Marginal Semi-Enclosed Seas and Basins

I. Smaller adjacent seas may be used as convenient models for various changes which occur in the open ocean.

II. Isolation: an aid in studying environmental budgets.

1. Isolated basins are easier to study since areas of inflow and outflow are limited.

2. Two types of cases:

   a. Conservative: Local change = diffusion - advection

   b. Nonconservative: Local change = diffusion - advection + biological effect + geological effect

   Local change - change in material (concentration) with time averaged over a volume of water which is centered about a fixed point in space.

   Diffusion - the sum of material added or subtracted from the volume due to diffusive transport processes.

   Advection - sum of material carried in and out of the volume by currents.

   Biological effect - change over the volume due to in situ biological processes which remove or liberate materials from or to the soluble state.

   Geological effect - change over the volume due to geological processes which remove or liberate materials from or to the soluble state.

3. If a steady state condition exists, change of water and salt is zero over a long time period.

$$To + E = P + R + Ti \qquad (1)$$

and

$$To \times So = Ti \times Si \qquad (2)$$

   To = average volume of water transported to the open sea.
   E = average volume of water removed by evaporation.
   P = average volume of water added by precipitation.
   R = average volume of river runoff.
   So = average salinity of outflowing water.
   Si = average salinity of the inflowing water.

4. If we assume that R is small, relative to P and E, it can be combined with P to yield P' which is the total average contribution of freshwater to the system. It can be shown, by combining equations (1) and (2) above, that

$$To = \frac{Si(E-P')}{So-Si} \quad \text{and} \quad Ti = \frac{So(E-P')}{So-Si}$$

5. If P' > E

    a. E-P' is negative. Fresh water is removed by To.
    b. Since To is positive, So-Si must be negative. Therefore, Si > So.
    c. If salinity alone determines density, flow at entrance to sea is seaward at the surface and inward at depth.
    d. To > Ti since To = Ti(Si/So).

6. If E > P'

    a. Ti > To and So > Si.
    b. To water more dense than Ti water so outflow occurs at depth and inflow occurs on the surface.

III. The classification of semi-isolated seas and coastal embayments.

1. Factors affects seas

    a. E and P'
    b. Degree of isolation
    c. Sill depth
    d. Ratio of width to depth
    e. Amount of freshwater runoff
    f. Tidal current strength
    g. In some cases, the wind

2. Factors affecting smaller shallower seas and estuaries

    a. E and P'
    b. Tidal and freshwater flow
    c. Slope of the bottom
    d. Width, length, and depth of the system

3. Estuary - a semi-isolated coastal body of water that has a free connection with the open sea and within which sea water is measurably diluted with freshwater derived from land drainage.

    a. Structural types of estuaries (Geomorphical)

        1. Coastal bar-built
        2. Drowned river valleys
        3. Fjords and fjord-like regions carved by glaciers
        4. Fault-formed
        5. Stream-cut channels

b. Dynamic types of estuaries

1. Type I salt-wedge estuary - ratio of freshwater runoff flow to tidal volume is large and the ratio of width to depth is small.

2. Type II salt-wedge estuary - tidal flow larger than freshwater flow. Boundary between inflowing and outflowing water is diffuse.

3. Type III salt-wedge estuary - tidal velocities so great that river outflow rate is insignificant. Interface becomes vertical.

IV. The flushing of semi-isolated embayments.

1. The shorter the flushing time, the more rapidly pollutants can be dispersed.

$$\text{Flushing time} = \frac{\text{F(total freshwater volume of estuary)}}{\text{R(rate at which freshwater is added)}}$$

2. In estuaries with large tidal volumes and moderate freshwater additions, $Ti \approx To$. In this case:

$$\text{Flushing time} = \frac{V}{To} = \frac{V(So - Si)}{Si(E - P')}$$

where V = total volume of estuary