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MARSH FORAMINIFERAL PATTERNS, PACIFIC COAST OF NORTH AMERICA

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ABSTRACT

Foraminiferal populations were analyzed from Pacific marshes between Alaska and northern Mexico. The following geographic assemblages are distinguished: a Californian assemblage in northern Mexico and southern California, an Oregonian assemblage from Oregon to Vancouver, British Columbia, and a sub-Artic assemblage in Alaska and British Columbia north of Vancouver. Distinctive faunas within a marsh characterize the tide flat, marsh channel, low marsh and high marsh environments. The largest living populations are in the high marsh. Relative rates of sediment deposition, based on population ratios, are high. Relative deposition rates are higher in the northern than in the southern marshes; this is related to heavy runoff in the northern areas and no runoff in the southern marshes examined.

There are more species in the southern marsh faunas than in the northern ones. Nearshore, opean-ocean species are introduced into the southern faunas with undiluted nearshore water which inhabits the southern lagoons. In the northern areas high runoff restricts invasion of open-ocean water and species. Northern marsh faunas are almost 100% of arenaceous species which generally characterize low salinity areas of high runoff. Southern faunas have an appreciable content of calcareous specimens, a result of open-ocean influence.

RESUMEN

Se analizaron poblaciones de foraminíferos de marismas del Pacífico, entre Alaska y el norte de México. Se distinguieron los siguientes conjuntos geográficos: un conjunto Californiano en el norte de México y el sur de California; un conjunto Oregoniano desde Oregón hasta Vancouver, Columbia Británica; y un conjunto Subártico, al norte de Vancouver. Las llanuras de marea, canales de marismas y ambientes de baja y alta marisma, poseen faunas características. Las poblaciones vivientes más altas se encuentran en las altas marismas. Las velocidades relativas de depósito basadas en los porcentajes de población, son altas. Las velocidades relativas de depósito son mayores en las marismas del norte que en las del sur; esto está relacionado con la fuerte descarga de los ríos en áreas del norte y a la carencia de descarga de los ríos en las marismas examinadas hacia el S.

Existen más especies en las marismas del extremo sur que en las del extremo norte. En las primeras, son introducidas especies de mar abierto cercanas a la costa, con el agua del mar sin diluir que penetra por acción de las mareas. En las áreas del norte, la elevada descarga de los ríos, restringe la invasión de especies de agua de mar abierto. Las faunas de marisma en el norte, están constituidas casi en un 100% por especies arenáceas, que generalmente caracterizan áreas de salinidad baja con fuerte descarga. Las faunas del sur tienen un apreciable contenido de ejemplares calcáreos, resultado de la influencia de mar abierto.

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INTRODUCTION

The Pacific coast of North America is characterized by highlands at or near the coast and there are only a few alluvial lowland areas where streams are present. As a result there are few marine marshes and most of those present are small in size. This is in contrast to the Atlantic and Gulf of Mexico coasts where marine marshes occur over large areas of coastal plain and are often extensive.

Living foraminiferal populations have been studied from eight Pacific coast marsh areas extending from about 27°40' N lat to 60° N lat. This report is a continuation of the description and interpretation of sedimentary patterns of marsh foraminiferal faunas from various areas such as those described from the Northern Gulf of Mexico (Phleger, 1965, 1966). The purpose is to discover whether the faunal composition are similar to those previously described, to describe and interpret any faunal patterns present in the marshes, and to determine size of living populations and relative rates of sediment deposition.

Samples for foraminifera have been studied from the following marshes (see figures 1 and 2).

A marsh area on the Copper River Delta, Alaska, on the Gulf of Alaska southeast of the city of Anchorage.

Phillips Arm, a small fjord on the west coast of British Columbia.

The Fraser River Delta at the city of Vancouver, British Columbia.

Gray's Harbor, Washington, at 47° N lat.

Coos Bay, Oregon at about 43°25' N lat.

Mission Bay, California, at the City of San Diego.

Ojo de Liebre Lagoon, Baja California, Mexico, at about 27°40' N lat.

Some marsh faunas were described previously from Guerrero Negro Lagoon in the same area (Phleger, 1965) and these are discussed.

Samples in most places were collected along transects which extended from the tidal flats bounding the marsh across both the lower and higher marsh plant zones. An effort was made to sample all the environments which were apparent along each transect. Approximately 10 sq. cm of surface sediment was collected by emplacing a plastic tube into the sediment. The surface 1 cm of sediment was taken from the short core and preserved in sea water to which a small amount of strongly buffered formalin was added. Specimens which were alive at the time of collection were determined by staining with Rose Bengal.

Many of the samples were collected by J. W. Cobarrubias and identifications of foraminifera in many samples were by J. P. Hosmer. The researchs was supported by the Petroleum Research Fund of the American Chemical Society, by the National Science Foundation and by the Office of Naval Research.

DESCRIPTIONS OF AREAS AND FAUNAS

Copper River Delta Marsh, Alaska

Eight samples were collected from a marsh on the Copper River Delta (Fig. 2) at about 60°15' N lat through the courtesy of Erk Reimnitz. These were taken along a transect approximately 1,000 m long in low marsh, on the mud flat and on the high marsh (Fig. 3). This delta area was uplifted several feet a few weeks prior to the collection of samples and thus the high marsh was inactive and dying.

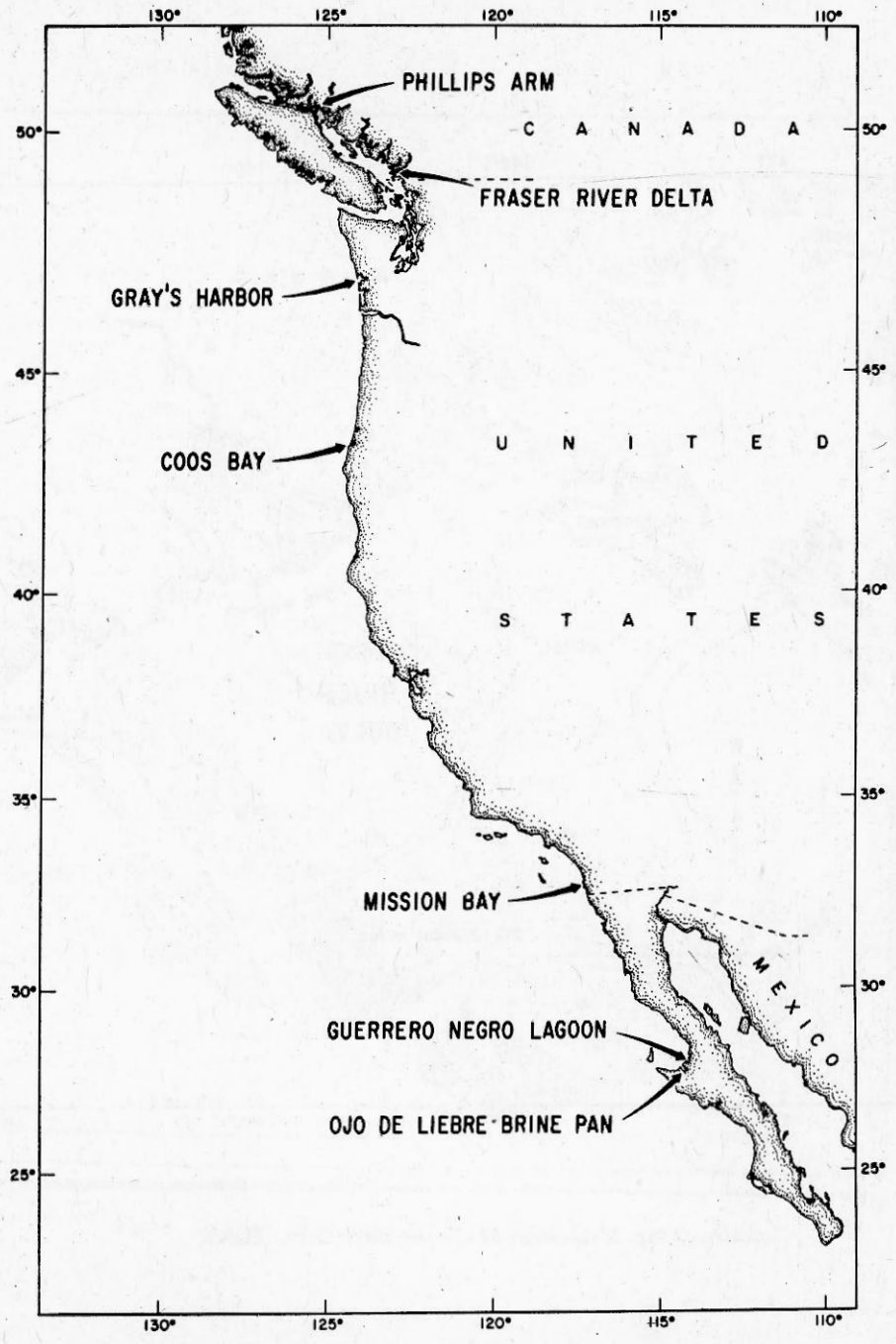

Fig. 1 Locations of marsh areas.

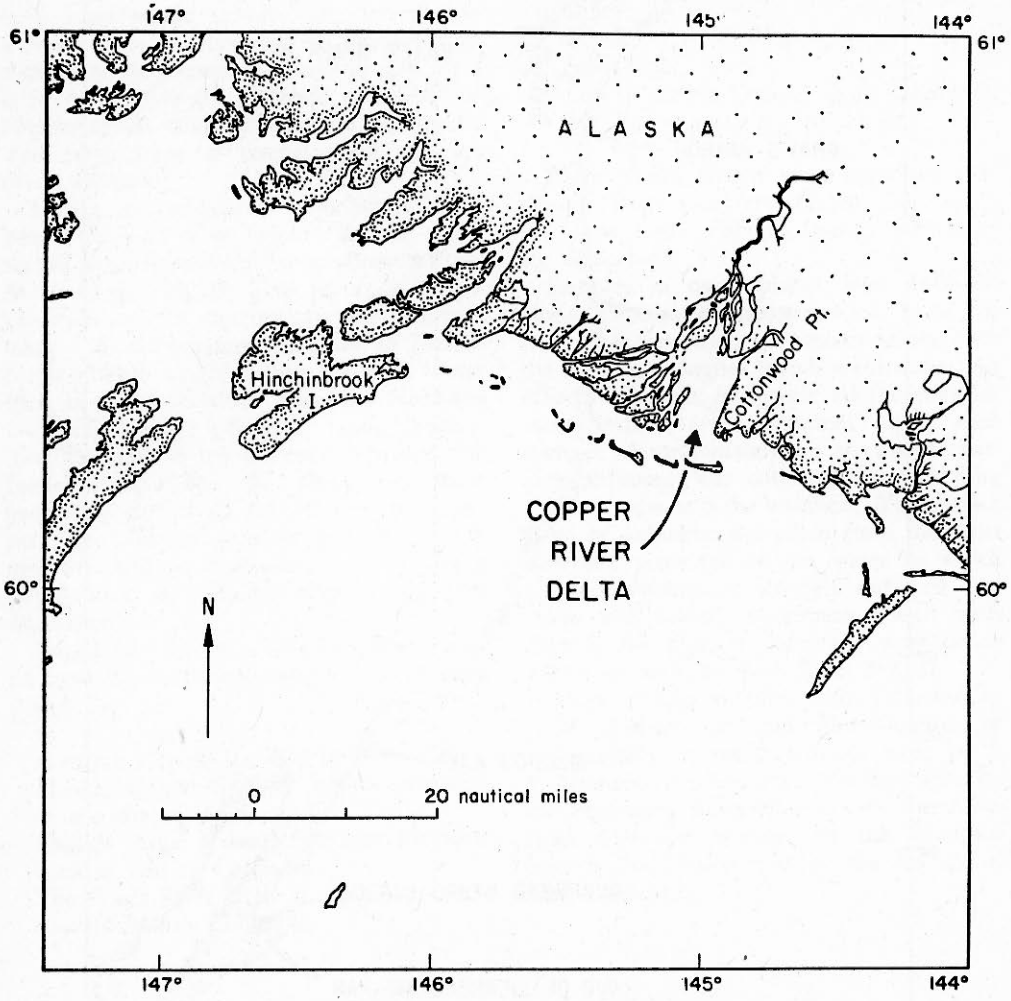

Fig. 2 Location of Copper River Delta, Alaska.

