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**Appendix A.** Individual core and mean benthic flux measurements for nitrogen species in the Cape Fear River Estuary. Fluxes are in $\mu mols \cdot m^{-2} \cdot d^{-1}$. Non-statistically significant fluxes are represented as '0' net flux. A negative flux (-) represents an inward flux into sediments. An 'X' in the table indicates no data. Experiments were completed with triplicate cores and represent by n=3. DON = dissolved organic nitrogen, AA = amino acids and TDN = total dissolved nitrogen.

| Season | Site | $NH_4^+$ | $NO_3^-$ | DON | AA | TDN |
|---|---|---|---|---|---|---|
| **Nov 2002** | **St 1** | -530, -810, 0<br>**-450 ± 410** | 130, 830, 230<br>**400 ± 380** | -640, -24, -230<br>**-300 ± 320** | 0,0 | -1000, 0,0<br>**-350 ± 600** |
| | **St 2** | 0, 60, 0<br>**20 ± 34** | X | X | X | X |
| **March 2003** | **St 1** | -7, 83, 110<br>**63 ± 62** | 100, 320, 290<br>**230 ± 120** | 480, 830, 890<br>**720 ± 250** | 0, 11, 0<br>**4 ± 6** | 530, 1200, 1300<br>**1000 ± 420** |
| | **St 2** | -29, 0, -20<br>**-17 ± 15** | 0, 0, 0 | 210, 370, 20<br>**200 ± 180** | -21, 0, 7<br>**-5 ± 14** | 180, 370, 0<br>**180 ± 190** |
| **June 2003** | **St 1** | 0, -210, 0<br>**-70 ± 120** | 0, 0, 0 | 0, 210, 0<br>**70 ± 120** | -38, 0, -70<br>**-36 ± 35** | 0, 0, x |
| | **St 2** | 0, -130, -170<br>**-102 ± 90** | 0, 0, 0 | 0, 130, 170<br>**100 ± 90** | -53, -34, 0<br>**-39 ± 27** | 0, 0, 0 |
| **August 2003** | **M61** | 3400, 3400, 3100<br>**3300 ± 180** | -290, -580, -260<br>**-380 ± 170** | 78, -75, -560<br>**-180 ± 330** | 480, 290, 570<br>**450 ± 140** | 3200, 2700, 2300<br>**2700 ± 460** |
| | **St 1** | 0, 0, -130<br>**-45 ± 78** | 100, 100, 700<br>**310 ± 340** | -110, -110, -280<br>**-170 ± 98** | 0, 0, 0 | 0, 0, 290<br>**95 ± 160** |
| **Nov 2003** | **M61** | 1200, 0, 0<br>**400 ± 700** | 0, 750, 650<br>**470 ± 410** | 120, -110, 1500<br>**500 ± 870** | 61, 28, 50<br>**46 ± 16** | 1300, 640, 2200<br>**1400 ± 750** |
| | **St 1** | -220, -120, -260<br>**-200 ± 70** | 700, 920, 800<br>**810 ± 110** | 93, 98, 130<br>**110 ± 18** | 0, 0, 0 | 570, 890, 680<br>**720 ± 160** |
| **Feb 2004** | **M61** | 5600, 4200, 8500<br>**6100 ± 2200** | -500, -650, -660<br>**-600 ± 91** | -3100, -1600, -4700<br>**-3100 ± 1600** | 260, 240, 440<br>**310 ± 110** | 2100, 2000, 3100<br>**2400 ± 610** |
| | **St 1** | 650, 830, 370<br>**610 ± 230** | 0, 240, 240<br>**160 ± 140** | -82, -41, 150<br>**10 ± 130** | 30, 60, 13<br>**34 ± 23** | 560, 1000, 750<br>**780 ± 240** |
| **April 2004** | **M61** | -330, 1400, 0<br>**360 ± 920** | 730, 2800, 1100<br>**1500 ± 1100** | -400, -540, -1100<br>**-680 ± 370** | -80, 0, 96<br>**5 ± 89** | 0, 3700, 0<br>**1200 ± 2100** |
| | **St 1** | 68, 190, -200<br>**19 ± 200** | 750, 640, 630<br>**670 ± 68** | -250, -330, -420<br>**-330 ± 85** | 0,17, 0<br>**6 ± 10** | 570, 500, 0<br>**360 ± 310** |

