DISTORTION OF THERMODYNAMIC EQUILIBRIUM OF WATERSHED

COASTAL SEAS' ECOSYSTEMS

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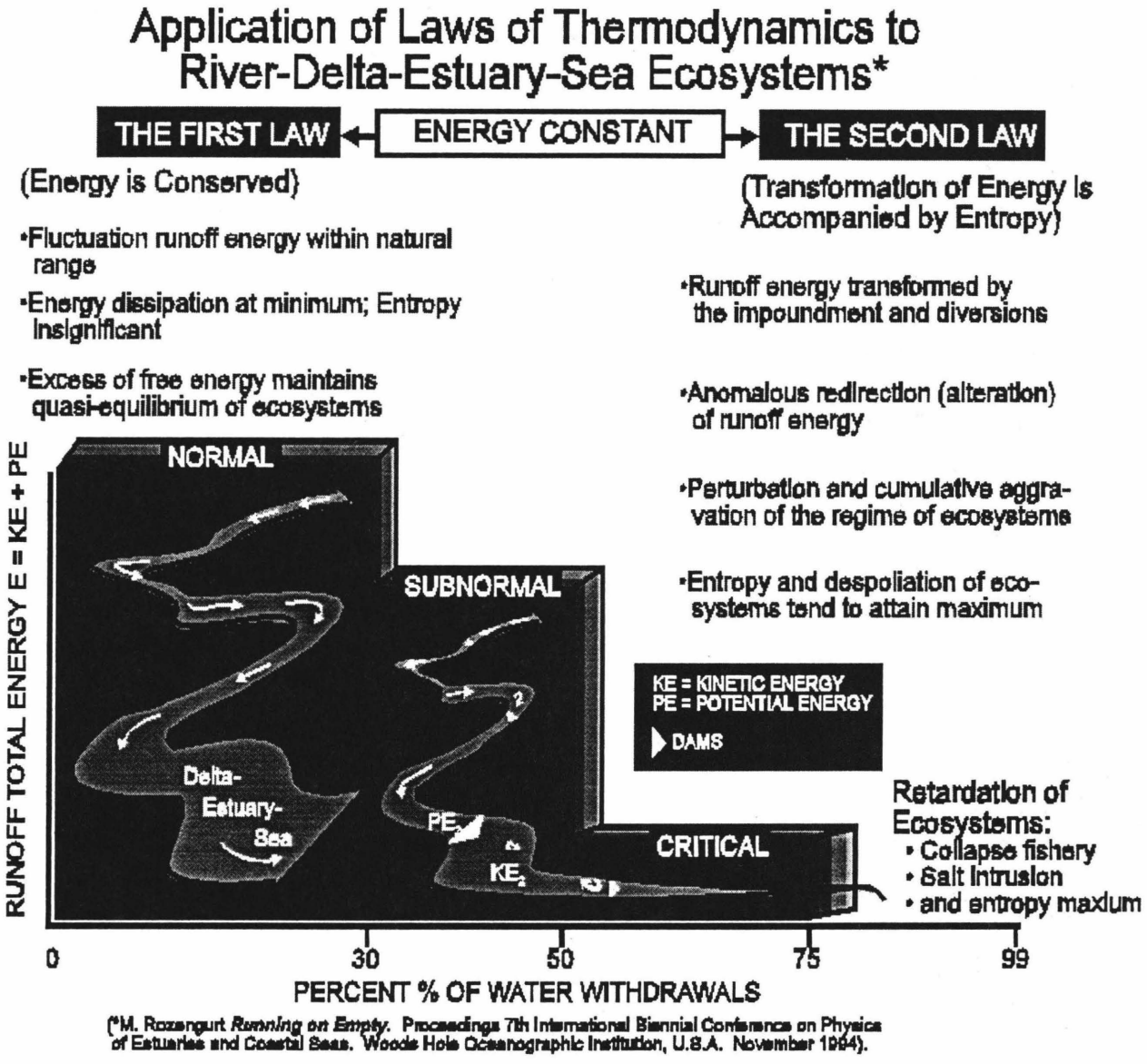
More than thirty years ago the first author concluded that when water annual withdrawals exceed 35% of a perennial norm (computed over 55 to 60 years; or 50 to 90% of normal spring runoff) then it takes an average of 10 to 15 years to impede the natural functioning of river continuum in deltaic- estuarine-coastal zone ecosystems bringing them to the brink of destruction. Today, watershed runoff depletion due to impoundment and subsequent, cumulative (seasonal and perennial) loss of water has facilitated: (1) a chronic river runoff deficit regardless of wetness of year; (2) an abnormal intra-annual redistribution of truncated flow residual; (3) annual regulated inflow to coastal seas corresponds to artificially made dry or drought conditions of a given year, particularly in spring; (4) coastal embayments have been deprived of thousands of cubic kilometers of runoff, millions of tons of sediment, nutrients, and oxygen that are vital for their survival, and (5) gradual increase of entropy that signify regime impoverishment and elimination of valuable fishery in coastal marine and large regulated lakes' ecosystems.

