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Global Distribution and Geomorphology of Fetch-Limited Barrier Islands

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ABSTRACT

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There are more than 15,000 barrier islands in fetch-limited nearshore environments around the world. About half that number are actively evolving (eroding, accreting, migrating) in response to oceanographic processes and are the subject of this study. The remaining half consists of inactive islands protected by surrounding salt marsh or mangroves. Despite their global abundance these islands have not been previously systematically studied or even recognized as a major landform type. More than 70% of fetch-limited barrier islands are found on trailing edge coasts because conditions there are favorable for formation of sheltered waters. Fully 50% are found in the coastal zone of Australia, Mexico, and Russia. We identify eight different types of fetch-limited barrier islands based on genesis and mode of occurrence. Most of the active islands form in estuaries or bays (Spencer Gulf Australia), behind open ocean barrier islands (Pamlico Sound, North Carolina), or on flood tidal deltas of open ocean tidal inlets (Tapora Bank, New Zealand). Others occur on river deltas sheltered by offshore islands (Menderes Delta, Turkey), in sheltered bays with thermokarst topography (Yensei Bay, Russia), and on glacial outwash plains in fjords (Golfo Esteban, Chile). Due to a Holocene sea level drop, some southern hemisphere islands have been stranded above mean sea level and are intermittently active (Maputo Bay, Mozambique); they are only surrounded by water during spring tides and storms. Intermittent islands also form under conditions of high tidal amplitude (Kings Bay, Australia). Fetch-limited barrier islands are much smaller than their open ocean counterparts, averaging roughly 1 km long and 50 m wide and 1 to 2 m maximum elevation. They evolve in similar fashion to ocean barriers except that overwash is almost always the dominant island building process and dune formation is much less important. The two biggest distinctions between open-ocean and fetch-limited barrier islands are (1) complete evolutionary dependence on storms and (2) the important role of salt marsh and mangrove vegetation in controlling the shape and location of fetch limited barrier islands. Stabilized by salt marshes and mangroves, vegetative control is responsible for the irregular shape of some fetch-limited barrier islands and often plays a role in creating the foundation upon which the island evolves. Few of these islands are settled or developed at present, but it is likely that in midlatitudes they will soon be under development pressure.

ADDITIONAL INDEX WORDS: *Chesapeake Bay, United States, Delaware Bay, United States, Kings Bay, Australia, Laguna Madre, Mexico, Maputo Bay, Mozambique, Pamlico Sound, United States, Spencer Gulf, Australia, low-energy coastline.*

INTRODUCTION

Ocean-facing barrier islands constitute 10% of the open-ocean shoreline worldwide. They exist in a variety of coastal environments and exhibit a range of morphological characteristics and behaviors. As features of open-ocean shorelines, they have been extensively studied around the world, especially in North America where more than 35% of them occur (Stutz and Pilkey, 2001). Important studies of barrier island evolutionary processes include those of Hoyt (1967), Schwartz (1973), Dolan (1972), Godfrey and Godfrey (1976), Hayes (1979, 1994), Oertel (1985), Davis (1994), Riggs, Cleary, and Snyder (1995), Martinez *et al.* (2000), and Pilkey (2003).

The characteristics and dynamics of embayed and low wave energy shoreline environments are far less documented and understood than their open-ocean counterparts. Barrier islands along shorelines of limited fetch have never been counted, described, measured, or otherwise examined in any systematic way. Yet active and inactive “fetch-limited barrier islands (FLBIs),” by our count, exceed 15,000 in total number globally. Open-ocean facing barrier islands, although longer and wider on average than their “quiet water” counterparts, number only 2200 worldwide. Following the seminal global summaries of coastal morphology of Inman and Nordstrom (1971) and Glaeser (1978), the latter of which focuses exclusively on open-ocean barrier island coastlines, this article takes a global view of a hitherto unrecognized coastal land form, the FLBI.

Jackson (1995) and Jackson *et al.* (2002) describe the characteristics of low-energy sandy beaches in marine and estu-

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arine environments, but stop short of detailing the presence and significance of barrier islands in these settings. The few previous references to barrier islands in low-energy environments include the Chesapeake Bay (Lewis, Cooper, and Pilkey, 2005); Delaware Bay (Lewis., Cooper, and Pilkey, 2005; Pizzuto, 1986); King Sound, Western Australia (Jennings and Coventry 1973); and the "lagoonal islands" of Pilkey (2003). Additionally, the "marsh-detached beaches," in Algarve, Portugal (Andrade *et al.,* 2004); inlet marsh islands in North Carolina lagoons (Buynevich and Donnelly, 2006; Buynevich, FitzGerald, and van Heteren, 2004; Cleary, Hosier, and Wells, 1979; Cleary *et al.,* 2004); and "low-energy beach ridges" in Laguna Madre, Texas (Tanner and Demirpolat, 1988) are here identified as barrier islands.

We seek to fill a glaring hole in coastal geomorphology by providing a global survey of the morphology, distribution, and origin of FLBIs. In accomplishing this, we hope to bring recognition to barrier islands in protected settings as a distinct and important geomorphic category. For the purpose of this article, the criteria for designation as a barrier island are based upon the Oertel (1985) definition of open-ocean barriers, requiring all or most of six connected, sedimentary components: (1) an unconsolidated, elongated body of sediment (typically sand); (2) backed and fronted by a body of water; (3) fronted by a shoreface; (4) bounded by inlets with tidal deltas; (5) sitting on a barrier platform; and (6) "protecting" a mainland shoreline.

Fetch-limited barrier islands form a continuum that ranges from linear sand bodies morphologically indistinguishable from transgressive open-ocean barriers (Xefina Island, Maputo Bay, Mozambique; James Island, Aleutians, Alaska; and Cedar Island, Pamlico Sound, United States) to narrow strips of sand perched along the margins of salt marshes (Delaware Bay, United States) or mangrove forests (Spencer Gulf, Australia). Primarily because of vegetative control, fetch-limited islands exhibit wider variability in shape than ocean-facing islands. For example, some islands in Chesapeake Bay virtually wrap around salt marsh patches, forming horseshoe-shaped islands.

We recognize three broad classes of FLBIs: active, inactive, and anthropic. *Active islands* are those that form within a fetch-limited environment and are subject to wave and current activity, resulting in ongoing modification (constructive and/or destructive) of the islands. *Inactive islands* (Figure 1) are those not being currently modified by oceanographic processes (usually because the features are enclosed by salt marsh). The evolution of inactive islands is more likely to be primarily impacted by subaerial processes rather than by ma-

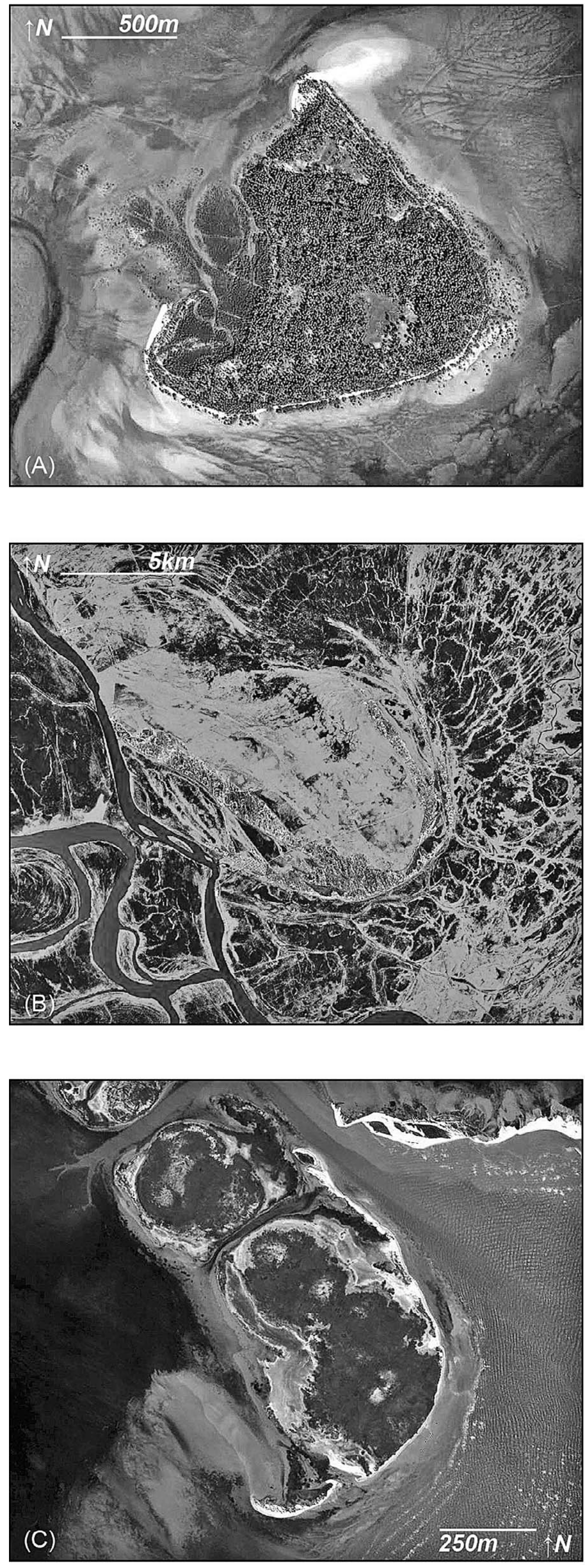

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Figure 1. (A) An active fetch-limited barrier island in Baie de Inhambane, Mozambique. The maximum fetch is to the lower right. (B) An inactive island surrounded by salt marsh in the Rio de la Plata estuary, Argentina. The shape clearly indicates that this island was once active, with a maximum fetch to the lower right. (C) Anthropic island created from dredge spoil in Laguna Madre, Texas. The island is being modified by present-day wave activity, a process that sometimes makes a distinction between active and anthropic islands difficult. **For a color version of this figure, see page 925.**

Table 1. *Distribution of Active Fetch Limited Barrier Islands by Fetch.*

Fetch (km)	Number	% of Total	Total Length (km)	Average Length (km)
<10	3116	44.4%	2828	0.9
10–30	1450	20.6%	1977	1.4
30–50	1540	21.9%	1304	0.8
50–100	779	11.1%	1052	1.4
>100	138	2.0%	249	1.8
Total	7023		7410	1.1

rine processes. Fetch-limited barrier islands created by marine intrusion around nonmarine topographic highs such as river levees (Nile Delta, Egypt) and "clay dunes" (Laguna Madre, Mexico) followed by the commencement of oceanographic island modifying processes we regard as active. There are, in addition, several large sandy features surrounded by water and currently located in fetch-limited environments that are being eroded under contemporary conditions (Roanoake Island, North Carolina) that are excluded from this study. The third class, *anthropic islands,* is formed entirely by humans, usually as dredge spoil islands, foul piles, ballast piles, causeways, and artificial reefs. Globally these islands, which we have tried to exclude from our survey, have become abundant with the widespread use of dredges in navigation channel maintenance. It is possible that some of the islands included in this survey once began as or are heavily influenced by disposed dredge spoil but have since been transformed by natural processes beyond recognition.

METHODS OF STUDY

The islands discussed in this article are restricted to those existing in fetch-limited marine, lagoon, bay, or estuarine conditions. Shorelines of lakes and other nonmarine bodies of water are excluded, although it has not escaped our attention that similar features occur in large lakes (*e.g.,* Lake Baikal, Russia). Jackson *et al.* (2002) provide an extensive description of low-energy shorelines that closely applies to the islands included in this study. The environments considered in this research are those that are sheltered from the open-ocean and subject to low-energy conditions. Common characteristics include:

- nonstorm wave heights less than 0.25 m
- waves driven primarily by local winds
- narrow shoreface widths
- evolution controlled primarily by occasional high energy events (*i.e.,* storms and/or high tides)

The average fetch for the barrier islands examined in this study is 30 km (Table 1). Water depth over the range of fetch and the bay morphology also influence shoreline wave energy.

