as the size and construction of the condenser, will be difficult to specify until a pilot plant can be built. Much progress has been made in recent years in heat-exchange technology. The use of surfaces plated with a noble metal to promote dropwise condensation, for example, might greatly reduce the required condenser area below that of conventional equipment (*12*). A condenser 200 m long and 10 m high would intercept about 1 billion (10^9) m^3 of air (moving at 6 m/sec) per day. With perfect efficiency our condenser might recover about 8000 m^3 of water per day. Realistically, we might recover half this amount, giving us the desired 3790 m^3 (1 million gallons).

Figure 2 also indicates some additional benefits that would accrue through the use of this system. The depth of 900 m from which seawater would be pumped corresponds (in this and many other ocean areas) to the depth of maximum nutrient salt concentration (Table 1). The content of dissolved phosphate and nitrate essential in biological productivity in the ocean is 10 to 20 times greater in this level than at the surface. Ryther (*13*) has shown that tropical seas have consistently low productivity owing to the paucity of nutrients from deeper levels. By contrast, the most productive waters in the world result in areas where upwelling of nutrients from deeper levels takes place. These considerations led Pinchot (*14*) to suggest chemical fertilizing and the pumping of deep, nutrient-rich water into circular atoll lagoons in order to culture captive whales. This proposal, which has been termed the "Coral Corral," would take advantage of the baleen whale's high efficiency in turning zooplankton into usable protein. Seawater flowing out from the condenser of our plant (unlike the harmful brine of a desalination plant) would thus be a valuable asset. Water in the zone of maximum nutrients contains about 2.0 μg-atoms of phosphorus per liter (*3*), or about 62 μg/liter. Our 114,000 m^3 (30 million gallon) per day input, containing 7200 g of phosphorus, would be delivered to a small lagoon where highly productive aquiculture experiments could be conducted. With a four-times-larger input of nutritious deep water providing 5 g of food per square meter per day, Pinchot calculates (*14*, pp. 37–38) that a lagoon 1.6 km (1 mile) in diameter could produce about 1 ton per week of food fish, or ten times this amount of plankton protein at the second trophic level.

Although many engineering problems require solution, the system outlined appears economically attractive, with the expectation of modest construction costs and very low operational costs. Its numerous advantages over desalination processes include low operating cost and simplified equipment and procedures. The proposed system may have important economies related to scale and location: a small island with a limited technology is not a likely place to install an atomic-powered desalination plant but might readily use the atmospheric water recovery method. We believe a detailed study will confirm the soundness of this plan. The best way to test these ideas is to construct a pilot plant. Preliminary tests might consist of setting up, in different areas, small, portable condensers using refrigerated water. Later phases of the program could use actual deep, cold seawater after a pipe line has been laid. Once the system has been refined, it might be feasible to make a ship-mounted system available, to be moved to a coastal area where an emergency develops. A large tanker could be a combined platform, storage vessel, and pumping station.

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Ionospherically Propagated Sea Scatter

Abstract. *Measurements of the spectrum of high-frequency radio waves scattered from the sea surface and propagated by the ionosphere show that the expected split-spectrum characteristic of scatter from the sea is preserved and suggests the possible use of high-frequency backscatter with a high-resolution receiving system to monitor varying sea state over wide areas.*

Several theoretical and experimental investigations of high-radio-frequency backscatter from the sea surface have shown that the scattering takes place by virtue of coherent addition of contributions from sea waves of length $L = \lambda/2$ moving radially from the transmitter-receiver, where λ is the wavelength of the observing frequency. The phase velocity of sea waves of length L is $(gL/2\pi)^{1/2}$. Thus, the Doppler shift of energy scattered by sea waves is given by

$$\Delta f \cong (g/\pi\lambda)^{\frac{1}{2}} \qquad (1)$$

where g is acceleration of gravity (*1*).

