Bol. Soc. Geol. Mexicana, t. 28, n. 1, p. 1-44, 22 figs., 10 tablas (1965)

PATTERNS OF LIVING MARSH FORAMINIFERA IN SOUTH TEXAS COASTAL LAGOONS

Fred B. Phleger *

ABSTRACT

Living populations of foraminifera are analyzed from ten areas of marine marsh in Matagorda Bay. The following zones can be recognized by distinctive foraminiferal assemblages: adjacent bay or channel, intertidal mud flat, *Spartina* zone, *Spartina-Salicornia zone and Salicornia zone.* Living populations are generally large but show great variation in size; they are considerably larger in the adjacent bay and mud flat than in the marsh plant zones. Relative rates of sediment deposition, based on living total ratios of foraminifera, are high, but are significantly smaller in the *Salicornia* zone than elsewhere. The number of species varies from 2 to 20/sample, but there is a tendency for 2-8 species/sample in the marsh and 9-12 species/sample in the bay and mud flat areas. There is an average of 41% living arenaceous specimens in all samples studied; other specimens have calcareous tests.

INTRODUCTION

Marine marshes are extensively developed in the coastal lagoons along the south Texas coast. Between Galveston and Corpus Christi the marshes are superficially similar in their floral successions. They have different locations within the lagoons, however, and the density of the marsh flora varies. The coastal región is characterized by periodic marked difference in rainfall and consequent differences in the salinity of the marginal marine water. There has been no systematic study of the sedimentary depositional environments in these marshes.

Foraminifera are abundant constituents of the marsh sediments, and since they are indigenous organisms are thus excellent indices to the environmental

* Institución Scripps de Oceanografía. Universidad de California, San Diego. Consejero del Departamento de Ciencias Marinas, Instituto de Geología. Universidad Nacional Autónoma de México.

patterns which obtain there. The distribution of foraminifera in marine marshes is poorly known and there has been little correlation with marsh floral or sedimentary geography. There is essentially no information on living faunas, so that little is known of the size of the standing crop or whether the species were alive when collected and thus represent the true fauna at the place collected. It is now apparent that many previously collected marsh samples were stored in such a manner that they quickly became acid due to the abundance of plant detritus. This destroyed most or all of the calcareous foraminifera which were present, and thus the myth has arisen that all marsh faunas are essentially arenaceous.

This is one of a series of papers describing and interpreting patterns of living foraminiferal populations from several different marshes, and is a continuation of a previous study reporting faunas from six marsh areas in Galveston Bay, Texas (Phleger, 1965). Populations are described from ten marshes between Matagorda Bay and Corpus Christi Bay. Some generalizations are suggested for foraminiferal distributions in these areas.

Acknowledgments.—The samples were collected by R. R. Lankford. Jean P. Hosmer assisted in the laboratory study. The work was supported by the Petroleum Research Fund of the American Chemical Society, by the National Science Foundation and by a contract of the Office of Naval Research with the University of California.

DESCRIPTION OF THE AREA

The south coast of Texas and northwest Mexico is an almost continuous series of shallow lagoons separated from the Gulf of Mexico by sandy lagoon barriers, broken only by the deltas of the Colorado River and the Rio Grande (Rio Bravo). The samples studied are from marshes in Matagorda Bay, San Antonio Bay, Copano Bay, Aransas Bay and Corpus Christi Bay. These lagoons are on the seaward fringe of a coastal plain of low relief. They are shallow, averaging approximately 2 m in depth and with a maximum depth not exceeding about 4 m.

The climate of the region is dry, subhumid (Hedgpeth, 1953) with a rainfall of 10-30 inches per year. Rivers are generally small. There is great variation in the yearly total rainfall. Water temperatures and salinities in these bays are characterized by considerable variation.

The water temperatures of Copano and Aransas bays range from 13°C to 31°C, according to Hedgpeth (1951). The actual average range of tempe-

ratures in these bays is at least 5-10°C greater than this, and during unusual years may be more. Water temperatures are occasionally sufficiently lowered to cause widespread fish mortality during winter cold periods. Summer water temperatures have been measured in the shallow bays as high as about 35°C. Maximum and minimum temperatures within the marshes are expected to be more extreme than in the bays.

Salinity ranges are considerable and have been recorded as low as 2 °/₀₀, and as high as 42 °/₀₀. (See Parker, 1960: Parker *et al*, 1953). The lowest salinities are near river effluents, such as the Guadalupe River in San Antonio Bay. During periods of flood, salinities throughout the bays may be reduced to 10 °/₀₀ or less. Occasional prolonged droughts may cause hypersaline conditions up to 40 °/₀₀ or more.

The present samples were collected during August, 1963, following a long period of drought. Higher areas of some of the marshes were dry and the marsh vegetation in many places appeared to be dying. It may be assumed that water on the marshes and in the bays was hypersaline under these conditions.

Tides are diurnal and semi-diurnal with a mean range of about 30 cm and a maximum up to about 60 cm. Strong and persistent winds occasionally cause a range of water levels of 1 m or more in the coastal lagoons.

LOCATIONS OF STATIONS AND SAMPLING

Eleven different areas of marsh were sampled in Matagorda, San Antonio, Aransas, Copano, and Corpus Christi bays (Fig. 1). An effort was made to collect from marshes in as many different kinds of locations within the bays as possible. Samples were collected from as many different environments within a marsh as could be easily differentiated in the field; including channels, intertidal flats, and within the various marsh floral zones. Most samples were collected along traverses more or less at right angles to the shore. Samples were taken by hand and were emplaced in a short plastic tube. The surface 1 cm of sediment was preserved in 5% formalin buffered with an excess of sodium carbonate. Living specimens were recognized by staining with rose Bengal.

SPECIES OF FORAMINIFERA

The foraminifera recognized in the Texas marshes are well-known species and are adequately illustrated in easily available modern publications. In the

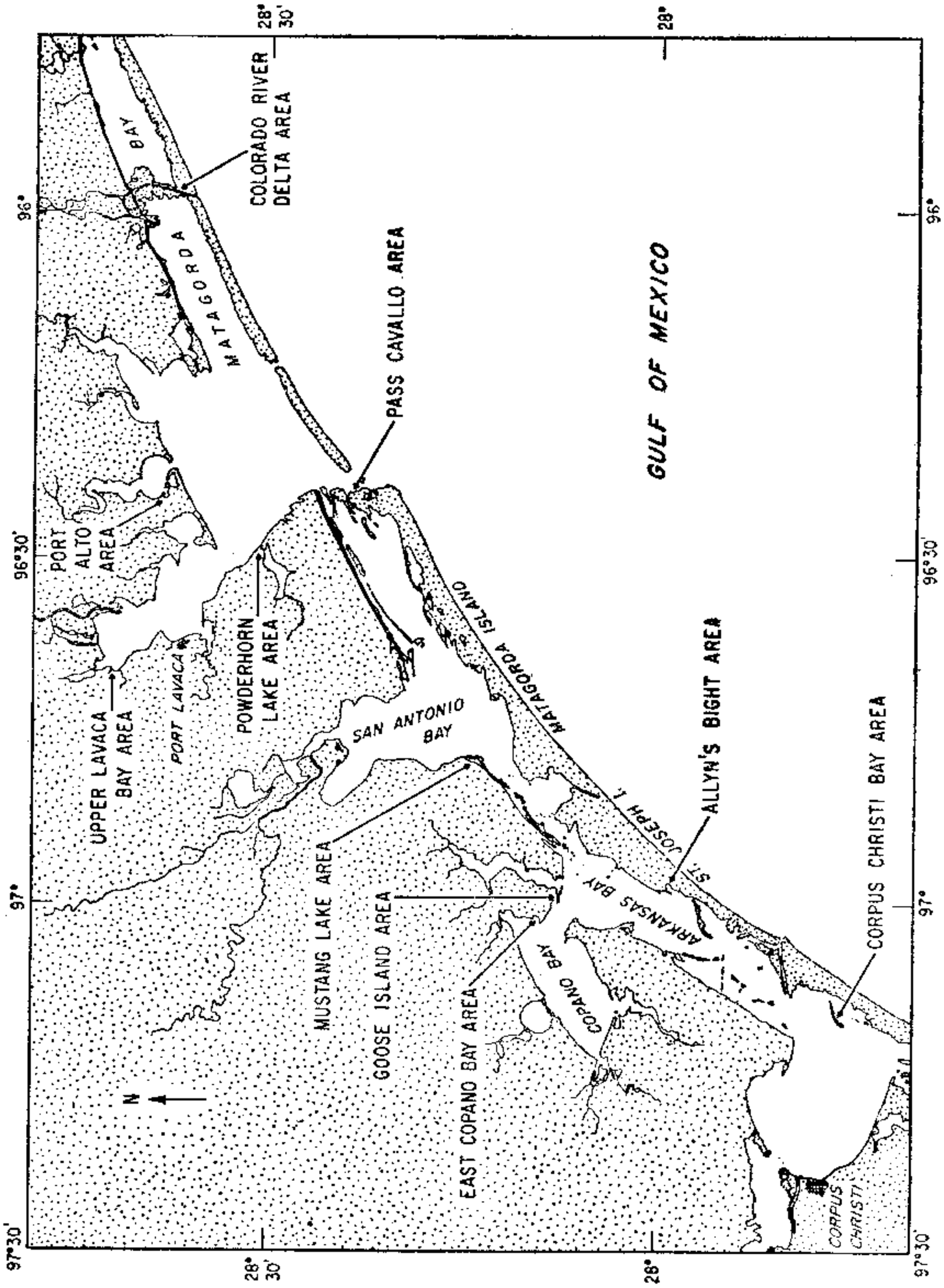


Figure 1. Locations of marsh areas sampled.

following the original references is listed for each species as well as a reference to a modern illustration. Reference is made to the distribution of each species in Galveston Bay, Texas, (Phleger, 1965) and the distribution in the present areas is summarized.

Ammoastuta inepta (Cushman & McCulloch); *Ammobaculites ineptus* Cushman & McCulloch, 1939, Allan Hancock Pacific Exped., v. 6, n. 1, p. 89, pl. 7, fig. 6; *Ammoastuta inepta* Parker, Phleger & Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 4, pl. 1, fig. 12.

This species occurred only at the upper end of Lavaca Bay where there are lowered salinities. In Galveston Bay it occurs rarely only in the low salinity areas.

Ammobaculites dilatatus Cushman & Brönnimann, 1948, Contr. Cushman Lab. Foram. Res., v. 29, pt. 2, p. 39, pl. 7, figs. 10, 11.—Parker, Phleger & Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 5, pl. 1, figs. 13-15.

This species is rare to common at several stations in most of the areas and appears to be characteristic of the intertidal flat environment. It is rare in the same environment in Galveston Bay.

Ammonia beccarii (Linné) variants; *Nautilus beccarii* Linné, 1758, Syst. Nat. Ed. 10, p. 710; "*Rotalia*" *beccarii* variants, Parker, Phleger & Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 13, pl. 4, figs. 20-22, 25-30.

Ammonia beccarii is common to abundant at most of the present stations and also is abundant at most stations in Galveston Bay. Frequencies generally are somewhat higher in samples from bays and mud flats than in samples from the marsh.

Ammotium salsum (Cushman & Brönnimann); *Ammobaculites salsus* Cushman & Brönnimann, 1948, Contr. Cushman Lab. Foram. Res., v. 24, pt. 1, p. 16, pl. 3, figs. 7-9.

A. salsum is abundant at most of the stations in bay, mud flat and *Spartina* zones in the south Texas marshes. It is very rare in the *Salicornia* marsh and in the mixed *Salicornia-Spartina* zone. This distribution is similar to that recorded from the Galveston Bay marshes where the species also is less

common in the *Salicornia* zone than elsewhere. It appears that this species is most characteristic of inner lagoon, lagoon borders such as mud flats, and edge of the marsh where it merges with mud flats.

Arenoparrella mexicana (Kornfeld). *Trochammina inflata* (Montagu) var. *mexicana* Kornfeld, 1931, Contr. Dept. Geol. Stanford Univ., v. 1, p. 86, pl. 13, figs. 5a-c; *Arenoparrella mexicana* Parker, Phleger & Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 6, pl. 2, figs. 33, 34.

This species is essentially restricted to the *Salicornia* zone and the mixed *Spartina-Salicornia* in the south Texas marshes where it is rare to abundant at most stations. A few specimens also are found in the bays and mud flats. In the Galveston Bay marshes its distribution is somewhat less restricted; it is common on marsh berms and marsh areas fronted by a low escarpment, but occurs in both *Salicornia* and *Spartina* plant zones.

Elphidium

Several species of *Elphidium* which are well-known from northern Gulf of Mexico lagoons are common in the marine marshes along the south Texas coast. These species appear to be distributed as a group. They are rare to abundant at most stations in the bay, mud flat and *Spartina* environments. They also occur in the other environments, but not at every station and generally in somewhat lower frequencies. Most of these species are common in the coastal lagoon of the area, and their common occurrence living in the marshes is of interest. The most common species are as follows:

Elphidium delicatulum Bermudez, 1949, Cushman Lab. Foram. Res., Spec. Publ. 25, p. 168, pl. 11, figs. 22, 23; Parker, Phleger and Peirson, 1953. Cushman Found. Foram. Res., Spec. Publ. 2, p. 7, pl. 3, figs. 12, 17.

Elphidium galvestonense Kornfeld; *Elphidium gunteri* Cole var. *galvestonensis* Kornfeld (part), 1931, Contr. Dept. Geol. Stanford Univ., v. 1, n. 3, p. 87, pl. 15, figs. 1a, b; *Ephidium galvestonense* Parker, Phleger and Peirson, 1953, Cushman Found, Foram. Res., Spec. Publ. 2, p. 7, pl. 3, figs. 15, 16.

Elphidium gunteri Cole, 1931, Florida State Geol. Surv., Bull. 6, p. 34, pl. 4, figs. 9, 10; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 8, pl. 3, figs. 18, 19.

Elphidium koeboeense Le Roy, 1939, Natuurk. Tijdschr. Nederl.—Indie, ab. 99, afl. 6, p. 240, pl. 9, figs. 6, 7; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 8, pl. 3, figs, 22, 23.

Elphidium matagordanum (Kornfeld); *Nonion depressula* (Walker and Jacob) var. *matagordana* Kornfeld, 1931, Contr. Dept. Geol. Stanford Univ., v. 1, n. 3, p. 87, pl. 13, figs. 2a, b.

Elphidium poeyanum (d'Orbigny); *Polystomella poeyana* d'Orbigny, 1839, *In* de la Sagra, Hist. Phys. Pol. Nat. Cuba, "Foraminifères", p. 55, pl. 6, figs. 25, 26; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 9, pl. 3, fig. 26.

Elphidium tumidum Natland, 1938, Bull. Scripps Inst. Oceanogr., Tech. Ser., v. 4, n. 5, p. 144, pl. 5, figs. 5, 6; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 9, pl. 3, fig. 26.

Massilina protea Parker, 1953, *In* Parker, Phleger and Peirson, Cushman Found. Foram. Res., Spec. Publ. 2, p. 10, pl. 2, figs. 1-4.

Massilina protea has been recognized only in the Corpus Christi Bay and Allyns Bight marshes where it is abundant in all environments except well-developed *Salicornia*. These marshes are both developed on the lagoon side of lagoon barriers. The distribution of the species suggests that it is characteristic of tide flats and adjacent areas in lower lagoon.

Miliammina fusca (H. B. Brady); *Quinqueloculina fusca* H. B. Brady, 1870, Ann. Mag. Nat. Hist., ser. 4, v. 6, p. 47 (286), pl. 11, figs. a-c, 3; *Miliammina fusca* Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 10, pl. 1, figs. 40, 41.

Miliammina fusca is common at essentially all stations in the bay, mud flat, *Spartina* and mixed *Spartina-Salicornia* environments. It is rare or absent at most stations in the *Salicornia* zone. It is generally abundant in the Galveston Bay marshes, including the *Salicornia* zone in that area.

Palmerinella palmerae Bermúdez, 1934, Mem. Soc. Cubana Hist. Nat., v. 8, n. 2, p. 84, text figs. 1-3; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 11, p l. 4, figs. 42-44.

This species was mostly found in the mud flat and bay environments. It was abundant at four marsh stations, of which 2 were in the East Copano Bay. marsh; it is recorded from only two other marsh stations where it is rare.

Pseudoeponides andersoni Warren, 1957, Contr. Cushman Found. Foram. Res., v. 8, pt. 1, p. 39, pl. 4, figs. 12-15.

This species is characteristic of the *Salicornia* zone in the south Texas marshes, where it is abundant at many stations. It also occurs at some of the stations in the mixed *Spartina-Salicornia* zone.

Jadammina polystoma Bartenstein and Brand, 1938, Senckenbergiana, v. 20, n. 5, p. 381, text figs. 1 a-c; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 9, pl. 2, figs. 35-37.

Jadammina is abundant in samples from the *Salicornia* zone in the Corpus Christi Bay marsh. It is rare at 2 stations in the Guadalupe Delta and is not recorded from any other stations.

Discorinopsis aguayoi (Bermudez). *Discorbis aguayoi* Bermudez, 1935, Mem. Soc. Cubana Hist. Nat., v. 9, n. 3, p. 204, pl. 15, figs. 10-14; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 7, pl. 4, figs. 23, 24.

