmaniella* spp. accidently wandered into the area from offshore or bay waters. In the open bay and the bay grass bed all species except *M. almyra*, *M. bahia*, and *Bowmaniella* sp. were probably accidentals.

The habitats in which the largest numbers of mysids were found

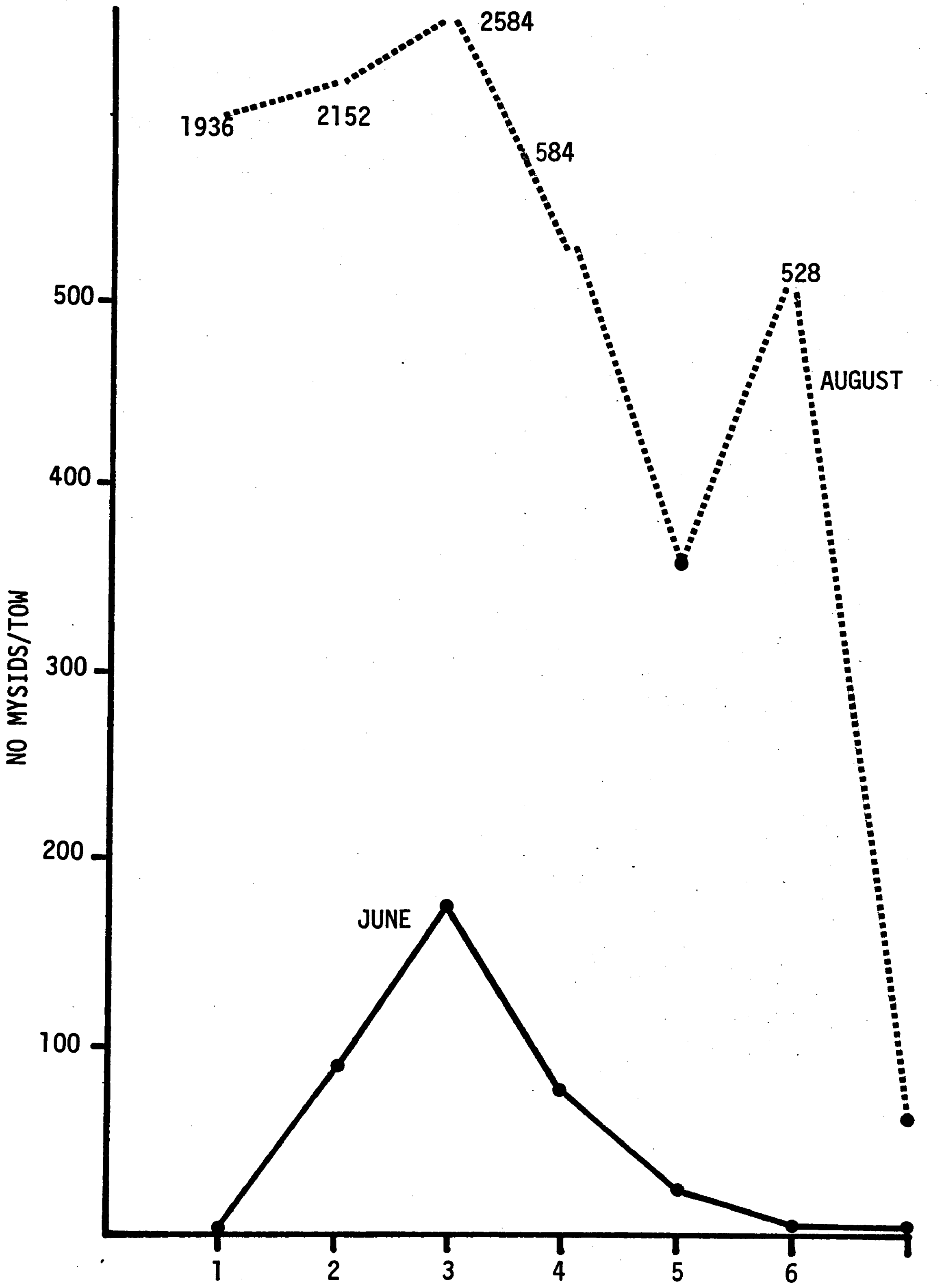

Figure 44. Number per tow of M. bigelowi at each station in West Bay in June and August 1973.

were probably more supportive than the other habitats in terms of detritus. The low numbers of mysids collected in most habitats were probably due either to the low availability of food there or to the harshness of the environment (seaside beach), with the exception of the biologically diverse bay grass bed. This habitat would have been expected to support a much larger mysid population than was found. The bay grass should have afforded mysids more than adequate amounts of detritus and protection. Possibly the bed was not sampled adequately. The beam trawl was dragged over the grass, perhaps allowing the mysids to stay in the grass under the net and avoid it. A 30 m drag could not be made through the grass bed, since the net would usually completely fill with grass. Since the bed was patchy, an effort was made to go in and out of the patches. If the mysids stayed exclusively in the patches, this type of sampling would give an underestimate of their abundance.

In summary, all the species were found together in the estuarine habitats studies with the exception of the fresh water to brackish water _Taphromysis louisianae_ which may lack access to the Galveston Island West Bay area because of a barrier of higher salinity in the bay. However, in each habitat type or biotope listed earlier, one species is dominant in numbers. The tremendous dominance of _M. almyra_ corresponds to its adaptation to the low salinity shallow water habitats so prevalent in the bay side estuarine habitats. The physically diverse grass bed had the most diverse fauna as would be expected, and served as a refuge for _M. bahia_ during episodes of hyposalinity. These field studies clearly indicate that through competitive interaction the realized ecotope is much smaller than the fundamental ecotope indicated by the actual wide distribution of the mysids, a conclusion supported by experimental studies discussed in the next section.

Relationships Between Temperature and Salinity and Abundance of Mysidacea

Mysidopsis almyra.--This is considered an euryhaline species (Conte and Parker 1971; Mackin 1971; Odum and Heald 1972; Tattersall 1969); however, the present and previous studies indicate that it prefers salinities of 10-20 ppt in the field. It was over 3 times as abundant in the nearshore area in year 2 (mean -17.4 ppt) as year 1 (mean-25.5 ppt). This species was nearly 3 times as numerous in Alligator Lake (mean-12.6 ppt) as in Oyster Lake (mean-17.0 ppt) although large numbers were collected in both areas (Conte and Parker 1971). Of the 10 areas in which Mackin (1971) sampled, 4 had mean salinities of less than 10 ppt, 3 had mean salinities between 10 and 20 ppt, 1 had a mean salinity of 25 ppt, and 2 were hypersaline (> 50 ppt). In the first group of areas (< 10 ppt) M. almyra was practically the only mysid collected and was taken in low numbers except in Lavaca River. In the second group of areas (10-20 ppt) it composed over 99 per cent of the mysids collected and was found in fairly large numbers in every area. Although M. almyra was the dominant mysid taken in the third area (25 ppt), it made up less than 50 per cent of the mysids taken and it was sparsely abundant in the hypersaline areas where it composed 1/4 of the collections.

