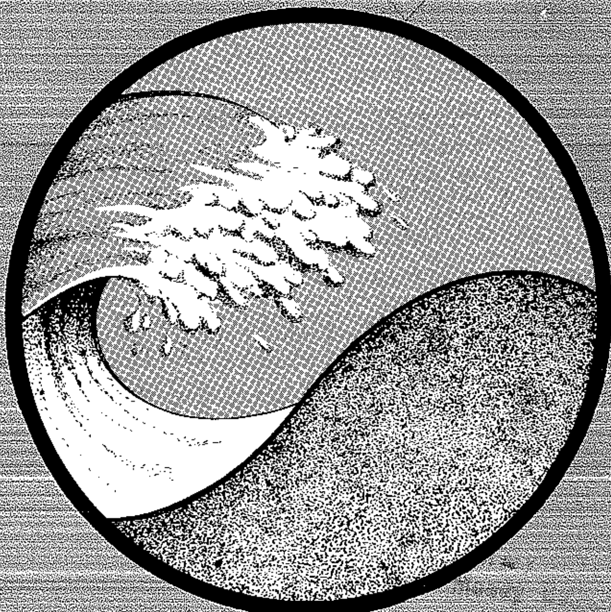
LITORALIA

AN INTERNATIONAL JOURNAL FOR THE COASTAL SCIENCES



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LITORALIA

Statement of Purpose

Litoralia, an International Journal for the Coastal Sciences, is dedicated to all aspects of coastal research. These include geology, biology, geomorphology (physical geography), climate, littoral oceanography, hydrography, coastal hydraulics, environmental (resource) management, engineering, and remote sensing. Although each field functions effectively within its own purview, the cross-disciplinary nature of coastal studies requires familiarity with other fields as well. Hence, the scope of topics is necessarily broad in order to address the complexity of coastal biophysical and socio-economic interactions. Because of the wide range of interrelated topics, the journal invites original contributions and manuscripts dealing with theory, methodology, techniques, and field or applied topic studies on interdisciplinary control issues.

The journal encourages the dissemination of knowledge and understanding of the coastal zone by promoting cooperation and communication between specialists in different disciplines. Natural scientists, for example, are encouraged to collaborate with professionals in other fields to prepare contributions relating to the coastal zone that foster increased appreciation of coastal environments and processes. By means of this journal, with its scholarly and professional papers, systematic review articles, book and symposia reviews, communications and news, and special topical issues, an international forum for the development of integrated coastal research is provided.

Call for Papers

Papers are invited for review by the Editor and the Editorial Board. Please address all queries and editorial correspondence to the Editor-in-Chief, Charles W. Finkl, Ph.D., Coastal Education and Research Foundation (CERF), Center for Coastal Research, P.O. Box 2473, Colee Station, Fort Lauderdale, FL 33303.

Subscriber Information

The subscription rate for one year is $96 for institutional subscribers and $48 for personal subscribers.

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EDITORIAL

Name, Scope, and Associations of the Journal

The volume of technical information now increases at a rate of 13 percent each year. At this rate of production the information data base doubles every 5.5 years. Under these circumstances it is becoming increasingly difficult for researchers in specialized fields to command the world literature. In cross-disciplinary fields such as coastal studies it is often difficult for authors to place their papers in journals that are closely reviewed by diversified audiences. There has always been broad interest in coastal topics and with the advent of this new international journal we hope to provide a forum for multidisciplinary studies in coastal regions. The launching of this new journal is, in a way, a measure of the continuing development of coastal studies and the rapid deployment of newly developed tenets that serve practical applications.

In addition to the maritime nations with close links to the sea, there are industrialized societies, as in the United States, where three-quarters of the population lives in the coastal zone. Everything considered, nearly half of the world's population lives near the coast. An expanding population base with such close ties to the coastal zone is the basis for ever-increasing interest in coastal environments. As sites for urban growth, industrialization, commerce, recreation, national defense, and habitat preservation, the coastal zone requires closer study for greater understanding of natural processes and human interaction. More information and warning, for example, are needed against hazards associated with storm surges, tropical and extra-tropical cyclones, tsunamis, tidal "singularities," and pollution. Littoral environments are particularly fragile and need specialized knowledge.

The title of the journal, "LITORALIA," is derived from the Latin term "litus" for coast. "Litoralis," which means 'of the shore,' in English is spelled "littoral" (both the noun and the adjective) with two t's. "Litterulae" means 'short notes' and perhaps we can combine the ideas. It is our international intention that caused the Latin style to be favored. One of the founders of modern stratigraphy, John Woodward, writing in 1695, observed that the naturalists of the day recognized the creatures of the nearshore belt as the "littorales," in contrast to the open-sea creatures, the "pelagiae." Both the substrate and its organic population are thus encompassed by our term.

This quarterly journal is, in part, an outgrowth of the newsletter (by the same name) for the Commission on Quaternary Shorelines of the International Union for Quaternary Research (INQUA). The newsletter will continue, under the able guidance of Douglas R. Grant, as an information bulletin. We thank Dr. Grant and the INQUA Shorelines Commission for allowing us to adopt the name "LITORALIA" for our title.

LITORALIA is published in collaboration with several national and international research organizations, including:

- The Coastal Society (US)
- The International Geographical Union (IGU) Commission on the Coastal Environment
- International Geological Correlation Program (supported by the International Union of Geological Sciences and UNESCO)
  Project No. 200—Sea Level Correlations and Applications
- International Union for Quaternary Research (INQUA)
  Commission on Quaternary Shorelines
  The Holocene Commission
  The Neotectonics Commission
- International Association of Meiobenthologists

News of their activities will be published as a regular feature, particularly reports of meetings, symposia, field excursions, and calendars of events.

An international board of editors, all of them respected scientists in the various specialized fields of coastal science, supported by the technical staff of the Van Nostrand Reinhold Publishing Company, will ensure publication of a quality journal with scientific standards of excellence.

—*Charles W. Finkl*
Editor-in-Chief

LITORALIA CALENDAR

September 1983

Sept. 21-22 **Estuarine and Brackish-Water Sciences Association** Symposium, Heriot-Watt University, Hugh Nisbet Bldg., Riccarton Campus, Edinburgh, Scotland.

November 1983

Nov. 13-17 36th Annual **Gulf and Caribbean Fisheries Institute,** Hilton International Trinidad, Port of Spain, Trinidad and Tobago.

Nov. 28-Dec. 2 Special Short Course in **Port Planning and Development,** Massachusetts Institute of Technology, Rm 5-230, Cambridge, MA 02139. Phone 617/253-4330.

January 1984

Jan. **Natural Formation Processes and the Preservation of Submerged Archaeological Sites** Symposium, 15th Annual Meeting of the Council for Underwater Archaeology, Williamsburg, VA. R. J. Ruppe, Department of Anthropology, Arizona State University, Tempe, AZ 85287.

Jan. 16-21 **Central Atlantic Ocean & its Continental Margins,** a Penrose Conference and field trip by the Geological Society of America, Giens, France. Jean Sougy, Laboratoire de Geologie Dynamique, L.A. CRNS n° 132, Faculte des Sciences et Techniques de Saint-Jerome, 13397 Marseille Cedex 13, France.

