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History

''The Rock,'' ''The Island,'' ''The Gulf Breeze Lab,'' all are familiar names for the place where ships once dumped ballast rock en route to the Port of Pensacola. What is now the Gulf Ecology Division (GED) is located on a 17-acre, federally owned, man-made island in Santa Rosa Sound just south of Gulf Breeze, FL, off the northern shore of Santa Rosa Island and Pensacola Beach (Fig. 1). The first known record of the island was made by William Davison, Port Inspector at the Pensacola Quarantine Station, when, in Sept. 23, 1876, he marked a location for Captain Klem to unload his ballast, about 55 tons of rock. Davison's journal from 1876 was transcribed by an anonymous editor; the transcription is available in the GED library (Davison, 1876). From the 1870s to the 1920s, ships entering the Port of Pensacola were required to discharge ballast before they were fumigated to stop the spread of yellow fever. Sediment was barged from the Mississippi Delta to cap the ballast rock island.

The island was first inhabited in 1906, when it became the site of the Pensacola Quarantine Station, under the jurisdiction of the Treasury Department's Public Health Service. The original eight buildings included a small hospital, quarters for medical staff (doctor, pharmacist's mate, four nurses) and a caretaker, a guest house, and a large dirt-floored disinfecting building. In 1925, when no longer needed as a quarantine station, the island was placed in caretaker status and remained so until 1937, when the Commerce Department's Bureau of Fisheries acquired the island and established a permanent marine laboratory to respond to concerns of the gulf fishing industry. Labor from the Works Progress Administration constructed aquaria and concrete tanks and enlarged the former doctor's residence into a laboratory facility.

In 1937, the U.S. Fish and Wildlife Service established the Pensacola Fisheries Biological Station on the island; at the time it was the only marine laboratory on the Gulf coast devoted to research. Under the leadership of Dr. A. E. Hopkins (1937–1948) and Dr. Philip A. Butler (1948–1968), the Biological Station conducted research on the biology of oysters and other mollusks and, from about 1960, the biology of the estuary. In 1958, the laboratory initiated studies on the effects of DDT on oysters and began monitoring concentrations in the local estuary. The Bureau of Commercial Fisheries (BCF) Estuarine Pesticide Monitoring Program, a cooperative federal–state program, was initiated in the early 1960s and expanded to 175 monitoring stations along the Atlantic, Gulf, and Pacific coasts to monitor the presence of persistent organochlorine pesticides in shellfish tissues. In 1960, Dr. Butler named the site Sabine Island as a postal address.

The laboratory was merged with the BCF Radiobiological Laboratory at Beaufort, NC, in 1968 and, under the leadership of Dr. Thomas W. Duke, became known as the Florida Fisheries Center. Dr. Duke and a staff of 27 performed research on the biological effects and dynamics of pesticides in estuaries. The Sabine Island facility transferred from the Department of Interior to the newly created Environmental Protection Agency (EPA) in 1970, as part of the agency's Office of Research and Development (ORD). The primary mission of the laboratory, under the leadership of Dr. Thomas W. Duke, was to ''bridge the gap from ecosystem health to human health by assessing the transport of chemicals in the marine environment and the potential transfer from the marine food web to man.'' Studies concentrated on the effects of toxic organic compounds on bacteria, algae, estuarine plants, invertebrates, fishes, and estuarine ecosystems. A large new building was constructed with facilities for seawater toxicology (a state-of-the-art wet laboratory) and analytical chemistry.

The laboratory and its research mission continued evolving to meet new environmental challenges through the 1990s. In 1995, it became the Gulf Ecology Division of the National Health and Environmental Effects Research Laboratory (NHEERL), one of several national laboratories and centers in EPA's reorganized ORD. The new mission reflected a more holistic approach to coastal ecology: ''To understand the physical, chemical, and biological dynamics of coastal wetlands and estuaries, determine ecological condition, evaluate rates and causes of declining systems, and predict future conditions.''

Fig. 1. Aerial photograph of Sabine Island and the Gulf Ecology Division. The Gulf of Mexico is at the top of the photo, with Santa Rosa Sound at the bottom.