Generally, numbers of *M. almyra* increased with increasing temperatures during years 1 and 2. However, the times of greatest abundance were determined by the salinity conditions which occurred during the warmer months. During times of high temperatures and salinities few mysids were collected. During year 1 few *M. almyra* were collected when temperatures and salinities exceeded 30 C and 30 ppt. These conditions occurred once during year 2 (West Bay, June) and again few numbers were found. During year 2 in the nearshore area and Tucker Bayou when temperatures approached 30 C, mean salinity values ranged from 13-25 ppt. It was under these conditions that the largest numbers of mysids were collected. These findings were supported by the survival tests which showed that at 30 C, survival of *M. almyra* was highest between 17 and 23 ppt and decreased at higher salinities.

Mysidopsis bahia.--Although *M. bahia* is also called an euryhaline species (Rhoads 1966) it is found in greatest abundances in the field in salinities over 20 ppt. This species was nearly 4 times as abundant in the nearshore area in year 1 as in year 2. Conte and Parker (1971) found *M. bahia* to be more than 6 times as abundant in Oyster Lake as Alligator Lake. However, less than 500 specimens were collected in Oyster Lake during the 2 year study indicating that 17 ppt is below the optimum salinity for this species. In Mackin's study (1971) 67 *M. bahia* were collected only in the hypersaline areas of Alazan and Baffin Bays in salinities ranging from 44-54 ppt. The times and intensities of the abundance peaks of *M. bahia* in years 1 and 2 depended on the temperature-salinity conditions that existed during the warmer months. During year 1 when temperatures and salinities exceeded 20 C and 20 ppt, large numbers of *M. bahia* were collected; but the greatest peaks were reached when temperatures and salinities neared 30 C and 30 ppt. During year 2 when temperatures reached 30 C and salinities were below 15 ppt, few mysids were collected. As the salinities rose to around 20 ppt and the temperature dropped slightly, numbers increased.

Metamysidopsis swifti.--Survival tests showed that *Metamysidopsis swifti* survived better in high salinities than at low ones. In the field few specimens were taken in salinities under 20 ppt. These results suggest that this species is well adapted to its seaside beach habitat, since this area is exposed to higher less fluctuating salinities than the bay area.

The largest numbers of *M. swifti* were collected at temperatures below 30 C. This agreed with survival tests in which survival decreased with increasing temperature. During year 1 few specimens were taken during the high temperature-salinity period. This was contradicted by the high survival of this mysid at these conditions in the lab. Although survival was high in the field these conditions may have been stressful enough to cause a migration into cooler waters.

Mysidopsis bigelowi.--This species was most numerous in the highest temperature and salinity groups recorded in West Bay. Since it has been collected from New England to Texas in offshore waters up to 179 m in depth (Wigley and Burns, 1971), *M. bigelowi* is more accustomed to higher less fluctuating salinities and more stable temperatures than those found in West Bay or any inshore area. Its absence from West Bay during the cooler months was possibly a result of migrations into the deeper more stable offshore waters. However, Hopkins (1965) found that M. bigelowi was most abundant in the inshore waters of Indian River Inlet, Delaware during the cooler months. More extensive inshore and offshore sampling must be done before the seasonal inshore distribution of M. bigelowi can be understood.

Temperature.--The survival rates of M. almyra and M. swifti at 30 C in the laboratory tests were drastically lower than at 15 and 22 C. Rhoads (1966) found that the survival of M. bahia at 28 C was much lower than at 12, 17, and 23 C. However, over the 2 year sampling period of the present study, M. almyra, M. bahia, and to a lesser extent M. swifti were collected in their largest numbers in temperatures around 30 C. A possible explanation for this discrepancy between lab and field studies concerns the effects of the constancy of laboratory temperatures versus the diurnal fluctuations of field temperatures on the organisms tested. During the 27 hr intensive sampling study in May, 1974, water temperatures varied from 27 to 31 C. During the warmest portion of the year in the shallow waters of Galveston Island, the water temperatures probably vary more than 4 C over a 24 hr period. Perhaps mysids can live for relatively short periods of time within a day at 30 C, but can not survive at this temperature for prolonged periods such as 10 days in the present laboratory study and 30 days in Rhoads' study (1966). During the warmest portion of the day in the field mysids may utilize various behavior mechanisms to escape extreme temperatures.

Few workers have compared the effects of constant and varying temperatures on the growth and survival of invertebrates. It has been long known some insects show faster development and increased survival at variable temperatures than at a constant temperature of the same mean value (Allee et al. 1949; Parker 1930; Peairs 1927). Khan (1965) found that the egg development of the copepod, Acanthocyclops viridis, was accelerated slightly in changing temperatures, but copepodid development was not. Costlow, Bookhout, and co-workers subjected decapod larvae to daily cycles of temperature throughout their development (Christiansen and Costlow 1975; Costlow and Bookhout 1969, 1971; Regnault and Costlow 1970). They found that developmental rates in cyclic temperatures were similar to those in constant temperatures. More work needs to be done in this area before any conclusions concerning crustaceans can be made, but certainly mysids with their fast developmental time and existence in diurnally varying estuarine habitats are likely to be responsive.

Another factor contributing to high mortalities of mysids at 30 C in the laboratory was the springing reaction of mysids in response to high temperatures. Several dead mysids were found adhering to the sides of the containers above the water or floating on the surface film of the water. They presumably got there by springing out of the water. Rhoads (1966) observed the same reaction with M. bahia at 28 C. Tattersall and Tattersall (1951) found that this springing mechanism of mysids was evoked in containers if water conditions such as high temperature or low oxygen were present. This may be a behavioral adaptation for escaping entrapment in small tide pools which are likely to get hot or in which oxygen may become very low.

The lack of complete acclimation of the mysids to the 30 C test temperature could have contributed to their mortalities. However, this is improbable since the mysids were collected in temperatures near 30 C (27-28 C) and the temperature change during acclimation was only 2-3 C per day, contrasting with the rapid diurnal changes occurring in the field.