This species is confined to the *Spartina, Salicornia* and mixed zones where it is rare at a few stations. It has been reported as abundant in two previously studied small marshes in San Antonio Bay.

MILIOLIDS. Several species of miliolids, are common in many of the present samples. These species seem to prefer the bay-mud flat environments, but are occasionally found in the marsh zones. The principal species recognized are the following.

Quinqueloculina poeyana d'Orbigny, 1839, *In* de la Sagra, Hist. Phys. Pol. Nat. Cuba, "Foraminifères", p. 191, pl. 11, figs. 25-27. Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 12, pl. 2, figs. 13, 14.

Quinqueloculina seminulum (Linné). *Serpula seminulum* Linné, 1767, Syst. Nat. ed. 12, p. 1264; *Quinqueloculina seminulum* Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 12, pl. 2, figs. 18, 19.

Quinqueloculina tenagos Parker, 1962, Contr. Cushman Found. Foram. Res., v. 13, pt. 3, p. 110; *Quinqueloculina rhodiensis* Parker, *In* Parker, Phleger and Peirson, *1953, Cushman Found. Foram. Res., Spec. Publ.* 2, p. 12, pl. 2, figs. 15-17.

Triloculina sidebottomi (Martinotti). *Miliolinella subrotunda* Sidebottom, 1904, Manchester Let. Phil. Soc., v. 68, n. 5, p. 8, pl. 3, figs. 1-7; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 14, pl. 2. figs. 25-28.

Triloculinella obliquinoda Riccio, 1950, Contr. Cushman Found. Foram. Res., v. 1, pts, 3, 4, p. 90, pl. 15, figs. 1a-c, 2a,-c; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 14, pl. 2, figs. 30-32.

Tiphotrocha comprimata (Cushman and Brönnimann), *Trochammina comprimata* Cushman and Brönnimann, 1948, Contr. Cushman Lab. Foram. Res., v. 24, pt. 2, p. 41, pl. 8, figs. 1-3; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 14, pl. 3, figs. 3, 4.

This species is rare in the marsh plant zones in the present areas and in Galveston Bay.

Trochammina inflata (Montagu). *Nautilus inflatus* Montagu, 1808, Test. Brit., p. 81, pl. 18, fig. 3; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 15, pl. 3, figs. 5, 6.

Trochammina inflata is especially characteristic of the *Salicornia* zone and the mixed *Spartina-Salicornia* where it is abundant, both in the South Texas marshes and in Galveston Bay. It is rare in other marsh environments.

Trochammina macrescens H. B. Brady. *Trochammina inflata* (Montagu) var. *macrescens* H. B. Brady, 1870, Ann. Mag. Nat. Hist., ser. 4, v. 6, p. 51, pl. 11, figs. 5a-c; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, p. 15, pl. 3, figs. 7, 8.

Trochammina macrescens is rare and shows a preference for a *Salicornia* association.

Additional species which were very rare in these samples are listed below.

Bolivina lowmani Phleger and Parker
Bolivina striatula Cushman
Buccella hannai (Phleger and Parker)
Buliminella elegantissima (d'Orbigny)
Cyclogyra involvens (Reuss)
Discorbis floridana Cushman
Gaudryina spp.
Glabratella spp.
Pseudoclavulina gracilis Cushman and Brönnimann
Reophax nana Rhumbler
Textularia earlandi Parker

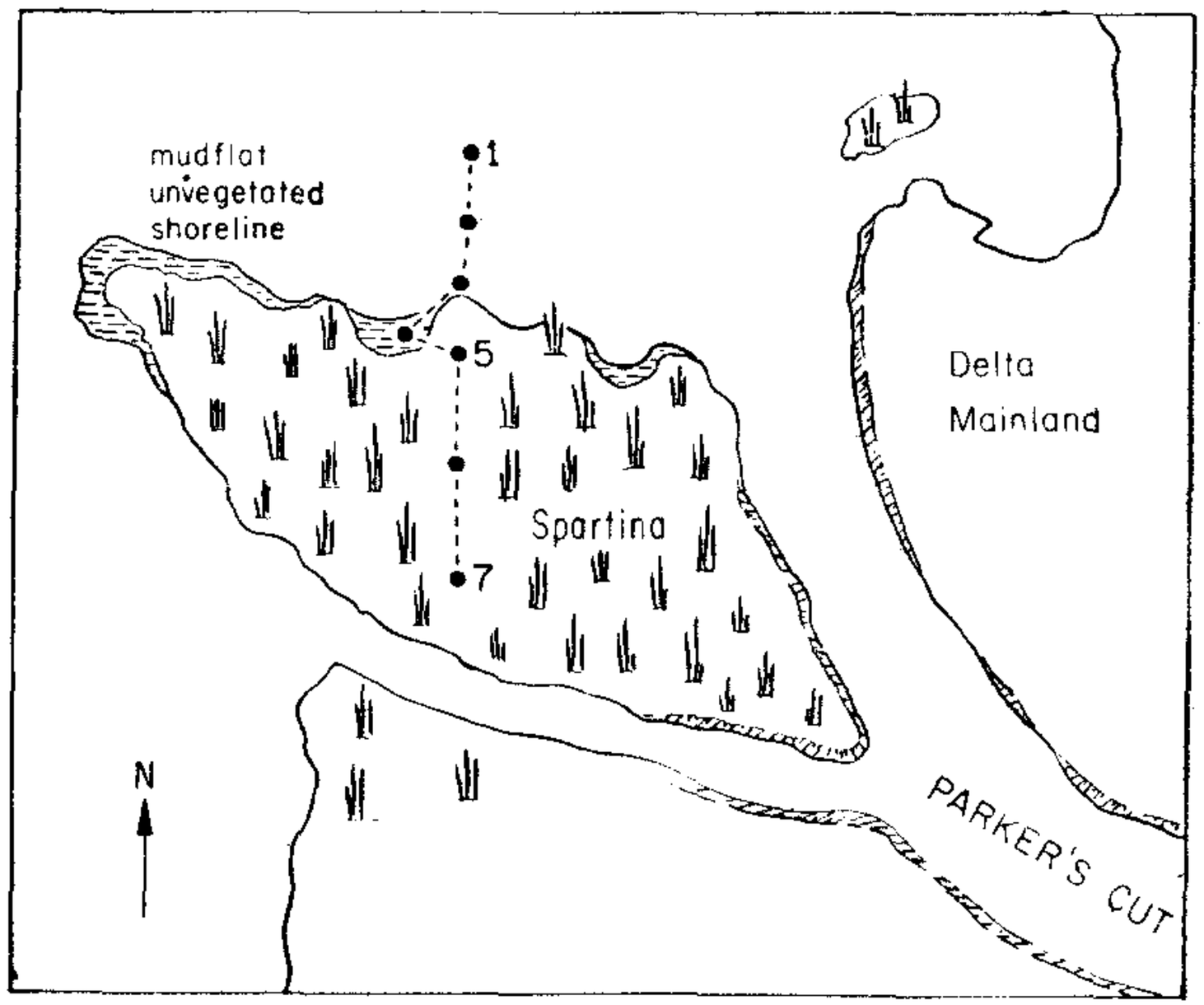


Figure 2. Locations of stations, traverse 1, Colorado River Delta area.

DECRIPTION OF THE AREAS AND FAUNAS

The marshes studied in the south Texas coastal lagoons have a plant zonation of *Spartina alterniflora* at the lower elevations and bordering the bays with *Salicornia* at somewhat higher elevations and also subject to flooding. A small community of *Spartina patens* was recognized at only one locality. A distinctive mixed *Spartina* and *Salicornia* zone also can be recognized. Much of the *Salicornia* area was completely dry at the time of sampling (August, 1963), and such dry areas were not sampled. This explains the relatively few samples from the *Salicornia* environment in most of the areas. The dryness of the *Salicornia*, following a prolonged drought, suggests that much of the wetting in this zone is due to runoff. The water level in the lagoons may have been abnormally low because of the drought.

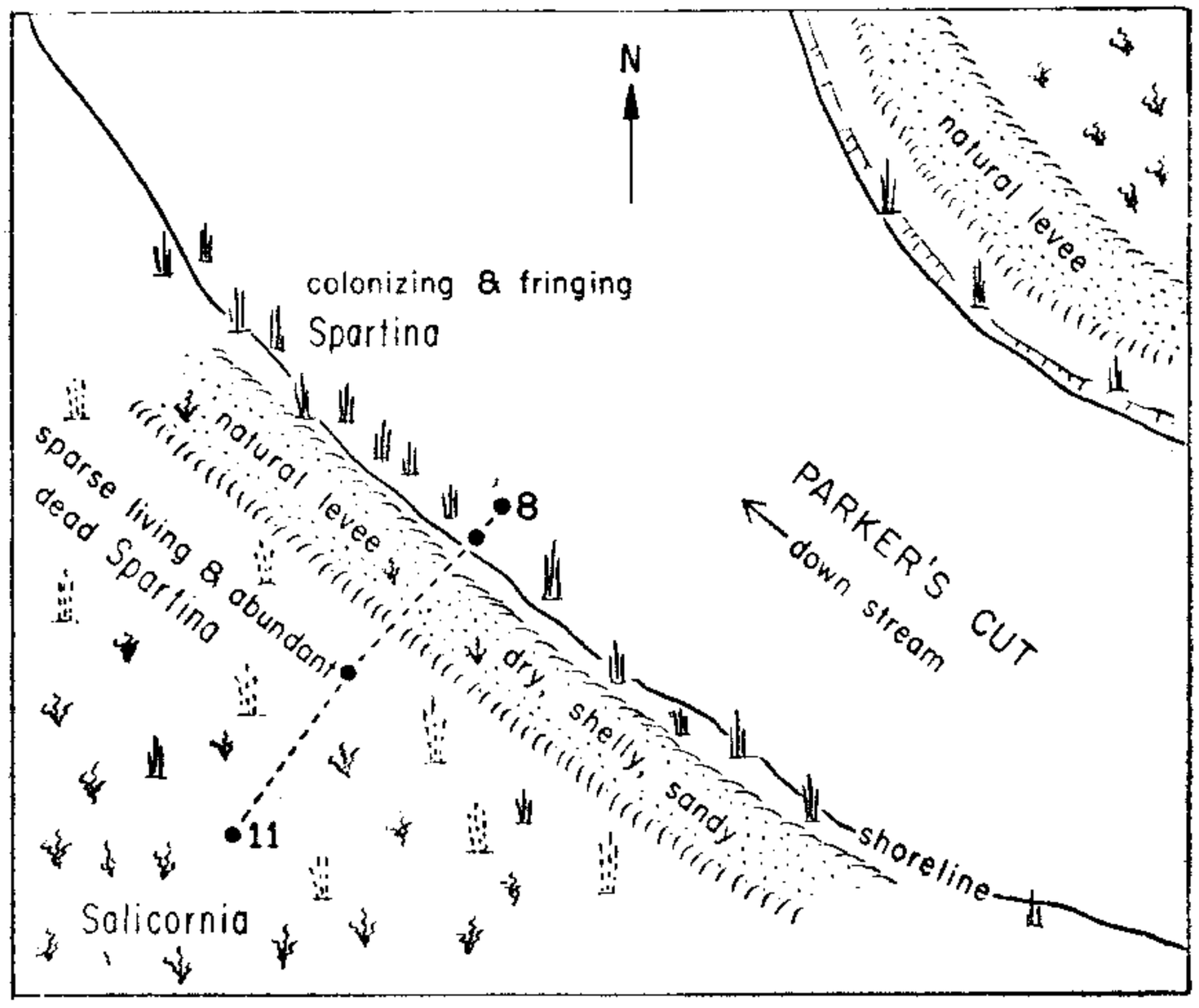


Figure 3. Locations of stations, traverse 2, Colorado River Delta area.

COLORADO RIVER DELTA

Samples were collected from 3 marsh areas in the lower Colorado River Delta. Two of these were adjacent to Parker's Cut (Fig. 2, 3) where the river water flows into Matagorda Bay, and one was adjacent to East Matagorda Bay (Fig. 4) which receives no Colorado River water.

The faunas are dominantly *Ammonia beccarii*. Most of them also contain abundant *Elphidium* and *Anmotium salsum*. *Miliammina fusca* is locally abundant and *Pseudoeponides andersoni* is abundant at 2 stations. The largest standing crops occur at 2 stations in the bay (Parker's cut).

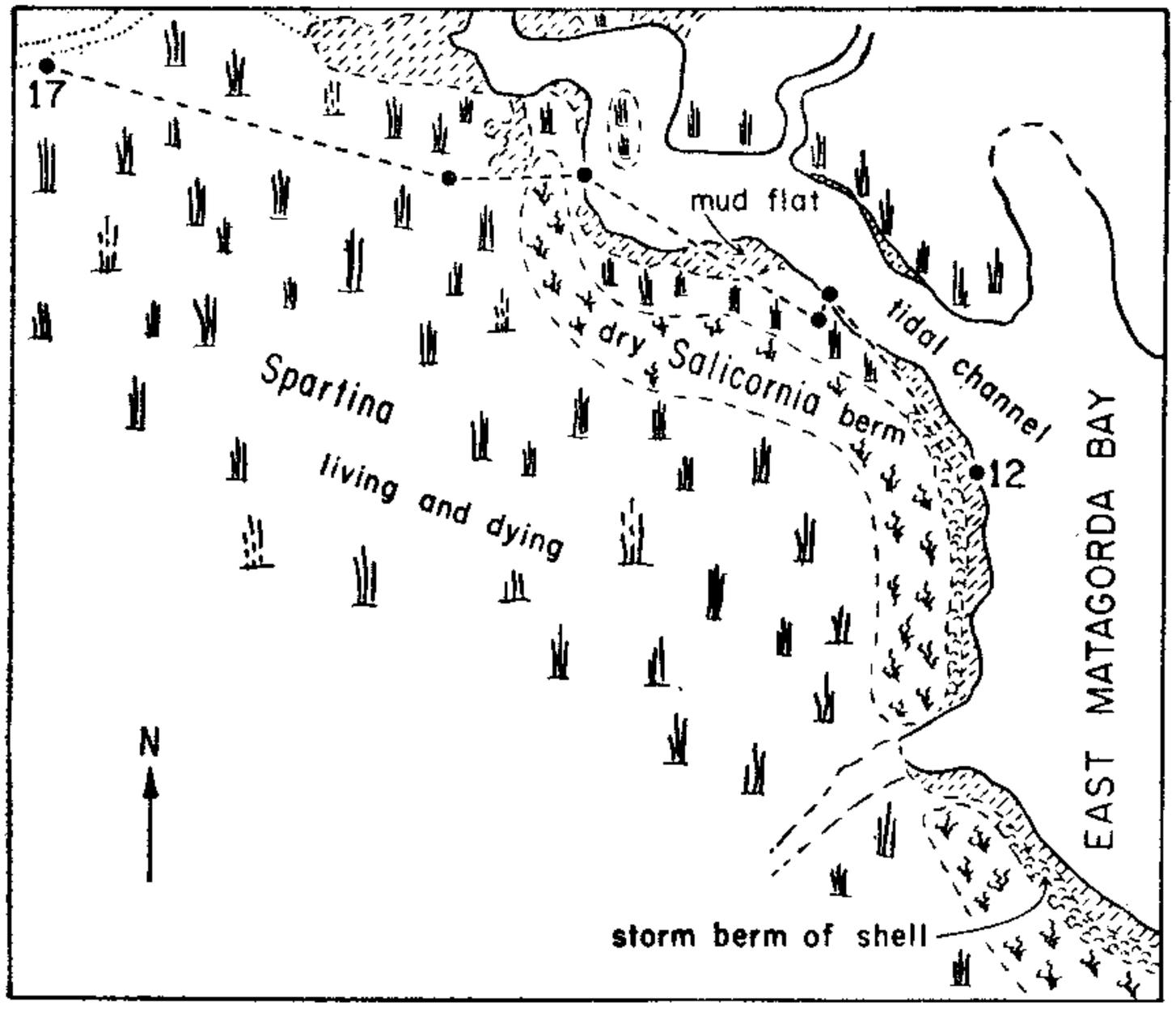


Figure 4. Locations of stations, traverse 3, Colorado River Delta area.

