Parentage-Based Tagging (PBT)

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Prepared by Tami Wilkerson and Ben Maceda, Columbia Basin Fish & Wildlife Library. For copies of the resources mentioned email librarystaff@critfc.org

Ashton, N. K., M. R. Campbell, P. J. Anders, M. S. Powell, and K. D. Cain. 2016. Evaluating microsatellite markers for parentage-based tagging of hatchery burbot. Northwest Science 90(3):249–259. https://doi.org/10.3955/046.090.0303

Determines whether microsatellites previously developed for burbot phylogeographic studies can be multiplexed for effective PBT.

Beacham, T. D. 2021. Parentage-based tagging combined with genetic stock identification is a cost-effective and viable replacement for coded-wire tagging in large-scale assessments of Canadian salmon fisheries. Fisheries Research 239:105920. https://doi.org/10.1016/j.fishres.2021.105920

Presents responses to arguments offered by coded-wire tag proponents supposedly limiting the effectiveness of a genetic stock identification and PBT fisheries assessment method.

Beacham, T. D., K. Jonsen, B. McIntosh, B. J. G. Sutherland, D. Willis, C. Lynch, and C. Wallace. 2020. Large-scale parentage-based tagging and genetic stock identification applied in assessing mixed-stock fisheries and hatchery brood stocks for Coho salmon in British Columbia, Canada. Canadian Journal of Fisheries and Aquatic Sciences 77(9):1505–1517. https://doi.org/10.1139/cjfas-2020-0035

Assesses the efficacy of PBT in genetic stock identification, finds PBT assignments, verified by CWTs, were 100% accurate for 308 individuals with respect to population of origin and age.

Beacham, T. D., K. Jonsen, B. J.G. Sutherland, C. Lynch, and E. B. Rondeau. 2022. Assessment of mixed-stock fisheries and hatchery broodstocks for coho salmon in British Columbia, Canada via parentage-based tagging and genetic stock identification. Fisheries Research 245:106136. https://doi.org/10.1016/j.fishres.2021.106136

Applies a genetic approach to coho salmon fishery assessment in British Columbia fisheries.

Beacham, T. D., K. Jonsen, B. J. G. Sutherland, B. Ramshaw, and E. B. Rondeau. 2022. Parentage-based tagging and genetic stock identification applied to assessment of mixed-stock fisheries and hatchery broodstocks for Chinook salmon in British Columbia, Canada. Fisheries Research 253:106369. https://doi.org/10.1016/j.fishres.2022.10636.

Studies whether genetic methods for stock assessment yield results that are consistent with those from coded wire tag methodology.

Beacham, T. D., C. G. Wallace, K. Jonsen, B. McIntosh, J. R. Candy, K. Horst, C. Lynch, D. Willis, W. Luedke, L. Kearey, and E. B. Rondeau. 2021. Parentage-based tagging combined with genetic stock identification is a cost-effective and viable replacement for coded-wire tagging in large-scale assessments of marine Chinook salmon fisheries in British Columbia, Canada. Evolutionary Applications 14(5): 1365–1389. https://doi.org/10.1111/eva.13203

Evaluates the application of the GSI-PBT methodology outlined by Beacham et al. (2018) to selected Chinook salmon fisheries to determine whether GSI and PBT can be used to provide more information on fishery contributions by hatchery and conservation units than is available from CWTs.

Beacham T. D., C. Wallace, K. Jonsen, B. McIntosh, J. R. Candy, D. Willis, C. Lynch, J.-S. Moore, L. Bernatchez, and R. E. Withler. 2019. Comparison of coded-wire tagging with parentage-based tagging and genetic stock identification in a large-scale coho salmon fisheries application in British Columbia, Canada. Evolutionary Applications 12(2):230–254. https://doi.org/10.1111/eva.12711

Evaluates the application of the GSI-PBT methodology outlined by Beacham et al. (2017) to coho salmon fisheries to determine whether GSI and PBT can be used to provide more information on fishery contributions by hatchery and conservation units than is available from CWTs.