In summary, the euryhalinity of the species corresponds to the range of habitat-types or biotopes in which the species occur in the field, but what is not shown by the experimental studies is that the realized ecotope established through competative interaction of the species is much smaller than the fundamental ecotope with respect to salinity and temperature. Furthermore, field data indicate a much wider temperature tolerance than the laboratory studies show, undoubtedly because of the abnormal constant conditions and physical constraints imposed upon the experimental animals. Mysids, as emphasized earlier, are highly mobile animals whose adaptations to physical parameters must be viewed in the context of their complex behavior reactions as studies on their microdistribution indicate.

Microdistribution of Mysidacea

Vertical distribution.--_Mysidopsis almyra_ showed a distribution similar to that of _Metamysidopsis elongata_ in Clutter's study (1969), the only other known study which examined the vertical distribution of shallow water mysids just above the bottom. He found that more than 90 per cent of the population was usually within 30 cm of the bottom during the day and night, although the mode was slightly higher at night. Clutter confirmed experimentally that the vertical movements observed in his study were associated with a decrease in light intensity rather than an endogenous rhythm. He suggested that M. elongata stayed concentrated near the bottom because of the greater availability of food there, especially detritus. This statement has greater importance in the case of M. almyra, which inhabits marsh areas, than M. elongata which is found in surf habitats, areas of low detrital content.

A greater proportion of mature females than immature females migrated into the upper water columns at night during the second 27 hr study. With this upward movement the gravid females possibly were preparing to release their broods, since the time of the study was in the peak breeding season of M. almyra. Whether or not the mature females of M. almyra migrate vertically only during the peak breeding season can be answered only by further investigations. The extent to which mature females migrate vertically seasonally could help determine peak breeding times of mysids such as M. almyra which reproduce throughout the year.

Judging from the population structures of the second 27 hr study and the 15 day study, the same population was sampled during both studies. Probably the same population was sampled from month to month in the seasonal sampling program. Variation existed in the population structures of the short term samples; however, this was to be expected since mysids of the same age group swarm and school together. Since the tow lengths were short, it is possible that at times only one swarm was sampled and at other times parts of several swarms were sampled. The total numbers collected during any one tow could vary widely depending on the patchiness of the mysids at that particular time. Low transparency of the inshore waters of the upper Texas coast is a definite hinderance to microdistribution studies. I was never able to make any direct visual observations of mysids in the field because of the turbidity of the water.

Horizontal distribution.--Observations which suggested that numbers of M. almyra were largest in the shallow waters during the ebbing tide agreed with Clutter (1967), Liao (1951, cited in Mauchline 1967) and Mauchline (1967) and were opposite to the findings of Percival (1929), Elmhirst (1931, 1932) and Liao (1951, as cited in Rice 1961). The latter investigators found that mysids moved shoreward with the flooding tide. Clutter (1967) observed that mysids swam against currents and could make headway against currents up to 1 cm/sec. He suggested that the shoreward movement of mysids during the ebbing tide was an overcompensating response to the seaward flow of water. Probably mysids swam against the incoming tide and moved seaward, explaining their low numbers in the shallow water during this tidal stage.

The results of the intensive sampling study showed that the numbers of mysids obtained during each collection period of the nearshore seasonal sampling program could serve only as rough estimates of the mysid population present at that time. Although approximate tidal records were kept during the seasonal sampling program, it would be a fruitless task here to attempt to correlate collections with tidal stages, partly because the collecting was designed to detect seasonal patterns, and partly because the tides are small on the Gulf coast so that local weather conditions greatly modify the levels.

Without doubt such information about the detailed relationships of the behavior of mysids with respect to social factors and physical factors such as diurnal, lunar and tide level conditions is of critical importance in understanding not only the microdistribution of the mysids, but also would have permitted a more reliable assessment of their seasonal patterns in abundance as will be evident in the next section. In any case, the information presented here would help permit the design of appropriate sampling programs to understand the variations of populations in space and time. As Clutter (1963) said: "This would increase precision of sampling as well as make proper use of the excess variability as a source of information rather than as a nuisance."

Seasonal Distribution of Mysidacea

The 4 most numerous species of mysids exhibited about the same seasonal cycle of lower numbers during the cooler months and larger numbers during the warmer months in all study areas both years. This seasonal population change could be attributed to migration or burrowing in response to environmental factors, predation, availability of food, or effects of the environment on reproductive capacity.

Temperature.--In response to cold temperatures in the present study there was no noticeable migration of mysid populations into the deeper waters of Tucker Bayou or West Bay. There was little difference in the surface and bottom water temperatures in the nearshore area, Tucker Bayou, and West Bay at this time due to the shallowness of the water and the mixing effect of the wind. Thus a migration would have had little survival value. The results of the preliminary burrowing experiment indicated that burrowing was probably not an explanation for the low numbers obtained in cold temperatures. Severe wave action could have caused a migration of mysids into deeper waters at times, especially in the seaside beach habitat. However, it seems doubtful that wave action in the nearshore area was severe or constant enough to cause a migration over a prolonged period of time.

During year 1 a drastic drop occurred in July-August numbers of _Mysidopsis almyra_, _Mysidopsis bahia_, and _Metamipidopsis swifti_ collected. The mean temperature and salinity for this period was extremely high - 32.3 C and 33.3 ppt. In my laboratory tests, survival of _M. almyra_ was low at 30 C and 35 ppt. Rhoads (1966) found that immature _M. bahia_ survived poorly at 28 C and 36 ppt. Cox (1974) observed that when _M. almyra_ was transferred from 20 C to 34 C, death was immediate and at 33 C death occurred in 5-6 hours.

This extremely high combination of temperature and salinity in the field may have increased mortality of the mysid populations or caused them to migrate into deeper cooler waters. Since the numbers of 2 of the 3 mysid species reached their highest peaks of the year in September, 1971, it is unlikely that large scale mortalities of the populations occurred in July-August. It is more probable that the mysids migrated into deeper, cooler waters. A summer migration from shallow to deeper waters in response to increased temperatures has been observed for Mysis relicta in lakes of Sweden, Norway, and North America (Wesenberg-Lund 1917) and for Praunus flexuosus in a dammed lagoon in Essex, England (Howes 1939).

