NOAA REPORT

Vol. XIV, no. 2 www.publicaffairs.noaa.gov/nr February 2005

Tsunami Center Responds to Earthquake Off Sumatra

—By Delores Clark

NOAA's Pacific Tsunami Warning Center in Ewa Beach, Hawaii, was catapulted into the world's spotlight Dec. 26, 2004, following the earthquake off Sumatra and the devastating tsunami that swept across the Indian Ocean, leaving unprecedented death and destruction in its wake.

The center began receiving hundreds of telephone calls Christmas night. "At first, callers were asking for technical information," said center director Charles "Chip" McCreery. "They heard about the tsunami and wanted to know what it was and find out what happened."

The Hawaii center's area of responsibility is the Pacific Ocean, where according to NOAA's National Geophysical Data Center 85 percent of all tsunamis occur. The Hawaii center and the West Coast/Alaska Tsunami Warning Center in Palmer, Alaska, are linked to a network of seismic sensors, coastal tide gauges and tsunami detection buoys placed around the Pacific Rim. The system is designed

continued on page 2

Delores Clark/NOAA

Geophysicists Barry Hirshorn (left) and Stuart Weinstein examine seismic readings for the Dec. 25, 2004, earthquake off Sumatra at the NOAA Pacific Tsunami Warning Center.

Rare Atmospheric Condition Spawns Southwest Storms

—By Chris Vaccaro

A rare atmospheric condition caused relentless rain and snow across California and much of the U.S. Southwest for two weeks in late December and early January, as a series of Pacific storms battered the West Coast.

Record-setting rainfall caused widespread flooding and a fatal and destructive landslide in La Conchita, Calif.

In the mountains, heavy snow clogged roads and kept skiers off the building fresh powder as the threat of avalanches increased.

With sprawling high pressure anchored over the northern Pacific Ocean, the jet stream was diverted from its typical position in the northern latitudes. Rather than keeping the Northwest damp and gray, the jet stream steered storms carrying abundant tropical moisture into the West.

Orographic lift—air forced to rise as it slams into ascending terrain—led to heavier precipitation in the higher elevations as cold air moving south provided the temperatures needed for snow to fall.

NOAA scientists said this extreme weather was the result of the Madden-Julian Oscillation, which causes variations from the typical atmospheric pressure and wind pattern, influencing tropical rainfall over a period of approxi-

continued on page 2

Tsunami Center

continued from page 1
to transmit data in real-time over sophisticated communication circuits to the centers.

As the news reports and television coverage of the tsunami catastrophe increased, many callers asked why the Pacific center had not issued a tsunami warning to Indian Ocean countries.

They were surprised to learn that while there is a network of ocean buoys maintained by NOAA in the Pacific Ocean to warn of potential tsunamis, there is no corresponding warning network in the Indian Ocean.

On the afternoon of Dec. 25, Stuart Weinstein and Barry Hirshorn were the on-call watchstanders at the Ewa Beach center, part of a group of four geophysicists and an oceanographer who work in teams of two to provide 24-hour coverage. Since they rent houses near the warning center owned by the Weather Service, watchstanders can quickly return to the center in an emergency.

Although not required to be at the office, at 3 p.m. local time, Weinstein was there catching up on work.

"I was trying to [send] a colleague a document about the behavior of seismometers when the alarm went off. I immediately began evaluating data to locate the epicenter," he said.

Hirshorn showed up a minute later. "My pager woke me up," Hirshorn said. "It showed readings from two stations that were far away from each other, so I had a feeling it might be a magnitude 6.0 or larger. I rode over on the duty bike and helped Stu get a location. Then I ran our magnitude software to get an estimate of the size of the earthquake."
continued on page 6

Jayme Laber/NOAA

On Jan. 9, floodwaters nearly reach the roadway of the bridge carrying Highway 1 over Calleguas Creek near Point Mugu Naval Air Station, Calif.