Maps, charts, GeoCover Land Sat Mosaic satellite imagery provided by the National Aeronautics and Space Administration and more recently GoogleEarth, and vertical aerial photographs from the National Oceanic and Atmospheric Administration and other government sources were used to determine the global distribution of islands. Shoreline shape-file and raster data were interrogated using ESRI ArcGIS and MrSID viewing software. Technical literature and other existing data sets complemented this geospatial data. Once an area was determined to be both fetch-limited and to possess active barrier islands, its location and size and the number, types, and lengths of islands were recorded. We conducted field and low-altitude aerial reconnaissance of several fetch-limited sites with abundant and unique islands. Areas of field reconnaissance observations included Western Turkey, Mozambique, South Australia, Mexican, and U.S. lagoons bordering the Gulf of Mexico, and a number of east coast U.S. environments, including Chesapeake and Delaware Bays and Pamlico Sound.

Differentiating anthropic islands, which are usually formed from dredge spoil, from active islands is the foremost challenge among the factors that impose limits upon this research in areas used for navigation. The overwhelming dominance of small sand features among the population of barrier islands in the bays, mostly sand bars atop salt marsh rims 10 to 25 m in length, posed another concern. Thus, the minimum island length was arbitrarily established as 50 m, primarily owing to limitations in remotely-sensed data and the accuracy of published maps and charts. Other small features, such as inlets, may have been occasionally missed because of limits to imagery resolution, and as a result the total tabulation of islands (determined in part by the number of inlets) may underrepresent the number and overrepresent the average length of active FLBIs in certain areas.

Distinguishing active islands from inactive ones is often based on the presence or absence of salt marsh. If an island is completely surrounded by substantial reaches of marsh the assumption was made that the impact of marine forces was limited, subaerial processes were dominant, and the island was inactive. Of course no coastal body of sand surrounded by water and protruding above sea level is completely detached from marine processes, especially during storms. Salt marsh apparently is more effective in protecting islands from marine processes than mangroves. We have observed a number of instances in the southern hemisphere (*e.g.,* Mozambique and Australia) where islands completely surrounded by mangroves still evolve actively due to storm processes.

GLOBAL DISTRIBUTION AND MORPHOLOGY OF ACTIVE FETCH-LIMITED BARRIER ISLANDS

We identify more than 7000 active FLBIs around the world, totaling more than 7400 km in length (Figure 2). Like open-ocean barrier islands, fetch-limited barriers exist on every continent except Antarctica and in a variety of tectonic, climatic, and tidal settings.

Low-energy, fetch-limited conditions occur where ocean swell is eliminated or restricted and wave energy is generated by local winds (Jackson, 1995). Such conditions occur in large estuaries and bays (*e.g.,* Maputo Bay, Mozambique [Figure 3]; Chesapeake and Delaware Bays, United States [Figure 4]; Spencer Gulf, Australia [Figure 5]; King Sound, Australia [Figure 6]; Gulf of Ob, Russia [Figure 7]), several fjords (*e.g.,* Golfo San Esteban, Chile [Figure 8]), inside back-barrier lagoons (*e.g.,* Pamlico Sound, United States [Figure 9]; La-

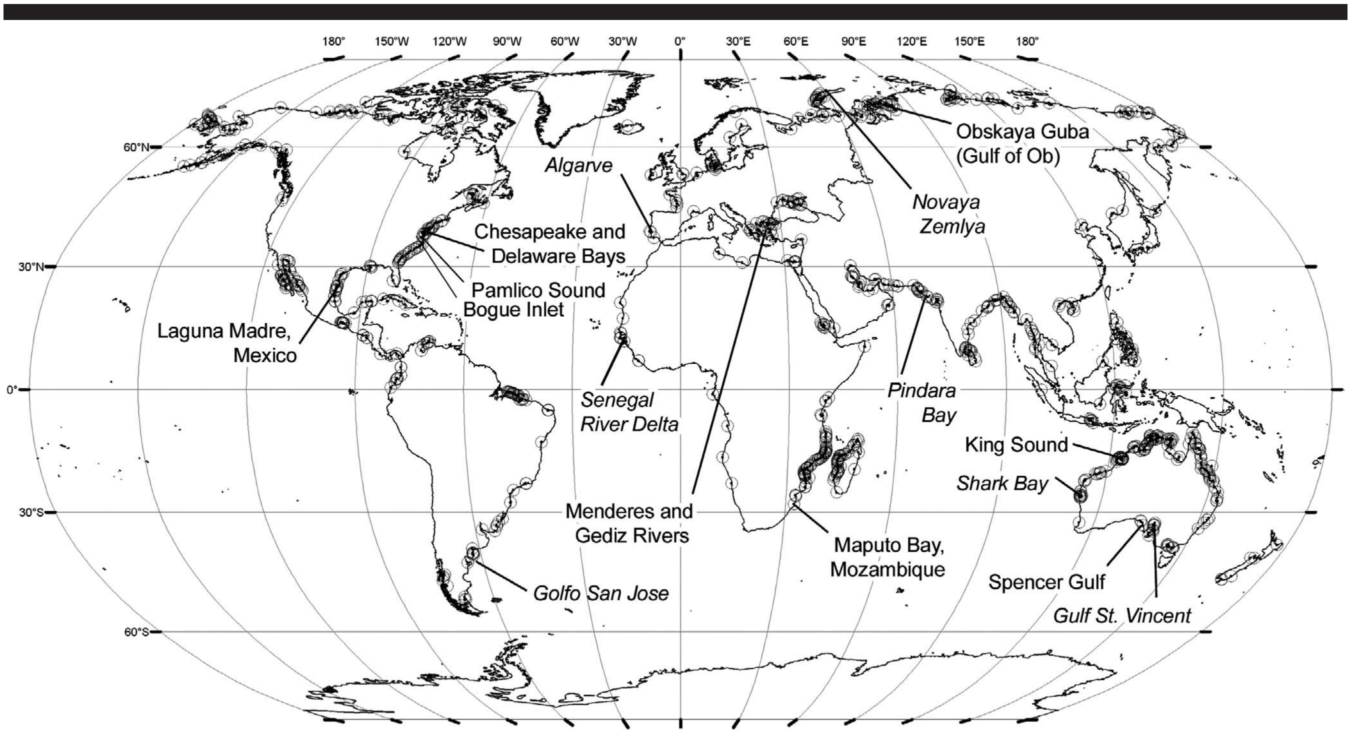


Figure 2. Index map showing the general location of fetch-limited barrier islands around the world. Important sites mentioned throughout this article are labeled.

guna Madre, Mexico [Figure 10]; and Bogue Sound, United States [Figure 11]), and in sheltered waters protected by offshore islands or reefs (*e.g.,* western Turkey [Figure 12]). The distribution of FLBIs by their geologic settings responsible for limiting fetch is shown in Table 2.

There are 10 bays or lagoons with particularly large numbers (>100 each) of well-developed FLBIs. These are Laguna Madre, Mexico (596); Obskaya Guba, Russia (405); Spencer Gulf, Australia (340); Shark Bay, Australia (338); Chesapeake Bay, United States (218); within the Senegal Delta, Mauritania (140); Gulf St. Vincent, Australia (139); King Sound, Australia (115); Delaware Bay, United States (104); and Pindara Bay, India (96). Together these 10 locations account for 35% of all FLBIs.

Active FLBIs exist within more than 600 different fetch-limited bodies of water, primarily along unlithified, allomorphic coastlines formed through marine depositional and erosional processes. In terms of large-scale coastal morphology, active fetch-limited islands are most abundant in the water bodies that form along wide shelf, low-slope coastal plains.

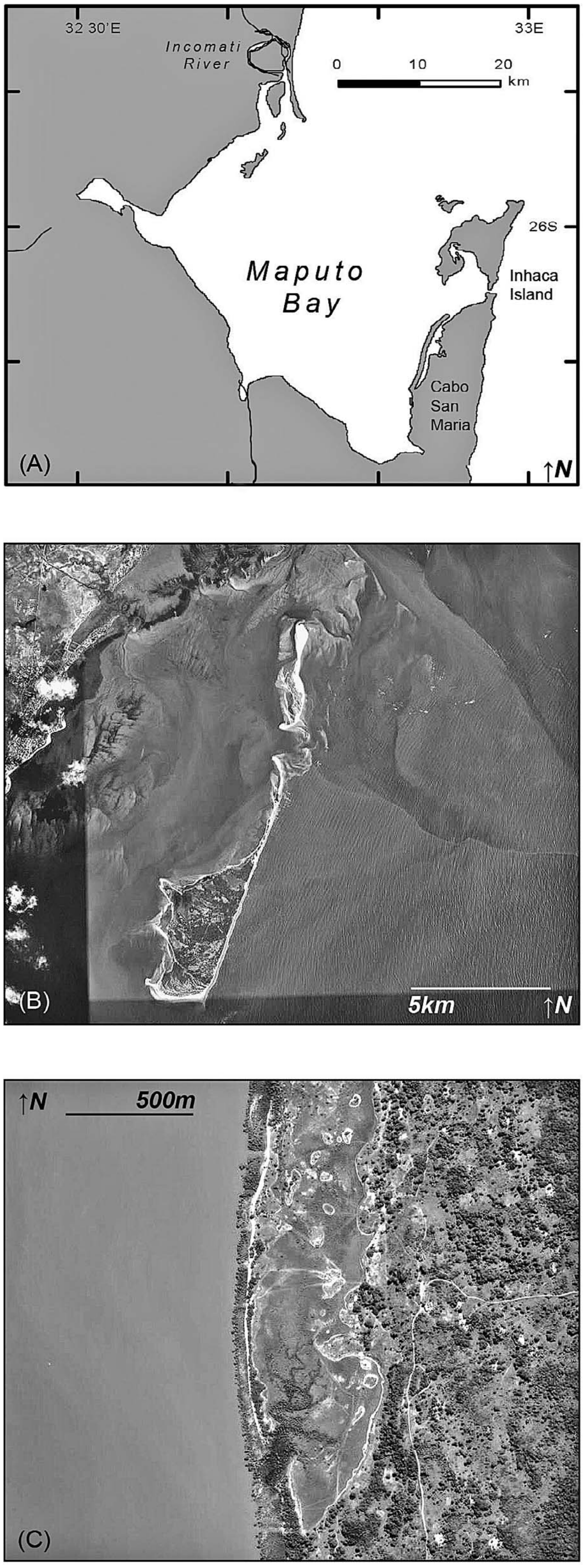
The coastlines with the greatest abundance of active islands (Table 2) are the Atlantic and Gulf Coasts of North America (19% of the total number in the world [Table 3]). The Indian Ocean coastlines of Australia have 15% of the total (mostly in three large bays), whereas the Arctic coastal plain of Russia has 12%. All of these coastal plain shorelines have extensive bay, lagoon, and estuarine waters, whereas the Pacific Coast of South America and the South Atlantic Coast of Africa have lithified, near-montane shorelines, few embayed waters, and correspondingly few FLBIs. The distribution of FLBIs by country, a number of interest from a coastal zone management perspective, is shown in Table 4. One-fourth of these islands worldwide are found in Australia; in combination Australia, Mexico, Canada, Russia, United States, and India account for 70% of all such islands.