Predators.--A large variety of fishes which inhabit bays and seaside beaches of the Gulf coast utilize mysids in their diets (Darnell 1958; Odum and Heald 1972). These fishes include anchovies, Anchoa mitchilli, silversides, Menidia beryllina, sand trouts, Cynoscion arenarius, speckled trouts, Cynoscion nebulosus, croakers, Micropogon undulatus, and spots, Leiostomus xanthurus. Usually mysids compose a larger portion of the diets of the younger smaller fish than older larger fish. All of the above fish reached their greatest abundance in the summer and fall and their least abundance in the winter in Copano and Aransas Bays in Texas (Gunter 1945). Anchovies and silversides spent the entire year in the bays, spawning in the spring and summer. During the winter they moved into the deeper more stable waters of the bay. The sand trout and speckled trout moved out into the Gulf during the winter and returned to the bays in the spring when the speckled trout spawned. The croaker and spot entered the Gulf during the fall to spawn and returned during the spring. Penaeid shrimp which also utilize mysids in their diets (Eldred et al. 1961; Ogle and Price unpublished), showed much the same seasonal pattern as croakers and spot. The seasonal abundance pattern of these fish and shrimp in the bays coincides with that of the mysids. With the relatively low numbers of fish and shrimp present during the winter, it would seem unlikely that predation was the major cause of the drop in the mysid populations during the cold temperatures. Nevertheless, the fish remaining in the bays during the winter (mainly anchovies and silversides) may feed preferientially on mysids. The burrowing experiment indicated that at low temperatures mysids became inactive and thus would be more susceptible to predation in winter than in warmer temperatures. In any case, while I do not think that predators are the main cause of the low winter mysid populations, certainly predation may be a contributing factor.

Food.--Mysids exhibit 2 methods of feeding. The more common method is filter feeding in which suspended particles are indiscriminately extracted from the water. The other is feeding on large masses of food - alive or dead. The food ingested by the filter feeding process include all kinds of small plankton and organic detritus (Tattersall and Tattersall 1951). Mauchline (1969, 1971b,c,d) identified particles of silt, sand, diatoms, dinoflagellates, filamentous algae, copepods, fragments of leaves, spores, seeds, and other terrigenous materials from several species of mysids. Mysids may also function as carnivores or scavengers feeding on live copepods, insects (Mauchline 1971b), and amphipods (Blevgad 1915), and dead mysids and amphipods (Cannon and Mantor 1927).

M. almyra is the only mysid taken in the present study on which stomach content analysis had been done. Odum and Heald (1972) examined the digestive-tract contents of 120 specimens collected from a mangrove area in the North River estuary on the west coast of Florida. The major portion of the identifiable contents was fine vascular plant detritus and inorganic particles. Small amounts of copepod parts and diatoms were present.

The marsh grasses, rushes, and sedges dominating the West Bay marsh-estuarine ecosystem are the primary contributors of organic matter into the detrital pool. Seasonal studies of a salt marsh community in St. Louis Estuary, Mississippi (Gabriel and de la Cruz 1974) showed that growth of vegetation continued year round with the greatest live biomass increase occurring in the spring and the maximum live biomass occurring in late summer. Standing dead biomass was about the same seasonally, but the biomass of partially decayed plants was greatest during the fall and winter, when most of the dead plants had fallen to the ground. This indicates that a large amount of detritus would be available for consumption by mysids during the colder months. Therefore, it is probable that the low numbers of mysids collected during these months can not be attributed to low availability of food.

Reproduction.--In the shallow water areas of the Texas coast seasonal changes in many crustacean and fish populations coincide with seasonal temperature changes (Fotheringham 1975; Gunter 1945, 1950; Wood 1967). Most crustaceans and fish spawn in the spring and summer, thus giving rise to their greatest numbers in the warmer months of the year. During colder months reproduction decreases or stops completely, causing total numbers to remain low. I believe the mysids in the present study follow a similar seasonal cycle because the effect of seasonal temperature and photoperiod changes on their reproductive capacity.

The following is my interpretation of the seasonal cycle of mysids in the inshore waters. During the winter large scale reproduction by mysids, although it occurs, is largely suppressed by cold temperatures and short photoperiods, as discussed later. The population is made up largely of offspring from the last large reproductive period in the fall. These mysids take a long time to mature since the maturation process is slowed by low temperatures. Most of their energy goes to growth rather than reproduction. They become larger than mysids taken during other seasons even though their growth rate is evidently slower. Some females reproduce but their incubation and generation times are much longer than those of mature females in warmer parts of the year. The number of eggs and young per brood are large, but few females are reproductively active. As temperature increases (and day length increases) the immatures become reproductively active and produce offspring. These young mature more quickly and at shorter lengths than mysids at lower temperatures, because the energy taken in goes to reproduction instead of growth. Breeding is continuous in the warmer months and incubation and generation times are short. The number of eggs and young per brood is small but mature females can presumably have several broods in rapid succession before they reach a post reproductive period or die. In the laboratory new eggs entered the brood pouches of _M_. _almyra_, _M_. _bahia_, and _M_. _swifti_ females within 24 hr after they had released their broods in most cases. When temperatures drop in late fall, reproduction slows and the seasonal cycle is completed.

Other factors, especially photoperiod, may be working in conjunction with temperature in controlling the reproductive state of the mysids: Lowered temperatures and shorter day lengths in winter may work together to suppress reproduction and higher temperatures and longer day lengths in the summer may stimulate it. Ovarian development in Palaemonetes paludosus was inhibited by short photoperiods and stimulated by long photoperiods and short photoperiods with the dark period interrupted by light (Paris and Jenner 1952). Stephens (1952) and Stephens (1955) observed that the ovarian cycle, development of secondary sexual characteristics, and moulting were stimulated in the crayfish, Cambarus virilis, by increased photoperiods. Lowe (1961) and Perryman (1969) found that increased photoperiods induced a more rapid cycling of maturation and resorption of oocytes in mature and immature Cambarellus shufeldti and Procambarus simulans. The effects of photoperiod on reproduction in crustaceans is a wide open area in which more investigation is needed.

Examining developmental stages within seasons did not indicate any distinct periods of maximum reproduction in the present study. It only reinforced the evidence that reproduction takes place throughout the year. Neither percentages of gravid females or ratios of immatures to gravid females showed any repeated seasonal trends which delineated definite breeding periods.

Other studies with mysids have shown that reproduction and growth decreased or completely stopped at low temperatures. Rhoads (1966) observed the generation times of M. bahia at 4 temperatures - 12, 17, 23, 28 C. At 12 C they did not reproduce after 92 days even though they appeared mature and were 6.8-9.8 mm long. Mean generation times at 17 C and 23 C were 51 and 41 days, respectively. No generation time was determined at 28 C because only females survived and copulation never took place. In another test Rhoads observed 25 day old *M. bahia* which had been reared at 23 C and 26-28 ppt with eggs in its brood pouch. She found that after 30 days the mean length of young reared at 12 C was much shorter (2.9 mm) then the lengths of young held at the 3 higher temperatures (5.9, 6.3, 6.1 mm).