If sea waves are moving toward the transmitter, a positive Doppler shift is encountered, and a negative shift is associated with waves moving away. Over a region of several thousand square kilometers, waves moving in opposite directions may be encountered, and thus the spectrum of the signal would be of a double side-band nature. Characteristics of this type have been seen by direct scatter observations (*2*) and have been suspected in ionospherically propagated sea scatter (*3*). A resonant scattering depending upon standing sea waves has been suggested to explain fading of sea scatter and sea scatter

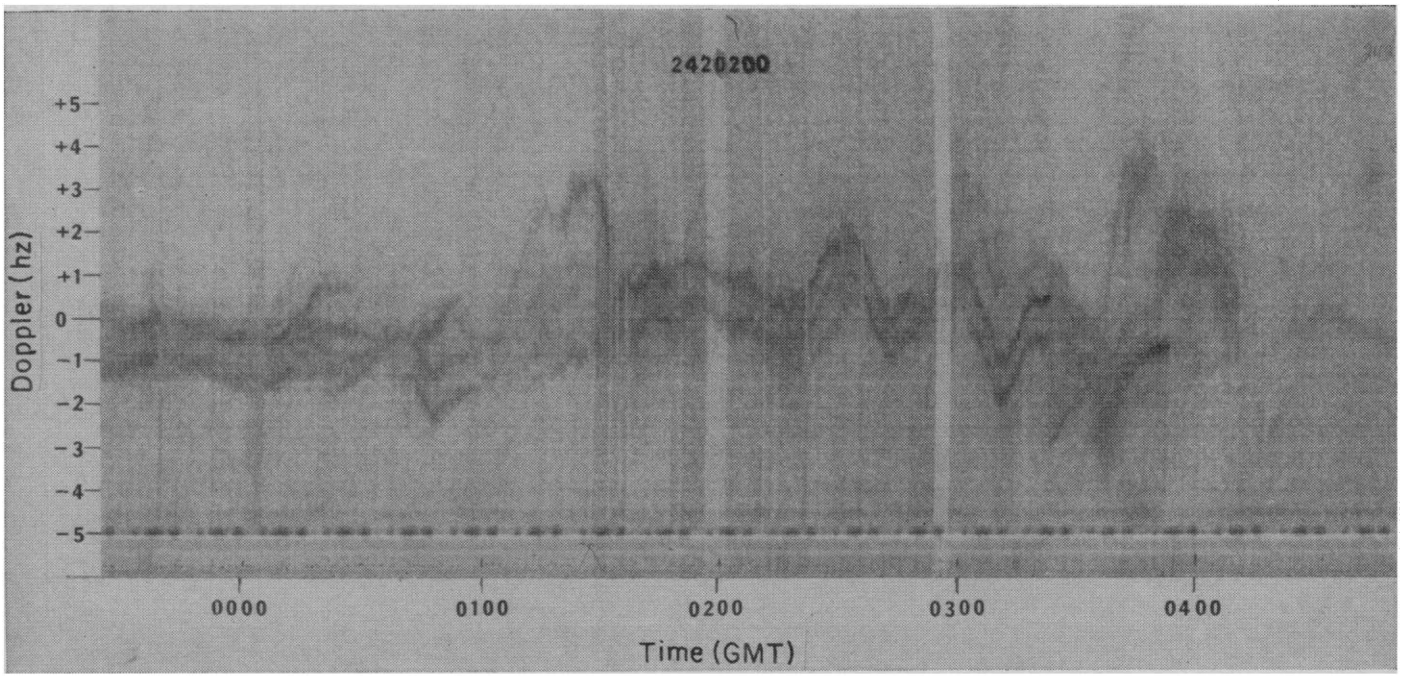

Fig. 1. Doppler record of backscatter from sea surface located 580 km from center of hurricane Inez on 6 October 1966.

with no associated Doppler shift (see *4*).

It is important to know whether the spectrum characteristics described above are preserved in easily recognizable form at high frequencies in sea-surface backscatter signals that are ionospherically propagated. On the basis of a few observations, it appears that under some conditions they are preserved.

During part of the time when hurricanes Faith and Inez were active, coherent backscatter observations at 19.8 Mhz were made with the high-resolution antenna array and pulse backscatter sounder (located near Boulder, Colorado) of the Institute for Telecommunication Sciences and Aeronomy (*5*). This array has a beamwidth of slightly less than 2° at the operating frequency. Spectrum analyses of the signals were conducted for different group-path lengths to sea-surface regions at varying distances from the hurricane center. Figure 1 shows the behavior of the spectrum content of backscatter signals over a period of several hours on 6 October 1966, at a range of 2300 km from Boulder and about 580 km from the hurricane.

