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NOAA REPORT

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Researchers Try Out State-of-the-Art Technology on Ancient Black Sea Wreck

—By Fred Gorell

A diverse team of scientists, engineers and archaeologists led by famed ocean explorer Robert Ballard and including NOAA Lt. (j.g.) Jeremy Weirich sailed to the Black Sea this past summer aboard the Woods Hole Oceanographic Institution's *RV Knorr* to test the latest in ocean exploration technology.

They brought with them *Hercules*—the first robot specifically designed to excavate deep ocean shipwrecks. Their aim was to examine close-up an incredibly well-preserved merchant trading ship, 1,500 years old and a thousand feet deep.

The team, which included researchers from Ballard's Institute for Exploration, Florida State University and the University of Rhode Island, also used advanced communications technology for live transmissions of expedition activities from the surface and sea floor to the public via satellite and the Internet 1 and the larger bandwidth Internet 2.

Weirich, maritime archaeological program officer for NOAA's Office of Ocean Exploration, was on watch as an expedition navigator when the tethered *Hercules* was guided from *Knorr* to the wreck, which Ballard had discovered on an earlier expedition.

Cheryl Ward/FSU

NOAA Lt. (j.g.) Jeremy Weirich holds an amphora brought up from an ancient merchant shipwreck in the Black Sea.

As *Hercules* descended into the Black Sea's dark waters, it passed through a stiff current where oxygenated water mixed with the anoxic layer—water with no oxygen and therefore with no wood-boring worms or other organisms that eat away at the wrecks of ships.

The anoxic layer is what brought Ballard to the Black Sea in the first place, with its promise of shipwrecks with intact

continued on page 2

NOAA Tests Non-Lethal Method for Surveying Fish

—By Jim Milbury

Scientists from NOAA's Southwest Fisheries Science Center in La Jolla, Calif., returned from a research cruise on the fishing vessel *Outer Limits* Nov. 20 after successfully testing what could prove to be one of the most valuable tools for monitoring West Coast rockfish.

The research cruise was part of a collaborative effort with the fishing industry, sponsored by the Pacific States Marine Fish Commission, to develop a non-lethal method for surveying fish in the complex underwater terrain off the coast of southern California.

Currently, the only non-lethal method of surveying is to use a slowly moving remotely operated vehicle or manned submersible that can only survey small areas.

Being able to accomplish this type of survey over vast areas of ocean in a reasonable time is extremely important due to the immensity of the marine habitat where these fish live.

"We're extremely excited by the prospect of being able to identify and survey rockfish in a manner that doesn't cause any fish mortality," said Norm Bartoo, director of the Fisheries Resource Division at the Southwest Fisheries Science Center. "It is especially important because of the tenuous existence of some rockfish species."

There has been an increased

continued on page 7

Recycled Paper

NOAA Brings GIS Computer Mapping to Local Schools

—By Alison Smith

Imagine this scenario. You're a town emergency manager, and your town is about to be pummeled with rain from a hurricane. How will you know where to evacuate people and how to protect your town from flooding?

This was the hypothetical dilemma posed to over 400 high school students in the Charleston, S.C., area Nov. 19 and 20 as part of a series of presentations about geographic information systems, or GIS, by employees of the NOAA Coastal Services Center in Charleston.

A GIS is a computerized mapping system that allows users to view data about a particular area—such as rivers, streets, houses and schools—on a computerized map. These data are entered into the system in layers so that users can overlay different kinds of data on top of each other to see their relationships.

The Charleston center and Silver Spring, Md., components of NOAA's Ocean Service and NOAA Fisheries presented seminars about this mapping technology to two local schools as part of "GIS Day 2003."

The day was devoted to showcasing GIS and educating the public about geography and its usefulness as part of a year-long National Geographic Society initiative called "Geography Action."

The Charleston center's presentations introduced students to the advanced computer mapping tool and illustrated its importance through a demonstration of how the center used the mapping technology to forecast flooding in

continued on page 6

Black Sea Wreck

continued from page 1

masts and rigging and perhaps traces of cargo.

The sunken merchant ship was mostly covered in soft sediment.

Hercules, linked by video to a pilot and researchers on *Knorr* and equipped with stereo still cameras to document the work in progres, mapped the wreck using an acoustical three-dimensional sonar to guide the team.