Mauchline (1971e) studied the seasonal distribution of 24 species of mysids on the west coast of Scotland. He found that although most species reproduced throughout the year, periods of intensive breeding occurred most often in warmer months. During winter individuals in the population were predominately juveniles produced at the end of the large scale breeding period in the fall. These juveniles did not mature until spring and developed secondary sexual characteristics at twice the length of those taken in warmer months (Mauchline 1967, 1969, 1971a,b,d).

Size.--Conte and Parker (1971) and Mackin (1971) collected greater numbers of mysids in the colder months, November through May than in the warmer months, June through October. High temperatures ($\geq$ 30 C) and low salinities (< 10 ppt) prevailed during most of the warmer months of Conte and Parker's study and could have caused the small collections of mysids then. Table 28 shows that the lowest survival of *M. almyra* in the entire temperature-salinity test was at 30 C and 11 ppt. Rhoads (1966) found survival of *M. bahia* was poor at 28 C and 12 ppt, although survival was low at all salinities at 28 C.

The discrepancy in the seasonal cycle of mysids observed in the present study versus the 2 studies mentioned above is due mainly to differences in the mesh sizes of the nets used in the 3 studies.

The mesh sizes of the nets used by Conte and Parker (3 mm) and by Mackin (2 mm) were larger than those used in the present study (.9 mm, .417 mm, .220 mm). Figures 31-33 show that all species of mysids studied were much longer at lower temperatures than higher temperatures. The nets used in the other 2 studies selectively collected only the larger mysids. Even though low numbers of mysids were present in the colder months, a large per cent of these were collected. Although large numbers were present in the warmer months, a large per cent of these passed through the nets. From the extensive sampling done with small meshed nets in the present study, it appears that the seasonal pattern observed in the Galveston Island area is real rather that apparent.

To summarize: Each species for which I had sufficient data displayed a very similar cycle of rapid reproduction and large numbers during the summer months and slow reproduction and low numbers during the winter months. While temperature was important, along with salinity to a much lesser extent, the seasonal pattern itself showed the strongest correspondence to the patterns of reproduction and abundance observed. This strongly implicates photoperiodicity as a primary factor, which is supported by an analysis of the size of the reproductive female.

Relationship of the Length of Mysidacea to Various Environmental Factors

The explanation for the seasonal length differential in mature females was given earlier. At low temperatures and short photoperiods, maturation and reproduction slowed down so that most of the energy taken in by mysids went to growth. As temperatures and photoperiods increased maturation times and reproduction speeded up and most of the incoming energy went to reproduction. The large differences between mean lengths of gravid females of all species from month to month and the small standard errors indicate that the females were short-lived and that all populations probably had a high rate of turnover.

Of the environmental factors analyzed, season (photoperiod) and temperature were the main ones governing the length of mature females. The coefficients of correlation indicate that season and temperature were closely related. As mentioned before, photoperiod may be interacting with temperature, and perhaps is of more importance than temperature, in regulating reproduction and thus lengths of mature females. Segerstrole (1971) concluded that photoperiod was more important than temperature in determining breeding times of the relict amphipod species, Pontoporeia affinis.

Rhoads (1966) found that temperature had a much greater effect on the growth of Mysidopsis bahia than salinity. She found that 30 day old M. bahia reared in 28 C and 4 salinities averaged 6.1 mm, and were still immature. In the present study large numbers of gravid females of M. bahia of much shorter lengths were collected in the field at comparable temperatures. The photoperiod used in Rhoads' experiment is unknown. If a short photoperiod or low light intensity was used, maturation could have been suppressed even though suitable temperatures were present. This is certainly a fertile area for future research.

The strong seasonal effects upon the life cycle of mysids and their reproductive sizes clearly points up the difficulty of interpreting population patterns in the field and the limitation of constant conditions so frequently used in laboratory studies of populations.

Population Studies of Mysidacea

As mentioned earlier the present study was not designed to determine the population dynamics of the different mysid species; however, the information presented here should be a basis for such studies in the future.

Reproduction.--The proposed general seasonal cycle of mysids in the shallow waters of the Galveston area was given earlier. The times of peak reproduction were indicated by large increases of numbers. As mentioned before, these periods could not be consistently discerned by examining the seasonal changes in the developmental stages. The effects of swarming on sampling could have had much to do with this result. Percentages of gravid females sometimes increased with increasing numbers, but at times decreased during this period. Clutter (1969) found an inverse relationship between population size and percentage of gravid females. He suggested that crowding may be a mechanism for population control by reducing the reproductive rate.

In any case, the intervals between samples were too long to accurately follow the generation times of an organism with such a short life history. Rhoads (1966) noted a 25 day old female Mysidopsis bahia already with eggs in its brood pouch, and I have made the same observation with Mysidopsis almyra. Both species were raised at 23 C and 26-28 ppt, a combination of conditions conservatively equivalent to field conditions since field temperatures are frequently higher. Although the incubation periods for these species are not known, they are probably no more than 5-6 days during the warmer portions of the year. Nair (1939) found that the incubation period of *Mesopodopsis orientalis* collected from the mouth of the Adyar River in Madras, India was consistently 4 days at temperatures between 25 and 30 C. It is reasonable to assume that during the warmer portions of the year in the shallow waters of Galveston Island mysids had a generation time of 30 days or less. During the cooler months generation times were probably quite a bit longer. However, because breeding occurred continuously, the generations were not synchronized, especially in the warmer months. This overlapping of generations would be virtually impossible to follow with data derived from monthly or bimonthly samples.

Sex ratio.--The ratio of females to males followed the same seasonal pattern for all species except *Metamysidopsis swifti* during year 2 in the nearshore area. Lower numbers of males were consistently collected in cooler months than warmer months. If males seek out females for the purpose of copulation, their chances of finding suitable females would decrease in winter due to the low numbers of reproductively active females at that time and the continued searching of the males would expose them more to possible predators. This searching coupled with the lowered activity of mysids at depressed temperatures could increase predation on males and be a possible explanation for their decrease in numbers during winter.

Age structure.--The ratios of immatures to mature females for the entire study in the nearshore area indicate that *M. almyra* had a vigorous rapidly growing population. The mature females probably had a high reproductive rate and were fairly short-lived. However, much more information about its life cycle, especially length of time spent in each developmental stage, is needed before any firm conclusions can be drawn.

