# BIOAVAILABILITY, RESUSPENSION AND CONTROL OF SEDIMENT-BORNE NUTRIENTS IN THE SALTON SEA

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Colorado River Basin Regional Water Quality Control Board

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### *Summary*

Preliminary studies have been completed evaluating the release of $NH_4$-N and SRP from bottom sediments resuspended in Salton Sea water. Release rates were comparable to rates previously reported from intact bottom sediments when normalized to a bottom sediment area. While calculations indicate that up to about 20% of the bottom sediments of the Sea may potentially be resuspended during very strong winds, preliminary consideration of the sediment properties, settling rates and observed nutrient release from suspended material suggests that sediment resuspension may not substantially increase rates of nutrient release when compared with bottom processes.

### *Bioavailability of Particulate Phosphorus*

Release of $NH_4$-N and soluble reactive phosphorus (SRP) from sediment suspended in Salton Sea water was evaluated. Sediment samples from sites 6-2 and 14-3, near the middle of north and south basins, respectively (Fig. 1), were collected March, 2002 using a Ponar sampler. Triplicated samples of known mass (approximately 10 g wet weight) sediment were suspended in 100 mL of Salton Sea water in 250 mL polyethylene centrifuge

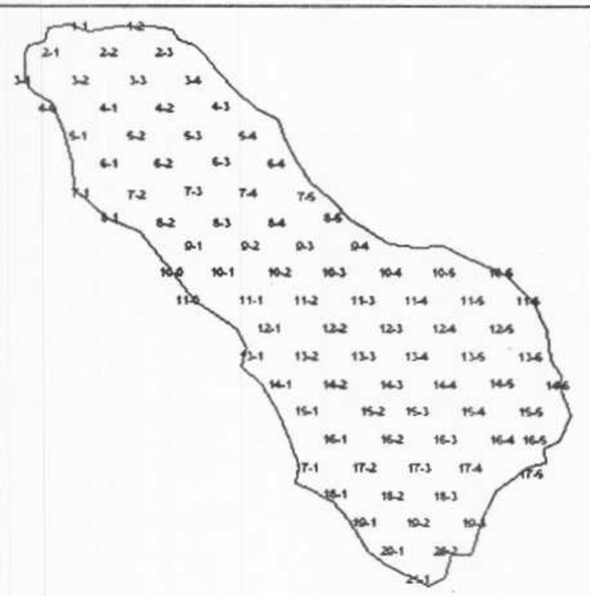

*Fig. 1. Sediment sampling stations.*

bottles. Samples were covered to exclude light and continuously mixed at room temperature (~23 °C) using an Eberbach shaker operating at about 60 Hz. Approximately 5 mL samples were withdrawn after 0.1, 0.3, 1, 2, 3, 4, and 5 days, filtered and analyzed for $NH_4$-N, $NO_3$-N and SRP.

Measured nutrient concentrations, after subtraction of background dissolved nutrient concentrations in the Salton Sea water samples and entrained $NH_4$-N and SRP added with the wet sediments (i.e., volume of porewater x concentration in the porewater), were used to calculate the amount of nutrient mass released from the suspended sediment material over time for the two sites (Fig. 2).