Beacham T. D., C. Wallace. K. Jonsen, B. McIntosh, J. R. Candy, D. Willis, C. Lynch, and R. E. Withler. 2019. Variation in migration pattern, broodstock origin, and family productivity of coho salmon hatchery populations in British Columbia, Canada, derived from parentage-based tagging. Ecology and Evolution 9(17):9891–9906. https://doi.org/10.1002/ece3.5530

Examines spatial and temporal variability in migration patterns among hatchery coho salmon populations in southern British Columbia based on PBT identifications in fishery catches.

Beacham T. D., C. Wallace, K. Jonsen, B. McIntosh, J. R. Candy, D. Willis, C. Lynch, and R. E. Withler. 2020. Insights on the concept of indicator populations derived from parentage-based tagging in a large-scale coho salmon application in British Columbia, Canada. Ecology and Evolution 10(13):6461–6476. https://doi.org/10.1002/ece3.6383

Applies PBT methodology based on variability at 304 single nucleotide polymorphisms to coho salmon sampled from coho salmon fisheries and escapements in British Columbia.

Beacham, T. D., C. Wallace, C. MacConnachie, K. Jonsen, B. McIntosh, J. R. Candy, and R. E. Withler. 2018. Population and individual identification of Chinook salmon in British Columbia through parentage-based tagging and genetic stock identification with single nucleotide polymorphisms. Canadian Journal of Fisheries and Aquatic Sciences 75(7):1096–1105. https://doi.org/10.1139/cjfas-2017-0168

Evaluates whether a PBT and genetic stock identification program has the potential to emulate the results from an existing CWT assessment program in British Columbia.

Beacham, T. D., C. Wallace, C. MacConnachie, K. Jonsen, B. McIntosh, J. R. Candy, R. H. Devlin, and R. E. Withler. 2017. Population and individual identification of coho salmon in British Columbia through parentage-based tagging and genetic stock identification: An alternative to coded-wire tags. Canadian Journal of Fisheries and Aquatic Sciences 74(9):1391–1410. https://doi.org/10.1139/cjfas-2016-0452

Uses PBT and genetic stock identification to identify individual coho salmon to specific populations and brood years.

Bingham, D. M., P. C. Gerrity, and S. Painter. 2018. Genetic tagging is an effective way to monitor survival of released hatchery saugers: conservation efforts in the Wind River, Wyoming. Environmental Practice 20(4):92–103. https://doi.org/10.1080/14660466.2018.1531667

Estimates the statistical sensitivity and accuracy of PBT using 17 microsatellites to identify hatchery-origin saugers captured in the wild.

Coykendall, D. K., T. A. Delomas, M. Belnap, and M. R. Campbell. 2022. Improving abundance estimates of spring–summer Snake River chinook salmon for fisheries management. North American Journal of Fisheries Management 42(6):1454-1464. https://doi.org/10.1002/nafm.10823

Compares stock-specific abundance estimates for Snake River Chinook salmon between PIT- and PBT-derived methodologies for return years 2016–2019.

Delomas, T. A., and M. R. Campbell. 2022. Grandparent inference from genetic data: the potential for parentage-based tagging programs to identify offspring of hatchery strays. North American Journal of Fisheries Management 42(1):85-95. https://doi.org/10.1002/nafm.10714

Presents a method to infer grandparent–grandchild trios by using only genotypes from two putative grandparents and one putative grandchild.

Delomas, T. A. and J. E. Hess. 2021. A new estimator to correct for bias from tag rate expansion on natural-origin fish attributes in mixed-stock analysis using parentage-based tagging. North American Journal of Fisheries Management 41(2):421-433. https://doi.org/10.1002/nafm.10537

Describes two estimators: one "accounting-style" estimator similar to previously described approaches and one maximum likelihood method, to account for tag rates.