Jan. 19 Society of Naval Architects & Marine Engineers' **Chesapeake Marine Engineering** Symposium. Sheraton National Hotel, Arlington, Virginia. LCDR Ken Smith, USN, 3034 Choctaw Ridge, Woodbridge, VA 22192.

Jan. 23-27 **Ocean Sciences** meeting, New Orleans, LA. American Geophysical Union, 2000 Florida Avenue, NW, Washington, DC 20009.

March 1984

Mar. 2-6 **Modern and Pleistocene Shelf Carbonates of Belize,** field seminar, Belize, Central America. Lola Igou, Permian Basin Graduate Center, Box 1518, Midland, Texas 79702. Phone: 915/683-2832. Included: overflight of reef tract, shallow and deep back-reef lagoon and atolls, clastic dominated shorelines, and tropical karst.

Mar. 12-15 **Marine Mineral Resources** short course, London. D. S. Cronan, Department of Geology, Imperial College, London, SW7.

Mar. 13-15 **Marine data** symposium by US Navy and Society of Exploration Geophysicists. J. A. Ballard, NORDA, MS 39529, NSTL Station, Miss. 39529. Phone 601/688-4760.

Mar. 17-23 **Offshore Mineral Resources** Seminar, Brest, France. Louis Galtier, Association Germinal, B.P. 6009, 45060 Orleans, Cedex, France.

April 1984

Apr. Americas Subcommission, **Neotectonics and Sea Level Variations in the Gulf of California Area.** Co-sponsored with International Union for Quaternary Research Neotectonics Commission. J. C. Guerrero G., INQUA Symposium, Instituto de Geologia, UNAM Cd Universitaria, 04510 Mexico, D.F., Mexico.

Apr. 23-May 5 **Modern and Ancient Clastic Tidal Deposits in Western Europe,** meeting and field trip, Utrecht, the Netherlands. Comparative Sedimentology Division, Institute of Earth Sciences, Budapestlaan 4, 3584 CD Utrecht.

Apr. 24-27 Pacific Congress on **Marine Technology.** PACON 84, Center for Engineering Research, University of Hawaii, Honolulu, HI 96822.

Apr. 30-May 3 Annual Meeting. **Offshore Technology,** Houston, Texas. Dennis Kennedy, Offshore Technology Conference, 6200 North-Central Expressway, Dallas, TX 75206. Phone: 214/361-6606.

May 1984

May 14-18 **American Geophysical Union,** spring meeting, Cincinnati, Ohio. A.G.U. headquarters, 2000 Florida Avenue NW, Washington, D.C. 20009. Phone 202/462-6903.

May 23-25 **American Association of Petroleum Geologists and Society of Economic Paleontologists & Mineralogists,** annual meeting, San Antonio, Texas. AAPG headquarters, Box 979, Tulsa, OK 74101. Phone: 918/584-2555.

June 1984

June 15-17 **Sedimentology of Nearshore & Shelf Sands & Sandstones,** symposium, Calgary. R. John Knight, Petro-Canada, Box 2844, Calgary, Alberta, Canada, T2P 3E3.

June 16-20 **The Bahamas,** symposium and field trips, San Salvador Island, Bahamas. James W. Teeter, Department of Geology, University of Akron, Akron, Ohio 44325. Phone: 216/375-7631.

August 1984

Aug. 4-14 27th International Geological Conference, session C.03.1.3: **Fluctuations of Ocean Level and Quaternary Paleoclimates,** cosponsored with International Geological Correlation Program (Project 200). Prof. Paul Kaplin, Faculty of Geography, Moscow State University, Moscow 117234 USSR.

Aug. 6-9 Society of Economic Paleontologists and Mineralogists Research Conference, **Fine-Grained Sediments,** San Jose, California. Donn S. Gorsline, Department of Geological Sciences, University of Southern California, Los Angeles, CA.

September 1984

Sept. 1-7 25th International Geophysical Congress, field symposium of the

IGU Commission on **Coastal Environments.** Prof. Roland P. Paskoff, 10, Square Saint-Florentin, 78150 Le Chesney, France.

Sept. 3-7 **Clastic Tidal Deposits,** short course, Utrecht, the Netherlands. Comparative Sedimentology Division, Institute of Earth Sciences, Budapestlaan 4, 3584 CD Utrecht.

Sept. 15-21 International Union for Quaternary Research Subcommission field conference, **North Sea Coastal Zone Between Jade Bay and Jammer Bight.** H. Streif, Niedersachsisches Landesamt für Bodenforschung, Stilleweg 2.

Sept. 30-Oct. 6 Americas Subcommission, **Late Quaternary Sea Level Changes and Coastal Evolution,** symposium and excursion with International Geological Correlation Program (Project 200). Dr. E. Schnack, Centre de Geolosia de Costas, C.C 722, Correo Central. 7600 Mar del Plata, Argentina.

October 1984

Oct. 7-12 Americas Subcommission, **Buenos Aires Coastal Plain and Northern Patagonia Coast** field meeting. Dr. E. Schnack, Centre de Geolosia de Costas, C.C. 722, Correo Central. 7600 Mar del Plata, Argentina.

May 1985

May 27-June 1 Fifth International **Coral Reef Conference.** Antenne Museum EPHE, Congres Recifs Coralliens 1985, B.P. 562, Papeete, Tahiti, Polynesie Francaise.

September 1985

Sept. 8-15 The Eighth International Conference on **Port and Ocean Engineering Under Arctic Conditions.** Danish Hydraulic Institute, Agern Alle 5, DK-2970 Horsholm, Denmark. Phone: 45-2-86-80-33, Cable: Hydroinstitute, Telex: 37402 DHICPH DK.

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Alternate Interpretations of Barrier Island Evolution

Apalachicola Coast, Northwest Florida

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ABSTRACT

The transgressive-regressive sequences of two Quaternary (Sangamon and Late Holocene) high sea level episodes were identified in numerous island, lagoon, and mainland drillholes from Apalachicola area core samples. As elsewhere on the Gulf coast, no conclusive indications of a Mid-Wisconsin (Farmdalian?) higher sea level stand had been preserved in marine units. By the use of biotope profiles, based on abundant salinity-sensitive foraminifer taxa, and strandplain configurations, it is suggested that all four original islands (including now-relict "Little St. George" Island) evolved through shoal aggradation in the Late Holocene. Seasonally alternating strong fresh and salt water influences on the microfauna account for the smaller salinity range of biotopes. In contrast with the Mississippi Sound area, very low and relatively high salinity biotopes occupy smaller areas, and intermediate salinity foraminifer biotopes dominate. Consequently, modern Apalachicola area lagoonal sediments generally show smaller contrasts in biotope salinities (with underlying units that formed before the islands were established), than do surface units in other nearshore areas (e.g., Mississippi Sound) with lesser stream runoff. The extent of subsequent lateral or seaward progradation depended on the spatial relationship with stream and littoral drift-sediment sources and on shelf bottom configurations. St. Vincent and "Little St. George" islands became strandplain (beach ridge plain) islands, while narrow Dog and St. George islands acquired an essentially linear character. Alternate theories (spit segmentation and mainland beach detachment-migration) offer far less convincing genetic explanations for these islands.

