**Supplementary Material**

**Table A1.** Site-level covariate summary. Asterisks indicate sites that were also surveyed for estuary carcasses in 2008 and 2009.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Section Length (m) | Total Length (m) | Estuary Section Length (m) | Stream  Bankfull (m) | Spawning Area (ha) | Meadow Area (ha) | Mean Depth (m) | Survey Years |
| Ada | 50 | 350 | 30 | 11.1 | 0.39 | 0.24 | 0.12 | 2009 to 2013 |
| Beales Left | 100 | 300 | 100 | 10.9 | 0.33 | 2.06 | 0.09 | 2009 to 2013 |
| Bullock Main \* | 100 | 550 | 50 | 10.9 | 0.60 | 0.68 | 0.08 | 2012, 2013 |
| Clatse \* | 100 | 800 | 220 | 22.8 | 1.82 | 2.07 | 0.16 | 2009, 2010, 2013 |
| Codville | 100 | 300 | 50 | 3.3 | 0.10 | 0.52 | 0.18 | 2009, 2013 |
| Fancy Head | 50 | 165 | 20 | 5.5 | 0.09 | 0.16 | 0.06 | 2009 to 2013 |
| Fancy Right | 100 | 500 | 60 | 4.8 | 0.24 | 0.45 | 0.06 | 2009, 2011 to 2013 |
| Fannie Left \* | 200 | 1375 | 80 | 12.8 | 1.76 | 1.52 | 0.16 | 2009, 2010, 2012 |
| Hooknose \* | 200 | 1800 | 45 | 16.9 | 3.04 | 1.02 | 0.18 | 2009, 2010, 2012, 2013 |
| Kill Creek \* | 100 | 480 | 40 | 3.5 | 0.17 | 0.22 | 0.04 | 2011 to 2013 |
| Kunsoot Main \* | 100 | 1000 | 240 | 13.1 | 1.31 | 1.67 | 0.04 | 2013 |
| Lee | 100 | 700 | 50 | 12.4 | 0.87 | 0.79 | 0.19 | 2010, 2011, 2013 |
| Mosquito Bay | 100 | 600 | 30 | 4 | 0.24 | 0.31 | 0.15 | 2012, 2013 |
| Neekas \* | 200 | 1800 | 260 | 17.7 | 3.19 | 1.19 | 0.16 | 2010, 2012, 2013 |
| Rainbow | 50 | 250 | 120 | 15.1 | 0.38 | 1.56 | 0.23 | 2009, 2012, 2013 |
| Sagar \* | 50 | 150 | 30 | 15.5 | 0.23 | 1.70 | 0.25 | 2009 to 2013 |

