freshwater, as well as portions of an ocean which are affected by freshwater, such as the Baltic Sea. For the purposes of this paper, however, the Chesapeake Bay was taken as an example. Geomorphologically, it is a drowned river valley or coastal plain estuary, as opposed to three other types: fjord-type estuaries, bar-built estuaries, and estuaries formed by tektonic processes. Coastal plain estuaries are further classified in terms of the degree of vertical mixing, which depends on the rate of inflow of freshwater versus the magnitude of the tidal current, and on the physical dimensions of width and depth. Depending on these factors, an estuary may go from a salt-wedge type (no mixing) to a completely mixed situation.

The most obvious parameter to control is freshwater inflow. An example is Charleston Harbor, located on the estuary of the Cooper River. Prior to a water diversion made some 30 years ago, the amount of freshwater flowing down the Cooper into the estuary was quite small compared to the volume rate of inflow and outflow of the tide, and the estuary was vertically homogeneous. When freshwater was added, it changed into a characteristic two-layered flow pattern with a surface layer flowing seaward and a deeper layer flowing up the estuary. Thus, Charleston Harbor became a trap for the increased amounts of sediment, and the dredging required to maintain the channel increased by more than an order of magnitude.

Nor is it always a good idea to reduce the very large seasonal variations in freshwater flow by controlling the river discharge through dams and through low-flow augmentation. Pritchard pointed out that the circulation in the small tributary embayments of the Chesapeake Bay is produced by salinity differences between the tributary and the Bay proper. Since the water is derived from the main Bay, the salinity in the tributary must lag behind the salinity in the Bay. If the discharge of the Susquehanna River were to be controlled to the extent that the seasonal changes in the salinity of the upper Bay were to disappear, then the prime mechanism for the flushing of a number of tributaries would also disappear. Pollution problems within the tributaries would increase and lead to significant ecological effects.

Another mechanism contributing to the flushing of tributary estuaries occurs when the tributary has a channel depth approximately equal to the depth of the parent estuary. Pritchard illustrated the peculiar convection pattern which arises from the gravitational convection induced by salinity differences. In Baltimore Harbor, the surface waters are higher in salinity than the surface waters in the Bay, and gravitational convection requires that the Bay waters flow into the Harbor at the surface. Near the bottom, however, the Bay waters are more saline than the waters of the Harbor at the same depth. The Bay waters must, therefore, also flow into the Harbor along the bottom. This inflow of water at the surface and bottom is balanced by an outflow at mid-depth. The existence of such a mechanism offers the possibility of artificially increasing the flushing rate of embayments which have little freshwater inflow but are tributaries to a partially mixed estuary, and also have a depth greater than the depth of the halocline in the adjacent estuary. One way to do this is to increase the vertical mixing in the embayment, thereby reducing the vertical salinity gradient and consequently increasing the horizontal difference in salinity between embayment and parent estuary at the surface and at the bottom.

Pritchard discussed various methods to achieve mixing, but also pointed out that engineering schemes which had been proposed for the Bay might result in unanticipated circulation patterns. For example, the present enlargement of the Chesapeake and Delaware Canal will result in the diversion of fairly fresh water from Chesapeake Bay and would undoubtedly affect the salinity regime of the upper Bay. This example, again, indicates the complex interrelations which must be considered when evaluating the balance between possible beneficial and detrimental changes which will result from a man-made modification to an estuary.

Ecological considerations were further reinforced in the discussion by L. Eugene Cronin (Director of the Natural Resources Institute of the University of Maryland), while Joseph Caldwell (Chief of the Coastal Engineering Research Center of the Army Corps of Engineers) stressed the engineering aspects of various modifications, such as hurricane barriers, again pointing to the need to investigate thoroughly the physical and biological consequences.

The symposium concluded with remarks by Stanley A. Cain (Assistant Secretary of the Interior) on the growing awareness of ecological consequences by physical scientists. "Maybe the Age of Ecology hasn't arrived yet, but we are certainly approaching it."

The program was arranged by Allen Kneese, Helmut Landsberg, and S. F. Singer. It was decided to organize it in the form of a major presentation, followed by two invited discussants who had had a chance to study the main paper in detail. In this way, the audience could witness an exchange of views by informed people, sometimes critical, sometimes complimentary, always complementary. The full account of the papers and of the discussion is to be published in *Symposium Proceedings* by the National Academy of Sciences.

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Calender of Events

Courses

Remote Sensing of Earth Resources, Berkeley, Calif., 25–27 September. Theory, current techniques, and future developments will be covered, with emphasis on applications in a wide range of disciplines including geography, geology, agriculture, forestry, range and wildlife management, hydrology, civil engineering, urban area analysis, and archaeology. Fee: $100; students, $60. (Letters and Science Extension, University of California, Berkeley 94720)

Radiation Effects in Semiconductors, Rolla, Mo., 26–30 August. The course will cover experimental approaches of the interaction of energetic nuclear and space radiation with semiconductor materials and devices, sources of the various types of radiation, and dosimetry involved, theories of the interaction of radiation with matter, and nature of crystalline imperfections. (Extension Division, University of Missouri-Rolla, Rolla 65401)

Laboratory Methods in the Detection of Rabies, Atlanta, Ga., 30 September–4 October. Laboratory training course. *Deadline for applications*: 5 August. (Training Office, Laboratory Program, National Communicable Disease Center, Atlanta 30333)

Aerospace Frontiers: Physics of Fluids, Boulder, Colo., 22 July–24 August. The courses offered are: *Quantum Fluid Dynamics*, including the two-fluid model, macroscopic quantum phenomena, and analogies with superconductivity and electromagnetism; *Dynamics of Interplanetary Material*, including theory of solar wind with and without solar rotation and magnetic field, anisotropic velocity distribution, and dynamics of cometary plasma and solar plasma; *Cosmic Gas Dynamics*, including convective zones, noise, wave propagation, shock waves, heating of chromosphere, and hydromagnetic waves. (Professor Mahinder S. Uberoi, Department of Aerospace Engineering Sciences, University of Colorado, Boulder 80302)