Southwest Storms

continued from page 1
mately 30 to 60 days. Discovered by scientists Roland Madden and Paul Julian in 1971, the oscillation can produce El Niño-like features, such as extreme precipitation in the western United States.

"It is important to emphasize that the pattern we've just experienced over California is a relatively rare event and not all MJO events will lead to precipitation extremes in the western United States," said Wayne Higgins, the lead climate specialist at NOAA's Climate Prediction Center in Camp Springs, Md. "It is unlikely that the recent blocking pattern will be repeated this winter.

"Though the MJO is a naturally occurring component of the coupled ocean-atmosphere system, the basic reasons that explain why it is active in some seasons and not in others are elusive and are the subject of ongoing research," he said.

California bore the brunt of each moisture–laden storm. Copious rainfall allowed high water to engulf roads, homes and businesses from the coastline to the foothills. In the Sierra Nevada Mountains, yard sticks were used to measure fallen snow. Even a few tornadoes touched down in the Golden State.

Downtown Los Angeles endured its wettest 15-day period since records began in 1877, according to the NOAA Weather Service forecast office in Oxnard, Calif. Between Dec. 27, 2004, and Jan. 10, 2005, the city was soaked by 16.79 inches of rain. This surpassed the previous record of 14.63 inches set Jan. 13-27, 1969.

Extreme precipitation was noted statewide in a short period of time: an estimated 152.5 inches of snow buried Farewell Gap in the central Sierra Nevada Mountains between Jan. 7-12. Two storms inundated Opids Camp, north of Los Angeles in the San Gabriel Mountains, with 51.77 inches of rain between Dec. 26 and Jan. 11.

Across the border in Reno, Nev., forecast office meteorologist-in-charge Jane Hollingsworth reported
continued on page 7

Bonnie Braun

Dr. Robert Braun.

Dr. Robert Braun Is the Team Member of the Month

—By Wende Goo

If there's a marine mammal in distress in the state of Hawaii, it's a good bet that NOAA February Team Member of the Month Dr. Robert Braun is working with others to aid in its recovery.

Over the past 17 years, Braun, president of the Hawaiian Island Stranding Response Group, has dedicated much of his career to the health of critically endangered Hawaiian monk seals, green sea turtles, whales and dolphins.

As a contract veterinarian for NOAA Fisheries' Pacific Islands region and a NOAA-authorized independent responder, Braun is on call 24-7. He reluctantly admitted that over the years he has worked for long periods without a single day off. "Animal response and care must be provided by someone, and I consider myself fortunate and lucky to make a living doing what I enjoy in life."

George Antonelis, chief of the Protected Species Division of the NOAA Pacific Islands Fisheries Science Center in Honolulu, said, "Dr. Braun is a key member of our research team and has made many valuable contributions toward our understanding of Hawaiian monk seal health and disease."

In addition to responding to stranding calls, Braun assists in the capture, translocation, disentanglement and necropsy of animals and trains NOAA staff to conduct monk seal necropsies, biomedical sampling, disease recognition and reporting from remote field sites.

In 2001, he was the field coordinator studying the deaths over a nine-day period of four yearling monk seals on remote Laysan Island, one of the seals' breeding sites. Because there are fewer than 1,300 Hawaiian monk seals left in the world, the deaths raised considerable concern.

"More yearling seals died in those nine days than we had ever seen die in the same time span over the last 20 years," Braun said. Although all the dead seals were emaciated, screenings of both healthy and unhealthy seals revealed no evidence of infectious disease or toxicosis that could be linked to the mortalities.

This past July 3, Braun and his team of stranding experts responded to a call on the Hawaiian island of Kauai, when 150 to 200 highly stressed melon-headed whales massed about 100 to 150 yards off shore in the shallow waters of Hanalei Bay. This was unusual since melon heads are normally deep water cetaceans. When Braun and his team surveyed the situation, they feared the whales were at serious risk of ending up on nearby beaches and coral reefs if action wasn't taken quickly.