PASS CAVALLO AREA, MATAGORDA ISLAND

Samples were collected on the western side of Pass Cavallo from two

swampy islands which separate the pass from Espiritu Santo Bay to the west. The sediments are predominantly sandy, apparently derived from the near-

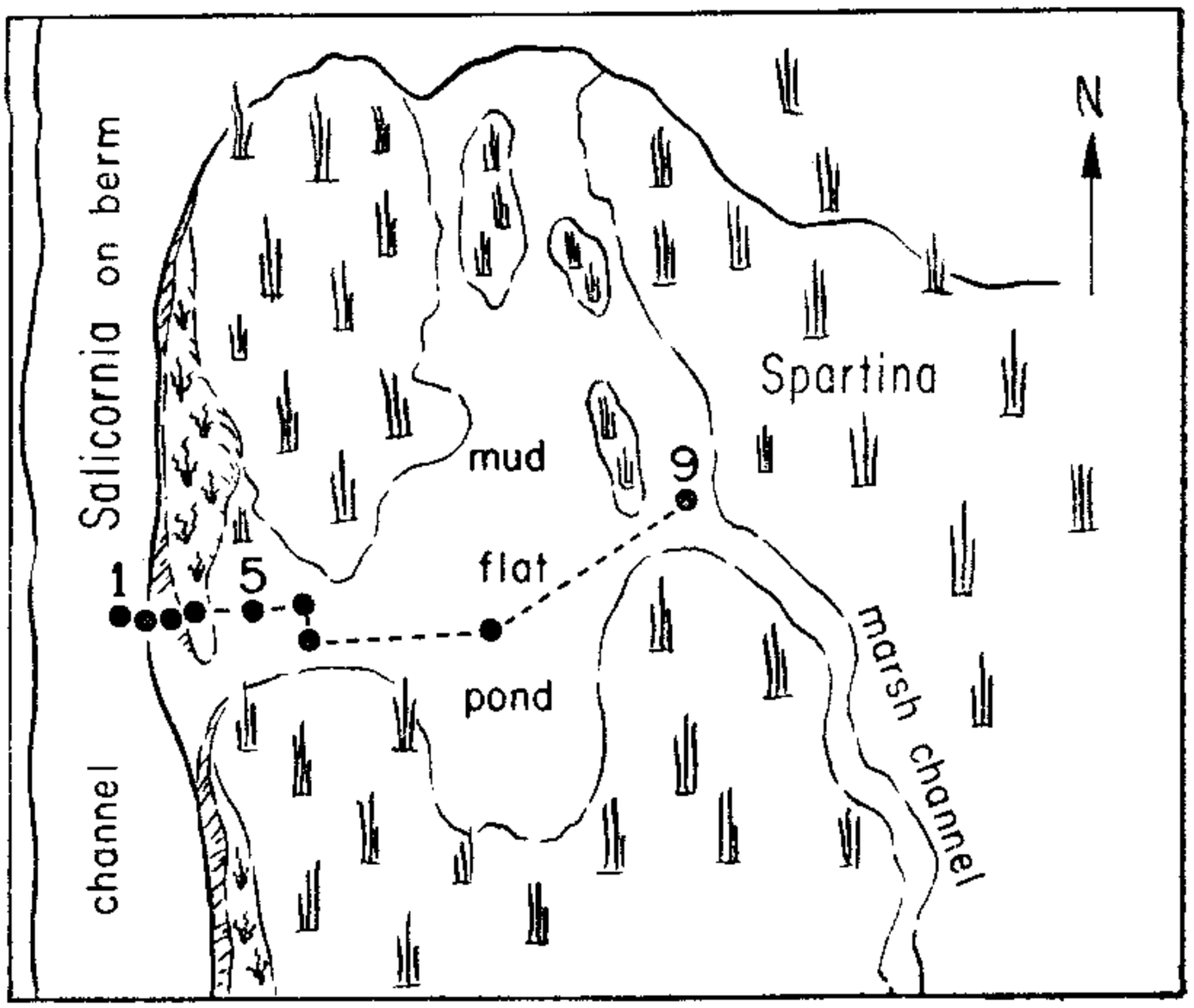


Figure 5. Location of stations, traverse 1, Pass Cavallo area.

shore Gulf and transported inland by currents in the Pass. The higher part of the marsh, the *Salicornia* zone, was dry at the time of collection and was therefore not sampled. Figures 5, 6, show relative locations of samples in the two marsh areas.

The faunas are somewhat variable in composition. The most abundant forms are *Ammonia beccarii*, *Ammotium salsum*, *Elphidium* spp. and miliolids. *Miliammina fusca* is common to abundant mostly in marsh ponds and in tide channels. *Palmerinella palmerae* is abundant on a *Salicornia* berm. The standing crops range from very small to very large, with the largest in marsh ponds and channels. Live-total ratios are high.

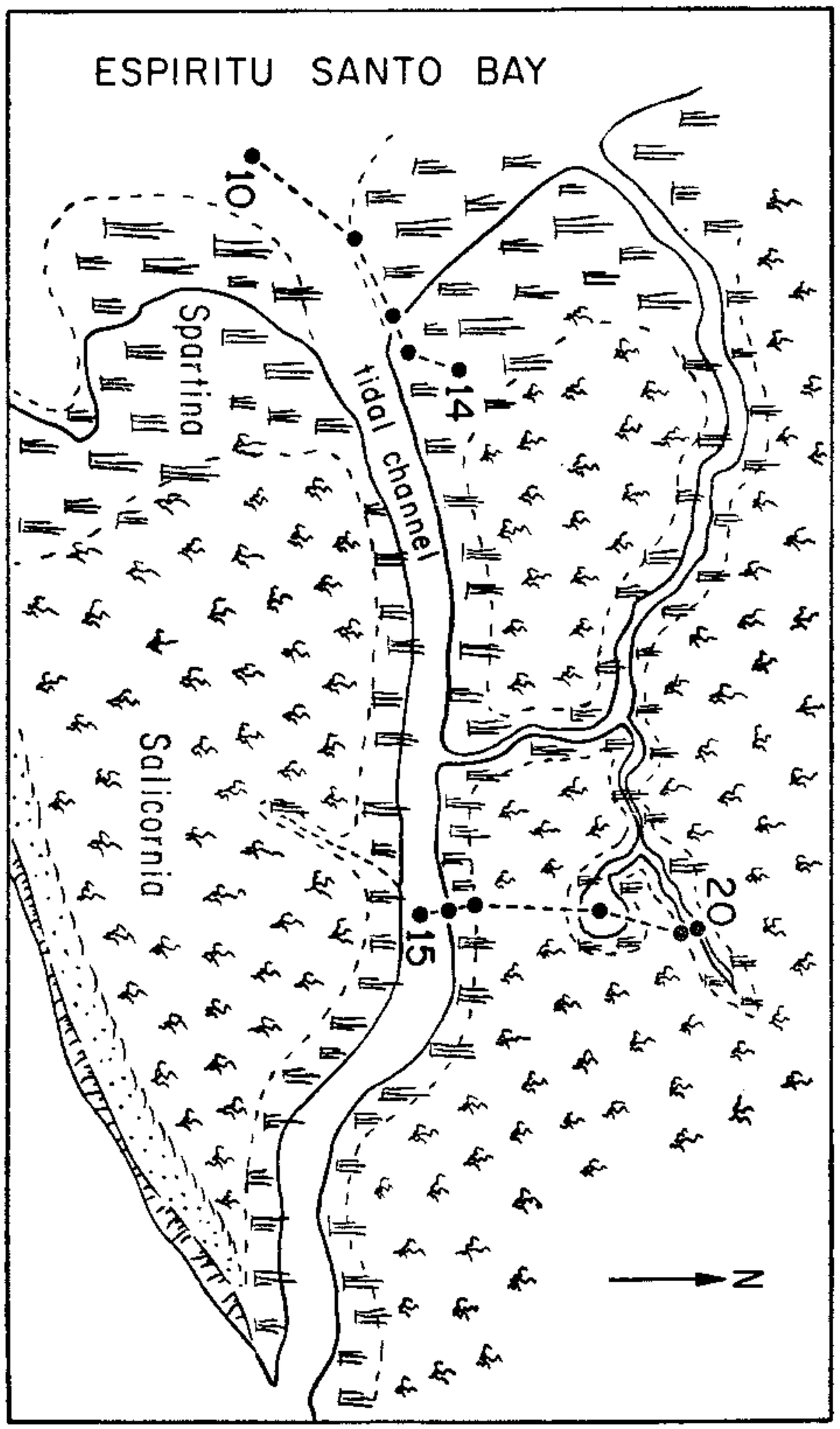


Figure 6. Location of stations, traverse 2, Pass Cavallo area.

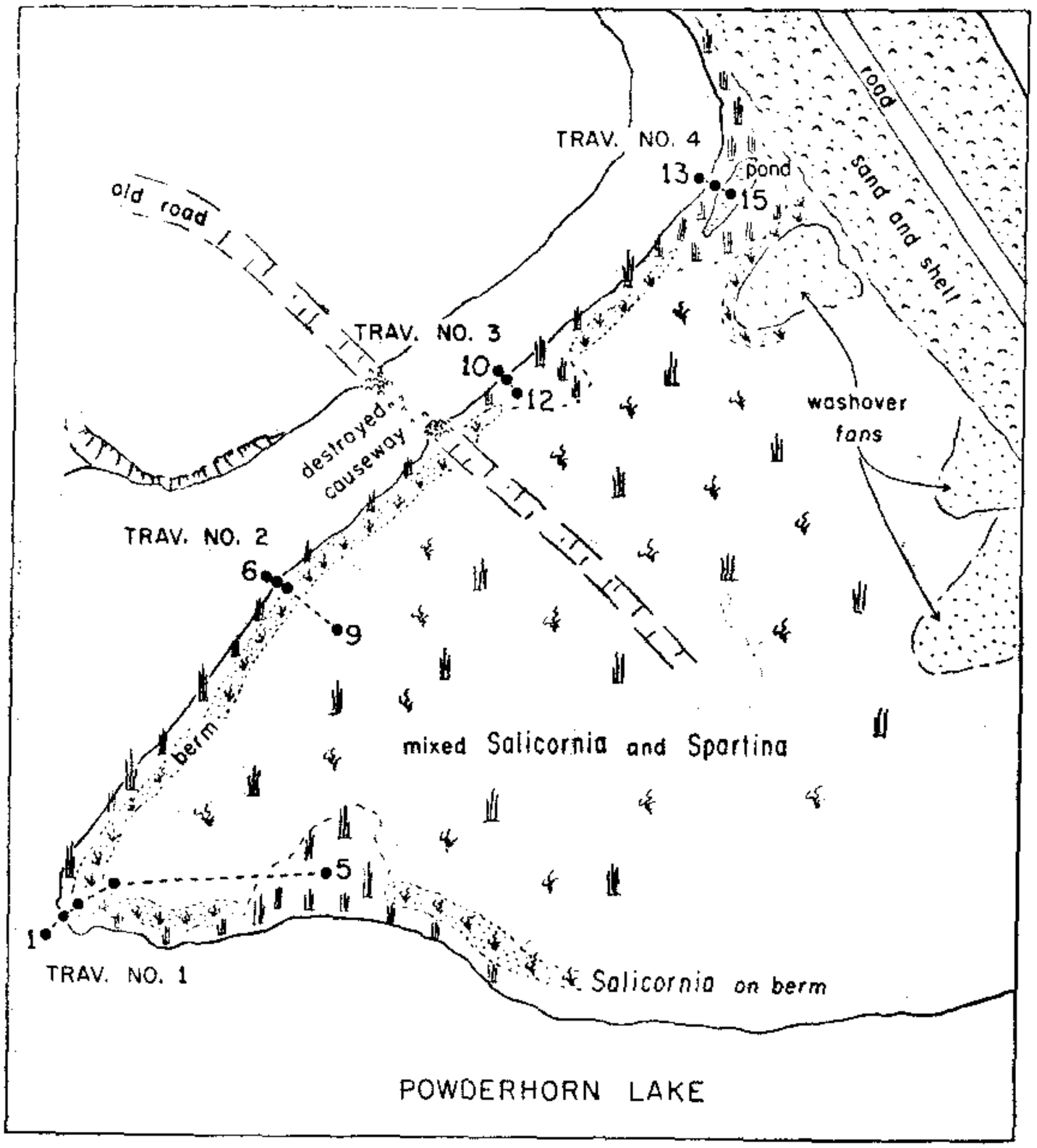


Figure 7. Location of stations in Powderhorn Lake area.

POWDERHORN LAKE

Powderhorn Lake is on the west shore of Matagorda Bay. It is a small lagoon separated from the bay by a narrow barrier and breached by a small inlet. The lake is the drowned estuary of Powderhorn Creek.

Samples were collected from a narrow marsh fringing an old inlet on the

bay side of the barrier, now closed, at four locations (Fig. 7). The marsh was relatively dry at the time of collecting and sampling was restricted to the moist areas near the channel.

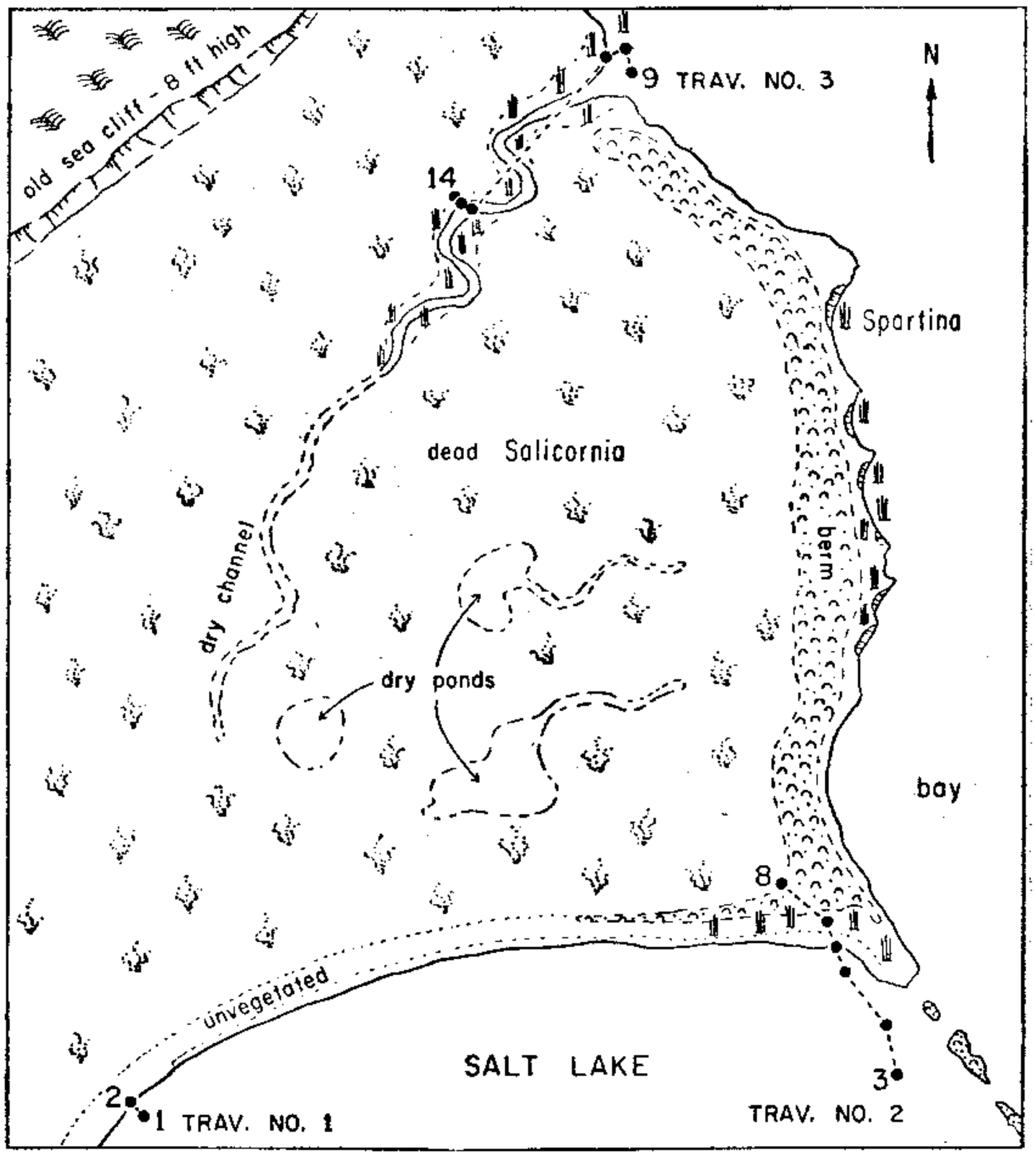


Figure 8. Locations of stations in Port Alto area.

The faunas are mostly *Ammotium salsum* and *Miliammina fusca*, with *Ammonia beccarii* common to abundant in many samples. At stations 3 and

4 *Trochammina inflata* is abundant in a zone of mixed *Salicornia* and *Spartina alterniflora*. The largest standing crops occur in the channel and in an algal pond in the *Spartina*.

PORT ALTO

This is on Carancahua Bay, a tributary of Matagorda Bay. The marsh is very narrow and is dry a few feet inland from the bay during the dry season. Bay samples were collected and a few samples were taken in the moist part of the fringing marsh (Fig. 8).