Among the primary factors controlling the global distribution of FLBIs must be the factors responsible for the formation of the protected shoreline environments, including coastline tectonics, sediment supply, and sea-level history. Within a particular low-energy environment, the ratio of readily-mobilized medium-fine to coarse sand relative to the depth and prevailing wave energy determines the existence and abundance of barrier islands. Except in the instances of barrier island development in conjunction with river deltas, island formation appears to be independent of river sediment discharge.

The dominant factors favoring FLBI development appear to be

- low seabed gradient or marsh platform
- shallow water depth
- abundant existing sediment supply (from the bay floor or coastal erosion)
- a moderate-to-strong storm climate

Tidal range is not a good predictor of FLBI development as active fetch-limited barriers exist in all ranges of tidal conditions. King Sound, Australia, with more than 100 barrier islands, experiences an 11.5 m spring tide range (Semeniuk,



1981), whereas the eastern Aegean in Greece, a region with several dozen fetch-limited barriers as well, experiences tides of just 0.16 m (Piper and Paganos, 1981). Moreover, FLBIs are common in meso-tidal environments such as along the Atlantic coasts of southern Brazil and along the southern Indian Ocean coast of Australia (Bird and Schwartz, 1985).

TYPOLOGY OF FETCH-LIMITED BARRIER ISLANDS

Hayes (1979) proposed classifying barrier islands based on wave energy and tidal amplitude. McBride, Byrnes, and Hiland (1995) and Pilkey (2003) present other classification schemes based on a variety of parameters such as morphology, coastal type (*e.g.,* coastal plain, delta), sediment type, and chronology. Because these schemes were devised specifically for open-ocean barrier islands they are largely inappropriate for the fetch-limited, low-energy features discussed herein.

We distinguish eight broad types of FLBIs according to their geologic/oceanographic setting and morphology (Figure 13). Table 5 gives the number, average length, and percent of total for each island type. Our typology excludes inactive barriers.

It is important to emphasize that the classification is not a genetic one. The database is largely satellite imagery–based, buttressed by field observations at localities selected on the basis of island type or abundance. Additional insight was gained from the sparse literature on these islands and their environments. Processes are considered to the extent that such can be discerned from imagery or field reconnaissance; islands with the same appearance may, however, have evolved by different processes in the various fetch-limited environments.

Classic Barrier Islands

The most abundant of all FLBI types, classic barrier islands differ little in form and behavior from open-ocean coastal plain barrier islands, although they are typically much smaller. Each of these islands has an "open water" side and a "quiet water" side analogous to the open-ocean and back-barrier sides of oceanic barrier islands. They also have tidal inlets and deltas with size and morphology that reflect prevailing oceanographic conditions. Like open-ocean barrier islands, they may occur either individually, such as Xefina Island in Maputo Bay, Mozambique ([Figure 3] Cooper and Pilkey, 2002), or more often in chains of multiple islands connected *via* alongshore processes, such as some in the lower

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Figure 3. (A) Index map of Maputo Bay, Mozambique. (B) Satellite image of Xefina Island, which displays most of the features normally associated with open-ocean barrier islands. The inlet formed within the last 10 years. Dunes are up to 5 m high on Xefina Island. Such extensive dunes are unusual on fetch-limited barrier islands. (C) Satellite image of an intermittent barrier island on the landward side of Cabo San Maria. The lagoon, which was dry at the time this photo was taken, is flooded only during spring tides and storm surges. **For a color version of this figure, see page 925.**

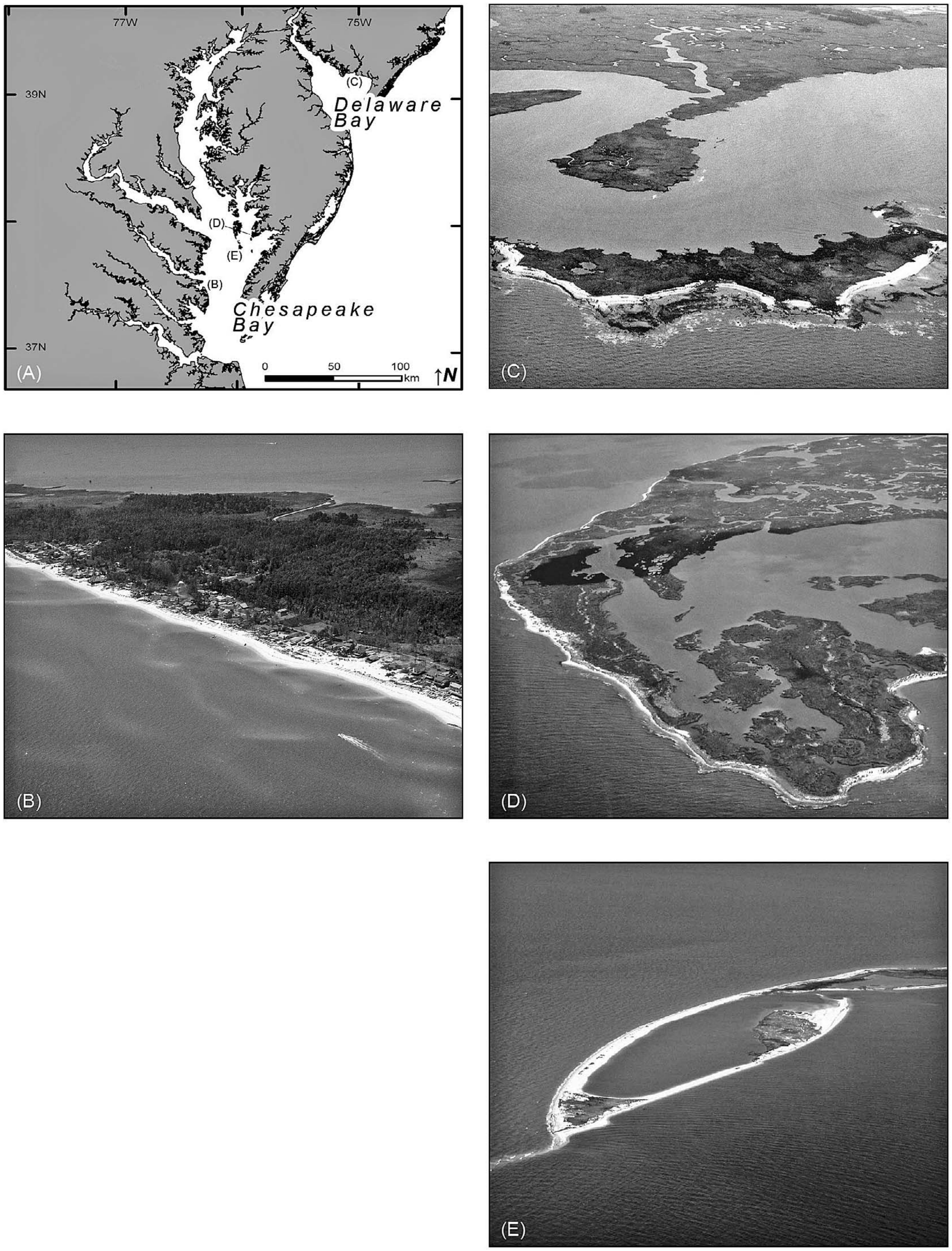

Figure 4. (A) Index map of Chesapeake Bay and Delaware Bay, United States. (B) A developed fetch-limited barrier at New Point Comfort, Virginia, along the western shore of Chesapeake Bay. Note the extensive sand storage in offshore bars. (C) A marsh fringe barrier island, perched on a salt marsh platform, along the eastern shore of Delaware Bay. Extensive salt marsh mud outcrops are found in the surf zone. (D) A wraparound marsh fringe barrier island in southern Chesapeake Bay, Virginia. The island is a narrow (<5 m) strip of sand along the salt marsh and partially encloses a marsh lagoon. The irregular outline is clearly controlled by pre-existing marsh surfaces. (E) The southern tip of Tangier Island in southern Chesapeake Bay is a “two-sided island” with roughly equal fetch on both sides. The smooth shoreline is a reflection of the dominance of longshore processes as opposed to antecedent topographic control in the other Chesapeake Bay images. **For a color version of this figure, see page 926.**

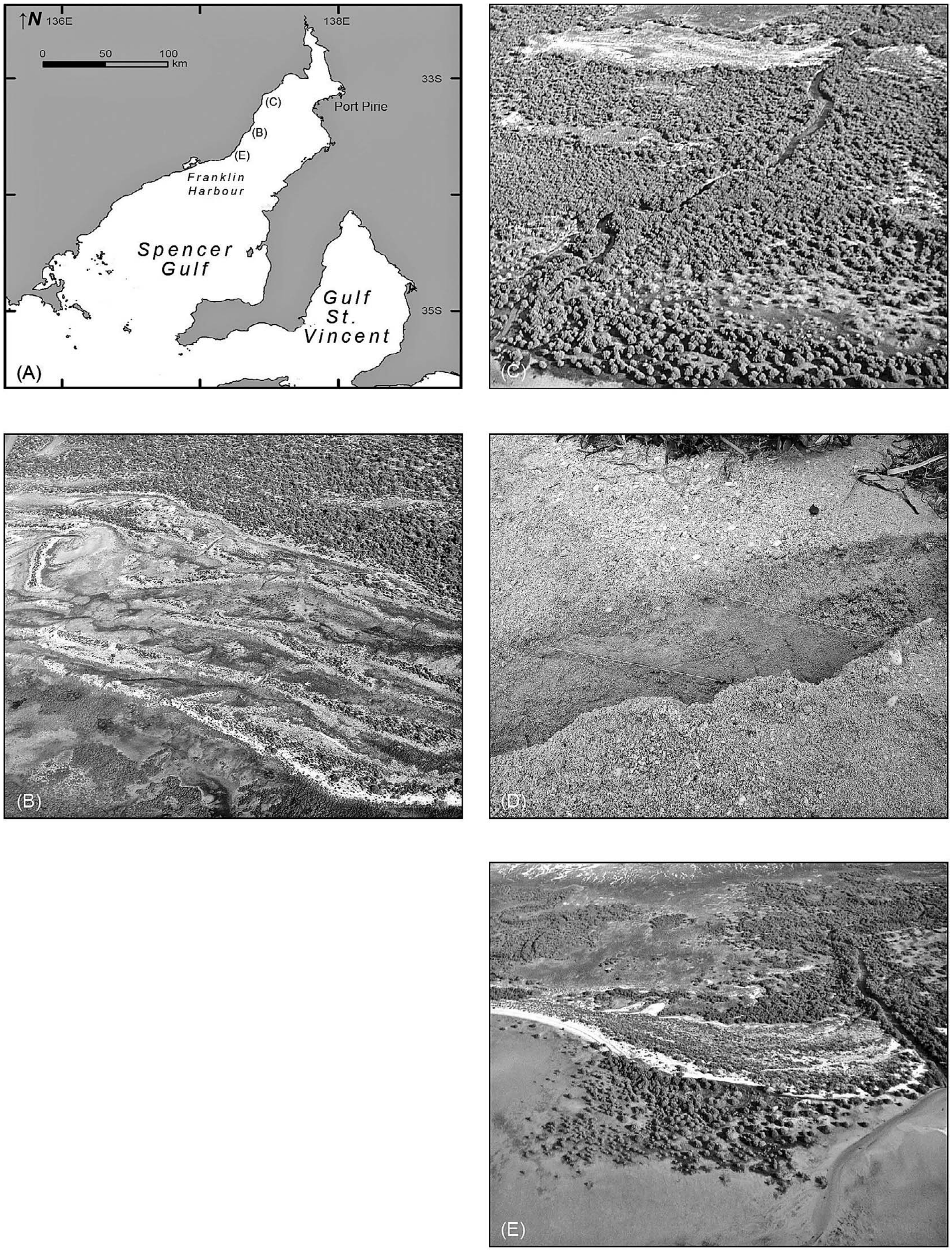

Figure 5. (A) Index map of Spencer Gulf and Gulf St. Vincent, South Australia. Fetch-limited barrier islands line the shoreline in the upper Spencer Gulf, north of Franklin Harbour. (B) Multiple rows of fetch-limited stranded barriers separated by samphire pans or mangroves along the western shore of Spencer Gulf. These Holocene islands were stranded as a result of a drop in sea level (Belperio, Harvey, and Bourman, 2002; Hails., Belperio, and Gostin, 1984). (C) Multiple rows of mangrove covered islands in Spencer Gulf. The tidal creek is coincident with the inlets of three successive islands. (D) A 50-cm-deep shore-perpendicular trench on the ocean-facing side of one of the multiple barriers shown in Figure 9B. The landward dipping stratification once on the backside and now on the frontside of the islands is evidence that the barrier island has migrated landward recently. (E) Recurved spits at the end of a barrier island in Spencer Gulf. The island is still active, and longshore processes are still important in spite of the mangrove forest on the open-water side of the island. **For a color version of this figure, see page 927.**