Key Words: Apalachicola Coast, Barrier Islands, Beach Ridge, Biloxi Formation, Gulf Coast, Gulf Port Formation, Holocene Deposits, Lagoonal Settlements, Sea Level.

Three barrier islands off the eastern Florida Panhandle enclose a chain of 1 to 12-km wide lagoonal embayments (St. Vincent Sound, Apalachicola Bay and St. George-Dog Island Sound), each isolated by shoals. Mean depths range between 1.2 and 3.3 m (Gorsline 1963). Substantial fresh water volumes (2 to 10 thousand m^3/sec; 3,530 m^3/sec mean discharge; [USGS] file data) reach the Bay through a sizable delta of the Apalachicola, second largest river on the northeast Gulf. The Carrabelle River, opposite Dog Island, carries insignificant amounts of fresh water. Late Pleistocene mainland barrier (Gulfport Formation) and units of probably alluvial origin front the mainland shore. The two western passes of the lagoonal system toward the Gulf are deeper (9 to 16 m) than the eastern ones (6 to 7 m maximum depths).

Triangular-shaped St. Vincent Island is about

15 km wide and extends about 7 km seaward. Dog and St. George islands, 1.5 km at the widest, narrow to 150 m and 250 to 600 m, respectively (Fig. 1). 48-km long St. George and 11-km long Dog islands are mostly covered by low sand dunes and sheets, and to a lesser extent by marshes. Subsiding and inundated interridge swales of St. Vincent Island contain large tracts of marsh. Only locally do dune ridges reach 10 m above sea level on east-central Dog Island and Sugar Hill, St. George Island. A sharp, near-perpendicular turn in the mainland and island shorelines at Capes San Blas and St. George and in the shelf contours probably reflects the impact of tectonic lineaments. Such influences on the configuration of the coast are also apparent farther to the west (Otvos 1981b).

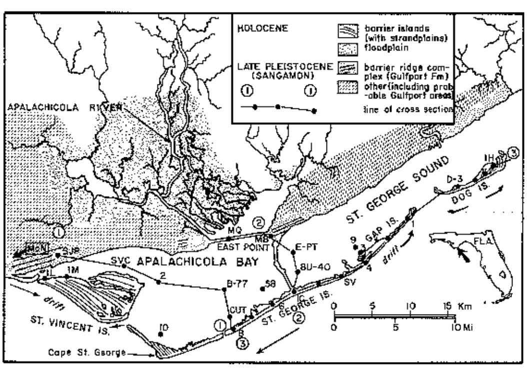

FIG. 1.

Apalachicola Coast Barrier Islands, Eastern Florida Panhandle. Surface Geology and Drillhole Locations. McN-Direction to Corehole at McNeils.

The lagoonal system is of the lower microtidal range (0.4 to 0.8 m), much affected by the intensities, durations and directions of winds. Salinities grade from less than 5 ppt at the delta front, 15 to 30 ppt by the passes. Seasonal variations in stream runoff and onshore winds greatly influence the yearly salinity range, which in central Apalachicola Bay may reach 25 to 30 ppt (Dawson 1955; Gorsline 1963; Livingston 1979). Two divergent, northeast and southwest-oriented shore littoral drift systems of unequal magnitude exist both on St. George and Dog islands (Stapor 1971). Sediment presently is eroded from the east St. Vincent, central Dog Island (Stapor 1971) and east-central St. George Island shore segments (U.S. Army 1971, p. d-125). Nearshore gulf bottoms, including Pleistocene and Holocene shelf sands, may also supply sand to prograding island segments. This is indicated by the continued integrity of St. George and Dog islands, despite the divergence of drift systems along their center (Fig. 1). The marsh-fringed "low energy" sector, immediately east of the subject area, provides no sand to the islands through littoral drift.

No quantitative information exists as to how much Apalachicola sand bypasses the lagoonal sediment sink and reaches the Gulf shores. There is little doubt, however, that resuspension of bay bottom sediments during heavy weather and wind-induced, ebb-tidal and river flood currents are instrumental in the process.

RESEARCH METHODS

During 1980-1981, 23 rotary core holes were drilled by Gulf Coast Research Laboratory on St. George and Dog islands, in Apalachicola Bay and St. George Sound, as well as on the adjacent mainland shore. In these rotary drillings, 45-cm long, 3.8-cm diameter split-spoon cores were taken on the average at 105-cm intervals with recovery rates of generally between 60 and 100%. Drill samples, obtained earlier by Schnable (1966) and preserved at Florida State University, were also included in the sediment studies. This supplemental material included three continuously drilled core sequences (Drillholes MQ, IC, and ID) and wash-boring samples from 13 mainland and island locations.

Grain size analyses, statistical sediment texture calculation and microfauna preparation on several hundred samples were performed at the Gulf Coast Research Laboratory. Granulometric data helped in identifying various units. Offshore marine and lagoonal deposits tended to be of muddy-sandy composition. The shoreface sands that immediately underlie intertidal island deposits and form the barrier platform (Otvos in press) usually were poorly-to-moderately sorted (inclusive graphic standard deviation: 0.71 to 2.00). Moderately good-to-very-good sorting ($\sigma_I = 0.35$-0.71) characterized the inter- and supratidal island sands (Fig. 2). As done earlier in other barrier systems, foraminifer faunas of several hundred samples were analyzed and integrated into cross sections. Foraminifer assemblages, with their known individual and specific abundance and sensitivity to salinity variations proved to be by far the best adapted fossil group for the study of changing Holocene facies conditions. When available, 300 to 400 specimens were identified in each sample. The Mississippi Sound and adjacent Gulf area has long provided a good testing ground (Phleger 1954; Walton 1960; Otvos 1981a, in press). The most brackish nearshore area of the Sound (with a salinity range of 4-26 ppt) supports an *Ammotium salsum-Ammonia beccarii* assemblage of few species (Table 1; P-1). *Ammonia beccarii, Elphidium* and several other species dominate the next moderately brackish zone (P-2). Farther seaward, in a biotope where salinities range between 16 and 30 ppt, *Nonion, Nonionella, Buliminella* species, *Hanzawaia strattoni* and *Rosalina columbiensis* play increasingly greater roles. The last two species are dominant in the inner neritic facies outside the islands. *Bigenerina irregularis* becomes an important fauna component (Table 1) as species diversity further increases seaward. Late Holocene development of Mississippi and Santa Rosa sounds, due to barrier island evolution (Otvos 1981a, 1982, in press), was marked by deposition of highly-to-moderately brackish sediments over higher salinity open nearshore marine deposits (Table 1).

