THE BENTHIC MARINE ALGAE OF TIMBALIER BAY, LOUISIANA

by Harold J. Humm and Theresa M. Bert

ABSTRACT

A study of the benthic algae of Timbalier Bay, Louisiana, was made from June 1972 to September 1974, as part of an interdisciplinary study conducted by the Gulf Universities Research Consortium to determine the effect of the petroleum industry on the bay. Eighty-three species of benthic algae were recorded in the bay, divided among the four major groups as follows: Cyanophyta 26 (32%), Rhodophyta 17 (21%), Phaeophyta 12 (15%), Chlorophyta 28 (33%). Apparently the oil and gas wells in Timbalier Bay have not had a significant adverse effect upon the distribution or abundance of benthic algae during 35 years of operation.

INTRODUCTION

From June 1, 1972, to September 15, 1974, the Gulf Universities Research Consortium conducted an interdisciplinary study, known as the Offshore Ecology Investigation, of the ecological impact of the offshore oil and gas wells of the Louisiana coast. Field work was carried on in Timbalier Bay and among the offshore platforms covering an area of about 400 square miles and to depths of 30.5 meters. This report represents the results of a study of the benthic algae of Timbalier Bay, which has not been studied previously for these organisms.

At the time of this investigation, Harold Humm and Theresa Bert were at the Department of Marine Science, University of South Florida.

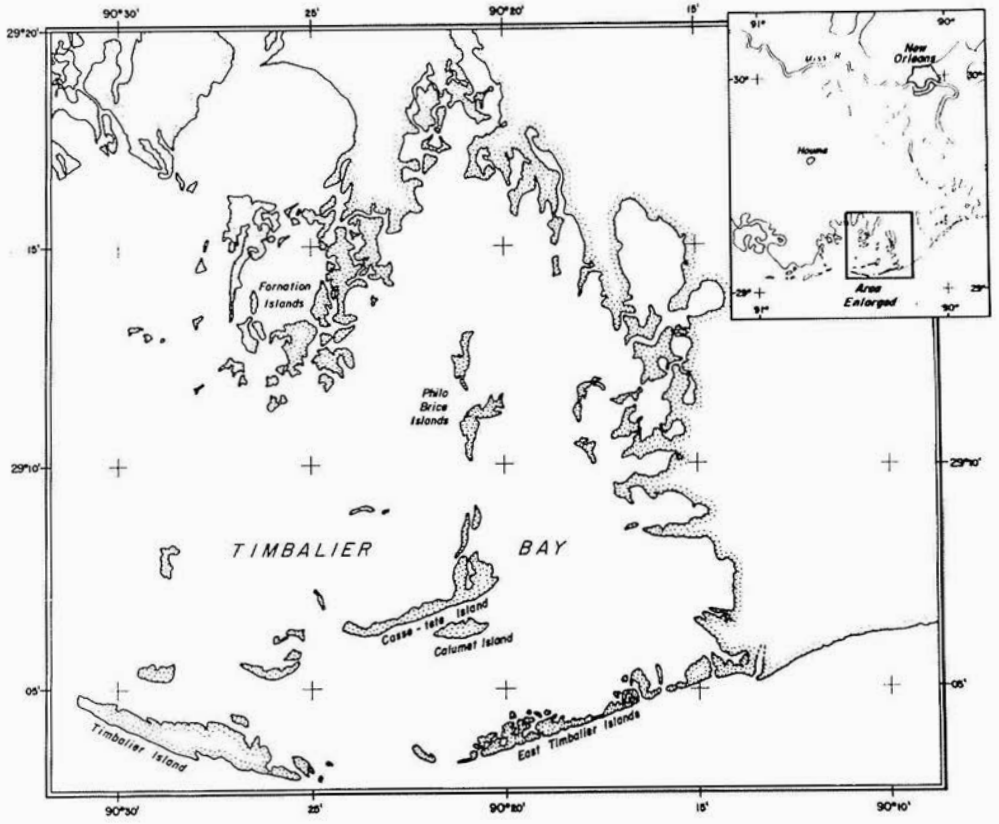

FIG. 1. MAP OF TIMBALIER BAY showing the location of the islands around which collections of algae were made. Inset shows the location of Timbalier Bay in relation to New Orleans and the Mississippi River.

THE HABITAT

Location

Timbalier Bay is the second largest bay west of the Mississippi delta on the Louisiana coast (figure 1). Its northern boundary is approximately at latitude 29°17 'N and its southern boundary at 29°03 'N. It is bounded on the east by marshlands and on the west by a diagonal line from Chinois Pass through the Fornation Islands to the western end of Timbalier Island at approximately 90°31 'W. The northern part of Timbalier Bay, an area of about 15 square miles, is known as Lake Raccourci, which was not included in this study. Separating Lake Raccourci from the southern part of Timbalier Bay are the Philo Brice Islands. Between these islands and the southern boundary of the bay are Casse-tete and Calumet Islands.