"We first saw the wooden stern post, a large piece of crafted wood that stood up proud off the bottom," Weirich said. "At first, the post looked old, gray-brown and waterlogged, and very much its age. But when *Hercules* used a paintbrush on the side of the post, a thousand years fell away. The post looked new, vibrant, hewn perhaps of oak, and it showed the adze marks of the fifth century craftsman who shaped it."

The top of the mast revealed more clues about the ship and those who sailed it.

"There's a notch on the top where another piece joined with it, perhaps another piece of mast, or a yardarm or even a piece of rigging. And fastened near the top there's a knotted binding that could be a piece of leather. Someone tied that knot," Weirich said.

Exploring the wreck was a systematic process because archaeological integrity was more important than speed.

"There was no comparison to anything ashore," Weirich said. "This wreck was unique and historically very important. Everything we learned from it was new.

"I wanted to see deeper into the wreck, to see the method of joining planks and to find the stem of the ship at the bow, which may have broken off as the ship hit the bottom bow first," Weirich said.

"We barely moved the top layer of sediment that fills the dozen or so frames that stick up a meter above the sea floor. I believe there are three more meters of frames still buried in the soft sediment that hides this wreck. But it's important to excavate at a pace that protects the integrity of the site. There's always another day," he said.

Weirich was impressed by *Hercules*' capabilities.

"We see it playing a role in our future as NOAA's Office of Ocean Exploration works with NOAA's National Marine Sanctuary Program and NOAA ships such as the *Ronald H. Brown* to find and excavate other shipwrecks of historic or cultural importance. We also see benefits for NOAA Fisheries and other NOAA programs and collaborators," he said.

The Mystic Aquarium and Institute for Exploration in Mystic, Conn., specifically designed and built *Hercules* to unlock the mysteries of what Ballard calls the "great ocean museum."

Hercules is armed with devices to suck sediment and with water jets to blow it away, allowing scientists to remove sediment without obstructing the view of their work. The robot also has advanced optical and imaging systems and a "force-feedback" manipulator that gives the remote operator a sophisticated sense of "feeling" when grasping delicate items and cradling amphorae.

The combination of specially designed features proved highly effective in supporting the institute's and NOAA's shared goal of learning how to protect ancient artifacts and ships of antiquity.

Scientists also wanted to learn more about ancient trade routes and trade goods, including amphorae, the elongated jars for transporting oil, grain, fish and other goods in the ancient world. Amphorae were designed to stack

continued on page 6

Terri Lei Beideman

Nelson R. Beideman.

Nelson Beideman Is the Team Member of the Month

—By Chris Smith

NOAA's December Team Member of the Month is Nelson R. Beideman, president of Fisheries Research Inc., a consortium of commercial fishing interests based at Barnegat Light, N.J., that he founded to further research into commercial long-line fishing in the open ocean.

For the past three years, Beideman has coordinated the participation of commercial fishing vessels in a research project with NOAA Fisheries to reduce bycatch, or fish and other sea life caught inadvertently, in a highly productive swordfish fishing area off Newfoundland, Canada, called the Northeast Distant Waters.

"The objective of the research was to develop gear modifications and fishing techniques to reduce the incidental take and mortality of leatherback and loggerhead sea turtles," said John Watson, team leader of the Harvesting and Engineering Branch at NOAA Fisheries' Pascagoula, Miss., Laboratory.

In 2001, eight boats participated in the research. In 2002, 14 participated. And in 2003, 11 participated.

"Our cooperative research mission was to develop fishing techniques to avoid as many sea turtle interactions as possible and to develop handling practices that minimize harm when interactions couldn't be avoided," Beideman said.

In the project's early stages, researchers found a link between the time baited fishing lines are left in the water and loggerhead turtle interactions.

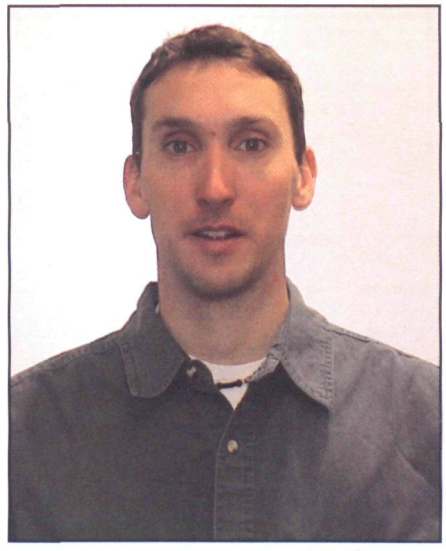
"Surprisingly, satellite tracking showed turtles swimming southwest against the Gulf Stream currents to apparently return to the U.S. mainland. Our captains found that daily communications to avoid migrating sea turtle clusters were helpful but did not achieve the desired level of reduction," Beideman said.

