Ripple Marks

The Story Behind the Story

BY CHERYL LYN DYBAS

DOUBLE, DOUBLE, TOIL AND TROUBLE FIRE BURN AND CAULDRON BUBBLE

In *Macbeth*, Shakespeare might have been writing not about three witches, but about deep-sea hydrothermal vents. "Some say," he continued, "the earth was feverous and did shake."

Indeed it did at the bottom of the sea, as scientists discovered in 1977 with the finding of the first hydrothermal vent system.

These undersea geysers spew out their metal-laden contents in silence, it was thought. Until scientist Timothy Crone of the University of Washington came along, microphone in hand, and listened to what the vents had to say.

"Hydrothermal vents are far from silent," said Crone. "They're in fact quite loud, and have acoustic signatures that will help in the study of how fluids flow through these systems."

A recording of the two vents—"Sully" and "Puffer," some 2,200 meters below the Pacific Ocean surface on the Juan de Fuca Ridge—sounds like a bubbling cauldron. The vents are 500 kilometers west of Seattle.

"While previous studies noted an apparent increase in ambient noise within several hundred meters of hydrothermal vent sites," wrote Crone and colleagues in a paper published in the December 2006, issue of the journal *PLoS ONE*, "another study found no conclusive evidence that hydrothermal vents generate sound."

Crone and colleagues set out to discover the answer and documented the first localized sound generation by mid-ocean ridge hydrothermal vents. Using a digital acoustic recording system, Crone recorded 45 hours of continuous sound at 1,000 Hz in 2004 and 136 hours of continuous sound at 1,920 Hz in 2005, from Sully and Puffer.

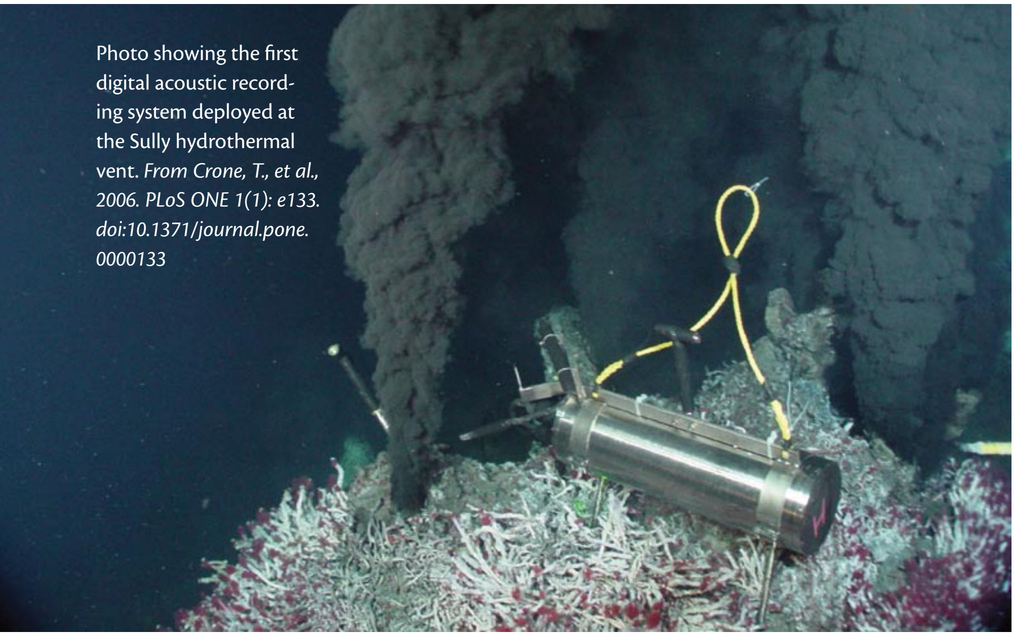


Photo showing the first digital acoustic recording system deployed at the Sully hydrothermal vent. *From Crone, T., et al., 2006. PLoS ONE 1(1): e133. doi:10.1371/journal.pone.0000133*

"Both vents radiate significant acoustic energy," said Crone. "They produce numerous narrowband and broadband sounds."

A variety of sources could operate in vent systems, said Crone. "The presence of both broadband and narrowband components in the acoustic signals indicates that multiple mechanisms are operating in vents like Sully and Puffer."

Potential broadband sources, for example, include boiling, turbulent shear, exit flow, fluid-structure interactions, and volume changes associated with the cooling of hydrothermal fluids. "We need to test this further with hydrophones capable of determining which sound mechanisms dominate in different frequency bands," said Crone.

