

Importancia biológica y productiva de una adecuada esmoltificación en salmón coho

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- Aquabench, 2023. Newsletter. Balance industria del salmón al Q2 año 2024*: Mayor Mortalidad, Menor Ingreso de Smolt y Disminución de Biomasa Cosechada, los indicadores destacados al cierre primer semestre año 2024.
- McCormick, S.D., Saunders, R.L., 1987. Preparatory physiological adaptations for marine life of salmonids: osmoregulation, growth, and metabolism. *Am. Fish. Soc. Symp.* 1, 211–229.
- Handeland, S.O.; A.K. Imsland, B.T. Björnsson, S.O. Stefansson. Long-term effects of photoperiod, temperature and their interaction on growth, gill Na⁺, K⁺-ATPase activity, seawater tolerance and plasma growth-hormone levels in Atlantic Salmon *Salmo salar* J. Fish Biol., 83 (5) (2013), pp. 1197-1209.
- Hofmann E. 2019. Nuevo enfoque en la transición a agua de mar. [<https://www.aqua.cl/2019/08/12/salmonicultura-abordan-un-nuevo-enfoque-en-la-transicion-a-agua-de-mar/#>]
- Stefansson, S. O., Björnsson, B. Th., Ebbesson, L. O. E. and McCormick, S. D. (2008). Smoltification. In *Fish Larval Physiology*. (eds. R. N. Finn and B. G. Kapoor), pp. 639–681. Enfield, NH, USA: Science Publishers.
- Stefansson, S.O, M. Haugland, B.T. Björnsson, S.D. McCormick, M. Holm, L.O.E. Ebbesson, J.C. Holst, T.O. Nilsen. Growth, osmoregulation and endocrine changes in wild Atlantic salmon smolts and post-smolts during marine migration. *Aquaculture*, 362 (2012)
- Stefansson SO, Berge Ål, Gunnarsson GS. Changes in seawater tolerance and gill Na⁺,K⁺-ATPase activity during desmoltification in Atlantic salmon kept in freshwater at different temperatures. *Aquaculture* 1998;168:271–7. [https://doi.org/10.1016/S0044-8486\(98\)00354-8](https://doi.org/10.1016/S0044-8486(98)00354-8).
- McCormick, S.; Saunders, R.L. Preparatory Physiological Adaptations for Marine Life in Salmonids: Osmoregulation, Growth and Metabolism. *Am. Fish. Soc. Symp.* 1987, 211–229.
- Barron MG. Tissue Chloride Levels of Coho Salmon Fry during Progressive Salinity Exposure. *Progress Fish-Culturist* 1986;48:294–6. [https://doi.org/10.1577/1548-8640\(1986\)48<294:TCLOCS>2.0.CO;2](https://doi.org/10.1577/1548-8640(1986)48<294:TCLOCS>2.0.CO;2).
- Björnsson BT, Young G, Lin RJ, Deftos LJ, Bern HA. Smoltification and seawater adaptation in coho salmon (*Oncorhynchus kisutch*): Plasma calcium regulation, osmoregulation, and calcitonin. *Gen Comp Endocrinol* 1989;74:346–54. [https://doi.org/10.1016/S0016-6480\(89\)80030-9](https://doi.org/10.1016/S0016-6480(89)80030-9).
- McCormick, S.D., Lerner, D.T., Monette, M.Y., Nieves-Puigdoller, K., Kelly, J.T., Björnsson, B.Th. Taking it with you when you go: how perturbations to the freshwater environment, including temperature, dams, and contaminants, affect marine survival of salmon. *Am. Fish. Soc. Symp.* 69, 195–214 (2009).
- Young G, Björnsson BT, Prunet P, Lin RJ, Bern HA. Smoltification and seawater adaptation in coho salmon (*Oncorhynchus kisutch*): Plasma prolactin, growth hormone, thyroid hormones, and cortisol. *Gen Comp Endocrinol* 1989;74:335–45. [https://doi.org/10.1016/S0016-6480\(89\)80029-2](https://doi.org/10.1016/S0016-6480(89)80029-2).
- Johnston, C.E.; Eales, J.G. Purines in the Integument of the Atlantic Salmon (*Salmo Salar*) During Parr–Smolt Transformation. *J. Fish. Res. Board Canada* 1967, 24, 955–964, doi:10.1139/f67-085.
- Mizuno, S.; Misaka, N.; Ando, D.; Kitamura, T. Quantitative Changes of Black Pigmentation in the Dorsal Fin Margin during Smoltification in Masu Salmon, *Oncorhynchus Masou*. *Aquaculture* 2004, 229, 433–450, doi:10.1016/S0044-8486(03)00368-5.
- Winans GA, Nishioka RS. A multivariate description of change in body shape of coho salmon (*Oncorhynchus kisutch*) during smoltification. *Aquaculture* 1987;66:235–45. [https://doi.org/10.1016/0044-8486\(87\)90109-8](https://doi.org/10.1016/0044-8486(87)90109-8).
- Gorbman A, Dickhoff WW, Mighell JL, Prentice EF, William Waknitz F. Morphological indices of developmental progress in the parr-smolt coho salmon, *Oncorhynchus kisutch*. *Aquaculture* 1982;28:1–19. [https://doi.org/10.1016/0044-8486\(82\)90004-7](https://doi.org/10.1016/0044-8486(82)90004-7).
- Folmar LC, Dickhoff WW, Mahnken CVW, Waknitz FW. Stunting and parr-reversion coho salmon (*Oncorhynchus kisutch*). *Aquaculture* 1982;28:91–104.
- Duan C, Plisetskaya EM, Dickhoff WW. Expression of insulin-like growth factor I in normally and abnormally developing coho salmon (*Oncorhynchus kisutch*). *Endocrinology* 1995;136:446–52. <https://doi.org/10.1210/en.136.2.446>.
- Collie NL, Bern HA. Changes in intestinal fluid transport associated with smoltification and seawater adaptation in coho salmon, *Oncorhynchus kisutch* (Walbaum). *J Fish Biol* 1982;21:337–48. <https://doi.org/10.1111/j.1095-8649.1982.tb02839.x>.
- Kubo, T., 1974. Notes on the phase differentiation and smolt transformation of juvenile masu salmon (*Oncorhynchus masou*). *Sci. Rep. Hokkaido Salmon Hatchery*, No.28, pp.9-26.
- Greenwell, M.G., Sherrill, J., Clayton, L.A., 2003. Osmoregulation in fish: mechanisms and clinical implications. *Vet. Clin. Exot. Anim. Pract.* 6, 169–189.
- Pisam M, Prunet P, Boeuf G, Jrambourg A. Ultrastructural features of chloride cells in the gill epithelium of the atlantic salmon, *Salmo salar*, and their modifications during smoltification. *Am J Anat* 1988;183:235–44. <https://doi.org/10.1002/aja.1001830306>.
- Lemmettyinen J, Piironen J, Kiiskinen P, Hassinen M, Matti Vornanen. Comparison of gene expression in the gill of salmon (*Salmo salar*) smolts from anadromous and landlocked populations. *Ann Zool Fennici* 2013;50:1–15. <https://doi.org/10.5735/086.050.0101>.
- Ebbesson, L.O. B.T. Björnsson, P. Ekstroem, S.O. Stefansson. Daily endocrine profiles in parr and smolt Atlantic salmon *Comp. Biochem. Physiol. Part A: Mol. Integr. Physiol.* 151 (4) (2008), pp. 698-704

