Finding a place to put the heat

The effects of heat on the ecology of bodies of water are not all known, but temperature remains an important feature in any ecosystem

by Richard H. Gilluly

Power plants, whether nuclear or fossil-fueled, are highly inefficient. Much of the heat from the plants is lost when steam that has passed through turbines is condensed back into water. The condensers are cooled with flow-through water from a nearby source, such as a river, lake or ocean. The cooling water reenters the body of water from which it came—with a temperature 10 to 20 degrees higher than when it entered the system.

The addition of heat to bodies of water is called thermal pollution by those who regard it as damaging to the ecology. But those who emphasize that the results are not always damaging prefer the term calefaction, a more neutral word which simply means the addition of heat.

The Federal Water Quality Administration this year has begun a major campaign against thermal effects from power plants. It has asked for an injunction against Florida Light and Power Co., which plans to build a canal to carry heated effluents into Card Sound south of Miami (SN: 2/28, p. 219). And it has asked that states surrounding Lake Michigan adopt water quality standards which would allow effluents to be no more than one degree above the natural temperature of the water in the lake. If such standards are adopted they would without doubt require power companies to go to cooling towers or other technologies which eliminate discharge of heated effluents altogether. Interior Secretary Walter Hickel announced recently, however, that he may alter FWQA's strict one-degree limit.

The problem will grow: Installed capacity on Lake Michigan south of Milwaukee, for example, was about 6 million kilowatts in 1969. By 1973, the figure will go to 11 million as new units go on the line. Nationwide, power loads nearly double every 10 years. The Edison Electric Institute says the nation's installed capacity at the end of 1969 was 315,000 megawatts and is expected to reach 576,000 megawatts by 1980, and EEI's estimates have been over-conservative in past years. By the year 2000 some 50 percent of all waters flowing across the surface of the United States would have to be used to cool power-plant condensers given existing technology and present trends in power use.

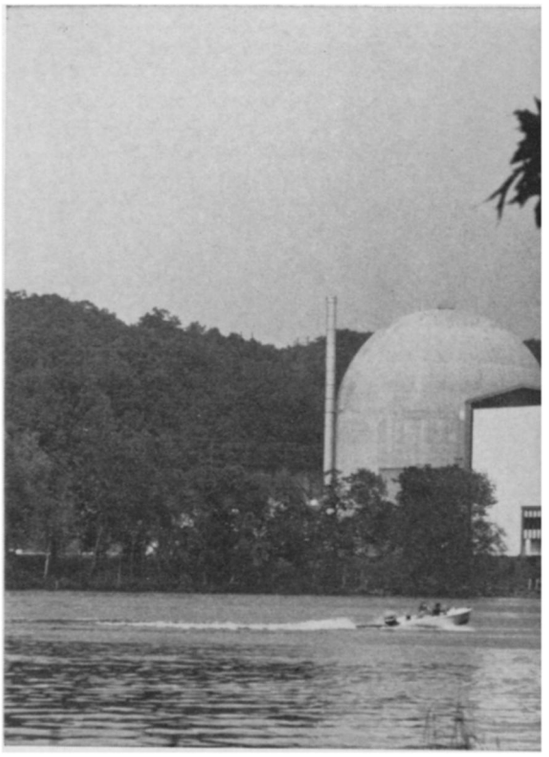
An additional problem is that much of the increased load is for air conditioners. Thus power plants experience their peak loads in the summertime—when the waste heat is most damaging and when it is least usable for other purposes, such as heating greenhouses.

The effects on the ecology of bodies of water from the addition of heat are still very poorly understood. But most ecologists agree that temperature is one of the most important features in any ecosystem, and some ecologists have even classified ecosystems according to their temperature range. Any change in temperature cannot help but have major effects.

"Temperature is very important in any environment," says Dr. William S. Osburn of the Atomic Energy Commission's environmental sciences branch. "When you raise the temperature anywhere, you can't help but drive it over the level where at least some of the myriad organisms in the system cannot survive." And he adds that generally the raising of temperatures is more traumatic to organisms than the lowering of them.

