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Coastlines
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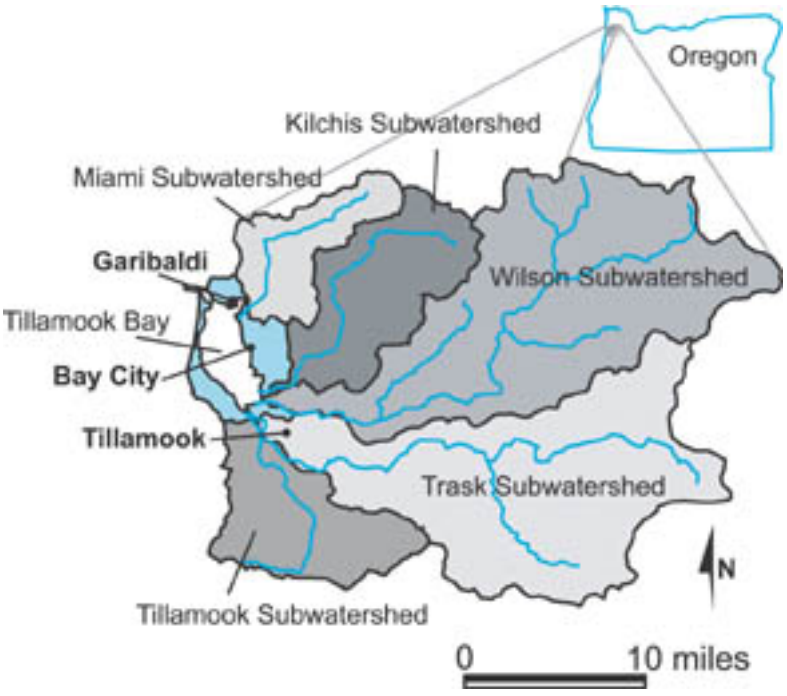
Tillamook Bay National Estuary Program: Assessing and Addressing Bacteria Contamination in Tillamook Bay, Oregon



Five major rivers tumble down the rugged Oregon Coast Range to the Pacific Ocean, converging in the Tillamook Bay estuary. They drain a 597-square mile watershed containing some of North America's richest timber and dairy land. Tillamook Bay is a shallow estuary that averages 6.6 feet in depth over its 13 square mile area. At low tide, about half of the estuary is exposed as intertidal mud flats, much of which is used for commercial shellfish culture. Although the

watershed is largely forested, the lower alluvial plain has been extensively diked and drained for dairy pasture and development.

The Tillamook Bay National Estuary Project (TBNEP) recently incorporated as a 501(c)(3) non-profit corporation and renamed itself the Tillamook Estuaries Partnership ("the Partnership"). The TBNEP can thus leverage its ability to fundraise and undertake restoration projects, partnering with private, public, and volunteer organizations.

Background

Tillamook Bay is the third largest estuary on the Oregon Coast, and was named as a National Estuary Project (NEP) in 1994 to enhance and protect the bay and its watershed. It supports 5 species of anadromous salmon and some of the most productive shellfish areas in the state. The Comprehensive Conservation and Management Plan (CCMP) identifies four top priority problems: habitat loss, sedimentation, negative impacts of flooding, and water quality degradation. To address water quality degradation, bacterial contamination of Tillamook Bay is being targeted.

Tillamook Bay and several of its tributaries do not meet state and federal water quality standards for bacteria under the Clean Water Act. In streams and rivers, fecal coliform bacteria levels commonly exceed the recreational standard. In the bay, bacteria levels exceed both the recreational standard and the shellfish harvest standard, causing frequent closures of shellfishing areas. Bacteria contamination is a significant threat to public health and aquatic function, and originates from point and non-point sources in runoff from agricultural, urban, and residential land uses along the rivers.

The TBNEP is monitoring bacteria to assess the severity and extent of watershed pollution, identify the most important bacteria sources, and document improvements in response to pollution-abatement measures. To meet these goals, TBNEP combined volunteer citizen monitoring, routine and storm-based sampling, and innovative DNA tracking methods.

Bacteria Monitoring Strategy

The CCMP's strategy for bacteria monitoring seeks to answer two key questions:

1. Is bacteria loading to the lower reaches of tributary rivers increasing or decreasing over years to decades?
2. Where, how often, and for what length of time do each of the five major tributary rivers violate state water quality standards for bacteria?

To answer these questions, the Partnership initiated two complementary monitoring approaches in 1995: the Storm-Based Monitoring Program and the Volunteer Monitoring Program. Then, in 2000, the Partnership embarked on a third exciting approach with Oregon State University: a Bacteria Genetic Marker Study of Tillamook Bay. This 3-year research study will try to identify bacterial pollution sources through DNA fingerprinting of bacteria in water samples and comparing them with DNA from known bacterial sources.

Storm-Based Monitoring

The most severe bacteria loading of the lower tributaries usually occurs episodically as a result of stormwater runoff. During rain events, which happen often between October and April, the bay is closed to commercial shellfish harvesting due to

elevated bacteria levels. The Storm-Based Monitoring Program measured fecal coliform bacteria concentrations and loads (and other water quality parameters) during storm events. Between 1996 and 2002, 28 separate storms were monitored along four tributaries. In each season, storms were classified into "storm types" based on precipitation and hydrology before and during storms, in order to analyze trends in bacteria contamination by storm type and season. With enough data (10+ years), long-term declines in bacteria loading should occur if pollution abatement measures are implemented.

Storm-Based Monitoring showed that seasonal differences in fecal coliform concentrations occur in all rivers, with fall storm events causing the highest levels, probably due to bacteria buildup during dry periods that "flushes" to rivers during early fall storms. Bacteria concentrations increased dramatically during storm events and varied greatly between rivers; some rivers exceeded the recreational contact standard for most storms sampled, while others sporadically exceeded this threshold. Bacteria concentrations in rivers were strongly influenced by the frequency, timing and intensity of rainfall events. Drier conditions prior to storms and greater rainfall during storms generally resulted in higher bacteria concentrations. After 6 years of data collection, no trends in improvement in water quality were observed.

To identify major bacteria sources, intensive storm monitoring was conducted over a 2-year period along two river reaches that were suspected to be major bacteria-contributing areas. Ten sites were monitored along 2-kilometer sections of the lower Trask River and the lower Wilson River. Potential bacteria sources were documented and mapped using photos, GPS, and field surveys. in order to link spikes in bacteria concentration to likely sources. Results are being used to identify and prioritize important source areas for corrective action.

Volunteer Monitoring

Since 1995, volunteers have been braving wind, rain, sleet and occasional sun to collect water samples from the Miami, Kilchis, Trask, Tillamook, and Wilson Rivers, the five major tributaries. Samples are collected from 37 locations throughout the watershed, representing many land uses, and are analyzed for E. coli bacteria at the Partnership's laboratory. Monitoring results are entered into a long-term database shared with local and state partners. The goal of monitoring is to compare measured water quality to the state's bacteria water quality standard, to document areas of chronic water quality pollution, and to link land uses to bacteria pollution.

The Volunteer Monitoring program showed that all five of Tillamook Bay's main tributary rivers routinely violate Oregon's bacteria water quality standard for water

contact recreation. Bacteria concentrations peak during the summer when river flows are low, and during some fall, winter and spring storms. The Tillamook River routinely has the highest bacteria concentrations of the five rivers.

Genetic Marker Study

Over the past 2 years, citizen volunteers have also collected samples for the Tillamook Bay DNA Marker Study, led by Oregon State University (OSU) researchers. Because bacteria contamination is due largely to non-point sources, new methods are needed to discriminate among potential bacteria sources. The OSU study seeks to identify bacteria sources by detecting host-specific genetic marker sequences. The goal is to be able to discriminate between fecal bacteria from humans, livestock, domestic pets, waterfowl, and other wildlife, and to measure relative bacterial loading from each of these sources to the rivers and bay.