By this time, a crowd of about 350 concerned onlookers gathered in the water and on the beach. In an effort to foster collaboration

continued on page 8

Ursula Jones/NOAA

Christopher Maier.

Christopher Maier Is the Employee of the Month

—By Tracey Lake

As the warning coordination meteorologist for the NOAA Weather Service forecast office in Juneau, Alaska, NOAA February Employee of the Month Christopher Maier makes sure that the warning services provided by his office are meeting customers' needs.

"What I enjoy most about this job is getting out and talking with customers and partners," Maier said. "I can help them understand the weather and what our mission is all about."

Maier was one of a group of individuals to travel to Prince of Wales Island in southeast Alaska to conduct tsunami outreach and education for a week in September 2004. "It was a great experience going to each school and community, educating them on the hazards of tsunamis and informing them about the [Weather Service's] Tsunami Ready [Program]. When you get the chance to interact with the kids, that's what it's all about."

continued on page 8

Focus On...

Imagining the New Smithsonian Ocean Hall

—By Fred Gorell

The NOAA-Smithsonian Institution plan for a major exhibit about Earth's life supporting ocean began with one-word descriptions: vast, diverse, deep, dark, powerful, mysterious, magical.

These were the responses of scientists, researchers, educators and designers from schools, government agencies, museums and aquaria brought together in the summer of 2003 to help plan a new, 21,000-square-foot Ocean Hall to open in 2008 at the Smithsonian Institution's National Museum of Natural History in Washington, D.C.

The group expanded these one-word descriptions into themes for educating and inspiring the public—ocean stewardship, an awareness of our human connection to the ocean, the global ocean, ecosystems—and for nurturing the next generation of ocean scientists and policymakers.

These themes were then expanded in a statement of purpose to guide exhibit planners. A floor plan and drawings helped visualize where and how exhibits would each tell part of the ocean's story, while showing the connection with the ocean as a whole.

Smithsonian

A full-size replica of an endangered North Atlantic right whale and other sea creatures surround human visitors in this illustration of what the new Smithsonian Institution Ocean Hall may look like.

Today, design planning is over one-third complete.

"I grew up in this area. I remember the old Marine Hall at the Smithsonian, with a model of a huge blue whale hanging from the ceiling. I was always so excited to go there," said Joanne Flanders, who has represented NOAA from the outset in the planning process and now serves as NOAA's Ocean Hall project manager.

"It's a real opportunity to plan for an ocean exhibit that's much larger, and one scheduled to last 30 years, because I want children who will visit, and their children, to have that same magical experience I had."

NOAA's "Science on a Sphere," which uses eight cameras and high-intensity lights to project videos and animations that simulate a view from 22,000 miles above the Earth's surface, will likely be one of the exhibits. Flanders said she expected it to be a "real eye-catcher," one of the more visually engaging presentations.

"Science on a Sphere will have the effect of a rotating Earth with ocean currents, ocean storms and other ocean dynamics moving across the spinning globe. People will understand almost immediately that our ocean is a dynamic, global system," she said.

There are also plans for an "Ocean Exploration Theater," where about 40 visitors at a time will make a simulated mission in a manned submersible launched from the deck of a research vessel.

