**Supplementary file**

*Table S1. PAH concentrations in water during exposure, sampled at end of the experiment (18 dph). The following PAH compounds were measured: naphthalene (N), C1-, C2-, C3-, C4-naphthalenes (N1-4), acenaphthylene (AC), acenaphthene (AE), fluorene (F), phenanthrene (P), C1-, C2-, C3-phenanthrenes (P1-3), dibenzothiophene (D), C1-, C2-, C3-dibenzothiophenes (D1-3), anthracene (ANT), fluoranthene (FL), pyrene (PY), benz[a]anthracene (BAA), chrysene (C), 1-methylchrysene (C1), 6-ethylchrysene (C2), 6-propylcrysene (C3), benzo(b)fluoranthene (BBF), benzo[bjk]fluoranthene (BKF), benzo[e]pyrene (BEP), benzo[a]pyrene (BAP), perylene (PER), indeno(1,2,3-cd)pyrene (IDP), dibenzo[a,h]anthracene (DBA), and benzo[ghi]perylene (BZP).*

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   |   |   |   |   |   |   |   |   |   |   |   |
|  |  | Control | Low | Pulse (Low) | Pulse (High) | High |
|  |  | (*n*=2) | (*n*=2) | (*n*=2) | (*n*=2) | (*n*=2) |
| PAH | PAH abbr | Conc ng/L | SD | Conc ng/L | SD | Conc ng/L | SD | Conc ng/L | SD | Conc ng/L | SD |
| Naphthalene | N | 1.4 | 0.2 | 24.1 | 2.1 | 1.5 | 0.1 | 263.7 | 13.8 | 255.1 | 15.8 |
| Total C1 naphthalenes | N1 | 4.2 | 0.9 | 88.0 | 7.3 | 13.4 | 11.9 | 926.1 | 58.7 | 971.8 | 43.4 |
| Total C2 naphthalenes | N2 | 5.7 | 1.6 | 161.7 | 15.8 | 52.1 | 70.3 | 1736.1 | 144.0 | 1941.4 | 46.0 |
| Total C3 naphthalenes | N3 | 10.3 | 2.5 | 91.0 | 8.1 | 48.7 | 40.3 | 736.9 | 21.4 | 561.9 | 55.7 |
| Total C4 naphthalenes | N4 | 2.6 | 0.1 | 0.4 | 0.3 | 1.0 | 0.7 | 0.2 | 0.1 | 0.1 | 0.1 |
| Acenaphthylene | AC | 0.1 | 0.0 | 0.5 | 0.4 | 0.2 | 0.3 | 8.1 | 0.7 | 8.8 | 0.3 |
| Acenaphthene | AE | 0.1 | 0.0 | 0.9 | 0.1 | 0.3 | 0.3 | 9.5 | 1.0 | 11.2 | 1.0 |
| Fluoren | F | 0.4 | 0.1 | 0.4 | 0.6 | 0.3 | 0.2 | 0.4 | 0.2 | 1.0 | 0.4 |
| Phenanthrene | P | 0.5 | 0.0 | 12.1 | 1.5 | 5.6 | 6.2 | 113.4 | 8.8 | 142.6 | 7.7 |
| Total C1 phenanthrenes | P1 | 0.5 | 0.1 | 35.2 | 6.6 | 23.7 | 20.8 | 345.9 | 42.1 | 483.7 | 71.1 |
| Total C2 phenanthrenes | P2 | 0.3 | 0.1 | 59.3 | 11.6 | 38.9 | 29.8 | 477.9 | 64.2 | 759.8 | 144.5 |
| Total C3 phenanthrenes | P3 | 0.3 | 0.3 | 63.1 | 11.1 | 37.8 | 29.3 | 516.6 | 62.0 | 890.0 | 201.1 |
| Dibenzothiophene | D | 0.1 | 0.0 | 3.8 | 0.5 | 1.6 | 2.0 | 38.2 | 4.1 | 47.6 | 2.5 |
| Total C1 dibenzothiophenes | D1 | 0.1 | 0.0 | 15.0 | 2.8 | 10.2 | 9.4 | 156.4 | 19.5 | 212.1 | 20.7 |
