U.S. Environmental Protection Agency
National Estuary Program

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Information About Estuaries and Near Coastal Waters December 2002 - Issue 12.6

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Morro Bay National Estuary: Partnering for Public Outreach

Morro Bay Estuary is located on California's central coast, roughly half way between

San Francisco and Los Angeles. The 2,300-acre bay and 48,000-acre watershed support many human uses, including agriculture, ranching, commercial and recreational fishing, recreational boating, a significant tourism industry, and a bayside population of over 25,000.

Although much of the California coastline has been developed and natural habitats have been lost or significantly impacted, the Central Coastal region that includes Morro Bay can boast some of the least disturbed coastal habitats south of San Francisco. More than 200 species of birds and two dozen special status species are found here at Morro Bay Estuary. Habitats include coastal sage scrub, coastal dunes, eelgrass beds, freshwater wetlands and salt marsh. Because of its value to wildlife and humans, Morro Bay Estuary was nationally recognized in 1995 and became one of 28 estuaries in the National Estuary Program (NEP).

As more and more people seek solitude and open space, the value of estuaries becomes a timely topic for public education. The Morro Bay National Estuary Program (MBNEP) Visitor Center recently opened to the public, providing an important educational tool. The Center provides information on human impacts on water quality, watershed dynamics, non-point source pollution, eelgrass beds, the global significance of the Pacific Flyway in bird migration, and the important role of Morro Bay in providing habitat for a wide variety of marine and terrestrial plants and animals.

Background

While the Bay may appear pristine to locals and visitors alike, there are several threats to this diverse ecosystem, including bacterial and nutrient pollution, sedimentation, habitat loss and degradation, and loss of freshwater flow. To manage these problems, local non-profit organizations, government agencies, and the public assisted in developing the Morro Bay Comprehensive Conservation and Management Plan (CCMP). The MBNEP is a non-profit, non-regulatory organization made up of community members including volunteers, businesses, environmental organizations, government agencies, and others.

The CCMP was completed and formally approved in January 2001. Final approval opened the door to implementation of more than 60 "Action Plans" to enhance estuary health. A small staff at the MBNEP oversees implementation of the CCMP and is working on restoring natural resources of Morro Bay and its watershed.

Currently, MBNEP projects include restoration of steelhead trout habitat in local creeks, reintroduction of native plants to establish habitats for special status species, and developing environmental education partnerships with schools. One of the most important partnerships to develop is with the public, because the daily choices of local residents and visitors impact estuarine health. Community support is also needed to undertake projects such as acquisition of sensitive habitats and reducing non-point source pollution.

As a result, many of the highest priority tasks in the CCMP focus on public education and outreach to increase stewardship and reduce daily impacts on the Bay. Yet there are many ways to provide public education and issue an environmental "call to action." Which method should an NEP choose?

Project Overview

Over 3.5 million people visit San Luis Obispo County every year, and tourism is the County's largest industry. Therefore, a Morro Bay Estuary Visitor Center quickly won strong support from both MBNEP staff and the community. Not only does a Visitor Center provide permanent learning opportunities for local residents; it also engages tourists and fosters a sense of stewardship of the land and its resources, in Morro Bay and elsewhere.

The purpose of the Visitor Center is to encourage people to help restore the Bay by

increasing their sense of stewardship. The Visitor Center focuses on 3 goals: 1) Raising public awareness concerning ways in which humans can impact the estuary; 2) Providing factual information concerning threats to the estuary; and 3) Providing information on potential solutions. Visitors can learn about specific threats, such as depletion of fresh water, non-point source pollution and nutrient loading, contaminants and pollution, bacterial and viral contamination from wastewater and runoff, and habitat loss due to development or encroachment by invasive non-native species.

Project Implementation

The idea of a Visitor Information Center came to life in the fall of 2000 and began with selection of a site in an existing waterfront building in the Town of Morro Bay. This location, in the heart of the retail and restaurant district, seemed ideal for targeting the main audience -- tourists who might otherwise miss seeing the natural beauty of the estuary.

To obtain the modest amount of $70,000 needed to fund renovations and construct exhibits, many different sources of funds were sought. Throughout the 2-year project, much time was spent writing grant applications to foundations, corporations and other donors. Funding sources included EPA annual grants to NEPs, various agencies, foundations and corporations, local government agencies, environmental organizations, and individual donors. With persistence, full funding was obtained, including $12,000 contributed by corporations and foundations, and a generous $50,000 granted by the California Coastal Conservancy, a state agency.

To help prospective donors envision how their contributions would be used, $2,000 of seed money was spent on draft exhibit designs and color sketches. These proved to be a clear and concise communication tool. Once 100% of funding was obtained, the NEP finalized the plans with the help of a professional exhibit designer, who also oversaw the construction and installation of the new exhibits. Obtaining the help of a professional, experienced exhibit designer was key to the success of the project. In less than 3 months, draft designs on paper were transformed into new exhibits in the new Estuary Visitor Information Center.

How did the MBNEP decide on the issues to be addressed in the exhibits? This process began when MBNEP staff, together with representatives of other organizations, developed lists of the most significant concepts and facts to present to visitors. Because exhibit space was limited (600 square feet), and because it was important to focus on a few key issues rather than bewilder visitors with too many issues, the list of exhibit topics was condensed to the following:

- What is an estuary?
- What is a watershed and what is non-point source pollution?
- Important habitats in and around the estuary
- The importance of eelgrass habitat
- Birds of Morro Bay and the Pacific Flyway (a corridor for seasonal bird migration)
- How healthy is the Estuary?
- Saving steelhead trout, and
- The MBNEP's Volunteer Monitoring Program

Once this list was developed, MBNEP staff then stood back and asked what overall theme the exhibits would convey. Developing a focused message was important for creating effective interpretation. The message the Center expresses is a simple one: "Morro Bay Estuary is worth saving." As the exhibit graphics were developed, staff kept reevaluating the exhibits and asking themselves the question "Does this exhibit help the visitor understand that Morro Bay Estuary is worth saving?" If the exhibit did not convey this message, it was redesigned or revised. Doing so required much discipline, but the end result - exhibits with a focused message - was well worth it.

