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# An Argument for the Open Ocean Siting of Coastal Thermal Electric Plants

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ABSTRACT

A great deal of research is yet to be done before we will definitely know all the effects of thermal electric generating plants. It is evident, however, that the chlorination of the intake water is definitely lethal to a high percentage of planktonic and other organisms; that thermal shock is detrimental to some of the more sensitive forms; that the continued exposure to high temperatures after thermal shock is lethal to many forms, especially the zooplankton; that the screening and turbulence in such plants is lethal to larval fishes and several invertebrates, and that immense amounts of waters are put through the plant and such transfer can be detrimental.

In view of these findings, I believe that in most instances bays and estuaries are not suitable for the location of a number of thermal electric plants. Discharges to the open ocean should be encouraged or required because acre for acre our bays and estuarine waters are more important and valuable for the production of marine life than is the open ocean. It is certain that we must have electricity; that the demand for electricity will increase, and that these plants must be built. It is recommended, however, that each situation be examined as to all possible adverse effects, and that these plants be so located or corrective measures built in so that they cause the least amount of damage to the aquatic environment and the various water uses. If damage cannot be prevented, it is best to damage the least valuable area.


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As more and more thermal electric generating plants are built or are enlarged to supply needed electricity, the problem of their effects on the aquatic environment becomes more serious. This is especially true for estuaries and bays. While one small plant might not cause significant harm, it is certain that the number of plants is increasing, and this increased load can be very harmful to the aquatic biota.

The problem is also increased by the conversion from fossil fuels to atomic generating plants, because the latter are less efficient and add considerably more heat to the aquatic environment for the same amount of electricity generated. An examination of the literature on the increase in temperature with different amounts of cooling water indicated that on the average, a 1,000-megawatt plant will require, for cooling, 4.9 million liters/min of water (1 million gal/min) and the temperature of this water will be raised 10C. This is an immense volume of water, equal to the low flow of many of our sizeable rivers. Plants with a capacity of 3,000 and 5,000 megawatts are now planned.

In the past, discussions of the effects of these plants have considered only the increase in temperature of the receiving water. However, these plants have several other effects which are definitely detrimental to the aquatic populations and the environment. The effects of thermal electric plants on the aquatic environment can be classified under six headings, as follows:

### TOXICITY DUE TO CHLORINATION

Chlorination of the intake waters in order to prevent fouling in the intake structures and damage to the condensers results in serious damage to not only many entrained organisms, but also those in the receiving water[3]. In the USA, chlorination is daily and intermittent and the time usually used for the operation varies from 10 to 45 min or more for each condenser[3]. Thus, a plant that has 4 condensers would be chlorinating their water for an over-all period of as much as 3 hours during each 24-hour period. However, chlorination for 6 hours per day has been reported (1). Treatment rate varies from a little more than 1 to 13 ppm chlorine in different plants. Concentrations of residual chlorine in the plant effluent varies. Data on this are meager but levels of 0.1 to 2.5 ppm have been recorded and reported[3]. In England, the most common procedure is to treat continuosuly at 0.5 ppm chlorine with the result that there is probably very little residual chlorine in the effluent from the plants. (Verbal communication from Dr. P. D. V. Savage of the Central Electric Generating Board, Fawley, Southhampton, England.) Concentrations of free chlorine of 0.1 ppm and lower can be toxic and lethal to many aquatic organisms as demonstrated by laboratory studies at the National Marine Water Quality Laboratory. Studies conducted to date by the National Marine Water Quality Laboratory at two thermal electric plants have indicated that during periods of chlorination 95 to 100% of the entrained organisms are killed. Kills due to chlorination are especially severe in northern areas in the spring and winter months when many fishes and other organisms are attracted to the warmer waters in the effluent canal or plume.[3] Those observed to be killed in this manner at a northern plant include alewives, menhaden (over a foot in length), squillid shrimp, small lobsters, and winter flounders. These kills occur after each chlorination, that is, daily. At one plant under study, fish kills became so extensive that chlorination was discontinued for a time.

Studies of the toxicity of chlorine at different concentrations and exposure times have indicated that a one-min exposure to 1 ppm and above of chlorine is lethal to certain diatoms.[3]

### THERMAL SHOCK

In passing through the condensers, the water surrounding the organisms is suddenly increased in temperature. With usual increases in temperature, 8 to 10C, this causes a thermal shock which will be immediately lethal to a few species, but lethal effects can be increased with greater increases in temperature. An immediate visual examination of water which has passed through a condenser will reveal many live and apparently unharmed zooplankters. This has led several investigators to conclude that the organisms are not harmed. However, studies have shown that there is a delayed lethal effect within a few hours and a large percentage of the entrained organisms may be killed.

Severe kills occur during periods of natural high water temperatures; namely, July and August. When the temperature in the condenser and the effluent exceeds the critical thermal maximum temperature of an organism, it is killed. *Acartia clausi* acclimated to 5C are killed when the temperature reaches 28C. When acclimated to 10, 15, and 20C, they are killed by a temperature of 32C. The maximum temperature from which they can recover when returned to water of ambient temperature depends on the acclimation temperature. For *Acartia clausi,* the acclimation temperature and the highest temperature which they can survive are as follows: 5 to 23C, 10 to 15C, 25 to 27C, and 20 to 28C. In the New England area, *Acartia tonsa* if acclimated at 25 to 27C can tolerate a temperature up to 37C for 9 min.

