environmentalresearchweb

TALKING POINT

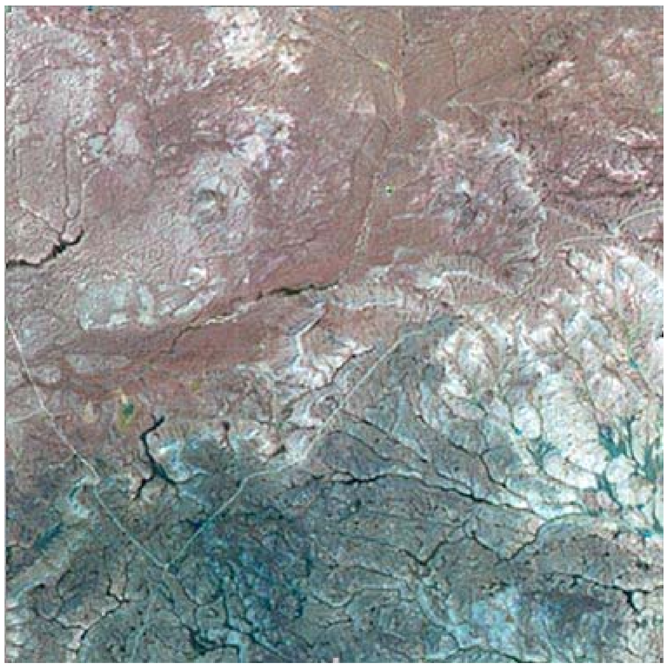
Aug 5, 2008

Satellites keep tabs on the environment

Satellite images can supply visual proof of environmental damage caused by man, such as changes in deer habitat use caused by oil and gas drilling and the sediment plumes thrown up by fishing trawlers, says John Amos of SkyTruth.

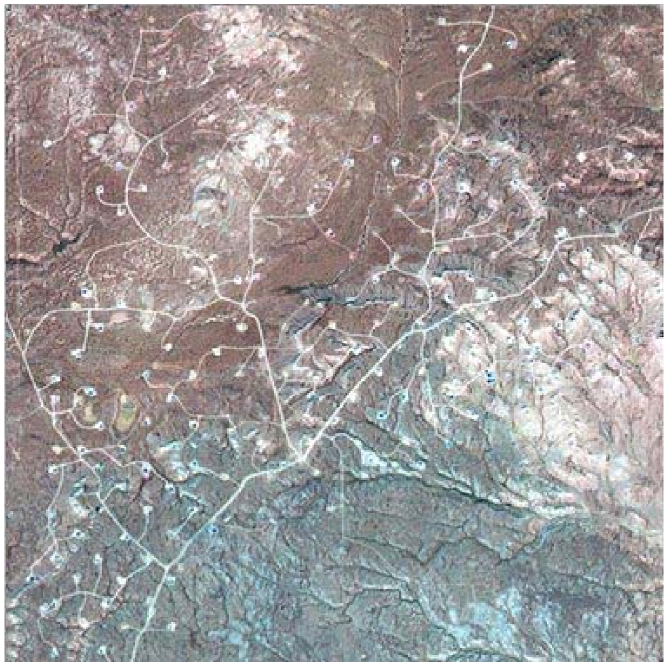
In 1999, a satellite image changed my life.

I had been working as an exploration geologist for nearly 10 years, using satellite images to help energy and mining companies hunt for resources around the world. Lately I'd been focused on the search for new supplies of oil and natural gas in the Rocky Mountain states, and a small oil company had asked us to look at an area in western Wyoming, about 40 miles south of the sleepy town of Pinedale in the valley of the Green River. I knew the area well; as a postdoctorate student in the late 1980s I'd kicked around those high, sagebrush-covered plains, seeing nothing but mule deer, pronghorn and the occasional group of cattle, revelling in some of the clearest air I'd ever experienced. Spectacular views of the rugged Wind River Range to the east and the Wyoming Range to the west framed the scene. Here's a Landsat satellite image, covering an area about 7 miles across, which was typical of the area. It was taken in 1986:



Yep, not much to look at then. Just grass and sage-covered plains (shades of brick-red and blue-grey in this composite of visible and infrared wavelengths), some bare eroded cliffs and badlands (bright white) and two dirt roads (thin pale lines, intersecting at lower left).