What might all of this noise mean to fish, crustaceans, and cephalopods making their living off vent ecosystems? "All these animals can detect and process sound," said Crone, "so they might very well be using it as a source of 'environmental information.'

"The acoustic detection of vent locations could help them avoid damage from hot hydrothermal fluids, for example, or could provide foraging or reproductive benefits by assisting with food- or mate-finding."

If you want to find others of your kind, believes Crone, paying attention to vent sounds might lead to a big payoff.

Perhaps more importantly, if you want to avoid being poached in the deep-sea equivalent of a kettle of boiling water, vent sounds are your early warning system. Like the "lamentings heard in the air" in *Macbeth*, they "prophesy dire combustion" for those who swim too close.

MOLLY MALONE'S COCKLES AND MUSSELS: ALIVE ALIVE OH?

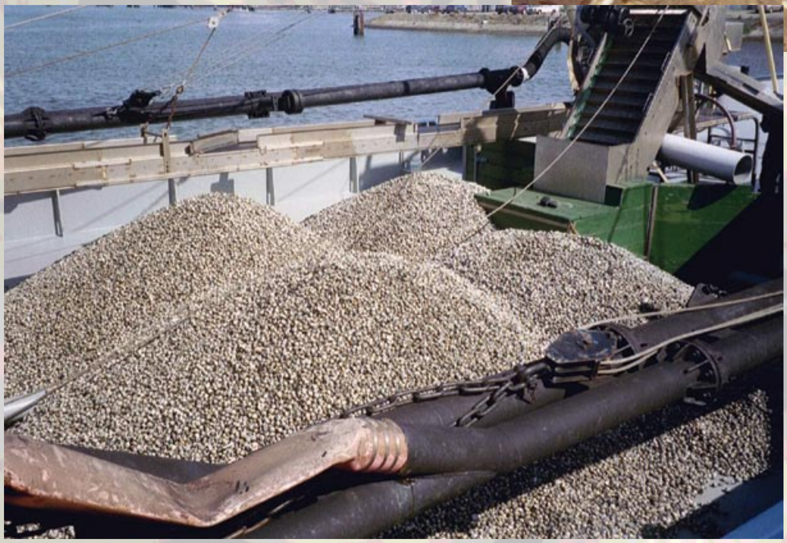


Photo credit: IMARES Yerseke

NOT IN THE DUTCH WADDEN SEA. Resource exploitation and species protection can exist in the same place. So say many government policies around the world. But do those policies work when applied to marine protected areas?

Those that allow commercial fishing operations are a setup for ecological disaster, found Jan van Gils of the Netherlands Institute of Ecology. Results of a study conducted by van Gils and others shows that commercial fishing in a marine protected area led to the decline by 80% of at least one seabird species. The dramatic fall in seabirds parallels a bottoming out of the shellfish on which they feed.

The site is the Dutch Wadden Sea, the seabird is the red knot, and the commercial fishery is for cockles. The Dutch government had given the nod to mechanical cockle-dredging in three-fourths of the intertidal flats of the Wadden Sea, protected under the Ramsar Convention and the European Union's Habitat and Birds Directives. The area is also a Dutch State Nature Monument.

Before suction dredging of the cockles (*Cerastoderma edule*) began in the 1960s, an estimated 2,000 tons of cockles were hand-harvested from the reserve each year. By 1989, the high-pressure, motor-driven water pumps were removing close to 80,000 tons. In 2004, the Dutch government decided the environmental impact was too great and closed the fishery.

Van Gils investigated the ecological impacts of cockle dredging on intertidal ecosystems by studying a long-distance migrant shorebird that feasts primarily on cockles: the red knot, *Calidris canutus islandica*. Some 50% of the global red knot population depends on the Dutch Wadden Sea during its annual migration.

Red knots have a digestive system that minimizes the energetic costs of flying 16,000 kilometers between arctic breeding grounds and wintering grounds in Europe (and the tropics)—their gizzards expand and contract to balance daily food intake. "The birds are exquisitely adapted to their lifestyle," said van Gils, "with a pressure-sensitive bill that senses hard objects buried in the sand, and a shell-crushing gizzard that allows the birds to swallow their catch whole."

To determine the effects of cockle-dredging on red knots, the scientists sampled more than 2,800 sites in the Wadden Sea during the late summer months, late July to early September, for five years beginning in 1998. Cockle-dredging occurred each year from September to December, right after the sampling.