The faunas are dominated by *Ammonia beccarii* at most stations with *Ammotium salsum* generally common. Faunas in the tidal creek at stations

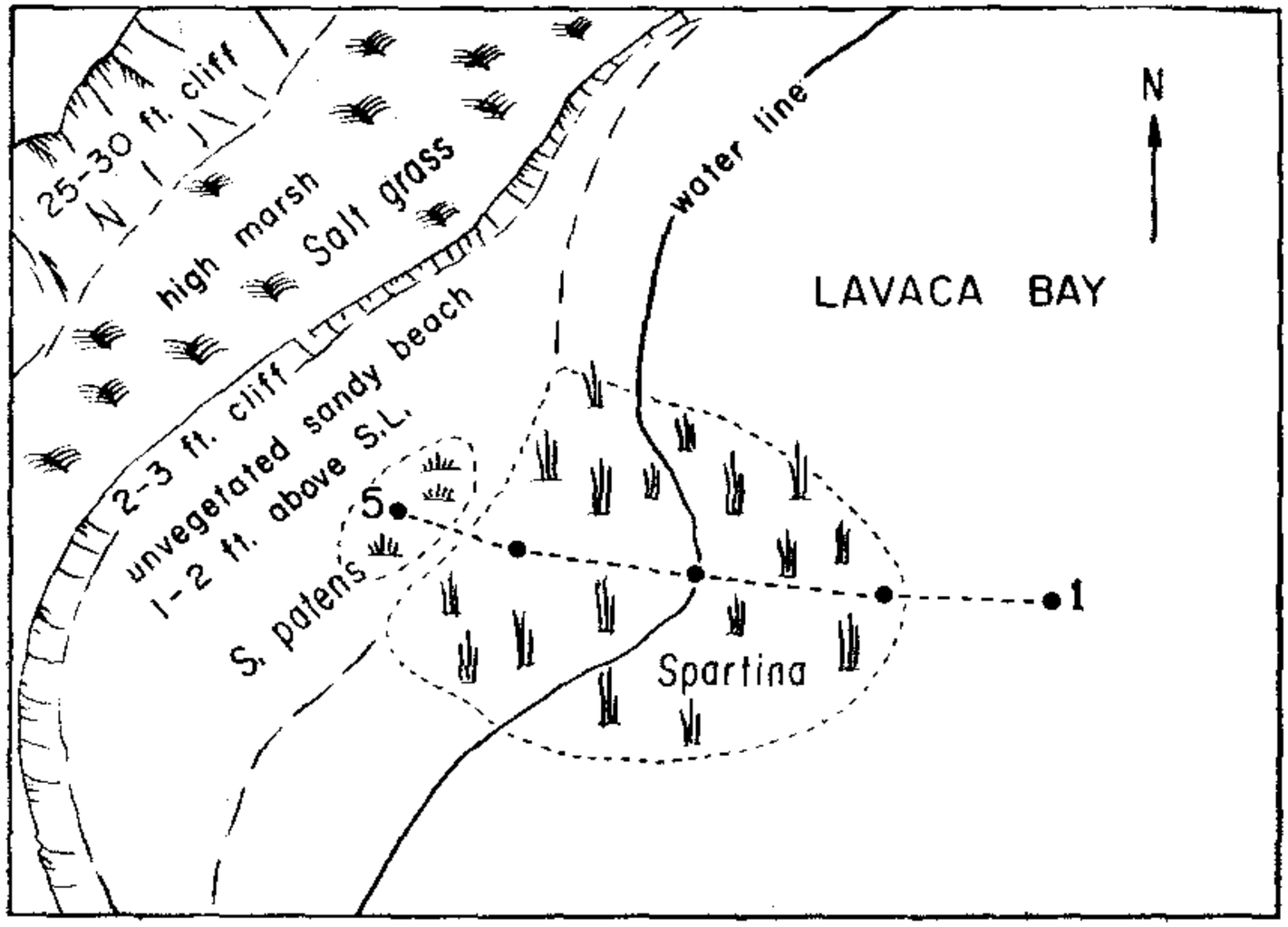


Figure 9. Locations of stations, traverse 1, upper Lavaca Bay area.

12-14 are dominated by *Palmerinella palmerae* and *Miliammina fusca*, with *Ammonia beccarii* and *Ammotium salsum* common.

Station 8, traverse 2, in the *Salicornia* contains a *Trochammina inflata* — *Ammonia beccarii* - – *Arenoparrella mexicana* — *Pseudoeponides andersoni* fauna. The largest standing crops are at the stations in the bay.

This island was essentially all *Salicornia* with narrow *Spartina alterniflora* in some places. The *Salicornia* area was not sampled because it was dry due to the long dry season, but the faunal assemblages appear to be strongly affected by the dominance of the *Salicornia*.

UPPER LAVACA BAY

Lavaca Bay is tributary to Matagorda Bay. The Lavaca River flows into Lavaca Bay as well as smaller streams and the bay generally is less saline than Matagorda Bay. Small marshes occur in and around small valleys on the edge of Lavaca Bay; two traverses of samples were collected from such an area in the northwest part of the bay (Figs. 9, 10).

The fauna in general is an *Ammonia beccarii — Ammotium salsum — Elphidium* one. *Miliammina fusca* and *Palmerinella palmerae* are common at many stations. The assemblage at Sta. 11 in mixed *Salicornia-Spartina* is dominated by *Triphotrocha comprimata, Trochammina inflata* and *Pseudo-*

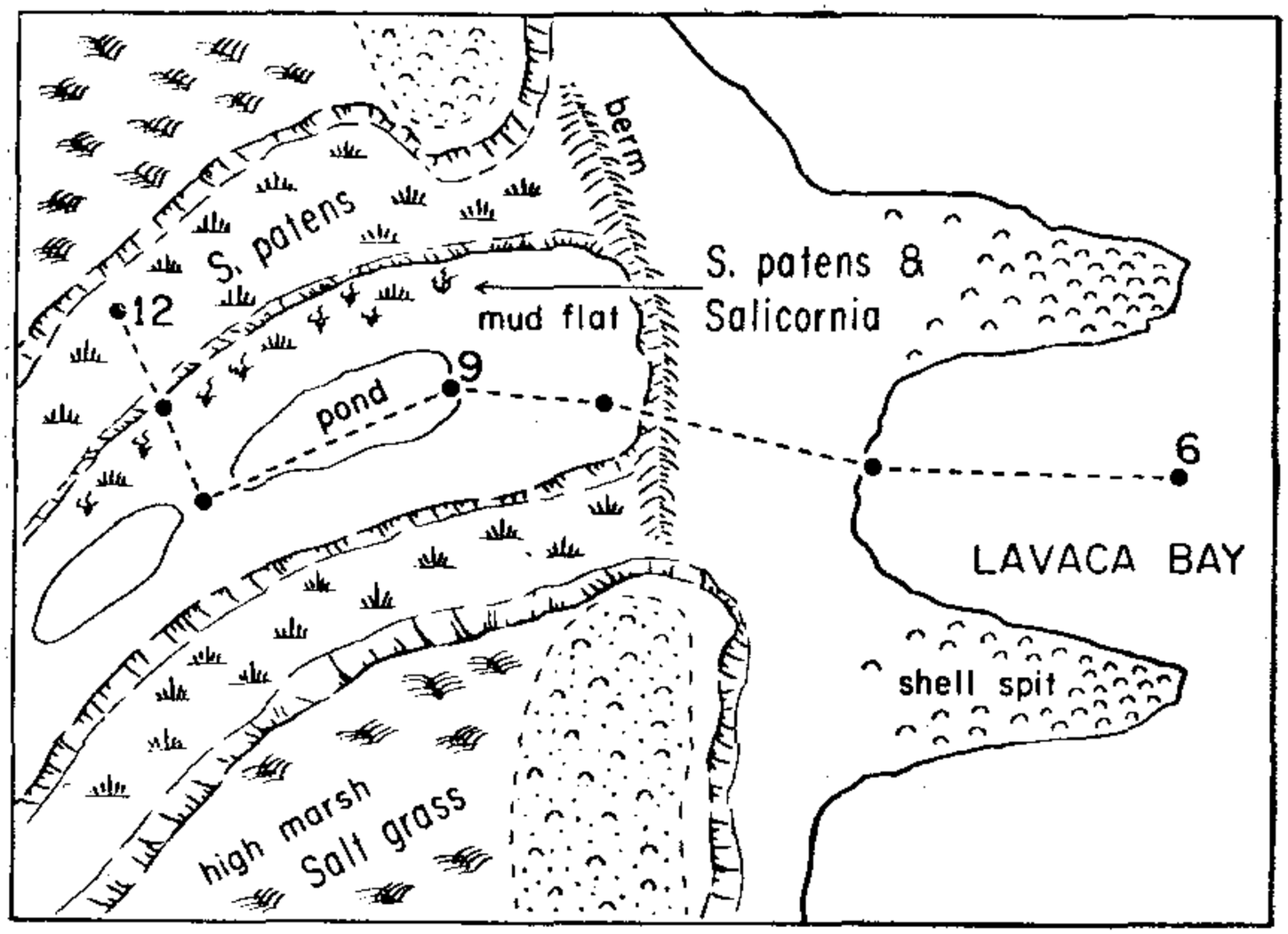


Figure 10. Locations of stations, traverse 2, upper Lavaca Bay area.

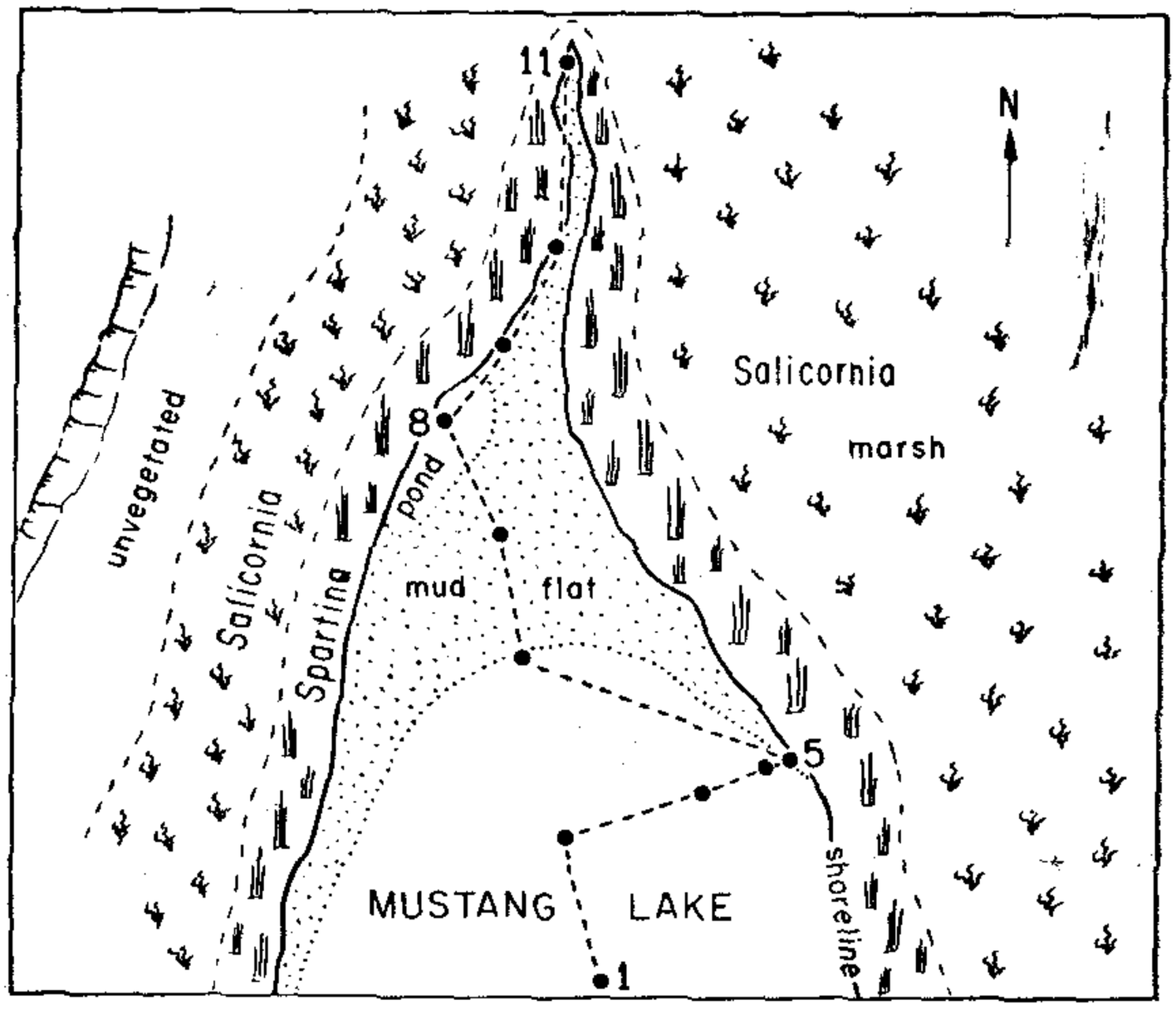


Figure 11. Locations of stations, traverse 1, Mustang Lake area.

eponides andersoni. Living populations are large except at 2 stations in the *Spartina* zone. *Ammoastuta inepta* is rare at 4 stations.

MUSTANG LAKE

Mustang Lake is on the southwest shore of San Antonio Bay, and separated from the bay by a low marshy barrier. The marsh in this area is fringed with a very narrow zone of *Spartina alterniflora* which extends into a broad area of the *Salicornia* marsh. The *Salicornia* zone soil was dry and dusty at the time of collecting and no samples were taken within this zone.

The fauna in all traverses (Figs. 11-13), is an *Ammotium salsum* — *Miliammina fusca* — *Ammonia beccarii* — *Elphidium* spp. one, *Areno-*

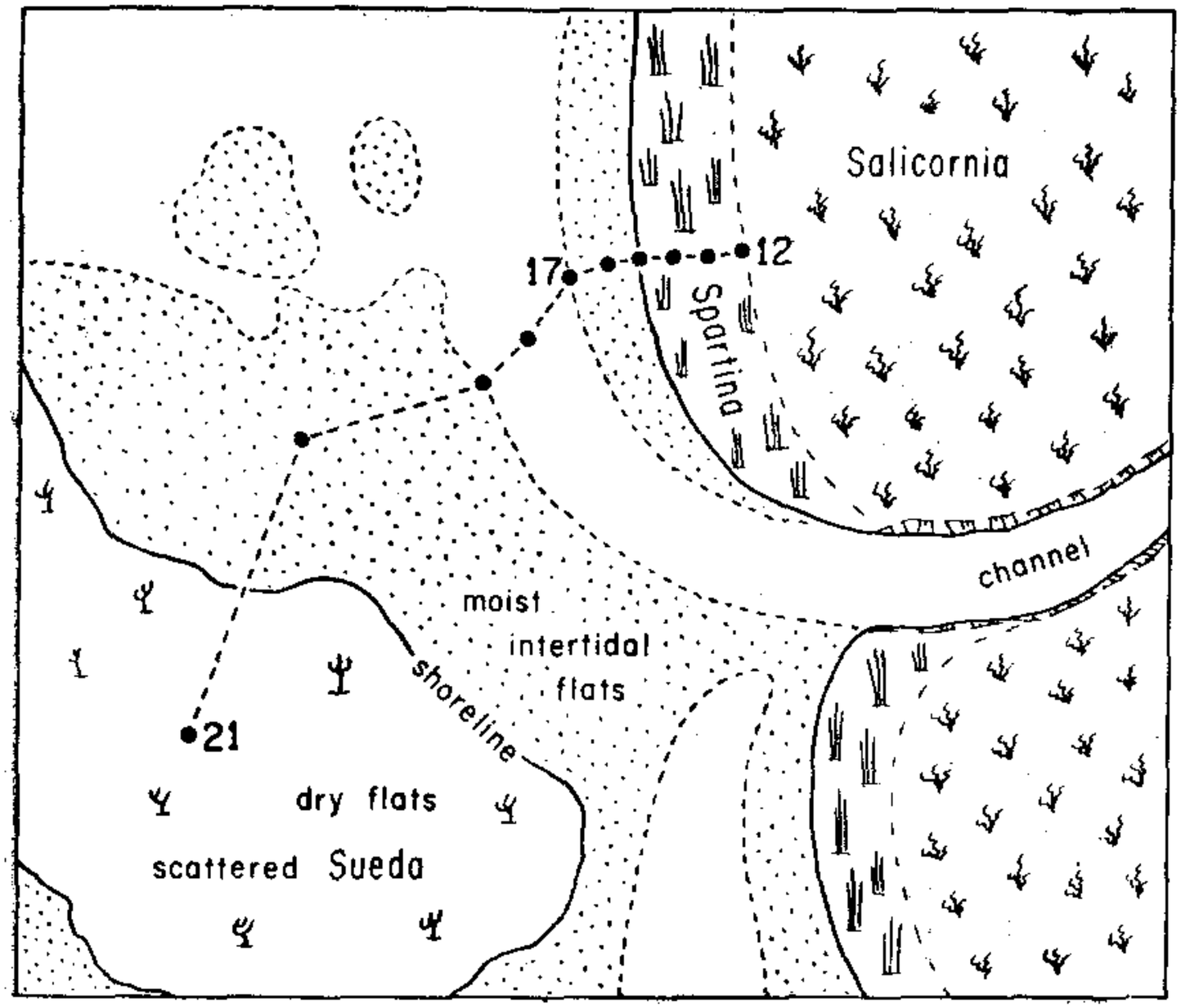


Figure 12. Locations of stations, traverse 2, Mustang Lake area.

parrella mexicana and *Trochammina inflata* are common at the inner edge of the *Spartina* where it is mixed with the *Salicornia*, but are not present elsewhere. Living populations in most samples are very large.