**Appendix B.** Exchangeable $NH_4^+$ from resuspended sediments and surface water particles in the Cape Fear River Estuary, an X indicates no data. One standard deviation is represented by ± for n = 3 except where n=2 (represented by 'a') and ± represents the range. Freshwater collected at the same time was used to resuspend sediments to see how much $NH_4^+$ is released from resuspension alone. Refer to Table 1 for salinity and temperature at the time of collection.

| Date | Site | Sediments | | Particles | |
|---|---|---|---|---|---|
| | | µmols NH4 released/g dry sediment | | µmols NH4 released/g particle | |
| | | 2 N KCl | FW | 2 N KCl | FW |
| November 2002 | Station 1 | 1.0 ± 0.9 | X | X | X |
| | Station 2 | 0.0 ± 0.0 | X | X | X |
| March 2003 | Station 1 | 1.2 ± 0.2 | X | X | X |
| | Station 2 | 0.1 ± 0.0 | X | X | X |
| April 2003 | M61 | 8.1 ± 3.1 | X | X | X |
| | M54 | 0.0 ± 0.0 | X | X | X |
| | Station 1 | 0.4 ± 0.0 | X | X | X |
| June 2003 | Navassa | 3.1 ± 0.4 | X | X | X |
| | M61 | 3.3 ± 0.2 | X | X | X |
| | Station 1 | 0.8 ± 0.1 | X | X | X |
| | M35 | 0.3 ± 0.0 | X | X | X |
| | Station 2 | X | X | X | X |
| August 2003 | Navassa | 7.3 ± 1.4 | 1.9 ± 0.9 | 70 ± 20 | X |
| | M61 | 5.1 ± 0.8 | 1.6 ± 0.1 | 260 ± 69 | X |
| | M54 | 0.1 ± 0.0 | 0.1 ± 0.0 | 190 ± 29 | X |
| | Station 1 | 1.0 ± 0.1 | 0.2 ± 0.2 | 300 ± 39 | X |
| | M35 | 0.0 ± 0.0 | 0.3 ± 0.1 | 300 ± 52[a] | X |
| | M18 | X | X | X | X |
| November 2003 | Navassa | 2.6 ± 0.4 | 1.2 ± 0.1 | 14 ± 9.0 | X |
| | M61 | 1.5 ± 0.3 | 0.4 ± 0.0 | 85 ± 55 | X |
| | M54 | 0.3 ± 0.0 | 0.1 ± 0.0 | 63 ± 0.5[a] | X |
| | Station 1 | 1.0 ± 0.0 | 0.2 ± 0.0 | 42 ± 7.3 | X |
| | M23 | 0.0 ± 0.0 | 0.0 ± 0.0 | 20 ± 4.3 | X |
| February 2004 | Navassa | 1.0 ± 0.1 | 0.9 ± 0.0 | 74 ± 7.4[a] | 78 ± 6.5 |
| | M61 | 2.0 ± 0.5 | 0.8 ± 0.4 | 66 ± 57 | 22 ± 15 |
| | M54 | 1.0 ± 0.0 | 0.2 ± 0.1 | 66 ± 5.1[a] | X |
| | Station 1 | 1.0 ± 0.1 | 0.2 ± 0.1 | 73 ± 8.7 | X |
| | M35 | 0.3 ± 0.0 | 0.0 ± 0.1 | 81 ± 23 | X |
| April 2004 | Navassa | 0.1 ± 0.0 | 0.0 ± 0.0 | 18 ± 1.3 | X |
| | M61 | 5.8 ± 1.4 | 2.1 ± 0.7 | 22 ± 3.9 | X |
| | M54 | 0.9 ± 0.1 | 0.3 ± 0.1 | 38 ± 3.8 | X |
| | Station 1 | 0.0 ± 0.0 | 0.0 ± 0.0 | 32 ± 2.4 | X |
| | M35 | 0.0 ± 0.0 | 0.0 ± 0.0 | 32 ± 9.8 | X |