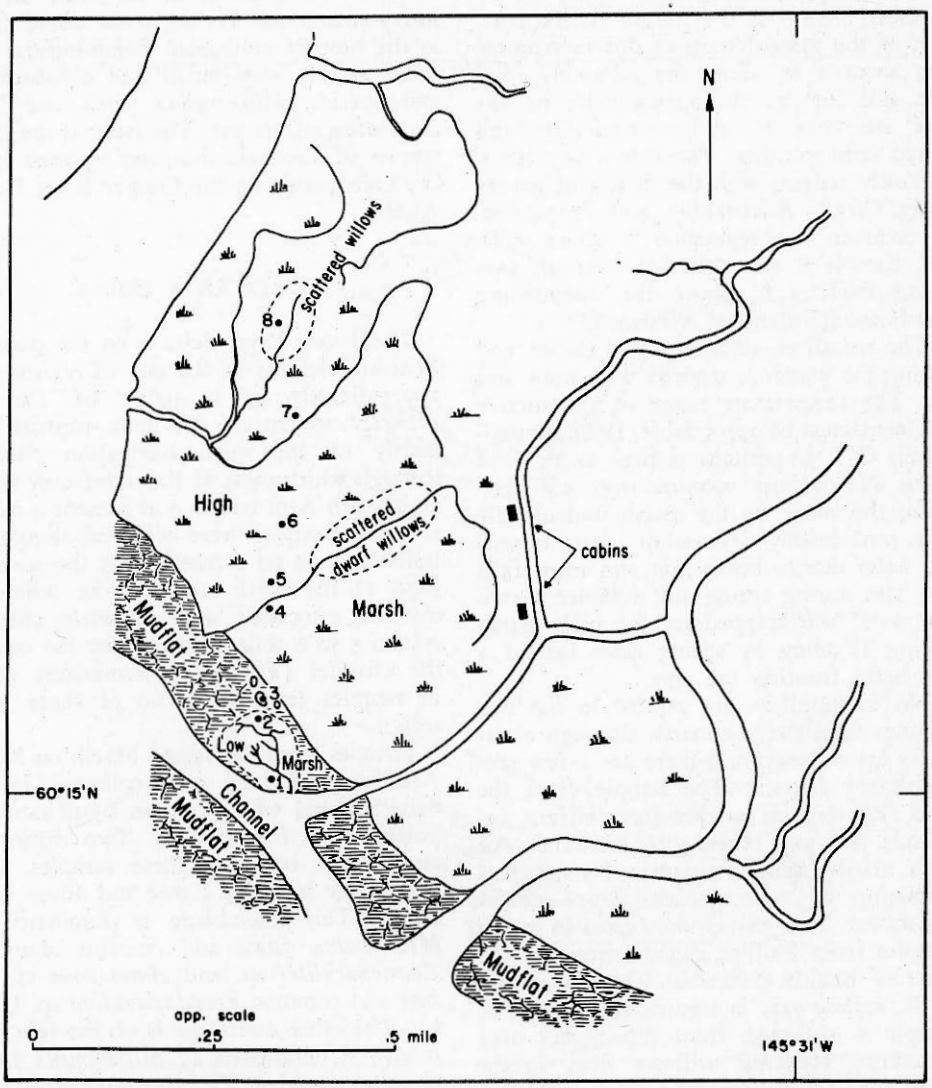

Fig. 3 Locations of stations in Copper River Delta marsh, Alaska.

Before the uplift (associated with the 1964 Alaska earthquake) the high marsh was at an elevation of approximately 13 ft. above mean lower low water, and in most places is separated from the mud flats by an escarpment 5 to 6 ft. high. At the position of the present transect this escarpment was about 1 ft. above the adjoining mud flat and low marsh. Spring tides in this area are +15 ft. and covered the high marsh semi-monthly. The marsh vegetation is mostly sedges, with the dominant genera being *Carex, Ranunculus* and *Triglochin*. In summer this vegetation is about 2 ft. tall. Sample 8 was collected from an area rising about 2 ft. above the surrounding marsh among scattered willows.

The marsh is adjacent to a glacier and during the winter is covered with snow and ice. The temperature range of the surface sediment must be appreciable, from approximately 0°C to perhaps as high as 15°C or more. No salinity measurements are available; the water on the marsh undoubtedly was considerably less saline than normal sea water due to heavy rain and snow falls and also during spring and summer thaws. Sea water was trapped on the high marsh during flooding by spring tides behind a low berm fronting the area.

No foraminifera are present in the two samples from the low marsh although ostracodes are common and there are a few cosconodiscid diatoms. The sample from the mud flat contains neither foraminifera, ostracoda nor any other shell material. All high marsh samples contain foraminifera belonging to one species, *Trochammina inflata* var. This species also occurs in marsh samples from Phillips Arm, a fjord on the coast of British Columbia. The population of *T. inflata* var. is significantly larger in sample 8 collected from the higher area containing scattered willows than in the other high marsh samples.

Phillips Arm, British Columbia

Three samples were collected from a small and narrow marsh fringing Phillips Arm, a fjord on the coast of British Columbia at approximately 50°30′ N lat. The marsh occurs at the head of the fjord in association with a small delta built by a stream. The salinity in this marsh must be very low most or all of the time due to heavy stream runoff; the water tasted fresh at the time of collection. Foraminiferal populations are very small and consisted of two species, *Miliammina fusca* and *Trochammina inflata* var. The latter is the same species of *Trochammina* also reported from the high marsh on the Copper River Delta, Alaska.

Fraser River Delta

The Fraser River delta is on the coast of British Columbia at the city of Vancouver, approximately 49° to 49°15′ lat. The distributary system on the delta consists primarily of the main navigation channel through which most of the water now flows and North Arm which is at present a minor channel. Samples were collected along five transects, one on a marsh near the seaward limit of the north arm and the others in marshes associated with the main channel system 5 to 8 miles inland from the end of the channel (Fig. 4). Foraminifera occur in samples from only two of these transects.

Samples from Sea Island Marsh on North Arm are the only ones collected in the delta marshes which contain significant populations of foraminifera. Two distinctive assemblages occur in these samples. One assemblage is in the *Carex* and silver weed marsh. This assemblage is dominated by *Miliammina fusca* and contains abundant *Ammobaculites* sp. and *Ammotium* cf. *sal. sum* and common *Pseudoclavulina* sp. (Tab. 1). The other assemlage is on the tide flat. It also is dominated by *Miliammina fusca,* contains abundant *Trochammina macrescens* and *Jadammina polystoma,* common *Haplophragmoides subinvolutum* and rare *Trochammina inflata.* Dead thecamoebinas are abundant in two marsh samples and are rare in the tide flat sample nearest the marsh. Living populations of foraminifera are large and living-total ratios are high. All specimens have arenaceous tests.

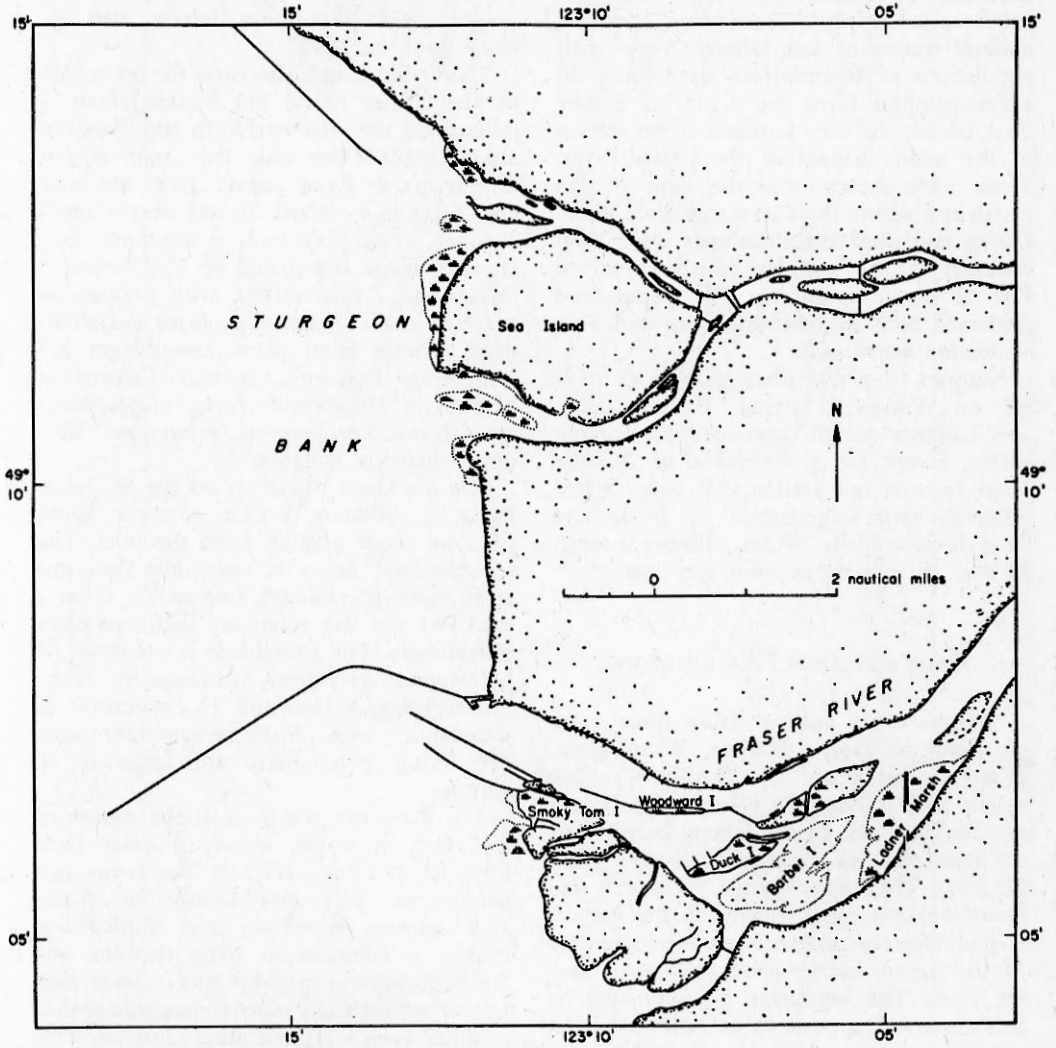

Fig. 4 Locations of march sample transects in Fraser River Delta, British Columbia.