"In the second year, on the suggestion of our fishermen, the experimental design included large circle-style hooks and mackerel bait, which not only demonstrated reductions up to 92 percent in sea turtle interactions but also increased the target catch and size of swordfish.

"Tank tests were conducted to find what size and style hook would be unacceptable to loggerhead turtles that pursue the baited hook while avoiding leatherbacks, which don't go after the bait, but are snagged by the hook and/or entangled in the gear. At this point it was obvious that we were heading in the right direction," he said.

Working with NOAA and industry fishing gear specialists, the research team came up with tools and techniques for carefully releasing turtles that could not be avoided, including dip nets for lifting small turtles onboard and

continued on page 8



Ron Stuvek/NOAA

Ed Plumb.

Ed Plumb Is the Employee of the Month

—By Tracey Lake

He doesn't realize that what he does is extraordinary. He thinks he's just doing his job, when he actually goes above and beyond what his duties require. That's what Edward Plumb's co-workers and supervisor say about the December Employee of the Month.

Plumb is the service hydrologist for NOAA's National Weather Service forecast office in Fairbanks, Alaska.

In addition to his normal hydrologic duties, he is often recruiting new river observers, submitting articles to local newsletters, writing or presenting talks on numerous subjects in hydrology or collaborating with University of Alaska hydrologists and geologists.

Plumb is also active in local school programs. "I love doing that stuff," he said.

He participated in "Outdoor Days," a four-day program designed to educate sixth grade children about outdoor awareness through various hands-on activities,

continued on page 8

Focus On...

Tim Purinton/Mass. Audobon Soc.

Contractors dig a new channel to reconnect Eastern Point salt marsh in Gloucester, Mass., with Gloucester harbor after a decade of blockage.

Eric Hutchins/NOAA

Contractors rebuild a road over a newly installed culvert at Eastern Point salt marsh that is expected to increase the area of tidal inundation from one acre to nine acres, benefitting important fish breeding habitat and enhancing habitat for migratory birds.

Restoring a Massachusetts Salt Marsh

—By Stephanie L. Hunt

Over 100 people gathered in Gloucester, Mass., Nov. 20 to celebrate the rebirth of the Eastern Point salt marsh—an estuarine system that had been slowly dying over the last 10 years.

With funding from NOAA's Community-based Restoration Program and nearly 20 other partners, a new culvert was installed under the road at Eastern Point, allowing saltwater to enter the marsh after more than a decade of blockage.

Saltwater is the lifeblood of coastal marshes in New England. Tides flood marshes, then recede back to the ocean leaving a mix of food and nutrients. This tidal flow is an essential part of the life cycle of 75 percent of commercially valuable fish species.

Throughout New England roads, railroads and other construction block saltwater input and choke coastal marsh systems. Without tidal influence, freshwater buildup can cause dramatic changes in the chemistry, geology and biology of the marsh, including allowing invasive plant species such as fragmites and purple loosestrife to dominate.

"A healthy marsh is flooded two times per day, leaving several inches of saltwater over the entire marsh surface," said fisheries biologist Eric Hutchins from the NOAA Fisheries Northeast Regional Office

"The culvert at Eastern Point was 100 percent non-functional. A pipe had been installed under the road. But after the first storm, the pipe filled in with sand, so absolutely no saltwater could enter the marsh," Hutchins said.

continued on page 5

continued from page 4

Soon after the pipe was blocked, the marsh began converting to upland habitat. Invasive freshwater plants replaced salt-tolerant marsh grasses. Saltwater bait fish, important to commercial fisheries, disappeared.

"The very day the new culvert went in, we set traps and caught fish. The recovery began immediately," Hutchins said.

Later, small mummichogs and sticklebacks, caught in Eastern Point's restored marsh, darted around a fish tank in the corner of Gloucester's City Hall, evidence of the site's enhancement.

Rollie Schmitten, director of the NOAA Fisheries Office of Habitat Conservation, praised project partners, including the commercial fishing industry which, he said, "readily stepped up to the plate with cash and in-kind services to make this project a success."

Restoring coastal salt marshes in Gloucester—one of the largest fishing ports in the world—supports local industry by providing forage fish and juvenile habitat for commercially and recreationally valuable species.

"Regulations alone will not restore our nation's fisheries without a healthy marine habitat," Schmitten said.