So far, the DNA study reliably discriminates between bacteria from humans and bacteria from bovine (cattle) sources. Early results indicate widespread contamination from cows and significant contamination from humans in certain river segments. Bacteria contamination from bovine sources was detected at all sites at least 75% of the time, whereas contamination from human sources was detected much less frequently and at 20-50% of the sampling sites, depending on the river.

Use of Monitoring Results

Any monitoring study should ask the question "what is the practical relevance of the monitoring results?" Here, the Partnership is using bacteria monitoring results to guide pollution abatement efforts.

The Storm-Based Monitoring Program quantified bacteria loads to the bay from four main tributary rivers. The Tillamook River was documented as the most severely contaminated river. Focusing on corrective actions along this river would result in the most "bang for the buck" in terms of improving water quality. Intensive storm-based monitoring on the lower Wilson and Trask Rivers also revealed "hotspots" that are top priorities for improvement, including municipal storm water drains, sewage outfalls, and agricultural ditches.

The Volunteer Monitoring Program generated a spatiotemporal picture of bacteria contamination in the watershed. Chronic problems were documented along specific river reaches. This information was crucial for developing a bacteria Total Maximum Daily Load (TMDL) for the watershed, as required by the Clean Water Act, and to prioritize areas for remediation. Again, the Tillamook River had chronically high bacteria concentrations, confirming the Storm-Based Monitoring results.

The Genetic Marker Study helped to identify which portions of the lower rivers are contaminated with bacteria from cows, humans, or both. Areas that regularly test positive for human sources of bacteria indicate failing septic systems or sewage treatment plant overflows/failures. This study documented widespread bacterial

contamination from cows throughout the Tillamook lowlands, pointing to the need to continue improving farm management practices. As genetic methods improve, the Partnership hopes to be able to measure the relative contributions of different sources to overall bacteria levels in the river. This will be a powerful scientific tool to guide mitigation and convince the public and policy-makers to address problem source areas.

These programs also established an excellent reference database, critical as a yardstick against which to compare future water quality. As corrective measures are undertaken, such as improvements in land use practices, sewer treatment plants, private septic systems, and stormwater management, it will be important to document success in cleaning up bacteria sources.

Next Steps

Based on these results, the Program has begun several top priority projects to reduce bacteria contamination of the bay. These projects are:

Tillamook Bay On-Site Sanitary Survey. In collaboration with the Tillamook County On-Site Sanitation Division, all private septic systems in the watershed will be inspected to ensure proper functioning. Failing septic systems will be repaired with assistance from low-interest loans.

City of Tillamook Stormwater Management Plan. This plan will identify stormwater contaminants and measures to reduce bacterial loading, total suspended solids, oils, and inorganic pollutants at outfalls entering rivers.

Buffer Strip Effectiveness Study. This project will design and test an experimental demonstration buffer strip system to determine its usefulness in removing bacteria from dairy pasture runoff and to help select BMPs for manure management and buffer strips.

The Tillamook River Solutions. The Partnership will facilitate a working group of partner organizations to develop improvement projects with local landowners along the Tillamook River.

Performance-Based Environmental Policies for Agriculture. This is a pilot project to develop and implement performance-based policies for agriculture, in order to meet or exceed water quality standards in the lower basin.

For further information, contact:

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Rhode Island Restores Shellfish Following *North Cape* Oil Spill

Tug *North Cape* and barge aground on Rhode Island beach.
NOAA photo

South County, Rhode Island, is undertaking several shellfish restoration projects aimed at restoring the region's once-thriving shellfish resources. Shellfish restoration efforts include restoring scallop and enhancing quahog stocks following a 1996 oil spill from the vessel *North Cape*, assessing submerged aquatic vegetation that provides habitat for shellfish, monitoring seeded scallops to determine survival factors, raising quahogs, and creating oyster beds.

As part of the legal settlement for the North Cape oil spill, NOAA's Fisheries Restoration Center and the Rhode Island Department of Environmental Management (RIDEM) began a pilot program for shellfish restoration and enhancement in 2002. This restoration program was conducted to address natural resource injuries from the *North Cape* oil spill in January 1996 that released 828,000 gallons of No. 2 fuel oil into Block Island Sound and Rhode Island's coastal ponds. The pilot program was the initial phase of a $1.5 million, multi-year effort to address shellfish losses amounting to more than 10 million surf clams and other bivalves that were killed as a result of the oil spill.

Restoration activities included conducting a baseline scallop and habitat survey of Point Judith Pond, seeding of northern bay scallop (*Argopecten irradians*), installing two upwellers to raise shellfish seed, and quahog (*Mercenaria mercenaria*) transplant and seeding projects.

Conducting a baseline survey of shellfish habitat was the first important step. The Point Judith Pond baseline survey involved randomly selected pond stations (100 m x 100 m areas) with three 1-m^2 randomly selected quadrats for each station. The study focused on potential scallop habitat areas of higher quality. Snorkeling/dive teams assessed eelgrass coverage, shellfish densities, abundance of crustaceans and macroalgae, and sediment grain size. A total of 471 quadrats were assessed over a two-month period in summer, representing 40% of the pond area.

Preliminary baseline survey results indicate that benthic conditions have changed significantly in portions of the pond since the late 1970s when RIDEM last conducted a major pond survey. While quahogs remained abundant throughout much of the assessment area, scallops were virtually absent. Eelgrass beds were limited to the mid-section of the pond, and only 16 adult scallops were observed, equating to a low population density of 0.0341per m^2. The survey data were used to pinpoint bay scallop habitat and select seeding areas.

Based on the dive survey results, approximately 640,000 scallops were released into Point Judith Pond in October. Ninety-seven community residents and other volunteers contributed nearly 400 hours measuring, tagging and seeding scallops. More than 8,000 scallops averaging about 1 inch in size were marked and released. Local residents also volunteered use of their boats for teams to go to predetermined release sites to seed scallops. This volunteer effort received press coverage from several local newspapers and an interview clip on a local TV station. Soon after, dive teams assessed initial scallop survival and density in planting areas. Observations of scallop shell fragments in 7.5 % to 46% of the quadrats surveyed suggest that crab predation may have been significant. Monitoring will continue in April 2003 and thereafter, with the hope that a scallop fishery can begin in October 2003.

Other shellfish restoration projects included purchase of approximately 1 million small (<2 mm) hatchery quahog seed, placed and grown in upwellers at RIDEM's Coastal Fisheries Lab and Roger Williams University. The upweller facilities are floating docks with plastic tanks containing shellfish suspended under the docks. The young shellfish are bathed in a slow current of seawater that is pumped into each bottom-screened holding tank. The slow flow of seawater provides oxygen, suspended particles and plankton to the filter-feeding shellfish, and carries away waste products, while the tanks protect the shellfish from predation. Very slow growth rates in the Rhode Island "white" quahog seed resulted in the seed being overwintered in bottom cages for a fall 2003 release.

The 2003 North Cape Shellfish Restoration Plan includes purchase, grow-out and release of 2 million 1-inch scallops to Point Judith Pond and other South County coastal ponds. Ninigret and Quonochontaug Ponds are potential release sites, and in the spring of 2003, baseline surveys will help to determine release sites. The agencies also plan to purchase and raise another 4 million quahog seed, for upweller grow-out, that will be released into both spawner sanctuaries and open shellfishing areas within several coastal ponds.