The signal shows evidence of a split spectrum corresponding to wave components moving toward and away from the sounder. The separation (about 0.9 hertz) is what one would expect for the operating frequency from Eq. 1, if the small effect of nongrazing incidence is neglected. The common variation of both the components about zero is imposed by the ionosphere

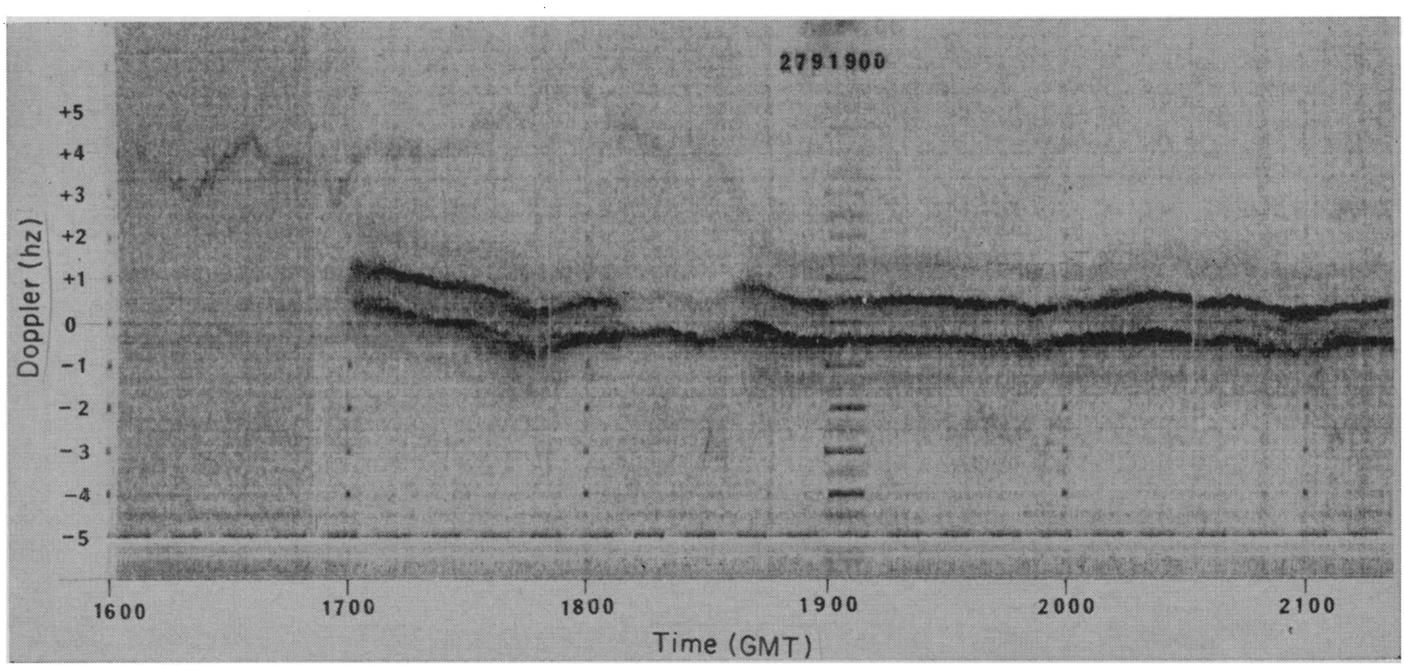

Fig. 2. Doppler record of backscatter from sea surface under disturbed ionospheric conditions.

during the refraction of the radio waves back to earth. Backscatter from land should show only the ionospheric spectrum shifts. A few observations at other times indicate that the split spectrum is not uniquely associated with the sea during a hurricane.

The split Doppler spectrum is not always shown as clearly. Sometimes one component is emphasized, and sometimes a third component corresponding to a condition of no surface-generated Doppler shift is also present. This component may possibly originate from nearby land contributions or from certain sea-state conditions.

During times of ionospheric disturbance, a sea-scatter spectrum record may appear as in Fig. 2. The spectrum is again sometimes recognizably split despite the large superimposed ionospheric Doppler perturbations. Backscatter samples from regions where the sea-wave motion was predominantly in one direction would be extremely difficult to identify as sea scatter under such disturbed conditions.

These observations suggest that, under favorable ionospheric conditions, the spectrum signatures of ionospherically propagated backscatter from the surface of the earth could be used to determine whether scatter was from land or sea. In addition, stronger emphasis of one component over another might be used to deduce sea-wave direction, other sea-surface conditions, and thus wind or weather systems over the several hundred thousand square kilometers of sea surface observable by a properly placed backscatter sounder at distances of several thousand kilometers.

Further research into these aspects of backscatter sounding is required before feasibility or usefulness of high-frequency ionospherically propagated backscatter for the monitoring of sea or, indirectly, of meteorological conditions can be established.

