Skeletal deformities in farmed Atlantic salmon (*Salmo salar* L.)

Ann Huysseune[1] & P. Eckhard Witten[2]

ann.huysseune@UGent.be & PEckhardWitten@aol.com

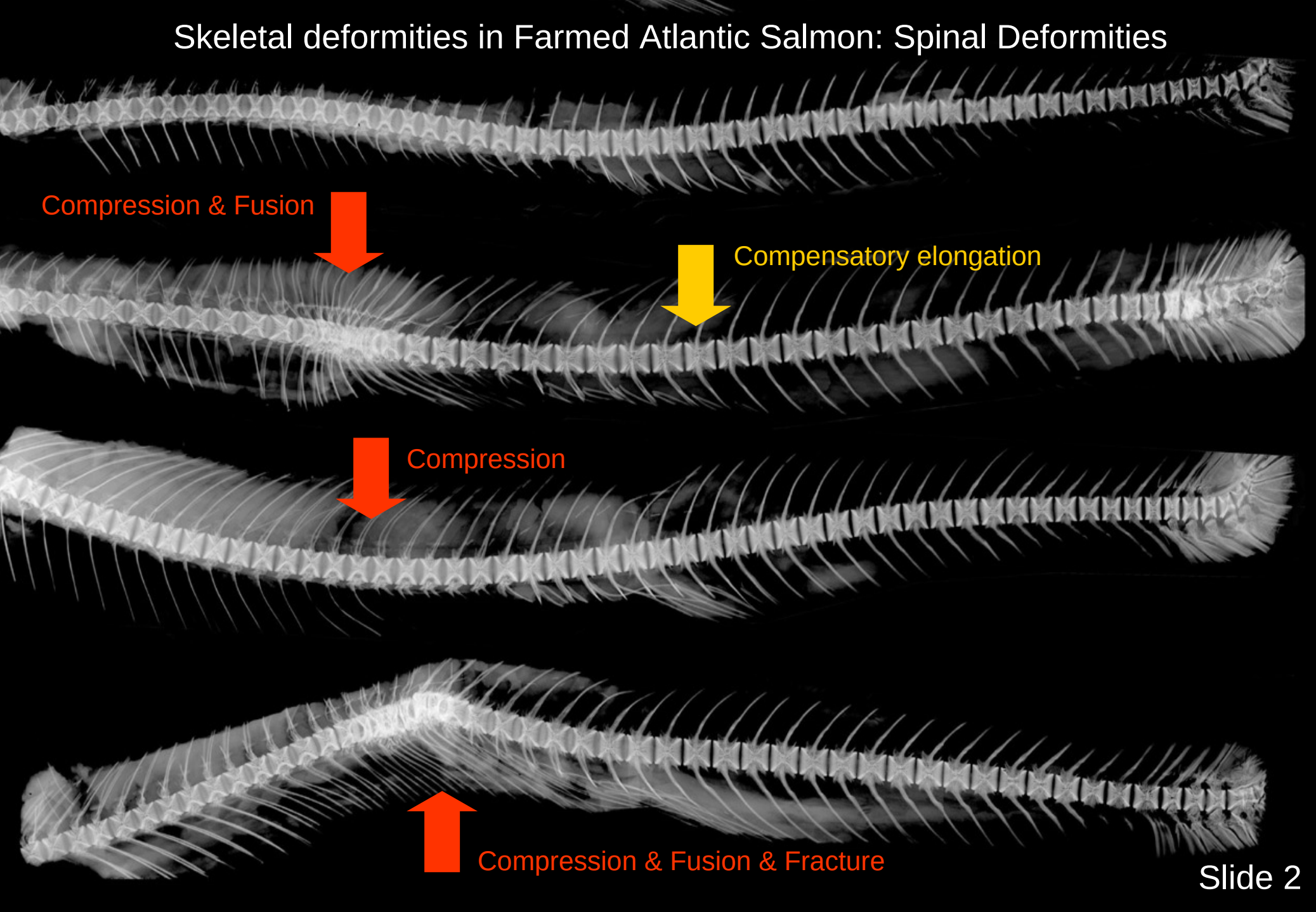
[1] Biology Department, Ghent University, Research Group 'Vertebrate Morphology & Developmental Biology'