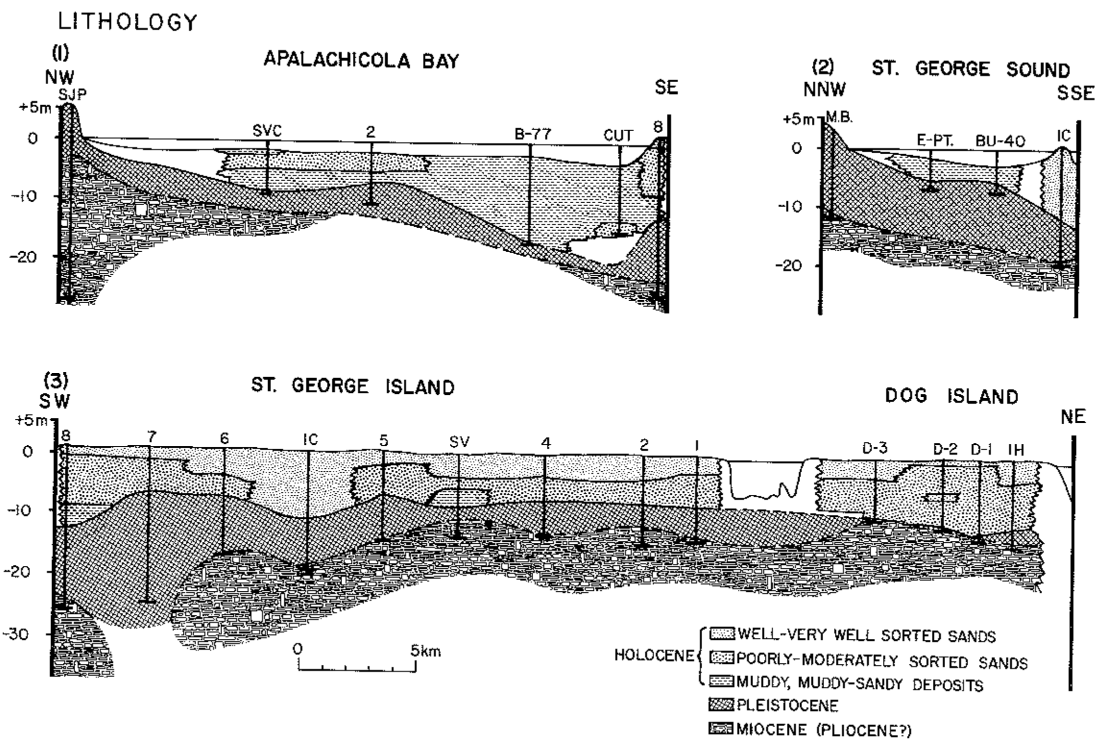

FIG. 2.

Cross Sections through Apalachicola Bay and St. George Sound; St. George and Dog Islands. Lithology of Holocene Units.

PREVIOUS WORK, PRESENT PURPOSE

The earliest detailed paper on the coastal geology of the Apalachicola Bay area dealt primarily with recent shelf and lagoonal deposits (Kofoed and Gorsline 1963). Stapor (1971, 1975) discussed sediment budgets in longshore drift cells as well as the morphology and ages of island beach ridges. Schnable (1966) was the first to drill in limited areas of the three present islands and the adjacent mainland coast in order to establish the regional stratigraphy. Detailed descriptions and thoughtful interpretation of the drill samples characterized his dissertation, later summarized by Schnable and Goodell (1968). The present work centered on the Quaternary evolution of St. George and Dog islands, lagoonal and immediately adjacent mainland areas, with a much expanded drillhole coverage. My purpose was to compare barrier island formation conditions with those of other northeast Gulf Holocene barrier island systems (Otvos 1981a, 1982a,b) and to learn more about the Quaternary evolution of the Apalachicola Coast.

STRATIGRAPHY

Pre-Quaternary Neogene

Sandy and clayey, consolidated biogenic limestones and poorly consolidated calcarenites were encountered below the Pleistocene units at particularly shallow depths under the land surface in the northeast. While a Miocene Choctawhatchee age has earlier been assigned to the upper part of the calcareous sequence (Schnable 1966; Schnable and Goodell 1968), it has been recognized since (Akers 1972; Schmidt and Clark 1980) that, in adjacent Bay County, limestone deposition did not terminate with the late Miocene regression. Based on planktonic foram zones, the upper member of the Intracoastal Formation and the Jackson Bluff Formation had been assigned to the Pliocene. Lateral continuity of the strata strongly suggests that correlatable units are also present in the Gulf and Franklin Counties subsurface. Recent reexamination of a sample from 6-m depth in Schnable's Drillhole MG at Lanark, Franklin County, produced taxa present both in Upper Miocene and Lower Pliocene foram ranges *(Globigerina nepenthes, Globorotalia acostaensis* and *G. menardi).* According to Huddlestun's studies of planktonic foraminifers (written comm.), in the Apalachicola Embayment the upper part of the calcareous sequence is of late Pliocene age. No trace of the mid-late (?) Pliocene Citronelle Formation, present at some distance inland on the Panhandle mainland, had been encountered.

Pleistocene

Intensive dissection of the limestone terrain west of Apalachicola resulted in widely varying Pleistocene thickness values. At Cape San Blas (Schnable 1966) the Pleistocene is 45.6-m thick, but thins to a few meters and less toward the northeast (Carrabelle-Lanark area), where Neogene limestone nearly reaches the surface (Schnable 1966). In the lower part of the Pleistocene sequence between Cape St. Blas-Apalachicola on the mainland and southwest St. George Island, sandy silts, silty sands, poorly sorted sands and granular, fine-to-medium sands were deposited with occasional woody matter. The sediments fill deeply incised channels, considerably east of the present Apalachicola River. These beds generally contain no brackish or marine fossils and apparently are fluvial in origin. A thin unit of the Biloxi Formation does underlie the fluvial deposits in Drillhole No. 8, St. George Island, while thin Biloxi Formation units interlayer with them in adjacent Drillholes Nos. 6 and 7.

Biloxi Formation

This coastal marine unit is correlatable along the entire northern Gulf coast and was deposited during the transgressive-regressive cycle of the Sangamon Interglacial (Otvos 1981a,b). Best preserved in the Apalachicola area in Drillholes McN (mainland), IC and ID (St. George Island), its muddy-clayey fine sands and sandy muds were deposited in open-nearshore environments, influenced to differing

TABLE 1
Mississippi and Florida Panhandle Coast Holocene Foraminifer Assemblages from Drillcore Samples, in Percentages

