SUBMARINE S

FEASTING IN THE FOOD CHAIN

When asked to identify the most important aspect of his work, Scripps graduate student Eric W. Vetter answers with a question; "Just how common *are* patches of hyperproductivity on the seafloor?"

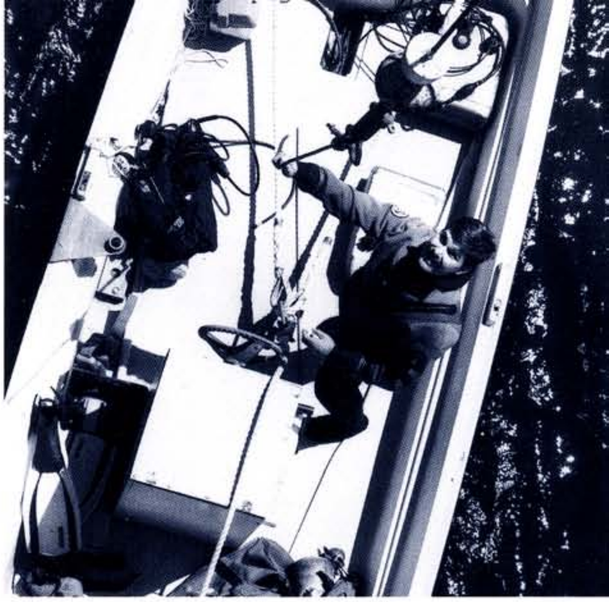
Vetter, a student in the lab of Professor Paul K. Dayton, is studying a local seafloor habitat that is home to the greatest known density of marine invertebrates–a habitat type that he calls a 'hot-spot'.

Vetter's hot-spots are detritus mats composed primarily of decaying surf grass and kelp. In a branch of the La Jolla submarine canyon adjacent to Scripps, accumulations of marine plant debris provide a dynamic habitat for a wide range of bottom-dwelling organisms and feeding stations

BY JOE HLEBICA

MORGASBORD

Leptostracan crustaceans–male (top) and egg-bearing female (shown above actual size)–of the genus *Nebalia*. This newly described species by Joel W. Martin, Vetter, and Cora Cash-Clark will be named after Scripps Professor Robert Hessler.



for large numbers of fishes.

Remains of invertebrates, fishes, birds, and mammals accumulate within the detritus mat. Also found in the mat are live animals from surrounding sandy-bottom areas. Moribund sea pansies, mussels, hydroids, bryozoans, sponges, and ascidians are all common, while scavenging crabs, octopuses, juvenile fishes, snails, polychaete worms, and isopods also inhabit the mat.

Typical food chains are termed *biotrophic*–the progression is from plant to herbivore to carnivore. The situation Vetter is studying has been termed *saprotrophic*–a system based on detritus decomposers. The base material being fed upon is not growing plants, but decaying plant matter. According to Vetter, most of it is being turned into decomposed and microbial biomass before it moves up to animals including small crustaceans, and then to the fishes that feed at this 'smorgasbord', as he describes it.

Vetter cites three basic requirements for a hot-spot such as the detritus-mat habitat to develop: generally mild surges or currents, a source of plant material, and a depression or valley in the seafloor. All three exist here.

For much of the year, ocean conditions are mild along the La Jolla coastline, as they are elsewhere in the Southern California Bight. Local kelp beds contribute an abundance of plant debris to the detritus mat. And, the topography of the La Jolla submarine canyon system provides a natural sink for anything settling on the adjacent bottom. Diving in a branch of the canyon north of Scripps Pier, Vetter has seen just about everything from fishes to Frisbees™ in the mix.

The most remarkable discoveries in this seafloor compost are a few species of scavengers (amphipod and leptostracan crustaceans), which occur in numbers far greater than any other known aquatic or terrestrial animal group. These tiny, distant relatives of beach hoppers and shrimps dominate the local detritus habitat, and their diet is primarily decaying plant matter.

