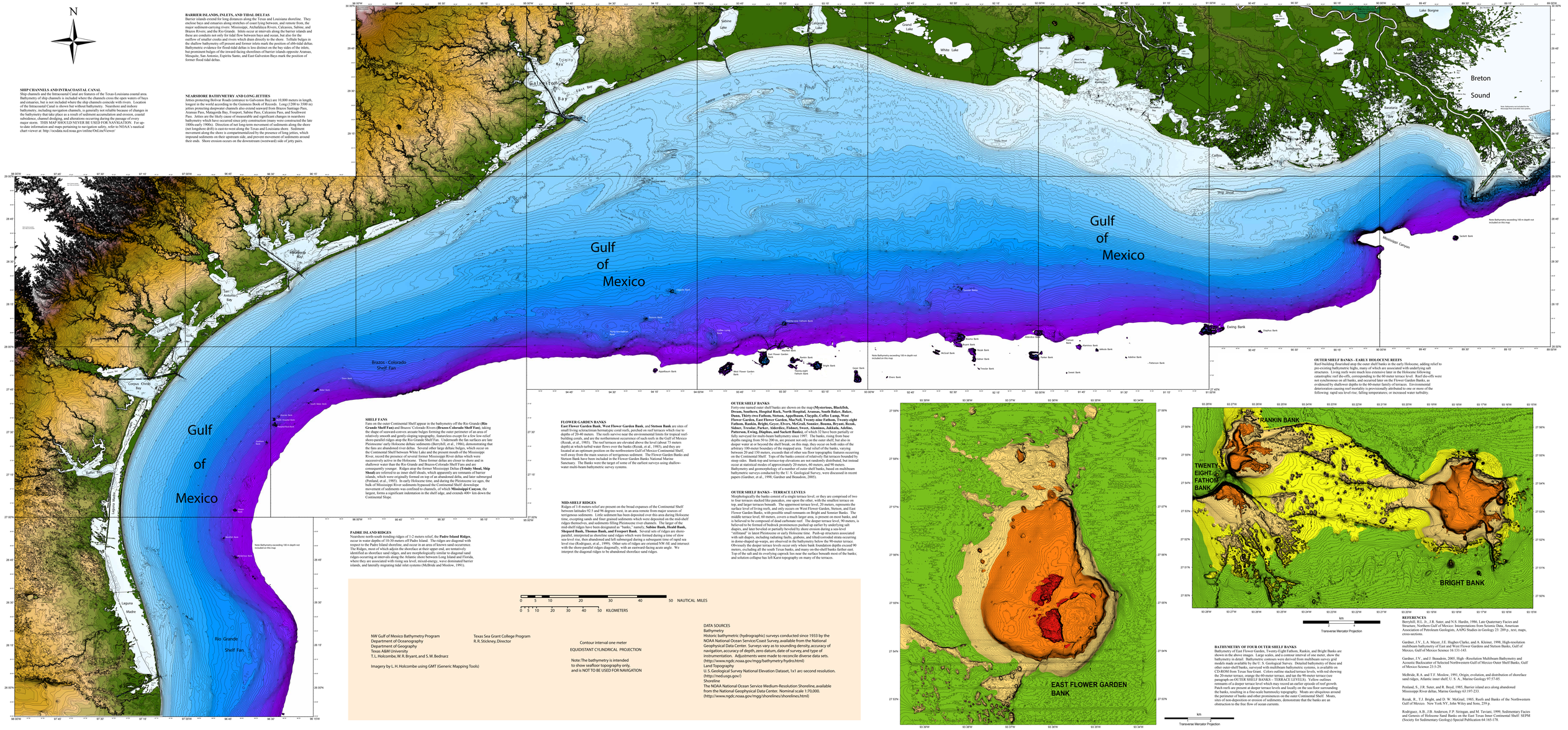
BATHYMETRY AND LAND TOPOGRAPHY OF THE TEXAS - LOUISIANA COASTAL REGION AND CONTINENTAL SHELF, NORTHWESTERN GULF OF MEXICO