**Table A2.** Summary of live and dead salmon counts by site and year. Live = live spawning salmon, Senescent = dead without signs of predation, Wolf = wolf transferred, Bear = bear transferred, Unknown = unconfirmed consumption and/or advanced decomposition.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Year | Pink Salmon | | | | | Chum Salmon | | | | |
| Live | Senescent | Wolf | Bear | Unknown | Live | Senescent | Wolf | Bear | Unknown |
| Ada | 2009 | 545 | 10 | 1 | 13 | 0 | 645 | 118 | 3 | 16 | 0 |
| Ada | 2010 | 12 | 0 | 0 | 0 | 1 | 688 | 30 | 0 | 10 | 39 |
| Ada | 2011 | 415 | 7 | 0 | 3 | 17 | 691 | 132 | 0 | 8 | 45 |
| Ada | 2012 | 3 | 1 | 0 | 0 | 0 | 1848 | 164 | 0 | 0 | 58 |
| Ada | 2013 | 172 | 49 | 0 | 4 | 63 | 988 | 627 | 0 | 17 | 73 |
| Beales Left | 2009 | 2164 | 799 | 29 | 202 | 17 | 85 | 118 | 3 | 28 | 6 |
| Beales Left | 2010 | 176 | 0 | 0 | 0 | 12 | 264 | 0 | 0 | 1 | 30 |
| Beales Left | 2011 | 80 | 27 | 1 | 10 | 12 | 4 | 26 | 0 | 7 | 15 |
| Beales Left | 2012 | 582 | 59 | 20 | 0 | 49 | 39 | 14 | 3 | 2 | 48 |
| Beales Left | 2013 | 1212 | 444 | 15 | 38 | 265 | 215 | 234 | 7 | 27 | 90 |
| Bullock Main | 2012 | 1301 | 133 | 2 | 22 | 165 | 569 | 780 | 2 | 14 | 297 |
| Bullock Main | 2013 | 2015 | 1092 | 14 | 7 | 33 | 366 | 1653 | 7 | 14 | 39 |
| Clatse | 2009 | 18271 | 7368 | 354 | 305 | 228 | 1041 | 5515 | 58 | 390 | 73 |
| Clatse | 2010 | 2309 | 198 | 18 | 15 | 107 | 3071 | 1100 | 62 | 281 | 291 |
| Clatse | 2013 | 9417 | 461 | 19 | 33 | 133 | 2844 | 94 | 2 | 6 | 11 |
| Codville | 2009 | 92 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 |
| Codville | 2013 | 82 | 75 | 1 | 15 | 43 | 0 | 23 | 0 | 2 | 21 |
| Fancy Head | 2009 | 207 | 33 | 0 | 1 | 36 | 40 | 93 | 0 | 2 | 16 |
| Fancy Head | 2010 | 2 | 0 | 0 | 0 | 1 | 118 | 1 | 1 | 10 | 19 |
| Fancy Head | 2011 | 32 | 0 | 0 | 0 | 26 | 152 | 34 | 15 | 15 | 35 |
| Fancy Head | 2012 | 30 | 1 | 0 | 0 | 3 | 595 | 13 | 0 | 0 | 44 |
| Fancy Head | 2013 | 106 | 12 | 0 | 7 | 27 | 288 | 284 | 0 | 11 | 50 |
| Fancy Right | 2009 | 529 | 1 | 0 | 1 | 1 | 133 | 6 | 0 | 4 | 0 |
| Fancy Right | 2011 | 183 | 6 | 1 | 1 | 7 | 189 | 58 | 5 | 9 | 27 |
| Site | Year | Pink Salmon | | | | | Chum Salmon | | | | |
| Live | Senescent | Wolf | Bear | Unknown | Live | Senescent | Wolf | Bear | Unknown |
| Fancy Right | 2012 | 2 | 0 | 0 | 0 | 7 | 389 | 4 | 0 | 0 | 40 |
| Fancy Right | 2013 | 167 | 4 | 1 | 8 | 5 | 489 | 124 | 1 | 79 | 31 |
| Fannie Left | 2009 | 13420 | 55 | 14 | 19 | 1 | 1151 | 153 | 5 | 0 | 6 |
| Fannie Left | 2010 | 519 | 17 | 0 | 3 | 3 | 2749 | 2251 | 0 | 104 | 79 |
| Fannie Left | 2012 | 900 | 66 | 5 | 1 | 39 | 2741 | 3802 | 0 | 5 | 179 |
| Fannie Left | 2013 | 3719 | 1205 | 53 | 90 | 181 | 289 | 2435 | 6 | 45 | 57 |
| Hooknose | 2009 | 4566 | 154 | 170 | 28 | 0 | 1247 | 65 | 46 | 55 | 9 |
| Hooknose | 2010 | 156 | 12 | 0 | 1 | 9 | 780 | 142 | 1 | 36 | 29 |
| Hooknose | 2012 | 448 | 5 | 4 | 2 | 2 | 757 | 74 | 6 | 30 | 9 |
| Hooknose | 2013 | 1542 | 2445 | 5 | 39 | 298 | 165 | 2428 | 2 | 54 | 246 |
| Kill Creek | 2011 | 510 | 220 | 5 | 4 | 16 | 115 | 1387 | 12 | 106 | 171 |
| Kill Creek | 2012 | 72 | 1 | 0 | 0 | 4 | 1316 | 311 | 1 | 29 | 98 |
| Kill Creek | 2013 | 545 | 51 | 1 | 16 | 138 | 1622 | 590 | 1 | 21 | 175 |
| Kunsoot Main | 2013 | 15172 | 187 | 378 | 42 | 282 | 2952 | 153 | 19 | 6 | 15 |
| Lee | 2010 | 8 | 6 | 0 | 0 | 3 | 142 | 183 | 0 | 33 | 108 |
| Lee | 2011 | 451 | 161 | 11 | 14 | 65 | 62 | 457 | 10 | 14 | 165 |
| Lee | 2013 | 586 | 74 | 2 | 1 | 2 | 1832 | 2117 | 1 | 51 | 24 |
| Mosquito Bay Right | 2012 | 161 | 16 | 0 | 2 | 11 | 230 | 172 | 2 | 9 | 38 |
| Mosquito Bay Right | 2013 | 1661 | 115 | 0 | 19 | 69 | 704 | 218 | 0 | 0 | 97 |
| Neekas | 2010 | 852 | 290 | 1 | 27 | 80 | 7225 | 11152 | 0 | 1011 | 1016 |
| Neekas | 2012 | 4746 | 1222 | 4 | 5 | 239 | 235 | 4397 | 7 | 22 | 675 |
| Neekas | 2013 | 5573 | 2270 | 7 | 27 | 887 | 7869 | 18983 | 8 | 126 | 2268 |
| Rainbow | 2009 | 14 | 1 | 0 | 0 | 0 | 62 | 25 | 0 | 7 | 0 |
| Rainbow | 2012 | 1 | 0 | 0 | 0 | 0 | 209 | 153 | 0 | 0 | 12 |
| Rainbow | 2013 | 27 | 2 | 0 | 2 | 0 | 325 | 7 | 0 | 4 | 0 |
|  | |  | | | | |  | | | | |
| Site | Year | Pink Salmon | | | | | Chum Salmon | | | | |
| Live | Senescent | Wolf | Bear | Unknown | Live | Senescent | Wolf | Bear | Unknown |
| Sagar | 2009 | 957 | 522 | 0 | 60 | 21 | 339 | 70 | 0 | 12 | 1 |
| Sagar | 2010 | 24 | 1 | 0 | 1 | 11 | 762 | 152 | 3 | 24 | 69 |
| Sagar | 2011 | 241 | 245 | 0 | 10 | 48 | 583 | 591 | 0 | 21 | 47 |
| Sagar | 2012 | 62 | 4 | 0 | 0 | 3 | 541 | 112 | 0 | 4 | 66 |
| Sagar | 2013 | 49 | 34 | 3 | 6 | 37 | 45 | 50 | 0 | 10 | 43 |