Project Results and Successes

With just a few weeks left until the last exhibit is installed in the new Estuary Visitor Center, much has been accomplished. The Visitor Center will officially reopen with a public celebration and the formation of new relationships with volunteer docents, teachers, students and visitors. However, some of the most significant collaboration has been facilitating the outreach work of local non-profit organizations which share similar goals. More than 10 non-profit organizations and their volunteers are working on estuary preservation and restoration projects. To assist these organizations and to encourage visitors to expand their estuary experience, the Center provides display space for other educational materials, such as newsletters and brochures. The posting of a schedule of events is important for coordinating estuarine education; these events include routine water quality testing conducted by the Morro Bay Volunteer Monitoring Program, Audubon bird walks, docent-led walks by the Museum of Natural History, and restoration projects in local reserves.

The Center also acts as a focal point for encouraging people to become involved in protecting their estuary. The local community has been asked to donate time to help with outreach, and local residents have responded by staffing the Center on weekends and during the busy summer months during weekdays. Local residents who have seen Morro Bay change from a sleepy fishing town to a major tourist destination can become a docent, share their knowledge with the public, and help

people to become better stewards.

With its interactive hands-on displays and informational materials, the Center provides a springboard for environmental education programs for young people. Working with schools, after-school programs and other groups, the Center brings young people into direct contact with the estuary, its values and its challenges.

Lessons Learned

As the MBNEP staff cheer the completion of the Center, they also offer pointers (in hindsight) for others contemplating such a project:

1. Patience, patience, and more patience is needed to undertake such a project
2. No matter how generous your budget may seem, be conservative in your exhibit design and allow for more funding, as hidden costs will surely surface
3. Using an existing building could be the best decision you make if you are on a modest budget
4. Choosing a highly visible location may cost more in acquisition costs, but pays off in reducing the costs of marketing the Center to the public, and,
5. Last but not least, a Visitor's Center will always need maintenance, and this must be considered in fundraising and budgeting.

For further information, contact:
Cheryl Lesinski, Education and Outreach Coordinator, Morro Bay National Estuary Program, 601 Embarcadero, Suite 11 Morro Bay CA 93442; Phone: (805) 772-3834; Fax: (805) 772-4162; E-mail: clesinski@mbnep.org.

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Remote Kachemak Bay NERR Faces Unique Issues

The Kachemak Bay Research Reserve (KBRR) in Alaska is the only fjord in the National Estuarine Research Reserve (NERR) System, which includes 25 estuaries. Like other NERRs, the Reserve emphasizes long-term ecological research and education. However, the Kachemak Bay Reserve faces some unique resource management issues due to its high latitude.

Kachemak Bay is one of the most productive, diverse, and intensively used estuaries in Alaska. Breathtaking scenery, recreational opportunities and a lucrative fishing industry support the local economy and attract thousands of summer tourists. In 1999, Kachemak Bay was designated as a NERR due to the efforts of local citizens, who wanted to protect these qualities and sustain the area's economy, and resource managers who have long worked to protect the Bay.

The Reserve is managed by the Alaska Department of Fish and Game and the National Oceanic and Atmospheric Administration (NOAA), with input from an advisory council of Kachemak Bay stakeholders. Part of the watershed is managed by the Kenai National Wildlife Refuge and the Kachemak Bay State Wilderness Park, one of the largest state parks in the nation.

The Reserve includes 4,000 km2 (365,000 acres) of terrestrial and marine habitats, making it the largest reserve in the NERR system. The Bay's bathymetry is characterized by a submerged moraine or sill at the mouth of the Bay, and deep trenches and holes over 200 m deep. On the south, the bay is guarded by jagged snow-covered peaks. Because the tree line is at only 500 m, the barren 2,000 m alpine summits resemble those of much loftier mountain ranges. The Harding Icefield, one of the last remaining alpine ice sheets left in North America, hosts seven glaciers that flow into Kachemak Bay. Copious amounts of sediments carried by these glaciers help to sustain sand and gravel beaches. The Fox River Flats, at the head of the bay, is a huge salt marsh that supports thousands of migratory birds every spring and fall. The inner bay is separated from Lower Cook Inlet by a 4 km long spit extending south from the village of Homer (pop. 5,000). This relict moraine restricts the surface circulation of the inner bay.

During the summer, glacial meltwater contributes approximately 70,000 cubic meters of fresh water each day to the inner Bay. Another 14 billion cubic meters of cold, nutrient-rich seawater from the Gulf of Alaska flows in and out of the outer Bay, partly driven by an amazing 8.7 meter tidal range that results from the complex geomorphology of the Gulf of Alaska and Cook Inlet.

Fjords such as Kachemak Bay often have a seasonally stratified water column that forms when a surface layer of fresh water develops above denser seawater. One unique feature of this high latitude NERR is that during the 6-month long winter, when the watershed is frozen, this fresh surface layer disappears and the bay becomes wholly marine. Interestingly, benthic biological diversity is highest during the spring before the Bay reverts back to an estuary. Overall annual biodiversity is

extraordinarily high compared to estuaries in warmer climates, due to an abundance of migratory birds, marine mammals and fish.

Research

Kachemak Bay scientists are leading efforts to understand interrelationships between oceanic, nearshore and watershed environments. Kachemak Bay and the Gulf of Alaska provide a nearly pristine living laboratory for large-scale spatial and temporal studies of these diverse, yet interconnected, systems. Reserve scientists are studying physical and biological processes that cause short-term variability and long-term changes, particularly in marine trophic levels. Examples of research include:

1. **Biodiversity and Community Structure.** The KBRR is monitoring changes in intertidal and subtidal biological communities (kelp beds, invertebrates, algae, fishes, and marine mammals) and population interactions.

2. **Physical Forcing Mechanisms.** The Reserve is researching effects of physical oceanic and atmospheric forcing mechanisms that help to determine spatial and temporal patterns of biological populations and communities. One example is how estuarine circulation and mixing dynamics affect the spatial and temporal patterns of primary productivity in the Bay. The sheer magnitude of physical processes in Kachemak Bay, such as tidal flushing and seasonal variation, lends itself to such studies.
3. **Biogeochemical Cycling.** Reserve scientists are studying biogeochemical cycling of nutrients and organic matter and the biological processes that affect such cycling, in order to better understand what natural processes to protect.
4. **Watershed Land Use Impacts.** Even in this remote corner of the nation, development, spruce bark beetle infestations, logging and forest fires have exacted a toll on vegetation cover in the watershed. KBRR scientists are studying how these watershed changes affect nutrient cycling, habitat quality, and biological communities.