Stephanie L. Hunt/NOAA

Fisheries biologist Eric Hutchins (left) and Rollie Schmitten, director of the NOAA Fisheries Office of Habitat Conservation, examine small fish caught in the newly established channel in the Eastern Point salt marsh.

The community-based Restoration Program within NOAA Fisheries has funded over 800 grass-roots habitat restoration projects since its inception in 1996, benefitting thousands of acres of fisheries habitat throughout the country.

"Restorations are key steps that lead to building sustainable fisheries and improving the health of the Gulf of Maine," said Laura Johnson, president of the Massachusetts Audubon Society, one of NOAA's habitat restoration partners.

In the Gloucester area alone, the Audubon Society identified 165 tidally restricted sites needing restoration.

To accomplish this ambitious task, NOAA looks to the partnerships formed through the Eastern Point restoration project.

"Just think of all the things we can accomplish if we work together," said Steve Parks, a fishing industry partner who contributed to the Eastern Point project.

Stephanie L. Hunt/NOAA

Project partners (left to right) Eric Hutchins, Rollie Schmitten and Robert Buchsbaum of the Massachusetts Audubon Society examine the new culvert at Eastern Point salt marsh.

Black Sea Wreck

continued from page 2

efficiently on ancient trading ships that were the counterparts of today's container ships.

"We saw a number of amphorae in the wreck," Weirich said. "Although we found none with cargo intact, one amphora still had the remains of sealant wax.

"There is a huge difference between seeing amphorae on the bottom and holding one in my arms, where I could put my thumb into the thumb print of the craftsman who made it," he said.

The scientists turned over to Turkish authorities all the recovered artifacts including the amphorae, a lead device perhaps used to fasten the ship's rigging, and a round jug that was likely used by the crew rather than to carry cargo.

The public was connected to the cruise through "telepresence," as Ballard and his research director, Dwight Coleman, hosted daily live presentations, followed by questions and answer sessions between mission scientists and explorers, students and scientists ashore.

In two large vans on the ship, scientists and operators were wired for an around-the-clock feed of their voices. The live feed included images from within the van, from the decks of *RV Knorr* and via *Hercules* from the submerged wreck site.

"When you go into the control van it's like going into church, and it's like God is listening," Ballard said.

Yet, from time to time, especially if something went wrong or when the scientists were overly excited about the images captured by cameras on *Hercules*, church was out.

"I've dreamt for more than 20 years of sharing our expeditions live with children and scientists all over the country, of allowing them to see what we see when we are exploring the deep, of giving them the tools to explore these remarkable places and do it on their own terms," Ballard said. "Our relationships with NOAA and others allow us to make that dream a reality. It's really fantastic."

The communications technology demonstrated during the Black Sea cruise is the same as the technology that will be used in the Immersion Project, a related education program that NOAA and the Mystic Aquarium and Institute for Exploration are jointly developing for the National Marine Sanctuary Program, managed by NOAA's Ocean Service.

In the Immersion Project, subsea camera systems installed in various marine sanctuaries will be linked live via the Internet 2 to classrooms, youth organizations and institutions such as Mystic Aquarium.

Monterey Bay National Marine Sanctuary was first to be wired with a remotely operated vehicle equipped with high-definition cameras to send images of the sanctuary's marine life and unique features.

"Education and outreach are vital parts of every one of our science expeditions," said Capt. Craig McLean, director of NOAA's Office of Ocean Exploration, who followed the use of advanced communications technology during the Black Sea expedition.

"From this expedition, we learned a great deal more about how best to communicate the excitement of discovery in the unexplored reaches of our oceans," he said.

"We intend to bring to other NOAA-sponsored explorations the real-time, high-definition communications that worked so well during the Black Sea cruise," McLean said.

GIS Mapping

continued from page 2

the Tar River Basin in North Carolina.

Using a computer map of the town of Greenville, N.C., presenters first pointed out to students some specific features of the town, such as houses and an airport, which make up one layer of the GIS map. They then explained to the students how they placed layers of different flood water heights on top of the town map to show how the water enveloped nearly the entire town.

While watching the mapped town flood as the layers were placed on top of each other, several students gasped or murmured "wow" in amazement.

Grabbing students' attention using such visual demonstrations of the power of GIS was especially impressive to the teachers.

"To have these students actually see that information rather than just hear it, and to know exactly what you do at the center, is great," said Ann Curio-Hurley, a career development facilitator in the school-to-careers office at West Ashley High School. "Applied learning is really important to raising their interest."