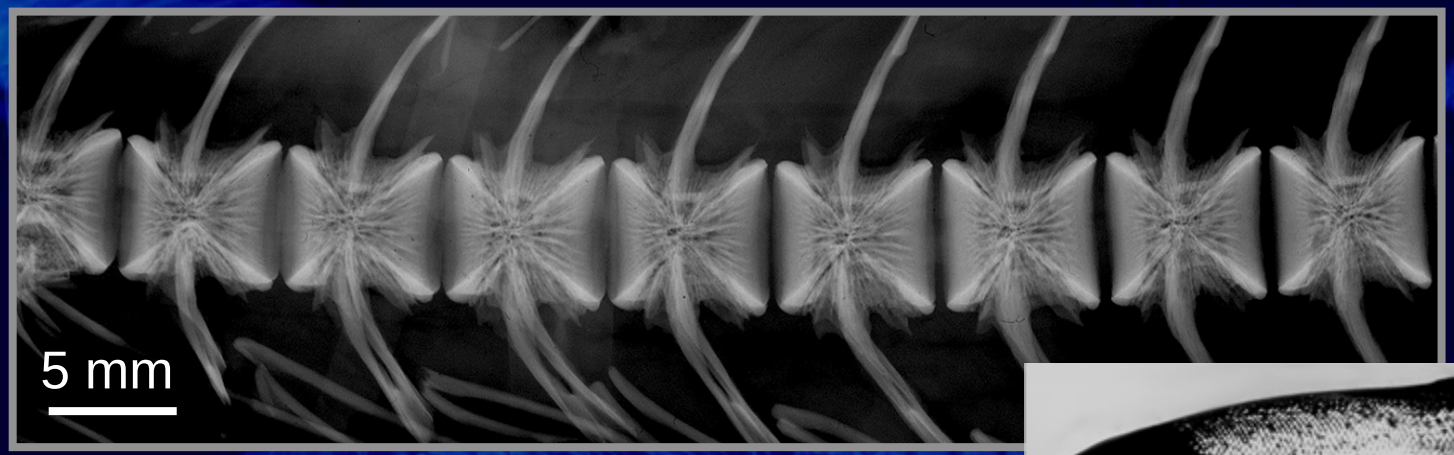
[2] Dalhousie University, Nova Scotia, Canada & Akvaforsk, Sunndalsøra, Norway

