According to the law of mass conservation, the modification of the storage of water in an estuarine system over time can be represented by the following:

$$\frac{dV_{\text{system}}}{dt} = V_Q + V_P + V_G + V_O + V_{\text{IN}} - V_E - V_{\text{OUT}}$$  \hspace{1cm} (1)$$

where:
- $V_Q$: river fluxes;
- $V_P$: precipitation;
- $V_G$: subsurface water fluxes;
- $V_O$: sewage fluxes or other contributions;
- $V_{\text{IN}}$: advective inflow;
- $V_E$: evaporation; and
- $V_{\text{OUT}}$: advective outflow.

In this way, the residual flow can be obtained by the following:

$$V_R = V_{\text{IN}} - V; \quad V_R = -\left( V_Q + V_P + V_G + V_O - V_E \right)$$  \hspace{1cm} (2)$$

Similarly, the variation in the salt storage within the system over time can be represented by the algebraic sum of its inputs and outputs:

$$V_{\text{SYSTEM}} \frac{dS_{\text{SYSTEM}}}{dt} = V_Q S_Q + V_P S_P + V_G S_G + V_O S_O + V_R S_R + V_X (S_{\text{OCEAN}} - S_{\text{SYSTEM}})$$  \hspace{1cm} (3)$$

where
- $S$: salinity.

Excluding the terms with little to no contributions, the volume of the mixture ($V_X$) can be computed as follows:

$$V_X = \left( -V_R S_R - V_G S_G \right) / S_{\text{OCEAN}} - S_{\text{SYSTEM}}$$  \hspace{1cm} (4)$$

The residence time ($\tau$) is determined by the following equation:

$$\tau = V_{\text{SYSTEM}} / \left( |V_R| \right)$$  \hspace{1cm} (5)$$
and the freshwater volume (VD) within the estuarine basin can be calculated through the following:

\[
VD = (1 - \frac{S_{\text{AVERAGE-SYSTEM}}}{S_{\text{OCEAN}}})
\]  

TERRESTRIAL AND OCEANIC DOMAINS OF NON-CONSERVATIVE FLUXES

Using the algebra described by Swaney and Smith (2003), we define the load DY (i.e., of either DIP or DIN) as the flux of terrestrial and atmospheric inputs of the average concentrations of either DIP or DIN (the losses of DIP to the atmosphere are minimal):

\[
\Delta Y_{\text{LOAD}} = -1/V_R \left( V_Q Y_Q + V_O Y_O + V_P Y_P + V_G Y_G \right) = \sum V_i Y_i / \sum V_i, i \in \{O, P, G\}
\]

Replacing the terms used for the definitions of \( V_R \) and \( V_X \) definitions, DY can be written as follows:

\[
\Delta Y = (\text{FLUX}_{AY} - V_R Y_R) + V_X (Y_{\text{SYSTEM}} - Y_{\text{OCEAN}})
\]

When the first term is smaller than the second term in Eq. 8, the system is considered to be dominated by the mixture gradient. Alternatively, if the first term is greater than the second, the system is considered to be dominated by continental or residual loads.

These simplifications can also be interpreted in terms of the control over the autotrophy and heterotrophy within a system. \( \Delta Y \) is the change (addition or reduction) in the concentration of \( Y \) due to physical, abiotic chemical or biotic chemical processes that take place within the system. Using stoichiometric linkages between the fluxes, the phosphorus and nitrogen budgets can be used for calculations of primary production minus respiration \((\text{p-r})\) and nitrogen fixation minus denitrification \([\text{nfix-denitr}]\), respectively, according to the procedures outlined by Gordon et al. (1996).

For the phosphorus budget, if it occurs that the difference in the concentration of dissolved inorganic phosphorus \( \Delta \text{DIP} \) is positive, then DIP is moving from the sediment to the system and the system is a net producer of dissolved inorganic carbon (DIC) through respiration, \([(\text{p-r})<0]\). If, on the contrary, \( \Delta \text{DIP} \) is negative, then DIP is moving to the sediment and the system is a net consumer of DIC through net organic production, \([(\text{p-r})>0]\). The value in the difference between primary production and respiration is given by:

\[
[\text{p - r}] = -\Delta \text{DIP} \times (C:P) \text{ part}
\]

where \((C:P) \text{ part}\) is given by the Redfield ratio \((C:P = 106:1)\) for plankton.

The nitrogen budget appears more complicated, since, during the measurement of dissolved inorganic nitrogen concentration (DIN) in the system, denitrification converts nitrate to nitrogen gas and nitrification converts nitrogen gas to dissolved inorganic nitrogen. The net effect of this transfer \([\text{nfix-denitr}]\) is the
difference between the measured dissolved nitrogen flux ($\Delta N = \Delta NO_3 + \Delta NH_4 + \Delta DON$) and that expected from the production and decomposition of organic matter:

$$[\text{nfix} - \text{denitr}] = \Delta \text{Nobs} - \Delta \text{Nexp} = \Delta \text{Nobs} - \Delta \text{DIP \times (N:P) part}$$

(10)

where (N:P) part is given by the Redfield ratio (N:P = 16:1) for plankton.

Figure S1 - Generalized box diagram illustrating the salt budget for a coastal water body. The arrows show the net salt flux associated with each process. In general, residual flow (that is, $V_r \times S_R$) is negative indicating flow from the system. Under such conditions, mixing ($V_x$) is likely to transport salt into the system. Quantities which are generally measured are shown in light typeface, while quantities which are calculated within the budget are shown in bold typeface.

Figure S2 - Generalized box diagram illustrating the budget for a nonconservative material, $Y$, in a coastal water body. The arrows show the net flux of $Y$ associated with each process. Mixing ($V_x$) may be to or from the system. Quantities which are generally measured are shown in light typeface, while quantities which are calculated within the budget are shown in bold typeface. $\Delta Y$ denotes the nonconservative flux of $Y$, and can be positive or negative with respect to the system.