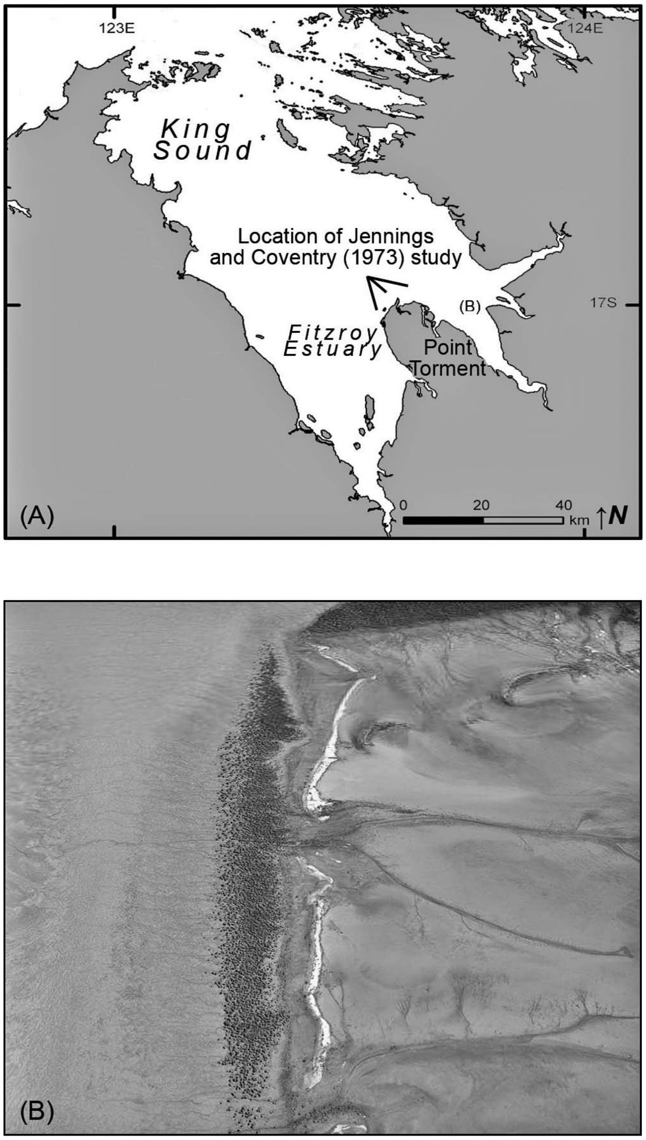

Figure 6. (A) Index map of King Sound, Western Australia. (B) Fetch-limited barrier islands behind mangroves in King Sound, Australia. These intermittent islands are active only during high tide (>11 m tidal range) and are most heavily impacted when high tide coincides with passing typhoons (Jennings and Coventry, 1973). These islands are up to 300 m long and <10 m wide.

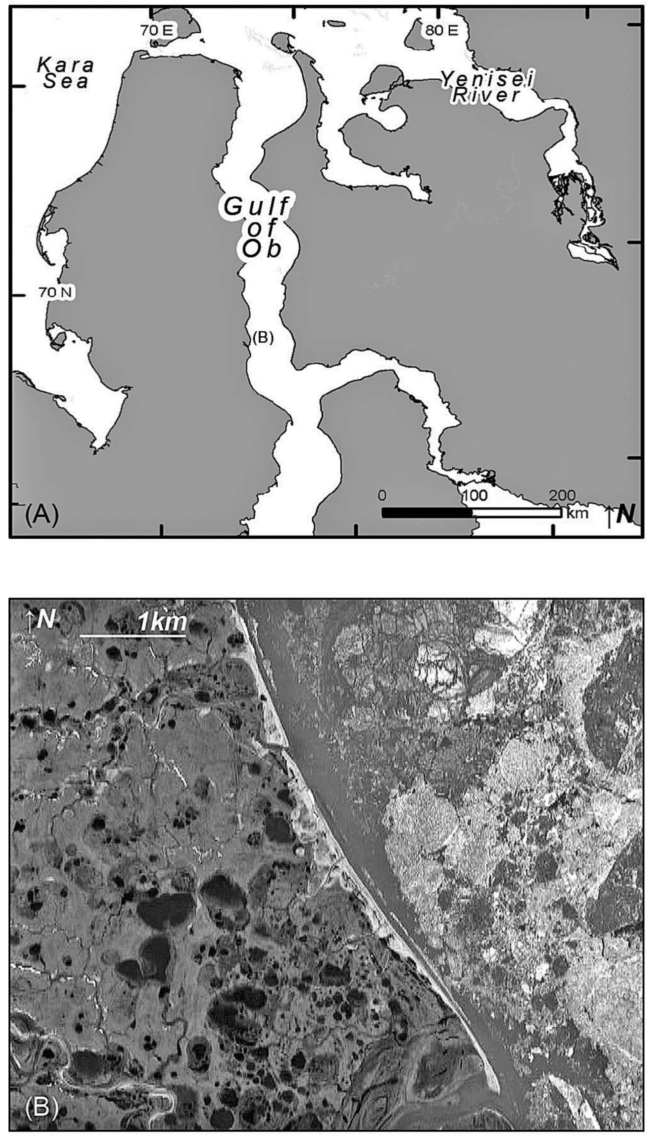

Figure 7. (A) Satellite image of Gulf of Ob, Russia. (B). Fetch-limited barrier islands on the western shore of the Gulf of Ob. To the left in the photo is mainland thermokarst topography, and to the right is the open gulf, partially covered with ice. Obviously floating ice has a large impact on fetch. The principal island shown exceeds 2 km in length and is currently prograding (Kuptsov and Lisitsyi, 2003).

Chesapeake Bay, United States (Figure 4) and Spencer Gulf, Australia (Figure 5).

Accounting for half of all active FLBIs worldwide, classic type islands exist in coastal environments with a variety of tidal ranges, sea-level histories, sediment regimes, vegetative settings, and storm climates. Their varying morphology indicates a variety of genetic and evolutionary pathways including bar emergence and spit elongation and breaching. Classic islands occasionally form by the alteration of an existing topographic high—such as a relict levee, "clay dune," or stranded Pleistocene barrier island. Figure 14 shows a model for the formation of barrier islands by wave reworking of topographic highs based on observations in Laguna Madre. Initial accretion of sand on a marsh fringe may also give rise to development of a classic barrier island. Cedar Island, Pamlico Sound, United States, likely arose via this mechanism. In general, these islands are only active during storms (Short, Buckley, and Fotheringham, 1989).

Vegetation may play a particularly significant role in the genesis and evolution of many classic type islands. Marsh outcrops, for example, are particularly influential on island planform. Islands experiencing significant vegetative control

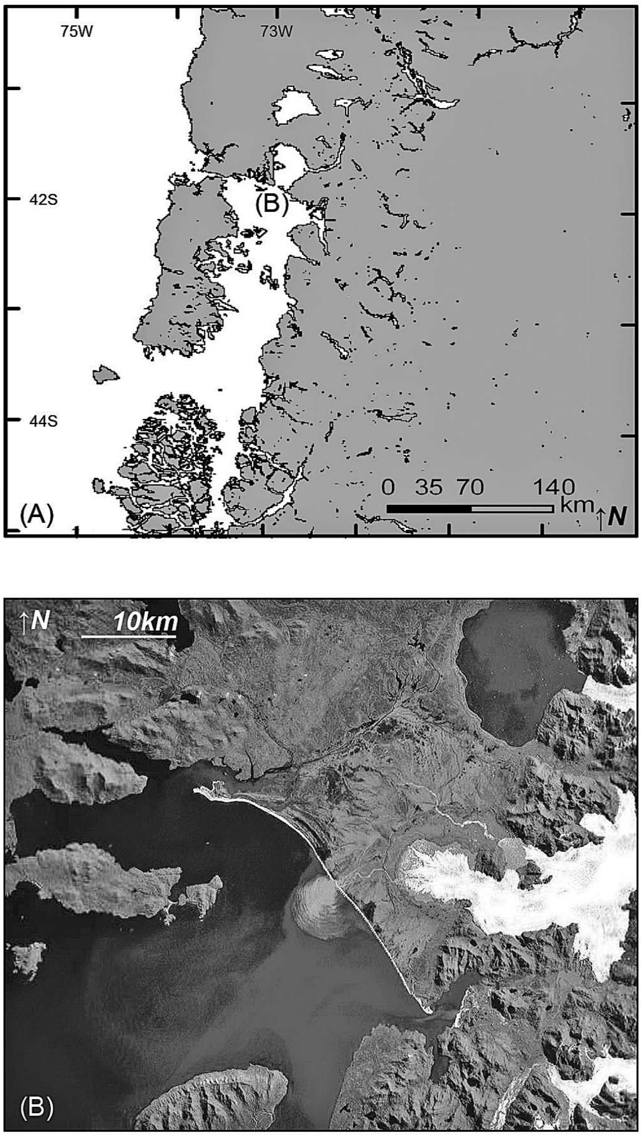

Figure 8. Fjord-head fetch-limited barrier islands in Golfo San Esteban in southern Chile. The sediment source for these islands is the glacial lobes upon the right. The islands form on the rim of the sandur plain.

wrap around the marsh, partially enclosing a marsh lagoon. Unlike oceanic barriers, salt marsh and/or mangroves can exist on the side of the barrier with maximum fetch. In King Sound (Figure 6) the active islands are fronted by up to 100-m-wide bands of mangroves. Mangroves can reduce wave en-