The population of *M. bahia* appeared to have a slow growth rate since immatures and mature females were collected in nearly equal quantities. This population structure was possibly due to a low reproductive rate coupled with other factors. Although *M. bahia* had about the same number of eggs and young per brood as *M. almyra*, a difference in generation times or number of broods produced by a single female could have decreased its reproductive potential. If the reproductive potential was fairly high, however, this situation could be caused by extremely long-lived adults, excessive mortalities of immatures, or a combination of the two. Again insufficient information is available to make definite conclusions.

The population of *M. swifti* appeared to be a very slow growing one; however, the mature females seemed to have a high reproductive potential as evidenced by their large percentages in the population and the large mean number of eggs and young per brood. The large numbers of mature females in relation to immatures could be caused by the same factors mentioned in reference to *M. bahia*. However, this relationship could have been apparent rather than real. *M. switfi* probably lives in a narrow band parallel to the shoreline to a depth not exceeding 9-10 m, but samples were taken only in the surf zone in depths of 1-1.5 m. It is possible that immatures were horizontally separated from mature females. After being released in the turbulent waters near the surf, the immatures may have migrated to deeper calmer waters, or the gravid females may have moved into deeper waters to release their broods and then migrated back into shallower waters. Clutter (1967) found that in 15 of 24 transects made perpendicular to the beach off La Jolla, California, juvenile M. elongata inhabited broader zones than adults. The median of the juvenile population was seaward of that of the adults in 9 transects, shoreward in 8 transects, and approximately the same in 7 transects. This distribution could not be related to any physical or biological factor. The causes of the population structure of M. swifti found in the present study can not be resolved without further investigation.

Brood size.--The relationship between body size and number of eggs and young carried by gravid females agreed with the findings of Jensen (1955). For individual species, the regression lines for the different areas and years were not compared since that is another study in itself. The number of eggs and young in equally large specimens of the same species differed seasonally as previously observed by Jensen (1955) and Mauchline (1965, 1967). The production of eggs and young for all species was highest during the warmer months; however, the pattern did not closely follow the pattern of total numbers or percentage of mature females during this time.

The seasonal pattern of egg and young production in all species agreed with Labat's (1957) findings and was closely correlated with their seasonal length pattern. Although gravid females carried large broods in cooler months, they represented a smaller index of population production than smaller broods carried in warmer months as discussed earlier.

Before an appropriate population dynamics study can be done, much more information about the different species is needed. Besides incubation and generation times at different temperatures, the following information is essential - length of time spent in each developmental stage at different temperatures; mean number of eggs and mean number of young per brood at different temperatures; average number of broods produced by single females; length of adult life; and mortality rates of different developmental stages. I intend to pursue studies in the future toward obtaining such information.

SUMMARY

1. A total of 7 species of mysid were collected during the 2 year period - 2 species, *Metamysidopsis swifti* and *Promysis atlantica*, are new records for the Texas coast. *Mysidopsis almyra* was the dominant species found in the study, composing nearly 82 per cent of the collections. The next 3 most abundant species were *Mysidopsis bahia*, *Mysidopsis bigelowi*, and *Metamysidopsis swifti*.

2. The ecological distributions of the mysids show a pattern of habitat segregation among the species: *Taphromysis louisianae* occurs in fresh to brackish waters; *Mysidopsis almyra* in lower salinity shallow waters; *Mysidopsis bahia* in shallow bay waters of higher salinity; *Mysidopsis bigelowi* in deeper bay waters and offshore; *Metamysidopsis swifti* in seaside surf; and *Brasilomysis castroi* and *Promysis atlantica* in deeper offshore waters. *Bowmaniella* is a burrowing species in contrast to the others which are hypopelagic.

3. *Mysidopsis almyra* and *M. bahia* live sympatrically in the shallow waters of the bayous and bays. During year 1, a high salinity year, *M. almyra* was dominant in the bayou-salt marsh habitats and *M. bahia* was dominant in the open bay habitats. During year 2, a low salinity year, *M. almyra* was numerically dominant in all shallow water habitats except the physically diverse grass bed which served as a refuge for *M. bahia* during this period of hyposalinity.

4. Over the 2 year period *M. almyra* was most abundant at temperatures of 30 C or more and in salinities of 10-20 ppt. *M. bahia* was most abundant at temperatures of 30 C or more and in salinities

approaching 30 ppt. M. swifti was found in largest numbers at temperatures of 20-30 C and in salinities of 20-30 ppt.

5. Survival studies at 15 temperature-salinity combinations indicated that M. almyra is euryhaline, but M. swifti prefers higher salinities of 23 ppt or more. Survival was much greater for both species at moderate temperatures (15,23 C) than at 30 C.

6. M. almyra was the only mysid species collected during the 3 intensive sampling studies. This indicated that there was probably no replacement of one species by another between monthly sampling trips in the bayou habitats. The population structures of this species were essentially the same for the 3 studies.

7. The 27 hr studies indicated that during the day M. almyra remains in the layer of water just above the bottom. At night the population spreads upward slightly, but the majority of mysids stay just above the bottom. The numbers of mature females and immature females were about equal in the upper levels of water at night; however, the latter outnumbered the former by nearly 4 to 1 in the lowest level.

8. The pattern of population change of M. almyra and the tidal cycles of the two 27 hr studies were closely related. As the tide ebbed, numbers increased and as the tide flooded numbers decreased. This relationship could serve as a possible explanation for differences in numbers found during the 15 day study. These results indicate that the numbers of mysids obtained during each collection of the seasonal sampling program can serve only as rough estimates of the mysid population present at that time.

9. Each species for which I had sufficient data displayed a similar cycle of rapid reproduction and large numbers during summer months and slow reproduction and low numbers during winter months. It is concluded that photoperiodicity and temperature are the major causes of this pattern.

10. The largest mature females of all species were collected in winter months, but were replaced by progressively smaller gravid females in spring and summer. In fall the trend reverted toward larger gravid females. The large differences between mean lengths of gravid females of all species from month to month indicates that the females are shortlived and that the populations have a high rate of turnover. Of the environmental factors analyzed, season (photoperiod) and temperature are the main ones governing the length of mature females.

11. Ratios of immatures to mature females indicate that _M. almyra_ had a more vigorous rapidly growing population than _M. bahia_ or _M. swifti_. Females outnumbered males in every species but a 1:1 ratio was approached in every species except _M. swifti_ in which the females were 3 times as numerous as the males. The ratio of females to males in colder months was usually greater than in warmer months. Seasonally, the ratio of immatures to mature females and mature females to the total population was erratic. Mature females of all species were collected every month indicating that reproduction occurred throughout the year. The number of eggs and young per brood was calculated to be a linear function of the volume (length^3) of female _M. almyra_, _M. bahia_, _M. bigelowi_, and _M. swifti_.