Public Outreach

Public outreach at the Reserve is closely tied to ongoing scientific studies. The Reserve's goal is to show that science and education can improve coastal management decision making and increase public understanding of coastal environments. Building public appreciation and stewardship of coastal resources is a key outreach goal.

In the fall of 2003, Reserve research and education programs will receive a huge boost with the completion of the Alaska Islands and Ocean Visitor Center. Shared jointly with the Alaska Maritime National Wildlife Refuge, this 37,000 square foot building will house interpretive exhibits, classrooms, and laboratories, as well as administrative offices for the partner agencies.

This beautiful and wild Reserve, the only high latitude NERR, should inspire residents and resource managers everywhere to better understand and protect coastal ecosystems.

For further information, contact Terry Thompson, Education Director, Kachemak Bay Research Reserve, Alaska Department of Fish and Game, 2181 Kachemak Dr., Homer, Alaska 99603; Tel: (907) 235-4799 Ext. 7; Fax: (907) 235-4794; Email: terry_thompson@fishgame.state.ak.us

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Remote Sensing Used To Map Habitats on the Lower Columbia River

Spectral characteristics refer to the "color" or wavelength of energy emitted or reflected by an object that is "lit" by energy. We see visible wavelengths of energy as colors. Remote sensing uses electronic detectors to detect more wavelengths of energy than humans can see (e.g., the CASI image can detect 19 spectral bands). Plants emit spectral patterns which can be identified using the 19 spectral band CASI image.

The Lower Columbia River Estuary Partnership is using remote sensing imagery to improve our understanding of habitat linkage and the complex habitat needs of salmonids, which use many habitats covering huge areas. The Estuary Partnership is developing multivariate maps of floodplain habitat in the lower Columbia River that are linked through a Geographic Information System, or GIS. The use of remote sensing images for mapping habitat provides a powerful tool for seeing and understanding the estuary and for public outreach. Like a central nervous system, the use of GIS to link maps, remote sensing images and other estuary and watershed data allows coastal managers to collect, organize, understand and use this information. In the lower Columbia River, this new approach is being used to map habitats of endangered salmon, trout and other organisms.

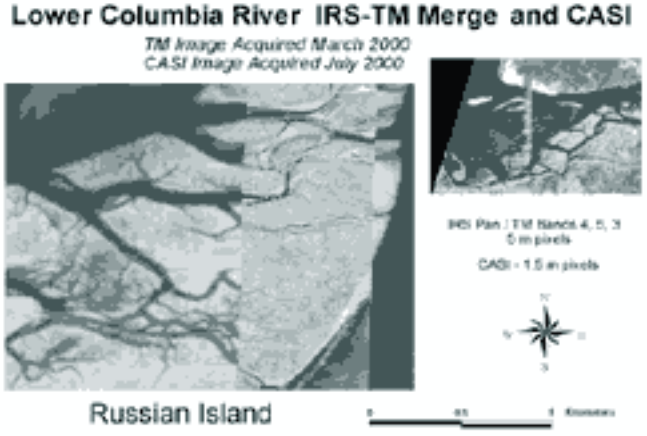
The Columbia River estuary provides critical habitat for 12 species of salmonids listed as threatened or endangered under the federal Endangered Species Act (ESA), and many other marine and estuarine species. The ESA classification

requires that a salmon recovery plan be adopted that includes significant habitat restoration. But there are many interests to balance. The Columbia River estuary also supports a major shipping industry that moves 30 million tons of trade worth $13 billion per year. It has traditionally supported a major fishing industry. The world's largest hydropower system is found here, and the river is popular for recreation.

Unfortunately, over the past 150 years up to 70% of certain habitats within the estuary have been lost to filling, draining, channelization, diking and dredging. In response to concerns about the ecological integrity of this vital ecosystem, the lower Columbia River was accepted into the National Estuary Program (NEP) in 1996. In 1999, the Estuary Partnership completed a Comprehensive Conservation and Management Plan (CCMP) containing 43 action items to address the problems facing the river and its estuary.

The CCMP identifies loss of habitat as the most serious threat to the river's vitality. High priority action items focus on developing an ecosystem-based approach to preserving and restoring habitat. However, implementation has been hampered by lack of an accurate habitat inventory. Surprisingly, little research has been conducted into understanding ecological relationships between Columbia River estuarine habitats and the organisms that rely on it, especially juvenile salmonids.

Despite this information gap, the push is on to restore and protect the lower Columbia River, due to requirements for salmonid recovery under the ESA. To fill this data gap and effectively use limited restoration funds, the Estuary Partnership teamed with Earth Design Consultants, Inc. and the University of Washington to develop a spatially linked, hierarchical habitat dataset for the 146 miles of the lower Columbia River. A cooperative multi-stakeholder framework was developed to undertake the project.



Resolution is the smallest distance between two points that can be distinguished in an image. The higher the resolution, the more detail one can see. A pixel is the smallest unit of resolution provided by the remote sensing system. The smaller the pixel size, the more resolution and detail can be seen, but the smaller the area of ground covered. The TM data provides a 25 meter pixel image, compared to the CASI data which gives 1.5 meter pixel image.

This innovative project combines remotely sensed imagery of the estuary and field

verification by teams of trained volunteers. Several types of imagery with different spectral and spatial qualities are obtained in order to characterize vegetation, water area, wetlands, soil, and so on. Just as an object viewed using visible light, ultraviolet light and x-rays can yield different kinds of information, so the use of remotely sensed images taken at different wavelengths and spatial resolutions yields different information concerning landscape features.

Remote sensing images are obtained from imaging satellites such as Landsat, airborne imaging aircraft equipped with remote sensors, and other sources. This project used two Landsat 7 TM scenes, IRS satellite imagery, airborne digital video imagery, and 19-band compact airborne spectrographic imager (CASI) hyperspectral imagery. Landsat images can be bought from commercial providers for a reasonable cost; however, acquiring and analyzing the CASI images is very expensive (e.g., an estimated $450,000 has been spent for the entire project). However, this has to be compared with the cost of conducting field surveys in difficult terrain, with large areas to cover.