BARRIER ISLANDS, INLETS, AND TIDAL DELTAS
Barrier islands extend for long distances along the Texas and Louisiana shoreline. They enclose bays and estuaries along stretches of coast lying between, and remote from, the major sediment-carrying rivers: Mississippi, Atchafalaya Rivers, Calcasieu, Sabine, and Brazos Rivers; and the Rio Grande. Inlets occur at intervals along the barrier islands and these are conduits not only for tidal flow between bays and ocean, but also for the outflow of smaller creeks and rivers which drain directly to the shore. Telltale bulges in the shallow bathymetry off present and former inlets mark the position of ebb-tidal deltas. Bathymetric evidence for flood-tidal deltas is less distinct on the bay sides of the inlets, but prominent bulges of the inward-facing shorelines of barrier islands opposite Aransas, Mesquite, San Antonio, Espiritu Santo, and East Galveston Bays mark the position of former flood tidal deltas.

SHIP CHANNELS AND INTRACOASTAL CANAL
Ship channels and the Intracoastal Canal are features of the Texas-Louisiana coastal area. Bathymetry of ship channels is included where the channels cross the open waters of bays and estuaries, but is not included where the ship channels coincide with rivers. Location of the Intracoastal Canal is shown but without bathymetry. Nearshore and inshore bathymetry, including navigation channels, is generally not reliable because of changes in the bathymetry that take place as a result of sediment accumulation and erosion, coastal subsidence, channel dredging, and alterations occurring during the passage of every major storm. THIS MAP SHOULD NEVER BE USED FOR NAVIGATION. For up-to-date information and maps pertaining to navigation safety, refer to NOAA's nautical chart viewer at: http://ocsdata.ncd.noaa.gov/onlineNoLimeViewer/

NEARSHORE BATHYMETRY AND LONG JETTIES
Jetties protecting Bolivar Roads (entrance to Galveston Bay) are 10,800 meters in length, longest in the world according to the Guinness Book of Records. Long (1200 to 3500 m) jetties protecting deepwater channels also extend seaward from Brazos Santiago Pass, Aransas Pass, Pass Cavallo, Matagorda Ship Channel, Freeport, Sabine Pass, and Calcasieu Pass. Jetties are the only man-made, stable and significant, short-term nearshore bathymetric which have occurred since jetty construction (many were constructed the late 1800s-early 1900s). Direction of net long-term movement of sediments along the shore (net longshore drift) is east-to-west along the Texas and Louisiana shore. Sediment movement along the shore is compartmentalized by the presence of long jetties, which impound sediments on their upstream side, and prevent movement of sediments around their ends. Shore erosion occurs on the downstream (westward) side of jetty pairs.



SHELF FANS
Fans on the outer Continental Shelf appear in the bathymetry off the Rio Grande (**Rio Grande Shelf Fan**) and Brazos/ Colorado Rivers (**Brazos-Colorado Shelf Fan**), taking the shape of seaward-convex arcuate bulges forming the outer perimeter of an area of relatively smooth and gently-sloping topography, featureless except for a few low-relief shore-parallel ridges atop the Rio Grande Shelf Fan. Underneath the fan surfaces are late Pleistocene/ early Holocene deltaic sediments (Berryhill, et al., 1986), demonstrating that the fans are abandoned river deltas. Several other large deltaic bulges, which occur on the Continental Shelf between White Lake and the present mouth of the Mississippi River, record the presence of several former Mississippi River deltas which were successively active in the Holocene. These former deltas are closer to shore and in shallower water than the Rio Grande and Brazos-Colorado Shelf Fans and are progressively smaller with age. Three of these deltas (**Sabine, Heald, Ship Shoal**) are referred to as inner shelf shoals, which apparently are remnants of barrier islands, which were originally formed on top of an abandoned delta, and later submerged (Penland, et al., 1985). In early Holocene time, and during the Pleistocene ice ages, the bulk of Mississippi River sediments bypassed the Continental Shelf: downslope movement of sediments was confined to channels, of which **Mississippi Canyon**, the largest, forms a significant indentation in the shelf edge, and extends 400+ km down the Continental Slope.