Applied learning was the primary focus of this year's presentation, as students had the chance to use a GIS computer mapping system first-hand on a state storm surge Web site. On this Web site, students first entered their home addresses into the mapping system. The system's software then layered the entered address onto other layers of roads and flood probability data to show the home's chance of being flooded by storm surge during a hurricane.

"Whoa, we'd be covered!" exclaimed one student after seeing her home in the section most likely to flood.

Fish Survey

continued from page 1

interest in recent years in conserving rockfish in the Pacific Ocean due to plummeting numbers of various rockfish species.

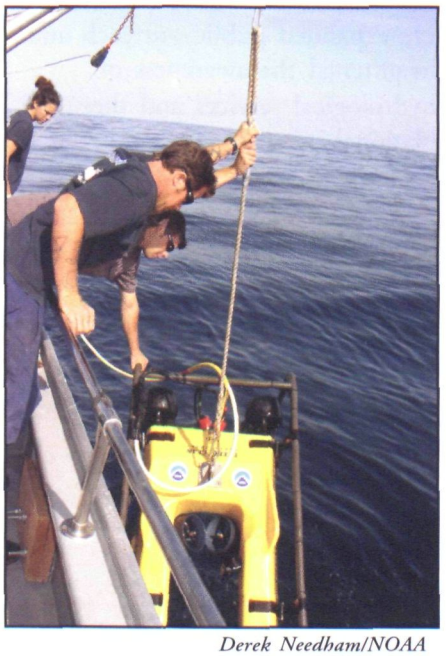
In 2001, the fish commission established a 4,500-square-mile marine protected area of waters off the coast of California, the Cowcod Conservation Area, where the catching of rockfish is strictly prohibited.

In 2002, fishery managers temporarily closed nearly the entire West Coast to commercial fishing.

In 2003, Congress approved a $46 million vessel buyout package for commercial fishermen to reduce fishing pressure on rockfish and other West Coast species.

Now scientists need to know if these conservation methods are working. An accurate assessment of the fish population is critical to ensure the rebuilding of the species to a self-sustaining population size.

Off the west coast of North America, there are approximately 60 species of rockfish, generally referred to as groundfish, snapper or rock cod.



Derek Needham/NOAA

Crew of the fishing vessel Outer Limits, (front to back) John Thompson, Paul Fischer and Nicole Sills, launch a remotely operated vehicle to investigate rockfish.

Each species has a preferred habitat.

Unfortunately, the typical survey methods for adult rockfish—hooking or catching in a net—kill those fish sampled.

Like most fish, rockfish have a bladder of air that helps them swim and stay neutrally buoyant. They often live at significant depths in the ocean. If they are brought to the surface, their bladder will expand and burst, causing the fish to die even if it is released back into the water.

Trawling, another common survey method, is impossible on rocky habitat preferred by many of the depleted rockfish species.

"Both trawling and hook-and-line surveys have the problem that you're killing a fish that may be a prohibited species," said John Butler, research fishery biologist at NOAA's Southwest Fisheries Science Center. "The question becomes how do you survey these animals without killing them?"

David Demer, an ocean acoustic engineer and leader of the advanced survey technologies program at the Southwest Fisheries Science Center, thinks the new method tested is the answer. Demer believes that sound waves can be used to locate, identify and count the number of rockfish safely within their habitat.

His team has been developing methods for using differences in the reflectivity and absorption of sound waves to identify animals underwater, much the same way that brightness and color are used to identify objects with light.

"Remote species identification is the holy grail of fisheries acoustics," Demer said. "That's what we're ultimately aiming for."

The new survey method relies on sophisticated multi-beam sonar, a multi-frequency echo sounding device and an underwater remotely operated vehicle working together to locate and identify various species of fish and their habitat.

From Nov. 17-20, researchers from the Southwest Fisheries Science Center plied a one-mile-square area off the coast of southern California aboard *Outer Limits* testing the new equipment.

"This is a great project," said Ken Franke, skipper of *Outer Limits*. "I'm learning so much about the fish I've caught for years. [Now] we need the scientists to learn what the fishermen know."

The multi-beam sonar was used to produce high-resolution bathymetric maps of the ocean floor, detailing areas such as rocky outcroppings where rockfish like to live.

During the recent tests, the echo sounder determined the type of sea floor substrate, such as sand or gravel. While observing the critical habitat identified by the multi-beam sonar, the echo sounder then monitored fish that live in the area.