In a recent paper, Vetter writes, "The leptostracans, which include two undescribed species of *Nebalia*, and the most abundant amphipods, *Orchomene limodes* and *Aoroides spinosus*, at times achieve a cumulative density of over three million individuals per square meter."

During an interview, he states emphatically, "Nothing else even comes close. In terms of biomass, you might find higher values in a beehive, but then that's a nest, not a habitat. If, on the other hand, we compare the detritus mat to the neighboring sandy bottom, the mat is a hundred times more productive."

The discovery has come as something of a surprise. "This situation is right next to Scripps, and up until now, nobody's looked at it," claims Vetter. Furthermore, the situation is widespread in the La Jolla canyon system, as it may be elsewhere in the ocean. The local detritus habitat is believed to cover an area of several acres, and the mat itself is often more than three feet thick. It lies at depths of from 45 feet to at least 300 feet, and probably much deeper.

Photos on these two pages: Marine ecology graduate students Eric Vetter (left) and Dale Stokes prepare to dive in Scripps submarine canyon.

Though the maximum depth limit observed by qualified Scripps divers is 200 feet, the relatively shallow depth of much of this habitat has allowed ample opportunity for discrete sampling and animal censuses. Hundreds of dives from March 1992 through March 1994 yielded the data from which Vetter has drawn his conclusions regarding the habitat's phenomenal secondary productivity. With the invaluable help of volunteer divers, he collected mat samples using methods that owe as much to gardening as to science.

Diving in the cold canyon depths, Vetter's group performed a difficult harvesting operation. First, they stationed a 20-inch-long, open-ended, 80-pound, steel cylinder on the bottom. The cumbersome cylinder was moved from spot to spot during each dive using an air-filled lift bag and all the strength the divers could muster. Acting somewhat like a cookie cutter, the cylinder's 1/2-inch-thick rim encircled 20-inch-diameter portions of mat, which were cut along the inside using hedge trimmers. The clippings were then sucked out of the cylinder through an air-injection vacuum tube with a plankton net attached to its end to trap samples. Once on shore, Vetter and his assistants painstakingly sepa-

rated animal from vegetable, sorted species, and measured the product: four to eight liters of tightly packed amphipods and leptostracans per sample.

In a laboratory of the Marine Life Research Group, Vetter takes a hefty jar from the shelf and inventories the contents, which look strangely like bugs packed in oil.

"This 1-liter jar contains the product of 1/20th of a square meter of detritus mat, sampled on an average day. One square meter yielded 380 grams of leptostracans and 120 grams of amphipods, dry weight."

If that doesn't seem like much, it's only an indication of just how small these animals are. In terms of population, however, the amounts are astonishing; the same dry weight represented 800,000 leptostracans and 844,000 amphipods.

"And," he cautions, "that's by no means an exceptional sample from this habitat."

What keeps these populations in check? Both physical and biological disturbances affect the habitat in what Vetter describes as "a seasonal cycle of disturbance."

During summer, expanses of detritus are home to large populations of animals that reproduce continuously. In the fall, larger waves begin agitating the detritus, and by late fall and winter, storm waves create a noticeable physical disturbance. According to Vetter, material is picked up and swept down the canyon at this time, and he has observed that as the area of the habitat is reduced, density of the animal population increases.

"You have a higher concentration of animals left in the remaining detritus. Laboratory experiments have demonstrated that when the concentration of animals increases and the thickness of detritus is reduced, the animals are more vulnerable to predation by fishes. So, you have a physical disturbance that doesn't directly kill off the animals, but it makes it easier for fishes to eat them."

Toward the end of spring, more plant material accumulates, and the mats start expanding again. The animals spread out as the habitat increases, and their density goes back down. Then, in the summer when temperatures rise and conditions are calmer, a biological disturbance occurs. A bacterial species begins to grow on the decaying mat, covering some areas with a veneer of white filaments, indicating unfavorable conditions for the animal populations. Thus, seasonal conditions–both physical and biological–and continuous predation keep populations in the mat habitat in check.