Divers, Hurricanes, and Geese

The Gulf Ecology Division hosts EPA's National Diver Training Program annually. Up to 30 divers from all over the United States spend an intensive week on Sabine Island to obtain certifications as scientific divers or dive masters (Fig. 2). Divers spend many hours in classroom instruction and in-water training and must pass written and practical tests to obtain their certifications. Certification from this program is required for all EPA divers.

Sabine Island is no stranger to hurricanes. Although the island is relatively high (>3 m above mean sea level), Hurricane Ivan in Sept. 2004 flooded a laboratory building with seawater and caused significant wind damage to some buildings. Power, water, and sewage services were off for several weeks. In July 2005, Dennis, a smaller storm than Ivan, but fierce nevertheless, did additional damage. The laboratory has fully recovered from these storms, thanks to the dedication and hard work of facilities staff, contractors and research staff, and support from EPA headquarters.

In a strange analogy to the recent history of Florida, GED was visited, roughly a decade ago, by a few Canada geese (*Branta canadensis*) on winter vacation (Fig. 3). They stayed. On Sabine Island, they found security, fresh water, and abundant food. Security was provided in the island environment with a large manicured lawn,

Fig. 2. Divers at the Gulf Ecology Division during EPA's National Diver Training Program.

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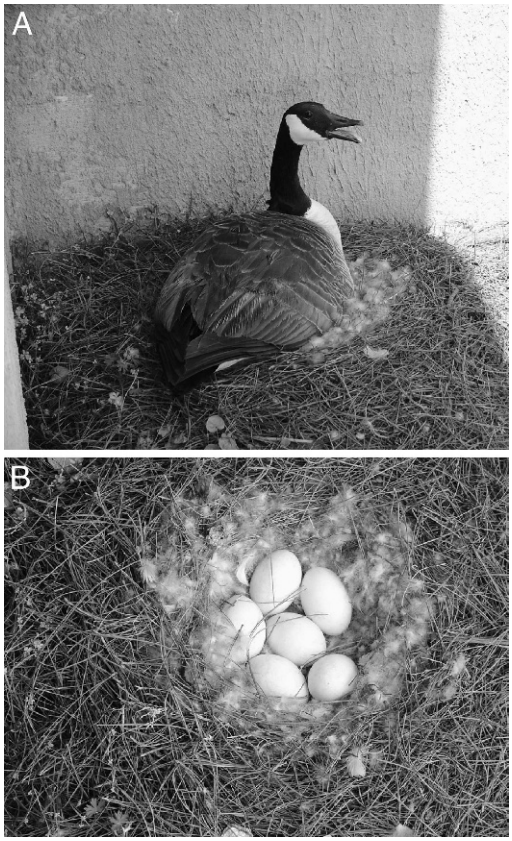

Fig. 3. (A) A resident goose nesting on Sabine Island; (B) goose nest with eggs.

a wide field of view, nesting material and shelter around the perimeter, and no natural predators. Their safety shield was supplemented by 24-hr security guards who protected, fed, and watered them. During times of drought, fresh water was provided by condensation from numerous air conditioning units. Nearly 10 acres of grass (a natural variety preferred by the geese), the guards, and staff supplied ample food. These ideal conditions contributed to geometric population growth, eventually resulting in more than 90 Canada geese as year-round residents. Other wildfowl followed the geese—at one time the flock included a few barnacle geese (*Branta leucopsis*), a fat Muscovy duck (*Cairina moschata*) named ''Elvis'' by the staff, a homegrown Canada-barnacle goose hybrid (sp. *novum?*) named ''Beaker,'' and a few families of mallards (*Anas platyrynchos*).

The geese consumed more than 180 pounds (82 kg) of grass daily and plainly marked their presence with a similar mass of droppings, reflecting low assimilation efficiency for cellulosic biomass. Like most animals, geese tend to walk where the least amount of energy is expended to get from one point to another. Thus, they frequently used the sidewalks and roads in their daily search for food and water. The result was large deposits of droppings on the roads and sidewalks which were picked up by shoes and cart wheels and carried into offices and laboratories. A second nuisance factor was the aggressiveness of the male geese during mating and nesting season—unwary people occasionally were nipped, and even the wary often had to change course to avoid a charging gander. One interesting phenomenon, resulting from use of paved paths, was that many geese wore holes in their webbed feet.