| Total C2 dibenzothiophenes | D2 | 0.2 | 0.1 | 44.8 | 8.7 | 30.0 | 23.5 | 368.6 | 50.2 | 597.6 | 114.2 |
| Total C3 dibenzothiophenes | D3 | 0.2 | 0.2 | 47.5 | 7.9 | 29.5 | 23.0 | 393.2 | 57.9 | 686.0 | 161.9 |
| Anthracene | ANT | 0.1 | 0.0 | 0.3 | 0.1 | 0.3 | 0.1 | 2.6 | 0.6 | 4.4 | 0.7 |
| Fluoranthene | FL | 0.4 | 0.0 | 1.4 | 0.2 | 1.1 | 0.6 | 9.4 | 0.7 | 15.1 | 3.0 |
| Pyrene | PY | 0.3 | 0.0 | 1.9 | 0.4 | 1.3 | 0.8 | 13.0 | 1.5 | 20.9 | 4.1 |
| Benz(a)anthracene | BAA | 0.1 | 0.0 | 0.4 | 0.0 | 0.2 | 0.1 | 2.4 | 0.2 | 4.3 | 1.2 |
| Chrysene | C | 0.1 | 0.1 | 0.9 | 0.1 | 0.7 | 0.3 | 6.7 | 0.4 | 10.3 | 2.7 |
| 1-methylchrysene | C1 | 0.1 | 0.0 | 0.6 | 0.1 | 0.3 | 0.2 | 4.4 | 0.5 | 1.7 | 2.8 |
| 6-ethylchrysene | C2 | 0.1 | 0.1 | 0.3 | 0.0 | 0.1 | 0.1 | 2.9 | 0.3 | 1.0 | 1.8 |
| 6-propylchrysene | C3 | 0.1 | 0.0 | 0.0 | 0.1 | 0.1 | 0.1 | 0.4 | 0.4 | 0.3 | 0.6 |
| Benzo(b)fluoranthene | BBF | 0.1 | 0.1 | 0.5 | 0.1 | 0.3 | 0.3 | 3.9 | 0.2 | 6.6 | 1.5 |
| Benzo(k)fluoranthene | BKF | 0.1 | 0.0 | 0.4 | 0.2 | 0.3 | 0.3 | 0.9 | 0.2 | 1.3 | 0.5 |
| Benzo(e)pyrene | BEP | 0.1 | 0.1 | 0.9 | 0.1 | 0.5 | 0.4 | 6.3 | 0.6 | 2.3 | 3.8 |
| Benzo(a)pyrene | BAP | 0.1 | 0.1 | 0.2 | 0.0 | 0.2 | 0.1 | 1.8 | 0.2 | 3.0 | 0.8 |
| Perylene | PER | 0.5 | 0.4 | 0.5 | 0.1 | 0.5 | 0.1 | 1.7 | 0.3 | 0.8 | 0.9 |
| Indeno(1,2,3-cd)pyrene | IDP | 0.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.1 | 0.7 | 0.6 | 0.8 | 0.5 |
| Dibenz(ah)anthracene | DBA | 0.1 | 0.0 | 0.2 | 0.0 | 0.1 | 0.2 | 1.0 | 0.4 | 1.4 | 0.9 |
| Benzo(ghi)perylene | BZP | 0.1 | 0.1 | 0.2 | 0.0 | 0.1 | 0.1 | 2.0 | 0.1 | 3.2 | 0.8 |
| Sum tPAH |   | 29.5 | 5.0 | 656.4 | 82.2 | 301.1 | 268.4 | 6151.3 | 473.7 | 7648.0 | 621.9 |
|  |  |  |  |  |  |  |  |  |  |  |  |

*Table S2. PAH concentrations in Atlantic haddock larvae (wet weight), sampled at end of the experiment (18 dph). The following PAH compounds were measured: naphthalene (C), C1-, C2-, C3-, C4-naphthalenes (N1-4), acenaphthylene (AC), acenaphthene (AE), fluorene (F), phenanthrene (P), C1-, C2-, C3-phenanthrenes (P1-3), ), dibenzothiophene (D), C1-, C2-, C3-dibenzothiophenes (D1-3), anthracene (ANT), fluoranthene (FL), pyrene (PY), benz[a]anthracene (BAA), chrysene (C), C1-, C2-, C3- chrysenes (C), benzo(b)fluoranthene (BBF), benzo[bjk]fluoranthene (BKF), benzo[e]pyrene (BEP), benzo[a]pyrene (BAP), perylene (PER), indeno(1,2,3-cd)pyrene (IDP), dibenzo[a,h]anthracene (DBA), and benzo[ghi]perylene (BZP).*

