4. BUDGETS FOR PAPUA NEW GUINEA ESTUARINE SYSTEMS

4.1 FLY RIVER

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Study Area Description

The Fly River (Site No.1) is one of a number of large rivers that drains the wet tropical interior of Papua New Guinea. It drains a basin that is 75 000 km^2 and disgorges into the Gulf of Papua at 143.30E, 8.30S (Figure 4.1; see Figure 1.1). The water-covered area of the Fly River Delta is approximately 500 km^2. Flow down the Fly River generally varies from 3 000 to 7 000 m^3 sec^{-1} during a given year. However, 1997 was an El Nino year, with a significant drought in the Fly River catchment. We estimate that flows were reduced to approximately 1 000 m^3 sec^{-1} during the study period.

The Fly River catchment has been the focus of much interest since the opening of the giant Ok Tedi mine, which is located in the headwaters of the river. Sediment load down the rivers of PNG is high but sediment from the Ok Tedi mine has made the sediment load on the Fly River quite extreme and the environmental impact is still being assessed. Human population in the Fly delta region is sparse.

Water and nutrient data were collected during the TROPICS cruise 5A on board the *R/V Harry Messel* in 1997.

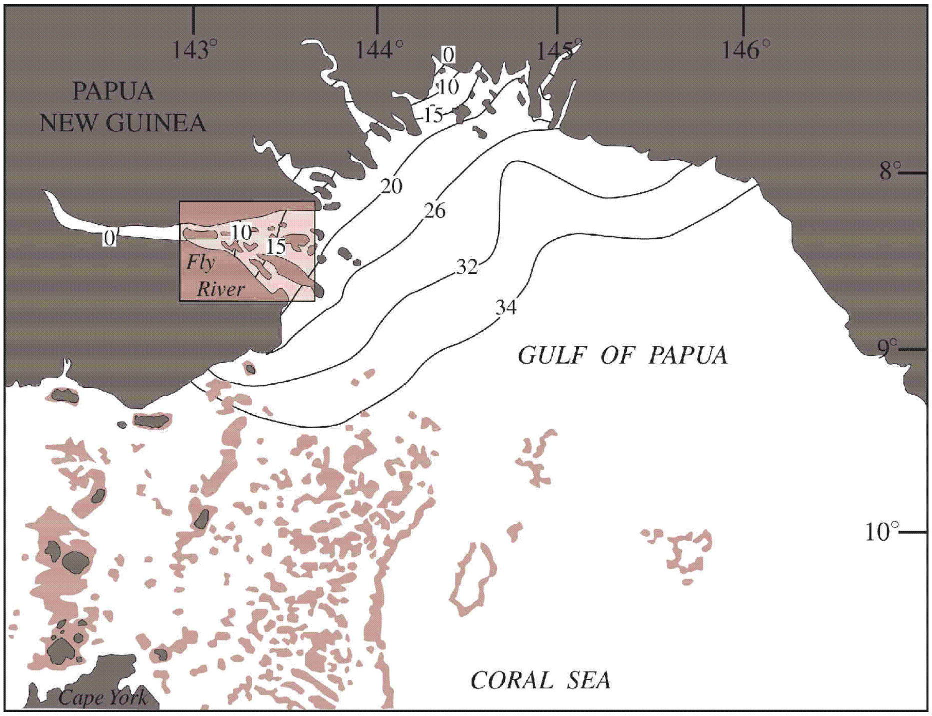

Figure 4.1 Fly River estuary and the Gulf of Papua.

Water and Salt Budgets

This is a system obviously dominated by the large flow of the Fly River. Both precipitation and evaporation are over a 1 000 mm yr^{-1}, constitute a small term in this equation and should largely offset each other. The "horn" of the delta is where most of the mixing takes place between freshwater and seawater, and hence an area of much dynamic sedimentation and organic carbon deposition. The delta is mesotidal, and the surface area of water within the horn is approximately 500 km^2. Average water depth within this area is approximately 5 m. This yields a volume of 2.5 x 10^9 m^3. Water and salt budgets are illustrated in Figure 4.2. Within the box defined in Figure 4.1, the average salinity of water arriving at the estuary is 0 psu; the average within the estuary box is 11psu, and the average on the shelf is 28 psu (Figure 4.2). The water exchange time for the drought-plagued Fly River estuary is 13 days. Typically, the exchange time would be a third of this or less.