Salinity

Timbalier Bay contains somewhat brackish water, and most of the year has a decreasing salinity gradient from its boundary with the Gulf of Mexico between Timbalier and East Timbalier islands northward to Chinois Pass. Since the major source of fresh water for the bay is drainage from the vast marshes to the north, rather than large rivers, the salinity of Timbalier Bay is generally higher than other similar bays of coastal Louisiana (figure 2).

The salinity pattern varies from year to year (Gagliano 1970), but the lowest salinities usually occur in the spring, when land run-off and river discharge are highest, and highest salinities occur in late summer or fall, when land run-off is minimal, when sea level in the northern Gulf of Mexico is highest, and when southerly winds tend to blow Gulf water into the lower part of the bay (Walsh 1969).

Figure 2 shows the salinity pattern at various times for the years 1972 and 1973, indicating that the range from the Philo Brice Islands southward is 15-30 ppt most of the time, a range tolerated by many species of euryhaline marine algae.

Temperature

During the years 1972 and 1973, the surface water temperature in Timbalier Bay ranged from 12° C in February to 32° in July and August, a range of 20°. Figure 3 shows the surface water temperature variations latitudinally in Timbalier Bay at all seasons from October 1972 to July 1973.

Turbidity

Light transmission through the water of Timbalier Bay is generally

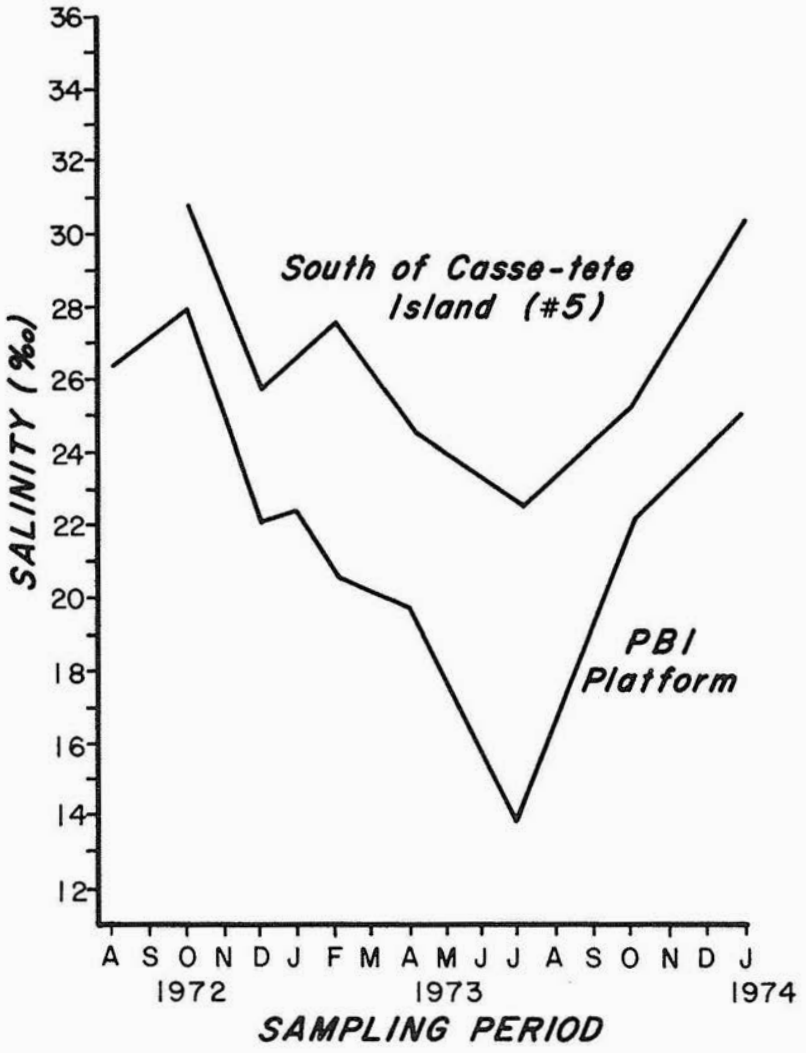

FIG. 2. SALINITY RECORDS IN TIMBALIER BAY for the period April 1972 to January 1974, from the Philo Brice Islands platform and from the south side of Casse-tete Island.