These anthropogenic phenomena have nearly eliminated: a) stochastic- periodic nature of watersheds' ecosystems; b) quasi-dynamic equilibrium of their water and salt exchange; (c) ecological continuity, and (d) biological tolerance.

To be precise, man's perceived needs have produced an artificial ecosystem on a new global scale, namely: **"an impounded river-lake, or river-delta-estuary-coastal seas."** Their transformations which have occurred only in the last several decades have exceeded many documented climatological fluctuations and related ecological disturbances over millennia.

This development has been exacerbated by disregarding the Laws of Thermodynamics that also apply to coastal seas as well as any other ecosystems. Subsequently, the scale of their regime modification exceeds known ecological tolerance and limitations beyond which entropy tends to reach measurable maximum (see figure).



(*M. Rozengurt *Running on Empty*. Proceedings 7th International Biennial Conference on Physics of Estuaries and Coastal Seas. Woods Hole Oceanographic Institution, U.S.A. November 1994).

In addition, methodical failure of the present analyses of in stream flow behavior in relation to water and salt balance of coastal ecosystems has accelerated the despoliation of these habitats.

However, for many years the public perception has been that discharge of outfall effluents into the marine environment were the major causes of the alarming depletion of living resources of coastal seas of the world ocean. As a result, while hundreds of billions of dollars were expended over the last few decades to improve the treatment processes, impoverishment of estuarine coastal seas' fisheries have continued to persist and traditional areas supporting commercial catches no longer exist. Oddly enough, commercial and recreational catches demonstrate an inverse relationship between them and the amount of effort and money spent on enhancing and upgrading the waste water

treatment. Although in some specific regions pollutants may have adversely impacted some local species, lacking sound scientific information some have mistakenly thought that more treatment or even "distilled" discharges will restore the coastal ecosystems' fishery. But even with "pure water" the coastal zone has been transformed into a "blue" desert. The European and American experience provides ample evidence that cumulative losses in fresh water supply during the last three decades have ranged from nearly 1,500 cub. km (Columbia River), 550 (to the San Francisco Bay) and Gulf of Mexico; 1,500 cub. km to each of Black, Caspian and Sea of Azov, and to the Nile River coastal zone, etc.

These and other irrevocable losses in water supply to estuaries and shelf have diminished the entraining effect of runoff on the intensity of advection, mixing, and repulsion of salt intrusion into the deltas, and have reduced its potential capacity for flushing of natural and man induced pollutants. As a result, catastrophic depletion (among others) of semi-anadromous and anadromous fish catches have occurred, leaving merely 1% of that of the redevelopment period of hundreds of large and small dams in 1950 and 1960.

Therefore, the systemic aggravations of regime characteristics of the coastal seas are directly linked both to excessive impoundment of rivers and the network of water conveyance and distribution facilities. The latter, when built in the deltas, eliminate the migration routes and nursery grounds for millions of estuarine dependent fish. These and other points are major topics of the presentation.