Opportunities for cooperation between ChinAquaNet and Ghent University

Ghent, August 31, 2007

Skeletal deformities in Farmed Atlantic Salmon: Spinal Deformities




5 mm

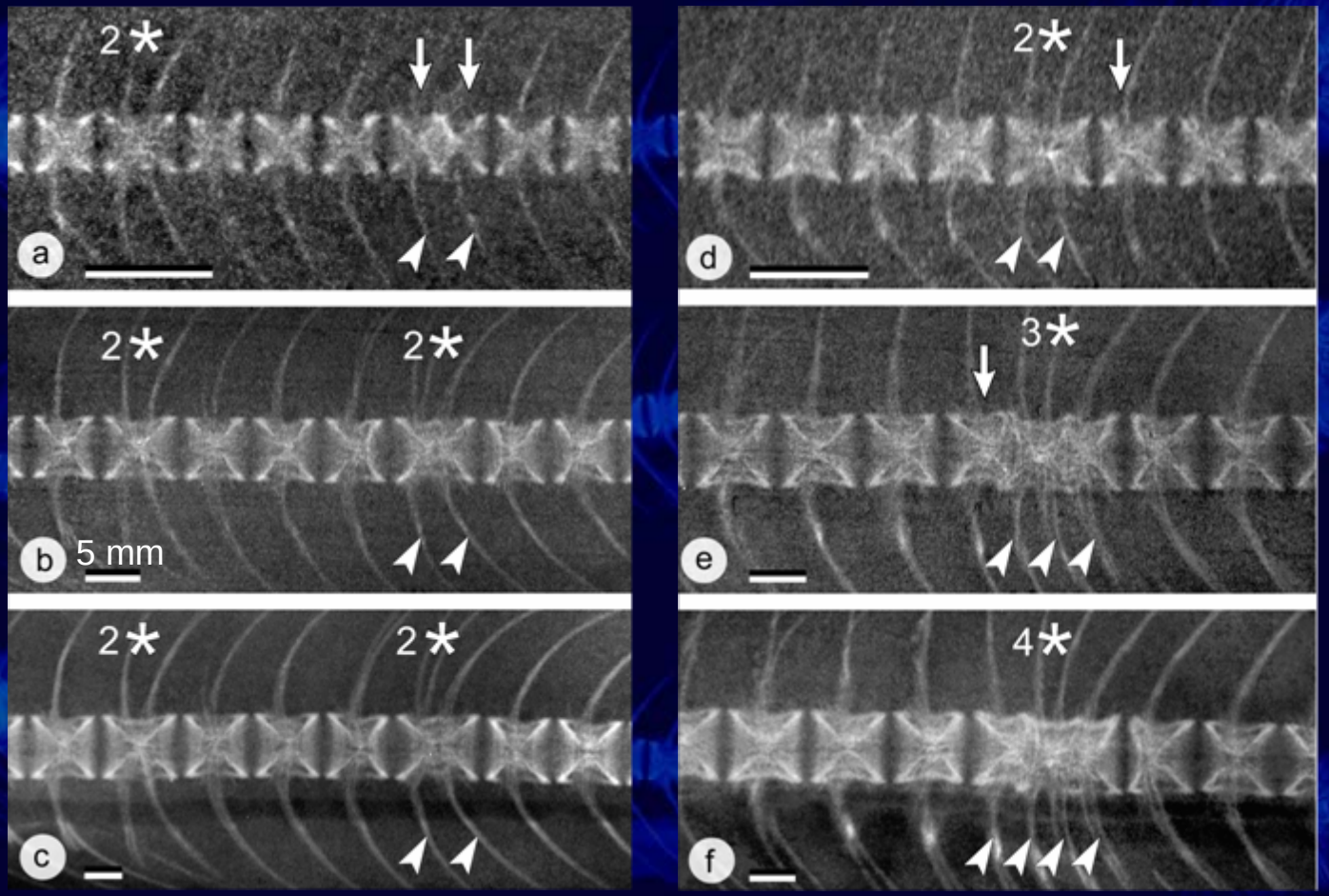
Containment scenario

Aggravation scenario

juveniles (pre-smolts)