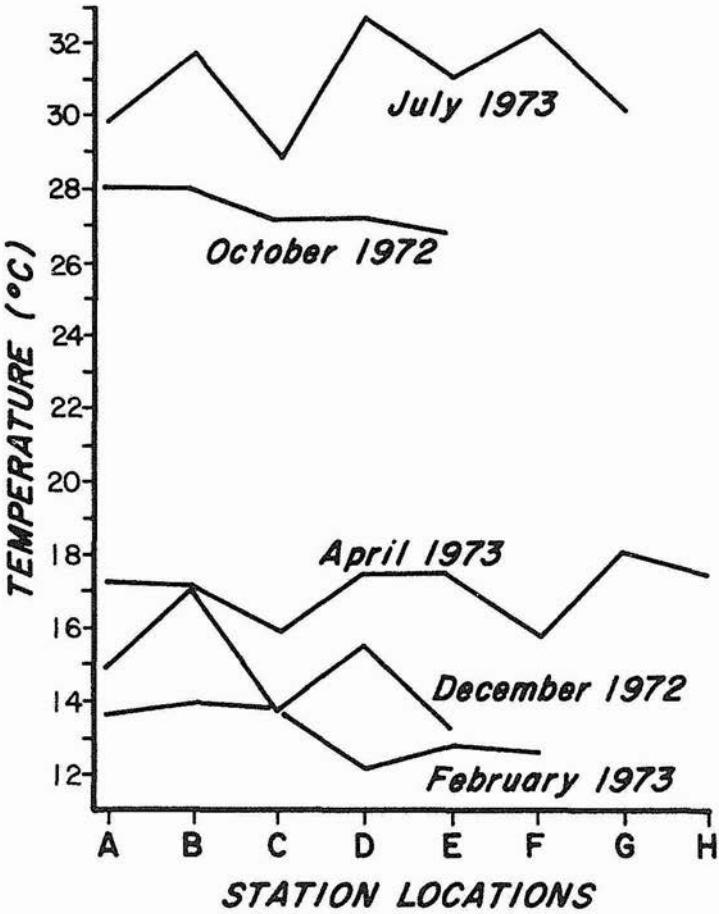

FIG. 3. WATER TEMPERATURE RECORDS at 5 to 7 stations in Timbalier Bay during five different months from October 1972 to July 1973.

so reduced that benthic algae are limited to a depth of from 10 cm to a few hundred mm below mean low water. The shallowness of the bay and the high proportion of silt and clay in its bottom sediments (Williams and Jones 1974) combine to keep the water turbid whenever the wind velocity exceeds 12 to 15 mph. In addition, boat traffic and shrimp trawling in the bay are a constant cause of resuspension of fine sediments. Periods of calm weather result in an increase in water clarity, but the duration of these periods is too short to permit benthic algae to colonize successfully at deeper levels.

Substrate

Since the benthic algae in Timbalier Bay are not able to grow deeper than 100 to 300 mm below mean low water, the principal natural substrates they colonize are the oyster shells and other molluscs, the pneumatophores of black mangroves, the stems of marsh grasses, the upper ends of annelid worm tubes, and the intertidal sediments in calm areas. Man-made structures added considerable substrate in the intertidal zone for benthic algae, especially rock break-waters, sea walls, pilings and timbers of oil platforms, channel markers, and buoys. A few species of benthic algae could survive and grow for long periods of time as loose, drifting plants in areas of low current velocity and reduced wave action.

Depth

The maximum depth of Timbalier Bay is about 1.8 to 2.1 m at mean low water. The depth of the northern half of the bay is 0.9 to 1.2 m and the southern half 1.2 to 1.5 m. Because the bay is shallow, water turbulence arising from prevailing winds keeps large amounts of silt and clay in suspension most of the time, and tidal currents distribute this turbidity rather evenly throughout the bay. The southernmost part of the bay, south of Brush and Casse-tete Islands, is slightly deeper, and the bottom sediments contain less silt and clay because of stronger tidal currents. For this reason the southern segment is generally less turbid than the rest of the bay, as shown by the latitudinal transparency variation data (Price 1974).

Tides and other sea level changes

The tides in Timbalier Bay are chiefly diurnal. The mean amplitude on the north side of Timbalier Island and around the Pelican Islands is about 365 mm. From the central part of the bay northward, the amplitude is progressively less. The maxima in amplitude occur in December and June at the approximate time of the winter and summer solstices. The minima occur in March and September in conjunction with the vernal and autumnal equinoxes. Lunar monthly maxima occur around new and full moon and minima during first and last quarters.

During the colder months of the year, mean sea level in Timbalier Bay is lower than that determined by celestial tidal forces because of prevailing north winds. During the warmer months of the year, the opposite is true.

Nutrients

Data on nutrient salts in the water of Timbalier Bay indicate that the quantities present most of the time are favorable to algal growth. The

highly organic sediments of the bay and the abundance of non-living particulate organic matter in suspension contribute to rapid regeneration of nutrients by bacterial activity. The rate of regeneration may be of much greater importance to algal nutrition than the level of concentration of nutrients at any given time. The shallowness of the bay and the constant turbulence resulting from tidal currents assure that nutrients released from bottom sediments are quickly mixed throughout the water column.

Between the Philo Brice Islands and the southern margin of the bay, the area in which the benthic algae were best developed, orthophosphate values in the water ranged from 62 to 100 μg/l, ammonia values from 0.08 to 0.75 mg/l, except for a 4.5 reading one mile north of Casse-tete Island in February 1973; nitrite plus nitrate values ranged from 0.03 to 1.8, except for a reading of 5.8 in Little Timbalier Pass in February 1973 (Burchfield et al. 1974).

All nutrients were highest during winter and lowest during summer, with some fluctuations during spring and fall that may have been caused by a surge or bloom of a species of planktonic diatom.

