Supplement Documentation for “Reservoir Correction for the Central and North Kuril Islands in North Pacific Context.: Ben Fitzhugh and William Brown

**APPENDIX 1**

**Estimating**

The Monte Carlo simulation approach we took to identify a probabilistic estimate of based on individual charcoal-shell pairs is as follows:

1. Identify a normal approximation of the predictive distribution of 14C ages for hypothetical marine specimens whose calendar age is identical to that of the paired charcoal specimen. (For a foundational discussion of predictive distributions in general, see Gelman et al. 2013: 7.)
   1. Draw a pseudorandom sample of independent and identically distributed (iid) calendric ages from the charcoal specimen’s posterior distribution

where

* denotes a single (th) draw or informed guess out of guesses;
* denotes the posterior distribution for the charcoal specimen across the entire calendric-age domain (), conditional on that specimen’s conventional 14C age () and accompanying error (), assuming that the IntCal13 model is an appropriate forward map model for the specimen.
  1. Stochastically map each calendar-age guess onto the 14C age domain through the Marine13 model (Reimer et al., 2013),

where denotes the th predicted 14C age of a hypothetical shell specimen having the same calendric age as the charcoal specimen, following a normal distribution whose mean () and standard deviation () are both conditional on both and the Marine13 model.

* 1. Given a sufficiently large value of and per the Law of Large Numbers, the distribution of the MC sample (Eq. 2) will approach the underlying predictive distribution of interest. A normal approximation of this predictive distribution may then be achieved by calculating the mean and standard deviation of the MC sample, treating these as plug-in estimates of the parameters governing the normal approximation:

1. Estimate for the th shell specimen by combining calculated per the preceding step and the conventional 14C age and accompanying error measured for that shell, and . Assuming that follows a normal distribution, and that the true but unknown 14C age of the th shell likewise follows a normal distribution, , may be probabilistically estimated as following a normal difference distribution

where

**Combining into an aggregate estimate of**

In attempting to concert our 13 individual charcoal-shell estimates toward a more accurate estimate of , we were obliged to confront the apparent presence of at least some spurious estimates in our dataset, as discussed in the main text. Lacking independent information regarding which of these estimates are spurious – or by how much – we instead assumed that the best guide to the location of the true value of is the highest concentration of individual-shell estimates (assuming that the distribution of all estimates has a single center of mass), and furthermore that the inclusion of spurious estimates has not shifted the center of mass away from that of the sound ones.

Given the uncertainty surrounding each estimate (summarized by ), our description of the distribution of all estimates takes the specific form of the mixture probability function

In effect, the distribution comprising such mixture probabilities constitutes an unweighted average of all individual-shell estimates. Because the mean and standard deviation of this mixture distribution is analytically intractable, we instead took a MC approach to their solution,

where was drawn per Eq. 5.

**Appendix I References**

Gelman, A., Carlin, J.B., Stern, H.S., Dunson, D.B., Vehtari, A., Rubin, D.B., 2013. Bayesian Data Analysis, 3rd ed. CRC Press, Boca Raton.