The plan is for Ocean Hall

continued on page 5
continued from page 4

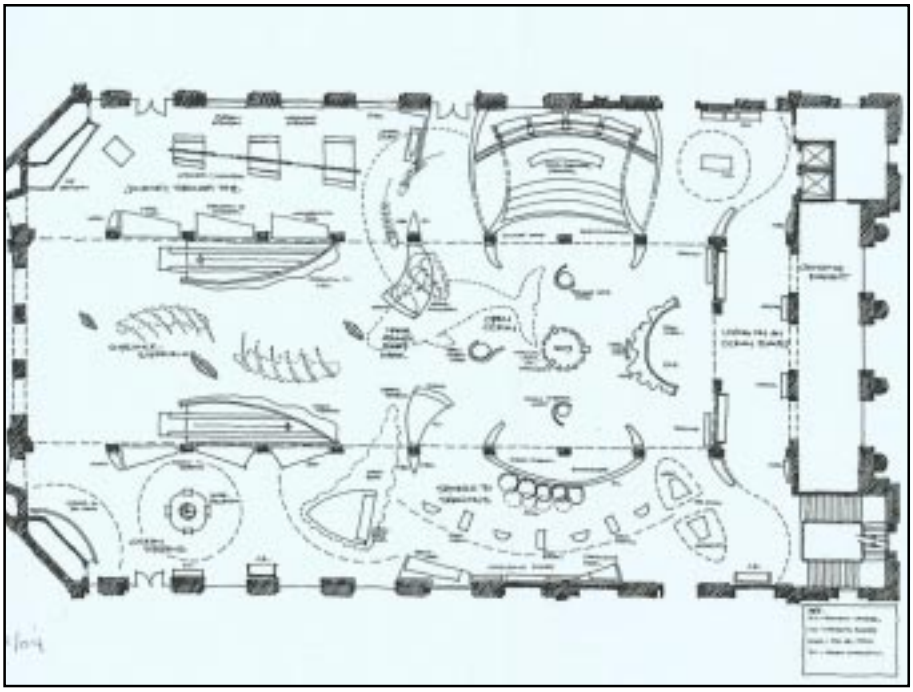
visitors to feel as if they are at the bottom of the ocean. Above them, images, projections and models will move across a high gallery, suggesting the depth of the ocean. Elsewhere, a surface "soundscape" could envelop visitors with vocalizations of marine mammals and other species, as well as sounds of waves hitting the shore.

There will also be a model of an endangered North Atlantic right whale, whose story will be told as if it's a living whale named "Phoenix." In addition to exploring the evolutionary histories of toothed and baleen whales, the exhibit will be the anchor for a many-faceted story of the marine food web, which begins with the ocean's primary producers—plankton.

Visitors will be able to get a plankton's eye view of the giant whale, as Phoenix's head will hang quite low in the exhibit hall.

"I think it's a great story for visitors, to see the model and learn in near real-time what's happening with the whale," Flanders said.

Other parts of the hall will show the interactions of the ocean's biology, chemistry and geology and demonstrate the ocean's connections to life on all parts of the planet.



Smithsonian

A schematic drawing of the new Ocean Hall shows one possible arrangement of exhibits, including a replica of a North Atlantic right whale in the center of the hall.

"It's likely that Ocean Hall will include an 'Ocean in the News' exhibit where visitors will see video news updates by NOAA or Smithsonian scientists," Flanders said.

"Shores to shallows, bioluminescence, a vertical water column showing diversity and a coral reef tank are also in the Ocean Hall plan.

"The plan is changing, evolving," she said, "and we are making design and content improvements on a regular basis."

As plans for Ocean Hall took form, NOAA expanded its core planning team to an Ocean Hall "extended team" of individuals from across the organization. NOAA's Ocean Council, Education Council and Executive Committee were briefed, and their comments were incorporated into NOAA's formal response to the plans.

"When we first began," Flanders said, "a number of us said we wanted Ocean Hall visitors to get the 'feeling' of the ocean. If visitors come away more educated and excited about the ocean, and just a bit in awe of an ocean on which life—including their life—ultimately depends, Ocean Hall will put up the 'success' sign. And it will be the ocean itself that will benefit."

Fred Gorell/NOAA

NOAA and Smithsonian Institution staff examine plans for a new Ocean Hall set to open in 2008 at the Smithsonian's Museum of Natural History in Washington, D.C.

Tsunami Center

continued from page 2

"We issued a bulletin with a preliminary magnitude within about 13 minutes and continued to analyze new data coming in. Within about 15 minutes, we issued a tsunami information bulletin to advise our clients that a magnitude 8.0 earthquake had occurred, but there was no tsunami threat in the Pacific," Hirshorn said.