In undredged areas, cockle densities remained stable, but the cockles' quality (flesh-to-shell ratio) declined by 11.3% each year. Dredging likely disturbs the silt the cockles prefer to settle in as well as their feeding conditions, said van Gils, reducing their quality as a food resource.

Based on cockle quality and densities, the researchers predicted energy intake rates for red knots with average-sized gizzards. From 1998 to 2002, the number of sampling sites that could not sustain red knots increased from 66% to 87%, "all attributable to dredging in what were once suitable places," said van Gils.

The degraded cockle shell population, van Gils and colleagues concluded, "explains why red knot populations have precipitously declined in the Wadden Sea." Increased red knot mortality in the area, which the scientists estimate at 58,000 birds over five years, accounts for the decimation of red knots across their entire northwest European wintering grounds.

"Dredging does not provide significant economic benefits in the Wadden Sea," wrote van Gils and colleagues in a paper reporting the results in the journal *PLoS Biology* (December 2006), "yet it's directly responsible for the widespread decline of protected shorebirds there."

These findings, the paper's authors believe, "put the lie to the notion that commercial exploitation is consistent with conservation, and underscore the risks of disturbing the critical habitats of threatened or endangered species."

Said van Gils, "It's time to let protection mean protection."

IT'S "JELLYFISH SEASON"—IN FRESHWATER LAKES AND PONDS

What do Lake Loch Lomond in Arkansas, Barrett Pit in Indiana and Clopper Lake in Maryland; Sand Bottom Lake in Nebraska, East Brunswick Park Lake in New Jersey and Weyerhouser Outlet Stream in Oregon; Peep Toad Pond in Rhode Island, Fallen Leaf Lake in California, and Lake Windjammer Sandpit in Ohio all have in common?

They are home to a tiny, alien-like creature called *Craspedacusta sowerbii. C. sowerbii* is the only jellyfish that lives in freshwater ponds, lakes, sinkholes, quarries, and anywhere else that is more than a puddle of "unsalted" water.

Jellyfish? In freshwater? "In fact, freshwater jellyfish are found in hundreds, if not thousands, of lakes and ponds across the U.S.," said Terry Peard, a biologist at Indiana University who has sampled many of those water bodies for *C. sowerbii*. "In Pennsylvania, for example, they have been found in the waters of 50 of 67 counties—so far."

Freshwater jellyfish are found not only in the U.S., but worldwide. Austria's Danube River near Vienna, England's Exeter Ship Canal, Germany's Lake Rahm, Guatemala's Lago Peten-Itza, Italy's Alserio Lake, New Zealand's Lake Brunner, Romania's "Pond" near Timis, Russia's Small River Inga, a tributary to the Upper Volga and Scotland's Loch Clachan are just a few of these jellies' international homes.

Perhaps most remarkable is their colonization of an artificial lake named, appropriately, Artificial Lake, located under the Al-Muthanna Bridge, Aadhamiya, Baghdad, Iraq. In 2002, the jellies were recorded there. *C. sowerbii* were perhaps the only inhabitants of Baghdad unaware of the war zone they had chosen to live in.

C. sowerbii isn't a true jellyfish, but because its medusa stage looks like that of a tiny ocean jelly, scientists and others have adopted the term "freshwater jellyfish."

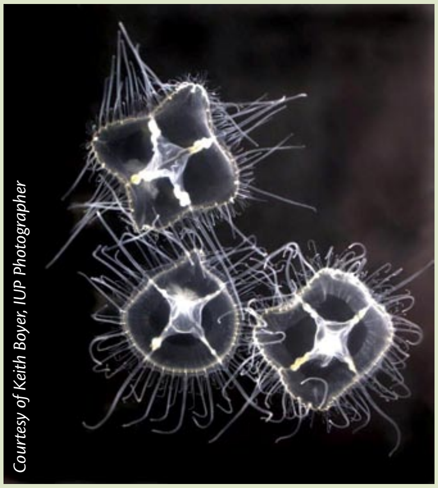
Craspedacusta is a member of the Cnidaria: hydras, marine jellyfish, corals, and sea anemones. Two basic body types in Cnidarians—attached and free-floating—are combined in marine jellyfish in a polyp and a medusa form. Although *Craspedacusta* is more closely related to hydras than to marine jellies, it also has a polyp and a medusa stage.

Freshwater jellies spend most of their lives as polyps living on or near lake bottoms on logs and other debris. During winter, the polyps contract and become "resting bodies," said Peard, "capable of surviving cold temperatures. The resting bodies, also called podocysts, may be one way the jellies are transported from lake to lake by aquatic animals, such as on the feet of birds."