**APPENDIX II**

ΔR data from the greater North Pacific Rim as discussed in the text and summarized in Figure 3.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Longitude (E) | Latitude (N) | Waters | ΔR | ΔR error | Reference |
| South Kurils (Kunashir Island) | | | | | |
| 145.72 | 43.92 | Subarctic | 445 | 45 | Kuzmin et al. 2001 |
| 145.72 | 43.92 | Subarctic | 465 | 40 | Kuzmin et al. 2001 |
| 145.72 | 43.92 | Subarctic | 350 | 45 | Kuzmin et al. 2001 |
| 146.08 | 44.23 | Subarctic | 500 | 40 | Kuzmin et al. 2001 |
| 145.68 | 43.9 | Subarctic | 220 | 45 | Kuzmin et al. 2001 |
| 145.7 | 43.9 | Subarctic | 275 | 40 | Kuzmin et al. 2001 |
| 147 | 44 | Subarctic | 489 | 36 | Yoneda et al. 2007 |
| 145.71 | 43.34 | Subarctic | 511 | 53 | Kuzmin et al. 2007 |
| 145.64 | 43.29 | Subarctic | 471 | 46 | Kuzmin et al. 2007 |
| Southeast Sakhalin (Okhotsk Sea coast) | | | | | |
| 144.7 | 48.68 | Subarctic | 698 | 50 | Kuzmin et al. 2007 |
| 142.77 | 48.61 | Subarctic | 611 | 50 | Kuzmin et al. 2007 |
| 142.77 | 48.61 | Subarctic | 468 | 50 | Kuzmin et al. 2007 |
| 143 | 47 | Subarctic | 420 | 35 | Kuzmin et al. 2007 |
| 142.8 | 47.41 | Subarctic | 533 | 50 | Kuzmin et al. 2007 |
| South Sakhalin (Gulf of Aniva) | | | | | |
| 142.5 | 47 | Subarctic | 377 | 35 | Yoneda et al. 2007 |
| West Sakhalin (Tatar Strait/N. Sea of Japan) | | | | | |
| 142.18 | 47.97 | Tropical/temperate | 8 | 50 | Kuzmin et al. 2007 |
| 142.19 | 48.08 | Tropical/temperate | 208 | 50 | Kuzmin et al. 2007 |
| 141.81 | 46.58 | Tropical/temperate | 68 | 50 | Kuzmin et al. 2007 |
| South Hokkaido (Tsugaru Strait/Hakodate) | | | | | |
| 141 | 42 | Tropical/temperate | 34 | 34 | Yoneda et al. 2007 |
| West Hokkaido (Otaru/Sea of Japan) | | | | | |
| 141 | 43 | Tropical/temperate | 94 | 36 | Yoneda et al. 2007 |
| Peter the Great Bay (Vladivostok/Sea of Japan) | | | | | |
| 133.08 | 42.73 | Tropical/temperate | 50 | 30 | Kuzmin et al. 2001 |
| 131.9 | 43.1 | Tropical/temperate | 35 | 40 | Kuzmin et al. 2001 |
| East Honshu (outer Tokyo Bay, Japan) | | | | | |
| 139.65 | 35.15 | Tropical/temperate | 130 | 50 | Shishikura et al. 2007 |
| 139.6 | 35.2 | Tropical/temperate | 40 | 40 | Shishikura et al. 2007 |
| 139.6 | 35.15 | Tropical/temperate | 110 | 40 | Shishikura et al. 2007 |
| 139.6 | 35.15 | Tropical/temperate | 140 | 40 | Shishikura et al. 2007 |
| 139.6 | 35.15 | Tropical/temperate | 60 | 40 | Shishikura et al. 2007 |
| 139.6 | 35.15 | Tropical/temperate | 250 | 40 | Shishikura et al. 2007 |
| 139.6 | 35.12 | Tropical/temperate | 200 | 40 | Shishikura et al. 2007 |
| Ryuku Islands | | | | | |
| 127 | 27 | Tropical/temperate | 40 | 31 | Yoneda et al. 2007 |
| 127 | 27 | Tropical/temperate | -6 | 30 | Yoneda et al. 2007 |
| 127.8 | 26.4 | Tropical/temperate | -126 | 7 | Konishi et al. 1982 |
| 129 | 28 | Tropical/temperate | 94 | 30 | Yoneda et al. 2007 |
| 129 | 28 | Tropical/temperate | 18 | 30 | Yoneda et al. 2007 |
| 129 | 28 | Tropical/temperate | -1 | 32 | Yoneda et al. 2007 |
| 124.33 | 24.55 | Tropical/temperate | 7 | 40 | Hideshima et al. 2001 |
| 124.33 | 24.55 | Tropical/temperate | -57 | 40 | Hideshima et al. 2001 |
| 124.33 | 24.55 | Tropical/temperate | 15 | 40 | Hideshima et al. 2001 |
| 124.33 | 24.55 | Tropical/temperate | 104 | 45 | Hideshima et al. 2001 |
| Boh Hai Gulf, South Korea | | | | | |
| 128.17 | 34.67 | Tropical/temperate | -154 | 35 | Kong and Lee 2005 |
| 126.33 | 36 | Tropical/temperate | -111 | 45 | Kong and Lee 2005 |
| 120.3 | 36.1 | Tropical/temperate | -81 | 60 | Southon et al. 2002 |
| 119 | 39 | Tropical/temperate | -178 | 50 | Southon et al. 2002 |
| Central Aleutians (Buldir Island; from sea mammal bones) | | | | | |
| 175.89 | 52.38 | Subarctic | 358 | 57 | Corbett et al. 2010 |
| 175.89 | 52.38 | Subarctic | 488 | 85 | Corbett et al. 2010 |
| Central Aleutians (Adak Island) | | | | | |
| -176.55 | 51.92 | Subarctic | 615 | 35 | Khasanov et al. 2015 |
| -176.55 | 51.92 | Subarctic | 605 | 35 | Khasanov et al. 2015 |
| -176.55 | 51.92 | Subarctic | 555 | 35 | Khasanov et al. 2015 |