These images are linked spatially in a GIS database. Volunteer field teams provide ground-truthing of the images at reference points. Ground-truthing involves checking the remotely-sensed habitat classifications on the ground, and correcting the GIS database if needed. Ground-truthed images are then used to estimate habitat cover throughout the estuary. This approach reduces the need for extensive field surveys by providing extensive aerial coverage. This approach is being used in the project by Charles Simenstad (University of Washington School of Aquatic Fisheries Sciences, Seattle), and Dr. Ralph Garono, Aquatic Ecologist (Earth Design Consultants, Inc., Corvallis, Oregon), who developed the method.

This multi-tool approach to mapping habitat was needed because of the sheer size and scale of the Columbia River system (Figure 1), and the difficulty and cost of accurately assessing floodplain habitat using traditional field surveys. Sampling strategy involved conducting imaging and fieldwork over short (1 week) periods in 2000 and 2001 to minimize the effects of seasonal changes in vegetation and to take advantage of extreme low tides. Huge amounts of data were collected in a short time, for later analysis as time and resources allow.

The two Landsat 7 images acquired in 2000 were classified using information collected by volunteers and the airborne digital videography. Classified Landsat TM scenes provide complete coverage of the entire study area at a relatively coarse spatial scale (~25 meter pixels). The relatively small number of spectral bands available in Landsat 7 TM imagery, however, limits the habitat cover types that can be resolved. The CASI imagery with its much greater spatial resolution allows much smaller estuarine features to be resolved (Figure 2) For example, features

approximately 4 m x 4 m in area can be identified in the CASI imagery, compared to 60 m x 60 m features in the Landsat TM imagery. In addition, the 19-band CASI imagery can better resolve features that are spectrally similar; for example, where the Landsat TM sensor ‘sees' salt marsh but does not provide information on the vegetative community, the CASI imagery can be used to determine the dominant vegetation in salt marshes.

Processing of CASI imagery for the study area is currently underway, and is being analyzed at several spatial scales to provide a comprehensive, accurate dataset describing tidal and freshwater habitat types, patterns and conditions.

Effective habitat protection and restoration in the Columbia River ecosystem requires a strong scientific underpinning due to the serious issues involved. Remote sensing provides a cost-effective way of collecting information over a large geographic area, and promises to be useful for characterizing other rivers and estuaries. The Estuary Partnership will see what works best and will have recommendations once the project is completed.

For further information, contact Bruce Sutherland, Program Scientist; Lower Columbia River Estuary Partnership, 811 SW Naito Parkway, Suite 120, Portland, Oregon, 97204; Phone: (503) 226-1565 ext 226; E-mail: Sutherland.bruce@lcrep.org.

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South Slough NERR Restores Coastal Stream in Oregon

Located within the South Slough National Estuarine Research Reserve (SSNERR) on the southern Oregon coast, Anderson Creek is popular with hikers and blackberry-pickers who are attracted by the forests of Douglas fir, Port Orford cedar, and Sitka spruce. The valley is home to elk, beaver, raccoons, birds and other wildlife. But this bucolic appearance can be deceiving. For more than a century, Anderson Creek Valley was managed for agricultural uses in ways that reduced fish and wildlife habitat.

"Anderson Creek Valley was a disturbed place where wildlife was doing its best to make a living," said Craig Cornu, stewardship coordinator for the South Slough Reserve. That all changed in August of 2002, when the SSNERR embarked upon

an extensive restoration of Anderson Creek following years of planning. The goal was to replace the altered creek, which had become little more than a straight, deep drainage ditch, with a meandering pilot channel that would evolve into a natural stream over time.

South Slough NERR includes about 4,800 acres within a nearly-pristine arm of Coos Bay, Oregonís third-largest estuary. The Reserve includes upland forest, salt marshes, mudflats and open water. Anderson Creek is a tributary of Winchester Creek, the main stream flowing through the Reserve. The Reserve is managed by the state and federal governments for long-term research, monitoring, education, and stewardship.

The South Slough ecosystem is recovering to a more natural state following a long history of alteration. Throughout the late 19th and early 20th centuries, South Slough was home to farmers, ranchers, miners and loggers. Early settlers used South Sloughís waterways to float log rafts out to sawmills. Salt marshes were diked and drained to convert them to pasture and crop land. Tidal and non-tidal streams, such as Anderson Creek, were diverted and straightened. Most of these activities stopped after South Slough was designated a National Estuarine Research Reserve in 1974.

But these alterations meanwhile diminished Anderson Creek's ability to support fish and wildlife. Stream length was shortened, bottom habitat was heavily altered, and the flooding regime was altered, which changed floodplain soils, hydrology and habitat. Anderson Creek became a highly simplified, deeply downcut ditch running straight down its valley. Over time, the creek channel deepened to a depth of eight feet due to the increased erosive power of the straightened stream. "The ditch was so deep that, even during high winter flows, there was no connection between the ditch and its floodplain," Cornu explained. "Fish habitat was limited to what a straightened and simplified ditch was able to provide over time."

Heavy erosion occurred during rain events because the stream's meanders, which absorbed flood energy by slowing the flow rate, no longer existed. In a typical August, Anderson Creek contained just a trickle of water. But during winter rains, the runoff of nearly 60 inches of annual rainfall caused the stream to swell to a torrent.

Streambed alterations also short-changed floodplain area, thereby decreasing the amount and diversity of habitat. Habitat features such as overhanging banks, woody debris, boulders, and slow-flowing pools no longer existed in the straightened channel.

Torrential flooding also periodically destroyed beaver dams. Beavers provide valuable habitat for other species, including coho salmon, an endangered species, by building dams that slow floodwaters and create ponds. Juvenile coho salmon prefer slow-flowing, murky water because it provides cover and protection from predators.

Thus the South Slough NERR began planning restoration of Anderson Creek in 1993. Funding was obtained in 1997 and 1998. Stream restoration engineers from Ducks Unlimited helped with the restoration design and construction. The Anderson restoration is part of a much larger project - the Winchester Tidelands Restoration Project, which involves re-establishing previously altered salt marshes and tidal channel.

Restoration design involved creating a pilot channel with a calculated sinuosity meandering down the Anderson Creek floodplain. The pilot channel would be constructed to accommodate only summer stream flows (1 foot deep x 2 feet wide). The design would allow high winter flows to determine the ultimate shape of the channel and floodplain. Logs and woody debris would be added in strategic locations to slow and deflect the current, create eddies, and reduce erosion. Features such as undercut banks, overhanging ledges, meanders and holes would be encouraged to diversify habitats.