The seasonal pattern of egg and young production of all species followed their seasonal length patterns closely.

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APPENDIX

Table 39. Temperature values (°C) for the stations in the nearshore area of Galveston Island in 1971-72.

Stations/ Months	1	2	3	4	5	6	7	8	9	10	JB_1	JB_2	12	13
February	-	20.2	22	22	22.7	24.6	18.8	22.3	21.1	17.6	-	21.1	22.0	17.7
March	16.5	19.0	19.0	19.0	19.0	19.0	16.0	19.0	19.0	15.0	11.0	17.0	12.0	15.0
April	21.0	22.0	21.0	21.0	21.0	22.0	21.0	23.0	22.0	21.0	22.0	22.0	22.0	22.0
May	23.0	21.5	21.0	22.0	21.5	23.0	25.0	27.0	23.0	27.0	23.0	25.0	26.0	25.0
June	32.0	37.0	35.5	36.0	34.0	36.0	28.0	36.0	36.0	29.5	36.0	36.0	35.0	28.0
July	30.0	32.0	32.0	31.0	32.0	32.0	33.0	33.0	34.0	33.0	34.0	35.0	34.0	33.0
August	31.0	31.0	30.0	31.0	30.5	30.0	32.0	31.0	30.5	32.0	31.0	33.0	32.0	32.0
September	28.0	27.0	27.0	27.0	27.0	27.0	26.5	27.0	27.0	27.0	28.0	28.0	28.5	27.0
October	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
November	11.0	16.0	17.0	16.0	17.0	17.0	17.0	16.5	16.0	16.0	16.0	16.0	16.0	17.0
December	18.0	20.0	22.0	20.5	20.0	22.0	18.5	22.0	22.0	18.0	22.0	22.0	20.5	17.0
January	17.0	18.0	18.0	18.0	17.0	20.0	-	19.0	19.0	-	19.0	19.0	-	-

Table 39 - (Continued)

Stations/ Months	14	15	16	17	18_1	18_2	19	20	21	Mean
February	18.2	19.4	19.3	21.1	-	-	16.4	16.8	-	20.2
March	14.0	18.0	18.2	18.0	21.0	-	16.0	16.0	17.0	17.0
April	22.0	20.0	25.0	21.0	21.0	-	21.0	21.0	21.0	21.6
May	25.0	25.5	28.0	-	31.0	-	30.0	26.0	24.0	24.9
June	33.5	28.5	29.0	28.5	28.0	-	28.0	28.0	29.0	32.1
July	35.0	30.0	32.0	30.0	31.0	31.0	31.0	33.0	32.0	32.3
August	34.0	33.0	35.0	35.0	37.0	35.0	32.0	31.0	32.0	32.2
September	30.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.3
October	27.0	27.0	27.0	24.5	24.2	24.5	24.5	27.0	26.5	26.5
November	16.0	13.0	13.0	14.0	14.0	14.0	16.0	16.0	14.0	15.4
December	20.0	18.0	18.0	18.0	18.0	18.0	17.5	17.0	18.0	19.4
January	-	20.0	20.5	21.0	21.0	21.0	15.6	15.6	11.6	18.4

Table 40. Temperature values (^{o}C) for the stations in the nearshore area of Galveston Island in 1973-74.

Stations/ Months	1	2	3	4	5	6	7	8	9	10	JB_1	JB_2	12
February	7.0	8.0	9.5	9.5	11.0	8.0	10.0	8.5	9.0	10.0	10.0	11.0	10.0
April	27.0	26.5	26.0	25.0	25.0	26.0	23.5	26.5	25.5	23.5	26.0	28.0	25.0
June	28.5	31.0	28.5	30.0	30.0	28.5	31.0	30.0	29.0	31.0	30.0	32.0	30.0
August	30.0	34.5	31.5	32.0	31.0	32.0	30.0	31.5	30.0	30.0	31.0	32.0	31.0
October	26.5	24.5	24.5	24.5	24.5	27.0	28.0	27.0	25.0	26.0	26.0	27.0	26.0
February	17.0	22.5	15.0	18.0	22.0	24.0	20.0	23.5	23.0	16.0	23.5	23.5	23.0

Table 40 - (Continued)

Stations/ Months	13	14	15	16	17	18_1	18_2	19	20	21	Mean
February	10.0	-	5.5	6.5	5.0	6.5	6.0	9.5	9.5	7.0	8.5
April	23.0	25.0	24.0	25.0	26.0	27.0	26.0	23.0	23.0	23.0	25.2
June	31.0	31.0	30.0	31.0	33.0	32.0	33.5	31.0	-	29.0	30.5
August	31.0	31.0	31.0	32.0	30.5	30.5	31.0	32.0	31.0	30.0	31.2
October	29.0	28.0	26.0	25.0	25.0	26.0	25.0	27.0	25.0	25.0	26.0
February	19.0	23.0	23.0	23.0	23.0	23.0	23.0	20.0	17.0	18.0	21.0

Table 41. Surface^{s} and bottom^{b} temperature values (^{o}C) for the stations of Tucker Bayou in 1973-74.

Stations/Months	1		2		3		4		Mean	
February	10.0^{s}	10.0^{b}	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
April	25.0	-	25.0	-	25.0	-	25.0	-	25.0	-
June	31.0	30.0	31.0	30.0	31.0	29.0	32.0	31.0	31.3	30.0
August	30.5	28.0	30.0	29.0	30.0	29.5	30.5	30.5	30.3	29.3
October	25.0	-	25.0	-	25.0	-	25.0	-	25.0	-
February	22.0	21.5	21.5	21.5	21.5	21.0	21.5	21.0	21.6	21.3

Table 42. Surface^{s} and bottom^{b} temperature values (°C) for the stations in West Bay in 1973-74.

Stations/Months	1		2		3		4		5		6		7		Mean	
February	10.0^{s}	10.0^{b}	10.0	10.0	10.0	11.0	10.0	10.0	10.0	10.0	10.0	10.0	11.0	11.0	10.1	10.3
April	24.5	-	25.0	-	24.0	-	24.5	-	24.0	-	24.5	-	25.0	-	24.5	-
June	29.0	29.0	28.0	28.0	29.0	29.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	29.4	29.4
August	29.0	29.0	30.0	29.0	29.0	28.5	29.0	28.5	29.0	28.5	29.5	28.5	30.0	30.0	29.4	28.9
October	25.0	-	25.0	-	25.0	-	26.0	-	25.5	-	25.5	-	26.0	-	25.4	-
February	20.0	20.0	20.0	19.0	18.0	18.0	18.5	18.0	19.0	19.0	19.0	19.0	20.0	19.0	19.2	18.9

Table 43. Salinity values (ppt) for the stations in the nearshore area of Galveston Island in 1971-72.