ANNOTATED LIST OF SPECIES

Cyanophyta

Twenty-six species of blue-green algae have been recorded in Timbalier Bay. Of these, 24 species are considered marine (though they may occur in fresh water as well), and two species (*Anacystis montana* and *Microcoleus vaginatus*) are regarded as primarily fresh water algae, although they are often found in brackish water, especially off mouths of streams. There are about 32 marine species of blue-green algae in the Atlantic ocean and Gulf of Mexico *sensu stricta* Drouet (Drouet and Daily 1956; Drouet 1968, 1973, 1978). Thus, 75% of all known marine blue-greens from the Gulf and Atlantic Ocean have been found in Timbalier Bay.

Coccochloris elabens Drouet and Daily. Common throughout Timbalier Bay during the warmer months in the intertidal zone and somewhat below; attach to a variety of substrates, especially barnacles.

Coccochloris stagnina Drouet and Daily. Forms a bright blue-green gelatinous layer low in the intertidal zone on an oil well platform piling near the Philo Brice Islands; apparently not common in the bay.

Anacystis aeruginosa Drouet and Daily. Occasional colonies on or in dead barnacle shells in the intertidal zone on an oil well platform piling near Philo Brice Islands and on leaves of *Halodule* about two miles north of Little Timbalier Pass.

Anacystis dimidiata (Kützing) Drouet and Daily. Mixed with other blue-greens from a piling near the Philo Brice Islands, intertidal zone.

Anacystis marina Drouet and Daily. Common in the intertidal zone on pilings around the Philo Brice Islands in the form of small colonies.

Anacystis montana (Lightfoot) Drouet and Daily, *forma montana* Drouet and Daily. Intertidal on pilings around the Philo Brice Islands the year around.

Johannesbaptistia pellucida Taylor and Drouet. Found in the bay only during the winter months on the north side of Casse-tete Island among pneumatophores of black mangroves.

Gomphosphaeria aponina Kützing. In lower Timbalier Bay only; on *Halodule* leaves, oyster shells, and waterlogged wood.

Agmenellum thermale (Kützing) Drouet and Daily. Scattered colonies mixed with *Microcoleus lyngbyaceus* and other mat-forming blue-greens on pilings and driftwood around the Philo Brice Islands, and on *Halodule* leaves along the north side of Timbalier and East Timbalier Islands, summer.

Family Chamaesiphonaceae

Entophysalis conferta (Kützing) Drouet and Daily. Epiphytic on larger algae throughout the study area of the bay and on seagrass leaves along the south side of Casse-tete Island.

Entophysalis deusta Drouet and Daily. At all collecting sites on the surface of and boring into shells and other forms of limestone.

Order Hormogonales
Family Oscillatoriaceae

Spirulina subsalsa Oersted. Forms bright blue-green patches in algal mats, on the concave surface of dead shells, in dead barnacles, on and within hydroid and bryozoan tests especially around the Philo Brice Islands, but distributed throughout the bay.

Oscillatoria erythraea (Ehrenberg) Kützing. Planktonic in lower Timbalier Bay during summer periods of high salinity, when it formed patches of tiny flakes visible without magnification, which often adhered to pilings or other surfaces following contact.

Oscillatoria lutea C. Agardh. A constituent of algal mats on muddy sand in the intertidal zone and on pilings the year around throughout the bay.

Oscillatoria submembranacea Ardissone and Strafforello. An epiphyte of other algae in small tufts from the Philo Brice Islands to the south end of the bay.

Schizothrix arenaria (Berkeley) Gomont. Mixed with other blue-greens, especially on pilings, from the Philo Brice Islands southward, the year around.

Schizothrix calcicola (C. Agardh) Gomont. Probably the most widely distributed species of blue-green in the bay. Found in all collections the year around, both on the surface of all substrates and boring into limestone.

Schizothrix mexicana Gomont. On the old leaf bases of *Spartina*, south side of Calumet Island; probably widely distributed in the bay.

Schizothrix tenerrima (Gomont) Drouet. Intertidal on muddy sand among the aerial roots of black mangroves, north side of Casse-tete Island, typically with many trichomes in the sheath.

Porphyrosiphon kurzii (Zeller) Drouet. On intertidal sand, north side of Timbalier Island; summer months.

Porphyrosiphon notarisii (Meneghini) Kützing. Intertidal on stones, shells, wood, and mangrove roots during the warmer months from the Philo Brice Islands to the south end of the bay.

Microcoleus lyngbyaceus (Vaucher) Gomont. Probably the blue-green species of greatest biomass in the bay the year around. At all collection sites, usually in the form of a mat of which it is the principal constituent, but also forming loose skeins over seagrasses south of Casse-tete; summer.

Microcoleus vaginatus (Vaucher) Gomont. In the upper part of the bay north of the Philo Brice Islands where the water is more brackish, but after the Mississippi River flood of 1973, it was also found in the lower bay.

Family Nostocaceae

Calothrix crustacea Thuret. One of the most widely distributed of blue-greens. Abundant on pilings and woodwork where it forms a black band high in the intertidal zone; common also as an epiphyte on larger algae throughout the bay at all seasons.

Nostoc spumigena (Mertens) Drouet. A constituent of the blue-green film or mat on pilings around the Philo Brice Islands, intertidal the year around; on intertidal sand, north side of Timbalier Island.

