Supplementary Information

Polyphyletic ancestry of expanding Patagonian Chinook salmon populations

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Table S1: Chinook salmon deliberate and accidental releases in Latin America (modified from Correa and Gross 2008).

| Country year(s) | Basin, Latitude | Number of Individuals Released | Ontogenetic Stage | Stock Origin | Adult Returns | Comments |
|-----------------|-----------------|--------------------------------|-------------------|--------------|---------------|----------|
| Mexico 1891-1900 | ?               | 50,000<sup>1</sup>              | ?                 | USA<sup>2</sup>, Sacramento River (<sup>?</sup>)<sup>1</sup> | No<sup>1,2</sup> |          |
| Mexico 1901-1910 | ?               | 50,000<sup>1</sup>              | ?                 | USA<sup>2</sup>, Sacramento River (<sup>?</sup>)<sup>1</sup> | No<sup>1,2</sup> |          |
| Nicaragua 1901-1910 | ?               | 20,000<sup>1</sup>              | ?                 | USA<sup>2</sup>, Sacramento River (<sup>?</sup>)<sup>1</sup> | No<sup>1,2</sup> |          |
| Argentina 1906 | Santa Cruz, 50°S<sup>4</sup> Gallegos, 52°S<sup>4</sup> | 300,000<sup>4</sup> | ?                 | USA, Sacramento River (<sup>?</sup>)<sup>4</sup> | No (?)<sup>5</sup> |          |
| Argentina 1908 | Chico, 50°S<sup>6</sup> Santa Cruz, 50°S<sup>6</sup> | 300,000<sup>6</sup> | ?                 | USA, Sacramento River (<sup>?</sup>)<sup>6</sup> | No (?)<sup>5</sup> |          |
| Argentina 1909 | Chico, 50°S<sup>6</sup> Santa Cruz, 50°S<sup>6</sup> | 200,000<sup>6</sup> | ?                 | USA, Sacramento River (<sup>?</sup>)<sup>6</sup> | No (?)<sup>5</sup> |          |
| Argentina 1910 | (Rivers of Santa Cruz Province<sup>6</sup>) | 200,000<sup>6</sup> | ?                 | USA, Sacramento River (<sup>?</sup>)<sup>6</sup> | No (?)<sup>5</sup> |          |
| Argentina 1901-1910<sup>1</sup> | ?               | 1,058,000<sup>1</sup>          | ?                 | USA<sup>2</sup>, Sacramento River (<sup>?</sup>)<sup>1</sup> | No<sup>2,5</sup> |          |

"From [1872-1930] the [US] Bureau of Fisheries, with benevolent intent, supplied over 100 million eggs of Pacific salmon (Chinook) to people in other countries, with the idea of establishing new salmon runs there—a considerable attempt to bring in the New World to right the Rest."<sup>3</sup>