GOOSE ISLAND

Goose Island is located off the southern end of Lamar Peninsula between Aransas and Copano Bays. It is an accumulation of shell and shell fragments with some sand, silt and clay. Samples were collected along 2 traverses on the protected, northern shore of the island; the traverses were 200 yards apart (Fig. 14). At the location of traverse 1 there is a very narrow

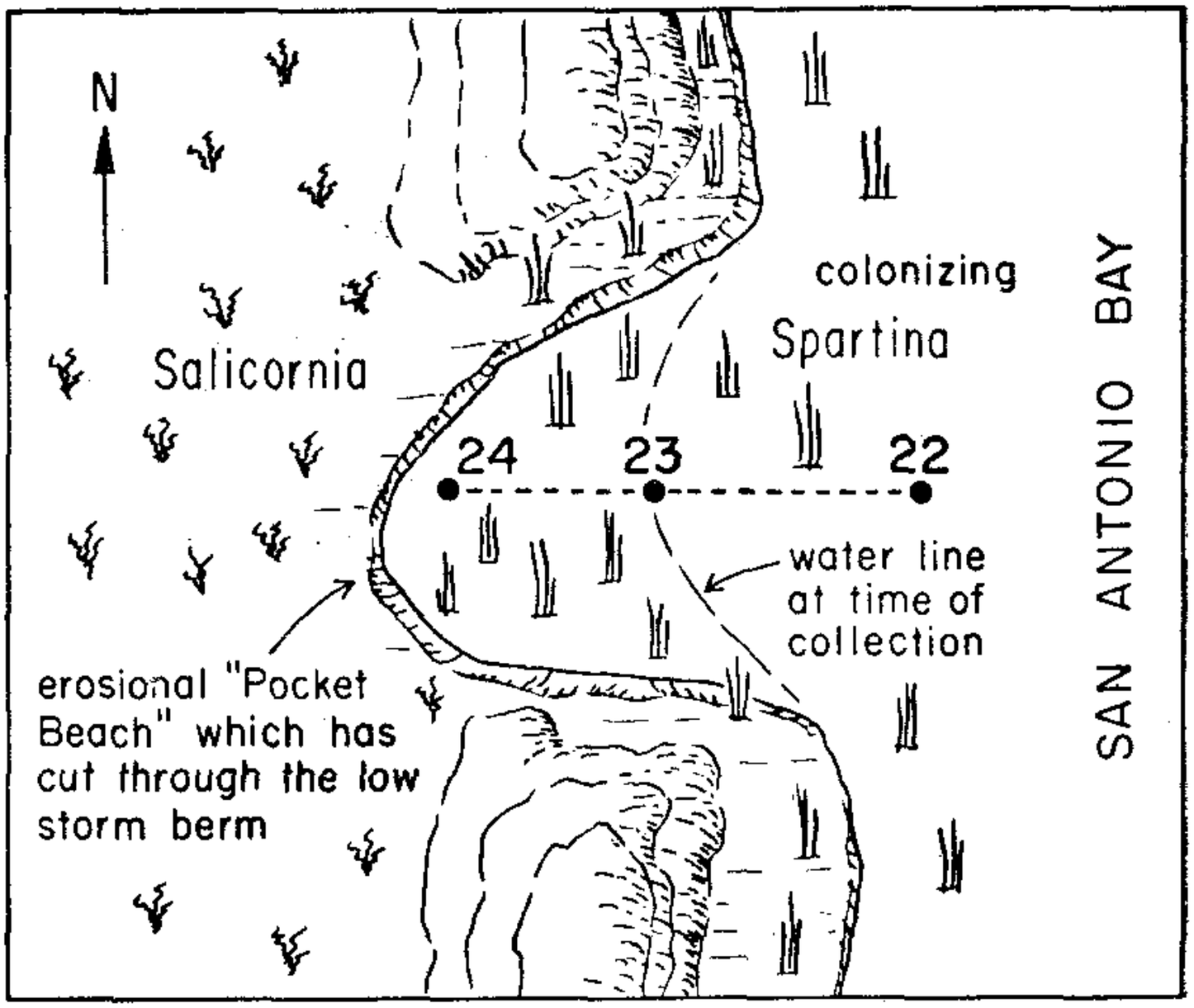
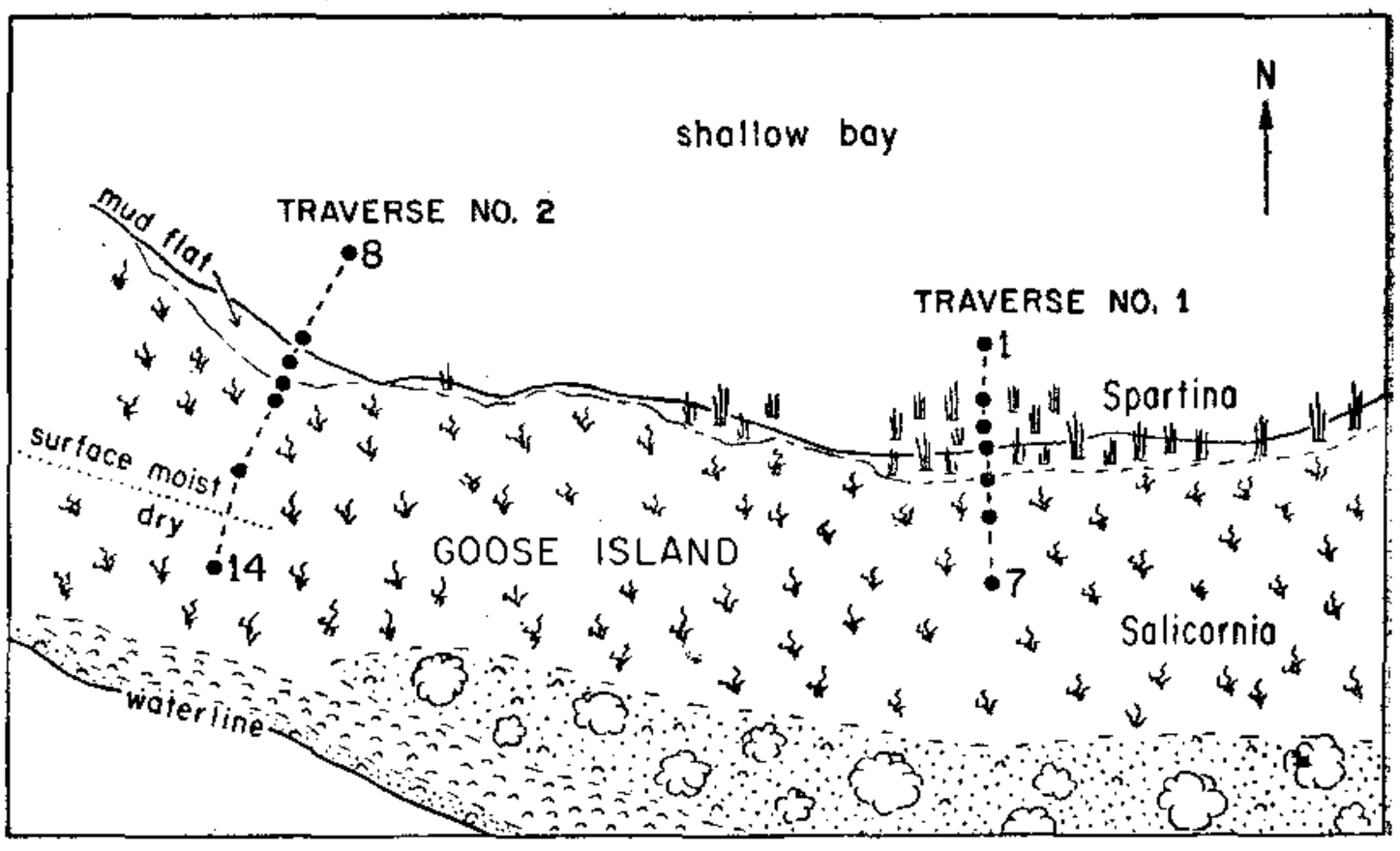


Figure 13. Locations of stations, traverse 3, Mustang Lake area.

Figure 14. Locations of stations, Goose Island area.



fringing zone of *Spartina* and this leads landward into a broad *Salicornia* marsh. Along traverse 2 the bay leads into a bare mud flat which extends into the *Salicornia* zone; no *Spartina* was present.

The foraminiferal faunas along these traverses are dominated by *Ammonia beccarii*, and *Miliammina fusca*. The bay, mud flat and *Spartina* zones are further characterized by the common presence of *Elphidium*, mostly *E. gunteri* and *Ammotium salsum*; these forms are rare or absent in the *Salicornia* marsh. Samples in the *Salicornia* contain abundant *Arenoparrella mexicana* and *Trochammina inflata*, and also *Miliammina fusca* is markedly more abundant here. Living populations are very large at most stations.

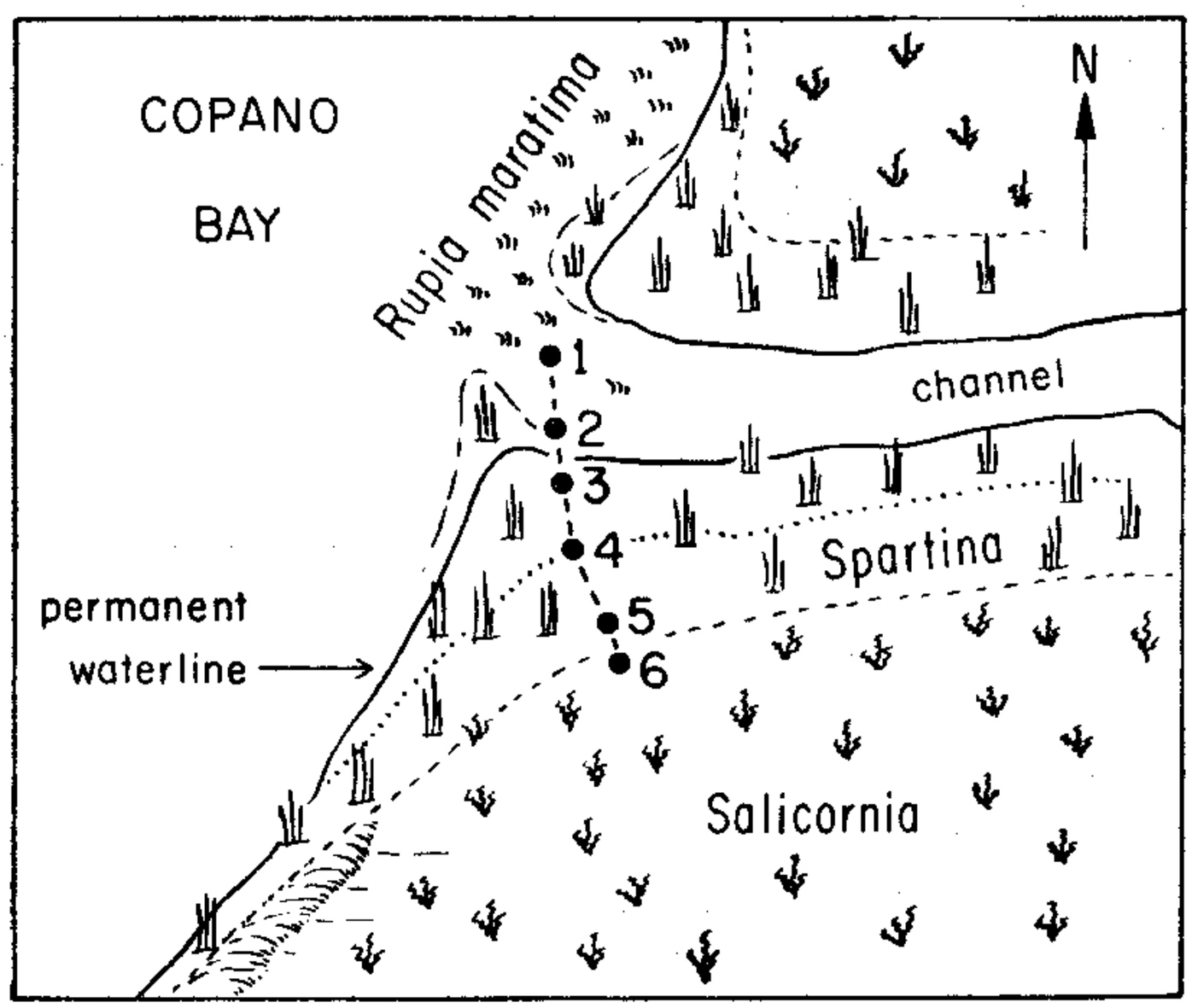


Figure 15. Locations of stations, traverse 1, east Copano Bay area.

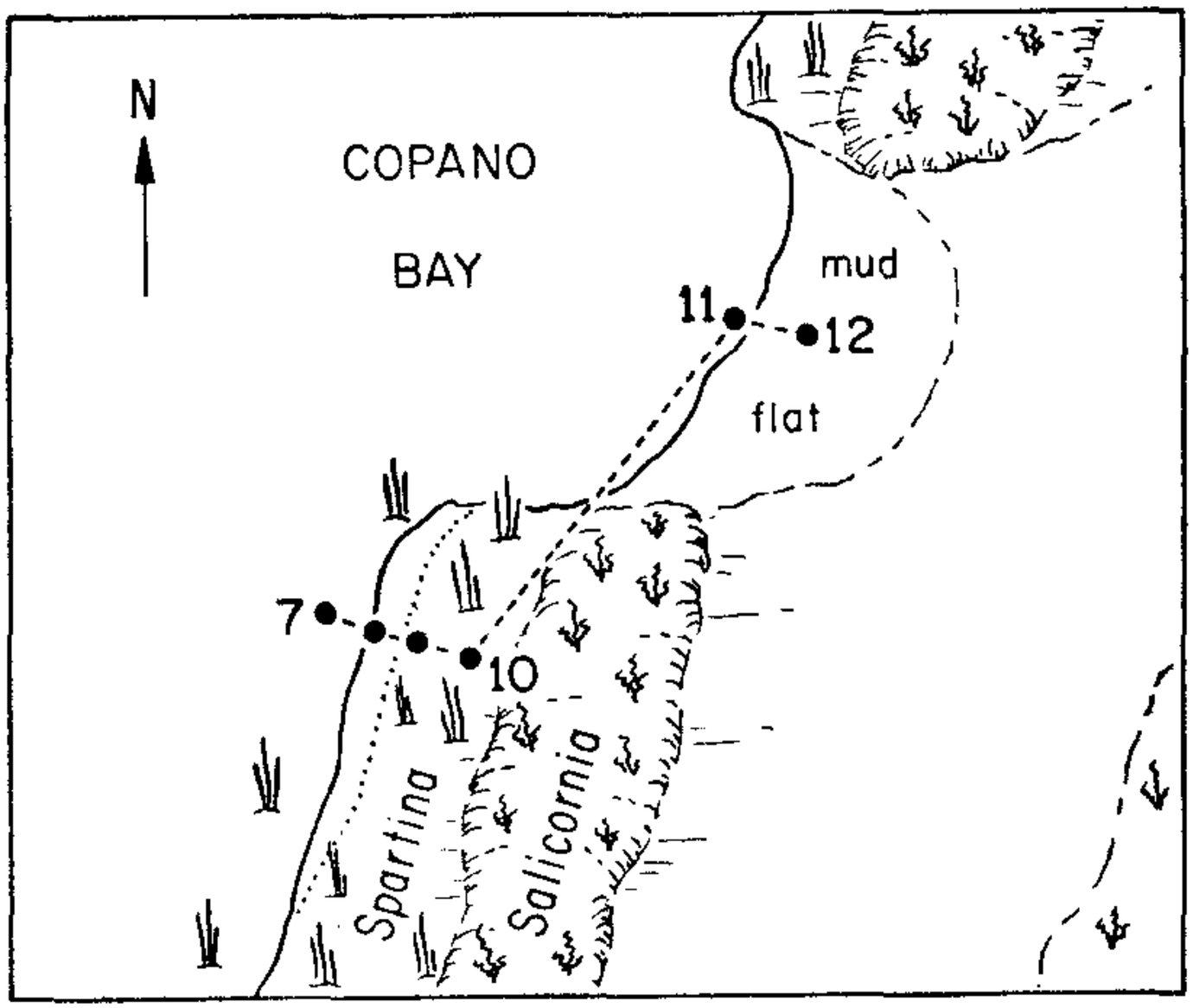


Figure 16. Locations of stations, traverse 2, east Copano Bay area.

EAST COPANO BAY

Two short traverses were made in East Copano Bay on the lower west side of Lamar Peninsula (Figs. 15, 16). The marshes in this area were generally dry, and only on that along the shoreline and fringing a tidal creek were the marsh plants healthy. Samples were collected only where there was surface moisture in the soil. The sediment in traverse 1 was fine grained and that in traverse 2 was more sandy with occasional shell patches.

The faunas in both traverses consist mainly of 4 abundant species: *Ammonia beccarii*, *Ammotium salsum*, *Miliammina fusca* and *Palmerinella palmerae*. In traverse 2 appreciable numbers of *Quinqueloculina poeyana* and *Elphidium* spp. occur at some stations; this may reflect the sandy and shelly composition of the sediment. The largest living populations occur in the tide channel in the flat fronting marsh where *Spartina* is colonizing.