Mastigocoleus testarum Lagerheim. Boring into the shells of dead barnacles and molluscs in lower Timbalier Bay the year around.

Rhodophyta
Class Rhodophyceae

Twenty-one species and one variety of Rhodophyta have been recorded for Timbalier Bay. The bay is not a favorable habitat for red algae because of the turbidity, salinity fluctuation, low water temperature of the winter months and rapid changes, and the limited amount of suitable substrata in the euphotic zone.

Order Bangiales
Family Bangiaceae

Goniotrichum alsidii (Zanardini) Howe. An epiphyte on the leaves of *Halodule* and on *Enteromorpha*, south side of Casse-tete Island, winter and spring 1972-73.

Erythrotrichia carnea (Dillwyn) J. Agardh. An epiphyte of *Halodule* leaves, *Gracilaria*, and *Enteromorpha*, the year around along the south side of Calumet and Casse-tete Islands and along the north side of East Timbalier Island.

Bangia fuscopurpurea (Dillwyn) Lyngbye. On *Halodule* leaves and aerial roots of black mangroves, southernmost part of Timbalier Bay, winter and spring.

Order Nemaliales
Family Acrochaetiaceae

Acrochaetium gracile Børgesen. On leaves of *Halodule*, south part of Timbalier Bay.

Acrochaetium sagraeanum (Montagne) Bornet. The most abundant species of *Acrochaetium* in lower Timbalier Bay on seagrass leaves and *Gracilaria*.

Acrochaetium virgatulum (Harvey) J. Agardh. Abundant on the leaves of *Halodule* during winter and spring along the south side of Casse-tete Island.

Order Gigartinales
Family Gracilariaceae

Gracilaria foliifera (Forsskal) Børgesen. Common on shells on the seagrass flats south of Casse-tete and Calumet Islands, winter and spring, occasional in summer.

Gracilaria verrucosa (Hudson) Papenfuss. On shells on the seagrass flats south of Casse-tete and Calumet Islands, from July to December 1973.

Gracilariopsis sjoestedtii (Kylin) Dawson. In great abundance as loose plants (hundreds of tons) on the seagrass flats along the south side of Calumet and Casse-tete Islands during the summer and fall of 1972, but in reduced quantity during 1973. These plants washed ashore in November and December. They appear in the spring as epiphytes of *Halodule* leaves but soon break off and continue growth as loose, drifting plants.

Family Hypneaceae

Hypnea musciformis (Wulfen) Lamouroux. Occasional as epiphytes of *Halodule* leaves or as larger, loose plants along the south side of Casse-tete and Calumet Islands from spring to early winter.

Order Ceramiales
Family Rhodomelaceae

Polysiphonia echinata Harvey. Occasional as an epiphyte of *Halodule* along the south side of Casse-tete and Calumet Islands, spring.

Polysiphonia hemisphaerica Areschoug. Occasional on shells and pilings low in the intertidal zone from the Philo Brice Islands to the southern end of the bay, year around.

Polysiphonia subtilissima Montagne. On pilings, shells, *Spartina* stems, and black mangrove aerial roots throughout the bay the year around. This species is one of the most euryhaline of the marine red algae since it occurs in salinity as low as 10 ppt.

Bostrichia radicans Montagne. On intertidal woodwork, aerial roots of black mangroves, around the base of *Spartina* stems, and in mats on mud, north side of Casse-tete Island and generally distributed around the fringes of salt marshes throughout the bay.

Bostrichia radicans forma moniliforme Post. On aerial roots of black mangroves along the north side of Casse-tete Island and on woodwork of an oil well platform, Philo Brice Islands.

Bostrichia tenella (Vahl) J. Agardh. On aerial roots of black mangroves along the north side of Casse-tete Island.

Lophosiphonia subadunca (Kützing) Falkenberg. On woodwork low in the intertidal zone, oil well platform near Philo Brice Islands, and on leaves of *Halodule*, south side of Casse-tete Island; rare.

Laurencia poitei (Lamouroux) Howe. One plant obtained by

dredging in upper Timbalier Bay, fall of 1973; a few plants on leaves of *Halodule*, south side of Casse-tete Island, winter.

Phaeophyta
Class Phaeophyceae

The brown algae are represented in Timbalier Bay by only 10 species that grow there and two additional species that occasionally drift into the bay from the Gulf. Of the four major groups of benthic algae, the Phaeophyta have the fewest fresh water species and few species that tolerate brackish water. In general, the brown algae of Timbalier Bay are species that do best during the cooler months of the year and tolerate reduced salinities.

Order Ectocarpales
Family Ectocarpaceae

Ectocarpus dasycarpus Kuckuck. On barnacle and oyster shells attached to well platform pilings low in the intertidal zone, central Timbalier Bay around the Philo Brice Islands and in the Bayou Lafourche boat channel, winter and spring. This species is the most tolerant of reduced salinity of any of the brown algae recorded for the bay.

Ectocarpus elachistaeformis Heydrich. An epiphyte during winter and spring on *Enteromorpha* and *Cladophora* from pilings around the Philo Brice Islands and southward in the bay.