The last Argentinean entry (1901-1910) might include the previous four.
| Location         | Date       | Eggs/SE/Smolts | Hatchery          | Returned | Notes                                                                 |
|------------------|------------|----------------|-------------------|----------|----------------------------------------------------------------------|
| Brazil, Jaquari  | 1958       | 400,000⁷       | USA, American River, California⁷ | No (?)⁷  | Although there were no reports of salmon returning to the Río Jaquari, large fish of a species unknown to local residents were seen leaping falls in the Río Uruguay in 1962⁷. |
| Chile, Imperial  | 1924       | 200,000⁹,10    | USA, Sacramento River; USA, McCloud River Hatchery (?)¹⁰ | No (?)⁸,⁸,¹⁰ | The U.S. government presented the government of Chile with 200,000⁹,¹⁰ fertilized ChS eggs. The embryos arrived at a recently built hatchery in Rio Blanco (near Santiago) just prior to hatching⁸,⁸. After four months, fingerlings were transported by rail and released⁹. |
| Chile 1970, 1971 | Bueno      | 50,000 (1970)¹¹ | USA, Green River Hatchery¹¹ (Cowlitz River, lower Columbia River, Washington). | ?        | Agriculture and Livestock Service of the Government of Chile and the U.S. Peace Corps. First shipment by plane¹¹,¹². Eggs were received at Lautaro Hatchery on December; stockings took place 36 (Sep 1970) or 23 weeks later (May 1971)¹¹. |
| Chile, Chiloé Island, Curaco de Vélez | 1978       | 120,000 (late 1978)¹³,¹⁴,¹⁶ | USA, Cowlitz River spring-run (lower Columbia River, Washington)¹⁶ | Yes¹³,¹⁴,¹⁶ | Domsea Pesquera Chile Ltd. (Union Carbide Corporation, USA), began salmon ocean-ranching experimentation¹⁰,¹⁴,¹⁵. In 1979, 334 returning jacks and 2 females were trapped¹³,¹⁴. In the period 1979-1982, 1050 returnees of this release were recorded¹⁶. |
| Country, Year | Location | Stock Size (°S) | Stage | Origin | Yes/No | Description |
|-------------|---------|----------------|-------|--------|-------|-------------|
| Chile, 1979 | Coastal, 42°S | Chiloé Island, Curaco de Vélez | 190,000 | Smolts (1+) | Yes | Domsea Pesquera Chile Ltd. In the period 1980-1982, 228 returnees of this release were recorded. |
| Chile, 1980-1981 | Same location | | 90,000 (late 1980, early 1981) | Smolts (1+) | Yes | In the period 1981-1982, 260 returnees of this release were recorded. |
| Chile, 1982 | Same location | | 3000 | Smolts (1+) | ? | In 1981, Domsea Pesquera Chile Ltd. was sold to Fundación Chile (private, non-profit), and renamed Salmones Antártica Ltd. Stocking continued at this location at least during the first year of the new administration. |
| Chile, 1982 | Same location | >1,000,000 fish were being raised, but their fate remains unknown to us. | Ova & subyearlings | USA, University of Washington's Hatchery fall-run; Chile, progeny from local returnees | ? | Through October 1982, 1538 adults had returned to the hatchery from previous brood years. Returnee's progeny (F2) was being raised at the facility along with fry from two additional importations. However, we found no posterior records of fish release at this location. |
| Chile, 1982 | Coastal, 54°S | Rio Santa María | 200,000 | Fry | ? | Fundación Chile through Salmoines Antárctica Ltd. launched new facility in the Magellan region subsequently destroyed by storm, and abandoned. Jacks seen returning in 1983. |
| Chile, 1983 | Prat, 51°S | Rio Prat | 5,000 | Smolts (1+) | Yes (~2.3%) | Fundación Chile through Salmoines Antárctica Ltd. launched another facility in the Magellan region with successfully returning spawners. |
| Location          | Year Range | Numbers   | Stage       | Origin(s)                                      | Return Rate | Notes                                                                 |
|-------------------|------------|-----------|-------------|-----------------------------------------------|-------------|----------------------------------------------------------------------|
| Chile, 1987       |            | 294,967   | Smolts (1+) | USA, seemingly University of Washington's    | Yes         | Continuation of the above enterprise. In 1998 Fundación Chile and Salmones Antártica created Salmotec S.A.   |
|                   |            |           |             | (Chilean origin)                               | (-0.07% until 1989) |                                                                |
|                   |            | 40,042    |             |                                               |             |                                                                    |
|                   |            |           |             |                                               |             |                                                                    |
