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NAVY UNDERWATER SOUND LAB NEW LONDON CT
ASPECTS OF THERMAL POLLUTION.(U)

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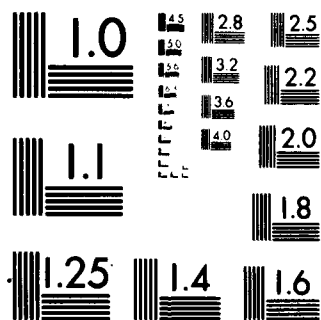
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NAVY UNDERWATER SOUND LABORATORY
NEW LONDON, CONNECTICUT

(6) ASPECTS OF THERMAL POLLUTION.

by

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Thermal pollution, the addition of heated water to the environment, is one of the many types of pollution which only recently has come to the forefront of public attention. Cairns (1956) states that in England the largest single industrial use of water is for cooling purposes, while in the U.S. in 1964, 49,000 billion gallons of water was used by industrial manufacturing plants and investor-owned thermal electric utilities. Ninety percent or 44,000 billion gallons of this amount was used for cooling or condensing purposes primarily by the electric utilities. With the increased demand for greater volumes and less expensive electric power, the power companies are rapidly expanding the number of generating plants, especially nuclear powered plants. Nuclear plants offer many advantages over conventional plants, but have one major drawback seriously affecting the environment, excess heat losses. These plants are only 40% as efficient as conventional plants in converting fuel to electricity and loss of efficiency manifests itself as waste heat. As the number of nuclear power plants and other industrial plants increase, an estimated ninefold increase in waste heat output by the year 2000 will result (Kolflat 1968, Ramirez 1968). Correspondingly, there should be an increase in the effort made to eliminate the addition of heated water to the environment. Further studies should be made to determine the distribution and dispersal of outflows of existing plants

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in order to improve the design of new plants for minimizing thermal pollution. The physical, chemical and biological effects of thermal pollution should be monitored to learn if the guidelines of pollution set up by the Committee on Water Quality Criteria of the Federal Water Pollution Control Administration are realistic or require additional modification. The Committee's report has recommended that the water outflow be no more than 5°F higher than the monthly average of the daily maximum temperature in spring, fall and winter and no more than 1.5°F above this mean in the summer. Also the rate of temperature change should not exceed 1°F per hour.

The effects of a heated outflow may be numerous. For example, possible physical effects may include increased evaporation which allied with the warmer surface water can result in foggy conditions. Vertical stratification would result in decreased mixing of the water column. This warm surface discharge might create thermal barriers, that is, a surface layer of warm water impeding the normal flow of cooler surface water. The decreased viscosity and density caused by the warmer water would result in greater sedimentation rates which may cause the geological conditions on the bottom to change with corresponding changes in the biological populations. Changes in the solubility and concentration of oxygen, carbon dioxide, and other gases may also result from heating the environment.

The possible biological effects are more subtle than the physical ones. Temperature is basic in determining the distribution as well as the physiological well being of most marine animals. The inshore marine animals of boreal waters depend upon temperature as an indicator of the time to reproduce, spawn, migrate etc. They acclimate to the environmental temperature and can withstand gradual but not rapid changes in temperature. The adults of fish are rather well able to undergo changes in temperature, but the eggs, larvae, and young are stenothermal and are only able to tolerate a small range in temperature. Most species of edible shellfish such as clams, oysters, crabs and lobsters are stenothermal and the time of clam and oyster spawning is triggered by a temperature rise above a specific temperature level. Higher temperatures may promote faster growth, but Kinne (1963) found that animals did not live as long or attain such a large size as those grown in normally cooler temperatures. The warming of water in a localized area may also redistribute many species, those with low tolerances to warm water being eliminated while those which prefer higher temperatures localizing there. Obviously these are basic effects of temperature change, but the effects usually are more complex.

The synergistic effects caused by temperature increases are more difficult to observe or evaluate, but are by far more common. Tempera-

ture rises are usually not large enough to cause lethal conditions by themselves, but by lowering the physiological tolerances, animals would be more susceptible to other toxic substances or diseases. Laberge (1950) has observed fish kills which accompanied small temperature rises which otherwise might have been relatively harmless in an area free of toxic substances.

The existence of warm water discharges will increase the rate of the Biological Oxygen Demand (BOD) of the water and therefore accelerate the depletion of available oxygen necessary for animal respiration. Also in some instances, these conditions are favorable to producing plankton blooms such as the toxic "Red Tide" blooms. Warmer water may also increase biological growth which can result in increased fouling of boats, buoys and other objects. The warmer outflows have been shown to cause exploding populations of jellyfish which make an area unsuitable for bathing or other water sports. The above examples represent just a few of the more obvious results of temperature changes which are sure to be accompanied by far more complicated, more subtle alterations in the ecosystem.

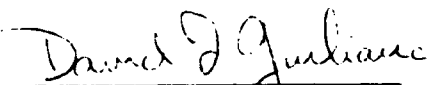
Lethal effects of thermal pollution have occurred already. At the Turkey Point steam electric plant of the Florida Power and Light Company (FP&LC) a test of two 432 megawatt oil fired steam generators at full capacity caused an effluent of 103°F to be discharged into Biscayne Bay. Observers of the Federal Water Pollution Control Administration (FWPCA) found all bottom vegetation dead within 1500 ft of the outlet and all sponges killed within 4500 ft. Many other animals were found to be dead within these areas. Water of 100°F was found 900 ft from the outlet and 90°F 1500 ft away. Although the FWPCA has set a maximum of 95°F (which also is the temperature when animals begin to die!) they were granted a variance permitting the FP&LC to exceed this temperature temporarily. There are also at the same site two 760 megawatt nuclear units which have yet to go into service! Fortunately this case is now being tried by the Federal government.

Hopefully by increased research into the effects of heated water, guidelines for setting limits on the thermal pollution will be better established. Possibly a use for the wasted heat energy could be discovered which would prove feasible economically. Applications such as aquaculture, home heating, desalination, ice prevention etc. have been proposed but as yet are not economically attractive.

Beginning in late 1970 a new nuclear generating plant will be operational at Millstone Point, Waterford, Connecticut. The heated effluent will be dumped into Millstone Quarry and then flow out into Long Island Sound. This heated effluent, when it enters Long Island Sound will be

essentially the same temperature as when discharged from the generating plant into the Quarry, because the surface area of the quarry is too small for evaporative cooling to be appreciable effective. Water which may be of a much higher temperature than that of Long Island Sound will discharge into the Sound with minimal mixing, because the sill depth at the point where the quarry joins Long Island is only about 8 ft deep, and unless the volume and velocity is very great the flow will be virtually laminar. There will, therefore, be a warm or perhaps hot layer of surface water flowing out of the quarry. This warm surface layer could be blown back into the shore in the summer south westerly winds or be blown out into Long Island Sound in winter northerly winds. A rapidly changing temperature cycle caused by changing tides and winds could very likely introduce a thermal shock to the organisms in this area.

The Oceanography Branch is now undertaking a preliminary survey of the area to determine how best to monitor the effects of the heated effluent. Although the effects of heated discharges cannot be ascertained in advance in the field, it is hoped that the effects will be well documented so that any necessary corrective measures will be undertaken before serious damage results. Together with other Laboratories such as University of Connecticut, Batelle Laboratories, University of Rhode Island, etc... which are working in the area off Millstone Point much data will be available by the time the second nuclear reactor is placed into service in 1972 or 1973.



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