Ectocarpus intermedius Kützing. On shells and seagrass leaves along the south side of Casse-tete and Calumet islands winter and spring. This species has been referred to as *E. confervoides* (Roth) LeJolis in much of the current literature.

Giffordia mitchaelliae (Harvey) Hamel. In lower Timbalier Bay on barnacles from pilings along the channel leading to Bayou Lafourche and on leaves of *Halodule* along the south side of Casse-tete and Calumet Islands and the north side of Timbalier Island. Present the year around but especially in spring.

Giffordia rallsiae (Vickers) Taylor. An epiphyte of *Halodule* along the south side of Casse-tete Island, year around except during periods of low salinity, but most common in spring.

Bachelotia antillarum (Grunow) Gerloff. Occasional on shells from the seagrass flats along the south side of Casse-tete Island, spring.

Phaeostroma pusillum Howe and Hoyt. Epiphytic on *Sphacelaria* from pilings around the Philo Brice Islands, winter.

Order Sphacelariales
Family Sphacelariaceae

Sphacelaria furcigera Kützing. Low intertidal on pilings around the Philo Brice Islands, especially on barnacles.

Order Dictyosiphonales
Family Striariaceae

Hummia onusta (Kützing) Fiore. Found only as an epiphyte on the leaves of *Halodule* in Timbalier Bay between Casse-tete and the Timbalier Islands. This dimorphic species was misunderstood until studied in culture by Fiore (1969, 1975). In the past, the gametophyte was known as *Myriotrichia subcorymbosa* (Holden) Blomquist and as *Farlowiella onusta* (Kützing) Kornmann. In both cases it had been originally described as *Ectocarpus*, and Taylor (1957, 1960) lists it as *E. subcorymbosus*. The gametophyte is found year around and is only a few mm in length. The sporophyte, previously known as *Stictyosiphon subsimplex* Holden, is several cm tall. It appears in late fall and disappears in spring.

Order Fucales
Family Striariaceae

Myriotrichia repens Hauck. On leaves of *Halodule* just inside Little Timbalier Pass and along the north side of East Timbalier Island in the extreme southern part of the bay, summer. This species may occur only sporadically in the bay during summer months.

Family Sargassaceae

Sargassum fluitans Børgesen and *Sargassum natans* (L.) Meyer. These two species of *Sargassum* are strictly pelagic, never attached. Their origin and center of distribution is the Sargasso Sea, but they often develop in considerable abundance in the Gulf of Mexico. During periods of abundance in the Gulf, both of these species are occasionally blown into Timbalier Bay and are to be found temporarily drifting in the bay or washed ashore.

Chlorophyta
Chlorophyceae

The green algae are better represented in Timbalier Bay (28 species) than any of the other three major groups. The reason is that the genera *Enteromorpha*, *Ulva*, and *Rhizoclonium* comprise species that tolerate a wide range of salinity and temperature. In addition, they tolerate turbidity and are able to grow in the intertidal zone. Species of these genera constitute half of all green algae known for the bay.

Order Tetrasporales
Family Palmellaceae

Pseudotetraspora antillarum Howe. Gelatinous colonies of this species were found adhering to *Enteromorpha* around the Philo Brice Islands in July.

Order Ulotrichales
Family Ulotrichaceae

Ulothrix flacca (Dillwyn) Thuret. Mixed with *Cladophora* and *Enteromorpha* from pilings along the channel leading to Bayou Lafourche and in drift algae on the seagrass beds along the south side of Casse-tete Island, winter and spring.

Stichococcus marinus (Wille) Hazen. An epiphyte on *Enteromorpha* from the seagrass beds in the southern part of the bay. This species is adapted to estuaries and salt marshes.

Family Chaetophoraceae

Pseudoendoclonium marinum (Reinke) Aleem and Schulz. Forms a green coating on barnacles and woodwork in the intertidal zone in the central and lower bay the year around.

Ulvella lens Crouan. An epiphyte on *Polysiphonia subtilissima* and probably other algae from the seagrass beds along the north side of East Timbalier Island, year around.

Family Gomontiaceae

Gomontia polyrhiza (Lagerheim) Bornet and Flahault. Boring into old mollusc shells in lower Timbalier Bay, year around.

Order Ulvales
Family Ulvaceae

Enteromorpha clathrata (Roth) J. Agardh. One of the most common species in the central and southern parts of the bay the year around, especially spring.

Enteromorpha compressa (L.) Greville. Common in at least the southern part of the bay, winter and spring.

Enteromorpha erecta (Lyngbye) J. Agardh. On pilings of the channel leading to Bayou Lafourche in the southeastern part of the bay and in other open, exposed places, winter and spring.

Enteromorpha flexuosa (Wulfen) J. Agardh. A common species on all substrata in the lower intertidal zone throughout the bay, year around, especially spring.

Enteromorpha intestinalis (L.) Link. Throughout the bay in the intertidal zone from December to April.

Enteromorpha lingulata J. Agardh. On pilings along the channel leading to Bayou Lafourche in the southeastern part of Timbalier Bay during winter and spring and probably the year around in forms difficult to recognize.