Actual restoration began in the summer of 2002, when SSNERR staff and volunteers donned hip boots and waders and captured and relocated fish, amphibians and other animals that would be affected by the work. They recovered several hundred fish, including juvenile Oregon Coast coho salmon (*Oncorhynchus kisutch*), juvenile steelhead trout (*Oncorhynchus mykiss*), cutthroat trout (*Oncorhynchus clarki*), juvenile western brook lamprey (*Lampetra richardsoni*), three different sculpin species, four Pacific giant salamanders, and northern red-legged frogs (*Rana aurora aurora*). Rescued animals were released into Winchester Creek.

Heavy equipment was then brought in and for about 10 days, crews shaped the new channel, filled the old ditch, and placed logs and branches at strategic locations along the new channel. Workers also took pains to ensure that beavers using beaver dams and lodges were not buried.

Following earth-moving, crews scattered a mulch of native slough sedge hay and sterile grain straw across the exposed soil. The mulch will spread native wetland vegetation seeds, protect seeded areas and reduce erosion when the winter rains begin. In February 2003, workers will begin planting native wetland vegetation along the new creek and in the floodplain.

Follow-up monitoring is critical for ensuring success of restoration. The SSNERR is documenting reestablishment of plant and animal communities in the newly restored stream valley. By using standardized biomonitoring methods used by Oregon state agencies, the data will be useful to other researchers and agencies.

Fisheries managers are particularly interested in seeing whether the endangered Coho salmon will survive and thrive in the restored stream. Winchester and Anderson Creeks are home to a small population of Coho salmon. After hatching in Winchester Creek in the spring, Coho salmon travel throughout the stream system. Growing juveniles remain within fresh water habitats for up to two years before migrating out of South Slough into the Pacific Ocean. After two more years at sea, the Coho return to Winchester Creek to spawn and die.

The Anderson Creek restoration project will be useful for studying other fish species. Life history strategies and population dynamics of steelhead trout, anadromous cutthroat trout, and western brook lampreys in these streams are not well understood. For example, not all cutthroat trout migrate to sea when they mature, and the genetic or environmental factors that determine migration are unknown.

Such questions will guide restoration research and work. As the new Anderson Creek matures, South Slough scientists will adaptively manage the project to respond to changing conditions and new information. As Craig Cornu says, "Experimental projects like this will always have unknowns, until they are put to the test."

Contact: John Bragg, Coastal Training Coordinator, South Slough National Estuarine Research Reserve, 61907 Seven Devils Road, PO Box 5417, Charleston, Oregon 97420; Phone: (541) 888-5558; Fax: (541) 888-5559; email: john.bragg@dsl.state.or.us

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Protecting and Restoring Great Lakes Sand Dunes

Did you know that the Great Lakes sand dunes are the largest system of freshwater dunes in the world? Coastal dunes dot the shores of each of the states bordering the Great Lakes. The State of Michigan, which borders Lakes Superior, Michigan, Huron and Erie, has the most dune area -- 275,000 acres. Unfortunately, only 70,000 acres of coastal dunes along Lakes Superior and Michigan are protected as designated critical areas.

Coastal dunes are of enormous ecological value to the Great Lakes area. They shelter inland ponds, wetlands, and woodlands from storms, and provide habitat for wildlife and rare species. The Federally endangered pitcher's thistle (*Cirsium pitcheri*) occurs on the dunes bordering Lakes Huron, Michigan, and Superior. The dunes offer shelter for migrating neotropical birds that seek quiet areas behind the foredunes to rest and feed. Foredunes, the portions of dunes closest to the beach, harbor vegetation such as marram grass (*Ammophila breviligulata*), which in turn traps wind-blown sand and stabilizes dunes. Globally imperiled communities, such as pannes or interdunal calcareous wetlands, are protected from wind and waves behind foredunes.

Coastal dunes are also economically important; coastal dunes supplied sand to Detroit auto makers and iron and steel manufacturing industries. Although many dunes were removed by mining, those that remain have scenic and recreational value and provide millions of dollars towards local economies that rely upon tourism and recreation. Coastal dunes buffer inland areas from storm winds and waves, thus reducing property damage.

In spite of their value, there are many threats to these dunes. Non-native invasive plant species such as baby's breath (*Gypsophila paniculata*) and spotted knapweed (*Centaurea maculosa*) have spread rapidly. Habitat destruction from sand mining and development poses the greatest threat. Recreational use by off-road vehicles and pedestrians damages vegetation and causes significant erosion. Along the New York shore of eastern Lake Ontario, years of unregulated, uncontrolled public use, including vehicle traffic, recreational activities, and sand mining caused a large dune to blow out and create a so-called walking dune. Walking dunes migrate more quickly than foredunes because there is no vegetation to hold sand in place.

Lake Ontario Coastal Dunes

Several groups are working to preserve and restore this valuable Great Lakes resource. The Ontario Dune Coalition decided to act to restore the dune described above. Their goals were to decrease sand loss, protect habitat for endangered species (Champlain beach grass and black tern, or *Chlidonias niger*), and stop the filling of North Pond, a wetland that provides habitat for the black tern.

The Coalition decided to relocate 44,000 cubic yards of sand from the walking dune to the foredunes. Using heavy equipment, sand was moved and graded. Volunteers transplanted any Champlain beach grass found within the work area to areas where

it could stabilize the dunes. Temporary snow fencing was installed on top of the dune to prevent prevailing winds off the lake from eroding the newly built dune. A 3-foot high fence was installed on all sides to protect the dune from vandalism. The Friends of Sandy Pond nursery provided 20,000 plugs of beach grass, which were planted by students and volunteers to stabilize the new dune.

The Coalition also addressed inappropriate uses. Dune stewards were hired to patrol the area and talk to visitors. They spoke at local schools, wrote articles for local papers, produced information brochures to distribute, and coordinated beach cleanup days. Dune stewardship was expanded to other areas of the barrier beach. So far, the restored dune is flourishing, beach grass has taken hold, and wildlife has returned.