**Appendix C.** Seasonal exchangeable amino acids from bottom sediments and suspended sediments in surface water in the Cape Fear River Estuary. An X indicates no data. One standard deviation is represented by ± for n = 3. Freshwater collected at the same time was used to resuspend sediments to see how much amino acids were released from resuspension alone. Refer to Table 1 for salinity and temperature at the time of collection. Amino acids were analyzed using a glycine standard, 'Gly' in the table represents glycine-equivalent units.

| Date | Site | Sediments | | Particles | |
|---|---|---|---|---|---|
| | | µmols Gly released/g dry sediment | | µmols Gly released/g particle | |
| | | 2 N KCl | FW | 2 N KCl | FW |
| November 2002 | Station 1 | X | X | X | X |
| | Station 2 | X | X | X | X |
| March 2003 | Station 1 | X | X | X | X |
| | Station 2 | X | X | X | X |
| April 2003 | M61 | X | X | X | X |
| | M54 | X | X | X | X |
| | Station 1 | X | X | X | X |
| June 2003 | Navassa | X | X | X | X |
| | M61 | X | X | X | X |
| | Station 1 | 0.1 ± 0.0 | X | X | X |
| | M35 | X | X | X | X |
| | Station 2 | 0.1 ± 0.0 | X | X | X |
| August 2003 | Navassa | 0.4 ± 0.0 | 0.1 ± 0.0 | X | X |
| | M61 | 0.2 ± 0.1 | 0.2 ± 0.1 | X | X |
| | M54 | 0.0 ± 0.0 | 0.0 ± 0.0 | X | X |
| | Station 1 | 0.1 ± 0.0 | 0.0 ± 0.0 | X | X |
| | M35 | 0.0 ± 0.0 | 0.1 ± 0.1 | X | X |
| | M18 | X | X | X | X |
| November 2003 | Navassa | 0.2 ± 0.0 | 0.1 ± 0.0 | 3.8 ± 1.6 | X |
| | M61 | 0.1 ± 0.1 | 0.1 ± 0.0 | 19 ± 1.4 | X |
| | M54 | 0.0 ± 0.0 | 0.0 ± 0.0 | 3.4 ± 0.8 | X |
| | Station 1 | 0.1 ± 0.0 | 0.1 ± 0.0 | 3.5 ± 1.0 | X |
| | M23 | X | X | X | X |
| February 2004 | Navassa | 0.2 ± 0.0 | 0.1 ± 0.0 | 23 ± 3.0 | 19 ± 0.4 |
| | M61 | 0.2 ± 0.0 | 0.0 ± 0.0 | 15 ± 1.7 | 10 ± 1.3 |
| | M54 | 0.2 ± 0.0 | 0.1 ± 0.0 | 12 ± 0.8 | X |
| | Station 1 | 0.1 ± 0.0 | 0.0 ± 0.0 | 10 ± 0.5 | X |
| | M35 | 0.1 ± 0.0 | 0.0 ± 0.0 | 14 ± 3.1 | X |
| April 2004 | Navassa | 0.1 ± 0.0 | 0.0 ± 0.0 | 3.1 ± 2.3 | X |
| | M61 | 0.7 ± 0.1 | 0.3 ± 0.0 | 1.7 ± 0.5 | X |
| | M54 | 0.1 ± 0.0 | 0.1 ± 0.0 | 8.3 ± 1.3 | X |
| | Station 1 | 0.0 ± 0.0 | 0.0 ± 0.0 | 5.2 ± 1.3 | X |
| | M35 | 0.1 ± 0.0 | 0.0 ± 0.0 | 4.2 ± 1.5 | X |