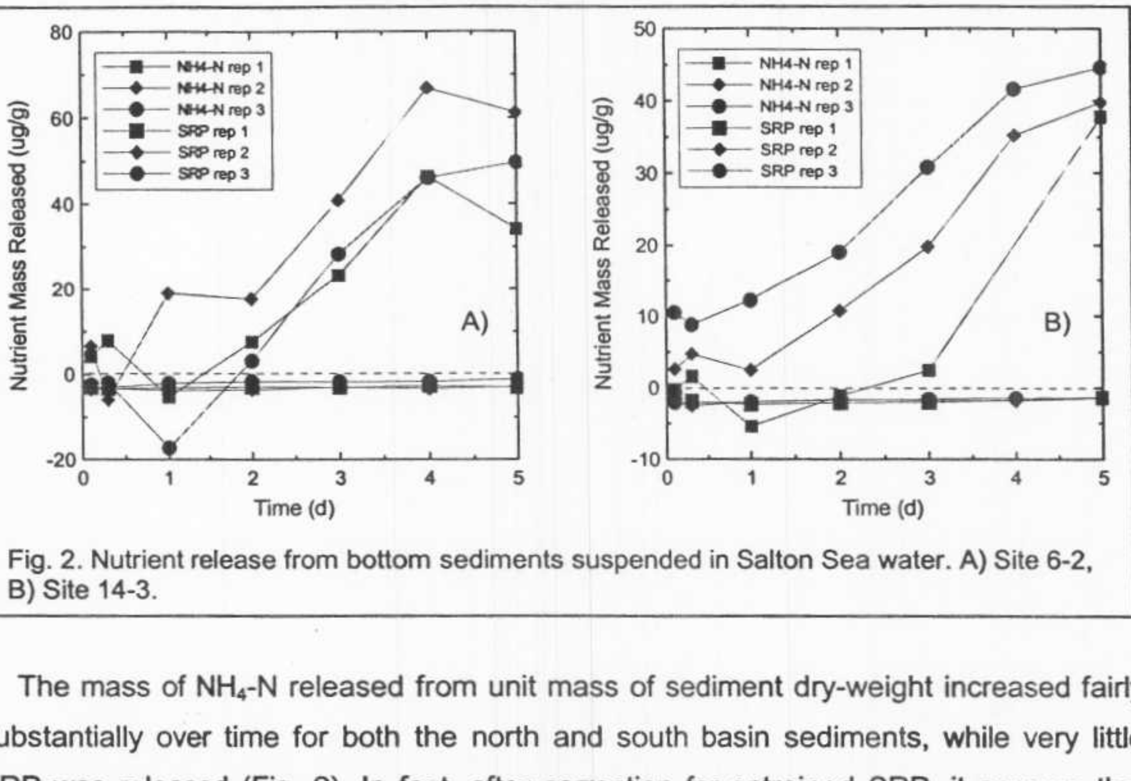


Fig. 2. Nutrient release from bottom sediments suspended in Salton Sea water. A) Site 6-2, B) Site 14-3.

The mass of $NH_4$-N released from unit mass of sediment dry-weight increased fairly substantially over time for both the north and south basin sediments, while very little SRP was released (Fig. 2). In fact, after correction for entrained SRP, it appears that SRP was actually lost from solution. This probably results from coprecipitation of SRP with $CaCO_3$ that would have formed from the excess alkalinity introduced into the water column upon mixing. Nevertheless, there is a slight increase in SRP desorbed over time (mean rates of 0.18 and 0.12 μg SRP/g dry-weight sediment/day for sites 6-2 and 14-3, respectively). This release is assumed to result from mineralization of organic P. The mean rates of $NH_4$-N release were much (64x) higher than SRP for these two sediments (11.7 and 7.6 μg $NH_4$-N/g/day). It appears that the rate of $NH_4$-N release started to slow down after 4 – 5 days; additional experiments will evaluate this further.

It is interesting to compare these rates of release with those found previously using core-flux experiments. Assuming a surficial sediment density of 1.2 g/cm$^3$ and an active zone of mineralization of 5 mm, the above SRP release rate corresponds to an areally-averaged rate of 1.08 and 0.72 mg/m$^2$/d, within the range reported previously (Anderson and Amrhein, 2002). The $NH_4$-N release rates correspond to areally-averaged rates of 70.2 and 45.6 mg/m$^2$/d. These rates are in very good agreement with rates measured using core-flux techniques (Anderson and Amhrein, 2002), especially in light of the above assumptions about the zone of active nutrient release. It appears then, that resuspension of bottom sediments does not hasten the release of nutrients from the sediments (e.g., through dissolution or exchange) relative to bottom sediments, and rather for SRP, may actually result in rapid coprecipitation of porewater P. The physical mechanism for resuspension of bottom sediments is evaluated below.

Studies are currently underway evaluating the release of N and P from suspended solids borne by the New and Alamo Rivers as they enter the Sea.

***Sediment Resuspension***

The long fetch and strong winds at the Sea could be expected to input a substantial amount of mechanical energy into the water column. Sufficient wind energy could result in resuspension of finely-textured bottom sediments; such resuspension delivers particulate-N and P to the water column and hastens the diffusive flux of nutrients and other chemicals from the sediments. As a result, resuspension processes may play a heretofore unquantified role in the release and cycling of nutrients in the Sea.

To provide an assessment of the potential for resuspension within the Salton Sea, a series of calculations were conducted. Relationships developed by the U.S. Army Corps of Engineers and others allow one to estimate wave properties subject to fetch, windspeed and other parameters. It has been shown that resuspension can occur when deep-water waves enter water shallower than one-half the wave length (Bloesch, 1995). The wavelength, $L$, of a deepwater wave is related to its period, $T$, by the relation:

$$L = \frac{gT^2}{2\pi} \tag{6}$$

where $g$ is the gravitational constant (Martin and McCutcheon, 1999). A wave's period can be estimated using the empirical equation developed by the US Army Coastal Engineering Research Center (Carper and Bachmann, 1984) that states:

$$T = \frac{2.4\pi U \tanh\left[0.077\left(\frac{gF}{U^2}\right)^{0.25}\right]}{g} \quad (7)$$

where $U$ is the wind speed and $F$ is the fetch.

Using these relationships, the wavelength, wave period and critical depth were calculated for different fetch lengths assuming a sustained windspeed of 10 m/s out of the WSW (Table 1). A 10 m/s windspeed represents a relatively frequently observed sustained windspeed during storms, Santa Ana-type winds, and other meteorological conditions (CIMIS, 2001).