Entermorpha plumosa Kützing. Common throughout Timbalier Bay on various substrata, especially barnacles, in the intertidal zone. The species is best developed during winter and spring, but is present the year around.

Enteromorpha prolifera (Müller) J. Agardh. On pilings, shells, and rocks, low in the intertidal zone around the Philo Brice Islands and southward in the bay the year around.

Enteromorpha salina Kützing, variety *polyclados* Kützing. An epiphyte on seagrass leaves in the southern part of the bay, summer and fall, and probably the year around.

Ulva curvata (Kützing) Detoni. Common throughout the bay, especially in spring, but not abundant.

Family Monostromataceae

Monostroma oxyspermum (Kützing) Doty. On roots of black mangroves along the north side of Casse-tete Island and around the base of *Spartina* stems in salt marshes throughout the bay, winter and spring.

Order Cladophorales
Family Cladophoraceae

Chaetomorpha brachygona Harvey. Common as an epiphyte on *Halodule* leaves along the south side of Casse-tete Island, summer and fall.

Chaetomorpha linum (Muller) Kützing. In loose masses on the seagrass flats along the south side of Casse-tete and Calumet Islands and at other stations in the central and southern part of the bay.

Chaetomorpha minima Collins and Harvey. On *Halodule* leaves, south side of Casse-tete Island, summer and fall.

Rhizoclonium hookeri Kützing. On aerial roots of black mangroves and mixed with the blue-green mat around the base of *Spartina* stems along the edge of salt marshes, Philo Brice Islands and elsewhere in the bay.

Rhizoclonium kerneri Stockmayer. On pilings just below the blue-green band, Philo Brice Islands and elsewhere in the central and southern parts of the bay, and around the base of black mangrove aerial roots.

Rhizoclonium kochianum Kützing. Mixed with other loose algae on the seagrass flats along the south side of Casse-tete and Calumet Islands, year around.

Rhizoclonium riparium (Roth) Harvey. Throughout Timbalier Bay on virtually all substrates in the intertidal zone and loose in salt marshes and on the seagrass beds.

Rhizoclonium tortuosum Kützing. Forms a central band on aerial roots of black mangroves on the north side of Casse-tete Island and on oyster shells and waterlogged planks in the intertidal zone. Some plants of this species had rows of empty cells each with a lateral protuberance, apparently pores through which gametes or spores had escaped.

Cladophora dalmatica Kützing. On shells in Little Timbalier Pass near the eastern end of Timbalier Island.

Cladophora delicatula Montagne. Abundant as an epiphyte of *Halodule* and many larger algae along the south side of Casse-tete and Calumet Islands, year around.

Cladophora gracilis (Griffiths) Kützing. Around the bases of *Spartina* at the edge of salt marshes around the Philo Brice Islands and elsewhere in the lower part of the bay.

DISCUSSION

The relative richness of the benthic algal flora of Timbalier Bay is indicated by a comparison with other areas of the Gulf and nearby areas as summarized in table 1. The algal diversity of Timbalier Bay, 83 known species, is noteworthy in comparison to records of only 53 around the

TABLE 1 -- COMPARISON OF THE BENTHIC ALGAE OF TIMBALIER BAY WITH OTHER HABITATS AND AREAS OF THE GULF OF MEXICO AND NEARBY REGIONS

Locality	Cyanophyta		Rhodophyta		Phaeophyta		Chlorophyta		Total Species	Reference
	Species	Percent	Species	Percent	Species	Percent	Species	Percent		
Timbalier Bay	26	32	17	21	12	15	28	33	83	This paper
Louisiana Offshore	22	17	38	29	23	17	49	37	132	Mueller 1976; Kapraun 1974
Chandeleur Island	4	7	26	49	11	21	12	23	53	Humm/Darnell 1959 Mullahy 1959
Mississippi Sound	16	25	24	37	13	20	12	18	65	Humm/Caylor 1957
Port Aransas Area	16*	16	51	51	12	12	21	21	100	Edwards/Kapraun 1973
Anclote Estuary	20	14	59	42	19	13	42	30	140	Ballantine/Humm 1975; Hamm/Humm 1976
Alacran Reef	21	11	79	40	29	15	69	35	198	Kim 1964
Biscayne Bay	32	10	151	47	43	13	96	30	322	Humm 1964, 1976
Gulf Region "D"	21	16	42	32	24	19	43	33	130	Earle 1972
Gulf of Mexico	26	4	325	53	82	13	173	28	617	Earle 1972

*Based on present author's estimate since Edwards and Kapraun (1973) did not include Cyanophyta.

Chandeleur Islands, 65 in Mississippi Sound, and 100 for the Port Aransas, Texas, area. In fact, 63% of all species recorded for the Louisiana coast have been found in Timbalier Bay.