**Appendix D.** Photochemical production of $NH_4^+$ (concentrations in μM) from the Cape Fear River Estuary. One standard deviation is represented by ± for n = 3 (3 analytical repetitions) except where n=6 (indicated by superscript a representing 2 experimental repetitions and 3 analytical repetitions each were performed), where n=5 (indicated by superscript b) or where n = 2 when it represents the range (indicated by superscript c). **a.)** Filtered with sediment **b.)** Filtered without sediment **c.)** Unfiltered without sediment

**a**.

| Season | Site | Filtered with sediment | | | |
|---|---|---|---|---|---|
| | | T0 | Dark | Light | **Δ** |
| **April 2003** | M61 | 1.6 ± 0.5 | 5.6 ± 0.1 | 6.2 ± 0.3 | **0.6** |
| | M54 | 1.6 ± 0.2[c] | 1.5 ± 0.0 | 1.9 ± 0.0 | **0.4** |
| | M42 | 0.9 ± 0.1 | 0.8 ± 0.1 | 0.6 ± 0.1 | **-0.1** |
| | M35 | 0.8 ± 0.1 | 2.4 ± 0.5 | 2.7 ± 0.7 | **0.3** |
| | M23 | 1.5 ± 0.2 | 1.4 ± 0.1 | 1.4 ± 0.1[c] | **0.1** |
| **June 2003** | Sta 1 | 3.0 ± 0.1[c] | 3.4 ± 0.7[a] | 6.4 ± 2.3[b] | **3.0** |
| | Sta 2 | 3.6 ± 0.2 | 4.6 ± 0.1[a] | 3.9 ± 0.8[b] | **-0.7** |
| **August 2003** | M61 | 3.1 ± 0.4 | 5.6 ± 0.5 | 5.2 ± 0.5 | **-0.4** |
| | Sta 1 | 3.2 ± 0.2 | 4.2 ± 0.3 | 5.0 ± 0.2 | **0.8** |
| **November 2003** | M61 | 8.0 ± 0.4 | 13 ± 0.1 | 13 ± 0.9 | **0.0** |
| | Sta 1 | 5.2 ± 0.2 | 7.3 ± 0.2 | 7.7 ± 0.3 | **0.4** |

**b**.

| Season | Site | Filtered without sediment | | | |
|---|---|---|---|---|---|
| | | T0 | Dark | Light | **Δ** |
| **June 2003** | Sta 1 | 3.4 ± 0.1 | 2.5 ± 0.2[a] | 2.2 ± 2.2[b] | **-0.3** |
| | Sta 2 | 0.9 ± 0.0 | 2.2 ± 1.0[a] | 3.7 ± 0.4[a] | **1.5** |
| **August 2003** | M61 | 3.1 ± 0.4 | 3.2 ± 0.3 | 7.6 ± 3.1 | **4.4** |
| | Sta 1 | 3.2 ± 0.2 | 3.7 ± 0.2 | 4.9 ± 0.1 | **1.2** |
| **November 2003** | M61 | 8.0 ± 0.4 | 6.9 ± 0.2 | 7.9 ± 0.3 | **1.1** |
| | Sta 1 | 5.2 ± 0.2 | 5.5 ± 0.2 | 5.2 ± 0.2 | **-0.3** |