The Sea Island Marsh is relatively exposed to the influence of marine water, being separated from the open ocean by approximately 3 miles of Sturgeon Bank. It is somewhat more isolated from the influence of river water than the other marsh areas sampled. The faunas, however, indicate waters of low salinity. Very small populations of foraminifera were found in a few samples form the marsh of Smoky Tom Island, the area fartherst down stream in the main channel of the Fraser River. These were mostly near the edge of the marsh and within the *Carex* and silver weed. Living and dead thecamoebinas were most common in the samples which contained few or no foraminifera. The populations contained only *Miliammina fusca* and *Trochammina macrescens*.

Samples from the other marshes examined, on Woodward Island, Barber Island, and Landner Marsh, contained no foraminifera, except for 4 specimens of *Miliammina fusca* at one station. All samples had relatively large populations of living and dead thecamoebinas. Water salinities measured near these marshes were very low.

Gray's Harbor, Washington

Samples were anlyzed from three areas of marsh on Gray's Harbor, Washington, at approximately 47° N lat (Fig. 5). One marsh area is near the inlet to the lagoon on the inner side of the lagoon barrier and the other marshes are at some distance from the inlet. They were located to sample different possible environments in the harbor.

The Westport marsh is on the inner side of the lagoon barrier about 1½ mile from the inlet. The vegetation is dominated by *Salicornia* and appears to be rather uniform over the entire marsh area. Sample 1 was taken from the channel edge of the tide flat fronting the marsh and about 75 m from the marsh vegetation. The fauna of this sample is 99% composed of species of *Elphidium*. The assemblage in most of the other samples is dominated by *Miliammina fusca* along with abundant *Jadammina polystoma* (Tab. 2). In samples from within the marsh plants *Trochammina inflata* and *T. macrescens* are common to abundant, and *Haplophragmoides* spp are rare to common. *Protoschista findens* is mostly restricted to the tide flats and to channels, and the largest frequencies of *Ammobaculites exiguus* and *Ammotium salsum* also are from these locations.

The Oyhut marsh also is on the inner side of the barrier island but located about 4 miles from the inlet on North Bay. Samples are available from only the inner section of this marsh about 100 ft. from the mud flat. Samples collected in and near a small channel where *Salicornia* is common have an assemblage dominated by *Trochammina inflata* and *T. macrescens*, with *Jadammina polystoma* and *Miliammina fusca* less abundant. Faunas from plant assemblages not containing *Salicornia* contain *Jadammina polystoma, Miliammina fusca, Haplophragmoides* and *Trochammina macrescens*. Thecamoebinas are common.

The markham marsh its on the St. Johns River, a tributary stream entering South Channel about 5 miles from the inlet. The foraminiferal fauna is essentially the same at all stations, although one station is on a mud flat and the others are different plant assemblages. The assemblage is composed of *Jadammina polystoma, Miliammina fusca, Trochammina inflata* and *T. macrescens* in abundance, with *Haplophragmoides* rare. The living populations are large in all samples.

The Hoquiem marsh is at the mouth of the Hoquiem River, about 10 miles from the inlet to Gray's Harbor. The fauna is a *Jadammina polystoma-Miliammina fusca-Trochammina macrescens* one. *Haplophragmoides* is common in some samples, and *Ammobaculites exiguus* and *Ammotium salsum* appear to be more common here than in other Gray's Harbor areas sampled. Thecamoebinas are abundant.

Coos Bay, Oregon

Coos Bay is on the coast of Oregon at about 43°25' N lat. This is a high rainfall area and there is considerable runoff into

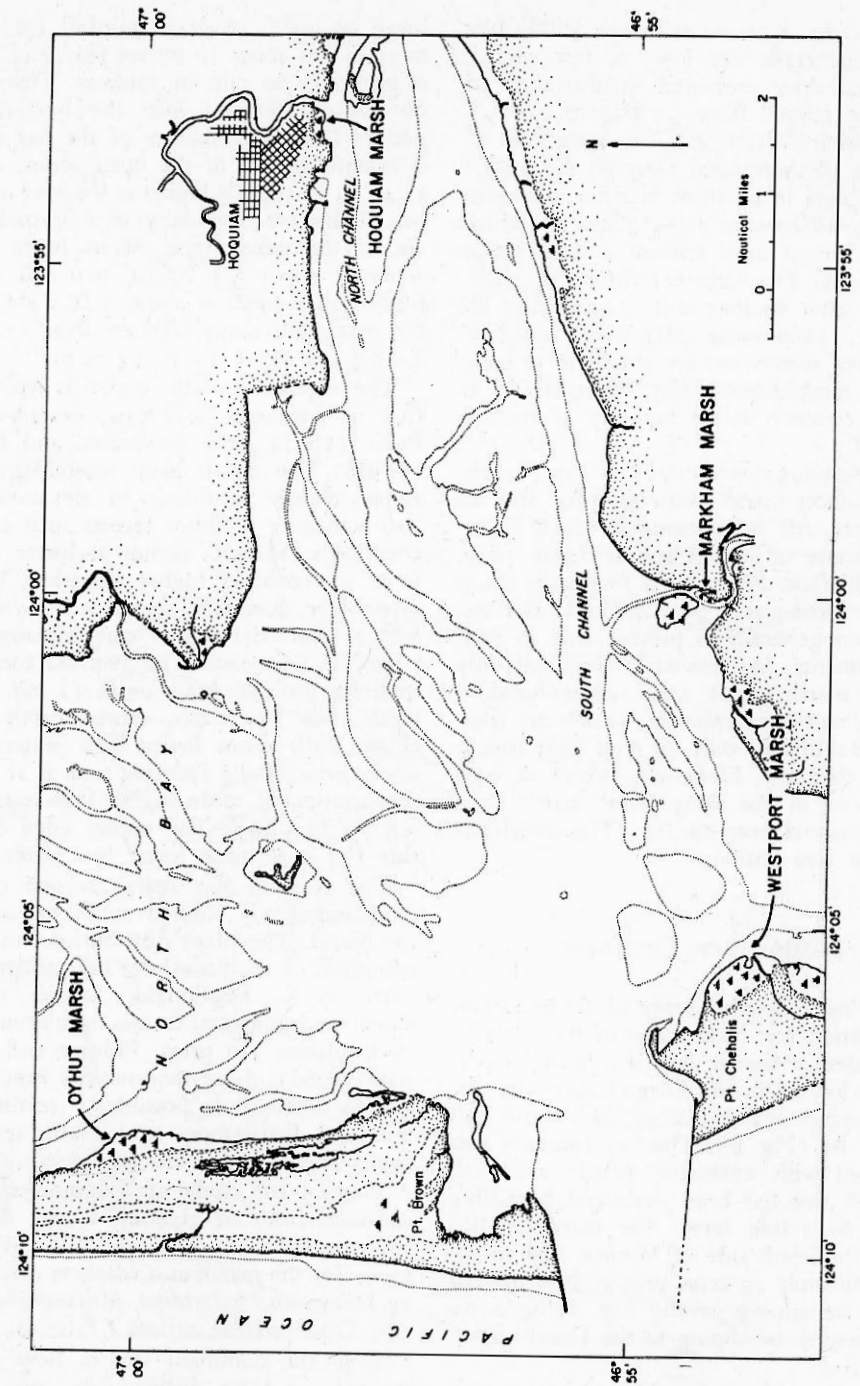

Fig. 5 Locations of march sample transects in Gray's Harbor, Washington.

the bay. As a result salinities within the lagoon generally are low. A few surface water salinities measured at the time of collection ranged from 0.1 ‰ to 9.0 ‰. The foraminiferal faunas are essentially similar in all three areas sampled (Fig. 6).

The fauna in all three marshes is dominated by *Miliammina fusca* (Tab. 3) which is abundant at most stations and occurs at all stations. *Trochammina inflata* is abundant at most stations and is present at all but one. *Jadammina polystoma* and *Trochammina macrescens* are abundant to common at most stations. *Haplophragmoides* is rare to common at the majority of stations sampled.

Trochammina macrescens is rare to absent in most marsh pools sampled and on mud flats. All the stations at which *T. inflata* is rare or absent are in marsh pools and mud flats. *Protoschista findens* is abundant at three marsh pool and mud flat stations and generally is present only in such environments. *Jadammina* is abundant only in the marsh plant areas. *Ammobaculites exiguus* and *Ammotium* cf. *salsum* are common to abundant only on mud flats and in marsh channels. *Elphidium* occurs at only 4 stations in the Pony Point marsh in a small channel near the bay. Thecamoebinas occur at five stations.

Mission Bay, California

The most detailed study of foraminiferal distribution has been made in the Mission Bay marsh. Mission Bay is a small coastal lagoon located in San Diego California, between approximately 32°45' N lat and 32° 49' N lat (Fig. 7). The bay formerly was bordered with extensive marsh areas but most of this has been destroyed by filling above high tide level. The marsh studied is on the north side of Mission Bay and is approximately 25 acres in size. It is the last marsh remaining in the bay, being a natural reserve belonging to the University of California.

The area has a dry Mediterranean type climate. Air temperatures are mild, ranging from a January mean of 13°C to a July mean of 20°C. Average rainfall for 1900 to 1940 was about 10 inches/year, and there is generally no rain in summer. There are no streams flowing into the bay at the present time. The salinity of the bay water is essentially that of the open ocean, about 33.4 ‰ or slightly higher at the head of the bay. Tides are essentially semi-diurnal and are of the mixed type. Mean lower high water is about 3.5 ft. (1 m) and mean higher high water is about 5 ft. (1½ m); the maximum range is from about - 1.5 ft. (—0.5 m) to + 7.5 ft. (2.25 m).