"An 8.0 is big, but not all earthquakes generate a tsunami," he said. "You have to look at the size, the depth, the location and historic records of the area and, most importantly, you must have water level data so that you can confirm or deny the tsunami's existence as soon as possible."

In 2001, an 8.4-magnitude earthquake hit Peru, generating a local tsunami, but not a damaging "teletsunami," a tsunami capable of causing fatalities and damage far away from the earthquake epicenter.

As it turned out, 8.0 was an underestimate of the Indonesian earthquake's true size, but was about the same as initial estimates from the West Coast/Alaska Tsunami Warning Center, the U.S. Geological Survey's National Earthquake Information Center and the French Polynesia Tsunami Warning Center.

"Over the next hour, we continued to analyze new data which showed that the earthquake was larger than we thought," Hirshorn said. "After consulting with the West Coast/Alaska Tsunami Warning Center, we upgraded the magnitude to 8.5. At this point we called Chip to let him know what was occurring, and to suggest that we send a second message with the new magnitude included."

"I was with my family at a friend's house exchanging gifts," McCreery said. "I agreed with Stu and Barry's decision to upgrade to 8.5 and decided to head home and go to the center. I wasn't overly concerned at that time because I hadn't seen the map and location. I remembered a magnitude 8 off Java in 1994 had caused a destructive local tsunami and knew it might happen in Indonesia. But, I also knew Indonesia had its own analysis system because they deal with a lot of earthquakes in the region."

At 4:04 p.m., the Pacific center issued a second tsunami information bulletin revising the earthquake magnitude to 8.5. The bulletin again indicated no tsunami threat to the Pacific, but added language advising of the possibility of a local tsunami near the epicenter. By that time, and unbeknownst to the center and other government agencies, the tsunami was quickly approaching the coasts of Thailand, Sri Lanka and India.

The first indication at the Pacific Tsunami Warning Center of a destructive tsunami came more than four hours after the earthquake occurred, McCreery said.

"I started looking at the news to see what was being reported," Weinstein said, "knowing it would be a while before the tide levels came from the Cocos Island gauge located roughly halfway between the epicenter and western Australia—the only sea level data we receive from the Indian Ocean. We had the TV on CNN, but there were no reports."

At 7:12 p.m., Weinstein found a Reuter's report on the Internet about 150 fatalities in Sri Lanka and 100 injuries in Thailand. By then, the waves had already swept throughout the Bay of Bengal and Andaman Sea, as well as the Maldive Islands.

"After reading the news reports, we were surprised to hear about Sri Lanka and Thailand instead of a local tsunami in Indonesia," McCreery said. "That's when we knew it was a teletsunami; but the whole scale still wasn't apparent. Unlike the Pacific, we didn't have sea level data to detect or measure the tsunami in that region. Nor did we have travel time or numerical forecast models for the Indian Ocean. What gave us the most concern was 10 minutes later when Harvard University upgraded to 8.9. Up until then, there was no other confirmation of 8.5. But the Harvard method is a standard in the seismology community and made us realize it was much larger than 8.5."

A magnitude 8.9 earthquake releases about four times as much energy as an 8.5.

Harvard's announcement was made at 7:25 p.m. Hawaii Standard Time, 4 1/2 hours after the earthquake. (It was upgraded the following day to a 9.0.)

At the same time, readings from Cocos Island confirmed that the tsunami had propagated from the source and was spreading throughout the Indian Ocean Basin.

Armed with this new information, personnel at the Pacific Tsunami Warning Center scrambled to notify authorities in the countries bordering the Indian Ocean, although they had no official contacts, established protocol or phone numbers to guide them.