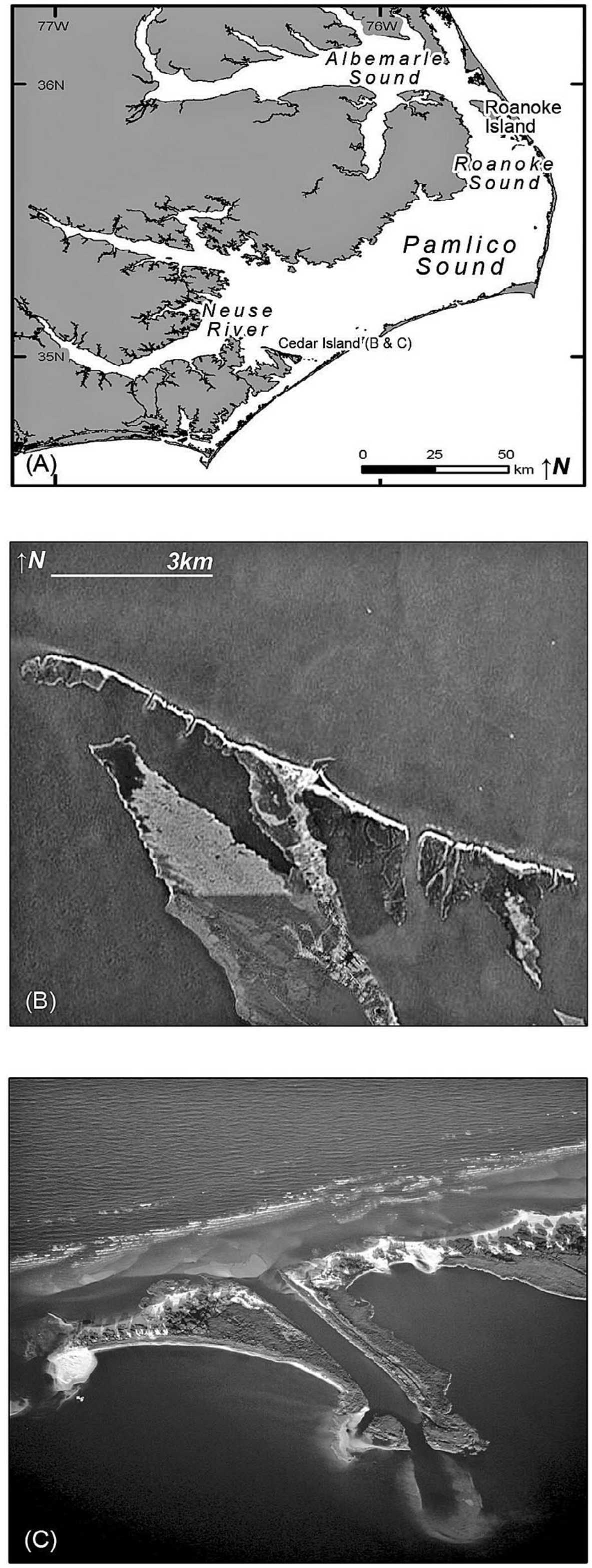

Figure 9. (A) Index map of Pamlico Sound, North Carolina. (B) Cedar Island, North Carolina, a chain of 11 islands facing in the direction of maximum fetch (100 km) to the northeast. The elongate inactive Pleistocene island behind Cedar Island is a major source of sand for the modern active barrier island chain. (C) Tidal inlet on Cedar island with a visible flood tidal delta. The island is fronted by multiple nearshore bars and ebb-tidal deltas are poorly developed.

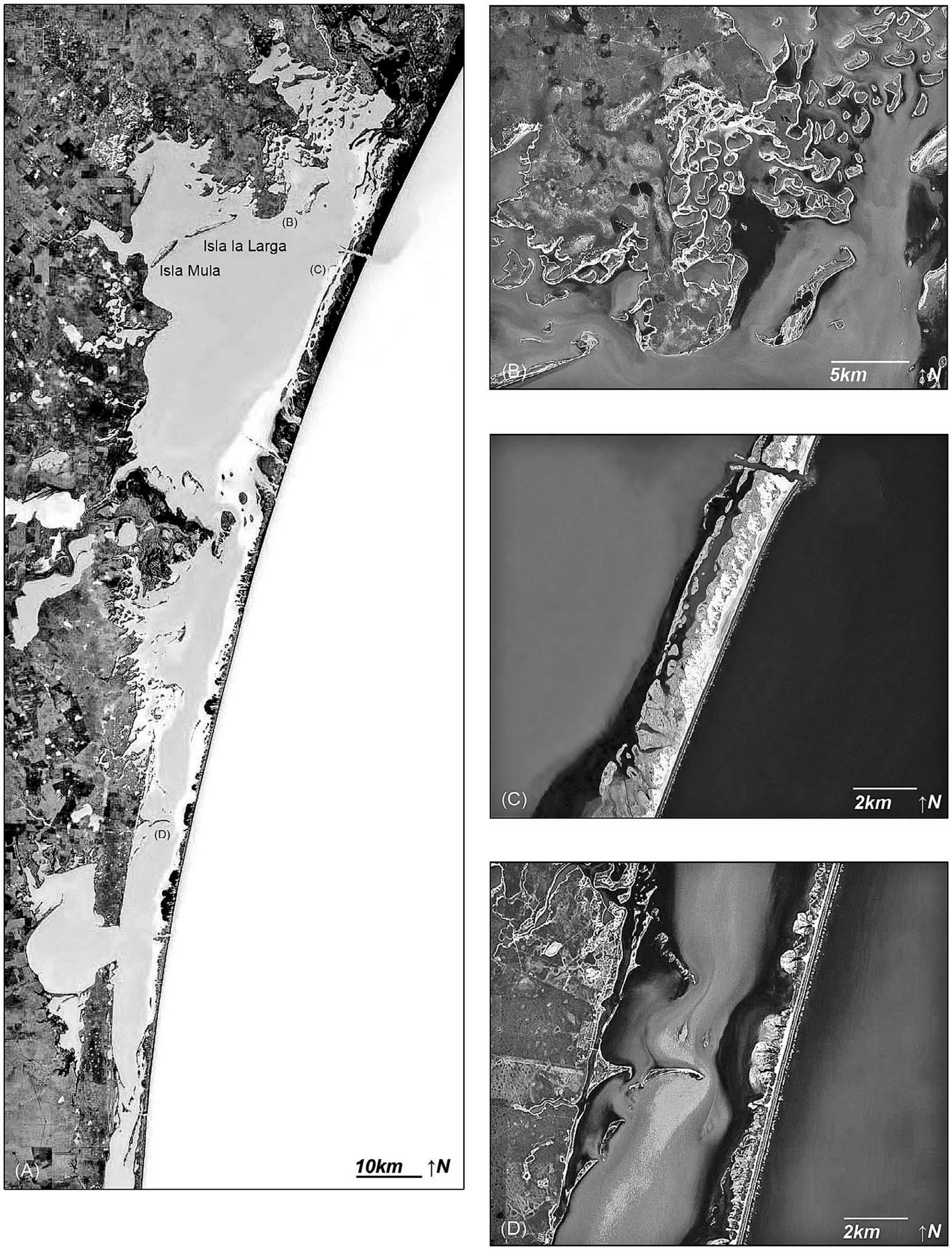

Figure 10. (A) Satellite image of the entire Laguna Madre, Mexico, which has the largest number and highest density of fetch-limited barrier islands in the world. (B) Fetch-limited barrier islands in the process of being formed through the reworking of pre-existing topography (clay dunes, Price, 1963) at the north end of Laguna Madre Mexico on the Rio Grande delta. (C) A chain of backbarrier-parallel barrier islands lagoon-ward of the open-ocean barrier island. The inlet to the north, crossing the open-ocean barrier island, is artificial. (D) A "two-sided" barrier island oriented perpendicular to the length of Laguna Madre, with roughly the same fetch in both directions. **For a color version of this figure, see page 928.**

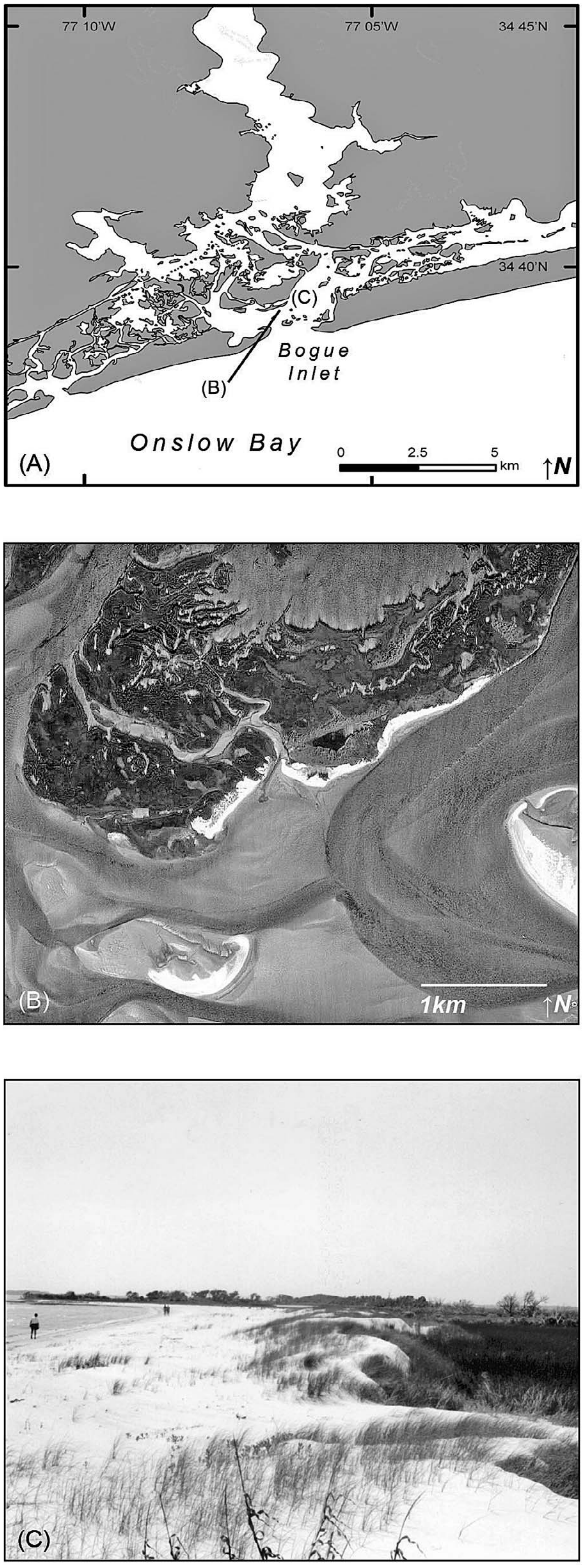

Figure 11. (A) Index map showing Bogue Inlet, south of Cape Lookout, North Carolina. (B) An inlet island on the flood tidal delta at Bogue inlet. These emergent islands occupy the uppermost parts of the flood tidal deltas and may rest on salt marsh rims. (C) Dune development on the inlet island at the mouth of Bogue Inlet. **For a color version of this figure, see page 929.**

Table 2. *Distribution of Active Fetch-Limited Barrier Islands by Geologic Setting.*

Island Location	Number	% of Total	Total Length (km)	Average Length (km)
Embayment	3846	54.8%	3987	1.0
Reef-protected lagoon	203	2.9%	457	2.3
Fjord	112	1.6%	147	1.3
Backbarrier lagoon	2355	33.5%	2190	0.9
Strait/protected by offshore island(s)	507	7.2%	629	1.2
Total	7023		7410	1.1

ergy, induce sediment settling, and provide an underlying stabilizing framework. Salt marshes are much more effective than mangroves in reducing the impact of oceanographic processes on fetch-limited islands.

A few classic islands—exclusively in the southern hemisphere—are intermittent: islands surrounded by water only at high tides, spring tides, or storm surges (or some combination of the three). Sometimes these are islands formed at a higher Holocene sea level, as exemplified by some of the islands in Spencer Gulf, South Australia (Figure 5B) and those adjacent to Cabo Santa Marta, Maputo Bay, Mozambique (Figure 3C). The other situation in which intermittent islands exist are megatidal environments, the prime example of which is Kings Sound, South Australia (Figure 6). Near Point Torment, Jennings and Coventry (1973) observed that the gravel barriers, which are surrounded by extensive mangroves and are affected by waves only in major storms, are actually migrating in a landward direction despite evidence of a local drop in sea level.