Table 1. Predicted wave properties as a function of fetch for a 10 m/s windspeed.

| Fetch (km) | Wave Period (s) | Wavelength (m) | Critical Depth (m) |
|---|---|---|---|
| 1 | 1.83 | 5.2 | 2.6 |
| 5 | 2.67 | 11.1 | 5.6 |
| 10 | 3.12 | 15.2 | 7.6 |
| 20 | 3.63 | 20.6 | 10.3 |
| 30 | 3.95 | 24.3 | 12.2 |

As one can see, wave periods and wavelengths increased with increasing fetch, reflecting the additional momentum imparted to the water surface due to wind shear forces (Table 1). As a result, resuspension due to oscillatory horizontal motion immediately above the sediments is expected to increase from depths up to 2.6 m for a fetch of 1 km to depths up to 12.2 m at a fetch of 30 km. Thus, sustained winds may be expected to resuspend unconsolidated, fine organic sediments at significant depths.

Using bathymetric data, one can then estimate the area of lake bottom sediments that could potentially be mobilized by wind (Carper and Bachmann, 1984) (Fig. 1). With winds principally out of the WSW (CIMIS, 2001), the eastern shore possesses

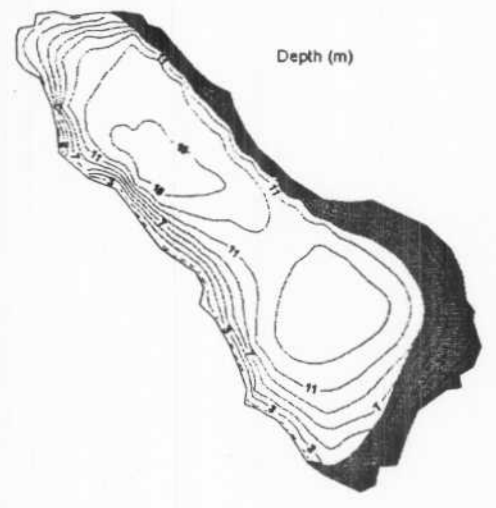


Fig. 3. Predicted area of bottom sediments potentially resuspended by strong (10 m/s ) winds out of WSW.

the greatest potential for sediment resuspension, with sediment as deep as approximately 9 m potentially being resuspended. Under these conditions, as much as 21.8 % of the bottom sediments of the Sea may be mobilized.

Given the potential for sediment resuspension, two key factors will control the importance of this process to the cycling of nutrients in the Sea. First of all, the cohesiveness and/or particle size of the sediment will define the capacity for resuspension. Because orbital velocities decrease with depth, only the finest surficial organic sediments would be mobilized in the deepest water within the shaded region depicted in Fig. 3. Consolidated or more coarsely textured sediment would not be moved until waves entered very shallow water.

The second factor influencing the importance of sediment resuspension in the Salton Sea is the rate of subsequent settling of resuspended particles. To evaluate this process, bottom sediments from site 14-3 were resuspended in deionized water or Salton Sea water at a total suspended solids concentration of ~300 mg/L and then monitored for turbidity as a function of time. Turbidity was found to be linearly related to suspended solids concentration for these sediments. In the absence of wind energy, suspended bottom sediments have a rather limited lifetime in the water column (Fig. 4). A somewhat more regular decrease in turbidity was found for the sediments suspended in deionized water, although it should be noted that entrained salts resulted in the TDS of the "deionized water" to still be quite high (>0.5 ppt). The high salinity promotes rapid agglomeration and settling, so it appears that if resuspension events occur, their impact on turbidity, light scattering, and (based upon preliminary results above) nutrient cycling appears to be of relatively short duration and likely of only rather limited scale.

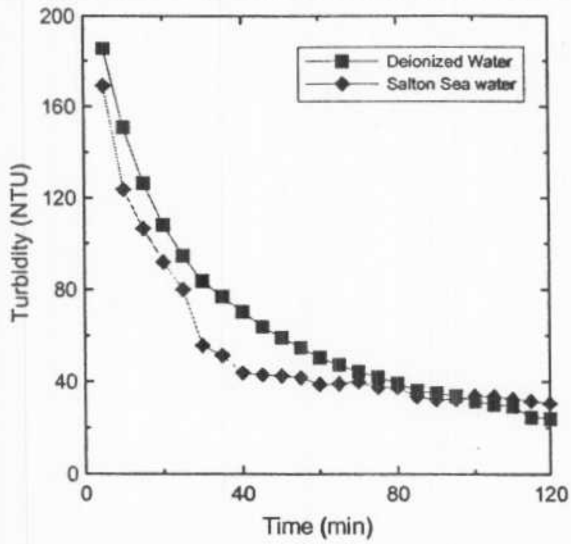


Fig. 4. Turbidity over time under quiescent conditions (site 14-3 sediments).