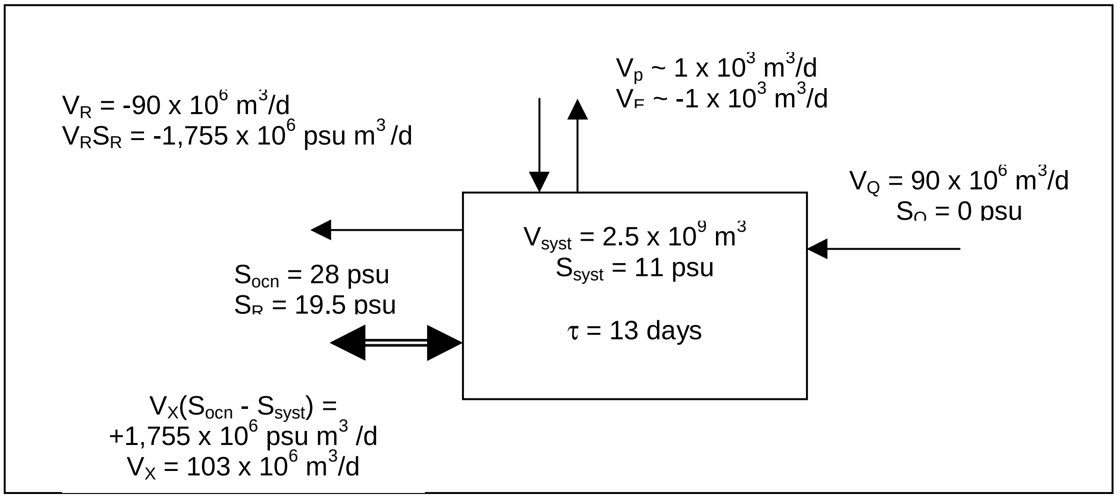

Figure 4.2 Water and salt budgets during the 1997 drought, Fly River estuary.

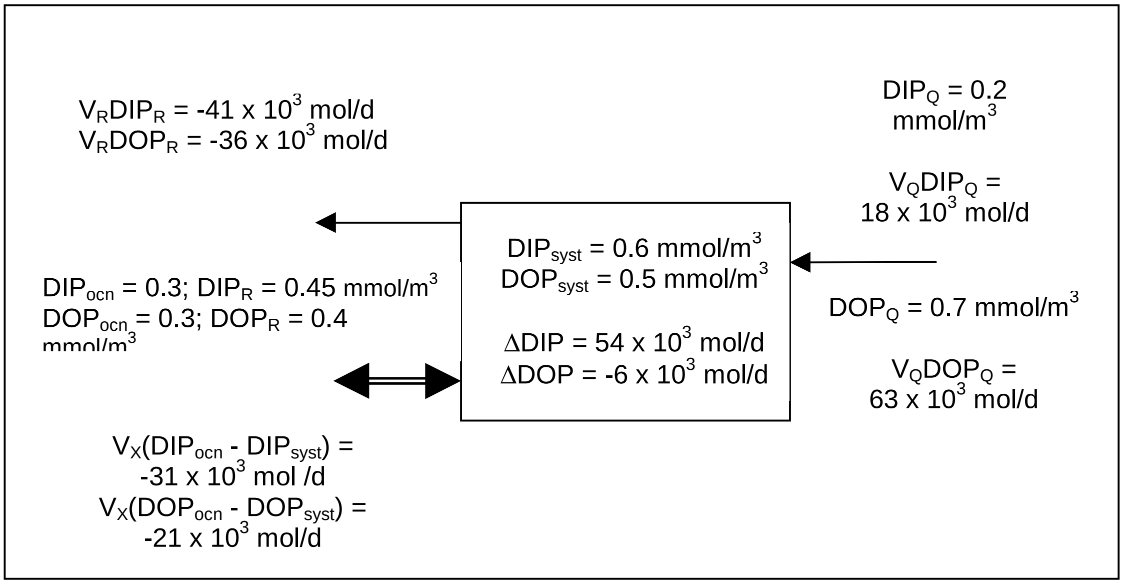

Figure 4.3 DIP and DOP budgets during the 1997 drought, Fly River estuary.

Budgets of Non-conservative Materials

P Balance

DIP concentration in the Fly River estuary is slightly elevated in comparison to the river and open shelf. ΔDIP is positive (+54 x 10^3 mol d^{-1} or 0.1mmol m^{-2} d^{-1}) (Figure 4.3). ΔDOP, on the other hand, is near 0 (-6 x 10^3 mol d^{-1} or -0.01 mmol m^{-2} d^{-1}).