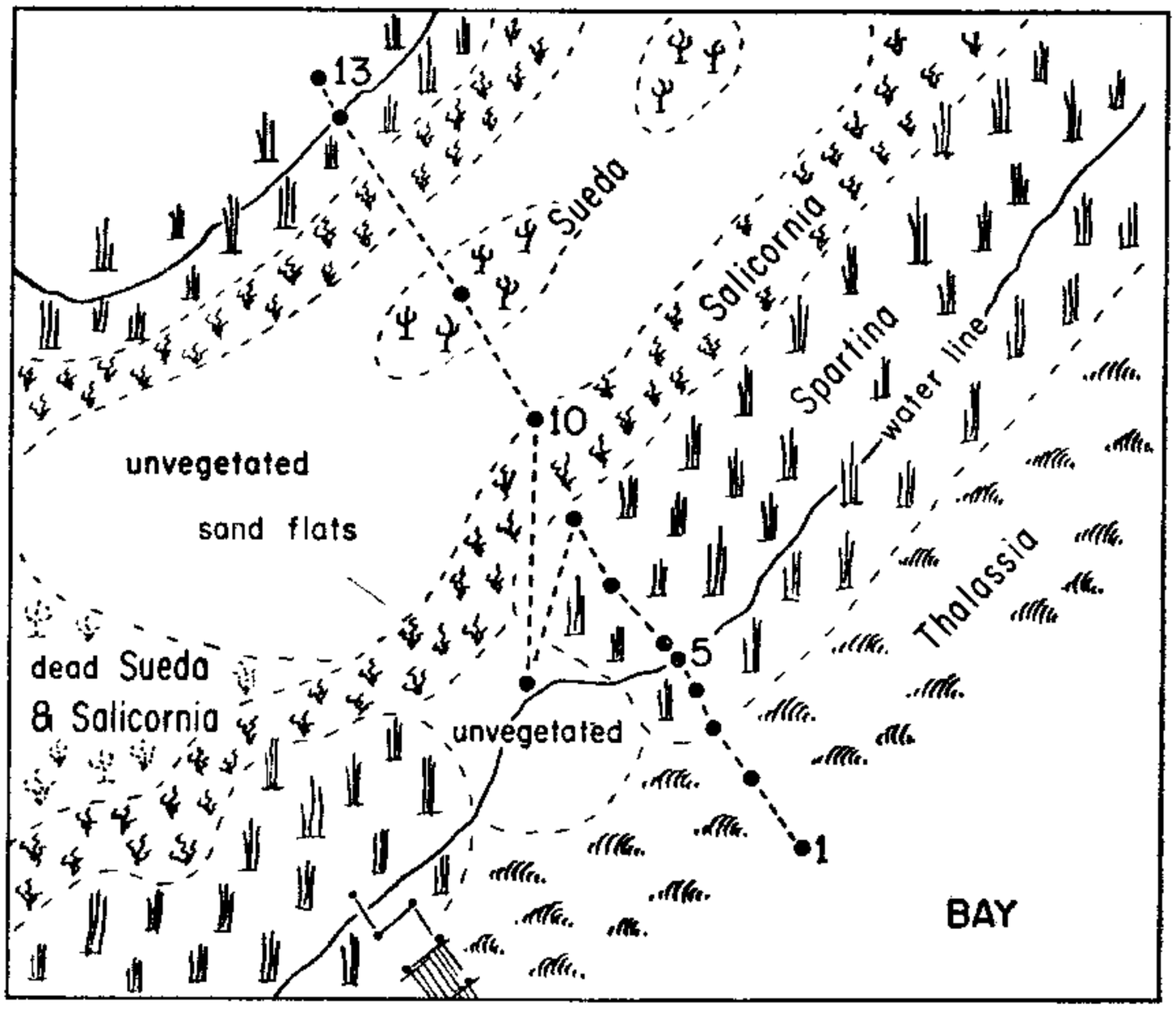


Figure 17. Locations of stations, traverse 1, Allyn's Bight area.

ALLYN'S BIGHT

The marsh in this area is located on the bay side of a lagoon sand barrier, St. Joseph's Island. The traverses collected on a marshy spit enclosing the small bay (Figs. 17, 18). In both traverses *Spartina alterniflora* is at low elevations near the bay; this is followed inland by *Salicornia* which surrounds a central sand flat having no vegetation.

The faunas at most stations are Miliolidae and *Ammonia beccarii*. *Ammotium salsum* and *Elphidium* are abundant to rare. Stations in and near the *Salicornia* marsh zone contain an *Ammonia beccarii — Arenoparrella mexicana — Trochammina inflata* fauna. *Palmerinella palmerae* is abundant throughout traverse 2, except in the *Salicornia* assemblage, but

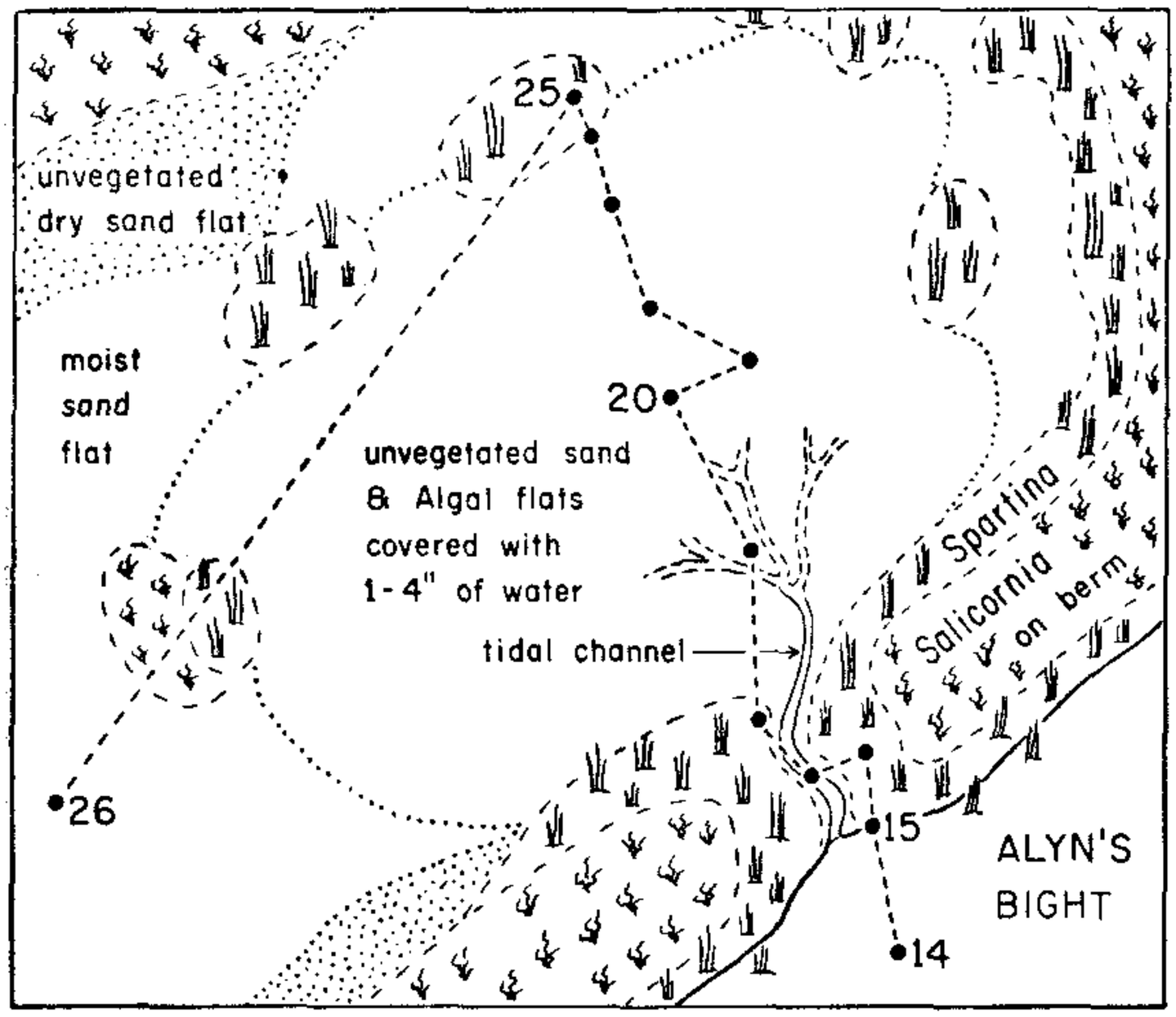


Figure 18. Locations of stations, traverse 2, Allyn's Bight area

does not occur in traverse 1. *Jadammina polystoma* and *Trochammina macrescens* appear to be confined to the *Salicornia*. Living populations are very large except in the *Salicornia*.

CORPUS CHRISTI BAY AREA

Shamrock Cove is on the bay side of Mustang Island, the lagoon barrier fronting Corpus Christi Bay. The cove is filled with low, irregular marshy islands separated by narrow tidal channels 4-5 feet deep.

Traverse 1 begins in 1 ft water depth and extends across a small, low marshy island. The island surface is moist and the sediment is mostly shelly sand. Vegetation is mostly very sparse *Salicornia* (Fig. 19). The faunas are dominated by miliolids except at stations 1 and 2 where there is an

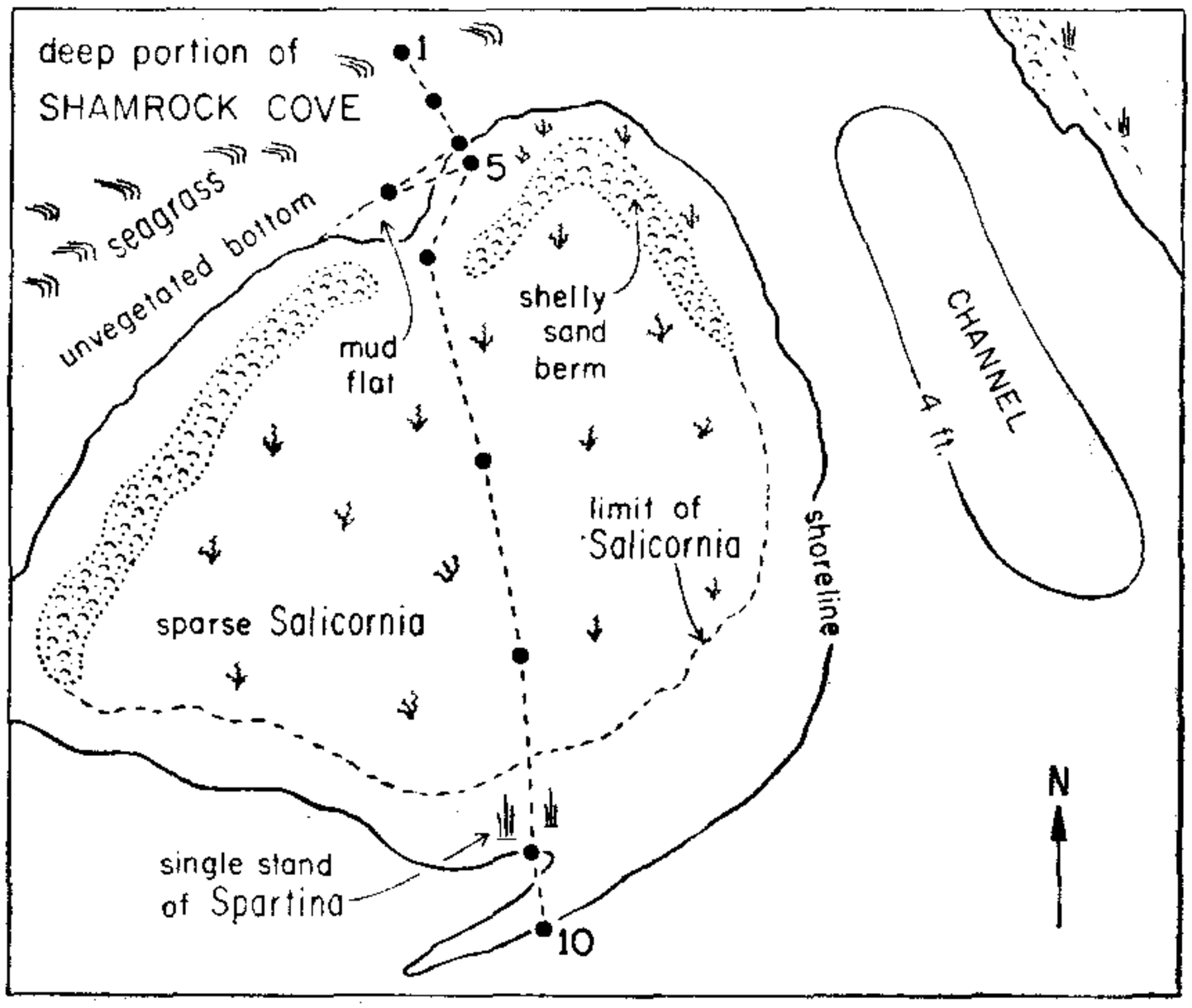


Figure 19. Locations of stations, traverse 1, Corpus Christi Bay area.

Elphidium — miliolid assemblage. *Ammotium salsum* is rare at most stations and *Ammonia beccarii* is common. *Miliammina fusca* is common at stas. 2-4 on the bare mud flats and is very rare elsewhere. Living populations are very large at stations 4, 8, 9 and 10 mostly on the mud flats. The zone of sparse *Salicornia* does not contain a foraminiferal assemblage typical of that zone, but the fauna of entire area is more similar to that of an intertidal flat.

Traverse 2 is on a small island 250 yds southeast of traverse 1 (Fig. 20). There is a peripheral border of *Spartina alterniflora* fronting a low berm, and a thick stand of *Salicornia* in the central part of the island. Faunas at stations on the tide flat and in the *Spartina* are dominated by miliolids with *Elphidium* common in the sea grass at Sta. 11. Faunas in the *Salicornia* contain abundant *Jadammina polystoma* and *Ammonia beccarii;*

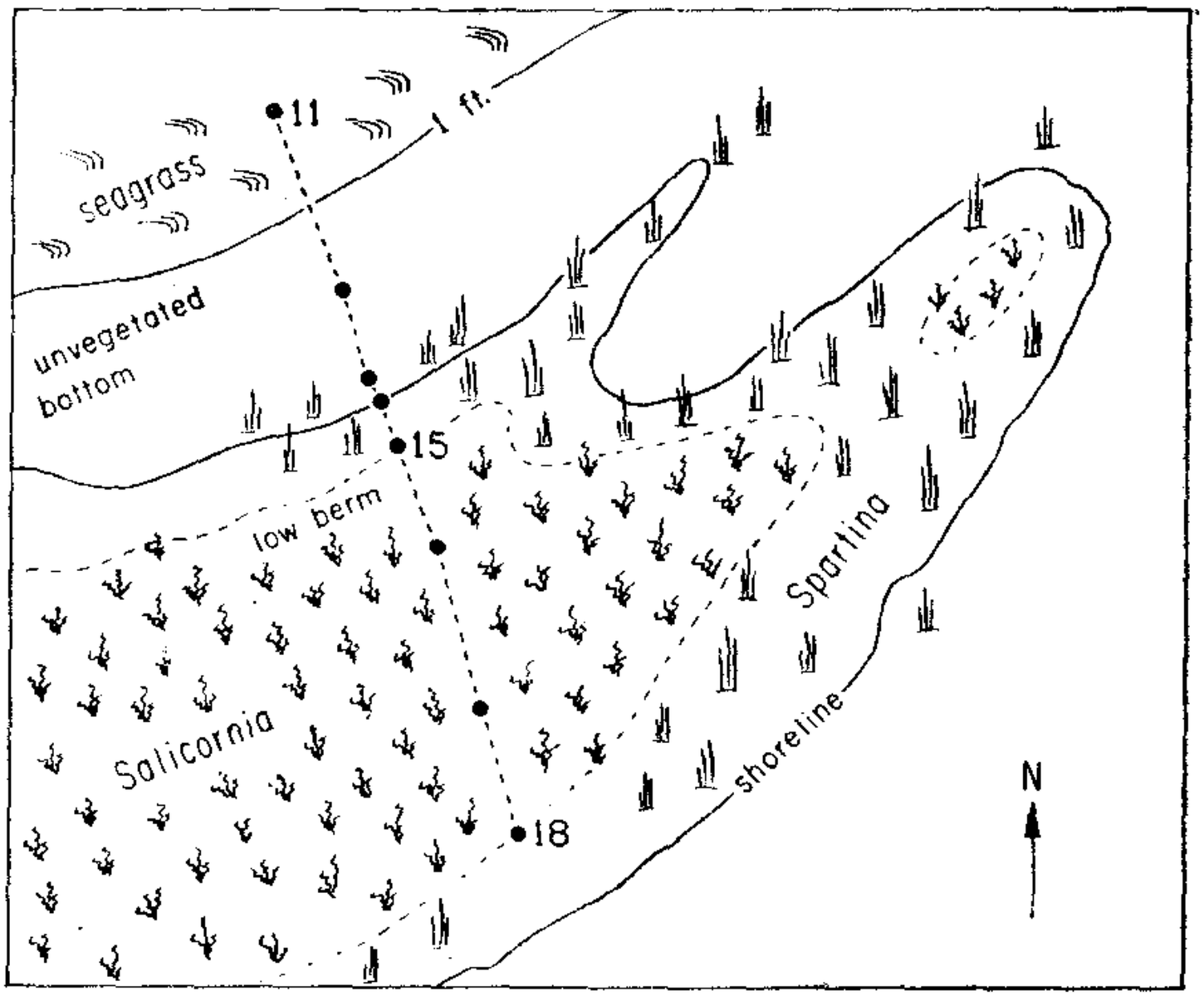


Figure 20. Locations of stations, traverse 2, Corpus Christi Bay area.

Trochammina inflata is restricted to this zone. The highest populations are on the intertidal flats.

FORAMINIFERAL DISTRIBUTION PATTERNS

MARSH ZONES

The marshes and adjacent areas which were sampled in the South Texas lagoons have several apparently distinctive zones based on field observations. These are based on physiography and on plant assemblages, and are useful in analyzing patterns of foraminiferal distributions within the marshes. They are as follows:

1. Bay or channel adjacent to the marsh. This habitat merges into the marsh with or without an intermediate mud flat zone. It is always covered with bay water and the depth range is approximately 15-100 cm.