This year a third project will create oyster beds using remote spat setting techniques. The remote set oyster project will involve using quahog shell material from the Rhode Island shellfish industry (Blount Seafood), weathering the shell over the winter, and then bagging the shell into biodegradable bags. Once the 500 shell bags are prepared, they will be taken to a contracted hatchery which will set approximately 1 million oyster spat onto the shell bags. The shell bags with spat will then be placed in shallow sub-tidal areas that may receive additional shell "hash" to enhance the bottom substrate to increase potential for oyster survival and growth. Several oyster reef pilot sites are proposed in Point Judith Pond and other possible management areas in the South County salt ponds and Narragansett Bay. The goal of the agencies is to develop sustainable oyster beds and fisheries in each of these management areas.

For further information, contact: Karin Tammi, North Cape Shellfish Restoration Coordinator, NOAA/NMFS Oil Spill Shellfish Restoration Program, Coastal Fisheries Lab, 1231 Succotash Rd., Wakefield, RI; Phone: (401) 782-3290, Email: Karin.Tammi@noaa.gov or James Turek, Assistant Northeast Team Leader, NOAA Restoration Center, Phone: (401) 782-3338,Email: James.G.Turek@noaa.gov.

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Federal Funding Database for Watershed Protection Now Online

EPA has recently updated the *Catalog of Federal Funding Sources for Watershed Protection*. This *Catalog* is now online as an easy to use, searchable Web site. The Web site provides information for watershed practitioners and others on Federal funding sources that may be available to help fund various watershed-related projects. The *Catalog* allows the user to find out about relevant federal funding programs, the level of funding available, average size of grant or loan, contact information, and other useful information. The database, which was developed by EPA's Office of Water, provides information from over 80 federal funding sources pertaining to air, water, solid waste, and other programs and projects. EPA plans to update the Web site on an ongoing basis.

The website is located at:
http://www.epa.gov/watershedfunding

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Keeping the Kelp

Just offshore from the Pacific Coast Highway exists one of the most unique, vibrant, and majestic forests in the world. California's giant kelp forests are often called rainforests of the sea, and the California Coastkeeper Alliance (CCKA) is working to protect and restore this precious natural resource.

Like rainforests, the towering golden kelp plants can grow up to 200 feet tall and support over 800 species, including several threatened and endangered species. Because of their rich diversity, kelp forests are critical to supporting commercial and recreational fisheries. In addition, many consumer products that we use everyday, like toothpaste and ice cream, include algin, a compound derived from sustainably harvested kelp. Many people consider kelp forests to be the most important marine habitat in California.

Giant kelp (*Macrocystis pyrifera*) was once abundant along the California coast, from San Diego to the North of Monterey. However, from 1967 to 1999, there was a

net decline in kelp abundance, with some areas experiencing near complete destruction. Under optimal conditions, giant kelp, which can grow up to two feet a day, will recolonize an area following destructive storms or periods of low nutrients associated with increased water temperatures.

In southern California, 2002 was a great year for kelp - mild winters and cold, nutrient-rich waters enabled many kelp beds to recover naturally and rapidly. However, many areas which historically supported kelp forests, have not recovered. Some regions like Orange County have seen very little natural recovery.

Natural kelp regeneration and the biodiversity that the forests support can be challenged by many factors. In some cases, layers of toxic sediment from widespread, polluted urban runoff have been deposited on reefs, preventing kelp spores from settling on the clean, rocky surfaces they require.

Overfishing of many species, such as California sheephead and spiny lobster, and the past hunting of sea otters have led to disruptions of the kelp eco-system. These predators are an integral part of kelp forest habitats, preying upon the primary kelp herbivores, sea urchins. Sea urchins graze on kelp at remarkable rates, often decimating entire forests, and creating what are called "urchin barrens" - depleted areas of the ocean that contrast starkly with lively kelp forests.

The California Coastkeeper Alliance (CCKA) is working to restore southern California's kelp forests. Giant kelp can be re-established using techniques that have been successfully tested and refined since the 1970s. CCKA, in partnership with the National Oceanographic and Atmospheric Administration, has launched a community-based program to increase the long-term quantity and quality of

southern California's kelp forests. The Alliance includes Baja California Coastkeeper, San Diego Baykeeper, Orange County Coastkeeper, Santa Monica Baykeeper, Ventura Coastkeeper, and Santa Barbara Channelkeeper.

CCKA's team of biologists collect sporophylls, which are kelp reproductive tissue, from wild adult kelp plants. At our Regional Kelp Mariculture Laboratory, the sporophylls are induced to release their microscopic spores through controlled changes in temperature and light. A solution containing millions of spores is added to a container holding seawater and small ceramic tiles. The spores settle on the tiles as they would do on a healthy, rocky reef and will eventually grow into adult kelp plants. When the kelp on the tiles has grown to one to two inches, the tiles are transported to the ocean and are attached to reefs using rubber bands.

At the heart of all Waterkeeper programs are community volunteers. Teams of volunteer divers work with Waterkeeper biologists to restore, maintain, and monitor the kelp forests. Dive teams conduct weekly maintenance dives of their "adopted" kelp sites to replant kelp and, where densities are high, to relocate sea urchins, reducing the possibility that the newly planted kelp will be eaten by these grazers. The kelp plants grow rapidly, reaching one to five feet within a few months, and when they attach themselves to the reef, the tiles can be removed. Within a year, a kelp canopy forms and will continue to expand in size, attracting hundreds of species of marine life.

In addition to this program, the CCKA also has an educational component that gives K-12 students an opportunity to study and grow kelp in their classrooms. Over the course of a school year, Waterkeeper biologists visit with students to introduce them to the project, teach them about marine ecology, kelp biology, coastal conservation, careers in SCUBA diving and science, and how to grow juvenile kelp. Classes participate by maintaining an eco-Kart, a self-contained kelp nursery aquarium. They monitor and care for the young kelp until it is ready for outplanting in southern California coastal waters. When it is time to plant the kelp, volunteer divers take it down to the reef and attach it. At the end of the school year, students take boat field trips out to the site of reforestation to view their accomplishments as a culmination of all they have learned.

The Alliance will continue its efforts to enhance the quality and quantity of our marine ecosystems through community-based protection, restoration and monitoring.

For further information, contact Sasha Sicks, Public Outreach Coordinator, California Coastkeeper Alliance, 2515 Wilshire Blvd, Santa Monica, CA 90403; Phone: (310) 829-1229; Fax: (310) 829-6820; Email: sasha@cacoastkeeper.org. Or visit the California Coastkeeper Alliance website at www.cacoastkeeper.org EXIT disclaimer

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Volunteers Monitor Harmful Algal Blooms In Delaware's Inland Bays

Sea Grant

Background

Delaware residents became concerned about the environmental and potential human health effects of harmful algal blooms (HAB's) when *Pfiesteria* was implicated in fish kills from North Carolina to New Jersey in the mid to late '90s. Many questions were asked: Was it safe to go in the water or eat seafood? What caused *Pfiesteria* and other harmful algal blooms? What are the potential economic impacts to the tourism and seafood industries? How do we fix things? Scientists, resource managers, and public health officials couldn't provide the public with definitive answers because the health risks posed by *Pfiesteria* were not well understood.

In the fall of '98 the University of Delaware Sea Grant Marine Advisory Service (SGMAS) conducted a survey of Mid-Atlantic residents to better understand their concerns, attitudes and perceptions about harmful algal blooms, particularly *Pfiesteria*. Respondents saw a significant potential negative impact to the tourism and seafood industries and expressed support for state funding of research and mitigation efforts. Survey results also suggested that officials needed to maintain open lines of communication by providing accurate information in a timely manner.

