

# Deformity diagnostics in salmon

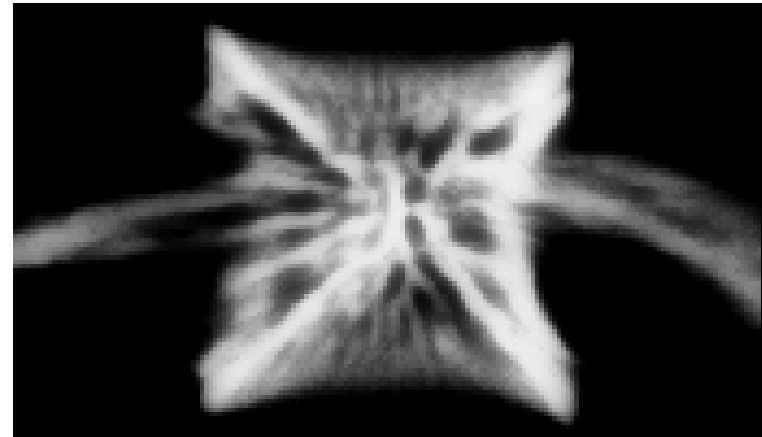
Kirsti Hjelde and Grete Bæverfjord



# Deformity diagnostics in farmed salmon

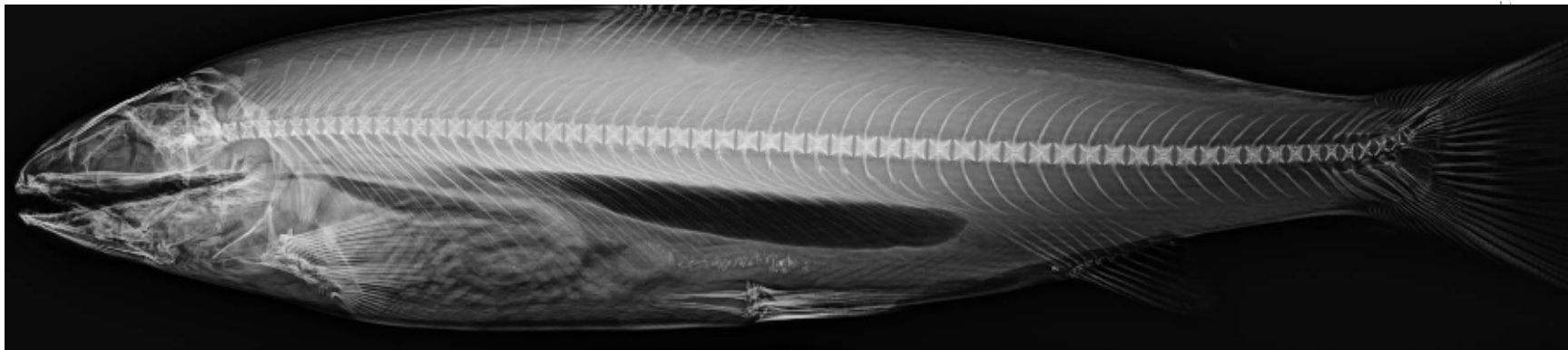
Four categories:

- Vertebral deformities
- Head deformities
- Axial deviations
- Rib appearance



## Some anatomical words commonly used to describe position:

- Cranial: Against the head end of the body
- Caudal: Against the tail end of the body
- Ventral: Against the abdomen of the body
- Dorsal: Against the back of the body
- Lateral view: From the side
- Laterolateral view: From the side to the side
- Dorsoventral view: From the back to the abdomen