While Weinstein and Hirshorn were searching files for names, at 7:32 p.m. McCreery sent a message over the UNESCO/International Oceanographic Commission's tsunami bulletin board that reaches international tsunami scientists and organizations, knowing the information would be forwarded. McCreery then contacted the International Tsunami Information Center and the Australia Bureau of Meteorology. He also alerted U.S.

continued on page 7

Tsunami Center

continued from page 6
military authorities in Hawaii, who in turn notified others, including the State Department, which set up conference calls with U.S. embassies in Madagascar and Mauritius. The State Department also indicated it would notify embassies in Kenya and Somalia.

"Now we are moving ahead to offer whatever technical support and assistance we can to help countries establish a warning system," McCreery said. "We have begun meeting with officials from many countries. Already we have received contacts to add to the dissemination list and many requests to visit the Pacific Tsunami Warning Center."

According to Laura Kong, director of the International Tsunami Information Center, "To be effective, a warning system requires several components: the technology to detect earthquakes and tsunamis and trained scientists who can make informed decisions, models and maps of areas likely to be in danger, a communications infrastructure to alert the public, a plan to evacuate people from the coast and shelters to house them, and a public education program to teach people the natural warning signs and what to do when a warning is issued."

On Jan. 10, the White House announced a plan to expand tsunami detection and warning capabilities in the U.S. and to work with international organizations to establish a global tsunami warning system in coordination with the Global Earth Observation System. Over the next two years, NOAA will deploy 32 new tsunami detection buoys in the Pacific, Atlantic and Caribbean, add 38 new sea level stations, expand the Tsunami Ready Program and continue tsunami inundation mapping along coastal areas at risk.

The implementation plan for the system is scheduled to be adopted at the third international Earth Observation Summit in Brussels, Belgium, in February, which will be attended by NOAA Administrator Vice Adm. Conrad C. Lautenbacher, Jr., U.S. Navy (Ret.).

"Just putting buoys in the Indian Ocean won't help," Lautenbacher said when he visited the Pacific Tsunami Warning Center Jan. 11. "It's a complicated information-delivery system. We will continue to do our part by sharing data, providing technical assistance and guidance, and issuing warnings. Countries who sign up have to have a system to receive the information and disseminate it to the public. Public education is a vital key, probably the most important piece. That's what makes our program such a good model for the rest of the world. We have an end-to-end process."

Southwest Storms

continued from page 2
snow accumulations of more than 80 inches during two separate storms between Dec. 29 and Jan. 11, with nearly 38 inches at the Reno airport.

"These storms ranked in the top five all-time record snowfalls for the area. The average snowfall for an entire season at the Reno airport is only 23.5 inches," Hollingsworth said.

Ski resorts along the Sierra Nevada reported accumulations between 14 and 19 feet during the two-week period.

Northern California's Butte County was the site of the nation's first reported tornado of 2005. On Jan. 8, a twister downed trees and power lines and damaged homes in Oroville. Local storm reports, compiled by NOAA's Storm Prediction Center in Norman, Okla., show that during the three days that followed, Riverside, Ventura and Solano Counties each reported a tornado touchdown. In only four days, California had a third of its average annual number of tornadoes.

Despite the adversities that came with the storms, there were some benefits for the Southwest, plagued with water shortages and a tinder-dry landscape. While a serious drought takes years to develop, heavy precipitation can eradicate one relatively quickly. The weekly drought monitor map issued by NOAA and partnering agencies showed a reversal in the trend of an expanding and deepening drought in the region. Improvements did not occur in the Pacific Northwest, which missed the brunt of these storms.

Once the jet stream retreated northward to its typical wintertime pattern, drier conditions returned to the West, and a change was felt downstream. As the last western storm moved eastward from Jan. 12-14, it spawned severe weather and flooding from the Plains to the East Coast. In its wake, Canadian air chilled the Midwest and East, as the temperature plummeted to 54 degrees below zero in Embarrass, Minn.

"Not all floods are associated with the MJO and not all MJOs are associated with flooding," said David Reynolds, meteorologist-in-charge of the Weather Service forecast office in Monterey, Calif. "However, under the right circumstances, forecasters monitoring the MJO, monitoring how it is tapping into the rich tropical moisture feed and understanding the rain enhancements that occur when this rich moisture-laden air is forced over steep terrain, will allow us to give several days notice, if not longer, that major flooding is not only possible but likely."