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|  |  |  |  |  |  |  |  |  |  |
|   |   | Control | Low | Pulse | High |
|  |  | (*n*=3) | (*n*=2) | (*n*=3) | (*n*=4) |
| PAH | PAH abbr | Conc ng/g | SD | Conc ng/g | SD | Conc ng/g | SD | Conc ng/g | SD |
| Naphthalene | N | 0.0 | 0.0 | 1.0 | 0.1 | 0.1 | 0.0 | 4.0 | 1.1 |
| Total C1 naphthalenes | N1 | 0.0 | 0.0 | 5.9 | 0.3 | 0.9 | 0.3 | 31.5 | 9.0 |
| Total C2 naphthalenes | N2 | 0.9 | 0.3 | 24.3 | 0.3 | 9.3 | 2.9 | 161.4 | 50.3 |
| Total C3 naphthalenes | N3 | 2.1 | 0.1 | 21.2 | 0.2 | 12.8 | 4.8 | 218.6 | 86.3 |
| Total C4 naphthalenes | N4 | 1.2 | 0.1 | 5.9 | 0.4 | 6.3 | 2.4 | 101.5 | 22.1 |
| Acenaphthylene | AC | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.0 | 1.5 | 0.3 |
| Acenaphthene | AE | 0.0 | 0.0 | 0.3 | 0.0 | 0.2 | 0.1 | 2.3 | 0.5 |
| Fluoren | F | 0.0 | 0.0 | 1.4 | 0.0 | 0.4 | 0.1 | 12.8 | 2.4 |
| Phenanthrene | P | 0.0 | 0.0 | 0.8 | 0.1 | 0.1 | 0.1 | 16.6 | 4.0 |
| Total C1 phenanthrenes | P1 | 0.2 | 0.1 | 5.4 | 0.1 | 4.2 | 2.4 | 61.5 | 24.1 |
| Total C2 phenanthrenes | P2 | 0.2 | 0.0 | 5.9 | 1.8 | 7.9 | 4.6 | 100.8 | 59.5 |
| Total C3 phenanthrenes | P3 | 0.1 | 0.0 | 4.0 | 0.1 | 7.8 | 5.4 | 50.4 | 34.1 |
| Dibenzothiophene | D | 0.0 | 0.0 | 0.6 | 0.0 | 0.3 | 0.1 | 8.6 | 1.0 |
| Total C1 dibenzothiophenes | D1 | 0.3 | 0.1 | 1.1 | 0.0 | 0.8 | 0.4 | 17.4 | 6.7 |
| Total C2 dibenzothiophenes | D2 | 0.4 | 0.1 | 1.8 | 0.3 | 3.0 | 1.1 | 58.5 | 41.5 |
| Total C3 dibenzothiophenes | D3 | 0.3 | 0.1 | 2.1 | 0.3 | 4.8 | 2.1 | 64.8 | 54.0 |
| Anthracene | ANT | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Fluoranthene | FL | 0.1 | 0.1 | 0.2 | 0.0 | 0.2 | 0.1 | 3.0 | 1.4 |
| Pyrene | PY | 0.1 | 0.0 | 0.2 | 0.0 | 0.2 | 0.2 | 2.7 | 1.7 |
| Benz(a)anthracene | BAA | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | 0.7 | 0.7 |
| Chrysene | C | 0.2 | 0.0 | 0.4 | 0.0 | 0.6 | 0.4 | 3.1 | 2.2 |
| Total C1 chrysenes | C1 | 0.1 | 0.0 | 0.4 | 0.1 | 0.8 | 0.4 | 6.3 | 4.0 |
| Total C2 chrysenes | C2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.0 | 3.6 |
| Total C3 chrysenes | C3 | 0.0 | 0.0 | 0.4 | 0.0 | 0.7 | 0.3 | 4.3 | 2.9 |
| Benzo(b)fluoranthene | BBF | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 | 0.3 | 1.1 | 1.0 |
| Benzo(k)fluoranthene | BKF | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | 0.3 | 0.3 |
| Benzo(e)pyrene | BEP | 0.0 | 0.0 | 0.1 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 |
| Benzo(a)pyrene | BAP | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 1.1 | 0.9 |
| Perylene | PER | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.4 | 0.4 |
| Indeno(1,2,3-cd)pyrene | IDP | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.3 |
| Dibenz(ah)anthracene | DBA | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.2 | 0.2 |
| Benzo(ghi)perylene | BZP | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.2 | 0.5 | 0.6 |
| Sum tPAH |   | 6.3 | 0.4 | 83.6 | 3.6 | 62.6 | 27.7 | 941.1 | 348.1 |
|  |  |  |  |  |  |  |  |  |  |