# Deformity diagnostics in salmon

- **Vertebral deformities**

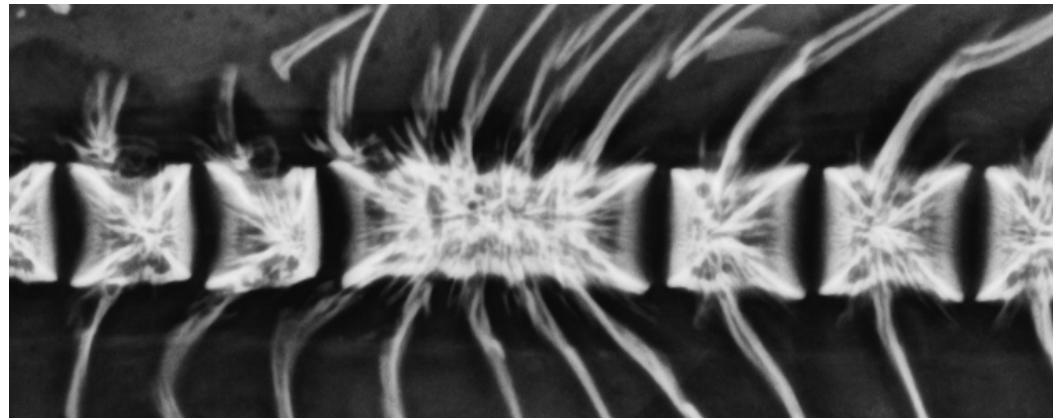
- Fusions and fusion associated changes
- Platyspondyly
- Osteopenia
- Hyper dense vertebrae





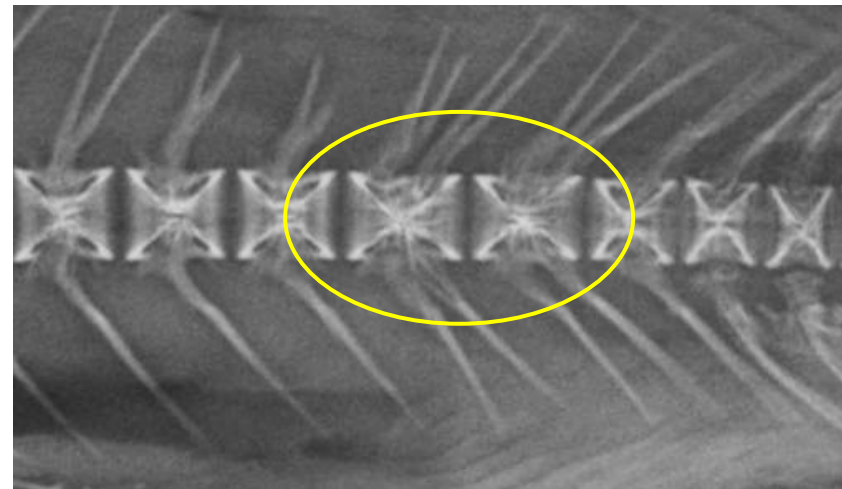
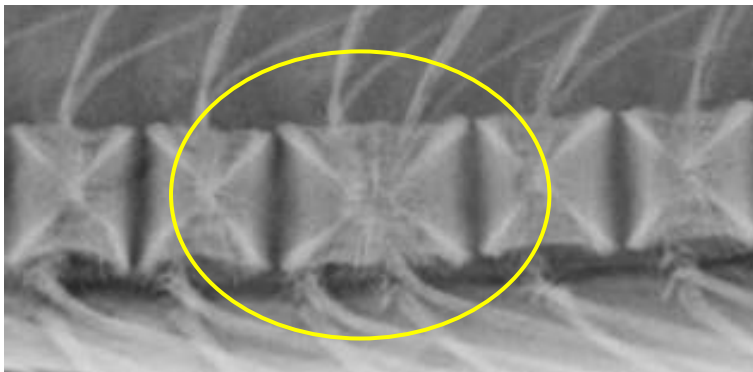
# Fusions and fusion associated changes

- By fusion we mean two or more vertebrae that are completely amalgamated
- By fusion associated changes we mean vertebrae that are in the process of fusing
- Develops both in early embryonic stages and later in larger fish
- Fusions appear in many species
- Fusions appear in all locations on the spine
- They may be present in connection to other deformities, like platyspondyly