Lake Michigan Coastal Dunes

Meanwhile, on the eastern shore of Lake Michigan, development and sand mining pose similar threats to the dunes there. The Michigan Dune Alliance formed to pool resources to restore the dunes. Partners include the Conservation Fund, Grand Traverse Regional Land Conservancy, Lake Michigan Federation, Land Conservancy of West Michigan, Leelanau Conservancy, Little Traverse Conservancy, Michigan Department of Environmental Quality, Michigan Department of Natural Resources, Michigan Natural Features Inventory, National Park Service, Southwest Michigan Land Conservancy, The Nature Conservancy, the U.S. Forest Service, the Mott Foundation, and the U.S. Environmental Protection Agency Great Lakes National Program Office. Alliance members are sharing information and resources for land conservation and stewardship.

The Lake Michigan Federation provides public outreach concerning Lake Michigan coastal dunes and encourages dune protection at the local level. The Federation developed a sand dune education packet that includes ecological fact sheets, a summary of state regulations concerning dune mining and development, a state contact list, and a tools booklet with case studies about protection of dune

ecosystems. These materials are available on their website.

The Federation's planning and zoning tools booklet, *Inspiring Sand Dune Protection*, is particularly useful for local officials because it describes options for protecting Lake Michigan's undeveloped shoreline and other natural resources. At the heart of this booklets is a section on how to conduct a natural resources inventory to identify and map physical and biological characteristics. Such an inventory forms the basis for planning and zoning protection measures and helps people to recognize rare or valuable resources before they are lost.

The Federation also developed other innovative outreach, including a student dune art and poetry project that culminated in a traveling exhibit, a booklet, and a sand dune ecology and stewardship classroom unit for southwest Michigan. Loss of the dunes was described in a performance folktale, A Most Unusual Thing, performed by the Bear Creek Players. Community meetings and workshops inform citizens about the value and history of the dunes, describe ways to become involved, and describe tools for protection. Partnerships such as these exemplify local actions to protect and restore these valuable coastal dunes.

For further information, contact Karen Rodriguez, U.S. Environmental Protection Agency, 77 W. Jackson, Chicago, IL 60604; Phone: (312) 353-2690; E-mail: rodriguez.karen@epa.gov.

Additional information about Great Lakes sand dunes and stewardship projects can be found at the following websites: Michigan Department of Natural Resources, www.michigan.gov/deq/ EXIT disclaimer; the National Park Service's Dunes National Lakeshore Parks, www.nps.gov EXIT disclaimer; Lake Michigan Federation, www.lakemichigan.org EXIT disclaimer; Save the Dunes Council, www.savedunes.org EXIT disclaimer; Lake Ontario dune education site, http://www.cce.cornell.edu/seagrant/glhabitat/glhabitathome.htm EXIT disclaimer ; and U.S. EPA's Great Lakes National Program Office, www.epa.gov/glnpo/ecopage.

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Seagrass Repair in Charlotte Harbor, Florida

Charlotte Harbor is located on the southwest coast of Florida between Sarasota and Fort Myers. It is the second largest estuary in the state and faces increasing environmental pressures from the growing population in the area. The condition of seagrasses in particular is of concern. Healthy seagrass beds provide habitat for fish, mammals, and shellfish and help to maintain water clarity and stabilize sediments. A 1995 study by the Florida Marine Research Institute indicates that damage due to boat propellers poses major impacts on the health of seagrass beds. Increased recreational use of powerboats in the shallow harbor has prompted a program to repair existing and future propeller damage to seagrass beds in the harbor.

The Charlotte Marine Research Team (CMRT), a local non-profit group, is conducting two studies to repair prop-scar damage and replant seagrass in barren areas. The National Fish and Wildlife Foundation and the Charlotte County government, respectively, support these studies, which began in May of 2002.

The first step was to conduct an aerial reconnaissance of the study area to identify scarred areas and record them using aerial photography. An example of a heavily scarred area is shown in Figure 1.

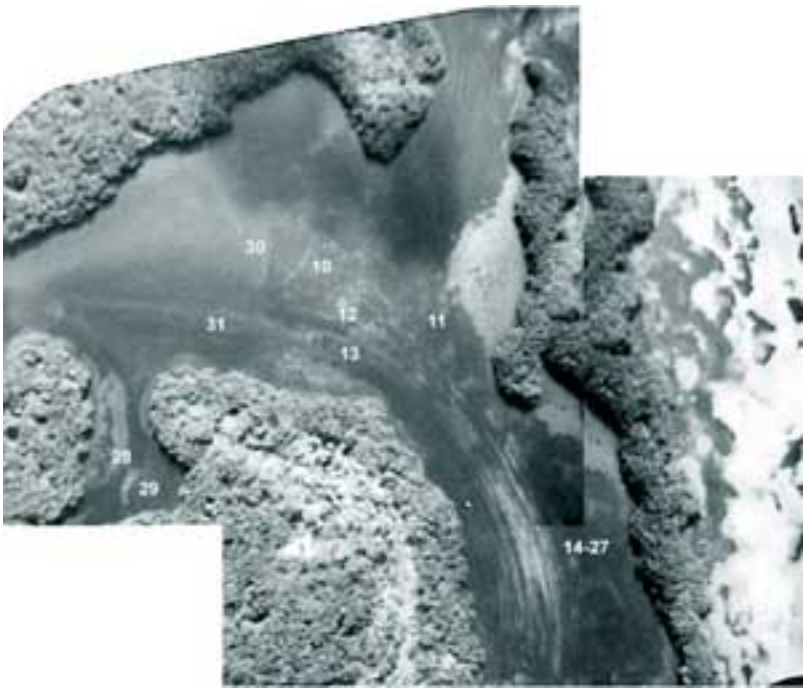

Figure 1: Heavily scarred area in Turtle Bay, part of Charlotte Harbor.

After this scarred area (e.g., Area 14-27) was identified, it was located by boat and the coordinates were recorded using GPS. The area was divided into control and

experimental areas receiving no restoration and restoration, respectively, in order to quantitatively evaluate the effectiveness of restoration.

Figure 2. Injection Wheel, tank and boat.

The restoration or repair process consists of injecting a nutrient solution of seawater, growth stimulant, and urea into sediment in the experimental area. The intent is to stimulate regrowth and expansion of seagrass beds. This approach differs from other vegetation restoration efforts that use planting or seeding. Nutrient injection is done using a system consisting of a tank of solution and a pump feeding

a wheel with injectors on the circumference (Figure 2).