| Same location     | 1987       |           |             |                                               |             |                                                                    |
|                   |            |           |             |                                               |             |                                                                    |
|                   |            |           |             |                                               |             |                                                                    |
| Chile, 1989, 1990, 1993 |           | ? (1989-1990) | Smolts (0+) | ? (1989-1990); Chile, progeny from returning adults (38 females + 12 males) | Yes, at least from 1989-1990 stockings | Universidad de Los Lagos' experimentation at Piscicultura Experimental Lago Ranco. |
| Bueno 40°S        |            | 3347 (Jan 1993) |             |                                               |             |                                                                    |
| Estero Huillín    | 24         |           |             |                                               |             |                                                                    |
| Chile, 1987-2000  | Coast, 39-45°S | 100,000   | Mostly subadults | USA, Washington Sate, USA, Oregon State, Canada, Vancouver Island, New Zealand, USA, Alaska, Australia | Yes | Chinook stocks were imported primarily to the Lakes District Region for commercial net pen rearing. Last recorded importation in 2000. |
| Inner seas        |            |           |             |                                               |             |                                                                    |
|                   |            |           |             |                                               |             |                                                                    |
Notes and references: The actual number of individuals released may be less than the figure reported due to mortality during transport and handling; pre-release mortality was accounted for whenever possible. Approximate latitude is given at the river mouth. ? = unreported, likely stock origin, or lack of adults return assessment; 1 Davidson and Hutchinson (1938); 2 Welcomme (1988); 3 Elton (1958); 4 Tulian (1908) in Ciancio et al. (2005); 5 Marini (1936) in Davidson and Hutchinson (1938); 6 Marini and Mastrarrigo (1963) in Ciancio et al. (2005); 7 Joyner (1980); 8 Golusda (1927); 9 Barros (1931); 10 Fundación Chile (1990); 11 Snyder (1971); 12 Ellis and Salo (1969) in Basulto (2003); 13 Lindbergh et al. (1981); 14 Lindbergh (1982); 15 Méndez and Munita (1989); 16 Lindbergh and Brown (1982); 17 Basulto (2003); 18 Donaldson and Joyner (1983); 19 Manuel Barros personal communication (2008) in Aedo (2011). At the time, M. Barros worked for Fundación Chile.; 20 Salmotec Ltd. in Sakai (1989); 21 Cristian Jémez personal communication (2005) in Aedo (2011). C. Jémez worked for Fundación Chile (1982).; 22 Fredy Carrasco personal communication (2005) in Aedo (2011). F. Carrasco worked for Fundación Chile (1982).; 23 United Nations (2006); 24 Del Real (1993). Aedo (2011) mentioned other stocking locations (Río Contaco and Río Maicolpué) by Universidad de Los Lagos, but we found no further records of these releases.; 25 Primarily marine aquaculture concessions in the Lake District region.; 26 Rough estimate of number of sub-adult Chinook salmon escapees (see main text); 27 Mostly 1+ year class and older since most escapes were from marine net-pens (Soto et al. 2001).; 28 Follow fragmentary records of ova imported (OI) by the Chilean aquaculture industry in 1987-2000 (Aedo 2011). Some information of suppliers was available for 60% of the imports; we report specific lineages and origins of livestock whenever possible, and ova suppliers and/or geographic origin of shipments otherwise. Additional potential sources of the unaccounted imports were identified from import permits (OP) issued by the Chilean National Fisheries Service (SERNAPECA), although it remains unclear if these planned importations ever materialized. Sources listed in decreasing order of importance (Aedo 2011); 29 OI: Columbia River. OP: Fish Pro Inc. and University of Washington; 30 OI: Springfield. OP: Aqua Food, Aquafoods, and Aqua Seed Corp.; 31 OI: Koksilah River. OP: Sea Spring Salmon Farms Ltd., Hardy Sea Farms, Hadfield Consultants Inc., Hatfield International SA., Fishpro, and Aqua Seed; 32 OI: Sanford Waitaki Salmon Hatchery (Kaitan Gata). OP: Big Glory Bay Hatchery, and Kaitan Gata Hatchery and Sanford Waitaki Salmon Hatchery (Stewart Island).; 33 OP: Sitka; 34 OP: Tasmania; 35 This study.