The vegetation of the marsh is typical of that in Southern California, described by Purer (1942) and Stevenson and Emery (1958). The marsh plant assemblages are zoned mainly according to elevation and also according to other factors such as soil conditions. *Spartina* occurs at lower elevations succeeded at higher elevations by an assemblage dominated by annual *Salicornia* and a somewhat higher one containing a perennial *Salicornia*. The *Spartina* zone has its lower limit at about 3.5 ft. (1 m) above mean lower low water, approximately comciding with mean lower high water. The upper limit of the *Spartina* zone is at about the position of mean higher high water, at 5.0 ft. (1.5 m). The outher edge of the tide flat is at mean lower low water.

The Mission Bay marsh is one of the most intensively studied small marshes in the world. The plant distributions and distributions of molluscs have been mapped in detail by K. Macdonald. Studies of the marsh environmental factors have been made by Bradshaw (in press; Phleger and Bradshaw, 1966). Since the area has been mapped in detail, it is possible to relate foraminiferal distributions to different apparent environments with some confidence.

Samples for study of foraminifera were collected from 61 stations, a very detailed coverage for so small an area (Fig. 8). The fauna for the marsh as a whole is dominated by *Jadammina polystoma, Miliammina fusca* and *Trochammina inflata* (Tab. 4).

Even the dominant species have certain patterns in their distributions, and other, less abundant forms have striking distribution patterns (Tab. 4). *Jadammina polys-*

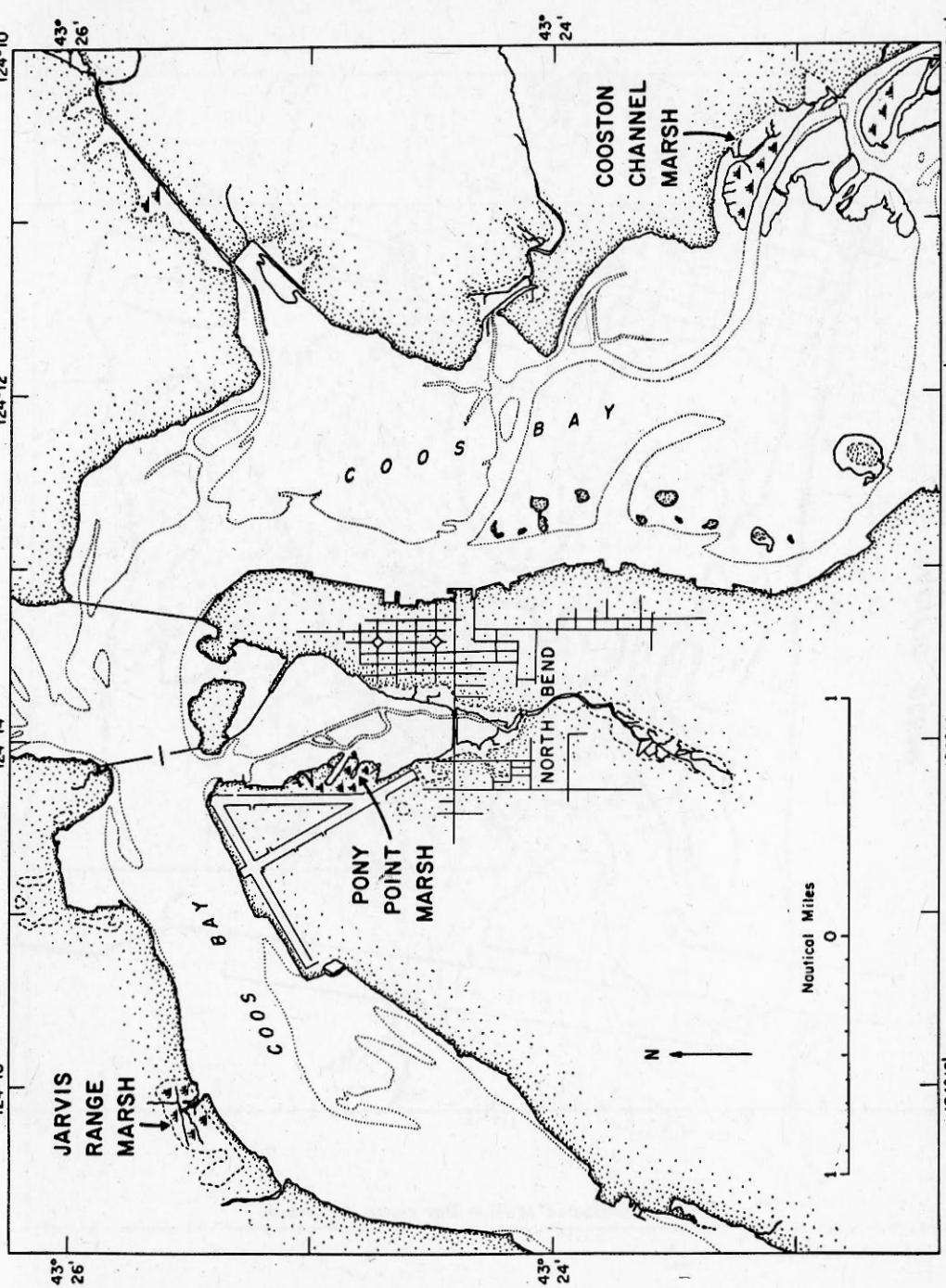

Fig. 6 Locations of marsh sample transects in Coos Bay, Oregon.

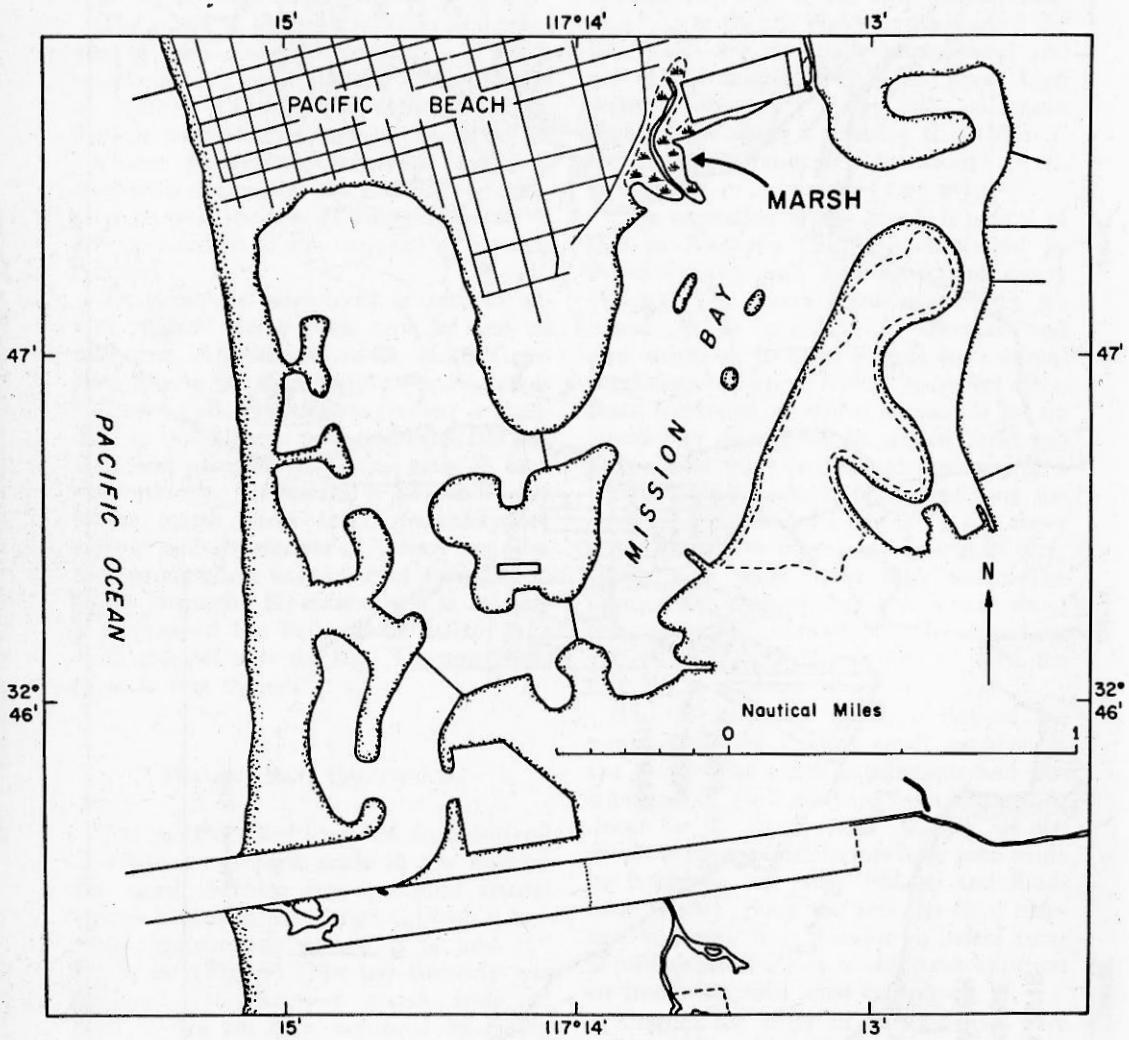

Fig. 7 Location of Mission Bay marsh, California.