### ADVERSE EFFECTS OF HIGH TEMPERATURE

After being subjected to a thermal shock, the organisms are further subjected to elevated temperatures for varying periods, depending on the volume of water in the plume discharged from the plant and the confinement of this water. If the water is carried away in a ditch or canal, the organisms may be exposed to the elevated temperatures for periods up to several hours (2). Although planktonic organisms may not be killed immediately due to heat shock after passing through the condenser, it has been found that if they remain for several hours in the heated water, such as they may in a plume or in a canal carrying the heated water from the plant, that many of them are killed outright, or the photosynthetic ability of algae is greatly reduced, as much as 90% (1)[3]. In a southern plant, it was found that during July and August 50% of the phytoplankton and 85% of the zooplankton were killed due to heat shock and subsequent exposure to the elevated temperature.

[3]Unpublished reports and data of the Staff of the National Marine Water Quality Laboratory.

## INJURIES DUE TO PLANT PASSAGE

Perhaps the greatest damage to the marine biota results from the mere passing of such tremendous volumes of water through the thermal electric generating plants (2). The water used by each of these plants represents the flow of a sizeable river and the largest plants now planned or in use will have a flow through the condensers of 5,000 $ft^3$/sec or more. This is comparable to the low water flow of our larger rivers. (Col. West of the US Corps of Engineers stated in a personal communication that the recorded low water flow of the Ohio River at Cincinnati before impoundments was 2,000 cfs).

The detrimental effects of the diversion of water for irrigation and the need for screens to keep fishes from irrigation ditches are well known. The immense flow of water through the power plants results in strong currents which carry many organisms with it. Bar screens or trash racks and revolving screens are designed to keep trash, vegetation, and solid materials out of the condensers and not to save fish and other aquatic organisms which may be swept into the plant. There is often no provision for bypasses to rescue organisms from these screens. The majority of those caught in this way are the benthic species and the weaker swimmers. However, a diversity of species are caught in these screens, among them crabs and fishes such as menhaden, alewives, sea robins, hog chokers, and other locally abundant species. The larger of the forms which pass through the trash screens may be caught on the revolving screen and flushed through a sluiceway to the discharge canal. The opportunities for mechanical injury in these operations are great. The smaller forms such as the larvae of fishes, arthropods, molluscs, and worms pass through the screen and are carried through the plant. In this process, they are subjected to great turbulence and shearing forces. Large schools of transparent larval menhaden 2.5 to 3.8 cm (1 to 1.5 in) long were observed in the intake of one of the plants under study. These are best noted by their dark eyes. In the plant outlet, all that could be found were the eyes; the fish were torn to pieces during their passage through the plant. The same destruction was observed with the larvae of several other species of fish, ctenophores, and arrow worms.

Because of the great reproductive capacity of marine organisms, some might argue that in a large estuary even the great amount of water and the destruction of its contained marine life upon passing through a thermal electric plant would not be significantly harmful to the production of marine life resources. However, in our large estuaries, such as Chesapeake Bay, which now has over 30 plants and several more planned, the total volume of water passing through the plants will be a very significant percentage of the total volume of the bay.

Many marine species have short reproductive periods. While large numbers of larvae may be observed, it must be remembered that they can be greatly concentrated in local areas. Dense populations of crab and worm larvae have been observed in isolated water masses. It is conceivable that a water mass containing the young organisms could be drawn into the plant cooling system, seriously reducing the number of surviving larvae for continuing the population and the production of a crop for that year or that year class.

## UNDESIRABLE WATER TRANSPORT

The fifth effect of the operation of these plants is the great transport and movement of water. Several of these plants on an estuary could pass the entire volume of the estuary through their condensers in a relatively short time (2). It is evident that plants on estuaries use and move immense quantities of the estuarine waters. If these waters are discharged to another area or pass out to sea, in a short time the estuarine water will be largely removed and replaced by seawater which is of entirely different character. Neglecting the harmful effects of heat shock, high temperature, toxicity, and mechanical injury, the mere removal of the water can be very detrimental, because these estuarine forms may be removed from sheltered areas and discharged into the open ocean or into a small bay or estuary where the outflow to the sea must be rapid. Further, the ocean forms brought in with the ocean water that takes the place of the bay or estuarine water may be entirely unsuited to bay or estuarine conditions. The estuaries are the nursery areas for many species. It has been estimated that about 90% of the important commercial and recreational species use the estuaries as their nurseries. Thus, acre for acre, estuarine waters are more important and valuable than are the open ocean waters. It is certain that we must protect our nursery areas. It is believed that, in this instance, protection can be most effectively obtained by placing thermal electric plants on the shore where they can take their water from and discharge their effluent to the open ocean.

## REFERENCES

1. Hamilton, D. H., Jr., D. A. Flemer, C. W. Keefe, and J. A. Mihursky. 1970. Power plants: Effects of chlorination on estuarine primary production. Science 169:197–198.
2. Tarzwell, C. M. 1970. Proc. Conference in the Matter of Pollution of the Navigable Waters of Biscayne Bay and its Tributaries in the State of Florida, US Dept. Interior, Fed. Water Poll. Contr. Admin. 1:264.