after 6 months in seawater

after 12 months in seawater

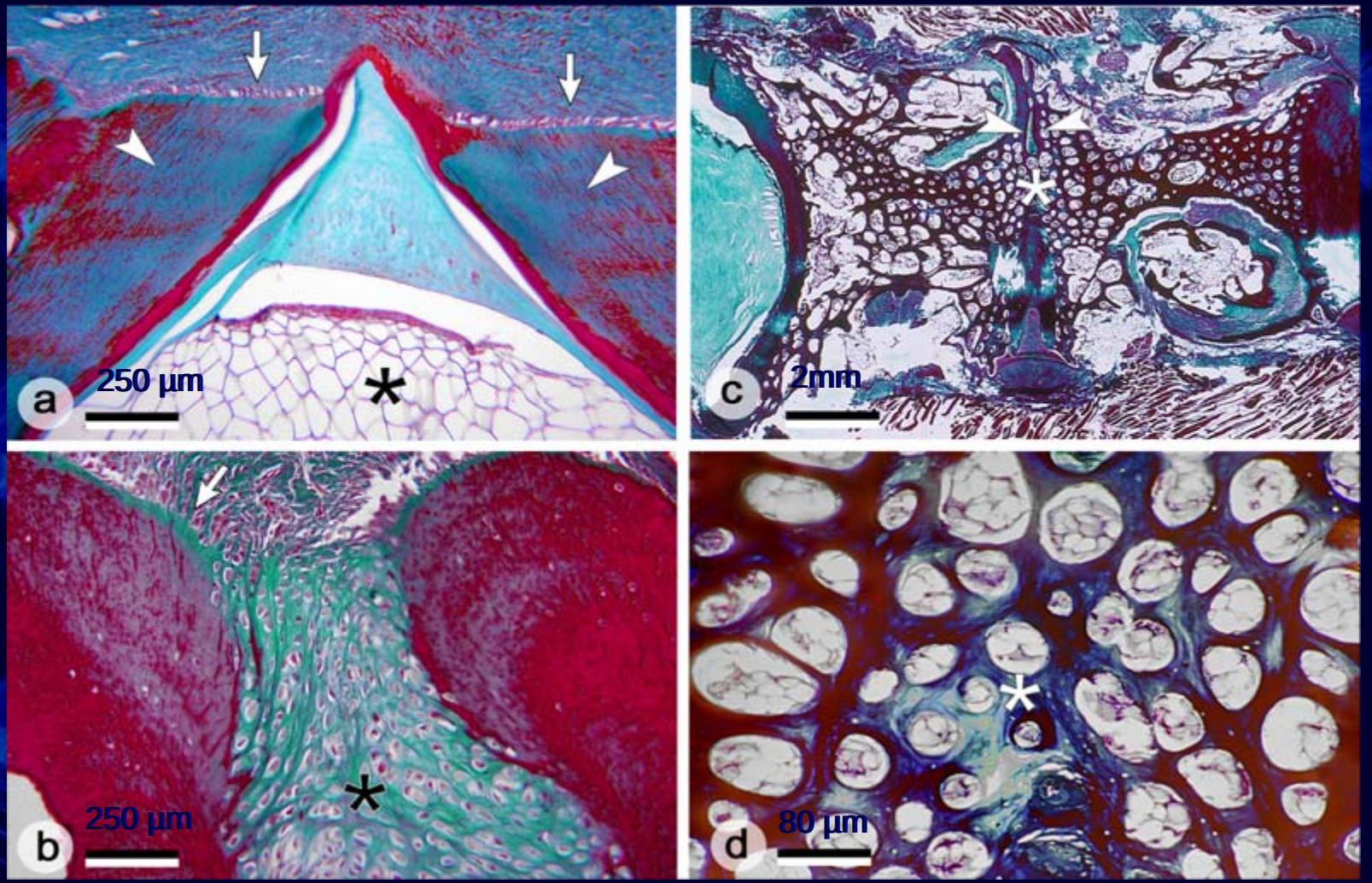


Witten et al. 2006

- bone growth zone
- notochord or cartilage
- end plate
- former intervertebral space

Between two vertebrae, notochord tissue (a) is replaced by cartilaginous tissue (b)

Cartilaginous tissue in the former intervertebral space (c) is completely remodelled into bone (d)



Witten et al. 2006

Recent Publications: Fish Farming and Fish Pathology related topics

Witten PE, Obach A, Huysseune A , Baeverfjord G (2006) Vertebrae fusion in Atlantic salmon (*Salmo salar*): Development, aggravation and pathways of containment. Aquaculture 258:164-172

Gil-Martens L, Witten PE, Fivelstad S, Huysseune A, Sævareid B, Obach A (2006) Impact of high water carbon dioxide levels on Atlantic salmon smolts (*Salmo salar L.*): Effects on bone and fish performance. Aquaculture 261 (1): 80-88

Helland S, Denstadli V, Witten P. E. et al. (2006) Occurrence of hyper dense vertebrae in Atlantic salmon (*Salmo salar* L.) fed diets with graded levels of phytic acid. Aquaculture 261:603-614

Witten PE, Gil-Martens L, Hall BK, Huysseune A, Obach A (2005) Compressed vertebrae in Atlantic salmon (*Salmo salar*): Evidence for metaplastic chondrogenesis as a skeletogenic response late in ontogeny. Dis Aquat Org 64:237-246

Phelan PE, Pressley ME, Witten PE, Mellon MT, Blake S, Nicholson B, Kim CH (2005) Characterization of Viral Infection with Snakehead Rhabdovirus in Zebrafish (*Danio rerio*). J Virol 79(3):1842-1852

Pressley ME, Phelan PE, Witten PE, Mellon MT, Kim CH (2005) Pathogenesis and Inflammatory Response to *Edwardsiella tarda* Infection in the Zebrafish. Deve Com Immunol 29 (6):501-513