Stations/ Months	1	2	3	4	5	6	7	8	9	10	JB_1	JB_2	12	13
February	-	9.7	23.2	23.2	24.3	24.8	30.2	23.8	24.3	29.7	-	23.8	28.1	30.2
March	15.1	7.6	23.8	23.8	24.8	24.3	25.9	24.8	22.7	25.9	25.9	27.0	28.1	27.0
April	23.8	11.9	25.9	25.9	24.8	28.1	25.9	25.4	26.5	26.5	25.4	27.0	23.8	24.8
May	24.8	13.5	26.5	28.1	28.1	29.2	27.5	29.2	28.6	27.0	29.2	28.6	26.5	27.0
June	24.8	18.9	28.1	28.1	28.1	31.9	31.9	29.7	31.3	30.2	32.4	32.4	31.3	32.4
July	25.9	40.0	32.4	32.4	33.5	34.6	32.9	34.6	35.6	33.5	37.8	36.7	34.6	33.5
August	31.3	8.6	31.9	31.9	32.4	32.9	35.1	33.5	33.5	35.1	32.9	35.6	33.5	34.6
September	5.4	8.1	25.4	20.5	22.7	21.1	24.3	22.1	23.8	23.8	19.4	23.2	23.8	23.8
October	20.0	11.9	23.8	23.8	23.8	24.3	27.0	24.8	24.8	26.5	24.8	24.8	23.8	26.5
November	1.33	19.4	24.8	24.3	24.8	25.9	26.5	25.9	25.9	27.0	25.9	26.5	25.9	26.5
December	16.2	4.3	20.5	20.5	21.1	20.5	24.8	20.5	22.1	23.8	21.0	22.4	21.6	23.8
January	4.3	3.8	18.4	18.4	18.4	17.8	23.2	18.4	18.4	22.7	19.4	19.4	21.1	23.8

Table 43 - (Continued)

Stations/ Months	14	15	16	17	18_1	18_2	19	20	21	Mean
February	30.8	25.9	27.0	23.2	-	-	27.0	28.1	-	25.4
March	29.7	27.0	26.5	23.8	27.0	-	24.8	21.6	23.8	24.1
April	24.3	25.9	30.8	-	-	-	26.5	26.5	23.2	25.2
May	27.0	25.9	29.7	28.1	28.1	-	27.0	27.0	23.8	26.8
June	33.5	27.5	35.6	32.4	28.1	-	31.3	31.9	27.0	29.9
July	34.6	34.6	31.9	36.7	36.7	40.0	34.6	33.5	29.2	34.3
August	34.6	32.4	30.2	33.5	35.6	33.5	34.6	34.0	32.4	32.3
September	24.8	18.4	20.5	22.7	22.7	19.4	24.3	23.8	25.9	21.3
October	25.4	24.8	23.2	25.4	25.9	24.3	27.0	27.0	24.8	24.3
November	28.1	22.1	12.4	25.9	25.9	25.9	26.4	27.0	13.0	23.4
December	22.7	20.5	21.6	20.5	20.5	18.4	22.7	23.2	20.5	20.6
January	23.8	18.4	22.1	19.4	19.4	18.4	23.2	23.2	19.4	18.9

Table 44. Salinity values (ppt) for the stations in the nearshore area of Galveston Island in 1973-74.

Station/ Months	1	2	3	4	5	6	7	8	9	10	JB_1	JB_2	12
February	1.1	4.3	16.2	18.9	21.1	16.0	25.9	20.5	20.5	25.9	-	21.6	22.7
April	12.0	2.0	16.0	16.0	16.0	12.0	15.0	14.0	15.0	14.5	15.5	16.0	16.0
June	6.0	8.0	9.0	12.0	9.0	15.0	17.0	13.0	12.0	17.0	12.0	12.0	10.0
August	16.5	3.0	21.0	19.0	21.0	22.0	22.0	25.0	24.0	20.0	25.0	26.0	28.0
October	18.0	13.5	18.0	18.0	16.0	18.0	26.0	19.0	18.0	26.0	19.0	20.0	20.5
February	16.0	12.0	16.0	18.0	17.0	16.0	22.0	18.0	18.0	27.0	18.0	20.0	18.0

Table 44 - (Continued)

Station/ Months	13	14	15	16	17	18_1	18_2	19	20	21	Mean
February	25.9	-	17.3	20.5	18.9	20.5	11.9	24.8	25.9	15.1	18.8
April	15.0	15.0	15.0	15.0	14.0	10.0	11.0	12.0	14.0	16.0	13.8
June	20.0	15.0	9.0	20.0	10.0	10.0	10.0	15.0	15.0	16.0	12.7
August	22.0	25.0	19.0	15.0	21.0	18.0	19.0	22.0	21.0	21.0	20.7
October	26.0	24.5	16.0	16.0	16.0	16.0	15.0	30.0	27.5	18.0	19.8
February	23.0	20.0	15.0	25.0	16.0	14.0	12.0	22.0	28.0	17.0	18.6

Table 45. Surface^{s} and bottom^{b} salinity values (ppt) for the stations of Tucker Bayou in 1973-74.

Stations/Months	1		2		3		4		Mean	
February	20.5^{s}	20.5^{b}	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
April	13.0	-	13.0	-	12.0	-	12.0	-	12.5	-
June	14.0	14.5	14.0	14.5	14.0	14.0	14.0	14.0	14.0	14.3
August	24.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
October	18.0	-	18.0	-	19.0	-	18.0	-	18.3	-
February	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0

Table 46. Surface^s and bottom^b salinity values (ppt) for the stations in West Bay in 1973-74.

Stations/ Months	1		2		3		4		5		6		7		Mean	
February	20.5^s	20.5^b	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5	20.5
April	14.0	-	15.5	-	15.0	-	15.0	-	14.0	-	12.0	-	11.0	-	13.8	-
June	29.0	29.0	28.0	28.0	29.0	29.5	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	29.4	29.5
August	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0	23.0	24.0	23.0	23.0	23.0	23.0	23.6	23.6
October	16.0	-	16.0	-	16.0	-	16.0	-	15.5	-	15.0	-	15.5	-	15.8	-
February	20.0	20.0	20.0	19.0	18.0	18.0	18.5	18.0	19.0	19.0	19.0	19.0	20.0	19.0	19.2	18.9