In the summer of 2000, two members of the Delaware Surfriders sent a sample of water implicated in a fish kill to Dr. Carmelo Tomas at the University of North Carolina at Wilmington, who detected *Chattonella cf. verruculosa*, an algal species not previously known to be present in U.S. waters. He also identified brevetoxin, previously associated only with the red tide species, *Karenia brevis*. Brevetoxin can accumulate in marine food chains and has been associated with fish kills, marine mammal deaths, shellfish toxicity and human respiratory irritation from aerosols.

This event prompted Sea Grant to consider how we could broaden our role in developing and disseminating information on algal blooms. As university outreach educators, we use a variety of approaches to educate marine resource users and consumers about public health and safety and environmental issues. One highly successful approach has been using citizen volunteers to assist in the collection and dissemination of information.

Citizen Monitoring

The goals of the Citizen Monitoring Program are to: 1) collect accurate water quality data to support resource management decisions, and 2) increase public participation and support for the conservation and management of the Bays. Since the program's inception, we have trained over 200 volunteers to collect water quality data for the Inland Bays.

By training volunteers to evaluate and identify phytoplankton, we believed we could make an important contribution to the state's Harmful Algal Bloom (HAB) Monitoring Program and improve public understanding about HABs.

Sea Grant has a longstanding partnership with the Delaware Department of Natural Resources and Environmental Control (DNREC), from which we receive base funding for our program. Additional funding for special projects, including the start up of the phytoplankton monitoring program, has been provided by the non-profit Center for the Inland Bays (CIB), established by the Delaware General Assembly to implement the goals of the Inland Bays Comprehensive Conservation Management Plan.

HAB Monitoring

With the support and guidance of Dr. Sherwood Hall, program manager of the U.S. Food and Drug Administration's Washington Seafood Lab, volunteer shellfish monitoring programs had already been initiated in several key shellfish producing states including California, Maine, and Massachusetts. Volunteers used field microscopes to detect the presence of toxic phytoplankton associated with shellfish

poisoning, providing a cost-effective early warning system.

While Delaware waters don't support a large commercial shellfish fishery, recreational clamming is common in the Inland Bays. Here, the main impetus for the program was public concern about possible human health effects from large fish kills related to harmful algal blooms. Our program goals were to:

- Increase the spatial and temporal coverage of HAB monitoring in the Inland Bays.
- Improve prediction of HAB occurrence for water quality and public health alerts.
- Improve public understanding of phytoplankton blooms by engaging citizen volunteers as stewards of the Bays.
- Provide samples of significant blooms to the DNREC HAB Monitoring Program, researchers at the University of Delaware College of Marine Studies, and other interested institutions.

Faculty and staff at the University of Delaware College of Marine Studies were instrumental in the development of our phytoplankton monitoring program. They taught volunteers to identify phytoplankton species and provided ongoing technical support.

By the first summer, volunteers were playing a key role in Delaware's HAB Monitoring Program. Phytoplankton blooms are often patchy and ephemeral. Because the volunteers live in places where algal blooms are likely, they can quickly collect and evaluate samples. Since quality assurance of our data is critical to the credibility of our monitoring program, we confirm volunteer algal identifications through several sources, including Dr. Ed Whereat, Volunteer Monitoring Coordinator, who holds a Ph.D. in plant ecology and physiology and a network of experts in algal morphology.

When large blooms of HAB species occur, immediate alerts are provided to the state DNREC. Our volunteers have detected several major blooms of *Chattonella cf. verruculosa*, a species that has been implicated in fish kills and has the potential to cause symptoms such as upper respiratory irritation and itching in humans. They have also found phytoplankton species not previously known to be present in the Inland Bays, particularly in the raphidophyte class. Monitoring efforts suggest that some of the species of concern are frequently present in the bays, albeit in low numbers.

Our volunteers enhance the efforts of both university researchers and state agency

personnel by providing greater spatial and temporal coverage, supplying scientists with live algal samples for culture, and collecting and relaying samples that would be difficult for university or agency staff to obtain. Samples that we have collected have been utilized to advance research on potential toxicity, the physiology of various HABs, and the development of genetic probes to detect or confirm their presence in water.

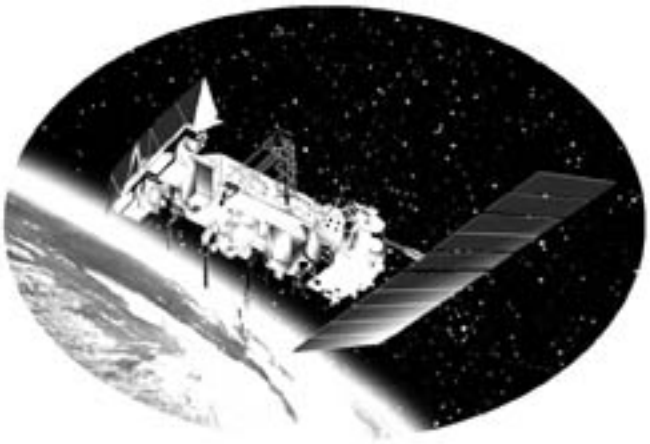
Since our pilot effort, with continued support from the CIB, DNREC, and the University of Delaware Sea Grant Program, we have expanded our coverage of regular monitoring sites and our "bloom response" efforts, primarily in areas where the most significant blooms occur. In 2003, we will extend our coverage into approved shellfish harvesting waters.

Building Partnerships

The success of our Citizen Monitoring Program largely depends upon a strong network of individuals and organizations, including the University of Delaware College of Marine Studies, the CIB and the DNREC, as well as our volunteers. Working together, we have been able to accomplish much more than we could by working alone. Volunteer monitoring programs can be highly cost-effective and complement state monitoring programs, provided that suitable training and quality assurance methods are used.

For further information, contact Joe Farrell, Marine Resource Management Specialist, University of Delaware Sea Grant Marine Advisory Service and Program Manager for the Inland Bays Citizen Monitoring Program, University of Delaware, College of Marine Studies, 700 Pilottown Road, Lewes, DE 19958; Phone: (302) 645-4250; Email jfarrell@Udel.Edu

NOAA Satellites Give Early Warning for Coral Bleaching in Northwestern Hawaii Archipelago



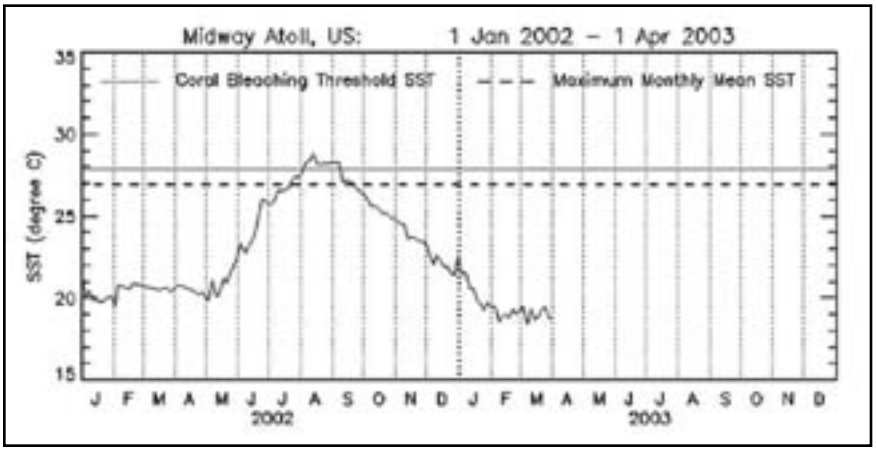
Filter-feeding corals first evolved hundreds of millions of years ago, but modern reef-building forms have only evolved over the last 25 million years. Today, coral reefs are Earth's largest biological structures and have taken thousands of years to form. Coral reefs not only provide important habitat for many marine animals and plants, but they also provide people with food, jobs, chemicals, protection against storms, and life-saving pharmaceuticals. Native cultures often depend heavily on reefs for marine resources.