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Table S2: Genetic diversity in Patagonian populations, putative North American founding populations, and overall North American baseline populations.

| Population          | Reporting group (North America) | N   | \(H_S\) | \(AR\) | \(F_{IS}\) |
|---------------------|---------------------------------|-----|---------|--------|-----------|
| **Patagonian populations** |                                 |     |         |        |           |
| Baker               |                                 | 24  | 0.851   | 9.683  | 0.039     |
| Aysén               |                                 | 24  | 0.826   | 9.450  | 0.011     |
| Petrohué            |                                 | 24  | 0.854   | 10.410 | -0.008    |
| Toltén              |                                 | 15  | 0.804   | 7.128  | 0.009     |
| **Mean**            |                                 | 21.75 | 0.834   | 9.168  | 0.012     |
| **SD**              |                                 | 4.500 | 0.024   | 1.420  | 0.013     |
| **Putative source populations** |                             |     |         |        |           |
| Skagit River upper  | Whidbey Basin                   | 55  | 0.869   | 10.700 | -0.031    |
| Cascade River upper | Whidbey Basin                   | 47  | 0.877   | 10.674 | 0.007     |
| NF Stillaguamish Hatchery | Whidbey Basin            | 350 | 0.876   | 10.927 | 0.006     |
| Suiattle River      | Whidbey Basin                   | 154 | 0.872   | 10.791 | 0.008     |
| Sauk River          | Whidbey Basin                   | 115 | 0.871   | 11.037 | 0.003     |
| UW Hatchery su/fa   | S Puget Sound fa                | 140 | 0.811   | 9.316  | -0.001    |
| Soos Hatchery       | S Puget Sound fa                | 184 | 0.815   | 9.988  | -0.006    |
| S Prairie Creek     | S Puget Sound fa                | 104 | 0.805   | 10.006 | 0.014     |
| Voights Hatchery    | S Puget Sound fa                | 95  | 0.814   | 10.318 | 0.007     |
| Clear Creek Hatchery| S Puget Sound fa                | 141 | 0.809   | 10.018 | 0.001     |
| Methow River        | Interior Columbia Basin su/fa   | 143 | 0.868   | 11.399 | -0.009    |
| Wells Hatchery      | Interior Columbia Basin su/fa   | 144 | 0.869   | 11.259 | -0.029    |
| Wenatchee River su/fa| Interior Columbia Basin su/fa  | 135 | 0.863   | 11.190 | 0.009     |
| Hanford Reach       | Interior Columbia Basin su/fa   | 273 | 0.886   | 11.974 | 0.008     |
| Lyons Ferry Hatchery| Interior Columbia Basin su/fa   | 186 | 0.870   | 11.160 | 0.017     |
| Deschutes River lower| Interior Columbia Basin su/fa  | 143 | 0.872   | 11.345 | 0.020     |
| Deschutes River upper| Interior Columbia Basin su/fa  | 144 | 0.861   | 10.648 | 0.005     |
| Location                      | Region          | Species            | Value 1 | Value 2 | Value 3 | Value 4 |
|-------------------------------|-----------------|--------------------|---------|---------|---------|---------|
| N_Santiam Hatchery            | Willamette R sp | 143                | 0.814   | 9.732   | -0.005  |
| McKenzie Hatchery             | Willamette R sp | 142                | 0.817   | 9.589   | -0.001  |
| Lewis River fa                | W Cascade fa    | 93                 | 0.882   | 11.360  | 0.006   |
| Sandy River                   | W Cascade fa    | 123                | 0.895   | 11.839  | -0.006  |
| Cowlitz Hatchery fa           | W Cascade fa    | 138                | 0.873   | 11.187  | 0.000   |
| Green River fa                | W Cascade fa    | 55                 | 0.880   | 11.418  | 0.031   |
| Cowlitz Hatchery sp           | W Cascade sp    | 139                | 0.854   | 10.679  | 0.003   |
| Kalama Hatchery sp            | W Cascade sp    | 143                | 0.863   | 10.844  | 0.016   |
| Lewis Hatchery sp             | W Cascade sp    | 143                | 0.868   | 10.934  | -0.015  |
| Necanicum Hatchery            | N Oregon Coast  | 77                 | 0.846   | 9.639   | 0.041   |
| Nehalem River                 | N Oregon Coast  | 150                | 0.811   | 8.803   | 0.014   |
| Wilson River                  | N Oregon Coast  | 137                | 0.866   | 10.375  | 0.003   |
| Kilchis River                 | N Oregon Coast  | 58                 | 0.866   | 10.262  | 0.015   |
| Trask River                   | N Oregon Coast  | 160                | 0.873   | 10.524  | 0.011   |
| Nestucca Hatchery             | N Oregon Coast  | 130                | 0.858   | 9.935   | 0.023   |
| Salmon River fa               | N Oregon Coast  | 102                | 0.878   | 10.535  | 0.021   |
| Siletz River                  | N Oregon Coast  | 163                | 0.882   | 10.702  | 0.010   |
| Yaquina River                 | N Oregon Coast  | 136                | 0.868   | 10.294  | 0.029   |
| Alsea River                   | N Oregon Coast  | 161                | 0.865   | 10.246  | 0.026   |
| Siuslaw River                 | N Oregon Coast  | 152                | 0.887   | 11.233  | 0.043   |
| **Mean**                      |                 | 137.784            | 0.858   | 10.618  | 0.008   |
| **SD**                        |                 | 55.123             | 0.026   | 0.703   | 0.004   |