In 2007, a concerted effort was undertaken to reduce the population of resident geese. It included several strategic actions, including requesting the staff to stop feeding and watering the geese, and eliminating access to water, including the condensate water from air conditioning units. These efforts had no significant, positive results; therefore, the U.S. Department of Agriculture (USDA) was requested to assist in reducing the resident goose population. During evening hours in the molting period, USDA staff collected more than 50 geese and relocated them. An additional 30+ geese were less domesticated and could not be caught. Most of the latter departed for greener pastures elsewhere, and the island was goose free as of April 2011. The saga of the geese on Sabine Island certainly belies the Irish proverb, ''A wild goose never reared a tame gosling,'' which, of course, isn't meant to apply to geese at all.

Synopsis of Current Research

The current (2011) mission of GED, adopted in the late 1990s, is ''To understand the physical, chemical, and biological dynamics of coastal systems in order to assess condition, determine cause(s) of declining systems, predict future risks, and assist in establishing criteria to protect the environment.'' There are approximately 125 people employed at GED; 66 are EPA employees, 24 have Ph.D. degrees, and most of the remaining staff members have B.S. or M.S. degrees. The non-EPA staff includes contractors, cooperators from other federal agencies, student interns, and guest workers. Facilities include 68,000 square feet of working space, with 25,000 square feet of laboratories, a wet lab supplied with temperature- and salinity-controlled seawater, unique facilities for coral culture and research, and a fleet of small research vessels ranging from 10 to 25 feet. Since 1999, GED has been under the leadership of Director Dr.

William H. Benson, currently (2011) assisted by Associate Directors Dr. Kevin Summers (science) and John Macauley (program operations).

For the past decade, research at the division has been conducted under the guidance of multiyear research plans developed by ORD to address EPA's strategic goals and major regulatory programs. Currently (2011) multiyear research plans for ecosystem services, safe pesticides/safe products, and water quality supply the research questions and commitments that direct research at GED. Virtually all of GED's research applies to one of three major themes: coastal assessments and ecosystem services, nitrogen and phosphorus (nutrient) pollution, and predictive ecotoxicology. Cross-organizational teams are organized around each of these themes, and individual research staff may serve on more than one team; some scientific and technical staff support all three teams. Because of its unique location and special mission within the larger organization, GED's research focuses almost entirely on coastal ecosystems, especially within the Gulf of Mexico, but also nationally.

Ecosystem services and coastal assessments.—Shallow water coastal habitats, including wetlands, submersed and emergent vegetation, and their adjacent, landward components deliver a wide range of ecosystem services, including fish habitat, water purification, water supply, climate regulation, flood regulation, coastal protection, recreational opportunities, and tourism. Information is needed to understand the limits, linkages, and consequences of ecosystem services loss and the actions needed to maintain or restore ecosystem services in the context of future growth and a changing climate.

Research by GED's Coastal Assessment and Services Team is a strongly multidisciplinary enterprise bridging the ecological, economic, and sociological realms in the interest of sustainable solutions. We illustrate with a few of the team's research goals for 2011–2012:

(1) Model the ecosystem production functions for multiple final ecosystem services associated with seagrass beds, coastal and freshwater wetlands, and terrestrial forests in the Tampa Bay region.
(2) Develop a user interface tool for predicting ecosystem services production and value using existing future scenarios for the Tampa Bay region (http://www.epa.gov/ged/tbes/, accessed 08/04/2011).
(3) Provide the information and methods needed by decision makers to assess the benefits of coral reef ecosystem goods and services for inclusion in management alternatives.
(4) Develop an index of well-being for the United States based on economic social and ecological services.

For several years, GED was a leader in the National Coastal Assessment, a state–federal partnership that generated the first complete assessments of the ecological condition of the nation's estuaries (U.S. EPA 2004, 2008). In 2007–2008, the team led a pilot assessment of the condition of U.S. Gulf of Mexico coastal wetlands, the first such assessment ever attempted at this large geographic scale. The pilot was a precursor to EPA's assessment of all U.S. wetlands conducted in 2011; its purpose was to test and validate designs and indicators for the coastal component of these comprehensive surveys.