But whether the overall effects of calefaction are harmful, harmless or even beneficial depends very much on the specific local situation. The Montana Power Co. recently went on the line with a 180,000-kilowatt plant on the Yellowstone River near Billings, for example. The Yellowstone has its source in the mountains to the southwest of Billings, and it is a clear, cold stream supporting trout and other game fish from its source to about 50 miles downstream of Billings. There it becomes a warmer, Midwestern type of ecosystem, inhabited by sauger and catfish, for example, instead of trout.

With the new power plant, the temperature of the entire river below Billings has been raised a degree to a degree and a half, according to a thermograph operated by the Montana Fish and Game Department. On a hot summer day, the water temperature goes as high as 79 degrees F. "Trout can survive this temperature for short periods,"



Nuclear power plant: Increasing the water tem

says Clinton Bishop, fisheries biologist with the Fish and Game Department. "But it is much too high for an extended period."

With the single power plant, the periods of high temperature have not been extended enough to kill the trout. Thus the Yellowstone remains a mountain-type ecosystem as far downstream as before, except insofar as other kinds of pollutants damage it.

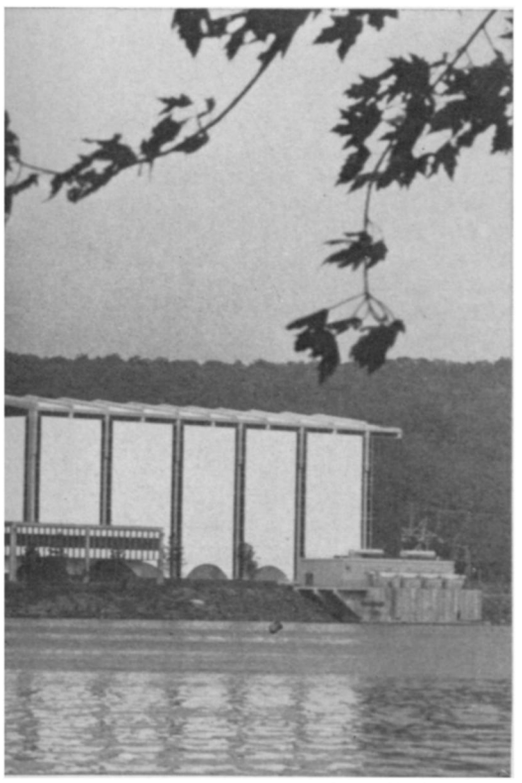
"But if more power plants were added, this could change abruptly," Bishop says. Thus, the State of Montana has adopted water quality standards which probably will prohibit additional water-cooled plants at the Billings site.

Whether moving the Yellowstone's transition point 50 miles upstream would be disastrous or not is a question that is asked, of course. "We think it would be," says Bishop. "The people here are trout oriented. It would be a great loss."

Another problem—on the Yellow-

stone and elsewhere—are the synergistic effects of heat with other pollutants. The Billings sewage treatment plant provides only primary treatment. Already there is a problem of eutrophication and consequent oxygen depletion downstream from the treatment plant. "All biological processes are speeded with heat," says Bishop. "Even with the single power plant, the eutrophication problem has been aggravated."

The Florida situation is more clear cut than the Yellowstone River one. Florida Power and Light Co. operates



Conn. Yankee Power

perature can either help or harm ecology.

two fossil-fueled units at Turkey Point on Biscayne Bay. The two plants—with a total capacity of 864,000 kilowatts—take in about 1,270 cubic feet of cooling water per second to cool steam. The company plans two new units, both nuclear, at the site, and they will triple the capacity; they also will quadruple the heat output—because nuclear plants are less efficient than fossil-fueled ones.

The company wants to build a canal to Card Sound for the effluents from both the old and new plants. FWQA and the Florida state government oppose the canal because they believe it would merely transfer damage from Biscayne Bay to Card Sound. A suit asking for a temporary injunction against construction of the canal was refused by a Federal judge recently on the grounds that construction itself would not be harmful. But he did not eliminate the possibility that he might rule against actually using the canal if the effluents were found to be causing ecological damage.