Most reef-forming corals contain symbiotic microscopic algae in their gastrodermal cells. The host coral provides the algae with protection from grazers and carbon

dioxide for photosynthesis. In return, the algae supply the coral with oxygen and nutrients and remove wastes. Healthy corals come in a variety of colors, depending on the photosynthetic pigments of their symbiotic algae.

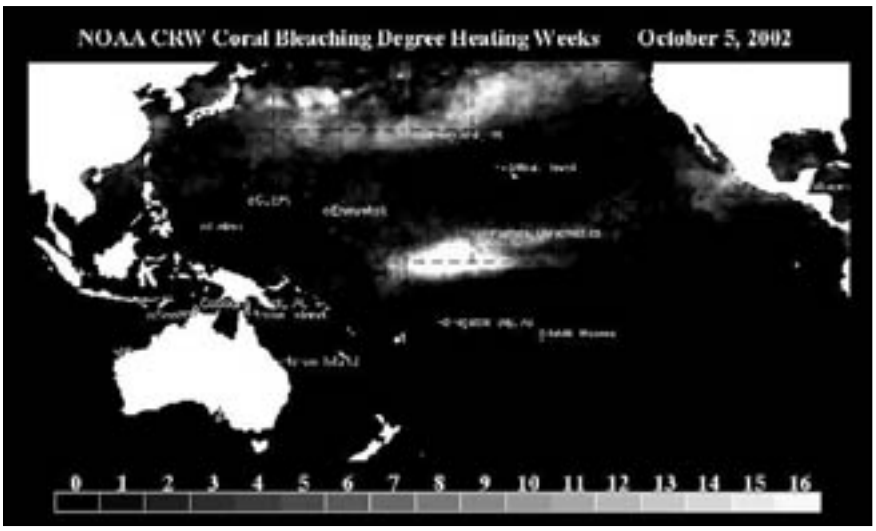
But under certain environmental stresses, the algae can be expelled by their hosts and the coral colony becomes stark white or pale in color, revealing the underlying white calcium carbonate skeleton. Coral bleaching is often caused by water temperatures that exceed the coral's tolerance level. This may be as little as 1 to 2ºC above the mean monthly summer values. High temperature not only contributes to bleaching, but also weakens coral's ability to fight diseases and grow. Reefs that are partly to totally bleached for long periods often die. Following coral death, the skeleton is colonized by algae and other encrusting organisms, often turning dirty brown in appearance. Dead reefs are vulnerable to waves and other reef organisms that bore into coral skeletons and as a result, the reefs soon break up and erode. Severe bleaching events have dramatic long-term ecological impacts, including loss of reef-building corals, changes in benthic habitat and, in some cases, changes in fish populations. Even under favorable conditions, it can take many years for severely bleached reefs to recover.

This is why reefs are being monitored extensively for elevated temperatures conducive to bleaching. During the summer of 2002, a major coral bleaching event was observed in the Northwestern Hawaiian Islands (NWHI). "To our amazement and horror, vast areas of the back reef were severely bleached," said Dr. Rusty Brainard, a scientist from NOAA's National Marine Fisheries Service (NMFS).

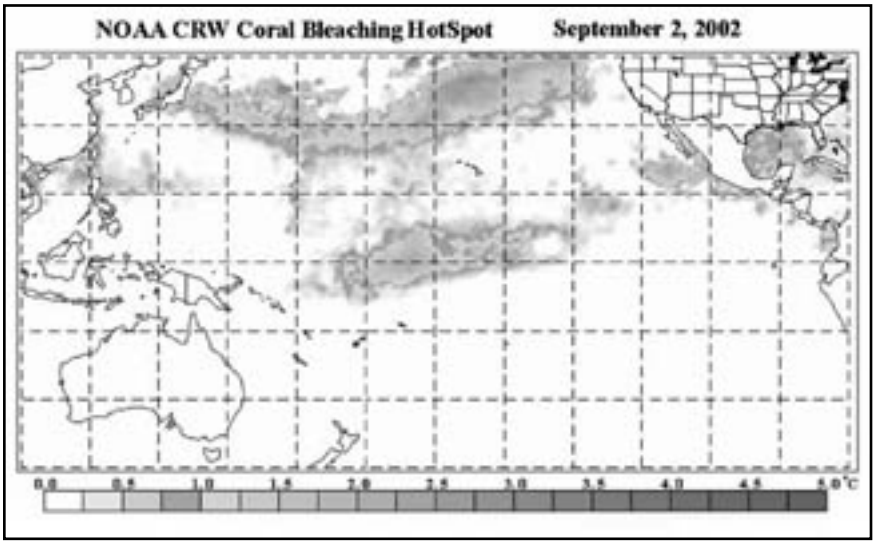


Based on satellite observations of anomalously warm sea surface temperatures (SSTs), NOAA Coral Reef Watch (CRW) Program sent a warning of potential bleaching in early August, 2002, to coral reef scientists and managers in the area. The *in situ* Coral Reef Early Warning System (CREWS) buoys, operated by NMFS Honolulu Laboratory, also detected elevated water temperatures. Following the warning, NMFS conducted diver surveys to assess conditions along 135 kilometers of prime reef habitat in the shallow back reefs and lagoons of Pearl, Hermes,

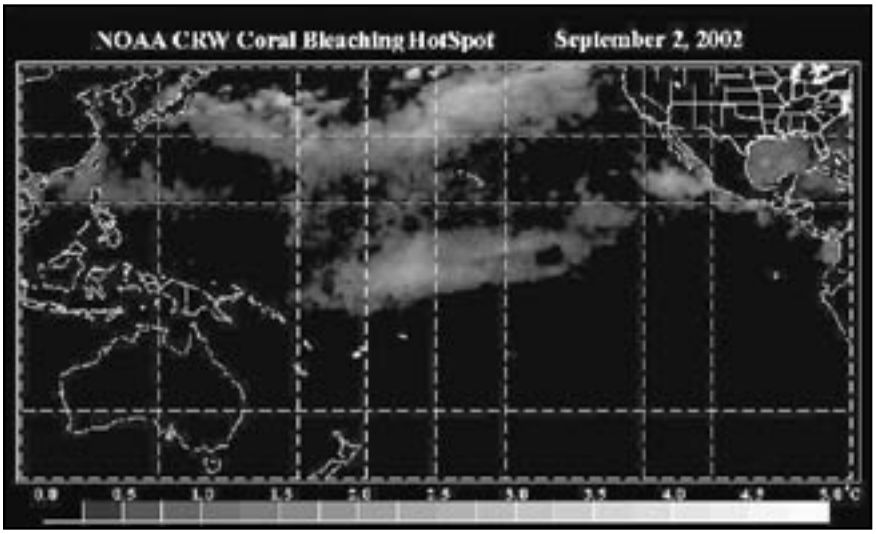
Midway, and Kure Atolls.



The key CRW satellite coral bleaching monitoring and prediction tools include the near-real-time satellite SST "HotSpot" anomaly detector, which detects thermal stress conducive to bleaching and "Degree Heating Weeks" (DHW), which measures cumulative thermal stress. The Coral Reef Early Warning System (CREWS) buoys also provide in situ data for these products.