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Modeling Air Pollution in the Washington, D.C., to Boston Megalopolis

Abstract. *Simplified meteorological models and pollutant source configurations were used to demonstrate the types of pollutant patterns that might be encountered in the Washington, D.C.–Boston megalopolitan corridor. A semirealistic source distribution and source intensity of carbon dioxide were used in this demonstration. The results of the computations suggest that local increases in quantities of pollutants may at times require regional rather than local source consideration.*

At the present time, the study of air-pollution patterns over areas as large or larger than a state has received but little attention. Air-pollution studies are now generally directed toward understanding the source distribution and meteorological characteristics of specific metropolitan or local areas. As population and industrial activity increase, it seems reasonable to expect that an airborne pollutant from one metropolis may occasionally contribute to the total loading of that pollutant in another and that both might have a dominant effect on the air quality in the intervening rural areas. Such conjecture might be expected to be most valid in the heavily settled and highly industrialized section of the eastern seaboard between Washington, D.C., and Boston. I investigated pollution patterns in two specific situations: (i) patterns in which the wind blows continuously along the Washington, D.C.–Boston axis and (ii) annual average pollutant patterns associated with an annual wind-direction distribution.

The pollutant used for demonstration purposes is carbon dioxide as estimated from total values of fuel usage in each state. Information on state fuel usage was obtained in discussions with personnel of the American Petroleum Institute (Washington, D.C.), the Bureau of Mines, Department of Interior (Washington, D.C.), the Institute of Gas Technology (Chicago, Illinois), and the National Coal Association (Washington, D.C.). In all cases, the calculated CO_2 values are increments to be added to the natural background. The total amounts of fuels used in each

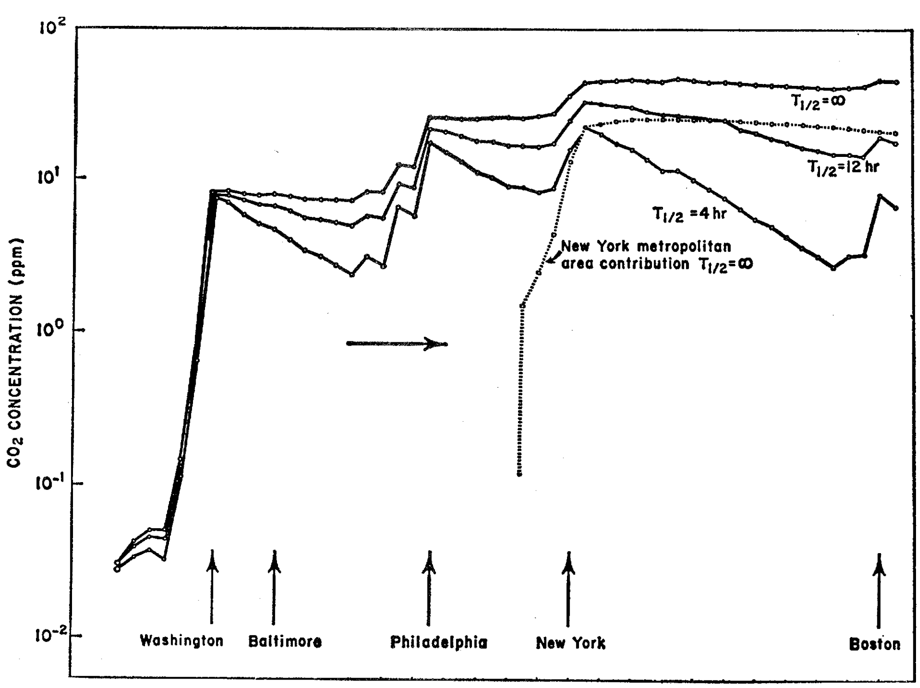

Fig. 1. Distribution of concentration increment above background along the Washington, D.C.–Boston axis for winds blowing continuously from Washington, D.C., toward Boston. Divisions on the abscissa are 30 km apart. Neutral stability conditions, an 800-m mixing depth, and a wind speed of 5 m/sec are assumed. The profile for infinite half-life ($T_{1/2} = \infty$) represents CO_2 concentration while the profiles ($T_{1/2} = 12$ hours and $T_{1/2} = 4$ hours) might represent the concentration of a gas released at the same rate as CO_2 but possessed of the appropriate half-life. The New York City metropolitan area contribution to the total concentration is also indicated.