Bjornsson, B.T., S.O. Stefansson, S.D. McCormick. Environmental endocrinology of salmon smoltification .Gen. Comp. Endocrinol., 170 (2) (2011), pp. 290-298

Dickhoff, W, B. Beckman, D. Larsen, C. Duan, S. Moriyama. The role of growth in endocrine regulation of salmon smoltification Fish Physiol. Biochem. 17 (1–6) (1997), pp. 231-236

Agustsson, T, K. Sundell, T. Sakamoto, V. Johansson, M. Ando, B. Bjornsson. Growth hormone endocrinology of Atlantic salmon (*Salmo salar*): (2001. pituitary gene expression, hormone storage, secretion and plasma levels during parr-smolt transformation. J. Endocrinol., 170 (1) (2001), pp. 227-234

McCormick S. Endocrine control of osmoregulation in teleost fish. Am. Zool., 41 (4) (2001), pp. 781-794

Kiilerich, P., K. Kristiansen, S.S. Madsen. Hormone receptors in gills of smolting Atlantic salmon, *Salmo salar*: expression of growth hormone, prolactin, mineralocorticoid and glucocorticoid receptors and 11 beta-hydroxysteroid dehydrogenase type. 2 Gen. Comp. Endocrinol., 152 (2–3) (2007), pp. 295-303

Zydlewski GB, Zydlewski J. Gill Na⁺,K⁺ +ATPase of Atlantic salmon smolts in freshwater is not a predictor of long-term growth in seawater. Aquaculture 2012;362–363:121–6. <https://doi.org/10.1016/j.aquaculture.2011.03.024>.