Water quality research.—The Nutrients Team at GED is leading a national, multiagency effort to improve understanding of the Gulf of Mexico hypoxic zone, the processes that cause hypoxia, and the relationships between hypoxia and inputs of nitrogen, phosphorus, and organic matter into the gulf from the Mississippi River Basin (MRB). A major goal of GED's research, in partnership with the Naval Research Laboratory and EPA's Mid-Continent Ecology Division, is to complete and apply state-of-the-art coupled hydrodynamic, water quality, and biogeochemical models to the gulf hypoxia problem. When operational, these models should for the first time support rigorous analysis of the MRB load reductions that will be necessary to satisfy strategic goals for reducing the extent of the gulf hypoxic zone (Nutrient Task Force 2001).

Establishing water quality criteria for nitrogen and phosphorus in estuaries and near-coastal waters poses a difficult set of problems. Scientists at GED have worked intensively with EPA's regulatory offices and Florida to develop defensible nutrient criteria for the state's coastal waters (U.S. EPA 2010). This research supports EPA's need for guidance to states as they develop standards to protect the quality of their coastal waters from excess loads of nitrogen and phosphorus. The division's support for Florida nutrient criteria development contributed significantly to EPA's Jan. 2010 nutrient criteria proposal, especially the provisions for downstream use protection. Much of this effort has focused on estuarine and coastal criteria development, including quantifying the depth of colonization of seagrasses in Florida estuaries, quantifying chlorophyll *a* in near-coastal waters

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using remote sensing, and computing downstream use protection criteria for nutrients using mechanistic watershed models.

In addition to chemical criteria, water quality management may employ biocriteria to gauge the health of biological communities and ecosystems. Coral reefs in south Florida and the Caribbean Sea are threatened by a variety of stressors, including climate change and pollution. GED has been working with partners in the region to develop biocriteria for corals (Fisher 2007) and to relate the condition of coral reefs to anthropogenic stressors and their sources.

Predictive ecotoxicology.—Predicting the effects of toxic pollutants at higher levels of ecological organization—populations and communities of native organisms—has been a long-term goal of ecotoxicology. Another important goal is to reduce the amount of expensive, inefficient, and destructive in vivo toxicity testing required to support regulation, product registration, and pollution management.

Scientists at GED have used proteomic techniques, multigenerational exposures, and population models to link molecular markers of toxicity, whole organism chronic effects, and real-world populations of fish and invertebrates that are important inhabitants of coastal ecosystems. The full realization of this comprehensive approach to ecotoxicology will mean that nondestructive biological samples collected in the field will be used to predict important ecological consequences of toxic pollution.

Large databases of existing toxic effects information have been compiled to support the web-based interspecies correlation estimation (ICE) and acute to chronic estimation models, developed by GED and partners (Asfaw et al. 2003, Ellersieck et al. 2003, http://www.epa.gov/ceampubl/fchain/webice/, accessed 08/04/2011). These models fill major gaps in the ability of regulators and risk assessors to estimate toxic effects across species, compounds, and types of effects. The ICE model has been particularly important for threatened and endangered species, where the needs for toxicity information are critical, but the organisms are generally not available for testing.

The future.—Staff and management at GED share a vision of leadership in coastal ecological research and of conducting research that ultimately helps to make a difference in the quality of the environment and the sustainability of communities and ecosystems. Our priorities in any particular time frame depend on the needs of EPA, as interpreted by ORD and NHEERL and translated into practical research questions through the creativity of our scientists. For the next several years, we believe that the research themes summarized above will continue to be our principal focus.

Continually shrinking budgets and staff are a reality we have had to adapt to over the past several years, and we expect that these trends will continue for some years to come. Our positive responses have been to reduce the amount of work done by contractors, while building a stronger, though smaller EPA research staff, to seek wider and stronger collaborations, and to depend more on modeling and synthesis of existing data and literature to develop valuable products, in contrast to generating large amounts of new data. We believe these responses are appropriate and strengthen us as a scientific organization, despite declining resources.

The GED, in the tradition of its antecedents on Sabine Island, continues to adapt to the environmental challenges of the United States. A highly professional and skillful team of scientists, managers, technicians, and administrative staff have learned to accept and welcome the opportunities brought by change. If history is a guide, the future always will bring changes—in mandates, resources, the environment, and the scientific landscape. The attributes of the organization that have not only endured, but flourished, are the dedication and quality of the staff and the value of its scientific research and products.

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