PADRE ISLAND RIDGES
Nearshore north-south trending ridges of 1-2 meters relief, the **Padre Island Ridges**, occur in water depths of 10-30 meters off Padre Island. The ridges are diagonal with respect to the Padre Island shoreline, and occur in an area of known sand occurrence. The Ridges, most of which adjoin the shoreface at their upper end, are tentatively identified as shoreface sand ridges, and are morphologically similar to diagonal sand ridges occurring at intervals along the Atlantic shore between Long Island and Florida, where they are associated with rising sea level, mixed-energy, wave dominated barrier islands, and laterally migrating tidal inlet systems (McBride and Moslow, 1991).

FLOWER GARDEN BANKS
East Flower Garden Bank, **West Flower Garden Bank**, and **Stetson Bank** are sites of small living sclractinian hermatypic coral reefs, perched on reef terraces which rise to depths of 20-40 meters. The reefs survive near the environmental limits for tropical reef-building corals, and are the northernmost occurrence of such reefs in the Gulf of Mexico (Rezak, et al., 1985). The reefs are developed preferentially on the highest terrace depths at which turbid water flows over the banks (Rezak, et al., 1985), and they are located at an optimum position on the northwestern Gulf of Mexico Continental Shelf, well away from the main sources of terrigenous sediment. The Flower Garden Banks and Stetson Bank have been included in the Flower Garden Banks National Marine Sanctuary. The Banks were the target of some of the earliest surveys using shallow-water multi-beam bathymetric survey systems.

MID-SHELF RIDGES
Ridges of 1-8 meters relief are present on the broad expanses of the Continental Shelf between latitudes 92.5 and 96 degrees west, in an area remote from major sources of terrigenous sediments. Little sediment has been deposited over this area during Holocene time, excepting sands and finer grained sediments which were deposited on the mid-shelf ridges themselves, and sediments filling Pleistocene river channels. The larger of the mid-shelf ridges have been designated as "banks," namely, **Sabine Bank, Heald Bank, Shepard Bank, Thomas Bank, and Freeport Bank**. Several sets of ridges are shore-parallel, interpreted as shoreline sand ridges which were formed during a time of slow sea-level rise, then abandoned and left submerged during a subsequent time of rapid sea level rise (Rodriguez, et al., 1999). Other sets of ridges are oriented NW-SE and intersect with the shore-parallel ridges diagonally, with an eastward-facing acute angle. We interpret the diagonal ridges to be abandoned shoreface sand ridges.

OUTER SHELF BANKS
Forty-one named outer shelf banks are shown on the map (**Mysterious, Blackfish, Decsan, Southern, Hospital Rock, North Hospital, Aransas, South Baker, Baker, Dunn, Thirty-two Fathom, Stetson, Appelbaum, Claypile, Coffee Lump, West Flower Garden, East Flower Garden, MacNeil, Twenty-nine Fathom, Twenty-eight Fathom, Rankin, Bright, Geyer, Elvers, McGrail, Sonnier, Bouma, Bryant, Rezak, Sidner, Treadaway, Parker, Alderdice, Fishnet, Sweet, Alaminos, Aikhala, Adeline, Patterson, Ewing, Diaphus, and Sackett Banks**), of which 32 have been partially or fully surveyed for multi-beam bathymetry since 1997. The banks, rising from base depths ranging from 50 to 200 m, are present not only on the outer shelf, but also in deeper water at or beyond the shelf break, on this map, they occur on both sides of the arbitrary 100-meter boundary of the mapped area. Total relief of the banks, varying between 20 and 150 meters, exceeds that of other sea floor topographic features occurring on the Continental Shelf. Tops of the banks consist of relatively flat terraces bounded by steep sides. Bank-top and terrace-top elevations are not randomly distributed, but instead occur at statistical modes of approximately 20 meters, 60 meters, and 90 meters. Bathymetry and geomorphology of a number of outer shelf banks, based on multibeam bathymetric surveys conducted by the U. S. Geological Survey, were discussed in recent papers (Gardner, et al., 1996; Gardner and Bensdson, 2005).