	Mississippi Sound, Miss.			Gulf Bottom, Of Horn Is. Pass, Miss. (off Miss. Sound)	8.5 km Seaward Of Mobile Bay Entrance,	Santa Rosa Sound, Fla. corehole S of Buoy #133 corehole (Otvos 1982, Fig. 3—Line B)	
Drillhole, depth interval	P-1 2.1 m (bottom)	P-2 5.3-5.9 m	P-3 4.9 m (bottom)	< SS-10 14.1 m	SG-27 12.6 m	2.1 m (bottom)	5.7-5.8 m (open nearshore)
Major Species							
Ammotium salsum	53.1	2.0	1.6	—	1.1	21.5	—
Ammobaculites exiguus	18.5	0.9	—	—	—	—	—
Elphidium galvestonense	1.2	6.4	6.9	3.2	11.1	19.0	2.8
E. incertum mexicanum	1.2	1.2	3.4	1.8	7.4	2.5	19.4
E. gunteri	3.7	1.3	—	—	—	—	—
E. delicatulum	—	—	0.5	—	—	—	—
E. latispatium pontium	—	—	—	—	—	—	—
Ammonia beccarii parkin.	6.2	1.2	3.9	1.5	3.4	31.6	2.8
A. b. tepida	9.9	67.4	36.1	21.3	26.9	22.8	8.3
Nonion depressulum matag.	2.5	3.5	5.3	3.2	1.1	—	—
Nonionella atlantica	—	—	2.1	2.4	1.4	—	—
N. opima	—	3.4	3.6	2.1	0.6	—	—
Buliminella elegantissima	—	4.3	4.5	1.5	1.7	—	—
Cribroelphidium poeyanum	2.5	—	1.9	1.5	3.4	1.3	5.6
Buccella hannai	—	—	0.5	—	0.3	—	5.6
Quinqueloculina sp.	1.2	—	4.4	8.1	8.3	—	2.8
Brizalina lowmani	—	1.2	2.1	1.8	0.6	—	2.8
Hanzawaia strattoni	—	1.9	7.8	20.1	9.3	—	41.7
Rosalina columbiensis	—	—	1.5	6.2	5.1	—	2.8
Bigenerina irregularis	—	—	—	4.7	1.7	—	—
Globigerinoides ruber	—	—	—	1.2	0.6	—	—
Sagrina pulchella primitiva	—	—	—	1.5	—	—	—
Guttulina australis	—	—	—	1.5	1.1	—	—
Globigerina bulloides	—	—	—	0.6	—	—	—

Locations: Otvos 1981a, 1982, in press; Depths: below sea level.

degrees by fresh water runoff from the mainland. Dominant foraminifer species included *Nonion depressulum matagordanum, Cribroelphidium poeyanum, Ammonia beccarii, Elphidum incertum mexicanum, E. galvestonense, Buliminella elegantissima, Rosalina columbiensis* and *Textularia mayori.* The last two species dominated the Formation in Drillholes IC and ID, reflecting deposition farthest offshore of all the analyzed Biloxi intervals. Due to landward shift of the delta during the high Sangamon sea level stage, salinities at the same locations were significantly higher than in the Holocene just before island formation.

In mainland drillholes SJP and McN, the Formation overlies the Pleistocene fluvial beds at 23 and 24 m (Fig. 2), indicating at the deepest level the arrival of the Sangamon transgression. As in the Santa Rosa area ("leached" Biloxi unit; Otvos 1982) and elsewhere, diagenetic changes eliminated almost all calcareous forams in the majority of drill holes. Fossiliferous intervals are thus represented only by *Ammonia beccarii* and/or *Ammotium salsum* tests, as well as unidentifiable tests with chitinous lining, diatoms and sponge spicules. While leaching severely affected the Biloxi sequence in Drillhole SJP (Fig. 1), foraminifera in Drillhole McN (7 km to the southwest, 1.1 km inland) were untouched by alterations.

Gulfport Formation

This barrier complex, that prograded on the mainland shore during high stand of the Sangamon Interglacial, overlies the Biloxi Formation and consists of 6 to 15 m of well-to-moderately sorted sands that form intermittent strandplain strips on the present mainland shore. This Formation is almost as widespread along the Gulf as the Biloxi Formation is. Absence of the ridge-and-swale topography west of Apalachicola and east of East Point where the land surface is even, may locally be attributed to variations in vegetative cover, ground water conditions, littoral sand supply and/or microclimate in dune ridge formation on beach sets during strandplain development (Otvos 1981a).

Schnable and Goodell (1968) had subdivided the Pleistocene sediments into a lower (Sangamonian) and an upper sequence. Based on finite radiocarbon dates from 11 wood samples (between 23.8 and 40.3 thousand yrs apparent ages), they attributed most of the presently defined Biloxi and all of the Gulfport sequence to a Mid-Wisconsin ("Silver Bluff") transgression and higher sea level stand. Seven of the dates, some with strongly inverted depth-age relationships (Schnable 1966, Appendix D) come from mainland Drillholes MK, and MN, adjacent to our Drillholes SJP and MB, respectively. The thick transgressive-regressive sequence, that include Schnable's dated intervals, is capped by the Gulfport sands, indicative of the high Sangamon Interglacial sea level, and not a brief episode of a much lower sea level stand. Drilling data of the time do not support the existence of a separate transgressive sequence that postdates Sangamon units. Nor has marine sedimentary evidence of a broader, regional Wisconsin transgression yet been documented in the subsurface under other Gulf shore segments. The cited finite dates appear to have been artifacts of contamination.

Holocene

(1) Development Prior to Island Formation

With the exception of Drillholes IC and ID, in all island drillholes the Holocene sequence starts with muddy, clayey fine sands, poorly sorted sands and fine sandy muds, deposited offshore over the oxidized Pleistocene surface. Differences in color and sediment consistency, as well as "dead" and finite (Holocene) radiocarbon dates, assisted in the distinction between the Pleistocene and the Holocene deposits. A thick Holocene sequence in Drillhole No. 7 outlined a filled Late Pleistocene river channel under St. George Island (Fig. 2). Well-sorted medium, subtidal shoal sands, that overlie the Pleistocene in Drillhole IC, contain rich foraminifer faunas. A fine sandy-clay lens in Drillhole IC indicates temporarily reduced energy conditions. Poorly sorted sands in adjacent Drillhole ID overlie shoal sands, also indicating that no barrier island emerged in these areas at this time. In all other drillholes in the three islands, the basal Holocene units consist of poorly-to-moderately sorted sands and muddy sands. In contrast, moderately well-to-very-well sorted, littoral-supratidal sands form the upper island sands (Fig. 2).

Holocene units that underlie the inter- and supratidal island sands were deposited in moderately brackish environments, dominated by foram species *Ammonia beccarii* (18 to 51%), *Elphidium incertum mexicanum* (2 to 37%), *E. galvestonense* (3 to 50%); to a lesser extent, by *Nonion depressulum matagordanum* and *Cribroelphidium poeyanum.* Higher concentrations of *Quinqueloculina* and *Remaneica* species occurred occasionally (Table 2). Salinities during deposition tended to be slightly higher in the Dog Island and northeast St. George Island area, more distant from the fresh water source. Intermediate brackish facies characterized also the fine sandy muds, clayey, muddy fine sands that underlie the highly brackish modern lagoonal sediments (Fig. 2).

A rich molluscan fauna (Schnable 1966, pp. 148, 150) in the lower Holocene sand sequence in Drillholes IC and ID contained mostly taxa that live in a wide range of salinities (*Anomia simplex, Bellucina amiantus, Corbula contracta, Mulinia lateralis, Nuculana concentrica, Olivella mutica* and others). Only a few typically marine salinity species had been identified (e.g., *Gemma gemma*).

In sharp contrast with salinities of the Holocene depositional environment off the Mississippi-Alabama coast (Otvos 1981a), foraminifer biotopes in the Apalachicola Coast lagoons and bays tend to be more uniform, although a seaward increasing biotope salinity gradient may be noted both in modern lagoonal and preexisting Holocene sediments (Fig. 3, Table 2).