Two-Sided Barrier Islands

Two-sided barrier islands are classic barrier islands except that they have roughly equal fetch in two directions perpendicular to the island long axis. Significant onshore winds occur on both sides of the island, and therefore they develop exposed barrier beaches on both the "seaward" and "landward" margin of the island. Physically there is little distinction between either margin of the island.

Two-sided islands are the least common of all FLBI types. There are only 125 such islands globally, representing less than 2% of the total. These islands usually form individually or, at the most, in very short chains of 3–5 islands. The southern tip of Tangier Island, in the Chesapeake Bay, United States (Figure 4E), is a prominent example of a two-sided island oriented parallel to the long axis of the bay. There are many examples in Laguna Madre, Mexico (Figure 10D) (Tunnell and Judd, 2002) where they are oriented perpendicular to the long axis of the north-south trending lagoon. These two-sided islands may sometimes enclose cat eye ponds or small lagoons.

Backbarrier Parallel Barrier Islands

Backbarrier parallel fetch-limited barrier islands form long chains of islands landward of and parallel to open-ocean barriers separated by gaps of a few meters to tens of meters. In total number, they comprise around 8% of all FLBIs worldwide and, like most islands in sheltered settings, are short, averaging less than 1 km each. Their distribution worldwide is limited to 30 locations: the most notable examples occur within lagoons of the southwestern Gulf of Mexico (Laguna Madre [Figure 10C]), the Arctic Ocean coast of Russia, and several Ukrainian lagoons in the Sea of Azov and the Black Sea. All occurrences of these islands are in tideless or microtidal lagoons.

The morphology of the islands and their inlets, as well as evidence gathered from sediment and shell observations in the Laguna Madre, Mexico, suggests that much of the sediment comprising backbarrier parallel islands was derived *via* overwash from the oceanic barrier after which it was reworked by lagoonal waves. Some rounded or fan-shaped backbarrier parallel islands are clearly derived from major overwash fans at the terminus of a frequently occupied overwash pass. The more linear form of backbarrier parallel islands likely originally formed as spits extending from the larger, rounded islands.

Deltaic Barrier Islands

Fetch-limited deltaic barrier islands develop in short chains along the rims of deltas of rivers emptying into fetch-limited environments. The longest and most numerous deltaic chains are along mountainous, tectonically active shorelines such as along the Aegean coasts of Turkey (Figure 12) (Aksu and Piper, 1983) and Greece and along the marginal seas of Indonesia (Milango River, Sulawesi) and the Philippines.

Storm-generated wave setup and alongshore transport are the primary processes responsible for reworking the fluvial sediments into barrier islands. Anthropic and climatic controls on catchment denudation rates and catchment lithology represent secondary controls.

Fjord-Head Barrier Islands

Fjord-head barrier islands are similar to deltaic islands except that they form at the margin of a sandur plain seaward of an active glacier (Figure 8). They typically exist in very short chains of 2–4 islands with an average length of 1.1 km. These islands are the most limited in distribution, accounting for just 1.3% of all islands worldwide. Fjord-head islands de-

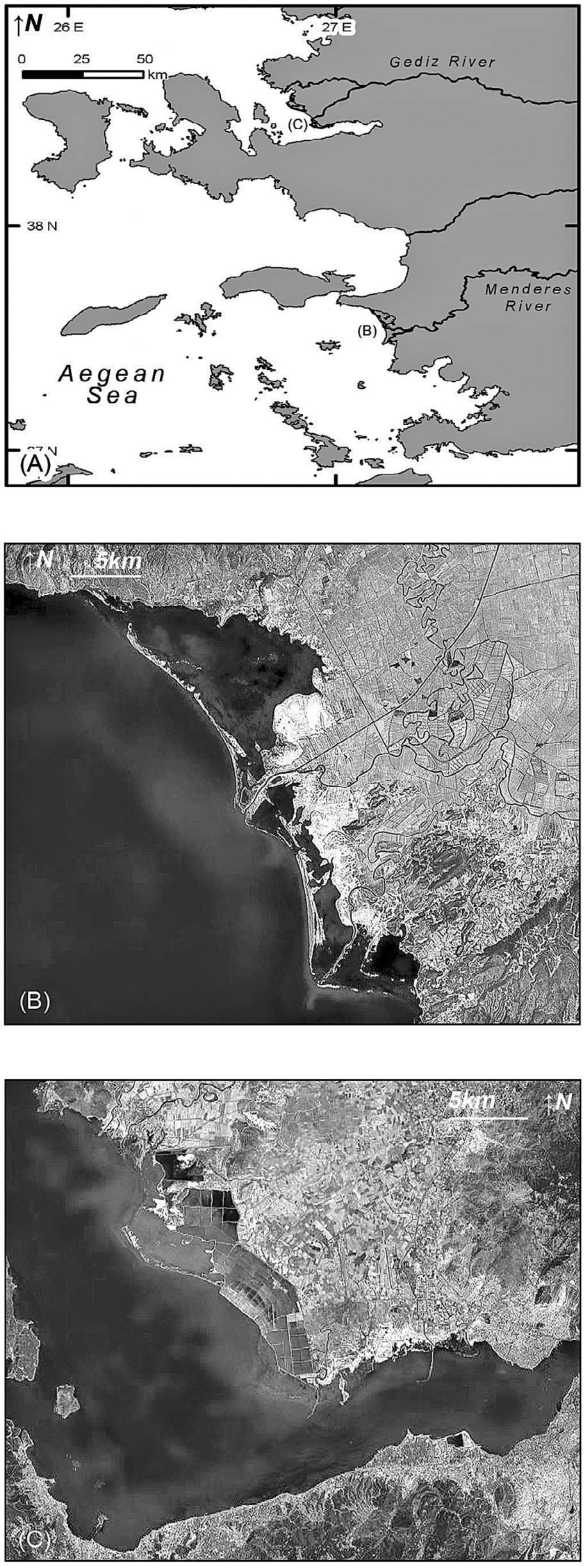

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Figure 12. (A) Index map of the eastern Aegean Sea showing western Turkey. (B) Fetch-limited barrier islands formed along the rim of the Menderes River delta. The fetch is limited here because of rocky, offshore islands. These barrier islands are less then 10 m wide and 1 m high and are heavily grazed by cattle. (C) Fetch-limited barrier islands rimming the Gediz River delta. These islands are heavily modified by various forms of shoreline stabilization and commercial salt pan construction in the lagoon. A few fisherman's shacks line the beaches. **For a color version of this figure, see page 929.**

Table 3. *Distribution of Active Fetch-Limited Barrier Islands by Continent and Body of Water.*

	Number	% of Total	Total Length (km)	Average Length (km)
Africa	728	10.4%	802	1.1
Atlantic Ocean	208	3.0%	234	1.1
Indian Ocean	83	1.2%	139	1.7
Mediterranean Sea	9	0.1%	11	1.2
Mozambique Channel	337	4.8%	345	1.0
Red Sea	91	1.3%	73	0.8
Australia	1710	24.3%	1475	0.9
Arafura	325	4.6%	332	1.0
Gulf of Carpentaria	65	0.9%	90	1.4
Indian Ocean	1075	15.3%	555	0.5
Pacific Ocean	245	3.5%	498	2.0
Eurasia	2005	28.5%	2483	1.2
Arctic Ocean	857	12.2%	1250	1.5
Atlantic Ocean	37	0.5%	32	0.9
Baltic Sea	22	0.3%	33	1.5
Black Sea	107	1.5%	116	1.1
Indian Ocean	506	7.2%	460	0.9
Mediterranean Sea	160	2.3%	194	1.2
North Sea	3	0.0%	4	1.3
Pacific Ocean	231	3.3%	295	1.3
Persian Gulf	58	0.8%	58	1.0
Red Sea	1	0.0%	2	2.0
South China Sea	23	0.3%	39	1.7
North America	2181	31.1%	2109	1.0
Arctic Ocean	378	5.4%	489	1.3
Atlantic Ocean	485	6.9%	400	0.8
Beaufort Sea	77	1.1%	124	1.6
Bering Sea	30	0.4%	34	1.1
Caribbean Sea	21	0.3%	24	1.1
Gulf of California	108	1.5%	99	0.9
Gulf of Mexico	818	11.6%	656	0.8
Pacific Ocean	264	3.8%	283	1.1
South America	399	5.7%	541	1.4
Atlantic Ocean	286	4.1%	373	1.3
Caribbean Sea	91	1.3%	114	1.3
Pacific Ocean	22	0.3%	54	2.5
Total	7023		7410	1.1

velop in the fjords of southern Chile, in southern Alaska, in the Canadian Archipelago, and within the fjords of Novaya Zemlya in the Arctic Ocean along the Siberian coast.

Inlet Barrier Islands

Inlet barrier islands develop on flood tidal deltas within lagoons immediately behind the inlets of open-ocean barriers. Active inlet islands almost always occur individually but as the inlet migrates, new inlet barrier islands form, creating chains of as many as five islands. Inlet islands are widespread globally; they are located behind open-ocean barrier islands of every continent, but primarily among the ocean barrier island systems of the southeastern United States (Figure 11), Colombia, Mozambique, Madagascar, and Portugal.

Inlet islands are typically 200–400 m long and narrow (50 m), but exhibit greater dune development than most fetch-limited barriers. Some of these dunes exceed 10 m high, perhaps because of their proximity to a sand-rich active tidal delta. During extreme conditions, ocean swells may affect these small islands while they are at the inlet mouth, but under fair weather conditions wave energy is low.

Inlets between oceanic barriers migrate and open and close on a variety of time scales. As the inlet migrates, flood tidal delta deposits form on the seaward rim of the marsh, the initial deposits accumulate, and salt-tolerant plant species pioneer the proto-island. Most often these islands form up against or drape over salt marshes or mangroves in the lagoon. After sufficient vegetative succession, the island stabilizes, dunes form, and the inlet island reaches its climax. Eventually as the inlet passes by or closes, the FLBI is disconnected from its sand supply and the wave energy that formed it and becomes stranded and inactive. Simultaneously, a new island may form landward of the new location of the inlet following the same cycle as its predecessor. Thus as an inlet migrates, a line of islands marking the migration can form in the lagoon (Figure 15).

Marsh Fringe Barrier Islands

Forming as sediment overwashed onto the salt marsh margins of fetch-limited waters, marsh-fringe barrier islands include those barrier islands that develop along shorelines subject to the lowest energy conditions. We identify more than 500 such active islands worldwide, 8.3% of the world total. These islands are limited to temperate and subtropical environments, often with brackish water, and are most numerous along the Atlantic and Gulf Coasts of North America and the Atlantic Coast of Argentina.

Marsh fringe barriers (Figure 4C) form in chains of as many as 20 islands, with small (1–4 m) gaps—rather than functional inlets—between them. Compared to other FLBIs, marsh fringe islands rank among the smallest, typically no more than a few hundred meters long, 10 m wide, and a meter above sea level. The islands themselves are thin (1–3 m thick) veneers of unconsolidated, coarse, sometimes shelly quartz sand resting upon the mud platform. Most marsh fringe islands lack a true subaqueous shoreface and rest instead upon an eroded mud platform that may extend seaward for tens of meters.

Unlike other barrier islands, marsh fringe barrier islands exhibit a variety of planforms, ranging from a crescent beach bound between marsh grass outcroppings (reminiscent of a pocket beach on a lithified coastline) to a wraparound (horseshoe) shape where the beach encloses a marsh lagoon on multiple sides. In nearly all cases, the barrier beach assumes a highly irregular shape because of the control exerted by the marsh vegetation.