What larger role does this extraordinary productivity play in the ecosystem? According to Vetter, "This high level of production is subsidizing fish stocks; putting it simply, there are more fishes here than there would be otherwise. And not just fishes that normally feed on small crustaceans. There are several species of fishes exploiting this food source that typically eat other, larger animals."

According to Vetter, this habitat features the greatest secondary

Photos on facing page left to right: Señorita fish feeding in Scripps canyon. Amphipods and leptostracans in the seafloor detritus mat.
Below: Divers Peter Brueggeman (at left) and Eric Vetter collect samples of organisms growing on a spar buoy anchored over Scripps canyon.
Top right: A cabazone rests on kelp debris amid the detritus.

BENCHMARK ECOLOGY IN HIS OWN BACKYARD

Professor Paul Dayton (left) and graduate student Eric Vetter review a map of the seafloor as part of their plans to explore the deep canyon near Scripps in a research submersible.

Though graduate-level research rarely becomes international news, doctoral candidate Eric Vetter's work is an exception. As noted widely in the media (including the authoritative journal *Nature*), his dissertation describes a habitat in the undersea canyons near Scripps that produces a greater animal population density than any known to science.

Describing what attracted him to Scripps, Vetter also gives a good working definition of ecology: "To study animals living in a particular environment it helps to understand the physical environment itself, and that's a real advantage here."

When asked how he got started on the road to his notable doctoral dissertation, Vetter describes a long and arduous process.

"During my first year, I went to the Antarctic with Professor Paul Dayton (Vetter's advisor), and started working on sediment core samples from the previous trip there. That was my introduction to working with infauna [animals that live in mud, sand, and other unexposed habitats].

"When we came back, I was furiously trying to find a good research topic, and coming up with all sorts of things–only to find out that other people had done them.

"But I was also going out diving and looking at the area. On one dive, we were just going to look at the canyon walls, and all this plant detritus was there. I became intrigued, and asked myself: What can be living in this, and what effect can it be having on the animals in the surrounding area?" He adds humorously, "I was actually a little bit wary of the detritus at first, just imagining what might be lurking in it."

Vetter admits that it took him a while to begin to see the whole picture of processes in the detritus habitat, but eventually he chose it as the subject of his thesis.

"Finally, about two and a half years ago, the proverbial light bulb went on over my head, and I began to understand what is really going on down there."

Proud of his accomplishment, Vetter explains "A lot of the good, easy, and convenient questions in this field have been considered. But here, I've found a good problem to tackle just a four-minute boat ride from Scripps Pier."

Eric Vetter on pier.

Marine ecology graduate student Eric Vetter has logged hundreds of research dives using Scripps Pier as his base of operations.

productivity of any known habitat. This is a bold claim. When asked how he substantiates it, Vetter replies, "It's not easy–and there's no guarantee that I haven't missed something–but computers have made it a lot easier. I searched a computer database using 'productivity' and other keywords to locate papers reporting on dense assemblages of benthic infauna [animals living in seafloor mud, sand, and detritus] elsewhere. Then I started talking to the people who wrote them."

Although he has not found a report that surpasses his own, Vetter is confident that hot-spots occur elsewhere, and not just in detritus mats. For example, the hydrothermal-vent communities of the deep-ocean floor may prove more productive. And, in the past, dense layers of krill (planktonic crustaceans) have been reported in submarine canyons off of Georges Bank, the highly productive fishing grounds of the northwestern Atlantic.

Vetter suggests "These layers may result from a funneling effect that concentrates krill into the canyons as they migrate deeper during the day." Researchers studying the situation believe squid and fish stocks may be subsidized by exploiting this resource.

Of such hot-spots, Vetter concludes: "Hyperproductivity has important ecological consequences, and probably enhances commercial and sport fisheries over wide areas. It deserves further study."