The injection wheel, deployed at the end of the arm over the boat's side, rolls on the bottom (Figure 3).

Figure 3. The injection wheel deployed. Red flags on the bottom are placed to indicate the length of a propeller scar.

Follow up injections are done after about 2 weeks and the area is monitored after 3-4 months to record growth. Regrowth is measured quantitatively by counting the number of new seagrass shoots in an area defined by a frame of PVC pipe, and qualitatively by aerial photographs. These are compared with "before" pictures to determine rate of regrowth.

Even though new scars will be made and repaired areas will be re-scarred by ongoing boat propeller use, CMRT hopes to initiate a maintenance program to "hold the line" and possibly increase seagrass acreage in Charlotte Harbor. Replanting of barren areas will begin the fall of 2002. We will report on the results of this project after post-injection counting of shoots and aerial photography are available.

For further information, contact Dr. Jon Hubertz, Charlotte Marine Research Team; Phone: (941) 505-4079; Email: Hubertz@isni.net or Dr. Nick Ehringer, Tampa Bay Education and Research Foundation; Phone: (813) 253-7833; Email: ehringer-jn@worldnet.att.net

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Join a Volunteer Monitoring Listserv

Need someone to talk to about your volunteer monitoring project?

Try the Volmonitor Listserv. It's a national listserv for volunteer monitors, established by EPA to encourage information exchange among the nation's growing number of volunteer environmental monitoring programs. You will receive news on upcoming conferences, workshops, special events, and new publications. The listserv also provides a forum for discussion and networking for volunteer monitors to ask questions and receive help on monitoring methods, data quality, data management, and more. Whether your group monitors wetlands, streams, or lakes, sign up and get in the loop. To subscribe, send an e-mail to listserver@unixmail.rtpnc.epa.gov with the following in the message body: subscribe volmonitor lastname firstname. Leave the subject line blank. You will receive a welcome message once subscribed.

Washington State also hosts e-mail listservs for volunteer monitors. In August 2000 the Washington Department of Ecology developed the Volunteer Monitor and NatureMapping/Watch Over Washington listservs to support volunteer monitors and keep stakeholders informed. The Volunteer Monitor has more than 350 members now. Other volunteer monitors, coordinators, teachers, and people working on restoration projects across the country use the NatureMapping/ Watch Over Washington Listserv, which has more than 250 members. Both listservs invite daily participation, announce volunteer monitoring events, job opportunities, training sessions, and more.

To subscribe to the Volunteer Monitor Listserv, visit listserv.wa.gov/cgi-bin/wa?SUBED1=volunteer-monitors&A=1 EXIT disclaimer, and visit listserv.wa.gov/cgi-bin/wa?SUBED1=naturemapping&A=1 EXIT disclaimer to subscribe to the NatureMapper/Watch Over Washington Listserv.

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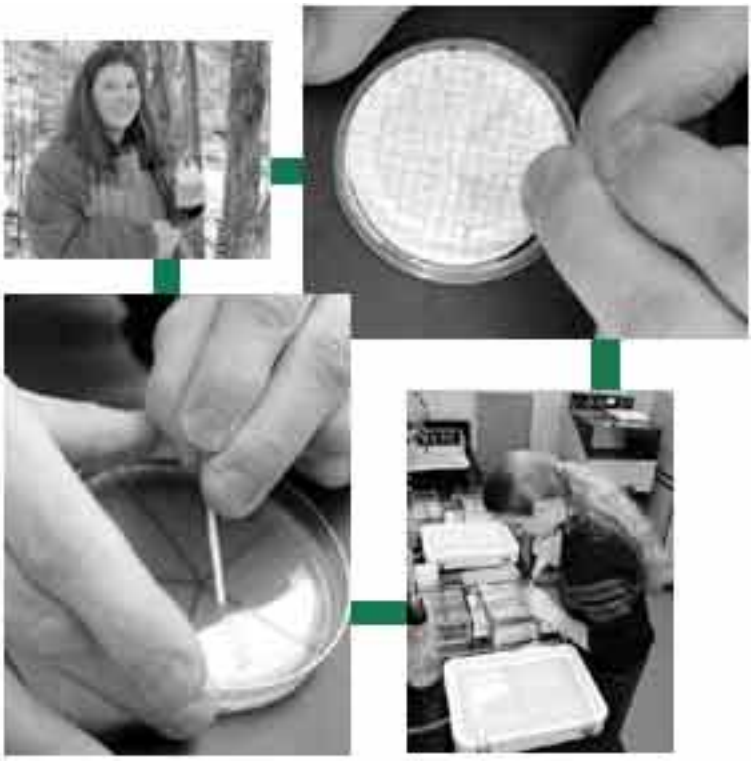
Tracking Down Microbial Sources in Coastal Maine Using Genetic Fingerprinting



In the summer of 2000, East End Beach in Portland, Maine, was closed five times due to elevated bacterial pollution in the water. The bacteria originated from fecal matter carried into streams and the ocean by stormwater runoff. From 1991 to 2000, Maine had 186 days in which there was an ocean or bay closure or advisory

due to poor water quality. Maine's shellfish harvesting area is the third largest in the nation, but almost one sixth of this area is off limits due to pollution, mostly due to non-point sources. New methods to identify sources of fecal contamination are needed in order to target sources of pollution.

In Maine, the National Oceanic and Atmospheric Administration (NOAA) is supporting a study to track and identify sources of fecal bacteria. A project entitled "Microbial Source Tracking in Two Southern Maine Watersheds" is using new biotechnology methods to identify bacterial sources to help guide remediation. The project has been funded for 2 years by NOAA's Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET), located at the University of New Hampshire (UNH).

The Maine project combines resources from many organizations. Researchers and volunteers from the Sea Grant Program at the University of Maine, Wells National Estuarine Research Reserve and AmeriCorps/Maine Conservation Corps collect and process water and fecal samples. Ribotyping, a genetic fingerprinting method described below, is done at UNH's Jackson Estuarine Lab.

According to the EPA, nonpoint source (NPS) pollution is the primary water quality problem in the U.S. today, causing 40% of all nationally surveyed rivers, lakes and estuaries to be unfit for swimming or fishing. Storm water runoff is a major source of bacterial inputs. Rain sometimes causes sewage treatment plants to overflow, spilling untreated or under-treated water into nearby surface water bodies or into ground water. Rain also washes any fecal matter on the ground, from pets, domesticated animals or wildlife, into streams.