Occasional heavy salt water influx, aided by onshore winds from the Gulf restricted development of the lowest salinity biotope along the mainland shore. The generally small lagoonal widths facilitate this influence. On the other hand, seasonal Apalachicola floodwaters keep the environment unsuited for higher salinity foram assemblages as far as the lagoonal shores of the islands and passes. Consequently, foram faunas of intermediate salinity facies are generally present, not only on bay-sound bottoms, but *also* in open nearshore Gulf areas. Dog Island has recently prograded over deposits that formed in such a setting (Table 2, D-2). Similar foram assemblages prevail under the other islands in general, in sharp contrast with inner neritic biotopes found, in the absence of comparable sized streams, beneath the Mississippi barrier islands (Table 1 and Otvos 1981a).

(2) Island Development

(a) *St. Vincent Island* is an exquisitely preserved island-strandplain that includes at least a dozen beach ridge generations (Fig.4). With the exception of the southernmost ridges in St. Vincent, ridge configuration in this island and "Little St. George" indicate sediment supply through south-east-directed littoral drift from the eroding Pleistocene headland. The oldest segment, eroded since, had emerged probably off the present northeast shore. Drillholes SVC and Apalachicola Bay No. 2 (Table 2, Fig. 1) encountered higher salinity Holocene deposits at a level that predates island initiation. *Nonion depressulum matagordanum* and *Buliminella elegantissima* were well-to-very-well represented in these intervals. Similar, relatively higher salinity open Gulf units in St. Vincent Island Drillholes IL and IM, beneath the third strandplain ridge have the same fauna composition. Indian artifacts found on these ridges suggested their formation by about 3500 BP (Stapor 1975, p. 134). Island emergence blocked marine waters, as reflected in the biofacies of recent lagoonal sediments (Table 2, Fig. 3). However, in contrast with recent deposits in the Mississippi Sound (Otvos 1981a), in the Apalachicola-St. George lagoons *Ammotium salsum* and other highly brackish agglutinated foraminifers are important only in restricted areas. Subsidence, as in the Cat Island, Mississippi, island strandplain (Otvos 1981a), probably resulted from the compaction of clay-bearing units under the strandplain. This process converted swale areas into lagoonal embayments. Stapor (pers. comm.) believes that late Holocene transgression and/or local subsidence may have been the reason for the low strandplain positions. Estuarine intrusion is shown by silty clay that covered some ridges by about 2100 yrs BP (Stapor 1975, p. 134).

TABLE 2
Apalachicola Area Holocene Foraminifer Faunas from Drillcore Samples, in Percentages.

	Drillhole, depth interval			
	Apalachicola Bay			
	SVC		No. 2	
Major Species	**1.52-1.55 m (Sound bottom)**	**2.25-2.28 m (open shore unit)**	**2.1 m (bay bottom)**	**4.40-4.42 m (open shore unit)**
Ammotium salsum	21.0	—	0.6	—
Ammobaculites exiguus	0.9	—	—	—
Elphidium galvestonense	28.7	7.2	38.3	22.5
E. incertum mexicanum	—	0.4	1.5	6.2
E. gunteri	0.3	—	—	—
E. delicatulum	—	0.4	—	—
E. latispatium pontium	0.3	2.3	0.9	1.8
Ammonia beccarii parkin.	33.2	0.4	34.7	4.1
A. b. tepida	10.8	7.3	22.8	21.8
Nonion depressulum matag.	3.4	71.2	0.3	24.1
Nonionella atlantica	—	—	—	0.2
N. opima	—	0.3	—	—
Buliminella elegantissima	—	7.3	—	4.6
Cribroelphidium poeyanum	0.6	1.5	—	9.9
Buccella hannai	—	—	—	3.2
Quinqueloculina species	—	1.0	—	—
Hanzawaia strattoni	—	—	—	0.2
Rosalina columbiensis	—	—	—	0.2
Sagrina pulchella primit.	—	0.3	—	—

	Apalachicola Bay			
	B-77		Cut	
Major Species	**4.57-4.64 m (bay bottom)**	**6.86-6.96 m (open shore unit)**	**3.96-3.98 m (bay bottom)**	**6.40-6.45 m (open shore unit)**
Ammotium salsum	7.0	0.4	—	—
Ammobaculites exiguus	—	—	—	—
Elphidium galvestonense	28.8	15.3	10.1	29.3
E. incertum mexicanum	1.6	—	6.1	5.4
E. gunteri	—	4.2	—	—
E. delicatulum	1.1	1.1	0.2	—
E. latispatium pontium	0.5	2.3	2.8	1.7
Ammonia beccarii parkin.	3.1	12.0	2.0	5.9
A. b. tepida	41.9	18.9	50.0	11.3
Nonion depressulum matag.	8.6	24.6	10.6	15.2
Nonionella atlantica	—	—	0.6	—
N. opima	—	—	—	—
Buliminella elegantissima	0.5	0.6	5.0	0.6
Cribroelphidium poeyanum	5.7	20.0	1.7	29.6
Buccella hannai	—	—	2.4	—
Quinqueloculina species	—	0.4	2.1	—
Hanzawaia strattoni	—	—	—	—
Rosalina columbiensis	—	—	1.8	—
Sagrina pulchella primit.	—	—	—	—

TABLE 2 *cont.*

Major Species	Apalachicola Bay No. 10 4.27-4.37 m (bay bottom)	Apalachicola Bay No. 10 5.18-5.25 m (open shore unit)	Dog Island D-2 4.57-4.65 m	Apalachicola Delta MQ 6.55-6.58 m	Apalachicola Delta MQ 8.66-8.69 m
Ammotium salsum	—	—	—	—	—
Ammobaculites exiguus	0.2	—	—	—	—
Elphidium galvestonense	5.0	7.3	3.4	19.3	19.7
E. incertum mexicanum	2.4	1.1	37.9	—	1.4
E. gunteri	—	—	—	0.4	—
E. delicatulum	—	—	—	—	—
E. latispatium pontium	0.6	0.5	—	—	5.0
Ammonia beccarii parkin.	—	—	—	44.8	12.5
A. b. tepida	59.7	13.2	5.2	26.6	36.3
Nonion depressulum matag.	11.9	43.0	17.2	4.2	13.8
Nonionella atlantica	1.1	0.5	1.7	—	—
N. opima	1.3	—	—	—	—
Buliminella elegantissima	3.5	17.2	—	—	—
Cribroelphidium poeyanum	1.9	2.4	25.9	4.6	6.6
Buccella hannai	3.4	3.2	3.2	—	1.4
Quinqueloculina species	2.1	4.5	—	—	2.7
Hanzawaia strattoni	1.6	0.5	—	—	0.3
Rosalina columbiensis	1.5	1.3	1.7	—	—
Sagrina pulchella primit.	0.2	0.3	—	—	—

Locations: Figs. 1 and 2; Depths below Sea Level.