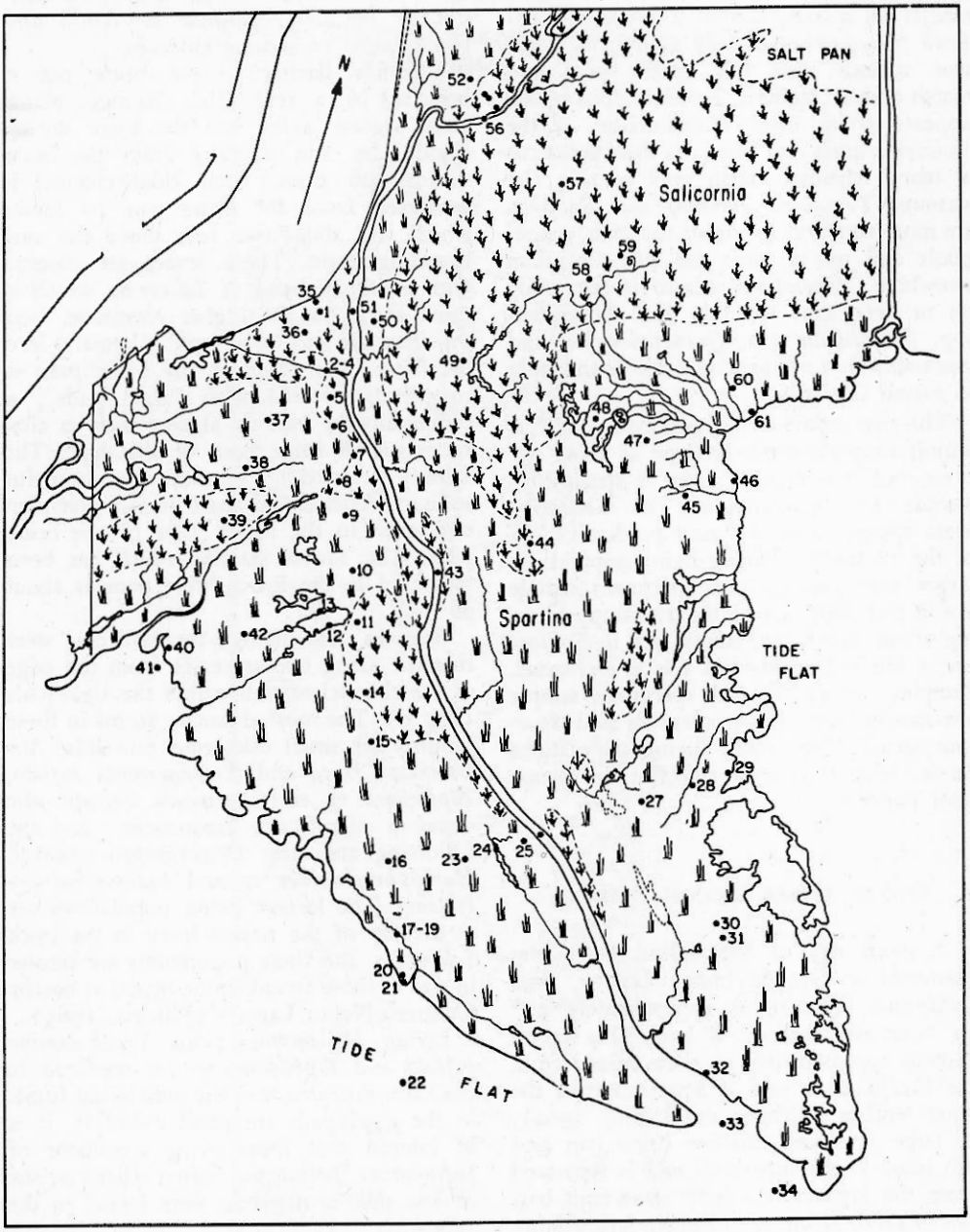

Fig. 8 Locations of stations in Mission Bay marsh, California.

toma is most abundant in *Salicornia* areas is rare at tide flat stations and is absent or rare at all marsh channel stations. *Miliammina fusca,* although very abundant, is absent at most tide flat, marsh pool and marsh channel stations. *Trochammina inflata* appears to be most characteristic of the *Salicornia* areas and generally does not occur at marsh channel marsh pool or tide flat stations. *Textularia earlandi* and *Reophax* are more common in marsh channels, marsh pools and on or near the tide flat than elsewhere. *Ammotium* salsum is seen only on or very near the tide flat. *Elphidium* spp., *Miliolinella* spp., *Quinqueloculina* and *Ammonia beccarii* generally are found only in marsh channels.

The size of the living population of foraminifera per sample is large at most stations, but the range is from 2 specimens/sample to 4400/sample. The *Salicornia* areas appear to be the most productive; 13 of the 16 stations having living populations larger than about 1,000 specimens/sample are in this zone. Six of the 12 samples having about 500-1,000/sample are in *Salicornia,* 5 are in *Spartina* and 1 is in a channel. Samples having 11-500 specimens/sample are mostly from marsh channels and *Spartina* areas. Very small living populations (2-60) characterize the tide flat and marsh pool stations.

Ojo de Liebre Lagoon, Mexico

A small area of hypersaline marsh was examined at Ojo de Liebre Lagoon, Baja California, Mexico, at approximately 27° 42' N lat and 113° 55' W long. This lagoon extends approximately 30 miles inland from the Pacific coast and is hypersaline in the inner reaches (Phleger and Ewing, 1962). A large and very shallow brine pan and salt basin at the innermost end is separated from the lagoon by a low, wave-built barrier of sand. Salinities in the bordering inner lagoon vary from about 42 ‰ to 60 ‰ and are much higher in the brine pan, occasionally reaching complete saturation and precipitation of sodium chloride.

The low barrier to the brine pan is breached by a few tidal channels which carry lagoon water into the basin during flood tides and partially drain the basin during ebb tides. Each tidal channel is separated from the brine pan by levees which rise about two feet above the surrounding basin. These levees are covered with a narrow band of *Salicornia* which is quite thick on the higher elevations near the channels and thins rapidly laterally into the basin. The floor of the brine pans is completely covered with "algal pads", a community of various algae which is characteristic of brine pans of this type. The salinity occasionally reaches saturation for sodium chloride and there is salt precipitation even in the lower parts of the brine pans. The lowest salinity which has been measured in the lower brine pans is about 90 ‰.

Samples for living foraminifera were colected along two traverses from the edge of the channel to well within the algal pads (Fig. 9). The most abundant forms in these samples are small calcareous miliolids, *Miliammina fusca* and *Trochammina inflata. Elphidium* sp and *Ammonia beccarii* also occur in significant frequencies, and the following are rare: *Discorinopsis aguayoi, Haplophragmoides* sp and *Jadammina polystoma.* The largest living populations are at the top of the stream levee in the thick *Salicornia,* and these populations are similar in size to those found in the marsh at nearby Guerrero Negro Lagoon (Phleger, 1965).

Living *Miliammina fusca, Trochammina inflata* and *Elphidium* sp are confined to the *Salicornia* area, and the only living forms in the algal pads are small miliolids. It is of interest that three living specimens of *Jadammina polystoma,* often characteristic of low salinity marshes, were found in the *Salicornia.*

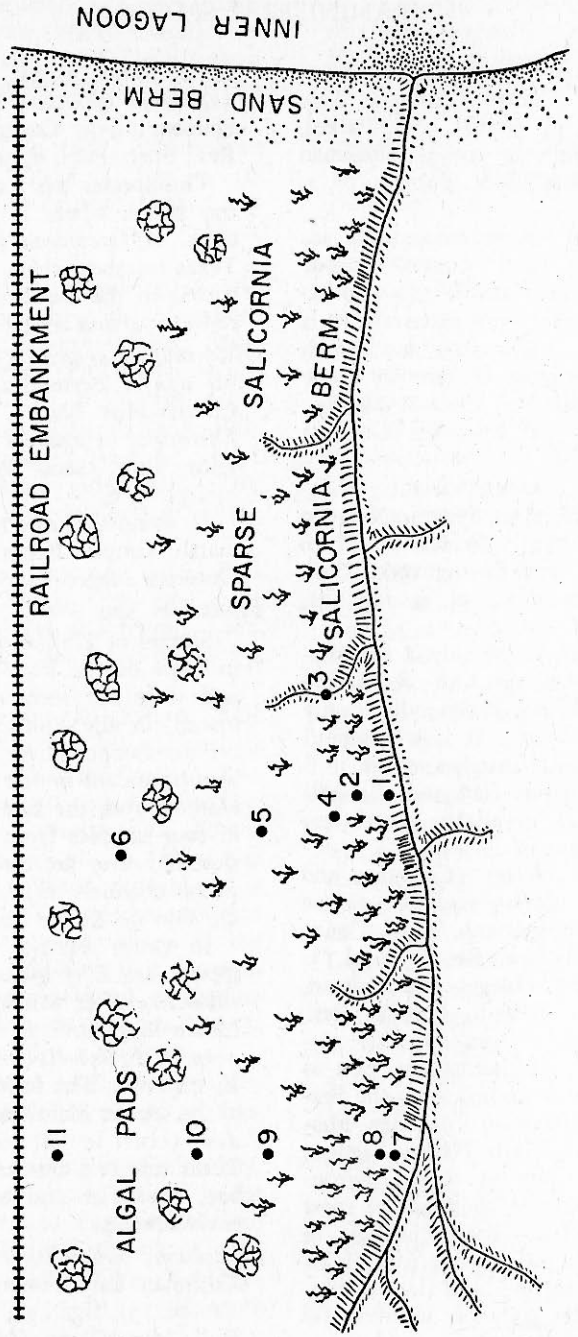

Fig. 9 Sketch of marsh station locations in Ojo de Liebre brine pan, Baja California, México.

FORAMINIFERAL SPECIES

Ammobaculites exiguus Cushman and Bronnimann, 1948, Contr. Cushman Lab. Foram, Res. 24, pl. 7, figs. 7, 8; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, pl. 1, fig. 6.

This species is rare to common in several Coos Bay and Gray's Harbor samples, and *Ammobaculites* sp also occurs in the Fraser river material. It is common only on mud flats and marsh channels. *A. exiguus* is rare in some marshes of the northern Gulf of Mexico, and also is reported from the Gulf of Paria.

Ammonia beccarii (Linné) variants; *Nautilus beccarii* Linné, 1758, *Systema Naturae*, 10th. Ed., 1:710; *Streblus beccarii* variants, Phleger and Ewing, 1962, Bull. Geol. Soc. America 73, pl. 5, figs. 22, 23.

A. beccarii was present only in the Mission Bay and Laguna Ojo de Liebre marsh. At Mission Bay it generally is only in the marsh channels. It is widespread in the Texas coastal marshes where it is most abundant in tide flats and channels although it occurs in all the marsh environments recognized.

Ammotium cf. *A. salsum* (Cushman and Bronnimann); *Ammobaculites salsum* Cushman and Bronnimann, 1948, Contr. Cushman Lab. Foram. Res. 24, pl. 3, figs. 7-9; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, pl. 1, figs. 17, 25.

Ammotium cf. *A. salsum* is rare to common in marshes studied from the Fraser River, Gray's Harbor, Coos Bay, Mission Bay and Guerrero Negro Lagoon. Most occurrences are in these environments. This species is abundant at most stations in the Texas coast marshes. In this region it is most characteristic of inner lagoon, channel and mud flat environments, and is less common in inner lagoon *Salicornia* zones.

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

This species was found only in Mission Bay marsh where it is rare at four stations. *A. mexicana* is abundant in the Texas marshes where it is esesntially restricted to the *Salicornia* and mixed *Salicornia-Spartina* zones.

Discorinopsis aguayoi (Bermudez); *Discorbis aguyoi* Bermudez, 1935, Mem. Soc. Cubana Hist. Nat. 9, pl. 15, figs. 10-14; *Discorinopsis aguayoi* Phleger and Ewing, 1962, Bull. Geol. Soc. America 73, pl. 5, figs. 5, 6.

D. aguayoi is rare to common in a few marsh samples from Mission Bay and Guerrero Negro Lagoon.

Elphidium spp

Species of *Elphidium* are relatively rare in most of the Pacific marshes sampled and were not seen in the Fraser River marsh, in the Phillips Arm marsh and on the Copper River Delta marsh. They were abundant in one sample from Gray's Harbor from the tide flat and were rare in four samples from Coos Bay. In Mission Bay they are essentially restricted to marsh channels. *Elphidium* is common in the Ojo de Liebre brine pan marsh.