**c**.

| Season | Site | Unfiltered without sediment | | | |
|---|---|---|---|---|---|
| | | T0 | Dark | Light | **Δ** |
| **June 2003** | Sta 1 | 3.2 ± 0.2 | 2.1 ± 0.4[a] | 3.3 ± 0.5[a] | **1.2** |
| | Sta 2 | 3.0 ± 0.1 | 3.2 ± 0.3[a] | 3.0 ± 0.5[a] | **-0.2** |
| **August 2003** | M61 | 3.1 ± 0.4 | 3.3 ± 0.3 | 3.4 ± 0.3 | **0.1** |
| | Sta 1 | 3.2 ± 0.2 | 3.8 ± 0.2 | 4.1 ± 0.4 | **0.3** |
| **November 2003** | M61 | 8.0 ± 0.4 | 7.4 ± 0.3 | 8.3 ± 0.3 | **0.9** |
| | Sta 1 | 5.2 ± 0.2 | 4.1 ± 0.3 | 6.0 ± 0.3 | **1.9** |

**Appendix E.** Photochemical production of amino acids (concentrations in μM) from the Cape Fear River Estuary. One standard deviation is represented by ± for n = 3 (3 analytical repetitions) except where n=6 (indicated by superscript a, and representing 2 experimental repetitions and 3 analytical repetitions each were performed) or where n = 2 when it represents the range (indicated by superscript b). **a.)** Filtered with sediment **b.)** Filtered without sediment **c.)** Unfiltered without sediment

**a.**

| Season | Site | Filtered with sediment | | | |
|---|---|---|---|---|---|
| | | T0 | Dark | Light | **Δ** |
| **April 2003** | M61 | 1.1 ± 0.1 | 0.9 ± 0.1 | 1.0 ± 0.1 | **0.2** |
| | M54 | 1.5 ± 0.1 | 1.0 ± 0.1 | 1.1 ± 0.1 | **0.1** |
| | M42 | 0.8 ± 0.0 | 0.9 ± 0.0 | 0.7 ± 0.1 | **-0.2** |
| | M35 | 0.9 ± 0.0 | 1.0 ± 0.1 | 0.9 ± 0.0 | **-0.2** |
| | M23 | 1.0 ± 0.0 | 0.9 ± 0.1 | 0.8 ± 0.0 | **-0.1** |
| **June 2003** | Sta 1 | 1.8 ± 0.1[b] | 1.5 ± 0.0[a] | 1.4 ± 0.2[a] | **-0.1** |
| | Sta 2 | 1.7 ± 0.0 | 11 ± 6.0 | 5.3 ± 1.0 | **-5.7** |
| **November 2003** | M61 | 2.9 ± 0.0 | 3.6 ± 0.1 | 3.2 ± 0.1 | **-0.4** |
| | Sta 1 | 1.7 ± 0.0 | 1.8 ± 0.1 | 2.1 ± 0.2 | **0.3** |

**b.**

| Season | Site | Filtered without sediment | | | |
|---|---|---|---|---|---|
| | | T0 | Dark | Light | **Δ** |
| **June 2003** | Sta 1 | 1.6 ± 0.2 | 1.9 ± 0.3 | 1.3 ± 0.2 | **-0.6** |
| | Sta 2 | 0.9± 0.0 | 1.0 ± 0.1[a] | 0.8 ± 0.0[a] | **-0.2** |
| **November 2003** | M61 | 2.9 ± 0.0 | 3.5 ± 0.1 | 3.1 ± 0.0 | **-0.4** |
| | Sta 1 | 1.7 ± 0.0 | 1.6 ± 0.1 | 1.2 ± 0.1 | **-0.4** |

**c.**

| Season | Site | Unfiltered without sediment | | | |
|---|---|---|---|---|---|
| | | T0 | Dark | Light | **Δ** |
| **June 2003** | Sta 1 | 1.4 ± 0.0 | 1.6 ± 0.2[a] | 1.5 ± 0.2[a] | **-0.1** |
| | Sta 2 | 1.7± 0.1 | 1.7 ± 0.2[a] | 1.4 ± 0.2[a] | **-0.3** |
| **November 2003** | M61 | 2.9 ± 0.0 | 2.5 ± 0.1 | 2.4 ± 0.0 | **-0.1** |
| | Sta 1 | 1.7 ± 0.0 | 1.4 ± 0.2 | 0.9 ± 0.1 | **-0.5** |