| -176.55 | 51.92 | Subarctic | 525 | 35 | Khasanov et al. 2015 |
| -176.55 | 51.92 | Subarctic | 515 | 35 | Khasanov et al. 2015 |
| -176.55 | 51.92 | Subarctic | 465 | 35 | Khasanov et al. 2015 |
| -176.57 | 51.94 | Subarctic | 245 | 35 | Khasanov et al. 2015 |
| -176.57 | 51.94 | Subarctic | 600 | 35 | Khasanov et al. 2015 |
| -176.65 | 51.85 | Subarctic | 495 | 35 | Khasanov et al. 2015 |
| -176.65 | 51.85 | Subarctic | 430 | 35 | Khasanov et al. 2015 |
| -176.65 | 51.85 | Subarctic | 665 | 40 | Khasanov et al. 2015 |
| -176.65 | 51.85 | Subarctic | 575 | 40 | Khasanov et al. 2015 |
| -176.65 | 51.85 | Subarctic | 580 | 40 | Khasanov et al. 2015 |
| -176.65 | 51.85 | Subarctic | 560 | 40 | Khasanov et al. 2015 |
| Chukchi Sea (NW Alaska) | | | | | |
| -156.48 | 71.4 | Subarctic | 420 | 40 | McNeely et al. 2006 |
| -156.48 | 71.4 | Subarctic | 560 | 30 | McNeely et al. 2006 |
| -156.48 | 71.4 | Subarctic | 470 | 40 | McNeely et al. 2006 |
| -161.42 | 70.4 | Subarctic | 610 | 40 | McNeely et al. 2006 |
| -161.42 | 70.4 | Subarctic | 310 | 50 | McNeely et al. 2006 |
| -161.42 | 70.4 | Subarctic | 320 | 25 | McNeely et al. 2006 |
| Norton Sound (W. Alaska) | | | | | |
| -166.37 | 65.27 | Subarctic | 580 | 40 | McNeely et al. 2006 |
| -166.37 | 65.27 | Subarctic | 450 | 20 | McNeely et al. 2006 |
| -166.67 | 65.25 | Subarctic | 350 | 50 | McNeely et al. 2006 |
| -166.67 | 65.25 | Subarctic | 520 | 20 | McNeely et al. 2006 |
| Gulf of Alaska | | | | | |
| -162 | 55.5 | Subarctic | 242 | 50 | Robinson and Thompson 1981 |
| -146.33 | 59.43 | Subarctic | 340 | 50 | McNeely et al. 2006 |
| -145.7 | 60.57 | Subarctic | 440 | 20 | McNeely et al. 2006 |
| -136.35 | 57.7 | Subarctic | 320 | 50 | McNeely et al. 2006 |
| Southeast Alaska | | | | | |
| -135.5 | 58.76 | Subarctic | 460 | 60 | McNeely et al. 2006 |
| -135 | 57 | Subarctic | 410 | 60 | McNeely et al. 2006 |
| -135 | 57.5 | Subarctic | 510 | 50 | McNeely et al. 2006 |
| -134.1 | 57.5 | Subarctic | 450 | 50 | McNeely et al. 2006 |
| -134.1 | 57.1 | Subarctic | 670 | 60 | McNeely et al. 2006 |
| -134.1 | 57.1 | Subarctic | 540 | 70 | McNeely et al. 2006 |
| -132.85 | 57.3 | Subarctic | 600 | 50 | McNeely et al. 2006 |
| -132.85 | 57.3 | Subarctic | 470 | 60 | McNeely et al. 2006 |
| -132.85 | 57.63 | Subarctic | 530 | 60 | McNeely et al. 2006 |
| Northern British Columbia coast (Canada) | | | | | |
| -132.1 | 54.02 | Subarctic | 390 | 50 | McNeely et al. 2006 |
| -132.42 | 53.3 | Subarctic | 220 | 50 | McNeely et al. 2006 |
| -132.42 | 53.3 | Subarctic | 320 | 50 | McNeely et al. 2006 |
| -132 | 53.23 | Subarctic | 230 | 50 | McNeely et al. 2006 |
| -132 | 53.23 | Subarctic | 200 | 40 | McNeely et al. 2006 |
| Gulf of Georgia (E. Vancouver Island and Mainland, Canada) | | | | | |
| -124 | 49.5 | Subarctic | 510 | 40 | McNeely et al. 2006 |
| -124.82 | 49.93 | Subarctic | 510 | 50 | McNeely et al. 2006 |
| -124.17 | 49.49 | Subarctic | 380 | 50 | McNeely et al. 2006 |
| -123.95 | 49.2 | Subarctic | 440 | 50 | McNeely et al. 2006 |
| -124.2 | 49.27 | Subarctic | 370 | 50 | McNeely et al. 2006 |
| -123.7 | 48.92 | Subarctic | 380 | 50 | McNeely et al. 2006 |
| -123.7 | 48.92 | Subarctic | 320 | 70 | McNeely et al. 2006 |
| -123.2 | 49.3 | Subarctic | 410 | 40 | McNeely et al. 2006 |
| Western Vancouver Island, Canada (Pacific) | | | | | |
| -125.91 | 49.14 | Subarctic | 310 | 50 | McNeely et al. 2006 |
| -125.87 | 49.13 | Subarctic | 470 | 50 | McNeely et al. 2006 |
| -125.73 | 49.05 | Subarctic | 340 | 40 | McNeely et al. 2006 |
| -125.55 | 48.93 | Subarctic | 400 | 50 | McNeely et al. 2006 |
| -125.55 | 48.93 | Subarctic | 450 | 50 | McNeely et al. 2006 |
| -125.55 | 48.93 | Subarctic | 270 | 20 | McNeely et al. 2006 |
| -125.54 | 48.92 | Subarctic | 360 | 50 | McNeely et al. 2006 |
| -125.41 | 48.95 | Subarctic | 220 | 50 | McNeely et al. 2006 |
| -125.5 | 48.94 | Subarctic | 320 | 25 | McNeely et al. 2006 |
| -124 | 48.4 | Subarctic | 402 | 50 | Robinson and Thompson 1981 |
| -123.72 | 48.38 | Subarctic | 360 | 50 | McNeely et al. 2006 |

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