Tidal, aeolian transport, and fair-weather wave processes do not appear to be significantly involved in the origin and evolution of these islands. Instead, storm-driven surges produce and maintain these islands through overwash deposits on the marsh grasses, which baffle waves and currents and induce sediment settling (Fonseca, 1996).

Thermokarst Barrier Islands

Found exclusively along the Arctic Coasts of Russia and North America, thermokarst barrier islands form as permafrost tundra erodes and fragments become stranded in fetch-

Table 4. *Distribution of Active Fetch-Limited Barrier Islands by Country.*

Country	Number	% of Total	Country	Number	% of Total
Australia	1699	24.2%	Namibia	15	0.2%
Mexico	1025	14.6%	Somalia	14	0.2%
Russia	899	12.8%	Chile	12	0.2%
United States	663	9.4%	New Zealand	11	0.2%
Canada	459	6.5%	China	10	0.1%
India	216	3.1%	Qatar	10	0.1%
Mozambique	213	3.0%	UAE	10	0.1%
Brazil	203	2.9%	Uruguay	10	0.1%
Madagascar	152	2.2%	Colombia	8	0.1%
Indonesia	149	2.1%	Thailand	7	0.1%
Mauritania	128	1.8%	Libya	6	0.1%
Ukraine	98	1.4%	Iceland	5	0.1%
Eritrea	91	1.3%	Japan	5	0.1%
Philippines	91	1.3%	Panama	5	0.1%
Venezuela	91	1.3%	Sierra Leone	5	0.1%
Argentina	73	1.0%	Cambodia	4	0.1%
Oman	66	0.9%	Guinea-Bissau	4	0.1%
Greece	57	0.8%	Nicaragua	4	0.1%
Burma	49	0.7%	Gabon	3	0.0%
Turkey	48	0.7%	Costa Rica	2	0.0%
Sri Lanka	46	0.7%	Ecuador	2	0.0%
Egypt	45	0.6%	El Salvador	2	0.0%
Angola	35	0.5%	Norway	2	0.0%
Iran	34	0.5%	Sweden	2	0.0%
Saudi Arabia	30	0.4%	Tunisia	2	0.0%
Portugal	27	0.4%	UK	2	0.0%
Bangladesh	26	0.4%	Vietnam	2	0.0%
Kenya	22	0.3%	Germany	1	0.0%
Pakistan	22	0.3%	Ireland	1	0.0%
Cuba	21	0.3%	Malaysia	1	0.0%
France	20	0.3%	South Africa	1	0.0%
Denmark	19	0.3%	The Netherlands	1	0.0%
Senegal	18	0.3%	Yemen	1	0.0%
Tanzania	18	0.3%	Total	7023	

limited waters (Figure 7B). These islands are on average the longest fetch-limited barriers (1.5 km average) and the second-most abundant, accounting for more than 16% of all islands worldwide.

Thermokarst barrier islands are highly interconnected alongshore both with each other and with nearby mainland shorelines. They are extremely low (1–2 m), storm-generated features, lacking in dunes, with notable outcropping peat, high amounts of gravel, and poorly sorted beachfaces, and are often fronted by large sand flats (Hill and Solomon, 1999; Hill *et al.,* 1994). The islands are fetch-limited because they exist behind chains of narrow Arctic barrier islands; within protected, shallow bays; or in channels between larger islands. The role of wave energy is further dampened by floating ice, permafrost hardening of sands, and the brief 2–3 month season of open, ice-free water.

The qualitative model of ocean facing barrier islands evolving from transgressed thermokarst (Ruz, Héquette, and Hill, 1992) also appears to apply to FLBIs. Thaw lakes formed from the compaction and subsidence of permafrost soils dominate thermokarst topography (Hill and Solomon, 1999). As the shoreline retreats, the lakes open up to the sea on one or more sides. Wind-driven alongshore transport results in the formation of spits off the remaining headlands. Over time, thawing permafrost in the headlands, further subsidence, storm breaching, and erosion result in the spit becoming separated from the mainland to form a barrier island. Sea-level rise and storm surge results in island rollover and migration. During periods of sea-ice cover, the ice alternately contributes to and prevents the transport of sediment, resulting in the morphological realignment of FLBIs in high latitudes.

DISCUSSION

The total number of fetch-limited barriers exceeds that of open-ocean barriers by a factor of three, yet the total length of fetch-limited barriers is just one-third that of ocean-facing barriers (Stutz and Pilkey, 2001). Nearly one-third of all active FLBIs are located in lagoons protected from the energy of ocean waves by open-ocean facing barrier island chains.

Table 6 provides a comparison of processes, island attributes, and human usage of fetch-limited and open-ocean barrier islands. Fetch-limited barrier islands are short ($\sim$1 km), narrow (10–50 m) and very low (1–3 m above sea level), whereas open-ocean barriers are on average much longer (10–20 km), wider (500–1000 m) and higher (5–10 m; occasionally with dunes in excess of 100 m as in Mozambique). On fetch-limited barriers, features such as dunes, tidal deltas, inlets, backbarrier lagoons, and shoreface profiles differ from their open-ocean counterparts. Dunes and tidal deltas are usually absent altogether or are much smaller. Inlets between fetch-limited islands have smaller cross sections in ac-

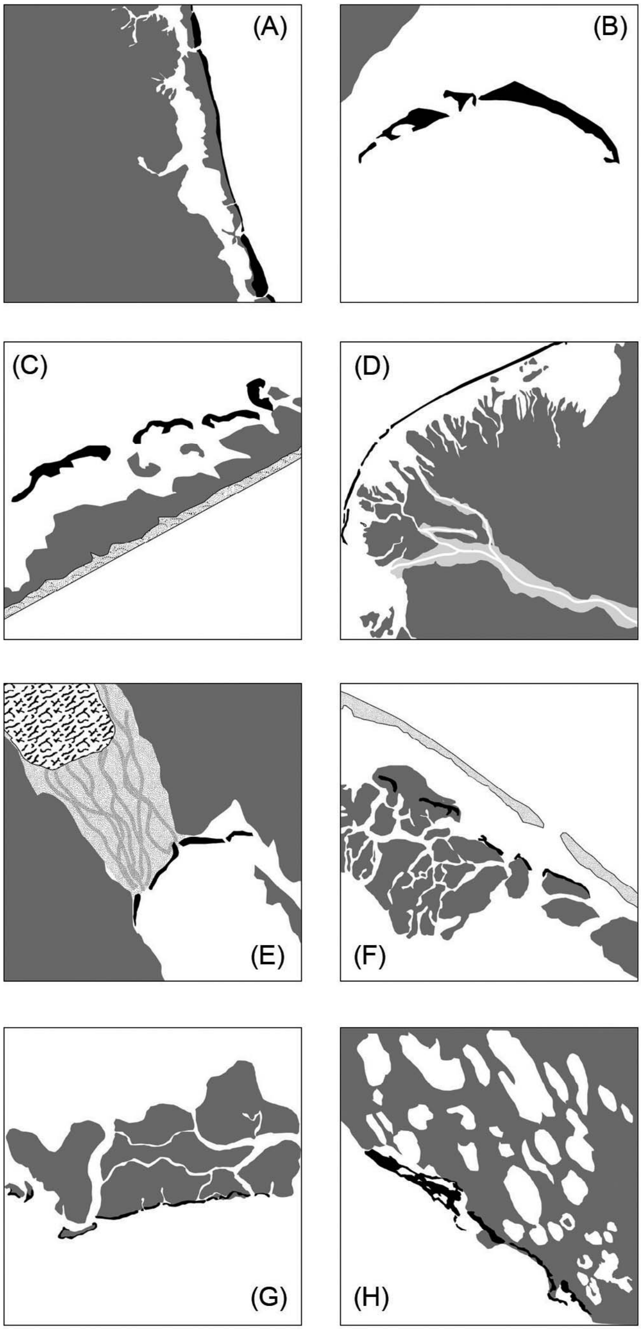

Figure 13. Types of fetch-limited barrier islands: (A) classic similar to open-ocean barrier islands, (B) two-sided with equal fetch in two directions, (C) backbarrier parallel landward of and parallel to the dominant trend of the open-ocean barrier, (D) deltaic on the rim of a fetch-limited delta, (E) fjord-head (or sandur) at the seaward of a margin of glacial outwash plain, (F) inlet formed on the flood tidal deltas of open-ocean barriers, (G) marsh fringe islands formed atop salt marsh rims, and (H) thermokarst formed from the breakup of thermokarst topography

Table 5. *Summary of Active Fetch-Limited Barrier Islands.*

Island Type	Number	% of Total	Total Length (km)	Average Length (km)
Classic	3535	50.3	3492	1.0
Two-sided	126	1.8	145	1.2
Backbarrier parallel	535	7.6	510	1.0
Deltaic	551	7.8	719	1.3
Fjord-head	90	1.3	98	1.1
Inlet	463	6.6	424	0.9
Marsh fringe	584	8.3	369	0.6
Thermokarst	1139	16.2	1653	1.5
Total	7023		7410	1.1

cordance with smaller tidal prisms and often serve dual roles as marsh drainage creeks (Figure 5C), river distributaries, or glacial outwash channels.

Open-ocean barriers usually have a well-defined shoreface that extends seaward to typical depths of 10–15 m. Shoreface morphology on FLBIs is much more variable, ranging from shallow (1–2 m) sandy shorefaces to multiple nearshore bars, subtidal sand flats, and, in some cases (perched islands), no shoreface at all. In any case, the shoreface performs the same function in fetch-limited and open-ocean islands, namely as a source, conduit, and sink of beach and island sediment.

Wrack lines are an important feature on the upper foreshore of low-energy beaches because fair weather wave conditions are insufficient to modify or remove debris deposited during storm events (Nordstrom and Jackson, 1990). In one barrier at the head of Spencer Gulf we noted a laterally extensive "bar," at least 1 km long, 1.5 m thick, and 5 m wide, of seagrass debris deposited above the spring high tide level on a FLBI. Wrack—including human litter as well as seagrass and other organic material—shelters underlying sediment, preventing aeolian resuspension and, to varying degrees, slows beach erosion (Jackson *et al.,* 2002). Higher wave energy prevents wrack from accumulating in proportional quantities on open-ocean barrier beaches.

One notable difference at large temporal scales is the effect of sea-level fluctuations. Whereas the morphological effect of sea-level changes is similar for both fetch-limited and oceanic islands (rising sea level and transgressive islands, Chesapeake Bay and Outer Banks United States; falling sea level and regressive islands, Spencer Gulf, Australia), fetch-limit-

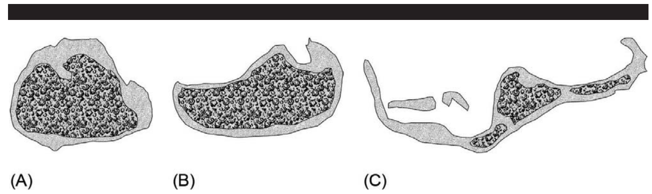

Figure 14. Evolution of pre-existing topography in Laguna Madre, Mexico. The (A) drowned clay dune with extensive vegetation and scarp in the center of the island (B) begins to be reworked by local waves (C) climaxing in a classic fetch-limited barrier island sometimes complete with its own backbarrier parallel island. This is an example of pre-existing topography drowned by sea-level rise, reworked by local waves, and resulting in the eventual formation of true fetch-limited barrier islands.