But here's what the same place looked like in a Landsat image taken in 1999:



What happened?

Well, my fellow geologists had discovered what turned out to be one of the biggest onshore natural-gas finds of the decade. Drilling had begun in earnest just a year earlier. Already there were dozens of wells, each drilled from a "well pad" – a flat area bulldozed into the ground, covering some 3 acres. They are all connected by a pervasive network of dirt access roads, pipelines and utility corridors.

I was amazed by how fast this had happened; and appalled by the heavy impact on the landscape – on public lands in the southern part of the Greater Yellowstone Ecosystem, home to the longest overland animal migration in the continental US. And finally, disappointed by the industry I'd been working for. I knew that advanced drilling technologies existed that could greatly reduce the "footprint" of gas and oil production. I had believed the industry and government spokespeople when they periodically implied that these lower-impact technologies were in routine use. My own eyes were telling me that was not the case on public lands.

I decided the whole world should know about this, and should be able to see the visual proof of human impacts on the planet, wherever they are happening. That's why talented, like-minded friends and I got together and started SkyTruth. Our mission is to illuminate environmental issues using images taken from orbiting satellites. Satellites provide a ubiquitous global tool that gives a big-picture perspective you can't get any other way, unless you're an astronaut. This "remote-sensing" technology also allows us to travel decades back in time, using historical images from data archives to show how landscapes have changed over the years as a result of drilling, mining, logging, urban sprawl and other human activities.

By the way, here's what the Jonah Field looks like now, with hundreds of wells drilled and thousands more recently approved by the federal government:

Satellite images provide scientists with unique, accurate data to study changing landscapes and habitats. SkyTruth is working with two groups of wildlife researchers to investigate possible correlations between the growth of oil and gas infrastructure and the behaviour and survival of important big-game animals. Both of these multiyear studies are funded in part by the oil and gas industry. At WEST Inc, Hall Sawyer and colleagues attach radio collars to mule deer that report the locations of the animals every 10 minutes. Plotted against the satellite imagery, the data give a clear picture of how active drilling has pushed the deer off their preferred winter habitat, possibly contributing to a 45% decline in the local population (http://www.earthsky.org/radioshows/50745/wyoming-deer-challenged-by-energy-development). In future years, as the current frenzy of drilling activity subsides – and meaningful habitat restoration is done – will the deer return? Only a long-term commitment to this type of work will answer that, as well as many other, important wildlife-management questions.

Joel Berger and other scientists at the US Wildlife Conservation Society recently initiated a similar study in the area of pronghorn antelope. Another iconic Western species, the pronghorn undergo a yearly migration from Grand Teton National Park in the north to the upper Green River valley in the south. This epic, 6,000-year-old event is the longest mammal migration remaining in the lower 48 states (http://www.wcs.org/353624/pronghorn).

One encouraging result of this work is the recent announcement (http://www.westgov.org/wga/press/am-wy01.htm) by the governors of Western states pledging to protect important wildlife corridors. The US Forest Service took the first step earlier this year, designating that portion of the pronghorn migration pathway that runs through Bridger-Teton National Forest as the first-ever US Wildlife Migration Corridor (http://www.ens-newswire.com/ens/jun2008/2008-06-17-091.asp). We at SkyTruth hope our imagery, and the ongoing efforts of conservation scientists, will help convince other federal and state agencies to act soon to protect the entire length of this threatened corridor.

But SkyTruth doesn't just address terrestrial issues. After all, most of the planet is covered by ocean, and humanity is busy there too. Drilling, fishing and now ocean-floor mining are reaching out from the coast into ever-deeper waters. It's hard to know what's happening offshore – it's over the horizon and out of sight for most of us here on terra firma, and we can't easily see what's beneath the surface of the water. That's exactly where satellite imagery can help.

Along with pollution and climate change, fishing is one of the major ways in which we impact our oceans. In 1998 my friend Elliott Norse, along with his colleague Les Watling, published a report on the effects of bottom-trawling. This fishing technique drags weighted nets along the seafloor to catch groundfish – like cod and haddock – and shrimp that hang out on the sea floor. The heavy gear crushes and flattens corals and other hard-shelled creatures and ploughs up the sediment; eliminating important habitat where juvenile fish can feed and escape from predators. All of this damage has been taking place for decades, out of sight and out of mind until Elliott and Les raised the alarm.