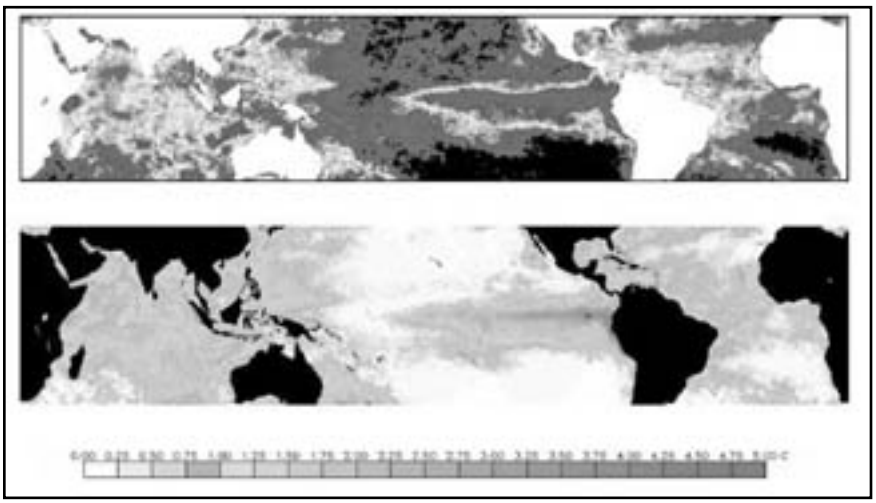


The satellites are operated by NOAA's National Environmental Satellite, Data, and Information Service (NESDIS, now also known as Satellite and Information Services). The coral bleaching satellite products are produced by NESDIS' CRW program, while the Pacific CREWS buoys are operated by the NOAA NMFS laboratory at Honolulu.

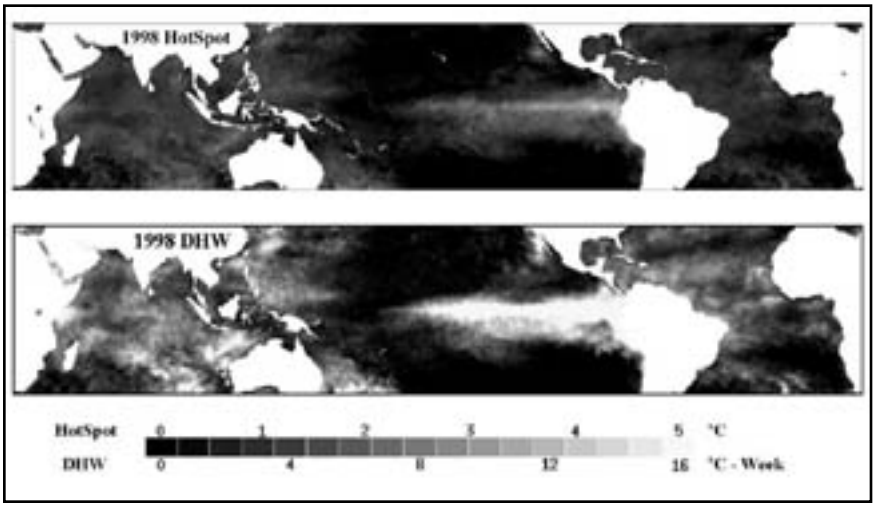


CRW's satellite SST observations showed that Midway Atoll, in the far northwest of the Hawaiian Islands, experienced significantly high SSTs from early August through early September, 2002, reaching 28.9 ºC in August. This was 1 ºC above the local SST bleaching threshold. HotSpot charts showed that maximum thermal stress developed around early September as DHWs peaked at 9.6 at Midway Atoll during the late-summer months (July-September).

(The charts were modified from the original color charts accessible at http://orbit-net.nesdis.noaa.gov/orad/sub/coastlines/figures_1998.html EXIT disclaimer)



Coral mortality exceeded 50% in many areas, and approached 75% in places. Bleaching was blamed on sustained high water temperatures resulting from lack of wind and clear sunny skies. "This was a major event for the NWHI, where widespread coral bleaching had never been observed before," Dr. Brainard concluded. But the CRW early warning system worked well by accurately monitoring and predicting the bleaching event.



Development of the CRW satellite-based coral bleaching monitoring tools began in 1997 at NOAA NESDIS. The Advanced Very High Resolution Radiometers (AVHRR) on NOAA's Polar-Orbiting Operational Environmental Satellites are used to measure SST. These SST data are used to derive global coral bleaching HotSpot and DHW charts twice-weekly in near-real time. Charts and explanations are Web-accessible at: http://orbitnet.nesdis.noaa.gov/orad/coral_bleaching_index.html
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The Bleaching HotSpot chart is an anomaly product based on the coral bleaching threshold for a region. While HotSpot measures intensity of thermal stress, it does not measure accumulation of the thermal stress experienced by corals. For this, a thermal stress index called DHW was developed. DHW is the sum of HotSpots for a given location, over a rolling 12-week period. Visible coral stress is usually not apparent until DHW reaches values of 2 - 4, and by the time DHW reaches 8 - 10, widespread bleaching is likely and some mortality can be expected. CRW uses these DHW thresholds when generating satellite bleaching alerts.

In February 2003, these monitoring tools became operational products. "Coral reef managers and stakeholders will now have up-to-date, accurate, and reliable information on the status of their reefs and may be able to take active measures to prevent further damage if their sites are approaching higher DHW levels," said Dr. Alan Strong, CRW coordinator at NOAA Satellite and Information Services.

Satellite SSTs have been used to successfully monitor major coral bleaching episodes around the globe. In recent years, abnormally high water temperatures, often linked to climate change and El Niño/La Niña weather patterns, have been one of the major causes of massive coral reef bleaching. "Coral bleaching is the result of a weather event," says Dr. William Skirving, a visiting scientist with the CRW team. "It is almost always a result of clear summer skies, little to no wind and neap (weak) tides. This allows the sun to heat the water to extraordinary temperatures. These weather events are most likely modulated by climatic events

such as El Niño."

During the very strong 1997-1998 El Niño, some of the most extensive and severe coral bleaching in modern history occurred, destroying approximately 16% of the world's remaining coral reefs. HotSpot and DHW charts (below) show that coral bleaching was associated with unprecedented high SSTs.

In 2002, yet another wave of bleaching swept coral reefs worldwide, possibly again related to another El Niño event, making 2002 the second worst year for bleaching after 1998.

During previous bleaching events, once water conditions returned to normal, most coral species were able to re-establish their symbiotic algae and their color and health returned to normal in weeks to months. But because prolonged or repeated bleaching can kill entire coral reefs, the increasing frequency of warm-water events is cause for concern. Global warming, sea level rise and bleaching of coral reefs are seen as "major, yet largely unmanageable threats" to coral reefs by reef managers from Florida, the Marshall Islands, and Palau in the Western Pacific.

Coral bleaching poses major economic and social concerns because of impacts on fisheries and coastal tourism. In the U.S., more than 10.5 million people live near shallow coral reefs, and some 45 million tourists annually visit these areas, according to "The State of Coral Reef Ecosystems of the United States and Pacific Freely Associated States: 2002". The U.S. has jurisdiction over approximately 7,607 square miles of coral reefs in the tropical-subtropical belt. The Pacific Freely Associated States (the countries of the Republic of Palau, the Republic of the Marshall Islands, and the Federated States of Micronesia) have coral reefs covering 4,479 to 31,470 square miles. Tourism in U.S. coral reef areas generates more than $17 billion annually, while commercial fishing generates an additional $246.9 million annually. Worldwide, coral reef habitats provide estimated annual benefits of $375 billion in fish, seafood, tourism and coastal protection.