*Table S3. Number of animals subjected for length measurements at each time point. DPH: days post hatching.*

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|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Control | Low | Pulse | High |
| DPH | Length (µm) | SD | N | Length (µm) | SD | N | Length (µm) | SD | N | Length (µm) | SD | N |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|   |   |   |   |   |   |   |   |   |   |   |   |   |
| 1 | 4948.0 | 186.9 | 24 | 4809.1 | 253.8 | 24 | 4732.7 | 276.9 | 24 | 4877.1 | 144.5 | 24 |
| 2 | 4581.1 | 163.3 | 48 | 4546.4 | 205.6 | 48 | 4510.1 | 252.8 | 48 | 4459.3 | 196.2 | 48 |
| 7 | 5664.8 | 242.2 | 12 | 5377.7 | 355.0 | 12 | 5447.6 | 228.8 | 12 | 5214.0 | 308.8 | 12 |
| 9 | 5462.3 | 254.9 | 48 | 5259.1 | 197.1 | 48 | 5258.3 | 234.5 | 48 | 4924.2 | 322.3 | 48 |
| 14 | 6596.2 | 451.2 | 48 | 6373.5 | 482.2 | 48 | 6422.4 | 456.4 | 48 | 5917.6 | 485.5 | 48 |
| 18 | 7024.7 | 574.3 | 24 | 6890.6 | 589.0 | 24 | 6645.3 | 674.6 | 24 | 6069.8 | 521.2 | 24 |
| 21 | 8503.0 | 610.0 | 18 | 7838.2 | 429.9 | 12 | 7797.1 | 836.5 | 18 | 6614.7 | 730.0 | 24 |
| 44 | 12809.1 | 1781.8 | 30 | 10532.5 | 1387.8 | 22 | 11394.8 | 1821.0 | 23 | 9612.9 | 1923.7 | 36 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Length (mm) | SD | N | Length (mm) | SD | N | Length (mm) | SD | N | Length (mm) | SD | N |
| 69 | 30 | 6 | 332 | 27 | 7 | 302 | 39 | 8 | 275 | 28 | 8 | 68 |
| 134 | 117 | 11 | 153 | 113 | 12 | 194 | 116 | 12 | 239 | 104 | 13 | 56 |
| 243 | 193 | 18 | 41 | 190 | 14 | 36 | 189 | 18 | 37 | 174 | 19 | 24 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|   |   |   |   |   |   |   |   |   |   |   |   |   |



*Figure S1. Accumulation of PAH metabolites was observed in exposed Atlantic haddock larvae but not in controls. The images show PAH-associated fluorescence (DAPI filter) in the bile bladder at 9 dph in representative larvae. In the graph, the light intensity is divided into four interval and the frequency (%) of measured light intensity is shown in 24-30 larvae from each treatment group. Light intensity comes from at scale where 0 is black and 255 is white.*



*Figure S2. Survival of Atlantic haddock larvae after oil exposure. A) Survival two days post exposure stop (20 dph). B) Survival at two months post exposure stop (juvenile stage: 76 dph).*

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*Figure S3. Typical split neural arch in 44 dph Atlantic haddock fry. A) Control fry. B) High exposure fry.*