SkyTruth got involved with trawling early last year, when a PhD student named Kyle Van Houtan sent Elliott some astounding satellite images. Kyle later published some of the images in **Nature**, with Daniel Pauly of the University of British Columbia. They clearly showed trawlers operating in coastal waters in the Gulf of Mexico and other places around the world. Each trawler was trailed by a long, brown plume not unlike a jet contrail. Only these trails weren't harmless water vapour: they were billowing clouds of mud, churned far up into the water by the heavy trawling gear dragging along the seafloor. The implications of this could be serious. Not only is the seafloor being severely altered but the mud may contain toxic chemicals from agricultural runoff and industrial pollution that are continually being re-suspended in the water and exposed to the fish we eat; it blocks sunlight from reaching into the depths, harming any species that depend on photosynthesis; it changes the water chemistry, possibly affecting the ability of the ocean to moderate global warming by acting as a carbon-dioxide sink; and when it ultimately settles back onto the seafloor it smothers marine organisms like sponges and corals that can't simply move out of the way.

We were intrigued, and wanted to investigate a few questions. How widespread is this phenomenon? Can we see it on older, lower-resolution Landsat satellite images? Can we see it in deep water? How long do these trails of sediment persist after a trawler has passed?

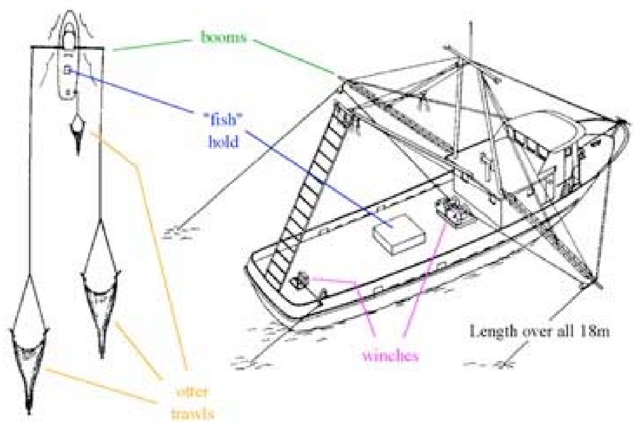
We started by looking systematically at high-resolution (1-metre detail) satellite images of the Gulf of Mexico, where we know lots of bottom-trawlers haul in shrimp. One of the great revolutions in information technology in the past decade has been the advent of free, Internet-based global image sources such as Google Maps (http://maps.google.com) and it's 3D cousin Google Earth (http://earth.google.com). We immediately found plenty of examples of Kyle's sediment plumes, like this panoramic Google image looking towards the northwest off the coast of Louisiana:

There are plenty of light-brown sediment plumes, for sure, crisscrossing the ocean surface, but are they really caused by fishing vessels? Here's the view from straight overhead:

And this is what we found when we zoomed way in on the head of an individual plume:

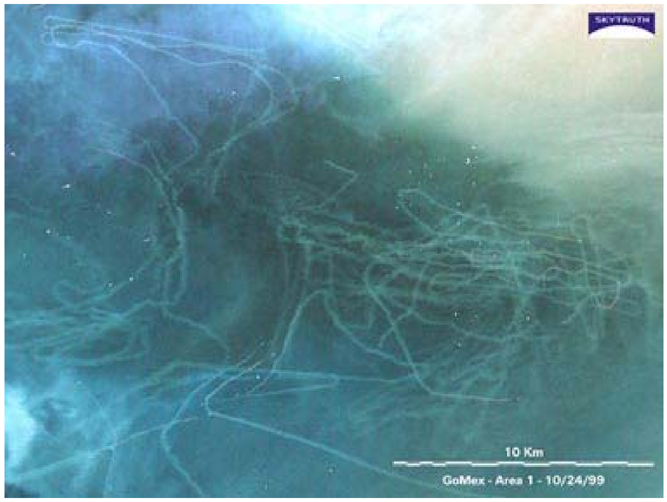
That white blob at the head of the plume is how a typical double-rigged Gulf shrimp trawler, like the one pictured below, looks from overhead.