In Grays' Harbor and Coos Bay the species are *E. frigidum, E. lene* and *E. subarcticum;* at Mission Bay and Ojo de Liebre *E. gunteri, E. incertum, E. sandiegoensis, E. translucens, E. tumidum* and *E.* sp. occur. The following are references to the species identified. Species of *Elphidum* occur in all environments in the Texas marshes, but are most common in bay, mud flat and by-fringing *Spartina* environments.

Elphidium subarcticum Cushman, 1944, Cushman Lab. Foram. Res., Spec. Publ. 12, pl. 3, figs. 34, 35; Parker, 1952, Bull. Mus. Comp. Zool. 106, pl. 5, fig. 9.

Elphidium frigidum Cushman, 1933, Smithsonian Misc. Coll. 89(9): 5, pl. 1, fig. 8.

Elphidium lene Cushman and McCulloch; *Elphidium incertum* (Williamson) var. *lene* Cushman and McCulloch, 1940, Allan Hancock Pacific Exped. 6(3):170, pl. 19, figs. 2, 4.

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

Elphidium sandiegoensis Lankford, 1962, Recent Foraminifera from the Nearshore, Turbulent Zone, Western United States and Northern Mexico, Ph.D. Diss., Univ. California, San Diego, pl. 3, fig. 19.

Elphidium translucens Natland, 1938, Bull. Scripps Inst. Oceanogr., Tech. Ser. 4, pl. 5, figs. 5, 6; Phleger and Ewing, 1962, Bull. Geol. Soc. America 73, pl. 4, fig. 17.

Elphidium tumidum Natland, 1938, Bull. Scripps Inst. Oceanogr. Tech. Ser. 4, pl. 5, figs. 5, 6; Phleger and Ewing, 1962, Bull. Geol. Soc. America 73, pl. 4, fig. 18.

Elphidium sp Phleger and Ewing, Bull. Geol. Soc. America 73, pl. 4, fig. 16.

Gaudryina pauperata Earland, 1934, 'Discovery' Rept. 10, pl. 5, figs. 47-49; Cushman, 1937, Cushman Lab. Foram. Res., Spec. Publ. 7, pl. 10, figs. 8-9.

This was rare at three stations in the Mission Bay marsh. Two of these stations are on the tide flat and one is in the *Spartina* near the tide flat. It is common in the tide flat environment at Laguna Guerrero Negro, Mexico (Phleger, 1965). It was not seen in Texas marshes.

Glabratella sp Phleger and Ewing, 1962, Bull. Geol. Soc. America 73, pl. 5, figs. 7-9.

Found at a few stations in Mission Bay. It is abundant at numerous stations in the tide flat and marsh at Laguna Guerrero Negro, Mexico (Phleger, 1965).

Haplophragmoides subinvolutum Cushman and McCulloch, 1939, Allan Hancock Pacific Exped. 6, pl. 7, figs. 3-5.

This was found at Coos Bay, Gray's Harbor and the Fraser River Delta where it is rare to common. It does not occur in the southern marshes. Various species of *Haplophragmoides* are rare in the Gulf of Mexico marshes where they are restricted to less saline areas.

Jadammina polystoma Bartenstein and Brand, 1938, Senckenbergiana 20, figs. 1a-c, 21-23; Phleger and Ewing, 1962, Bull. Geol. Soc. America 73, pl. 4, fig. 5.

This is one of the dominant species in the Fraser River, Gray's Harbor, Coos Bay and Mission Bay marshes where it occurs in most of the samples. It is rare at the Ojo de Liebre brine pans but is common to abundant in nearby Guerrero Negro marshes (Phleger, 1965). At Mission Bay the species is most abundant in the *Salicornia* zones.

In the Texas coastal marshes *Jadammina* is known only from Corpus Christi and San Antonio Bays where it also is characteristic of *Salicornia*.

Miliammina fusca (Brady); *Quinqueloculina fusca* Brady, 1870, Ann. Mag. Nat. Hist., Ser. 4, 6, pl. 11, figs. 2a-c; *Miliammina fusca* Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, pl. 1, figs. 40, 41.

Miliammina fusca is a very abundant species in all the marshes sampled except the Copper River Delta, Alaska, where it was not present. At Mission Bay it is absent at most tide flat, marsh pool and marsh channel stations. It was not recorded on the tide flat at Guerrero Negro Lagoon, Mexico (Phleger, 1965). This species is abundant in marshes in several different areas of the world.

Protoschista findens (Parker); *Lituola findens* Parker; Dawson, G. M., 1870, Canadian Naturalist 5:176-177, fig. 1.

This species was found only in the Gray's Harbor and Coos Bay marshes, and one specimen was seen in the Fraser River marsh. It appears to be essentially restricted to tide flats, marsh channels and marsh pools where it is often abundant.

Reophax nanus Rhumbler 1913, Ergeb. Plankton Exped. Humboldt Stifting 3 (2), pl. 8, figs. 6-12; Parker, Phleger and Peirson, 1953, Cushman Found. Foram. Res., Spec. Publ. 2, pl. 1, fig. 11.

Reophax is more common on tide flats, marsh pools and marsh channels than elsewhere in Mission Bay. Only one specimen was recorded from a northern marsh. It is abundant on the tide flat at Guerrero Negro, Mexico.

Textularia earlandi Parker, 1952, Bull. Mus. Comp. Zool. 106(10):458; Parker and Athearn, 1959, Jour. Paleont. 34, pl. 50, fig. 7.

This species was seen in Mission Bay where it is rare to common at several stations and most common in marsh channels, marsh pools and on or near the tide flat. It was reported from a few stations in the Guerrero Negro marsh (Phleger, 1965).

Trochammina inflata (Montagu); *Nautilus inflatus,* Montagu, 1808, Test. Brit., Suppl.: 81, fig. 3; *Trochammina inflata* Parker and Athearn, 1959, Jour. Paleont. 33:341, pl. 50, figs. 18-20.

Trochammina inflata is abundant in all the marshes studied along the Pacific coast. In Phillips Arm, B. C., and the Copper River Delta, Alaska, *T. inflata* var. replaces *T. inflata.* In Mission Bay *T. inflata* is most abundant in the *Salicornia* and generally does not occur at marsh channel, marsh pool or tide flat stations. It appears that this species is most characteristic of the *Salicornia* or other plant assemblages of the high marsh in the areas studied. In Texas marshes *T. inflata* also is characteristic of the *Salicornia* zone.

Trochammina macrescens Brady; *Trochammina inflata* (Montagu) var. *macrescens* Brady, 1870, Ann. Mag. Nat. Hist. 6:51, pl. 11, figs. 5a-c.

Trochammina macrescens Parker, Phleger and Peirson, Cushman Found. Foram. Res., Spec. Publ. 2:15, pl. 3, figs. 7, 8.

Trochammina macrescens is abundant at most station in the Fraser River Delta, Gray's Harbor and Coos Bay. In Mission Bay, Guerrero Negro and Ojo de Liebre it was not identified. In most of the areas where it was found *T. macrescens* is most abundant within the marsh plant zones. It is believed that the abundance of this species in the northern marshes is related to the relatively low salinities which prevail there. Distribution of *T. macrescens* in the Texas area also suggests that it is characteristic of more brackish marshes and for the *Salicornia* zone.

DISCUSSION

Faunal Patterns

Generalized occurrences and relative abundances of species in the Pacific coast marshes are shown in figure 10. There are three different geographic assemblages ranging from north to south. In the northern part of the region the marshes at the Copper River Delta and at Phillips contain *Trochammina inflata* var. which was not found at any of the other marshes further south. At the Copper River Delta only *T. inflata* var. was present and at Phillips Arm *Miliammina fusca* also occurred. These subarctic faunas may be termed a Columbian and Aleutian assemblages, following the terminology of Valentine (1966).

A second geographical assemblage occurs in the samples from the Fraser River Delta, Gray's Harbor and Coos Bay. This contains the following species which were not found in the California and Baja California marshes: *Ammobaculites exiguus, Haplophragmoides subinvolutum, Protoschista findens* and *Trochammina macrescens.* In addition, the *Elphidium* species differ from those to the south, including *E. frigidum, E. lene* and *E. subarcticum.* This marsh fauna occurs in the Oregonian zoogeographic province (Valentine, 1966).

The assemblages at Mission Bay, Guerrero Negro Lagoon and Ojo de Liebre Lagoon contains the following forms not found in the northern marshes: *Ammonia*

beccarii, Arenoparrella mexicana, Discorinopsis aguayoi, Gaudryina pauperata, Glabratella sp, *Reophax nanus* and *Textularia earlandi.* Species of *Elphidium* which occur in these faunas and have not been seen in the northern marshes are *E. gunteri, E. incertum, E. sandiegoensis, E. translucens,* and *E. tumidum.* This fauna is in the Californian zoogeographic province. (Valentine, 1966).

The following species are abundant in both the Californian and Oregonian marshes: *Jadammina polystoma, Miliammina fusca,* and *Trochammina inflata.*

Ammotium salsum is rare to common in both regions.

It is of interest to compare the faunal compositon of these Pacific coast marshes with the marsh faunas studied on the coast of Texas in the northwest Gulf of Mexico. The following species have been found in both regions:

Ammobaculites exiguus
Ammonia beccarii
Ammotium salsum
Arenoparrella mexicana
Discorinopsis aguayoi
Guadyrina pauperata
Jadammina polystoma
Miliammina fusca
Reophax nanus
Trochammina inflata
T. macrescens

The following Gulf Coast marsh species were not identified from the Pacific marshes:

Ammoastuta inepta
Tiphotrocha comprimata
Pseudoeponides andersoni
Palmerinella palmerae

The following Pacific forms were not reported from the Gulf Coast marshes:

Haplophragmoides subinvolutum
Protoschista findens
Textularia earlandi

There are also differences in the composition of the *Elphidium* assemblages in the two regions.

A faunal pattern also can be recognized within all the Pacific coast marshes except those at Copper River and Phillips Arm. The general marsh environments which can be distinguished by foraminiferal assemblages are tide flat, marsh channel, low marsh and high marsh (Fig. 10). Species which are characteristic of lagoons occur on the tide flats; these species in this region are:

Ammobaculites exiguus
Ammonia beccarii
Ammotium cf. *salsum*
Elphidium spp
Gaudryina pauperata
Protoschista findens
Reophax nanus
Textularia earlandi

These forms usually also occur in the marsh channels, undoubtedly because of the close association of the two environments.