**Table A3.** Estuary-carcass site summary.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Year | Pink Dead | Pink Live | Pink Density (#/m2) | Chum Dead | Chum Live | Chum Density (#/m2) | Spawning Length (km) | Stream Discharge (m3/s) |
| Bullock Main | 2008 | 10 | 20 | <0.00 | 112 | 220 | 0.04 | 0.62 | 1.43 |
| Bullock Main | 2009 | 2317 | 6300 | 1.05 | 399 | 2100 | 0.35 | 0.62 | 1.93 |
| Clatse | 2008 | 337 | 2300 | 0.13 | 830 | 1700 | 0.09 | 0.90 | 9.14 |
| Clatse | 2009 | 12429 | 29000 | 1.59 | 998 | 8000 | 0.44 | 0.90 | 4.70 |
| Fannie Left | 2008 | 28 | 784 | 0.04 | 53 | 462 | 0.03 | 1.50 | 6.25 |
| Fannie Left | 2009 | 296 | 12800 | 0.73 | 17 | 1820 | 0.10 | 1.50 | 0.36 |
| Hooknose | 2008 | 0 | 149 | <0.00 | 8 | 864 | 0.03 | 1.80 | 2.68 |
| Hooknose | 2009 | 620 | 4566 | 0.15 | 65 | 1282 | 0.04 | 1.80 | 3.60 |
| Kill Creek | 2008 | 0 | 0 | 0.00 | 122 | 175 | 0.10 | 0.45 | 0.07 |
| Kill Creek | 2009 | 290 | 1023 | 0.61 | 31 | 750 | 0.45 | 0.45 | 0.15 |
| Kunsoot Main | 2008 | 9 | 200 | 0.02 | 142 | 220 | 0.02 | 1.28 | 0.82 |
| Kunsoot Main | 2009 | 8042 | 23190 | 1.77 | 53 | 567 | 0.04 | 1.28 | 0.04 |
| Mosquito Bay | 2008 | 0 | 991 | 0.41 | 12 | 567 | 0.24 | 0.75 | 0.09 |
| Mosquito Bay | 2009 | 333 | 2625 | 1.09 | 23 | 677 | 0.28 | 0.75 | 1.68 |
| Neekas | 2008 | 62 | 10200 | 0.32 | 2133 | 8200 | 0.26 | 2.10 | 4.84 |
| Neekas | 2009 | 21909 | 88454 | 2.78 | 7820 | 34000 | 1.07 | 2.10 | 1.26 |
| Sagar | 2008 | 0 | 50 | 0.02 | 65 | 550 | 0.24 | 0.18 | 16.43 |
| Sagar | 2009 | 194 | 1601 | 0.69 | 163 | 421 | 0.18 | 0.18 | 6.19 |