**All North American baseline populations**

| **Mean**                      |                 | 133.733            | 0.833   | 9.810   | 0.008   |
| **SD**                        |                 | 46.405             | 0.038   | 1.131   | 0.002   |
Table S3: Genetic ancestral contribution of North American lineages to Patagonian Chinook salmon based on population-level CML mixture analysis.

| ID  | Reporting Group     | NA Population | Patagonian watershed |
|-----|---------------------|---------------|-----------------------|
|     |                     |               | Toltén | Petrohué | Aysén | Baker | Pooled |
| 1   | Central Valley fa   | Stanislaus R  | 4.1 (1) |         |       | 1.2 (1) |         |
| 1   | Central Valley fa   | Tuolumne R    | 4.1 (1) |         |       | 1.2 (1) |         |
| 5   | Klamath R           | Klamath R fa  | 6.9 (1) |         |       | 1.3 (1) |         |
| 6   | Chetco R            | Chetco R      | 7.3 (1) |         |       | 1.3 (1) |         |
| 9   | Willamette R sp     | N Santiam H   | 4 (1)   | 3.3 (1) |       | 1.9 (2) |         |
| 9   | Willamette R sp     | McKenzie H    | 1.3 (0) | 15.0 (4) |       | 4.6 (4) |         |
| 13  | N Oregon Coast      | Salmon R f    | 0.6 (0) | 4.1 (1) |       | 1.3 (1) |         |
| 13  | N Oregon Coast      | Siuslaw R     | 2.9 (0) | 4.2 (1) | 0.5 (0) | 1.9 (1) |         |
| 13  | N Oregon Coast      | Trask R       | 5.9 (1) | 0.1 (0) |       | 1.1 (1) |         |
| 15  | W Cascade fa        | Cowitz H fa   | 8.9 (2) | 3.2 (1) | 16.8 (3) | 5.4 (1) | 8.2 (7) |
| 15  | W Cascade fa        | Sandy R       | 0.6 (0) | 0.6 (0) | 0.5 (0) | 5.5 (2) | 2.0 (2) |
| 16  | W Cascade sp        | Kalama H sp   | 3.0 (0) | 15.2 (4) | 26.9 (7) | 28.7 (7) | 19.7 (18) |
| 16  | W Cascade sp        | Cowitz H sp   | 4.3 (1) | 6.4 (1) | 44.4 (8) | 35.8 (8) | 23.7 (18) |
| 17  | Interior Columbia Basin su/fa | Wenatchee R s/f | 6.8 (1) | 0.4 (0) |       | 1.4 (1) |         |
| 17  | Interior Columbia Basin su/fa | Hanford Reach | 6.2 (1) | 8.5 (2) | 4.4 (1) | 5.5 (1) | 6.2 (5) |
| 17  | Interior Columbia Basin su/fa | Lyons Ferry H | 6.0 (1) | 0.1 (0) |       | 0.1 (0) | 1.1 (1) |
| 19  | S Puget Sound fa    | Clear Cr H    | 0.1 (0) | 2.1 (0) | 1.3 (0) | 0.9 (0) |         |
| 19  | S Puget Sound fa    | Soos H        | 16.9 (5) |       | 0.1 (0) | 4.9 (5) |         |
| 19  | S Puget Sound fa    | S Prairie Cr  | 0.1 (0) | 1.0 (0) |       | 0.3 (0) |         |
| 22  | Washington Coast    | Sol Duc H     | 4.0 (1) | 0.1 (0) |       | 1.2 (1) |         |
| 22  | Washington Coast    | Forks Cr H    | 6.5 (1) | 4.0 (1) | 0.1 (0) | 2.4 (2) |         |
| 23  | Straits of Juan de Fuca | Elwha R    | 0.2 (0) | 5.7 (1) |       | 1.7 (1) |         |
| 24  | Whidbey Basin       | Suiattle R    | 4.2 (1) |       |       | 1.2 (1) |         |
| 24  | Whidbey Basin       | Cascade R U   | 20.1 (3) | 0.3 (0) | 0.2 (0) | 3.8 (3) |         |
| 26  | E Vancouver Is      | Big Qual H    | 6.3 (1) | 2.2 (1) |       | 1.8 (2) |         |
| 31  | S Thompson R        | L Adams H     | 6.4 (1) | 0.1 (0) |       | 1.2 (1) |         |
| 38  | SSE Alaska          | Clear Cr      | 0.6 (0) | 4.4 (1) |       | 1.4 (1) |         |
| 39  | Nass R              | Kincolith R   | 3.9 (1) |       |       | 1.1 (1) |         |