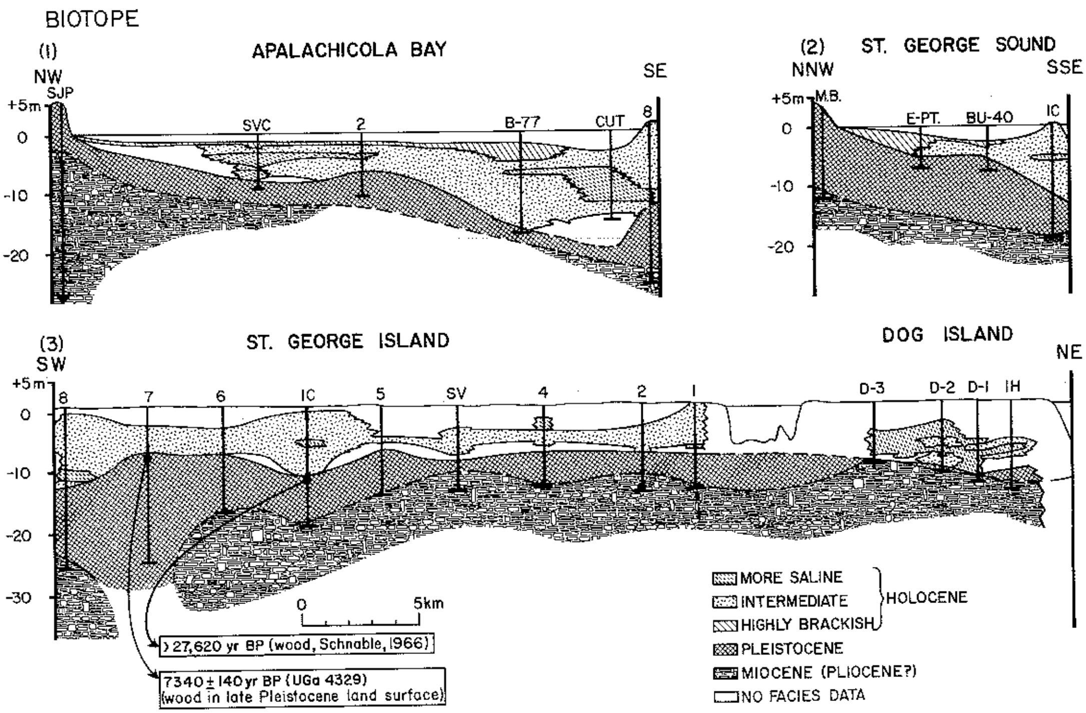

FIG. 3.

Cross Sections through Apalachicola Bay and St. George Sound; St. George and Dog Islands. Biotopes of Holocene Units.

(b) *"Little St. George Island"* at Cape St. George, a triangular-shaped, maximum 3.5-km wide remnant of another, earlier existing strandplain-island, had been incorporated into St. George Island (Fig. 1 and Plate 1). The Gulf beach abruptly truncates the northwestward-curving beach ridges at angles 40 to 70°. These ridges appear to be in continuation of and contemporaneous with the fourth and fifth ridge generations of St. Vincent Island. Apalachicola Bay Drillhole No. 10 (Fig. 1) contained Holocene muddy fine sands between 9 and 7.5 m and clay at 7.5 to 4.2 m below sea level. Emergence of the island that barred sea water was marked by a sudden foram spectrum change between 5.1 and 4.4 m, from a marine open nearshore to a less saline (bay bottom unit) character (Table 2). The *Nonion depressulum matagordanum* content decreased from 43.0 to 11.9%, *Buliminella elegantissima* from 17.2 to 3.5%, with an increase in the *Ammonia beccarii* content from 13.2 to 59.7%. A dated, near-surface peat layer on the bay side (Stapor, 1975, p. 132) sets the island's age as older than 1545 B.P. As in the case of St. Vincent Island, the original island subsided but was even more severely eroded.

(c) *Gap Island,* as Stapor (1975) stated, a spit-like attachment on the Island's Sound shore, represents the oldest part of St. George Island. Seaward-convex beach ridges reflect Gulfward progradation from a core area, eroded away since, and its site covered by the bay. The ridge configuration shows that Gap Island was not a recurved spit attached to the main island, but predated it. St. George Sound Drillhole No. 9 (Fig. 1) in the area of Gap Island's emergence and adjacent drillhole St. George Island No. 3 encountered moderately brackish, moderately sorted fine (shoal) sands at the probable level of island initiation. The greater offshore depths of the Gulf may partially explain why St. George Island did fail to grow by strandplain progradation seaward. The narrow, southwest-northeast-trending island aggraded roughly shore-parallel over a shoal belt. Schnable (1966 p. 117) also believed that the island built itself above sea level, but his drillholes in the "waist" of the island penetrated an island segment that emerged through gradual *progradation* much later than the Gap Island core did by *aggradation.* The 2-km long, narrow, recurved strandplain, that prograded only since 1855 (U.S. Army 1971), forms the present northeast island tip. Most of the island growth occurred in the opposite direction, linking St. George up with "Little St. George Island" in prehistoric times.

(d) *Dog Island.* The central, core segment of this small island is flanked on both sides by younger strandplains, formed by progradation. Archeological evidence indicates (Stapor 1975) that the core area is at least 3,000 to 3,500 years old. Drillhole D-3 encountered moderately-to-poorly sorted, fine-to-medium shallow subtidal sands below sea level (Figs. 1 and 2). From these shoal sands, deposited in Apalachicola runoff-influenced brackish environments, did the island emerge.

Positions of the evolving islands, in relation to transport paths of Apalachicola River sediments and the mainly westward-directed littoral drift, may partly help to explain why St. Vincent and "Little St. George" islands "downstream" from the eroding headland and the river delta, developed into strandplain islands. Meanwhile the eastern islands, with a probably dominant but meager offshore sediment source, remained narrow.

Conclusions-Alternate Modes of Island Formation

In addition to the aggradational island barrier origin, a number of other island formation theories gained apparently wider acceptance in the literature. By using certain diagnostic criteria, developed from very extensive literature and personal research, two mutually not necessarily exclusive alternatives, that could conceivably apply in the given instance, should be reviewed.

(1) Barrier Spit Segmentaton

St. Vincent and "Little St. George" islands are close to the mainland, and the noted vertical salinity change recorded in Core SVC would not be incompatible with this type of origin

(Table 3.11). While a short spit does presently extend eastward from the Pleistocene headland toward St. Vincent Island, there are no remnants of a major barrier spit left along the Island's north shore that would have mirrored the large St. Joseph Spit, opposite the northern flank of the headland. The isolated tip of such a spit, that would have extended to the present northeast island corner, may have served as nucleus for island progradation. However, the configuration of beach ridge sets is totally incompatible with a hypothetical strandplain that would have prograded eastward, while attached to the southern shore of a barrier spit.

Had a spit existed between the island's present north shore and corehole SVC, it would have been quickly destroyed to allow for the strandplain progradation from the nuclear area toward the southwest (Plate 1). How could such a large barrier spit disappear without a trace in a relatively very short interval, while the nearby St. Joseph Spit remained well preserved over a longer time and under comparable hydrodynamic conditions? A segmented-spit origin of St. Vincent Island seems unlikely.