Evans, H. K., K. B. Carlson, R. Wisser, M. E. Raley, K. M. Potoka, and K. J. Dockendorf. 2017. Genetics and hatchery management: A parentage-based tagging approach to blueback herring conservation. Journal of Fish and Wildlife Management 9(1):4–13. https://doi.org/10.3996/022017-JFWM-011

Analyzes previously described microsatellites as well as new microsatellite markers identified through sequencing to create a suite of 14 blueback herring markers useful for parentage-based tagging.

Fitzpatrick, K. B., N. Overgaard Therkildsen, B. Marcy-Quay, H. B. Borchardt-Wier, and S. A. Sethi. 2023. Parentage-based tagging using mothers balances accuracy and cost for discriminating between natural and stocked recruitment for inland fisheries. Fisheries Management and Ecology 30(6):592–602. https://doi.org/10.1111/fme.12614

Demonstrates the efficacy of parentage-based tagging based on broodmothers in the Lake Ontario Chinook salmon fishery, which uses thousands of broodparents and has potential for substantial relatedness between stocked and naturally reproduced fish.

Hance, D. J., T. J. Kock, R. W. Perry, and A. C. Pope. 2022. Assessing the efficacy of using a parentage-based tagging survival model to evaluate two sources of mortality for juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in Lookout Point Reservoir,

Oregon. U.S. Geological Survey Open-File Report 2022–1096. https://doi.org/10.3133/ofr20221096

Assesses the efficacy of using a parentage-based tagging survival model (PBT N-mixture model) to evaluate two sources of mortality for juvenile Chinook salmon in Lookout Point Reservoir, Oregon.

Hargrove, J. S., C. A. Camacho, W. C. Schrader, J. H. Powell, T. A. Delomas, J. E. Hess, S. R. Narum, and M. R. Campbell. 2021. Parentage-based tagging improves escapement estimates for ESA-listed adult Chinook salmon and steelhead in the Snake River Basin. Canadian Journal of Fisheries and Aquatic Sciences 78(4):349–360. https://doi.org/10.1139/cjfas-2020-0152

Demonstrates that PBT can improve the accuracy of escapement estimates by significantly reducing the number of hatchery-origin fish falsely classified as natural-origin.

Hargrove, J. S., M. R. Campbell, A. C. Harris, S. R. Narum, R. L. Horn, and J. E. Hess. 2025. Genetic methods for informing conservation and management of salmonids in the Pacific Northwest, USA. Journal of Fish Biology Early View. https://doi.org/10.1111/jfb.70143

Provides a case study of how genetic stock identification and PBT are used to address diverse management goals in the Columbia River basin with a particular focus on the Snake River basin.

Hargrove, J. S., K. J. Dockendorf, K. M. Potoka, C. A. Smith, V. Alvarez, and J. D. Austin. 2022. Largemouth bass hatchery contributions quantified via parentage-based tagging. North American Journal of Fisheries Management 42(3):758–774. https://doi.org/10.1002/nafm.10763

Utilizes a robust microsatellite panel for PBT with largemouth bass that reliably discriminated among individuals and siblings and had low parentage error rates.

Hess, J. E., M. W. Ackerman, J. K. Fryer, D. J. Hasselman, C. A. Steele, J. J. Stephenson, J. M. Whiteaker, and S. R. Narum. 2016. Differential adult migration-timing and stock-specific abundance of steelhead in mixed stock assemblages. ICES Journal of Marine Science 73(10):2606–2615. https://doi.org/10.1093/icesjms/fsw138

Utilizes PBT together with mixed stock analyses to estimate stock-specific abundance and migration-timing in anadromous adult steelhead sampled at Bonneville Dam in the lower Columbia River.

Hess, M. A., J. E. Hess, A. P. Matala, R. A. French, C. A. Steele, J. C. Lovtang, and S. R. Narum. 2016. Migrating adult steelhead utilize a thermal refuge during summer periods with high water temperatures. ICES Journal of Marine Science 73(10):2616–2624. https://doi.org/10.1093/icesjms/fsw120

Combines parentage-based tagging with mixed stock analyses to test whether steelhead use a non-natal tributary as a thermal refuge and if this migratory behavior is associated with stock-specific run-timing.