Species which are characteristic of the marsh plant communities are:

Arenoparrella mexicana
Discorinopsis aguayoi
Glabratella sp
Haplophragmoides subinvolutum
Jadammina polystoma
Miliammina fusca
Trochammina inflata
T. macrescens

Size of Living Population and Rates of Deposition

The living population of foraminifera is large but there is a great range in size similar to the range of population size in the Gulf Coast marshes (Phleger, 1965, 1966), and averages for any marsh area probably are not significant. In the Mission Bay marsh the largest living populations are in the *Salicornia* zone and the smallest populations are on the tide flat. At Coos Bay the largest populations are in the high marsh containing some *Salicornia.* In the Ojo de Liebre brine pans the largest populations

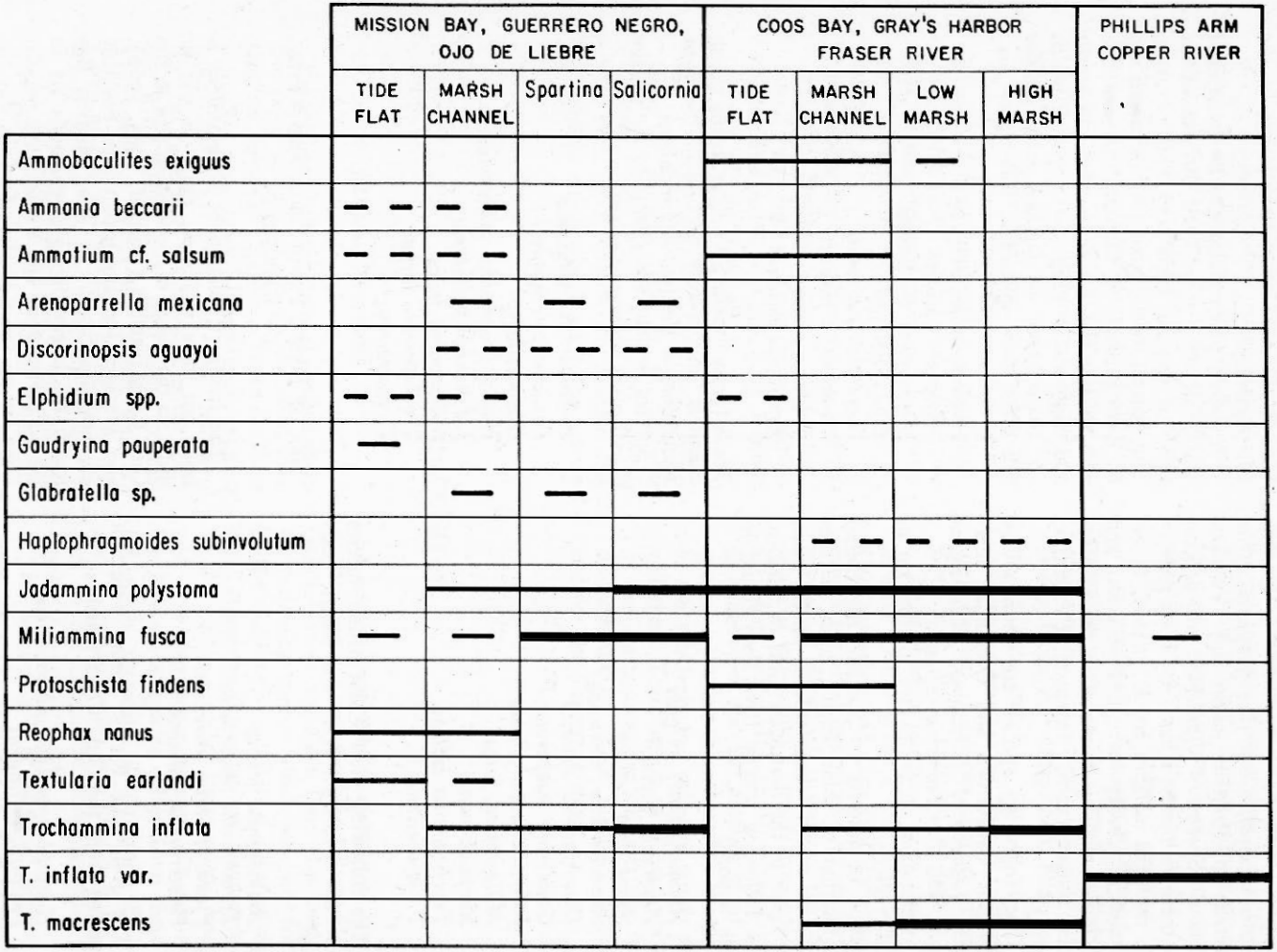

Fig. 10 Occurrences and relative abundances of species in Pacific coast marshes.

are in the dense *Salicornia* at the top of the berm bordering the tidal stream; no living forms were seen in the algal pads where there is no *Salicornia.*

This distribution of population size is in contrast to that on the south coast of Texas (Phleger, 1966) where the largest living population is on the tide flats and the smallest is in the *Salicornia* zone. The difference in productivity related to marsh zones in the two regions probably is related to tide range. On the south Texas coast the tide range is low, 30 cm or less. The flooding of the *Salicornia* zone occurs during times of higher wind tide and/or times of high runoff, and it is frequently subjected to long periods of no flooding. This tends to cause occasional drying and is not the most favorable condition for the *Salicornia* assemblage. The tide flats are covered with water most of the time, and since tide range is low there are no strong currents within the lagoons where the marshes occur. This tends to create a favorable environments for organisms inhabiting the flats.

In Mission Bay, as an example of a Pacific marsh, tide ranges average 1½ m and spring ranges are more than 2½ m. The *Salicornia* zone is thus flooded regularly and a favorable environment exists at all times. High tidal ranges cause frequent emergency of the tide flats and relatively strong currents within the lagoon. This tends to create a relatively unfavorable environment for certain organisms living on the tide flat.

The living total population ratios are generally large, as noted previously, for many marshes. The average ratios are smallest in the Ojo de Liebre Lagoon brine pans, intermediate in value in Guerrero Negro Lagoon and Mission Bay, and largest at Coos Bay, Gray's Harbor and the Fraser River Delta (Tab. 6). These ratios may be used to indicate relative rates of deposition of detrital sediment (Phleger, 1960). The relatively rapid deposition indicated for the northern marsh areas is reasonable because of the large river runoff and thus large supply of sediment in those areas. Significantly slower deposition is suggested at Mission Bay and Guerrero Negro Lagoon where no streams enter the lagoons and all sediment supplied is windblown or from the lagoon or open ocean. The still slower sedimentation rate indicated in Ojo de Liebre is due to two factors: no rivers presently supply sediment to the area and the sediment furnished from the lagoon is only supplied during the highest tides and thus only a small part of the time.

The living-total ratios of foraminifera in the Californian Pacific marshes are comparable to those reported from south Texas marshes. The Texas marshes are in an area of sporadic runoff, and collections were made after a long dry period. Moreover, the amount of tidal flooding due to low tide range tends to furnish less of the sediment which may be available than does a higher tidal range. The small amount of tidal flooding of the *Salicornia* zone in the south Texas marshes is indicated by the low average living-total foraminiferal ratio indicating a slow deposition rate. In the Californian marshes the rates of deposition shown by the living-total ratio is the same in the high marsh and *Salicornia* zone as elsewhere in the marsh. This reflects frequent flooding and supply of sediment.

Number of Species

The number of species per sample and in the total fauna of an environment is a general characteristic of a fauna which may be an important ecological indicator. These data for each Pacific marsh area are shown in table 6.

Mission Bay and Guerrero Negro Lagoon marshes have the largest number of species (more than 20) reported from all the samples in those areas of any of the marshes examined. Coos Bay, Gray's Harbor and Fraser River Delta marshes, on the other hand, average about half the number of species reported from all samples as in the two southern marshes. The two Californian lagoons have no river runoff and as a result nearshore open-ocean water fills these lagoons. This introduces nearshore species into the lagoons and some of these species get into the marsh, although they are never dominant members of the fauna. The as-

semblage found on these marshes is a mixture of marsh species, lagoon species and open-ocean species.

Coos Bay, Gray's Harbor and the Fraser River, on the other hand, have abundant runoff. This prevents undiluted open-ocean water from reaching the marshes. The marsh fauna is thus primarily composed of marsh species with a few lagoon species inhabiting mainly the tide flats and marsh channels.

The Ojo de Liebre brine pan marsh has only 8 species in the total fauna, although the nearby Guerrero Negro Lagoon marsh has 26. The brine pan borders the inner end of Ojo de Liebre Lagoon, a much larger lagoon than either Guerrero Negro or Mission Bay. An inner lagoon water mass develops in Ojo de Liebre which has little direct communication with the open ocean. This water mass supports a less varied foraminiferal fauna than that in the lower lagoon which is in constant communication with the open ocean.

The occurrence of only one species in the Copper River Delta marsh and two species in the Phillips Arm marsh may be due to the relatively rigorous temperature and runoff conditions in these environments. The fact that the dominant form, *Trochammina inflata* var., is not found farther south may support this interpretation. The small number of species in the Ojo de Liebre brine pans may be due to the rigorous conditions in a strongly hypersaline environment.

In the Ojo de Liebre marsh there is an average of 3.3 living species/sample at stations which contain foraminifera. The other marshes studied from the Fraser River south average about 5 to 6 living species/sample, and this compares favorably with similar data from the south Texas marshes (Phleger, 1966).

Percent of Arenaceous Specimens

The marsh faunas from Coos Bay, Gray's Harbor, Fraser River, Phillips Arm and Copper River are entirely composed of arenaceous specimens, with the exception of a few samples. The average percents of arenaceous specimens at Mission Bay and Guerrero Negro Lagoon are significantly smaller than in the northern marshes (Tab. 6), and there is a strikingly low average of arenaceous foraminifera in the Ojo de Liebre samples.

The wholly arenaceous character of the faunas in the northern Pacific marshes is in contrast to the faunas of the south Texas coast where an average of only 41% of the fauna is composed of arenaceous specimens. High runoff in these Pacific marshes appears to deter the invasion of open-ocean species, most of which have calcareous tests. There is also a possibility that the low salinity water on the marshes in these areas has a lower pH than in some other areas; low salinity water also is expected to be less resistant to lowering of pH than normal sea water.

The high percent of calcareous specimens in the Ojo de Liebre brine pan marsh reflects the brine pan environment where the water is concentrated sea water. Several pH measurements have been made in the brine pans, all of which are 8.3 or higher. In the algal pads which cover the entire brine pan daytime pH values of 9.0 or more have been measured. Calcium carbonate, in the form of aragonite, precipitates out of the brine and is found underneath the algal pads in the same environment where a foraminiferal fauna of exclusively calcareous tests was found.