(2) Mainland Beach Ridge Detachment and Migration

Schnable (1966) believed that the present bay sediments reflect the presence of since-drowned islands in front of the Apalachicola Delta, at a time of slightly lower sea level, that restricted water exchange with the Gulf. In his view, the recent islands emerged later during the present high sea level stage. However, there is no compelling need to invoke the existence

TABLE 3

Genetic Categories of Barrier Islands-Suggested Main Diagnostic Criteria

Categories of island origin: 1-nearshore marine shoal aggradation; 2-spit segmentation; 3-mainland beach ridge detachment, island not migrated; 4-mainland beach ridge detachment followed by landward island migration: (a) transgressive model without delta subsidence; (b) delta/permafrost terrain subsidence model; 5-island aggradation/progradation around pre-Recent (usually Pleistocene) core of high ground (composite islands). References: in Otvos (1981a, 1982, in press, and present paper).

Key: +-condition always or often present; *Δ*-condition may occur; 0-condition absent or unrelated to island formation.

		1	2	3	4a	4b	5
(1)	Mainland lagoon shoreline (often indented) behind island chain not modified by open marine Holocene wave regime	0	0	+	+	+	+
(2)	Historic record of compactional (deltaic/perma-frost) and/or tectonic subsidence below sea level and subsequent erosion of mainland coast plain	0	0	0	0	+	0
(3)	Thick Holocene deltaic sequence underlies areas of island formation/ landward migration	0	0	0	0	*Δ*	0
(4)	Holocene subaerial-deltaic, continental and/or pre-Holocene sediments directly underlie marine intertidal, backbarrier island and lagoonal deposits	0	0	+	+	0	+
(5)	Holocene lagoonal/bay sediments directly underlie marine intertidal and backbarrier island deposits	0	0	0	+	+	0
(6)	Thin island-shoreface sediment veneer of open marine sediments on seaward side with significant admixture of lagoonal, deltaic or other reworked sediments/fossils	0	0	+	+	+	0
(7)	Relatively thick Holocene open marine deposits under island shoreface without paralic units	+	+	0	0	0	0
(8)	Historic record of landward migration of spits or islands in subject area	0	0	+	+	+	0
(9)	Historic record of spit growth (and segmentation)	0	+	0	0	0	0
(10)	Configuration of earliest island beach ridges indicate their origin as recurved spits	0	*Δ*	0	0	0	0
(11)	Salinity of depositional facies decreases upward in the Holocene sequence under lagoon	+	+	0	0	0	*Δ*
(12)	Historic record of shoal aggradation to sea level in subject area	+	0	0	0	0	0
(13)	Intertidal island sands grade downward into (usually finer--grained) open marine nearshore sediments under whole island or seaward margin	+	+	0	0	0	+
(14)	Pre-Recent (usually Pleistocene) island core present in surface or shallow subsurface	0	0	0	0	0	+

of earlier islands in such positions: *Ammonia beccarii-Elphidium* assemblages under brackish conditions do prevail even in unsheltered nearshore areas with sufficient fresh water runoff. Brackish foraminifer biotopes exist along the open Gulf shores of southwest Louisiana (Kane 1959; Byrne et al. 1959), off Atchafalaya Bay, south-central Louisiana (Phleger 1954, p. 609) and opposite the Mississippi birdfoot delta (Phleger 1955). Even comparisons of inner neritic foram assemblages in Gulf bottom samples, taken at equal distances off Mississippi and Alabama passes, reflect great differences in fresh water influence (Table 1). Cores, drilled in parts of northeast St. George and Dog islands that formed during very recent, even historic times, yielded sediments under the intertidal island sands that were deposited in open nearshore environments. These deposits, as in St. Vincent Island drillholes IL and IM, also contained brackish foram faunas that reflected the strong influence of estuarine runoff.

It has recently been suggested (Penland written comm.) that "St. George and Dog islands represent transgressive barrier islands, associated with a slightly older Apalachicola delta at a lower sea level standstill", and that St. Vincent Island represents a "flanking barrier island associated with the most recently abandoned delta". This view (Table 3; Category 4b) is regional extension of interpretations (Morton 1979; Penland and others 1981), according to which mainland beach ridges on sinking, inactive delta lobe flanks in Texas and Louisiana were initially nourished by sediment from eroding shores of lobe apexes and later isolated from the deltaic plain. In these theories, this is caused by compactional subsidence and subsequent marsh erosion that allows lateral encroachment of lagoons and their gradual merging with coalescing delta plain lakes. The next stage would be landward migration of the islands across the newly formed lagoons and bays. Northern members of the transgressive Chandeleur chain of Louisiana (an island group cited as an example for such evolution by Penland and others 1981), seaward of their present location, may have originally formed in this fashion. There is no historical record for an aggradational origin (Otvos in press) and they are underlain by compacted thick deltaic units. Muddy-sandy delta front units in our vibracores occurred at only 5 to 7 m below sea level around northern Chandeleur Island, an area part of the tectonically and actively subsiding Mississippi delta region. In contrast, Holocene fluvial deposits, proper in all but one (MQ) of the Apalachicola area drillholes, were conspicuous by their absence. The comparisons also fail in that the headland northwest of St. Vincent Island is *not* composed of Holocene age deltaic deposits (Fig. 1).

The progradational beach ridges of Dog and Gap island core areas indicate the regressive, not transgressive nature of those islands. Central St. George Island, although its Gulf beach did undergo minor erosional retreat, formed essentially at its present location by lateral progradation and clearly postdates Gap, "Little St. George" and St. Vincent Islands. Those three islands could not have developed as they did through progradation had they existed in a low energy lagoonal environment, in the shelter of an assumed landward migrating ancestral St. George Island.

There can be little doubt that deltas and islands did exist south of the present island shores during various Holocene sea level stages, but a landward shift, uninterrupted by total destruction of islands on occasions during the late Holocene, can not be automatically assumed. The belief in such a continuous migration is refuted by relatively higher salinity sediments beneath very brackish bottom deposits in St. George Sound and Apalachicola coreholes (Fig. 2, Secs. 1 and 2, Table 2).

Higher salinity deposits occur not only in the present lagoons and bays but also in Drillhole MQ at the present front of the Apalachicola Delta (Fig. 1, Table 2). A 22.5-m thick transgressive-regressive sequence here fills a deeply incised (Schnable 1966) Pleistocene river channel. In the 6.6 to 9.9-m depth interval a *Nonion* and *Cribroelphidium*-rich horizon testifies to the farthest landward penetration of more saline waters during the later Holocene transgression. Much higher salinities are reflected in this interval than those above 6.6 m where estuarine sediments, including only *Ammotium salsum* and brackish diatoms *(Cosmiodiscus beaufortianus, Terpsinoe musica, Eupodiscus radiatus, Actinoptychus splendens, Auliscus pruinosus, Triceratium favus)* were deposited. Interestingly, the open nearshore, *Nonion-Cribroelphidium*-dominated faunas have not yet been found in late Holocene lagoonal deposits of Apalachicola Bay and St. George Sound.

It seems highly likely that at the peak of the late Holocene transgression, when the Apalachicola delta front was located further inland than at present, no major islands or delta remants existed off the Apalachicola Coast.

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