Hinrichsen, R. A., C. A. Steele, M. W. Ackerman, M. R. Campbell, S. R. Narum, M. A. Hess, W. P. Young, B. A. Shields, and B. L. Maschhoff. 2016. Maximum likelihood estimation of the proportion of hatchery-origin fish on spawning grounds using coded wire tagging and parentage-based tagging. Transactions of the American Fisheries Society 145(3):671–686. https://doi.org/10.1080/00028487.2016.1146163

Derives a maximum likelihood estimator of proportion of hatchery-origin adults in spawning areas and applied it to the 2012 and 2013 carcass survey data for spring–summer Chinook salmon in the South Fork Salmon River, Idaho, using PBT.

Horn, R. L., M. Hess, S. Harmon, J. Hess, T. A. Delomas, M. R. Campbell, and S. Narum. 2023. Multigeneration pedigrees to monitor hatchery broodstock composition and genetic variation of spring/summer Chinook salmon in the Columbia River Basin. North American Journal of Fisheries Management 43(3):794-820. https://doi.org/10.1002/nafm.10890

Compiles 11 years of PBT data from nearly 125,000 interior stream-type Chinook salmon from 24 spawning hatcheries located on tributaries of the mid- and upper Columbia River and in the Salmon, Clearwater, and Grande Ronde River subbasins.

Horn, R. L., H. M. Nuetzel, B. Johnson, C. Kamphaus, J. Lovrak, K. Mott, T. Newsome, T., and S. R. Narum. Utility of parentage-based tagging for monitoring Coho salmon (*Oncorhynchus kisutch*) in the interior Columbia River basin. Evolutionary Applications 17(2):e13607. https://doi.org/10.1111/eva.13607

Presents the first coho salmon PBT baseline from seven hatchery programs located in the interior Columbia River basin, and two sites at or downstream of Bonneville Dam.

Idaho Department of Fish and Game and Columbia River Inter-Tribal Fish Commission. 2010-2019. Parentage-based tagging of Snake River hatchery steelhead and Chinook salmon. Annual Report to Bonneville Power Administration, Project 2010-031-00, Portland, Oregon. https://catalog.cbfwl.org/cgi-bin/koha/opac-detail.pl?biblionumber=32618

Reports on the development and evaluation of PBT as a versatile tool for genetically tagging steelhead and Chinook salmon in the Snake River basin.

Idaho Department of Fish and Game and Columbia River Inter-Tribal Fish Commission. 2022-2024. Genetic monitoring of Snake River salmonids: progress report. Annual Report to Bonneville Power Administration, Project 2010-031-00, Portland, Oregon. https://catalog.cbfwl.org/cgi-bin/koha/opac-detail.pl?biblionumber=46227

Reports on the application of PBT tools for the management and conservation of steelhead and spring-summer Chinook in the Snake River basin

Jensen, A. J., C. B. Schreck, J. E. Hess, S. Bohn, S., K. G. O'Malley, and J. T. Peterson. 2021. Application of genetic stock identification and parentage-based tagging in a mixed-stock recreational Chinook salmon fishery. North American Journal of Fisheries Management 41(1):130-141. https://doi.org/10.1002/nafm.10542

Applies genetic stock identification and PBT to a recreational Chinook salmon fishery in the Columbia River to illustrate the value of genetic analysis in management.

Kaylor, M. J., L. R. Ciepiela, M. Feden, J. T. Lemanski, C. Justice, B. A. Staton, J. B. Armstrong, S. Kelly, S. R. Narum, I. A. Tattam, and S. M. White. 2025. Watershed-scale dispersal patterns of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) revealed through genetic parentage analysis. Movement Ecology 13(1). https://doi.org/10.1186/s40462-024-00524-3

Quantifies dispersal patterns of a spring-run Chinook salmon population in Northeast Oregon using genetic PBT to trace juveniles captured from summer rearing habitats back to their maternal parent and associated spawning location.