And there appears to be little doubt that effluents from the existing plants have done severe damage in Biscayne Bay, according to FWQA. Moderate to severe damage to life has occurred in an area of about 670 acres in an irregular pattern out into the bay from the plant outlet works. Severe damage—the virtual killing of most life on the bottom—has occurred in a 300-acre area. Among the casualties are fish, shrimp, crabs, molluscs, worms and plant life. Also affected are estuarine corals. "The vast majority of organisms were killed," says Lee Purkerson, FWQA biologist.

What is worse, far more widespread subtle effects will take place, probably in the entire southern portion of Biscayne Bay, if the company continues to discharge heated effluents, according to Purkerson. The plant itself acts as a kind of huge predator, killing larvae and eggs that go through the condensers. Temperature is critical in spawning of most fish, and alteration of temperature either causes spawning to take place at the wrong time or prevents spawning altogether.

The reason for the severe effects in Biscayne Bay is that natural water temperature is high, sometimes approaching 90 degrees in shallower areas. Organisms have made a fine adjustment to this temperature and even small increases cause problems. "When it gets to 92 degrees, there are definite kills," says Purkerson.

Water temperatures in the vicinity of the plant outlet have reached 103 degrees 300 yards offshore, and 95 degrees is usual in much of the affected area. Purkerson believes that moving the effluent to Card Sound will simply transfer problems there—in addition to interfering with tidal flows and salinity.

The Lake Michigan situation has features in common with Biscayne Bay. Water circulation in the shallower areas of the lake is slow, and thus heat is dissipated into the lake slowly. These shallow areas are used by fish for spawning. Too much additional heat can upset this very fragile process, which depends on precise temperature changes in the springtime to trigger reproductive activities.

Thermal effects are not always harmful. The AEC heats a 2,800-acre pond with waste heat from a reactor located near the Savannah River in South Carolina, and fishermen are pleased because of the increased growth rate of fish, including bass. Dr. Daniel Merriman of Yale University reports that a study of the Connecticut River where effluents from a nuclear power plant enter it shows no indication of short-term damage (SN: 5/30, p. 532). He suggests that long-term effects may be beneficial—although he concedes that these are not yet measurable.

But there is no doubt that profound ecological alterations usually take place when heat is added to water. Some of these are very subtle. "For example," says Dr. Osburn, "the behavior of animals which are thermally shocked may alter even after they return to normal temperatures. Catfish stop patrolling and defending their territory after thermal shock. These behavioral changes, especially if they involved reproduction, could amount to extinction."

Little is known about the effects of heat on the various life stages of various animals. Heat increases that might not harm adult animals could be lethal to the same animals as larvae. Temperature changes trigger many biological cycles: migration, spawning and hatching, for example.

There are a number of possible solutions to the thermal problem, all of them fairly expensive. Cooling towers —which cool steam to water through evaporation—have long been used in water-short areas. Also possible are cooling ponds where transpiration of water from plants—such as mangrove trees or cattails—might provide a different kind of evaporative cooling. In dry areas, such as parts of the Pacific Northwest, it has been proposed that water from power plants be used for irrigation. The heat in the water might lengthen the growing season and increase crop productivity.

But these techniques are not feasible in many areas. Even cooling towers pose the problem of adding excess heat and humidity to the air some places. Estimates of the added cost of cooling towers or other new technologies run as high as 20 percent of the total cost of producing power. However, power production averages only about a fifth of the total cost of bringing power to homes and businesses, and thus the additional cost to the average user might amount to about four percent. On an average homeowner's $10 monthly electric bill—for 500 kilowatt hours—this would amount to 40 cents.

Another approach is the development of wholly new techniques for power generation. Magnetohydrodynamics, which converts heat almost directly to electrical energy through use of a high temperature ionized gas as a conductor, would very substantially reduce waste heat, for example (SN: 2/14, p. 172).

But most such exotic techniques lie in the distant future. Lack of Federal or industry funds for research and development have reduced further the possibility of commercial feasibility soon. It appears that like so many environmental problems, thermal pollution will be solved only by an infusion of money and the passage of time. □