Coral reefs face many natural stresses, such as storms, floods, diseases, and natural climate change. Today, these natural stresses are compounded by impacts from human activities such as pollution, sedimentation, over-fishing, vessel groundings, anchor damages, and marine debris. Coral habitats worldwide are declining rapidly. An estimated 27 percent of the world's shallow coral reefs may be past recovery and an estimated 66 percent are severely degraded, according to the 2002 Report. Although some U.S. reefs are in good to excellent health, every U.S. reef system is suffering from both human and natural disturbances.

Using satellites to measure SST provides coral reef managers and scientists with a

valuable tool to measure, predict and understand coral bleaching and to protect and preserve these "rainforests of the sea." NOAA's CRW program welcomes field observations on coral bleaching. An online report system is available at http://www.reefbase.org/input/bleachingreport/index.asp EXIT disclaimer

For further information, contact: Dr. Alan E. Strong, NOAA Coral Reef Watch Project Coordinator, NOAA/NESDIS/ORA - E/RA3, NOAA Science Center, RM 601, 5200 Auth Road, Camp Springs, MD 20746-4304; Tel: 301-763-8102 x170; Fax: 301-763-8572; Email: Alan.E.Strong@noaa.gov, or Dr. Gang Liu, NOAA/NESDIS/ORA - E/RA31, SSMC1, RM 5307, 1335 East-West Highway, Silver Spring, MD 20910-3226; Tel: 301-713-9386 ext 131, Fax: 301-713-3136, Email: Gang.Liu@noaa.gov.

For information on CREWS in Hawaii Islands, contact: Dr. Rusty Brainard, NOAA/NMFS/SFSC, F/SWC2 - Honolulu, 2570 Dole Street, Honolulu, HI 96822-2396; Tel: 808- 983-5392; Fax: 808-983-2902; Email: Rusty.Brainard@noaa.gov.

Note: This information is provided for reference purposes only. Although the information provided here was accurate and current when first created, it is now outdated.

Manatees: Friendly Neighbors

In the Tampa Bay area of Florida, neighborhoods that help to promote manatee protection can now earn special recognition for their efforts through an innovative program developed by the Tampa Bay Estuary Program's (TBEP) Manatee Awareness Coalition (MAC). The "Manatee-Friendly Neighborhood" program honors communities that complete activities to educate their residents about manatees and the seagrass habitats they depend upon. To earn "Manatee-Friendly" status, a neighborhood must complete five activities. Examples of activities include posting manatee caution signs on a percentage of neighborhood docks, conducting neighborhood monofilament line cleanups, and supplying nearby boating businesses with boater's guides and other informational materials for distribution to patrons. Neighborhoods that meet criteria will earn official designation as a "Manatee Friendly Neighborhood" and be given a distinctive sign to post at their community entrance.

Although some of the activities are designed for waterfront neighborhoods, land-

locked communities also are eligible and encouraged to participate. These neighborhoods may earn designation in a variety of ways: marking neighborhood storm drains with "No Dumping" messages, publishing manatee protection tips in their association newsletter, or adopting a Tampa Bay manatee through Save The Manatee Club's Adopt-A-Manatee program, for example.

Neighborhood Manatee Watch is an extension of the existing boater-oriented Manatee Watch program, which is administered by Tampa BayWatch and coordinated by the MAC. Currently, the Manatee Watch program recruits and trains volunteers to provide safe boating information and tools such as polarized glasses and nautical charts to area boaters, both on the water and at area boat ramps.

The neighborhood program expands outreach to waterfront communities where a high percentage of residents have private docks and boats. The neighborhood program not only encourages safe boating, it discourages feeding manatees or giving them water, which can alter their natural behavior or harm the animals.

Interested communities will receive a brief presentation about the program and a Neighborhood Notebook filled with activities, resource lists, and samples of free educational materials. They will be assigned a personal "community advisor" from among the MAC membership to help them implement their Neighborhood Manatee Watch activities. To learn more about Neighborhood Manatee Watch or to schedule a presentation, contact Nanette Holland, Public Outreach Coordinator, Tampa Bay Estuary Program, 100 84th Avenue S.E. MSI-I/NEP St. Petersburg, Fl. 33701; Phone: (727) 893-2765; Email: nanette@tbep.org

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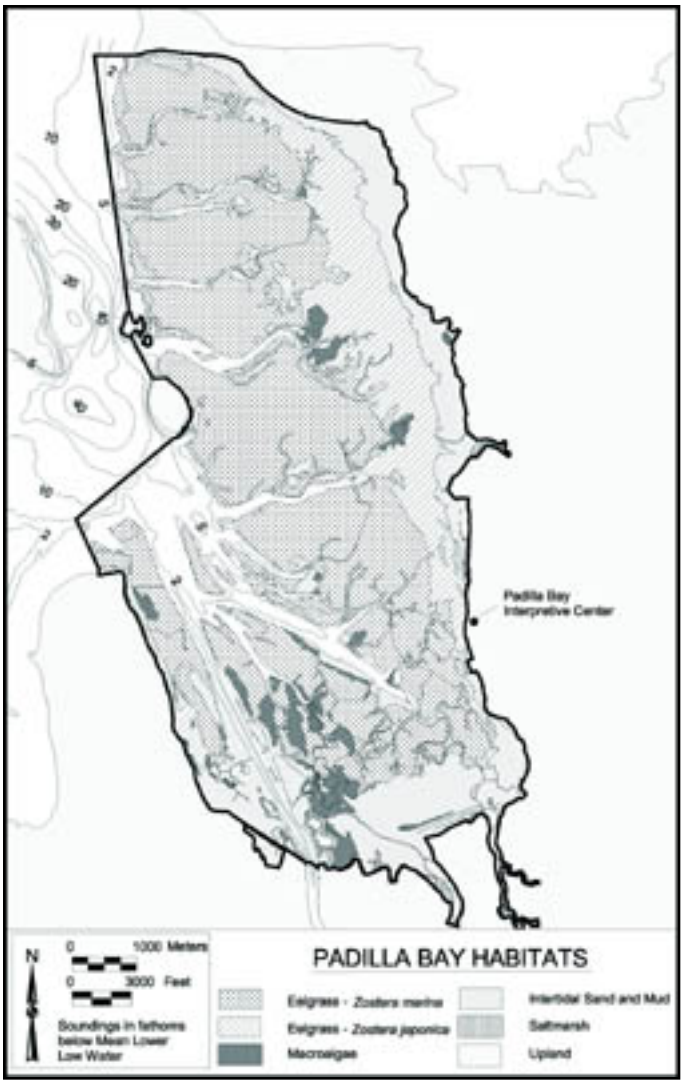
Mapping Vegetation On a Budget -- Padilla Bay Leads the Way

Researchers at the Padilla Bay National Estuarine Research Reserve (NERR), in the State of Washington, are developing a method of mapping vegetation that could be helpful for coastal managers with limited resources.

Coastal vegetation such as salt marsh or seagrass beds provide critical habitat for many estuarine and oceanic species. As coastal populations and development pressures have grown, many coastal vegetation communities have declined. Resource managers often need to map vegetation on a large scale in order to identify areas in need of protection and to assess effectiveness of management decisions. However, many planners in small coastal communities don't have the resources to afford expensive remote sensing methods to do large-scale mapping.

With funding from the Cooperative Institute for Coastal and Estuarine Environmental Technology, Douglas Bulthuis and Suzanne Shull, of the Padilla Bay Reserve, are developing and testing a methodology for mapping and monitoring coastal vegetation using widely available desktop PCs and ESRI's ArcView software. The method has applications in restoration projects, invasive species control, land-use planning and resource management.