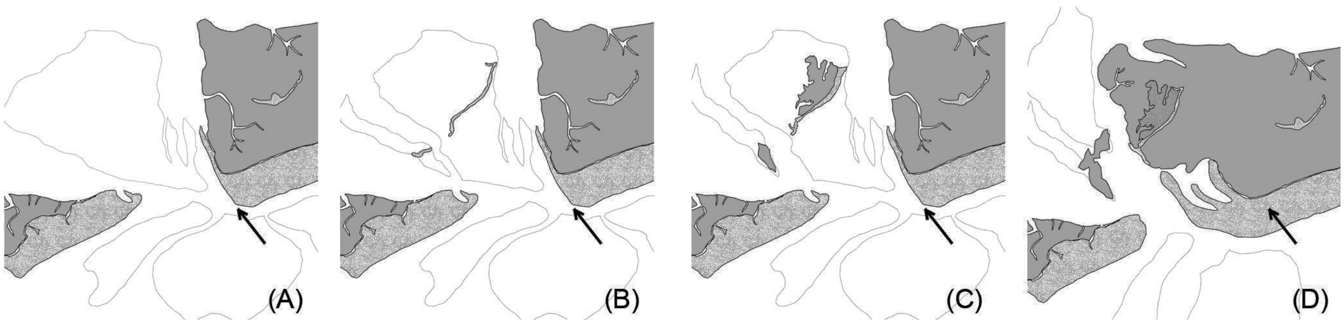

Figure 15. Genesis and evolution of inlet islands. (A) As a new inlet forms (B) an island will form on the rim of a new flood tidal delta and (C) will widen with the addition of salt marsh or mangroves. (D) As the ocean barrier-inlet complex migrates, the inlet island is surrounded by salt marsh and becomes an inactive island.

ed barriers may respond more rapidly to sea-level change because of their lower sediment volume, smaller sand supply, and smaller size.

Except for very specific regional climatic conditions, the morphology and distribution of FLBIs is a function primarily of local, rather than regional, conditions such as pre-existing topography, sediment supply, shoreline orientation, and local sea-level history. The significance of local conditions explains the variation of island numbers between fetch-limited environments in close proximity. For example, Laguna Madre in Texas has 94 islands whereas the smaller Laguna Madre in Mexico has 596 islands.

Although Riggs, Cleary, and Snyder (1995) illustrate the importance of geologic control on oceanic barrier island development, it is far more significant in fetch-limited environments, stabilizing islands, forming platforms, and trapping sediment. Geologic control is evident in such barrier platform-creating features as flood tidal deltas, rock outcrops, vegetation platforms, dunes, and pre-existing permafrost topography. The local underlying geologic structure is also an important control on the local surface gradient, determining nearshore bathymetry, which influences island width, water depth, and wave energy (Cooper and Navas, 2004)

The sediment supply of FLBIs is strongly dependent upon local wave activity. In Pamlico Sound, United States, and Spencer Gulf, Australia, the only islands wider than a few tens of meters are those with the orientation that provides maximum fetch.

Apart from size and total evolutionary dependence upon storms, probably the most important single difference between fetch-limited and open-ocean barrier islands is vegetative control. Vegetation exerts a major control on fetch-limited barrier morphology that does not exist in open-ocean settings. Salt marshes, mangroves, and seagrasses all introduce baffling effects on sediment transport in the nearshore area of fetch-limited beaches (Christiansen, Wiberg, and Milligan, 2000; Fonseca, 1996; Furukawa, Wolanski, and Mueller, 1997; Ward, Kemp, and Boynton, 1984), whereas mud and peat associated with marsh vegetation often constitute the barrier platform. When islands become surrounded by wide expanses of marsh or mangroves they may become inactive, no longer being impacted by waves and currents. However, in this role mangroves exhibit far more permeability to storm wave action (King Sound, Australia) than salt marsh.

Because significant wave heights are rarely greater than 0.25 m, most low-energy beaches are only "active" during storms. In areas of high tidal range, storms are effective only when they coincide with high tide (Goodfellow and Stephenson 2005; Hegge, Eliot, and Hsu, 1996; Jackson *et al.,* 1995, 2002). Storm-driven overwash is typically the most important sediment transport process responsible for fetch-limited island evolution. Because storm overwash does not generate significant return flow within sheltered environments, low-energy beaches move predominantly in the landward direction (Jackson *et al.,* 2002). Moreover, because waves are very locally generated, often within a few hundred meters of the beach, the waves are shorter and therefore refract less than do oceanic swell waves. Less wave refraction nearshore increases the shore parallel component of wave energy and results in proportionally greater alongshore transport relative to open-ocean beaches (Finlayson and Shipman, 2003).

A range of processes, including fair-weather wave activity, tidal currents, aeolian processes, alongshore transport, and storms impact ocean barrier islands (Komar, 1998). Fair weather waves, tidal currents, and aeolian sand transport are, however, only locally important in FLBI evolution. For example, large dunes on fetch-limited barriers are essentially restricted to inlet islands.

Human activities—such as dredging, nourishment, sediment mining, construction, shoreline stabilization, boat wake, and seagrass killoffs—are major factors in the processes that shape fetch-limited islands. Given the small size and low elevation of fetch-limited barriers, human activities can be expected to exert rapid and significant impacts on erosion rates and other aspects of island evolution.

DEVELOPMENT POTENTIAL OF SHELTERED ISLANDS

As open-ocean barrier islands reach a development saturation point in the western world, increasingly more attention will be focused on development along low-energy shorelines. These islands offer the possibility of beachfront living and are largely "undiscovered" by tourists and developers

Table 6. *Generalized characteristics (inevitably with exceptions) of fetch-limited barrier islands and open-ocean barrier islands.*

Parameter	Fetch-Limited Barrier Islands	Open-Ocean Barrier Islands
Process		
Dominant process	Overwash, swash	Overwash, swash, aeolian
Waves	Sea only	Sea and swell
	Short period	Long period
	>1 m	Up to several meters
Tides	Many active only at high tide	Islands active at all tides
Local wind regime	Very important (generates waves)	Negligible
Events (wind and wave)	Event driven	Event and fairweather driven
	Long periods of inactivity between events	Always active
Storm surge	Very important	Variably important
Overwash	Very important (dominant process)	Very important
Aeolian	Negligible	Often important
Longshore transport	Variably important	Very important
New inlet formation	Uncommon	Common
Sea level change	Immediate response	Gradual response
Geological control	Very important	Variably important
Biological control mangrove/marsh	Very important	Negligible
Biological control seagrass	Very important	Negligible
Island Character		
Abundance	Tens of thousands	2500
Size (length, width, elevation)	Short	Long
	Narrow	Wide
	Low	High
Tidal prism	Small	Variable
Inlet depth	Shallow	Deep
Tidal deltas–ebb	Occasional	Common
Tidal deltas–flood	Uncommon	Common
Shape	Variable	Linear
Lagoon	Very shallow	Deep
	May be intertidal, vegetated	Subtidal, often open water
Shoreface	Not useful concept	Important feature
Human Use		
Development	Few developed	Many developed
Type/use	Limited: shacks and boat ramps	Wide range: shacks–highrises
Natural hazards–inundation	High	Variable
Natural hazards–waves	Moderate	High
Natural hazards–erosion	High	High
Natural hazards–inlet migration	Low	High
Natural hazards–durability of stabilization	High	Low

alike. Globally, small fishing and hunting shacks already abound on these islands, frequently constructed on a squatter basis. On some Turkish islands, small, semipermanent buildings have been built to shelter cattle herders, and small "hunting shacks" are found on some low-energy Arctic shorelines. In Spencer Gulf, Australia, and Chesapeake and Delaware Bays, United States, a number of small holiday homes and small fishing and holiday villages exist on FLBIs. Individual fishermen homes and small fishing/farming villages are found on the islands in Maputo Bay, Mozambique.

Along the East Coast of North America, a few of the larger islands have been occupied by fishing villages for centuries (for example, Tangier Island in Chesapeake Bay, Virginia, and Harkers Island in Core Sound, North Carolina). Two small villages, Thompsons Beach and Moores Beach, New Jersey, on a Delaware Bay FLBI were ultimately abandoned in 1987 due to local sea-level rise and storm-induced erosion. The villages moved to the mainland but retained the same name. Foundations, seawalls, and other structures are still visible on the island.

Development pressure on the smaller islands is basically a recent phenomenon and promises to present significant environmental problems. In South Carolina, a policy debate currently centers on whether to allow bridges connecting islands to other islands and bridges linking islands to the mainland.

Problems created by development on sheltered islands are different from those of open-ocean islands (Table 6). Inevitably development on active fetch-limited barriers will be affected by erosion and almost equally inevitably the response is hard stabilization. In most backbarrier waters of the eastern United States, permits for seawall construction are readily granted and because of low wave energies hard structures are more durable and can be constructed at lower costs. Large sections of Tangier and Harker Islands in Chesapeake Bay, for example, are armored by seawalls.

There will be less concern about beach loss from seawall construction on sheltered islands than on open-ocean shorelines because lagoon beaches are relatively unimportant as tourist beaches. But a more important problem may be the loss of salt marsh due to sea wall construction (Park, *et al.,* 1989; Titus, 1996). Salt marsh migrates inland with the rising sea level but is prevented from doing so by seawalls. In theory, seawalls should eventually result in the complete loss of adjacent marshes as sea level rises.

"Solving" the erosion problem of protected shorelines is likely to be more complex than that of open-ocean shorelines. Differences in erosion rates and mechanisms may occur over very short shoreline distances depending on shoreline orientation, marsh and mangrove locations, and nearby lagoon bathymetry. In addition, most low-energy shoreline erosion is a one-way process; that is, erosion loss is not recovered. These islands are generally not migrating in the sense of ocean barrier islands. Thus the decision as to the use of hard stabilization can be also a decision as to whether an island will survive for a future generation.

In the seawall debate on open-ocean barrier beaches the question often comes down to which is more important: beaches or buildings? In the seawall debate on fetch-limited barriers the important question will come down to which is more important: preservation of salt marsh or preservation of islands?

CONCLUSIONS

We identify more than 7000 active fetch-limited barrier islands around the world, closely following the general distribution of open-ocean barriers. These low-energy features are typically very short (~1 km), narrow (10–100 m), and low (1–3 m). Fetch-limited barrier islands generally conform to the definition of ocean barrier islands of Oertel (1985), but differ from them in several important respects. Fetch-limited barriers often lack dunes and tidal deltas; have very shallow, intertidal backbarrier lagoons; narrow inlets; and broad foreshore terraces rather than a concave upshoreface profile.

Barrier island abundance and evolution vary greatly depending on local controls such as sediment supply, local topography and bathymetry, vegetative control, and storm climate. Storm-driven overwash, alongshore transport, and wave deposition are universally dominant processes. Tides are of variable importance (*i.e.,* important for inlet islands and those in the megatidal King Sound; less important elsewhere), and aeolian processes are rarely important. Sea-level history is an important confounding factor, as evidenced by the multiple lines of prograding barriers in South Australia and Argentina and rapid erosion (0.8 ma^{-1}) in the Chesapeake Bay.

Based on morphology, location, and developmental processes, we divide active fetch-limited barriers into eight categories: classic, backbarrier parallel, two-sided, deltaic, fjord-head, inlet, marsh-fringe, and thermokarst.

Fetch-limited barrier islands are globally abundant features and serve as important indicators of coastal evolution at a variety of timescales. Their formative and evolutionary processes, however, require more detailed examination.

Fetch-limited barrier islands have a high preservation potential due to their sheltered nature and proximity to low-energy fine-grained sediments. In the geologic record they are an additional category of coastal sand body that has petroleum reservoir potential. The most pressing societal need is for an understanding and appreciation of the operative processes of these islands as they are likely to be exposed to growing development pressure.

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