Braun

continued from page 3

with the local community and out of concern for the well-being of the pod, Braun met with community leaders and listened to their ideas. After consulting with NOAA staff, the team devised a plan to try to gently coax the whales out of the bay. The community would contribute by weaving a 400-foot "lau," a traditional Hawaiian rope four to six inches in diameter, made by twisting beach vines together and used by early Hawaiians to herd and catch fish.

The next morning, after all scientific preparations had been made, onlookers and rescuers participated in traditional Hawaiian prayers and chants.

During their stay in the bay, the melon-head whales remained in a tight group, as if huddling close together protected them. The lau was suspended between two canoes placed at opposite ends of the bay on the beach side of the pod. As the onlookers steadily chanted in low tones, the canoes moved slowly and carefully, dragging the lau with them toward the mouth of the bay.

The whales seemed to approach the lau tentatively. Suddenly, all prayers, hopes and chants by the onlookers seemed to be answered when a few of the larger adult whales approached the lau, turned, then dashed off to sea and out of the bay. The rest of the pod followed, some breaching the water as if scripted for a perfect Hollywood ending.

"The successful encouragement of the animals out of the bay was very rewarding," Braun said, "but it could not have happened without the collaboration of the many people who contributed cultural, physical and financial support. I am extremely thankful to all the people that helped make the response such a great success."

Maier

continued from page 3

But outreach is not Maier's only job. He's also an incident meteorologist, one of a cadre of highly trained fire weather forecasters who are sent by the Weather Service to remote locations throughout the U.S. to support wildfire operations. He's been on site at numerous fires and has worked at state and regional command centers, keeping track of and supporting many other wildfires.

Trained to respond to oil spills, Maier was the first IMET on site for the recovery and clean-up operations for an oil spill by the *M/V Selendang Ayul*, a tanker that went aground in December 2004 near Unalaska Island in the Aleutian Island chain, creating a major environmental crisis.

Maier volunteered without hesitation to deploy to this extremely remote location, 800 miles west of Anchorage, on very short notice. Less than 72 hours after the grounding, he arrived at the Joint Command Center in Dutch Harbor, Alaska, and immediately began working with the Unified Command and his NOAA team members from the National Ocean Service's Office of Response and Recovery.

"Having never worked on an oil spill incident, the hardest part was understanding the operational needs of the team and forecasting effectively to meet those needs," Maier said. "I had the support of the folks in the Anchorage forecast office to provide me with the products and information I needed to do my job. In a lot of ways an IMET is only as good as the support they get from the local office, and Anchorage went above and beyond the call of duty to provide that support. I couldn't have done my job without the support of other National Weather Service staff, and the work of the individuals in the NOAA Hazmat Office."

The weather conditions were a critical factor during the response to this incident, often grounding air and marine support operations and creating dangerous conditions for responders. Maier was able to forecast lulls in the weather, which were windows of opportunity when the team could safely operate.

"His years of experience working in the Incident Command System and his weather forecasting accuracy quickly earn Chris respect from everyone he serves with on these interagency response teams," said Thomas Ainsworth, meteorologist in charge of the Juneau Weather Service forecast office. "Chris has a knack for delivering the exact environmental information needed by our customers to maximize their safety while carrying out precision air and ground operations."

Maier, due to be relieved in Dutch Harbor a few days before Christmas, said an IMET must be ready and able to respond immediately despite family responsibilities. Bad weather delayed his relief IMET until Christmas Eve. Maier said he still managed to make it home in time to be with his wife, Virginia, to enjoy his daughter Zelly's first Christmas.

*The **NOAA Report** is a monthly publication for NOAA employees from the Office of Public, Constituent and Intergovernmental Affairs, Washington, D.C.*
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