Gil-Martens L, Obach A, Ritchie G, Witten PE (2005) Analysis of a short tail type in farmed Atlantic salmon (*Salmo salar*). Fish Vet J 8:71-79

Lewis LM, Lall SP, Witten PE (2004) Morphological descriptions of the early stages of spine and vertebral development in hatchery-reared larval and juvenile Atlantic halibut (*Hippoglossus hippoglossus*). Aquaculture 241:47-59

Roy PK, Witten PE, Hall BK, Lall SP (2004) Effects of dietary phosphorus on bone growth and mineralisation of vertebrae in haddock (*Melanogrammus aeglefinus* L.). Fish Physio Biochem 2002/27:35-48

Witten PE, Falk TM, Abban EK, Lüssen A, Villwock W, Renwrantz L (2003) The use of xenoantigenic antisera for the identification of tilapiine species: Comparative laboratory and field studies. J Appl Ichthyol 19:352-358

Recent Publications: Salmon Skeletal Development related topics

Huysseune A, Witten PE (2007) An evolutionary view on tooth development and replacement in wild Atlantic salmon (*Salmo salar* L.) *Evol Dev (in press)*

Huysseune A, Hall BK, Witten PE (2007) Establishment, maintenance and modifications of the lower jaw dentition of wild Atlantic salmon (*Salmo salar* L.) throughout its life cycle. J Anat, *in press*

Hall BK, Witten PE (2007) The Origin and Plasticity of Skeletal Tissues in Vertebrate Evolution and Development. In: Anderson JS, Sues H-D (eds), Major Transitions in Vertebrate Evolution. Indiana University Press, Bloomington, IN. 432p

Witten PE, Huysseune A (2007) Mechanisms of Chondrogenesis and Osteogenesis in Fins. In: Hall BK (ed.) Fins into Limbs: Evolution, Development, and Transformation. The University of Chicago Press, Chicago:79-92

Huysseune A, Witten PE (2006) Patterning of development in continuously replacing osteichthyan dentitions. J Exp Zool (Mol Dev Evol) 306B (3):204-215

Gillis JA, Witten PE, Hall BK (2006) Chondroid Bone and secondary cartilage contribute to apical dentary growth in juvenile Atlantic salmon, Salmo salar Linnaeus (1758). J Fish Biol 68:1-11

Franz Odenthal T, Hall BK, Witten PE (2006) Buried alive: how osteoblasts become osteocytes? Dev Dyn 235:176–190

Witten PE, Hall BK, Huysseune A (2005) Are breeding teeth in Atlantic salmon a component of the drastic alterations of the oral facial skeleton? Arch Oral Biol 50:213-217

Witten PE, Huysseune A, Franz-Odendaal T, Fedak T, Vickaryous M, Cole A, Hall BK (2004) Acellular teleost bone: primitive or derived, dead or alive? Palaeontol Newsletter 55:37-41

Witten PE, Rosenthal H, Hall BK (2004) Mechanisms and consequences of the formation of a kype (hook) on the lower jaw of male Atlantic salmon (*Salmo salar* L.). Mitt hamb zool Mus Inst 101:149-156

Witten PE, Hall BK (2003) Seasonal changes in the lower jaw skeleton in male Atlantic salmon (*Salmo salar* L.):remodelling and regression of the kype after spawning. Journal of Anatomy 203:435-450

Witten PE, Hall BK (2002) Differentiation and growth of kype skeletal tissues in anadromous male Atlantic Salmon (*Salmo salar*). International Journal of Developmental Biology 46:719-730

Acknowledgments & collaborations

Norway	Akvaforsk, Ås	Harald Takle
	Nutreco (Skretting) ARC, Stavanger	Wolfgang Koppe Alex Obach
	Institute for Marine Research, Matre	Tom Hansen
	National Institute of Nutrition and Seafood Research (NIFES), Bergen	Laura Gil-Martens Robin Ørnsrud
Portugal	University of the Algarve, Faro	Leonor Cancela Paulo Gavaia Vincent Laizé
Germany	Kiel University	Harald Rosenthal
Canada	National Research Council, Halifax	Santosh Lall
	Dalhousie University, Halifax	Brian Hall