Unfortunately, conventional bacterial indicators, such as fecal coliforms or *Escherichia coli* (*E. coli*) only involve counting of bacterial colony forming units (CFUs). However, conventional bacterial counts do not tell you whether the bacteria originate from humans, dogs, waterfowl, deer, a poorly maintained septic system, or a leaky sewer pipe. Remediation would be much easier if the sources could be identified.

Many Microbial Source Tracking (MST) techniques were developed in the 1990s to identify sources of fecal-related microbial contamination in fresh, marine or ground water. MST can use phenotypic characteristics, such as antibiotic resistance patterns in bacteria. MST can also use g enotypic characteristics and genetic analysis such as ribotyping, DNA fingerprinting, or pulsed field gel electrophoresis to distinguish bacterial proteins. Backup detective assistance is provided by other indicators of human fecal sources and wastewater (e.g., detergents, optical brighteners, chlorination by-products such as trihalomethane, caffeine, coprostanol,

and others).

The Maine MST project uses ribotyping of *E. coli* to identify source species of bacterial contaminants in water. Ribotyping is a well-established genetic fingerprinting technique that has been used in other applications for many years. Ribotyping uses the fact that distinct, characteristic strains of bacteria live in digestive tracts of mammal and bird species. Ribotyping zeroes in on the portion of DNA that codes for production of ribosomal RNA.

The Maine MST project focuses on providing resource managers with information to identify microbial sources in the Webhannet and Little River watersheds in York County, Maine. Another goal is to field-test ribotyping as an MST technique. Similar projects are being conducted in New Hampshire and Vermont.

The Maine study involves collection of fecal samples from wild and domestic animals, birds and humans from two watersheds. *E. coli* from these samples are isolated and ribotyped. Ribotyping produces a banded pattern of the genetic fingerprint of the host species, similar to a barcode. These banding patterns are compiled in a "library" of known sources. When someone wants to find the source of *E. coli* in a water sample, the *E. coli* in the sample are ribotyped. The banding patterns of the sample bacteria are compared to catalogued bacteria in the reference library. If the banding patterns are very similar (85% similarity or greater), then the fecal bacteria in the water sample are probably identical to the catalogued source species.

The use of ribotyping to identify sources of fecal contamination is relatively new. Some key questions must be answered before the method can be generally applied: 1) How many samples are needed to adequately characterize bacterial contaminants in a given watershed? and 2) How can representative sampling be done? Coastal waters that experience dramatic seasonal and daily tidal changes, such as the coast of Maine, pose challenges for sampling.

Another unknown is whether a particular bacterial species can differ geographically or over time. To answer this question, microbiologists compare the unknown bacteria to catalogued bacteria from the watershed being studied and from a regional database. Using a larger database increases the chances that the bacterial source can be identified.

So far, the Maine project shows that 65% of the bacterial isolates can be tracked back to catalogued source species. The most common identified sources for fecal bacteria are humans. Fecal bacteria sources from all combined wildlife species are slightly more common than humans, however, while livestock sources are slightly less common. Pets and birds account for a small number of sources.

For more information, contact Kristen Whiting-Grant, Project Manager, Maine Sea Grant Extension, kristen.whiting-grant@maine.edu or Dr. Stephen Jones, Jackson Estuarine Lab/UNH, shj@cisunix.unh.edu. Results will be posted to the web site: www.umseagrant-mst.org EXIT disclaimer .

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Emerging Technologies, Tools, and Techniques to Manage Our Coasts in the 21st Century

Technology Transfer Conference
Sponsored by the U.S. EPA Office of Water,
Office of Wetlands, Oceans, and Watersheds, Oceans and Coastal Protection Division

January 28 - 31, 2003
Holiday Inn Hotel
Cocoa Beach, Florida

This year marks the 30th anniversaries of the Clean Water Act, the Marine Protection, Research, and Sanctuaries Act, and the Coastal Zone Management Act. To celebrate, the U.S. Environmental Protection Agency (EPA) has designated 2003 as the Year of Clean Water. January 2003 focuses on our coastal and ocean waters. The EPA is sponsoring a ***Technology Transfer Conference*** to examine current and emerging coastal and ocean management tools, and strategies to improve our ability to protect and manage coastal ecosystems over the next 25 years. The goals of the Conference are to:

- Share information about new, effective, transferable tools, techniques, and approaches to improve coastal ecosystems;

- Provide information about new environmental, socioeconomic, and cultural trends which will impact coastal ecosystems over the next 25 years;
- Promote broad understanding of coastal ecosystem science;
- Promote inquiry and discussion on how current scientific knowledge and technology can address emerging coastal ecosystem challenges;
- Develop strategies to integrate technology with research to anticipate and address emerging coastal challenges.

The Conference will be organized around four themes: assessment, management, restoration, and measuring results. The Conference will include: 1) Case studies about successful transferable technologies and tools; 2) Presentations and panel discussions on the state of knowledge of specific coastal ecosystem issues; 3) Poster sessions highlighting tools, techniques, research, and management approaches; and 4) Problem-solving sessions integrating case studies, research findings and technical approaches needed to anticipate and address emerging coastal challenges.

For more information, please contact Ms. Noemi Mercado, EPA Office of Wetlands, Oceans and Watersheds, Coastal Management Branch; Phone: (202) 566-1251 or see http://www.tech-transfer-conference.com 

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EPA's Online Directory of Volunteer Programs

Want to know more about volunteer monitoring programs in your area?

Check out yosemite.epa.gov/water/volmon.nsf for information on more than 800 volunteer water monitoring programs underway across the U.S. View programs by state or program name, and add (or edit) your own information Each entry lists program contacts, parameters and environments monitored, and approximate number of volunteers. Many entries also include information on quality assurance plans, budget, data users, and more.

EPA first collected volunteer monitoring program information in 1988, when the directory listed fewer than 50 programs. Now, the most recent directory lists 772 programs! EPA now accepts online updates to the database. Work is underway to make the directory more searchable and to update information about existing programs. A summary of the 1998 edition is available at www.epa.gov/owow/monitoring/dir.html.

[For more information on the directory or EPA's volunteer monitoring program, visit www.epa.gov/owow/monitoring/vol.html.]