OUTER SHELF BANKS – TERRACE LEVELS
Morphologically the banks consist of a single terrace level; or they are comprised of two to four terraces stacked like pancakes, one upon the other, with the smallest terrace on top, and larger terraces beneath. The uppermost terrace level, 20 meters, represents the surface level of living reefs, and only occurs on West Flower Garden, Stetson, and East Flower Garden Banks, with possible small remnants on Bright and Sonnier Banks. The middle terrace level, 60 meters, covers a much larger area, is present on most banks, and is the level of the most extensive dead coralgreen algal reefs. The deeper terrace level, 90 meters, is believed to be formed of thick accumulations of dead coralgreen algal reefs, capped by salt diapirs, and later beveled or partially beveled by shore erosion during a slow rise, "stillstand" in latest Pleistocene or early Holocene time. Push-up structures associated with salt diapirs, including radiating faults, grabens, and tilted/corroded strata occurring in dome-shaped up-warps, are observed in the bathymetry below the 90-meter terrace. Obviously the deeper terrace levels occur only where bank foundation depths exceed 90 meters, excluding all the south Texas banks, and many on-the-shelf banks farther east. Top of the salt and its overlying caprock lies near the surface beneath most of the banks; and solution collapse has left Karst topography on many of the terraces.

OUTER SHELF BANKS – EARLY HOLOCENE REEFS
Reef-building flourished atop the outer shelf banks in the early Holocene, adding relief to pre-existing bathymetric highs, many of which are associated with underlying salt structures. Living reefs were much less extensive later in the Holocene following catastrophic reef die-offs, corresponding to the 60 meter terrace level. Reef die-offs were not synchronous on all banks, and occurred later on the Flower Garden Banks, as evidenced by shallower depths to the 60-meter family of terraces. Environmental deterioration causing reef mortality is provisionally attributed to one or more of the following: rapid sea level rise; falling temperatures; or increased water turbidity.

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Imagery by L. H. Holcombe using GMT (Generic Mapping Tools)

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Contour interval one meter
EQUIDISTANT CYLINDRICAL PROJECTION

Note: The bathymetry is intended to show seafloor topography only, and is NOT TO BE USED FOR NAVIGATION

0 5 10 20 30 40 50 NAUTICAL MILES
0 5 10 20 30 40 50 KILOMETERS

DATA SOURCES
Bathymetry
Historic bathymetric (hydrographic) surveys conducted since 1933 by the NOAA National Ocean Service/Coast Survey, available from the National Geophysical Data Center. Surveys vary as to sounding density, accuracy of navigation, accuracy of depth, zero datum, date of survey, and type of instrumentation. Adjustments were made to reconcile diverse data sets. (http://www.ngdc.noaa.gov/mgg/bathymetry/hydro.html)
Land Topography
U.S.Geological Survey National Elevation Dataset, 1x1 arc-second resolution. (http://ned.usgs.gov/)
Shoreline
The NOAA National Ocean Service Medium-Resolution Shoreline, available from the National Geophysical Data Center. Nominal scale 1:70,000. (http://www.ngdc.noaa.gov/mgg/shorelines/shorelines.html)

BATHYMETRY OF FOUR OUTER SHELF BANKS
Bathymetry of East Flower Garden, Twenty-Eight Fathom, Rankin, and Bright Banks are shown in the above images. Large scales, and a contour interval of one meter, show the bathymetry in detail. Bathymetric contours were derived from multibeam survey grid models made available by the U. S. Geological Survey. Detailed bathymetry of these and other outer-shelf banks, surveyed with multibeam bathymetric systems, is available on CD-ROM from Texas Sea Grant. Colors outline stacked terrace levels, with red showing the 20-meter terrace, orange the 60-meter terrace, and tan the 90-meter terrace (see paragraph on OUTER SHELF BANKS – TERRACE LEVELS). Yellow outlines remnants of a deeper terrace level which may record an earlier episode of reef growth. Patch reefs are present at deeper terrace levels and locally on the sea floor surrounding the banks, resulting in a fine-scale hummocky topography. Moats are ubiquitous around the perimeter of banks and other prominences on the outer Continental Shelf. Moats, sites of non-deposition or erosion of sediments, demonstrate that the banks are an obstruction to the free flow of ocean currents.

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