No. Individuals in mixture (15) (24) (20) (24) (83)
Notes: Values represent average percent genetic contribution; in brackets, frequency of individual assignments to baseline populations, as inferred from individual's highest assignment probability. Identifiers (ID) correspond to those in Figure 1 (main article).
Figure S1: Confusion matrix of leave-one-out, self assignment test of individual genotypes after conditional maximum likelihood (CML) mixture analysis of North American samples. Values, and colour saturation, correspond to proportion of assignments. Samples (11800 fish genotypes, from 146 populations) were pooled by lineage (45 reporting groups), and sorted by decreasing latitude for display. Note how samples assign to their lineages with high accuracy and rarely to unrelated (distant) lineages, as observed in some simulated, admixed individuals (main article).
Figure S2: Frequency distribution of individual maximum assignment probabilities from population and reporting group-level CML mixture analysis of Patagonian samples.
Figure S3: Conditional maximum likelihood (CML) mixture analysis of the simulated mixed-origin Chinook salmon population derived from Cowlitz River Hatchery spring run in the West Cascade spring-run reporting group and Soos Creek Hatchery fall run in the South Puget Sound fall-run reporting group. Distribution of maximum assignment probabilities (a), average percent genetic contribution of reporting groups to the simulated population (b), and individual alternative assignments based on best and second-best assignment probabilities (c). Equivocal assignments [i.e., low assignment probability, symbolized with darker lines in (c)] typically split probabilities between founder lineages, or between founder lineages and genetically similar reporting groups. A small fraction of simulated individuals assigned to unrelated lineages, even with high assignment probabilities in some cases. Reporting groups with no assignments were omitted. Reporting groups were ordered by decreasing order of estimated contribution (b) or increasing latitude (c).
Figure S4: Delta-$K$ plot to determine appropriate number of groups in model-based clustering present in 8,228 fish from 31 populations distributed among seven North American lineages that potentially contributed founders of Patagonian populations.
Figure S5: Individual stacked bar plot (STRUCTURE plot) of (a) North American baseline data-set of 8,228 fish from 31 populations distributed among seven North American lineages, and (b) Patagonian samples treated as having unknown origin in the analysis, and plotted by watershed ($n = 81$). The number of groups was set to $K = 5$, and estimated individual group membership probabilities is shown in colours.