Similar to the life cycles of marine jellyfish like Chesapeake Bay's well-known sea nettle *Chrysaora quinquecirrha*, freshwater jellyfish "blossom" in summer into the floating bells, or medusae, familiar to beach-goers. Unlike true jellyfish, however, these medusae are small—the size of a quarter at most, said Peard—and their tentacles ("yes, they do have tentacles") aren't large or strong enough to sting like those of marine jellyfish.

How did freshwater jellyfish get into U.S. water bodies in the first place? "The most likely way," said Peard, "is that somehow they came from the upper Yangtze River in China, where native freshwater jellyfish populations are still found today. They were discovered in water lily tanks in Regents Park in London in the late 1800s, presumably having arrived there as polyps on imported plants from China. We have no idea how they got to the U.S."

The jellies were first found in this country in the late 1800s in Tacony Creek near Philadelphia. The records after that are sporadic, said Peard, "perhaps leading to the belief that they're rare, when in fact, they're anything but."



Courtesy of Keith Boyer, IUP Photographer

Anecdotal evidence abounds.

Last summer a man brought a goldfish bowl with 15 or so tiny jellyfish to the New York Department of Environmental Conservation office in Ray Brook, New York. His children had found the jellies while swimming in Lincoln Pond in New York's Adirondack Mountains.

In fall, young schoolchildren discovered *C. sowerbii* in Stephens Lake near Minneapolis. They called their finds "Jelly Bellies." The students kept the jellies out of Stephens Lake and in a canning jar just long enough to show their biology class. Then they returned the jellies to the lake.

"You might find them in a certain place this year," said Peard, "then next year, there are none. No one knows why it is that once the jellies are in a lake, first you see them, then you don't."

One biologist visiting a man made lake in Arizona spotted tens of thousands of them at one time. That was 25 years ago. He's never again seen a single *Craspedacusta sowerbii*.

"Sometimes there's an explosion of them in a particular lake or pond," said Peard. "But it only lasts a few days before the jellies are gone, disappearing as mysteriously as they came."

Photo of the partitioned container set-up used to investigate the bystander effect in small trout (approximately 2 months after hatching). Inset is a close-up of one of the containers with the small trout. *Photos courtesy of Richard Smith, McMaster University*

THESE FISH ARE HOT

It sounds like something out of science fiction: fish that can transmit the effects of radiation—fish to fish—without ever touching.

But the fish in question is hardly fictitious. In fact, it's a summer favorite on restaurant menus from coast to coast: the rainbow trout.

Research results recently reported show that responses to radiation indeed can be "communicated" between animals, at least in rainbow trout. The study is one of the first to demonstrate such effects.

Radiation biologists have discovered that rainbow trout exposed to x-rays can pass on what are known as "bystander effects" to others of their kind, fish that have not been irradiated.

"Bystander effects are biological effects detected in cells not themselves exposed to ionizing radiation, but that receive signals from irradiated cells and respond as if they had received the dose," write radiation biologists Colin Seymour and Carmel Mothersill of McMaster University in Ontario, Canada, in a paper published online on September 27, 2006, in the journal *Environmental Science & Technology*. Radiation bystander effects appear in unexposed nearby tissues as cell death and mutations.

Fish are good candidates for the study of these effects, said Seymour and Mothersill, because they communicate via chemical signals in water.

The scientists x-rayed pairs of rainbow trout in a water-filled tank for up to five minutes. The amount of radiation delivered was high relative to the background levels in the environment from such sources as radon, but much lower than doses given to people undergoing CT scans or radiation therapy for cancer.

To find out whether radiated fish send signals to other fish, rainbow trout were irradiated, then removed from their tank. Into the tank next went non-irradiated trout, swimming in the same water as the radiated fish.

When the scientists looked at the "newcomers," they found similar radiation effects to those seen in the original fish. Cells in several organs had died, and other cells expressed proteins linked to radiation responses. It is likely, say Seymour and Mothersill, that the radiated fish secreted chemicals, as yet unidentified, into the water, resulting in radiation-like effects in the unexposed fish.

Although the exact nature of the signal hasn't been discovered, "it's likely to be water soluble and must be stable in water, because it can affect [other] fish even when the irradiated fish have been removed from the water," wrote the scientists. "This has significance for aquatic shoaling species' biological responses to ionizing radiation in the environment."

Bystander effects likely occur in many living organisms and should be considered in determining radiation risks in humans and in other animals, the scientists believe.

As a result of their research, "radiation hazard" signs soon may have a new—and far-reaching—meaning.

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