The estuarine habitats of the localities given in table 1 are characterized by the high percentage of Cyanophyta, ranging from 14% in the Anclote River estuary (at Tarpon Springs, Florida) to 32% in Timbalier Bay. The high salinity habitats are characterized by a high percentage of Rhodophyta in the following order: the Gulf of Mexico as a whole, the Port Aransas area, the Chandeleur Islands (east of the Mississippi delta), and Biscayne Bay at Miami. Only 5% of all the Rhodophyta known for the Gulf of Mexico have been found in Timbalier Bay, but nearly all the Cyanophyta were found. The total number of species of Cyanophyta recorded previously for the entire Gulf of Mexico (Earle 1972) and in this work for Timbalier Bay are the same, 26 species. However, several species are known for the Gulf that have not been found in the bay, and vice versa.

There are about 10 species of algae missing from the Timbalier Bay records whose known distribution is such that it seems they should grow in the bay. These species include the following:

Vaucheria (Xanthophyta, Vaucheriales) is a genus specifically adapted to the environment of the bay. Several species of *Vaucheria* are expected to be present within the bay. Reproduction in *Vaucheria*, essential to species determination, is usually restricted to the winter-spring season in the Gulf of Mexico.

Caloglossa leprieurii (Rhodophyta, Ceramiales) is another species that is highly adapted to bay conditions. It probably is present on the aerial roots of black mangroves, on intertidal woodwork, around the bases of *Spartina*.

Enteromorpha linza (Chlorophyta, Ulvales) is a winter-spring species in the Gulf of Mexico that is sufficiently tolerant to grow in lower Timbalier Bay.

Ectocarpus siliculosus (Phaeophyta, Ectocarpales) is a winter-spring species in the northern Gulf of Mexico and should occur in lower Timbalier Bay.

Fosliella (Rhodophyta, Cryptonemiales) is a common epiphyte on seagrass leaves. However, it was not found on leaves of *Halodule* in southern Timbalier Bay. It may invade the lower bay during favorable seasons, however, and from one to three species are to be expected.

Ceramium (Rhodophyta, Ceramiales) is a common epiphyte of seagrass leaves. Although not yet found on the seagrass leaves in southern Timbalier Bay, *C. byssoideum* and *C. fastigiatum* are to be expected there during favorable seasons.

Intertidal zonation

Although a detailed study of intertidal zonation was not made in Timbalier Bay, some general observations were made. Two species of algae mark the highest intertidal band in the bay, the blue-green *Calothrix crustacea*, and the green *Pseudoendoclonium marinum*. In the southern part of the bay, *Pseudoendoclonium* appears to form a slightly higher band where shading occurs, as on stems of the salt marsh grass, *Spartina*. It also occurs under bridges and on the north side of pilings. In exposed places, *Calothrix* is the highest alga, forming a band known as the "black zone" (Stephenson and Stephenson 1952), which has often been mistaken as a high tide stain caused by an oil spill.

Below the *Calothrix-Pseudoendoclonium* zone, *Microcoleus lyngbyaceus* is the dominant alga on treated pilings and woodwork. It tolerates the toxic compounds that leach from creosoted pilings better than any other species, with the result that it may be the only alga on the newer or more heavily treated intertidal wood.

On substrate suitable for its attachment, *Bostrichia radicans* forms the second highest band. *Bostrichia* does not tolerate creosote or other treated wood nor does it attach to smooth surfaces.

Below the *Bostrichia* or *Microcoleus* band, a green zone is present consisting of tufts of *Enteromorpha* and *Ulva*. They will grow on treated pilings that have been in the water for some time. A variety of blue-greens is also present beneath *Enteromorpha* and *Ulva* or between the tufts as well as upon the barnacles and oysters that are present at this level.

Below the green band is a fourth but poorly developed zone dominated by red algae as scattered plants or patches. *Polysiphonia hemisphaerica* is a common constituent of this band in the southern part of the bay from Philo Brice Islands southward. North of Philo Brice, *Polysiphonia subtilissima* is common in this low intertidal position.

In southern Timbalier Bay aerial roots of black mangroves exhibit a distinct intertidal zonation involving several species of algae. On the upper part of the tallest roots of the black mangrove, *Pseudoendoclonium marinum* formed a dark green band or patches 25 to 50 mm wide. Just below this zone near the central part of most roots, *Rhizoclonium tortuosum* formed a dense gray-green fuzz over a vertical band 8 to 12 mm high, along with *Entophysalis conferta* as an epiphyte. Below this band and downward to the soil surface, *Rhizoclonium riparium* was the dominant alga in a narrow zone that included several species of blue-greens and small patches of *Rhizoclonium kerneri*.

CONCLUSIONS

The distribution of the benthic algae in Timbalier Bay is apparently a product of the natural environment, which has not been significantly affected by the activity of the petroleum industry except possibly locally and temporarily. Oil spills soon spread widely in the bay so that areas distant from the wells are affected about as much as those close to the spill. In order to compare, qualitatively, the algal flora of Timbalier Bay with other similar bays of the Louisiana coast in which there is no petroleum activity, collections were made along the Louisiana coast from Timbalier Bay westward to Sabine Pass and the Texas border, including collections at various seasons in Atchafalaya Bay, Cote Blanche Bay, Vermilion Bay, and along the Gulf coast. Only two species were found that were not recorded from Timbalier Bay.

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