Arnesen, A.M.; Halvorsen, M.; Nilssen, K.J. Development of Hypoosmoregulatory Capacity in Arctic Char (*Salvelinus Alpinus*) Reared under Either Continuous Light or Natural Photoperiod. Can. J. Fish. Aquat. Sci. 1992, 49, 229–237, doi:10.1139/f92-027.

Usher, M.L.; Talbot, C.; Eddy, F.B. Effects of Transfer to Seawater on Digestion and Gut Function in Atlantic Salmon Smolts (*Salmo Salar* L.). Aquaculture 1990, 90, 85–96, doi:10.1016/0044-8486(90)90285-U.

Berge AI, Berg A, Fyhn HJ, Barnung T, Hansen T, Stefansson SO. Development of salinity tolerance in underyearling smolts of Atlantic salmon (*Salmo salar*) reared under different photoperiods. Can J Fish Aquat Sci 1995;52:243–51. <https://doi.org/10.1139/f95-024>.

Van Rijn, C.A.; Jones, P.L.; Evans, B.S.; Afonso, L.O.B. Physiological and Growth Responses of Juvenile Atlantic Salmon (*Salmo Salar*) Transferred to Seawater during Different Stages of Smolt Development. Aquaculture 2021, 538, 736527, doi:10.1016/j.aquaculture.2021.736527.

Kendrick N. A (2014) gene's mRNA level does not usually predict its protein level. Kendrick Labs, Inc. Available at: http://www.kendricklabs.com/WP1_mR-NAvsProtein-New2014.pdf

Cuadrado, E., van den Biggelaar, M., de Kivit, S., Chen, Y. yen, Slot, M., Doubal, I., Meijer, A., van Lier, R.A.W., Borst, J., and Amsen, D. (2018). Proteomic Analyses of Human Regulatory T Cells Reveal Adaptations in Signaling Pathways that Protect Cellular Identity. Immunity 48, 1046–1059.e6.

Hukelmann, J.L., Anderson, K.E., Sinclair, L.V., Grzes, K.M., Murillo, A.B., Hawkins, P.T., Stephens Len R., Lamond A. I., Cantrell D.A. The cytotoxic T cell proteome and its shaping by the kinase mTOR

Nicolet B y Wolkers M. (2020). Correlación limitada pero específica de clase de gen de ARNm y expresión de proteína en células T. bioRxiv 2020.04.21.053884; doi: <https://doi.org/10.1101/2020.04.21.053884>

Banco Central, (2022). Indicadores de Comercio Exterior Cuarto Trimestre 2022. Disponible en: <https://www.bcentral.cl/es/web/banco-central/contenido/-/details/indicadores-de-comercio-exterior-cuarto-trimestre-2021>

Ibarra, R. (2019). Asia y Oceanía: Oportunidades para el salmón chileno. Reportaje Revista salmonexpert. Disponible en: <https://www.salmonexpert.cl/article/opor-tunidades-de-mercado-en-asia-y-oceana/>

Garces, J. (2022). El camino de Aysén Coho para lograr un explosivo crecimiento en EE.UU. Entrevista en Salmonexpert. <https://www.salmonexpert.-cl/ayasn-chile-coho/el-camino-de-aysn-coho-para-lograr-un-explosivo-crecimiento-en-eeuu/1226071>

Skretting (2016). Reportaje revista AQUA: " Entregan detallado informe de indicadores productivos de la salmonicultura chilena " Disponible en: <http://www.aqua.-cl/2016/07/05/entregan-detallado-informe-de-indicadores-productivos-de-la-salmonicultura-chilena/>

Almonacid C. (2022) Evaluación técnico-económica de la obtención de ovas de salmón coho (*Oncorhynchus kisutch*) en verano y su impacto en la industria chilena. Tesis de grado Ing. Civil Industrial. Universidad de los Lagos.

Rolland JB, Winton JR (2003) Relative resistance of Pacific salmon to infectious salmon anaemia virus. J Fish Diseases 26:511–520.

Hamilton-West C, Arriagada G, Yatabe T, y col. (2012) Epidemiological description of the sea lice (*Caligus rogercresseyi*) situation in southern Chile in August 2007. Preventive Veterinary Medicine 104:341–345.

Pontigo JP, Saravia J, Oyarzún R, González MP, Hawes C, Morera FJ, y col. Modulation of the expression of immune-related gene in atlantic and coho salmon during infestation with the sea lice *caligus rogercresseyi*. Fishes 2019;4:1–13. <https://doi.org/10.3390/fishes4030042>.

Speare DJ. Non-infectious and iatrogenic diseases of salmon in commercial aquaculture. Anim Heal Res Rev 2003;4:11–26. <https://doi.org/10.1079/ahrr200349>.