N Balance

Net non-conservative DIN flux is low in this system, with ΔDIN = -82 x $10^{3\,1}$ mol d^{-1} or -0.26 mmol m^{-2} d^{-1}) (Figure 4.4). There is, however, DON production in the system: ΔDON = +560 x 10^3 mol d^{-1} or +1.1 mmol m^{-2} d^{-1}).

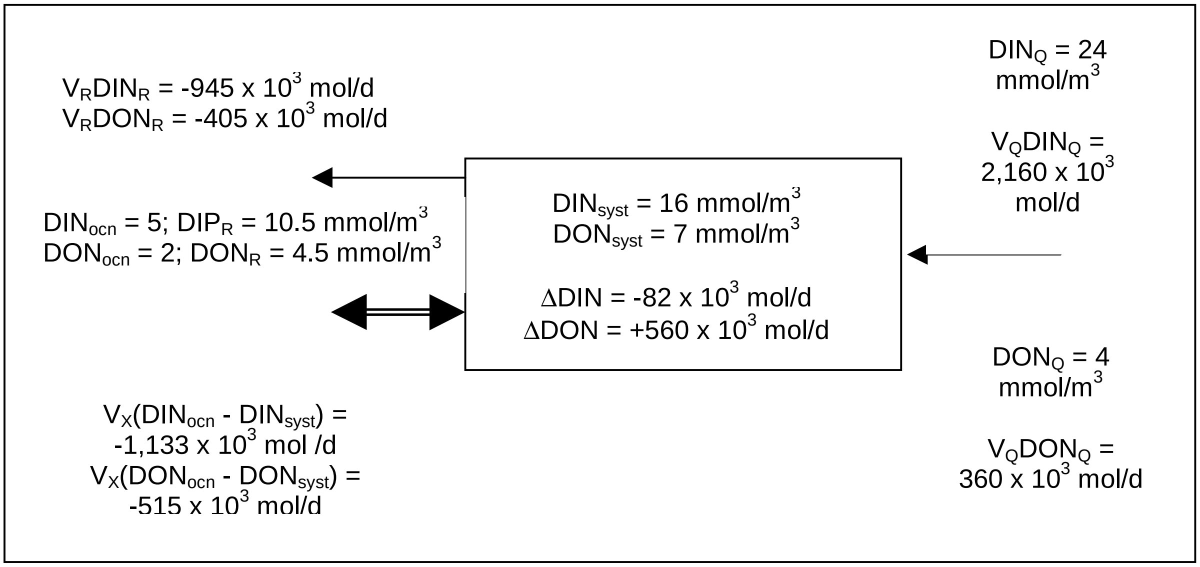

Figure 4.4 DIN and DON budgets during the 1997 drought, Fly River estuary.

Stoichiometric Calculations of Aspects of Net System Metabolism

Net nitrogen fixation minus denitrification (*nfix-denit*) is calculated as the difference between observed and expected ΔDIN + ΔDON. Expected ΔN is ΔP multiplied by the N:P ratio of the reacting particulate organic matter. In this case we have employed the Redfield ratio for marine plankton (16:1).

(*nfix-denit*) = 478 x 10^3 – 16 x (+48 x 10^3) = -290 x 10^3 mol N d^{-1} (-0.6 mmol m^{-2} d^{-1})

Therefore we see apparent slight net denitrification. For most systems, organic N and P calculations are not available. It is therefore instructive to compare these results with calculations based strictly on the observed and expected ΔDIN. In that case, (*nfix-denit*) = -946 x 10^3 mol d^{-1}, or about -1.9 mmol m^{-2} d^{-1}. Thus, the magnitude, but not the qualitative conclusion, is changed.

Net ecosystem metabolism (*NEM = p-r*) can also be estimated in a similar way, as the negative of the non-conservative DIP flux multiplied by the C:P ratio of the reacting organic matter. If the organic matter is plankton, then the particulate C:P Redfield ratio is 106:1 and

(p-r) = -106 x (+54 x 10^3) = -5.7 x 10^6 mol C d^{-1} or -11 mmol m^{-2} d^{-1}.

The system appears to be net heterotrophic. If the reacting organic matter is mangroves or other terrigenous organic detritus, the C:P ratio may be as high as 1000:1. In that case, (*p-r*) = -54 x 10^6 mol C d^{-1}, or -108 mmol m^{-2} d^{-1}.

As an aside, Δalkalinity for this system is about +82 mmol m^{-2} d^{-1}. The source of the alkalinity is presumably the oxidation of organic matter via sulfate reduction in the sediments, as discussed by Gordon *et al*. (1996). This implies that the higher net respiration rate may be more correct.