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MARSH AREA	SEA IS.					SMOKY TOM IS.							
STATION	1	2	3	5	6	1	2	3	4	5	6	7	8
LIVING POPULATION	7,250	430	1350	980	1110	15	4	80	0	4	0	0	4
TOTAL POPULATION	11,250	1050	1900	3200	4500	19	8	110	0	4	0	0	4
LIVING / TOTAL	64	41	71	31	25	79	50	73		100			100
Ammobaculites sp.		3		16	24								
Ammotium cf. salsum				19	15								
Haplophragmoides subinvolutum	15	3	5										
H. sp.			2										
Jadammina polystoma	21	23	22	2									
Miliammina fusca	11	58	55	59	46	93		10		100			
Protoschista findens				.4									
Pseudoclavulina sp.				4	14								
Trochammina inflata	4		.9										
T. macrescens	49	13	15		1								
Thecamoboeans (dead)	550	140	20	12		24	37	112	108	72	224	104	360
" (living)	75					1	4	8	24	20	32	16	160

Table 1 Occurrences of species in Fraser River Delta marsh in per cent of living population.

MARSH AREA	OYHUT								HOQUIAM								WESTPORT														MARKHAM						
STATION	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	1	2	3	4	6	7	8	9	10	11	12	13	14	15	2	3	5	6	7	8	9
LIVING POPULATION	1450	25	280	175	640	570	1600	1050	250	300	1550	3450	1150	320	3000	3550	210	46	170	940	770	100	2150	2350	570	2300	1650	1800	60	5600	3800	3250	1750	1800	3400	3050	2400
TOTAL POPULATION	3450	25	2250	500	2850	1700	2100	1400	880	580	2100	7500	3200	1080	4600	6050	330	130	650	1250	1100	260	5000	3450	1190	6750	2600	2800	195	9750	5550	8250	3950	3100	7250	4050	5200
LIVING / TOTAL	42	100	12	35	22	34	76	75	28	52	74	46	36	30	65	59	63	35	26	75	70	38	43	68	48	34	64	64	31	57	68	39	44	58	47	75	46
Ammobaculites exiguus	2								22			.7	7					4			2		5		.7			1				.8				.8	
Ammotium cf. salsum									28		.9	.7	7	8	1				2		.5	4			.7	1											1
Buliminella elegantissima																	1																				
Elphidium frigidum																	15								.7												
E. lene																	70																				
E. subarcticum																	13				.5																
Haplophragmoides subinvolutus	12		30								11	20	11		17	7			12	29		4		1		7		7	3	3	2	7		3	3	6	
H. sp.	3						8	40				4			4			9	2						.7	2	2	10		.4	2		5	1	.7		
Jadammina polystoma	26		5	14	30	22	28	10		75	64	30	29	8	22	21		13	12	21	.5	8	13	17	6	33	18	4	17	39	34	18	17	5	5	7	9
Miliammina fusca	46	100	15		13	10	2	2	39	25	14	12	24	23	20	29	1	44	48	22	92	64	81	68	88	19	70	61	65	4	14	52	20	27	11	8	12
Protoschista findens	2								11	8		.7			3			26	2	.4	1	8	1		2										.8		
Trochammina charlottensis																			5	.4																	
T. inflata	2		25	57	30	29	2				2			15	11	13		4	12	7	3	12		1	.7	14		6	12	19	15	11	29	20	6	11	11
T. macrescens	7		25	29	26	39	60	48		42	8	32	22	46	22	40			5	20				13		24	10	11	3	35	33	11	29	44	74	66	66
Thecamobinids (dead)	50	225		50	29	42	450	350		100	56	575	175	75	750	75		4		8	4			14	4							125	25				
" (living)					28		25		14			225			100	25			4	8																	

Table 2 Occurrences of species in Gray's Harbor marsh in per cent of living population.

AREA	JARVIS					PONY POINT															COOSTON							
STATION	9	10	11	12	13	2	3	4	5	6	7	8	9	11	12	13	14	15	17	19	20	1	4	5	6	7	8	9	10
LIVING POPULATION	388	51	344	262	132	356	3790	1550	1050	1370	1960	5700	755	6950	4275	1500	2530	1210	3520	1470	3960	8450	920	8600	4400	125	4500	870	1150
TOTAL POPULATION	2600	530	1370	720	630	940	6500	3180	3600	4600	6760	10,700	1890	12,500	7600	3950	5080	1850	5275	2930	5100	14,600	1310	14,050	7600	675	8075	3430	1475
Ammobaculites exiguus	1	10				17	1				1					8	1		3	15	1							10	
Ammotium of. salsum						7				3			7			8	3		3	24	2	1	2					24	2
Elphidium subarcticum								7	1	2	1																		
Haplophragmoides subinvolutum	22		1	1	3	1	3		11	5	1	2	2	9	8		2	2	1			5		9	9		10	3	4
H. sp			3	2		2	3		3	1	2	1	2	1	1				1		1		2	1	2				
Jadammina polystoma	26		46	33	27		3	17	15	5	2	2		3	6	8	2	18	37		32	9	23	23	15		18	2	15
Miliammina fusca	2	86	28	50	43	47	26	25	23	36	71	18	54	38	44	64	83	54	14	22	7	8	17	6	17	60	4	10	13
Protoschista findens						20				1	1		27				4		2	39								43	2
Trochammina inflata	26	4	22	14	24	6	52	38	20	22	12	39	2	18	16	2	2	7	16		46	24	17	13	12	20	9	5	24
T. macrescens	23				3		12	13	27	25	9	38	6	31	25	10	3	18	23		11	53	39	48	45	20	59	3	40
"Thecamoebians" (total no.)														75										50	25				975

Table 3 Occurrences of species in Coos Bay marsh in per cent of living population.

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	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
LIVING POPULATION	4420	1700	100	516	4610	3370	1650	784	876	444	640	14	2390	896	948	848	596	82	414	25	2	2	2250	52	60	9	84	38	134	231	40	180	21	46	574	3260	3120	1080	3360	328	224	870	72	4060	31	48	56	3	2580	1430	72	4070	3020	48	3930	420	1050	18	690	13	19
Ammonia beccarii			8											2		5							2	4						5	5												3								22	1											
Ammotium salsum																		2		4		50							3		2		5	9							2			3	4																
Arenoparrella mexicana																									7																			8							6	1										
Discorinopsis aguayoi			12		2																		2	2					1						2	1								10																		
Elphidium gunteri																													1	2																														
E. incertum var.			4																										1																																
E. sandiegoensis											7			25		1													9														14	1								1										
E. translucens										2				2		4		2											1														1																				
E. tumidum			4															4			50			9	3				5													22								22		8		1			62	11
E. spp.																2		7					6	6																		8		4																			
Gaudryina pauperata																													4			5	9																											
Glabratella sp.														3		1		2					2	17					5													10																		1	15
Jadammina polystoma	87	34	16	31	49	34	70	30	38	31	22	21	22	16	28	66	26	23	14	24			24	19	3		14	32	4	26	13	2	19	4	73	62	30	1	73	16	9	28	11	28	19	21	21	100	84	32	38	36	12	19	65	9	80	83	64	8	47
Miliammina fusca	9		12		1	22	4	45	17	56	55	21	70	31	60	6	16	9	79	4			15	6	40	45	55			3	10	89	14	2	5	15	57	75	4	73		47	11	3	6		61		2	60		45	36	21		87					
Miliolinella circularis					1				1																				1														1																	
M. elongata		51	8	21	7	2	1		25		4					5							36	21					20							9	5						22									5	12		5			3	16	
Protoelphidium sp.														2						4				2																																						
Quinqueloculina laevigata				23	24	30			2							1			1	4			7	6																		10									1	6	6	32	6	7	1		12		
Reophax nanus																	3	1	1										4				4																												
R. sp.								1				51	3		3			3	1						17	11	14	42	14	1	35	7	43	52		1	23		4	85	7	11		6	71															42
Textularia earlandi										1								1		4		50		4		11	4	5	15				5	17					1		2				4															
Trochammina inflata	3	13	28	18	17	12	25	19	15	9	11	7	5	19	9	9	3	5	4	52			6		23	33	13	21		17	33	2	9		20	13	7	1	23	6	2	16	8	14	6		14		14	7	6	5	6	44	22	1	20	17	20		
MISCELLANEOUS	1	2	8	7	1		3	2	1	1							52	41			50			4	7								3							2		4									2	2	1	1					
LIVING / TOTAL POPULATIONS	45	37	4	5	23	24	52	27	33	12	49	20	74	27	42	32	66	52	57	38	100	3	57	29	12	5	26	50	30	49	25	67	20	36	14	55	51	60	42	58	62	35	23	34	55	35	54	43	11	66	16	52	61	21	25	38	55	7	38	57	31
PERCENT Arenaceous SPECIMENS	100	48	56	50	66	68	99	100	70	100	89	100	100	66	100	81	100	85	99	92	50	100	46	33	97	100	100	100	100	50	93	100	100	98	98	91	95	100	100	100	100	100	63	45	100	96	100	100	100	99	72	87	54	84	88	98	100	100	84	8	89
NO. SPECIES	4	5	6	7	8	5	4	5	7	6	6	4	4	8	4	10	5	12	6	7	2	2	9	12	7	4	5	4	5	15	7	4	7	8	4	5	5	4	3	5	5	5	10	10	5	4	4	1	3	4	6	8	6	6	5	6	2	2	5	4	3

Table 4 Occurrences of species in Mission Bay marsh in per cent of living population.

STATION		1	2	3	4	5	6	7	8	9	10	11
LIVING POPULATION		30	90	144	115	4	1	34	187	3	0	0
TOTAL POPULATION		275	690	1155	524	43	15	137	1345	28	6	0
LIVING / TOTAL		11	13	12	22	10	7	24	14	11	0	0
Ammonia	L	3										
beccarii	T	2	1	2	1	2	20	2		4		
Discorinopsis	L		3	3					3			
aguayoi	T	1	6	2					1			
Elpbidium	L	6		5	1			31				
sp.	T	6	2	5	6	2	33	21	2		83	
Haplohragmoides	L		1									
sp.	T		2	1								
Jadammina	L				1				2			
polystoma	T	1		1	1				1			
Miliammina	L	46	1	56	70			57	4			
fusca	T	15	2	16	48	18		26	3			
Milioidae	L	30	47	26	19	100	100	12	61	100		
	T	53	41	58	27	68	47	40	77	96	17	
Trochammina	L	15	48	10	9				30			
inflata	T	22	46	15	17	10		11	16			

Table 5 Occurrences of species in Ojo de Liebre marsh in per cent of living population (L) and per cent of total population (T).

Marsh Areas	Av. No. Species/ Sample	Total Number Species	Av. % Arenaceous Specimens	Average L/T	Number Stations
Ojo de Liebre Brine Pan	3.3	18	38	14	9
Guerrero Negro Lagoon	5.6	26	79	29	58
Mission Bay	5.6	23	85	38	61
Coos Bay	6.2	10	99	45	29
Gray's Harbor	5.5	14	100	51	37
Fraser River Delta	5.4	14	100	46	5
Phillips Arm	2.0	2	100	--	5
Copper River Delta	1.0	1	100	--	8

Table 6. Some general features of the foraminiferal faunas