Kinziger, A. P., S. R. Fong, and J. C. Garza. 2022. Pedigree analysis of an integrated hatchery steelhead program from the Mad River, California, provides insight into life history patterns and informs management. North American Journal of Fisheries Management 42(5):1285-1295. https://doi.org/10.1002/nafm.10821

Applies PBT methods to assess the origin (wild versus hatchery), age structure, and spawn-date heritability of steelhead returning to the Mad River Hatchery.

McCane, J., C. Adam, B. Fleming, M. Bricker, and M. R. Campbell, M.R. 2018. FishGen.net: An online genetic repository for salmon and steelhead genetic baselines. Fisheries, 43(7):326-330. https://doi.org/10.1002/fsh.10105

Describes the development of FishGen, a final repository for Pacific salmon and steelhead genetic data generated as part of the genetic stock identification and PBT projects in the Columbia River basin and throughout the Pacific Coast of North America.

Pepping, M. Y., S. M. O'Rourke, C. Huang, J. V. Katz, C. Jeffres, and M. R. Miller. 2020. Rapture facilitates inexpensive and high-throughput parent-based tagging in salmonids. PLoS ONE 15(11). https://doi.org/10.1371/journal.pone.0239221

Demonstrates the feasibility of a new genotyping method for PBT using rapture sequencing, a combination of restriction-site associated DNA and capture sequencing.

Pope, A. C., T. J. Kock, R. W. Perry, K. M. Cogliati, K. G. O'Malley, C. A. Murphy, D. J. Hance, and S. D. Fielding. 2024. Using parentage-based tagging to estimate survival of Chinook salmon fry in a large storage reservoir. Environmental Biology of Fishes 107(7):735–754. https://doi.org/10.1007/s10641-024-01564-9

Develops a sampling design and associated model using parentage-based tagging in hatchery-raised juvenile Chinook salmon to estimate survival over a 2-year study period in a large storage reservoir in western Oregon.

Reinhardt, L., T. Copeland, and M. Davison. 2022. Validation of scale-derived ages in wild juvenile and adult steelhead using parental-based tagging. North American Journal of Fisheries Management 42(2):260-269. https://doi.org/10.1002/nafm.10737

Utilizes parental-based genetic tagging to validate ages determined from scales collected from juvenile and adult steelhead in two streams within the Snake River basin.

Sattherwaite, W., E. Anderson, M. Campbell, J. C. Garza, M. Mohr, S. Narum, and C. Speir. 2015. Multidisciplinary evaluation of the feasibility of parentage-based genetic tagging (PBT) for management of Pacific salmon. Report to the Pacific Salmon Commission, Vancouver, British Columbia. https://docs.cbfwl.org/biblio39204.pdf

Discusses the possibilities of using PBT for assessing the status of Pacific salmon stocks.

Steele, C. A., E. C. Anderson, M. W. Ackerman, M. A. Hess, N. R. Campbell, S. R. Narum, and M. R. Campbell. 2013. A validation of parentage-based tagging using hatchery steelhead in the Snake River Basin. Canadian Journal of Fisheries and Aquatic Sciences 70(7):1046–1054. https://doi.org/10.1139/cjfas-2012-0451

Reports on the implementation of PBT in the Snake River basin using hatchery steelhead and suggests the adoption of this technology could be useful for salmonid research in the region.

Steele, C. A., M. Hess, S. Narum, and M. Campbell. 2019. Parentage-based tagging: Reviewing the implementation of a new tool for an old problem. Fisheries 44(9):412-422. https://doi.org/10.1002/fsh.10260

Reviews the development of PBT in the Pacific Northwest focusing on the technical and logistical challenges for implementing a regional PBT program.

Wąs-Barcz, A., and R. Bernaś. 2023. Parentage-based tagging and parentage analyses of stocked sea trout in Vistula River Commercial catches. Journal of Applied Genetics 64: 341-350. https://doi.org/10.1007/s13353-023-00749-9

Performs PBT and an analysis of the origins of parent animals used for artificial spawning in 2013, and offspring returning to the Vistula River, Poland, in subsequent years.