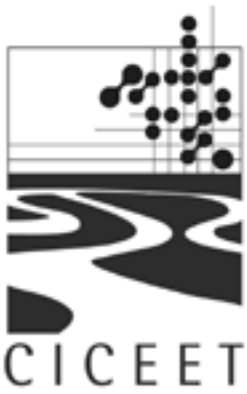
"We are testing this methodology on eelgrass here at Padilla Bay, but the same techniques could be applied to a *Spartina* marsh on the east coast," states Dr. Bulthuis. "The purpose of our project is to provide a practical method that can be used in part or in its entirety to map a variety of intertidal vegetation. This is especially useful in inaccessible areas that make on-the-ground monitoring nearly impossible."

When on-the-ground monitoring cannot be achieved, researchers turn to remote sensing, including aerial or satellite imagery. Digital imagery requires costly software and hardware and personnel with specialized training to perform the work. Many local planners lack the budget and the staff to use digital imagery.

The use of aerial photography is more affordable than satellite imagery in developing maps, and aerial photos are more accessible to local planners. However, the photogrammetric techniques for transforming the photography into an accurate map can be expensive and require specialized training that is often unavailable to local planners.

Bulthuis and Shull developed a multiple step methodology conforming to many of the recommendations in the National Benthic Habitat Mapping Guide, published by the National Oceanic and Atmospheric Administration Coastal Services Center. The methodology includes procurement of aerial photographs, ground truth sampling, obtaining rectified reference photographs, scanning the photos, georectifying of the photos, mosaicking, photointerpretation, on-screen digitizing and developing the vegetative cover polygons in a Geographic Information System (GIS).

"This is not a single method, but an overall approach," states Dr. Bulthuis. "It's a series of steps with options at every intersection. Users can customize this approach, using different alternatives depending on the application and the resources available to them."



The methodology was developed, tested, documented and demonstrated with eelgrasses in the Padilla Bay National Estuarine Research Reserve, in Washington, for the year 2000 and with historical aerial photos of selected areas of Padilla Bay. At one site in Padilla Bay, eelgrasses have been dying back over the course of 11 years, which is cause for further investigation. In other areas of Padilla Bay, there have been large changes in the area covered by eelgrasses, both increases and decreases, from year to year.

This methodology has applications for identifying and tracking the growth and/or loss of a variety of intertidal vegetation. Local government planners, coastal resource managers, GIS specialists and scientists with limited access to sophisticated remote sensing methods have the potential to benefit from part or all of the methodology.

NATIONAL
ESTUARINE
RESEARCH
RESERVE
SYSTEM

For more information or a copy of the methodology report, contact: Suzanne Shull, Padilla Bay Reserve, 10441 Bay View-Edison Road, Mount Vernon, WA 98273-9668; Phone: (360) 428-1558; Email: sshull@padillabay.gov

Submitted by: Theresa Eisenman, NOAA's Estuarine Reserves Division; Phone: (301) 563-7105; Email: theresa.eisenman@noaa.gov

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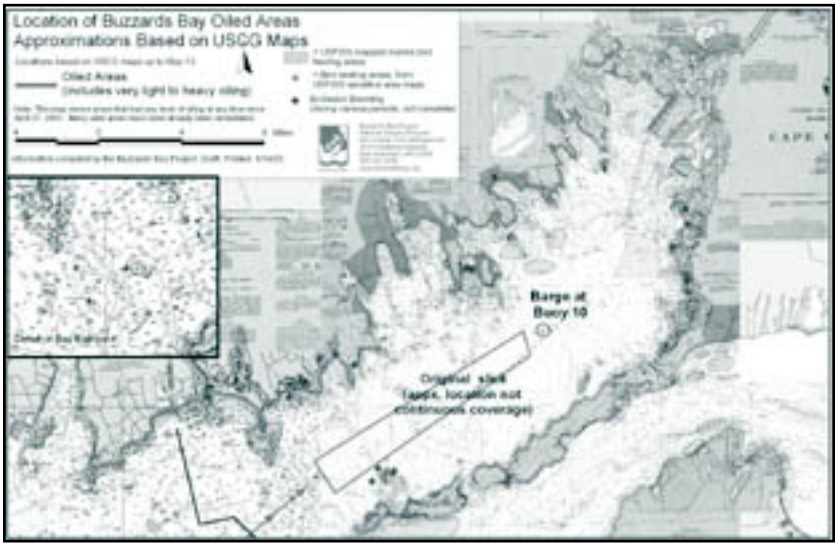
Second Worst Oil Spill in Buzzards Bay



On the night of April 27, 2002, a tanker barge containing 4.1 million gallons of Number 6 fuel oil started leaking in the waters south of Buzzards Bay, Massachusetts. The U.S. Coast Guard directed the single-hulled tanker to anchor in central Buzzards Bay to help contain the oil. Initially, an estimated 14,700 gallons were spilled before a safety boom could be placed around the damaged vessel. The spilled oil generated a slick 13 miles long and two miles wide, that broke up during the following days and spread widely, affecting the coastal communities on the east and west sides of the Bay. Subsequently, the spill was estimated at 100,000 gallons, making this the second worst spill in Buzzards Bay.

Nine municipalities surround Buzzards Bay, all with unique and fragile resources, and the area has been designated as a National Estuary. The Bay is one of the

state's best fishing grounds, producing quahogs, softshell clams, scallops, and oysters. As a precaution, the Massachusetts Division of Marine Fisheries closed all of Buzzards Bay to shellfishing after the incident happened, halting a $4 million dollar shellfishing industry. Two islands in Buzzards Bay are also the nesting sites of the largest colony of Roseate terns in North America, a federally endangered species. Only 3,000 mating pairs are known in Northeastern North America. The spill occurred during the mating and nesting period between April-early May. Fifty to sixty percent of the Roseate tern population of the Northern hemisphere nest on Bird Island, Marion, and Ram Island, Mattapoisett. Scientists and environmentalists took precaustions to keep the endangered terns from landing on the most contaminated of the two islands, while placing nesting boxes on the other island to provide habitat and enncourage nesting.

This is not the first oil spill in Buzzards Bay. In 1969, 140,000 gallons of fuel oil were spilled in West Falmouth, and in 1974, a barged owned by the same company responsible for the current spill, Bouchard, ran aground on a submerged ledge and spilled 100,000 gallons of No. 2 fuel oil, contaminating salt marshes in Bourne. Buzzards Bay is a major transit route for small tanker and barge traffic transpoting heating and industrial oil and gasoline into Sandwich, greater Boston, and northern New England markets. Nearly 1.6 billion gallons of oil pass through the Cape Code Canal annually.

For further information on the oil spill, visit the Buzzards Bay National Estuary program at:
http://www.buzzardsbay.org/ 

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2003 Maine Beaches Conference

Maine's annual Beaches Conference will be held July 9, 2003, at the Thorton Academy, Saco, Maine. Entitled "Challenges & Opportunities for Coastal Communities," this year's themes include Creating a Storm-Resistant Community, Maine's New Regulations, Being a Coastal Property Owner, Best Management Practices, and Water Quality at Swimming Beaches.

In previous Beaches Conferences, events included field trips to Scarborough River inlet beaches, Saco's Ferry Beach, and Camp Ellis jetty. During the luncheon buffet, lively round table discussions were held on subjects such as beach grass die-off, Scarborough River dredging, Wells and Saco Bay beach plans, national beach issues, and marine debris.

Registration for the 2003 Maine Beach Conference is $15.00 (lunch included).

For further information contact Kristen Whiting, Marine Extension Associate, Maine Sea Grant Extension; Phone: (207) 646-1555 ext. 115; Email: kristen.whiting-grant@maine.edu or visit the 2003 Maine Beaches Conference website at http://www.state.me.us/doc/nrimc/mgs/marine/beach/beachconference.htm