searchers lack good data on the levels of organochlorines in seals that died and on those that survived the PDV oubreak.

Something Fishy in Great Lakes

Environmental scientists applauded the news last May that several toxic pollutants in Great Lakes water had sunk to their lowest levels in two decades. But one finding left them puzzled: Many species of lake fish are just as tainted by pollutants—including PCBs and DDT—as they were several years ago. How can levels of these damaging compounds remain high in the fish when they're falling in the lakes?

New evidence presented in Denver suggests that invaders are to blame. Not humans, but two organisms introduced into the Great Lakes within the past 15 years. These two, the zebra mussel and a zooplankton known as BC (*Bythotrephes cederstroenii*), seem to have been sucking organochlorine pollutants out of the water and concentrating them in the food chain. The bad news for humans is that the two species are favorite snacks for little fish that are consumed by the Coho salmon, another non-native species that is fished commercially and for sport.

The levels of DDT and PCBs have been declining since the U.S. government banned the compounds in the 1970s. PCB levels in Lake Superior, for example, fell from about 2 nanograms per liter in 1978 to less than 0.5 nanogram per liter in 1992. But David DeVault, an aquatic biologist with the U.S. Environmental Protection Agency (EPA) in Chicago, David Anderson of EPA, and Robert Hesselberg of the National Biological Survey found that levels of PCBs and DDT in lake trout, walleye, and Coho salmon have held steady in some Great Lakes regions—and even gone up slightly over the past few years in others.

One probable culprit is BC, a species of zooplankton brought to the Great Lakes in the ballast of Eurasian ships in the late 1970s or early 1980s. BCs, which contain elevated levels of organochlorine pollutants drawn from the water, are eaten by another exotic species, the alewife fish. Great Lakes Coho salmon feed almost exclusively on alewife, says DeVault.

Ohio State University scientists who presented findings at the meeting also put the blame for the high toxicity in fish on zebra mussels, but through a different mechanism. The researchers believe feces from the pollutant-laden mussels (which are so numerous in Lake Erie that the population can filter the lake's entire volume in one week) are consumed by invertebrates living in lake sediment. The invertebrates are then eaten by fish, which leads to the buildup of the pollutants in predators higher up the food chain.

–Richard Stone

PALEONTOLOGY

Crowding Innovation Out of Evolution

Life in the sea, with the exception of a brief creative frenzy half a billion years ago, has been in a rut. And scientists wonder why. About 530 million years ago, during the Cambrian Period, after a long period in which animals were essentially jellyfish or worms, marine animal life exploded into a variety of fundamentally new body types. Arthropods turned up inside external skeletons, mollusks put on their calcareous shells, and seven other new and different body plans appeared; an additional one showed up shortly thereafter. But since then, nothing—at least in terms of basic body types, which form the basis of the top-level classification of the animal kingdom called phyla.

A new look at the worst of times in the history of life suggests there may not have been any more room for invention. The analysis, presented last month at the Geological Society of America (GSA) annual meeting in Seattle, lends support to the idea that once evolution fills the world with sufficient variety, further innovation may be for naught. There are only so many ways marine animals can feed themselves—preying on others or scavenging debris, for example. And there are only so many places to do it—on the sea floor, beneath it, or some distance above it. When all the nooks and crannies of this "ecospace" are filled, latecomers never get a foot in the door.

Paleontologists David Bottjer of the University of Southern California, Jennifer Schubert of the University of Miami, and Mary Droser of the University of California, Riverside, tested this theory by zeroing in on a period when ecospace should have been emptier than at any time since the Cambrian: the immediate aftermath of the mass extinction between the Permian and the Triassic periods 251 million years ago, when perhaps 95% of all marine species perished. Yet no new body plans appeared.

That might seem to contradict the ecological hypothesis, but, in fact, Bottjer and his colleagues reported at GSA that extinction's bite out of ecospace may not have been large enough to allow new phyla to appear. In part they sized up that bite by analyzing the abundance of stromatolites—pillars or reefs of blue-green algae and cemented sediment. Stromatolites thrived during the 2 billion years before the Cambrian, then took a nose dive as the first animals appeared in the fossil record. The algae pillars retreated to harsh environments like briny lagoons where the new creatures that grazed on them couldn't follow. Through field work and literature searches, Schubert and Bottjer found that while stromatolites rebounded during the first few million years after the Permo-Triassic blight, they didn't quite rebound to their pre-Cambrian abundance. This limited return indicates there were still predators around to keep the stromatolites in check—in other words, postextinction ecospace wasn't as empty as it was when the Cambrian explosion struck.

JENNIFER SCHUBERT

Simple life. This monotonous community of bivalves typifies life forms after the Permo-Triassic extinction.

More direct evidence that ecospace was occupied comes from animals that live on the sea floor, such as mollusks. Bottjer, Schubert, and Droser found that, after the extinction, the vertical range occupied by bottom-dwellers narrowed: They extended upward 5 centimeters and burrowed down 12 centimeters. But their range prior to and even during the Cambrian explosion was even smaller. The researchers therefore conclude that there was less latitude for evolutionary diversity after the Permo-Triassic extinction—because the mollusks and their relatives were occupying too much ecospace.

Although these findings are certainly consistent with ecological control of phylum innovation, they do not exclude the possibility that control lies elsewhere—in the genes, for example. However, the strengthened ecological hypothesis looks like the best explanation, according to the paleontologist who helped introduce both the ecological and genomic hypotheses, James Valentine of UC Berkeley. If, as recent studies suggest, control "isn't in the genome," he says, "it must be in the ecosystem." And if that is so, life's resilience in the face of mass extinction also ensured 500 million years of monotony.

–Richard A. Kerr