**Table A4.** Live salmon top model. NZ = non-zero data points.

|  |  |  |
| --- | --- | --- |
| Model: |  |  |
| Covariates | Estimate | SE |
| Intercept | 4.28 | 0.35 |
| Distance upstream | -1.92 | 0.32 |
| Spawning area | 0.97 | 0.28 |
| Salmon species | 0.51 | 0.15 |
| Distance X Spawning Area | 0.91 | 0.20 |
| Distance X Salmon species | 2.19 | 0.33 |
| Spawning Area X Salmon species | -0.92 | 0.14 |
| Neg. binomial dispersion parameter | 0.59 | 0.05 |
| Zero-inflation parameter | 0.06 | 0.02 |
|  |  |  |
| Random Effects: |  |  |
| Site | Variance | SD |
| Intercept | 1.14 | 1.07 |
|  |  |  |
| Year | Variance | SD |
| Intercept | 0.19 | 0.43 |
|  |  |  |
|  | Total | NZ |
| Data points | 718 | 104 |
| Sites | 16 |  |
| Years | 5 |  |

**Table A5.** Averaged models for salmon transferred by wolves and bears.NZ = non-zero data points.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Model | Wolf | | Bear | |
| Covariates | Estimate | SE | Estimate | SE |
| Intercept | -0.82 | 0.37 | 0.52 | 0.41 |
| Distance upstream | -0.98 | 0.29 | -0.24 | 0.34 |
| Salmon density | 0.38 | 0.32 | 2.43 | 0.39 |
| Spawning area | 0.88 | 0.21 | 0.43 | 0.24 |
| Salmon species | -0.02 | 0.17 | 1.44 | 0.15 |
| Distance X salmon species | -0.03 | 0.39 | 0.92 | 0.32 |
| Distance X Spawning area | -0.07 | 0.27 | 0.29 | 0.22 |
| Salmon density X Salmon species | -1.08 | 0.34 | -0.78 | 0.78 |
| Meadow area | 0.89 | 0.32 | 0.28 | 0.37 |
| Distance X Salmon density | -2.86 | 0.72 | 0.37 | 1.09 |
| Stream depth | -11.57 | 3.45 | -0.29 | 3.83 |
| Neg. binomial dispersion parameter | 7.4 | 0.99 | 0.43 | 0.04 |
| Zero-inflation parameter | 0.02 | 0.02 | 1X10-6 | 9.6X10-9 |
|  |  |  |  |  |
| Random Effects: |  |  |  |  |
| Site | Variance | SD | Variance | SD |
| Intercept | 0.39 | 0.62 | 0.68 | 0.82 |
|  |  |  |  |  |
| Year | Variance | SD | Variance | SD |
| Intercept | 0.41 | 0.64 | 0.53 | 0.73 |
|  | Total | NZ | Total | NZ |
| Data points | 716 | 553 | 716 | 374 |
| Sites | 16 |  | 16 |  |
| Years | 5 |  | 5 |  |

**Table A6.** Estuary carcass top model. NZ = non-zero data points.

|  |  |  |
| --- | --- | --- |
| Model: |  |  |
| Covariates | Estimate | SE |
| Intercept | -1.72 | 0.21 |
| Spawning channel length | -0.89 | 0.26 |
| Salmon spp | 0.40 | 0.41 |
| Salmon density | 1.04 | 0.23 |
| Spawn length X Salmon spp | 1.35 | 0.39 |
|  |  |  |
| Quasibinomial dispersion parameter | 319.66 |  |
| Null deviance 22578.4 | Null df | 34 |
| Residual Deviance 8752.4 | Residual df | 30 |
|  | Total | NZ |
| Data points | 35 | 32 |
| Sites | 9 |  |
| Years | 2 |  |

**Table A7.** Authors, sources and license information for open source images.

| Image | Author | Source | License |
| --- | --- | --- | --- |
| Pink Salmon | Timothy Knepp,  US Fish and Wildlife Service | https://commons.wikimedia.org/wiki/File:Pink\_salmon\_FWS.jpg | http://creativecommons.org/publicdomain/zero/1.0/ |
| Chum Salmon | Timothy Knepp,  US Fish and Wildlife Service | https://commons.wikimedia.org/wiki/File:Salmon\_chum\_fish\_oncorhynchus\_keta.jpg | http://creativecommons.org/publicdomain/zero/1.0/ |
| Wolf Silhouette | Tracy A. Heath | http://phylopic.org/image/e4e306cd-73b6-4ca3-a08c-753a856f7f12/ | http://creativecommons.org/publicdomain/zero/1.0/ |
| Bear Silhouette | Steven Traver | http://phylopic.org/image/05f87521-20d4-4a05-8ac6-aa0bab7f1394/ | http://creativecommons.org/publicdomain/zero/1.0/ |