2. Mud flat adjacent to or within the marsh. This is intertidal and is always moist.

3. *Spartina alterniflora* zone at the lowest level of the marsh plants and merging into the tidal flat or bay.

4. Mixed *Spartina* and *Salicornia*, intermediate in position between the two assemblages.

5. *Salicornia*, at the highest level in the marine marsh and wetted only at highest tide.

6. Marsh channel.

7. Marsh pond.

8. *Spartina patens*. Small patches of *S. patens* were seen in only two of the ten areas sampled.

SPECIES PATTERNS

There appear to be somewhat different patterns of species distributions as follows:

1. Species characteristic of the *Salicornia* and *Salicornia-Spartina* zones:

Arenoparrella mexicana
Jadammina polystoma
Pseudoeponides andersoni
Tiphotrocha comprimata
Trochammina inflata
T. macrescens

These species also have rare occurrences in some of the other zones, but they are neither so abundant nor so ubiquitous as they are in the *Salicornia*.

2. The following foraminifera are most abundant in the bay, mud flat and *Spartina alterniflora* zones:

Ammotium salsum
Miliolidae (various species)
Elphidium spp.

These forms also occur in the other zones but they are less common. They are interpreted as being typical of the lagoon rather than the marsh. Their presence in the marsh zones is a result of their abundance and the proximity and narrowness of the marsh.

3. *Miliammina fusca* is common or abundant in all zones except the *Salicornia* where it was found only rarely.

4. *Palmerinella palmerae* is most characteristic of the bay and mud flat samples, although it does occur at occasional stations in other zones.

5. *Ammonia beccarii* is abundant in all zones.

Figure 21 summarizes these ranges.

THE LIVING POPULATION

All 10 marsh areas are similar in having large living populations and great range in size of the population, from 10 to 3 300 specimens per sample. If the size of the population is considered by environmental zones, there are significant differences. In the following table populations which are abnormally large have been excluded from the average size.

SIZE OF LIVING POPULATION

Zone	No. Spls.	*Range* in size	Av. Size
Bay	28	185–2200	1400
Mud flat	45	15–2250	935
Spartina alterniflora	49	25–1500	565
Spartina – Salicornia	12	25–540	240
Salicornia	18	25–530	235

It is apparent that the bay and mud flat zones support significantly larger populations than the zones of marsh plants. One may speculate that the large bay populations are due to a combination of the following: a) continuous flooding and tidal replacement of marine water, b) the presence of submerged plants such as *Thalassia* and algae, and c) supply of trace materials by drainage from the marshes and adjacent streams. Mud flats are subjected to similar influences as the adjacent bay, except they are not continuously flooded and they do not contain *Thalassia*. The relatively smaller populations in the *Salicornia* and *Salicornia-Spartina* zones may be due to less flooding than in the other zones. It may also be in part a result of the prolonged drought which preceded the sampling.

The ratio between the living and the total populations of foraminifera

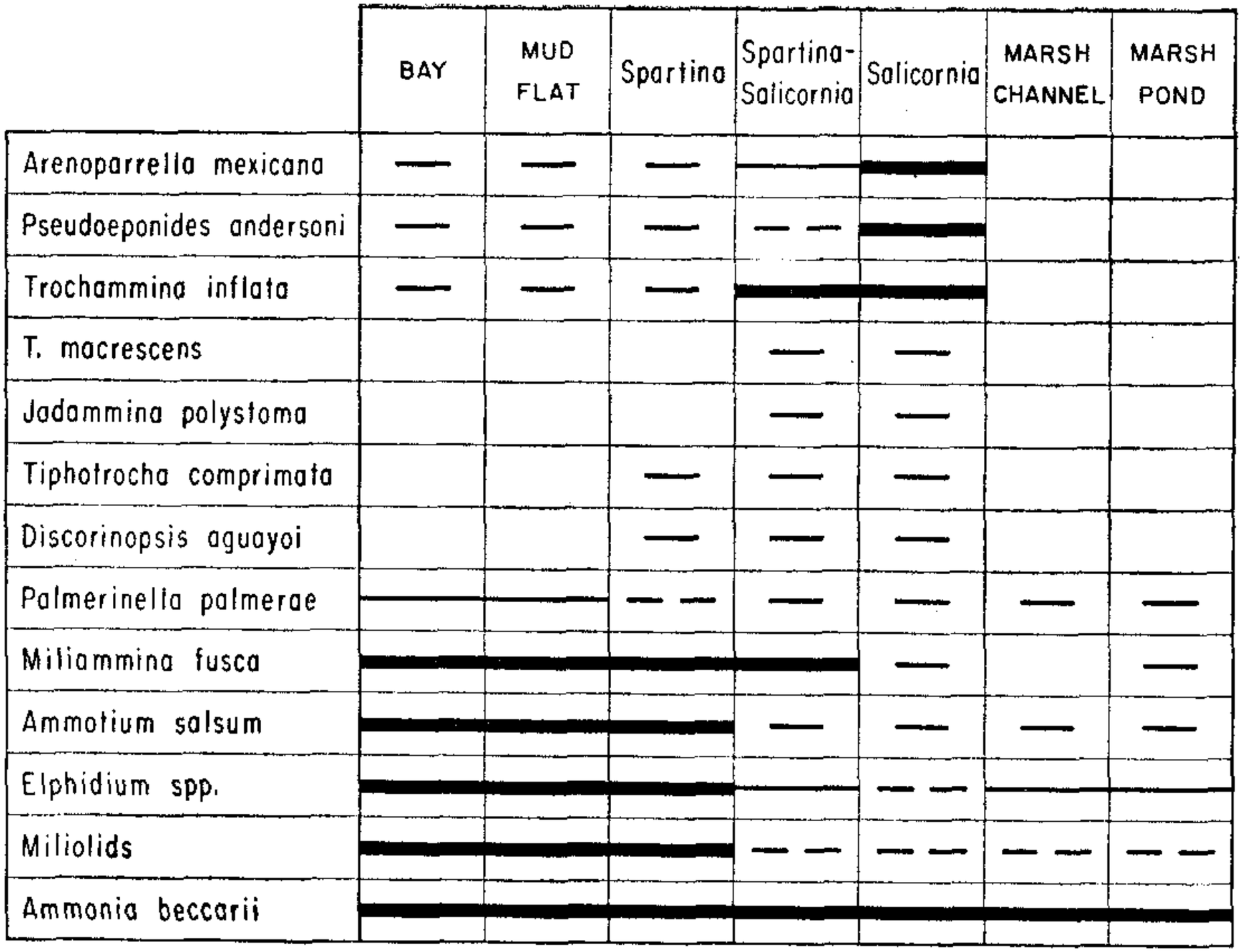


Figure 21. Generalized distributions of species and groups of foraminifera in South Texas marsh areas.

has been used as an indication of the relative rate of sediment deposition $\frac{\text{Living population}}{\text{Total population}} \times 100$; see Phleger (1960). The average ratios in the principal zones are as follows:

Bay	32
Mud flat	27
Spartina alterniflora	27
Spartina — Salicornia	21
Salicornia	6.5

These ratios indicate relatively rapid deposition rates when compared with data from other areas, as expected in these lagoon edge and marsh environments. The significantly smaller relative rate of sedimentation suggested for the *Salicornia* zone reflects the infrequency of flooding and sediment transport into this zone.

Number of species

The number of foraminiferal species living in these environments varies from 2 to 20 species/sample. A plot of number of species per sample for all samples (Fig. 22-A) shows the bimodal nature of this distribution. A plot of number of species/sample for the bay and mud flat zones only (Fig. 22-C) shows a spread from 3 to 20, but a tendency for the number of species to be from about 9 — 12 per sample. A plot of the samples within the marsh plant zones a marked tendency for 2 — 8 species/sample (Fig. 22-B). This difference in tendency between the marsh zones and the adjacent lagoon zones is suggestive. The considerable overlap shown in figure 22 is believed due to the proximity between the marsh and the lagoon zones and the relatively narrow width of the marshes.

Per cent of arenaceous specimens

It has generally been assumed that the foraminiferal populations in marine marshes are mostly or completely of arenaceous specimens (Phleger, 1960, p. 258). The data from the South Texas marshes and also a recent study of marsh foraminifera from Galveston Bay (Phleger, 1965) indicate that this generalization is only partly correct. Parker and Athearn (1959) have shown that there is a high percentage of calcareous tests in the living population in the marsh at Poponesset Bay, Massachusetts. Only a very small percentage of calcareous specimens, however, remained in the dead population.

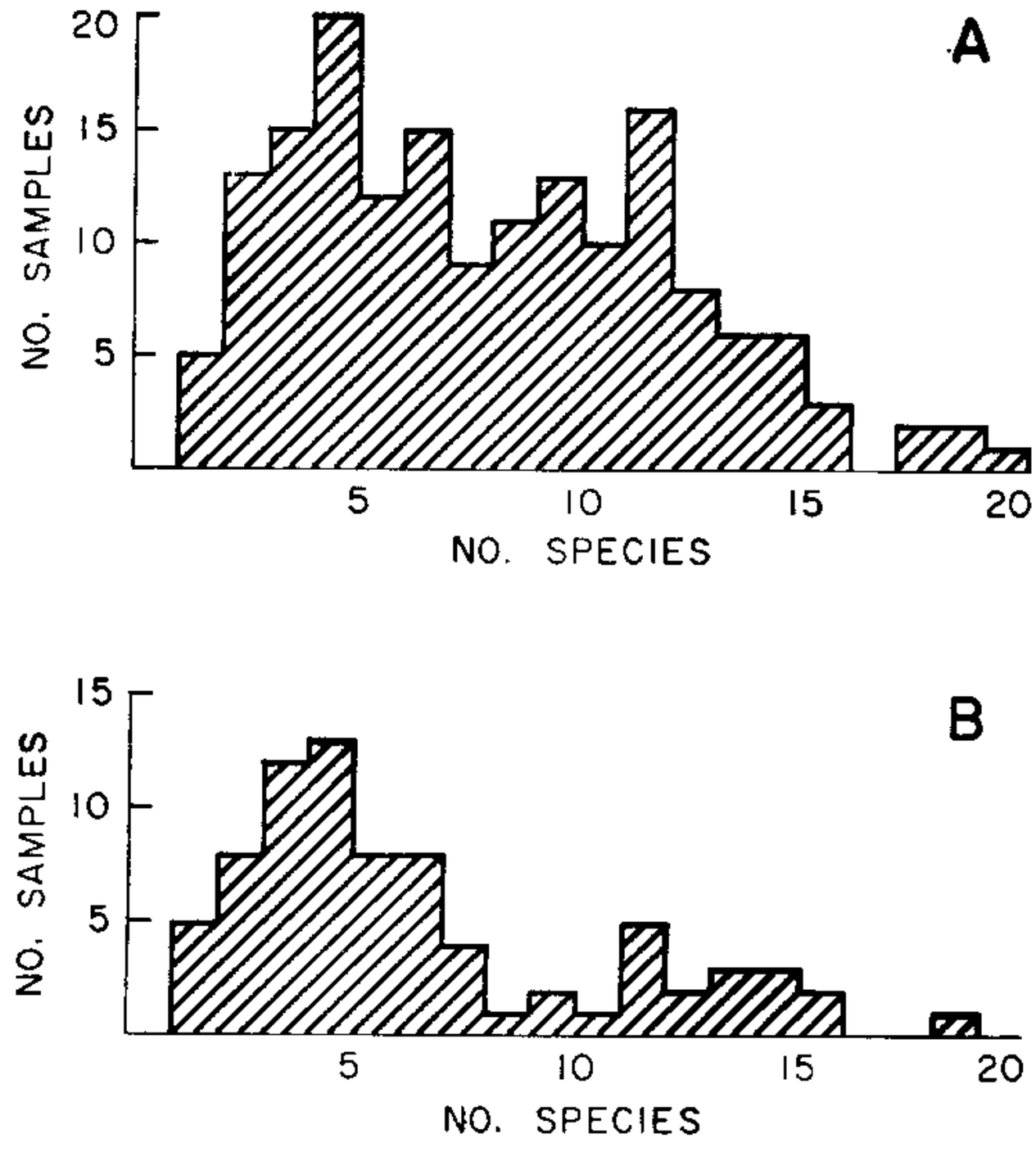


Figure 22. Number of species per sample: A, at all stations; B, at stations in marsh plant zones; C, at bay and mud flat stations.

In the present samples the per cent of living arenaceous specimens varies from 0% to 100%, with the mean values as follows:

all samples (168)	41%
Bay	33%
Mud flat	33%
Spartina	48%
Spartina-Salicornia	60%
Salicornia	38%

There is an indication that the marsh plant zones may contain larger percentages of living arenaceous specimens than the adjacent lagoon zones but the evidence is not conclusive. Data were not obtained on the per cent of arenaceous specimens in the dead population.

Many previous records of completely arenaceous marsh foraminiferal populations may be due to method of collection, method of preservation or method of study of samples. *It is apparent from the work of Parker and* Athearn (1959) and from preliminary experimentation by J. S. Bradshaw (personal communication) that living foraminifera resist solution of their calcareous tests due to lowering of the pH.

Solution of dead calcareous foraminifera is not resisted as it is in the same forms when alive. Available information indicates that diurnal variations of pH in a marsh can be as low as 7.0 and possibly lower (Bradshaw, 1965) in the water draining the Mission Bay, California Marsh. At Newport Bay, California, Stevenson and Emery (1958) report pH measurements down to about 6.7 in the surface of the *Spartina* zone. The thin surface layer of the marsh sediment is generally relatively light in color and is apparently an oxidized layer. Beneath the thin surface layer the sediment is usually much darker in color and many samples have an odor of hydrogen sulfide. This *lower sediment has a pH less than 7 where it has been measured.*

Samples taken of the surface, oxidized layer of sediment contain the living foraminifera. It is possible that some of the dead calcareous specimens have been destroyed in the surface deposits. Samples which are collected from the lower layers of sediments probably do not have a fair representation of the calcareous assemblage which originally lived at the place of collection. An additional hazard in obtaining a true assemblage of calcareous forms results from improper storage of samples. Marsh sediments contain abundant organic material, mainly in the form of plant debris. A closed container of wet sediment quickly becomes acid due to organic decomposition. Such samples can be buffered by the addition of sodium carbonate of sodium

borate. Even with strong buffering, they should be prepared for study as soon as possible after collection.

Evidence from the present samples and from the previous study in Galveston Bay marshes (Phleger, 1965) indicates the following for marshes of these types: a) the indigenous foraminifera contain a large percentage of arenaceous specimens but also significant abundances of calcareous forms; and b) the frequencies of arenaceous and calcareous populations vary widely.

BIBLIOGRAPHY CITED

BRADSHAW, J. S. (1965). *A multi-factor instrument for recording ecological parameters.* Marine Foram. Lab., Scripps Inst. of Oceanography.

HEDGPETH, J. W. (1951). In a Report of the Committee on a Treatise on marine ecology and paleoecology n. 11, p. 49-56.

— (1953). *An introduction to the zoogeography of the northwestern Gulf of Mexico with reference to the invertebrate fauna.* Publ. Inst. Marine Sci., v. 3, n. 1, p. 111-124.

PARKER, F. L., and ATHEARN, W. D. (1959). *Ecology of Marsh Foraminifera in Poponesset Bay, Massachusetts.* Jour. Paleont., v. 33, n. 2, p. 333-343.

PARKER, F. L., PHLEGER, F. B. and PEIRSON, J. F. (1953). *Ecology of Foraminifera from San Antonio Bay and environs, southwest Texas,* Cushman Found. Foram. Res., Spec. Publ. 2, p. 1-75.

PARKER, R. H. (1960). *Ecology and distributional patterns of marine macro-invertebrates, northern Gulf of Mexico. In Recent Sediments, Northwest Gulf of Mexico,* American Assoc. Petrol. Geol. Tulsa, Oklahoma, p. 302-337.

PHLEGER, F. B. (1960). *Ecology and Distribution of Recent Foraminifera,* John Hopkins Press, Baltimore, 297 p.

— (1965). *Patterns of marsh Foraminifera, Galveston Bay, Texas.* Limnol. Oceanogr., Suppl., v. 10, p. 169-184, text figs. 1-8, tablas 1-2.

STEVENSON, R. E., and EMERY, K. O. (1958). *Marshlands at Newport Bay, California.* Allan Hancock Found., Occ. Papers, n. 20.

TRAVERSE	1							2				3					
STATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
LIVING POPULATION	3850	1850	320	700	340	44	195	620	480	85	70	1160	500	1200	1020	340	540
TOTAL POPULATION	5200	2650	3600	3000	2150	810	1850	1850	840	1190	560	3650	2050	8500	3700	1500	1800
LIVING-TOTAL RATIO	74	70	9	23	16	5	11	34	57	7	12	32	24	14	28	23	30
Ammonia beccarii vars.	40	28	31	44	59	64	64	64	82	50	60	50	75	77	57	54	35
Ammotium salsum vars.	30	39	22	22	8	18		16	6	17		16	3	10	16	2	2
Arenoparrella mexicana																1	
Bolivina lowmani	.4	.8	4														
striatula	.7	.8										1					
Buliminella bassendorfensis	.4																
elegantissima	7	2															
Discorinopsis aguayoi							7										3
Elphidium galvestonense								2				1					1
gunteri	14	19	17	28	12			9	6		20	1		2			1
cf. E. koeboeense												5			4		11
matagordanum	1	2	13	4	4	9		7				4	8	2	7	42	37
cf. E. tumidum	.4		13	2									-				.7
Helenina anderseni							7			33	20						3
Miliammina fusca	1	.8			8	9						13	11	8	11		.7
Miliolinella microstoma	.7	.8			4		21										.7
obliquinoda	1	2						2	3			6	3				1
Miscellaneous miliolids	.7	2			4							1			4		.7
Oolina sp.	1	.8															
Palmerinella palmerae	.4														1		
Quinqueloculina poeyana	.7	2															
Tiphotrocha comprimata																1	
Triloculina sidebottomi									3								.7
Trochammina inflata																	2

Table 1. Living foraminifera in Colorado River Delta area, in per cent of the living population.