Notice the structure of the sediment plume itself – five separate mini-plumes appear about 50 metres from the stern of the vessel and coalesce into a single large plume within 150–metres. The vessel itself is about 20 metres in length. This jives with the gear configuration of a typical double-rigged trawler, shown in the diagramme below. Each of the two large nets mounted from the long booms is held open against the seafloor by a pair of heavy metal panels called “otter boards”. A third, smaller net is dragged off the stern. The four otter boards and the third net each raise a mini-plume of mud off the bottom of the ocean.



(Image source: Oregon State University)

Convinced that the plumes are indeed caused by trawling, we processed several older Landsat satellite images from the same parts of the Gulf as we saw sediment trails in the Google imagery. Landsat satellites have been collecting digital pictures of the earth since 1972, but with a lot less detail than the high-resolution images in Google; the best Landsat images have 15-metre resolution. Now that we knew what to look for, thanks to the detailed Google imagery, we identified numerous similar sediment trails on the Landsat images. This example is from 1999:



We measured an individual plume and found that it stretched for 27 kilometres. At a typical trawling speed of 2.5 knots the sediment at the far end was still concentrated enough to be visible about 6 hours after the trawler had passed. This implies that once the sediment is churned up it may take a long time to settle back out of the water. With the intensity and frequency of trawling shown on these images, it's not hard to imagine that the water is perpetually muddy wherever this fishing activity is taking place.

This Landsat image from 1986 shows plumes interwoven along the coast near Cameron, Louisiana, proving that our muddy mess isn't a recent phenomenon:

All of these examples have been in fairly shallow water (<20 metres), close to shore. But we know trawling is also happening far offshore. How deep can the water be and yet still show signs of trawling on satellite images? The Landsat image below shows ghostly sediment trails 130 kilometres offshore in water that's about 70 metres deep. So far, it's the deepest-water example of the plumes that we've found:

What's next?

We'd like to correlate the spectral properties of these sediment plumes with actual measurements of the density and depth of sediment in the water, so we can estimate the total amounts of sediment being churned up by a typical trawler. With that information we can help other scientists investigate how trawling may affect climate by altering the way carbon that is exchanged at the interface between ocean and atmosphere, and whether trawling threatens the foodchain – seafood-lovers included – by continually re-suspending industrial and agricultural pollutants that would otherwise remain buried on the seafloor.

This is just another example of how satellite images can help us understand the many different ways that our actions affect the planet. But don't take our word for it – see it for yourself. Come and visit us at www.skytruth.org (http://www.skytruth.org), check out our growing roster of image galleries (http://skytruth.mediatools.org/gallery/browse/9) and keep up with all the action. Let us know what you think – at the SkyTruth blog (http://blog.skytruth.org).

SkyTruth is a small group of highly trained remote-sensing specialists, but we're thrilled by the ongoing democratization of this valuable information technology. Satellite images aren't just for us "experts" anymore. When I started this work almost 20 years ago, I needed a big computer, complicated software and a hefty budget to afford satellite images costing thousands of dollars each. Those barriers are falling. With the proliferation of free, web-based image and mapping sites like Google Earth (http://earth.google.com/), Microsoft Virtual Earth (http://www.microsoft.com/VirtualEarth/) and NASA WorldWind (http://worldwind.arc.nasa.gov/), anyone can join us in this work by becoming an environmental witness for the places they care about. If you've got experience with remote sensing, image processing and analysis, GIS modeling, or digital mapping – or if you just love to spend your free time zooming around the planet in Google Earth – and you'd like to volunteer those skills to promote conservation efforts in your own neighborhood, or around the world, then look us up. We'll put you to work saving planet Earth.

About the author

John Amos is the founding director and executive director of SkyTruth. He has nearly 20 years of experience with remote sensing, emphasizing innovative and cost-effective applications for public- and private-sector clients. His expertise spans project design, image processing and image analysis, commercial remote-sensing market development, and training. He has performed image-based investigations of land-use status, environmental change and pollution assessment, including a three-year NASA study to develop new techniques for detecting natural and man-made oil spills on the continental shelf.