The fish reflected sound waves in such a manner as to make a unique "acoustic signature."

The ROV broadcast an image of the fish back to the vessel to match the fish with the multi-frequency acoustic signature.

"The research goal is to come up with acoustic signatures for each species," Butler said. "And while we're not willing to say we'd be able to identify every different species of rockfish, we're hoping we'll be able to identify some of the key species."

"We're trying to expand and refine our techniques so we can measure the total amount of rockfish in a much larger area," Demer said. "Once we have acoustically characterized rockfish and their essential habitat, we can more rapidly survey a much larger area, with only spot checks by the relatively slow ROV, and increase our coverage many fold."

Beideman

continued from page 3

"dehookers" and line cutters for disentangling turtles.

In 2003, the team came up with new ways to differentiate between target and bycatch species.

As an experimental control, one vessel used an inflatable Zodiac boat to capture and tag loggerhead turtles with satellite tracking devices and tested a leatherback lifting cage and hoist. Tagging is important for determining post-release stress on turtles, as well as adding to knowledge of sea turtle migrations.

Throughout the project, each participating vessel had one or more NOAA Fisheries observers onboard to ensure that all research protocols were met and to document the results.

Thus far, the accomplishments of the research team are quite remarkable.

Compared to data compiled in 1999, there was an 83.8-percent reduction in loggerhead interactions and a 70-percent reduction in leatherback interactions during 2002.

The preliminary figures for 2003 are an 88.3-percent reduction for loggerheads and an 86.1-percent reduction for leatherbacks. In addition, the mackerel bait has increased overall swordfish landings as well as the size of individual fish.

"It's taken a phenomenal amount of cooperation among the NOAA researchers and the vessel captains and crew and a lot of discipline to adhere to the details of the experimental design," Beideman said.

"Working closely, we've learned a great deal from NOAA about what it takes to execute a complex research project. And the scientists, I'm sure, have learned a lot about what is practical aboard the deck of a longliner at sea," he said.

Plumb

continued from page 3

such as helping them build anemometers and explore various weather topics. He also participated in the Alaska Summer Research Academy, a 10-day program in which high school students become actively involved in various engineering projects around the state.

During an early spring flood that persisted through the summer, Plumb developed a detailed and informative presentation titled "Ice Jam Flooding in Salcha" on extremely short notice. The presentation was used to brief the Fairbanks manager of the Alaska Department of Transportation, the director of the Alaska Division of Emergency Services, the director of the U.S. Army Corps of Engineers and the mayor of the Fairbanks North Star Borough.

The briefing also provided information necessary for Alaska gov. Frank H. Murkowski to support declaring a disaster area.

At the height of the Salcha flooding, water rose nearly six feet in 30 minutes, flooding 100 homes and resulting in an estimated $2 million in damages. During this unusual event, Plumb provided daily weather and river briefings and participated in airboat reconnaissance with Salcha rescue crews, as well as aerial reconnaissance with the Alaska Division of Emergency Services.

He also coordinated river watch aircraft flights, provided numerous media interviews and briefed the entire Salcha Elementary School about flooding and flood safety.

In a thank you letter calling Plumb's service "an invaluable asset to the overall management of the incident," the Fairbanks North Star Borough emergency operations manager wrote, "Ed Plumb went above and beyond the call of duty before, during and after the 2003 Salcha flood."

According to his superiors, Plumb's research studies, presentations and training have enhanced the local community's and region's understanding of the Fairbanks weather forecast office's hydrologic program. He has also contributed to improvements in the regional hydrology program by bridging communication gaps between the river forecast center and the weather forecast office through activities such as the establishment of routine teleconferences.

In support of the river forecast center's ice and snow survey program, Plumb designed a monthly schedule to perform ice thickness and snow depth measurements for all rivers and lakes in his area of responsibility. The data are crucial to the center's spring breakup forecasts and in determining changing climatological trends.

According to John Dragomir, meteorologist in charge of the Fairbanks weather forecast office, "Ed took an already well established hydrology program for northern Alaska and made it better. He expanded public outreach and heightened the awareness of hydrological services and the National Weather Service in the local area."

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Address comments to:
Editor, The NOAA Report
1315 East-West Highway
SSMC3, room 10853
Silver Spring, MD 20910
301-713-9042 *(voice)*
301-713-9049 *(fax)*
Email: dane.konop@noaa.gov
NOAA Report Online: *http://www.publicaffairs.noaa.gov/nr*
Jordan St. John, director, OPCA
Dane Konop, editor

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