TRAVERSE	1									2										
STATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
LIVING POPULATION	85	85	200	70	380	1550	1650	800	1550	3300	240	580	1450	700	1600	450	250	1550	90	2450
TOTAL POPULATION	340	830	1350	1750	1020	2200	2250	1300	2150	4600	490	650	2850	1350	2350	850	1250	3050	390	3200
LIVING-TOTAL RATIO	25	10	15	4	37	70	69	61	72	72	49	89	51	52	67	53	20	51	23	76
Ammonia beccarii vars.	17	50	63	40	15	20	20	24	20	22	53	39			14		40	32		28
Ammotium salsum vars.	17				48	21	9	10	10	19	41	48	94	12	36	66		35	32	33
Bolivina lowmani																	10			
Buliminella elegantissima	17																			
Clavulina gracilis														2	2			1	5	
Elphidium galvestonense										1		4								
gunteri				40			2	2							3		40			
incertum mexicanum			12																	
cf. E. koeboeense			12		4	30	26	7	10	9		4			19	6		5		20
matagordanum		17					3	2	5	4	6				2					3
cf. E. tumidum			12				2													
Gaudryina exilis					7					4										
Massilina protea						3	3	14	11					86				5		
Miliammina fusca					18	2	5	12	4	1		4	6		12	16			63	7
Miliolinella microstoma						3	2	2	5	6								1		6
obliquinoda						7	8	2	4	2					3			4		1
Miscellaneous miliolids	33	17				2	3	18	14	8					2			12		2
Palmerinella palmerae				20		2			2											
Protoschista findens															2	6				
Quinqueloculina poeyana	17				4	7	15	3	14	21					2					
seminulum		17			4	3	2			4					3					
tenagos								2	1	5								4		
Textularia earlandi										.4										
Triloculina sidebottomi								2		.4							10	1		
Trochammina inflata																6				

Table 2. Living foraminifera in Pass Cavallo area, in per cent of living population.

TRAVERSE	1					2				3			4		
STATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LIVING POPULATION	640	1700	1700	2900	4200	1550	9700	5300	2400	2250	4200	5000	160	2700	6400
TOTAL POPULATION	1180	3600	3400	9900	2400	2650	11000	18500	17500	5300	16500	4400	1300	10100	22000
LIVING-TOTAL RATIO	54	44	50	49	17	58	91	29	14	42	25	11	12	27	29
Ammonia beccarii vars.	13		17			8	13			27	7	15	50	5	9
Ammotium salsum vars.	28	42	17	31	67	16	25	11	94	34	70		25	11	78
Arenoparrella mexicana		8		3											
Clavulina gracilis						3									
Elphidium gunteri							.4								
matagordanum	9					.9	2							5	
cf. E. tumidum						.9									2
Miliammina fusca	26	50	41	49	33	68	57	89	6	39	23	77	25	79	11
Miliolinella microstoma												8			
obliquinoda	17						.4								
Miscellaneous miliolids						.9	.8								
Oolina sp.	2														
Reophax nana	4		8			2	.4								
Tiphotrocha comprimata							.4								
Trochammina inflata			17	17											

Table 3. Living foraminifera in Powderhorn Lake area, in per cent of living population.

TRAVERSE	1		2						3					
STATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LIVING POPULATION	1250	165	1800	720	1700	1500	650	28	310	430	740	120	60	170
TOTAL POPULATION	5150	360	6500	5850	9000	9250	6200	1010	2550	4650	7500	360	170	1300
LIVING-TOTAL RATIO	22	46	28	12	19	16	10	3	12	9	10	33	35	13
Ammonia beccarii vars.	45	51	40	56	54	63	69	29	41	70	42	29	3	7
Ammotium dilatatum	1			.6	.2					1				
salsum vars.	13	10	10	10	21	4	2		16	12	31	2	10	1
Arenoparrella mexicana		2			.9	1	4	14	1	2	4		3	1
Bolivina striatula			3						1					
Buccella hannai				.6		1								
Buliminella elegantissima												2		
Clavulina gracilis			1											
Discorinopsis aguayoi							1							
Elphidium galvestonense					.5		.6							
gunteri	2	7	17	6	7	7	4		21	2	4	6		1
cf. E. koeboeense	1			1					1					
matagordanum	3		1	1	2	2			4	1	4			4
poeyanum	.6			.6					1		.5			
cf. E. tumidum	1				.2	1				1	.5	2	3	1
Helenina anderseni			1		.2		.6	14			.5			2
Jadammina polystoma	.3					1								
Miliammina fusca	10	2	1	.6	2	8	2		6	4	11	2	40	61
Miliolinella microstoma	3	5	7	2	1				1					9
obliquinoda	2		6	1	2	1	2							
Miscellaneous miliolids	12	2	4	3	2		2		1					
Palmerinella palmerae					.2				5	5	2	54	40	6
Protoschista findens	.3				.7									
Quinqueloculina poeyana	2	2	7	12	4	1	2		1		1			
seminulum	2			1	.2									
tenagos	1			1	.5		.6							1
Rosalina floridana				.6			2							
Textularia earlandi										1				
Triloculina sidebottomi		15	1	2	.5	2	4							
Trochammina inflata	.6	2		.6	.5	8	2	43				3		6
Miscellaneous spp.	.3			1										

Table 4. Living foraminifera in Port Alto area, in per cent of living population.

TRAVERSE	1					2						
STATION	1	2	3	4	5	6	7	8	9	10	11	12
LIVING POPULATION	4 2 0	1 0 0 0	7 5 0	5 5 0	55	6 2 0	6 2 0	2 4 5	9 0 0	1 2 2 0	3 4 0	1 4
TOTAL POPULATION	2 4 5 0	3 1 5 0	5 6 0 0	4 9 5 0	1 7 5 0	1 0 8 0	1 0 7 0	9 0 0	1 8 5 0	2 3 0 0	7 8 0	2 8
LIVING-TOTAL RATIO	17	32	13	11	3	57	58	27	49	53	44	50
Ammoastuta inepta	1		3		7						4	
Ammonia beccarii vars.	31	48	36	38	43	32	43	29	40	46	4	
Ammotium dilatatum									5			
salsum vars.	12	15	17	5	14	5	9	7	11	26		
Arenoparrella mexicana									.4			
Elphidium gunteri	16	5	9	10	7	23	22	34	42	28		
cf. E. koeboeense		2	.5					10	.4			
matagordanum	5	2	.5	8	14	2	.6					
poeyanum		2	.5	3								
cf. E. tumidum	1					2		3	.4			
Glabratella sp.		5	3	3		16	14					
Helenina anderseni			1		7	5					17	
Miliammina fusca	2	5	18	20		2	5	2				
Miliolinella microstoma			.5	3								
obliquinoda	5		3			7	3	8	.4			
Miscellaneous miliolids	1		1			2	.6	2				100
Oolina sp.						2						
Palmerinella palmerae	26	15	6	8	7		1	3				
Quinqueloculina poeyana						2						
seminulum			.5				.6					
Tiphotrocha comprimata											50	
Triloculina sidebottomi							.6	2				
Trochammina inflata			.5	3			.6				21	
Miscellaneous spp.											4	

Table 5. Living foraminifera in upper Lavaca Bay area, in per cent of living population.

TRAVERSE	1											2										3		
STATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
LIVING POPULATION	980	1800	2200	690	820	700	1900	820	900	50	100	240	1500	840	980	1100	850	1180	880	950	600	200	450	620
TOTAL POPULATION	6750	7750	7250	3100	2750	3750	6000	3400	2700	360	640	4850	5100	3150	10750	8750	8000	9250	8000	10750	7000	2600	2750	3550
LIVING-TOTAL RATIO	14	23	30	22	30	19	32	24	33	14	16	5	29	27	9	13	11	13	11	9	9	8	16	17
Ammoastuta inepta																					4			
Ammonia beccarii vars.	12	18	8	12	9	32	26	12	12	13		41	24	10	21	13	24	24	28	17	17	38	22	40
Ammotium dilatatum			5	2	18	14	8		5						1	5	6	1	2					
salsum vars.	54	41	36	35	33	25	41	52	67	61	14	6		7	7	16	15	35	10	8	17	25	61	2
Arenoparrella mexicana										3	14	6	11											
Discorinopsis aguayoi													1	7										
Elphidium gunteri	3	3	1	2			1								6	5	6			3				
cf. E. koeboeense	5	7	9	4	3		1	12							6			11	2	3	12	12		
matagordanum	3	3	1	4	3	4	1	3			29		1	5	1	9	6	2	2	8	8			
cf. E. tumidum		1	3	2	3		4	6	2				1		4	2	3	4		8	17			
Helenina anderseni										3		6	21	5					2	3				4
Miliammina fusca	20	19	30	35	30	25	12	12	14	20	43		7	46	47	33	31	18	39	44	21	12	11	36
Miliolinella microstoma			2									12	29	20		2		2	2		4			
obliquinoda															1				5					
Miscellaneous miliolids				2											1		6	2		3				
Palmerinella palmerae	3	1	2				3	3							4	5	3	1				12		
Quinqueloculina poeyana		7														5			2				6	
seminulum			1	2			3									5			3					
tenagos			1												1									
Trochammina inflata												29	5											
Miscellaneous spp.																			3	3				

Table 6. Living foraminifera in Mustang Lake area, in per cent of living population.

TRAVERSE	1							2						
STATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LIVING POPULATION	1950	330	450	620	450	1750	1350	1300	1450	1650	1800	310	980	480
TOTAL POPULATION	5100	1070	600	1850	2850	7750	19250	2950	5400	5050	6150	2650	12750	16500
LIVING-TOTAL RATIO	38	31	75	33	16	23	7	44	27	33	29	12	8	3
Ammonia beccarii vars.	65	72	71	20	17	29	30	59	50	46	18		15	47
Ammotium dilatatum											1			
salsum vars.	10	1	.4	41	6			6	22	18	10		3	
Arenoparrella mexicana		.6		5	22	16	13		3	1	8	41	31	37
Elphidium galvestonense				9										
gunteri	5	6	23	5				11	2	6	7			
cf. E. koeboeense		.6						1						
matagordanum	.7	2		5		1	2	1		1	1			
poeyanum							2							
cf. E. tumidum	.7	1								1				
Helenina anderseni						1								
Miliammina fusca	12	8	2	11	32	33	43	13	14	24	40	9	41	16
Miliolinella microstoma	5	4	2			4	2	6	7		1	9		
obliquinoda		3	.4											
Miscelloneous miliolids		.6	.9					1	2		1			
Oolina sp.	.7						2	1			1			
Palmerinella palmerae								1				5		
Quinqueloculina seminulum	1										4			
Tiphotrocha comprimata				2										
Trochammina inflata		.6		2	17	16	6			3	6	36	10	
macrescens					6						1			
Miscellaneous spp.											1			

Table 7. Living foraminifera in Goose Island area, in per cent of living population.

TRAVERSE	1						2					
STATION	1	2	3	4	5	6	7	8	9	10	11	12
LIVING POPULATION	1250	300	1300	370	240	100	420	1250	260	30	460	48
TOTAL POPULATION	1800	830	2750	770	880	570	500	1600	360	185	510	140
LIVING-TOTAL RATIO	72	36	47	48	27	18	84	78	72	16	90	34
Ammobaculites exiguus	.3		.3									
Ammonia beccarii vars.	46	5	41	49	36	8	42	30	5	40	38	56
Ammotium dilatatum		.7						2				
salsum vars.	41	83	50	13	21	20	19	21	51		23	
Discorinopsis aguayoi					.8	2						
Elphidium galvestonense								2			.9	6
gunteri	1			.5								6
spp.			.3	.5			3		2		.9	6
Miliammina fusca	4	11	4	11	30	27	6	15	26	60	10	6
Miscellaneous miliolids	2		.3	1				7			8	6
Palmerinella palmerae	5		4	25	12	43	17	14	16		10	13
Quinqueloculina poeyana							13	9			10	

Table 8. Living foraminifera in east Copano Bay area, in per cent of living population.

TRAVERSE	1										2													
STATION	2	3	4	5	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
LIVING POPULATION	500	750	900	630	180	28	180	175	600	340	1250	1550	250	480	1300	1600	1300	1160	2100	1600	2050	590	310
TOTAL POPULATION	1300	2150	1650	2400	2750	1700	630	2350	1300	810	9000	5500	3600	3450	11750	9500	15000	12250	38000	23750	28750	5750	25000
LIVING-TOTAL RATIO	36	35	55	26	7	2	29	7	46	42	14	28	7	14	11	17	9	9	6	7	7	10	1
Ammonia beccarii vars.	20	18	8	16	8	28	8	5	5		26	28	33	32	33	22	20	12	12	10	21	36	16
Ammotium dilatatum																			.7		.7		
salsum vars.			61	51					49	88	8	24		41	1	10	2	28	3	4	6	.7	
Arenoparrella mexicana					15	14		2	2					3									
Discorinopsis aguayoi								2															
Elphidium galvestonense							8							3	3		2	1	2		1	.7	
gunteri	5	7									6	.9	6		4	2	1	1	2	.9	1	.1	1
cf E. koeboeense	5	3																					
matagordanum		3	3	2							4	5		3	7	7		5	2	3	5		1
poeyanum															1						.7	.7	
cf. E. tumidum											1				2								
spp.											2				1								1
Glabratella sp.	5	3																					
Helenina anderseni						28		9			1		17										
Jadammina polystoma								2															
Massilina protea	5	30	11	9							23	12		6	16	14	29	12	23	34	17	9	33
Miliammina fusca		3		2	15				42	4	2	5		3	2	4	3	13	5	3	8	31	7
Miliolinella microstoma	40	3	6	14		14	15				3	2			2	.9	13	2	7	10	8	2	4
obliquinoda				4													1		2			6	
Miscellaneous miliolids	5	13	8				15				14	5			5	6	4	4	14	6	17	4	9
Palmerinella palmerae											6	14		3	20	29	20	21	19	26	10	7	18
Quinqueloculina poeyana	5	7													1	2	3	1	4	2	3		5
seminulum	10											2											
tenagos		7									1				2	.9	2		3	.9	1	.7	4
Reophax nana									2	4						.9							
Triloculina sidebottomi		3		2			46					.9											1
Trochammina inflata			3		62	14		80			1	.9	11	3		.9							
macrescens													22										
Miscellaneous spp.							8			#	1		11	3		.9			.7			1	

Table 9. Living foraminifera in Allyn's Bight area, in per cent of living population.

TRAVERSE	1										2							
STATION	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
LIVING POPULATION	420	210	380	920	140	150	380	2000	1230	1080	590	2250	1350	200	130	170	280	300
TOTAL POPULATION	1550	570	12750	12500	9250	7750	15750	19500	13500	16000	6150	12250	9500	4700	4400	4050	4050	10250
LIVING-TOTAL RATIO	27	37	3	7	2	2	2	10	8	7	10	18	13	4	3	4	7	3
Ammonia beccarii vars.	24	8	7	11	18	16	11	10	8	5	7	6	5	20	26	26	10	15
Ammotium dilatatum	3															1		
salsum vars.	17	11	7	5	1		3	1	1		19	3	4	3		10		5
Arenoparrella mexicana						1												3
Discorinopsis aguayoi															2			1
Elphidium galvestonense				5	2	1		1				3	1	3	3	2		1
gunteri				5	4	1	.5	1		2	14	.6		1	2	2		
cf. E. koeboeense	7					1					2		3					
matagordanum	10	25			1						17	.6		11	9	1	5	1
poeyanum					.7				1							1	5	
cf. E. tumidum	17	4		3	.7		.5				2	3						
spp.	3	2												1				
Helenina anderseni							1							2	3	4		19
Jadammina polystoma															22	7	70	13
Massilina protea	3	8	13	11	11	15	16	14	6	16	19	35	16	4	2			
Miliammina fusca	3	11	13	14	1	1				2	7	5	12	24	8	40		14
Miliolinella microstoma	3	4		14	9	20	17	15	51	21	2	9	24	20	12	1	5	11
obliquinoda		6	13	5	6	4	3	8				8	8	3	2			
Miscellaneous miliolids		13	13	16	22	26	18	16	20	23	10	17	12	5	2	2	5	1
Oolina sp.							2	1										
Quinqueloculina poeyana	10		7		2		8	10	6	16		1	4	1	2			
seminulum					.7	3	2	9		2		6	8	1				
tenagos			13	5	15	3	10	10	1	9		3	2					
Triloculina sidebottomi			13	5	5	7	7	2	5	2								.7
Trochammina inflata					.7										3	2		15
Miscellaneous spp.		8					.5	1	1						2	1		

Table 10. Living foraminifera in Corpus Christi Bay area, in per cent of living population.