# Simple fusions

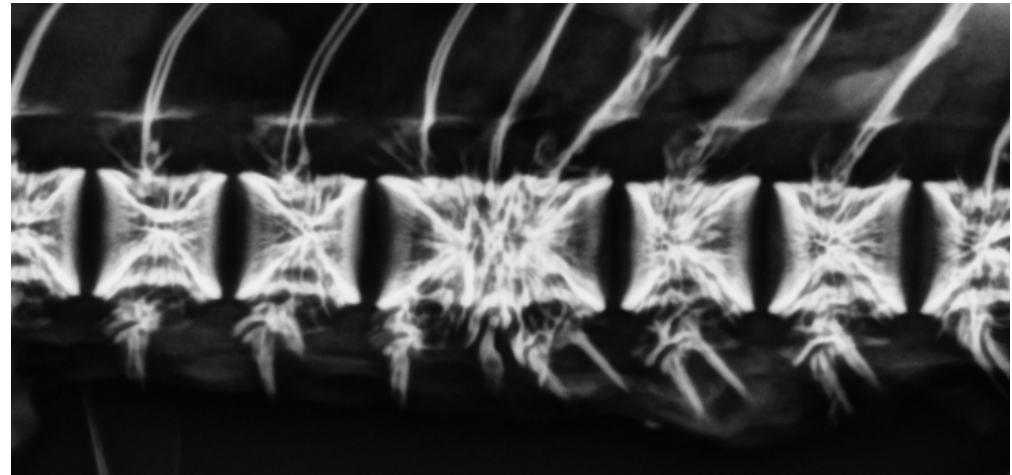
- Simple fusions are two fused vertebrae with vertebral centra amalgamated
- Neighbouring vertebrae are not visibly included in the process
- These fusions may be reorganized, finished processes



# Complex fusions

- Fusions involving more than two vertebral bodies
- Often have neighbouring vertebrae about to become involved in the fusion

Three vertebrae involved in a fusion, aberrant neighbours

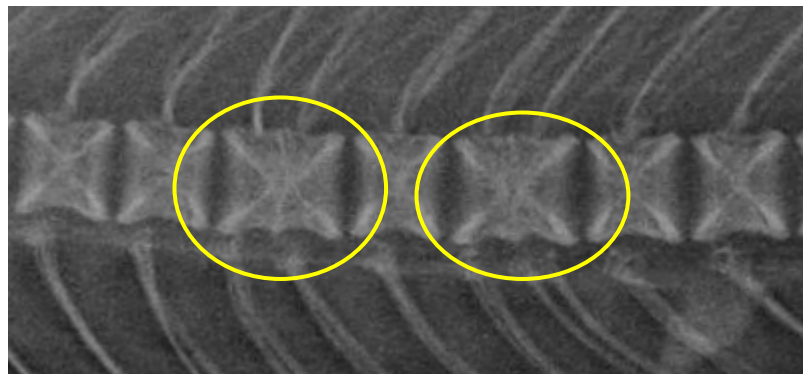
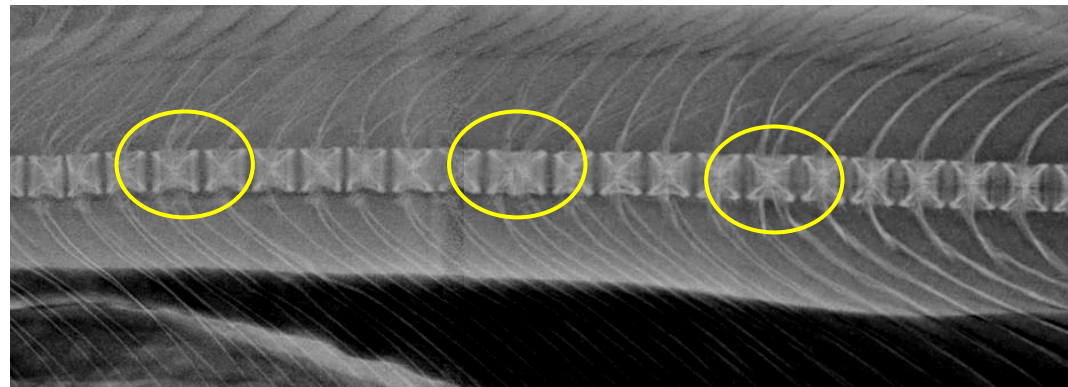


Seven fused vertebrae and clearly affected neighbours

# Multiple fusion

- More than one fusion centre separated by apparently normal vertebrae

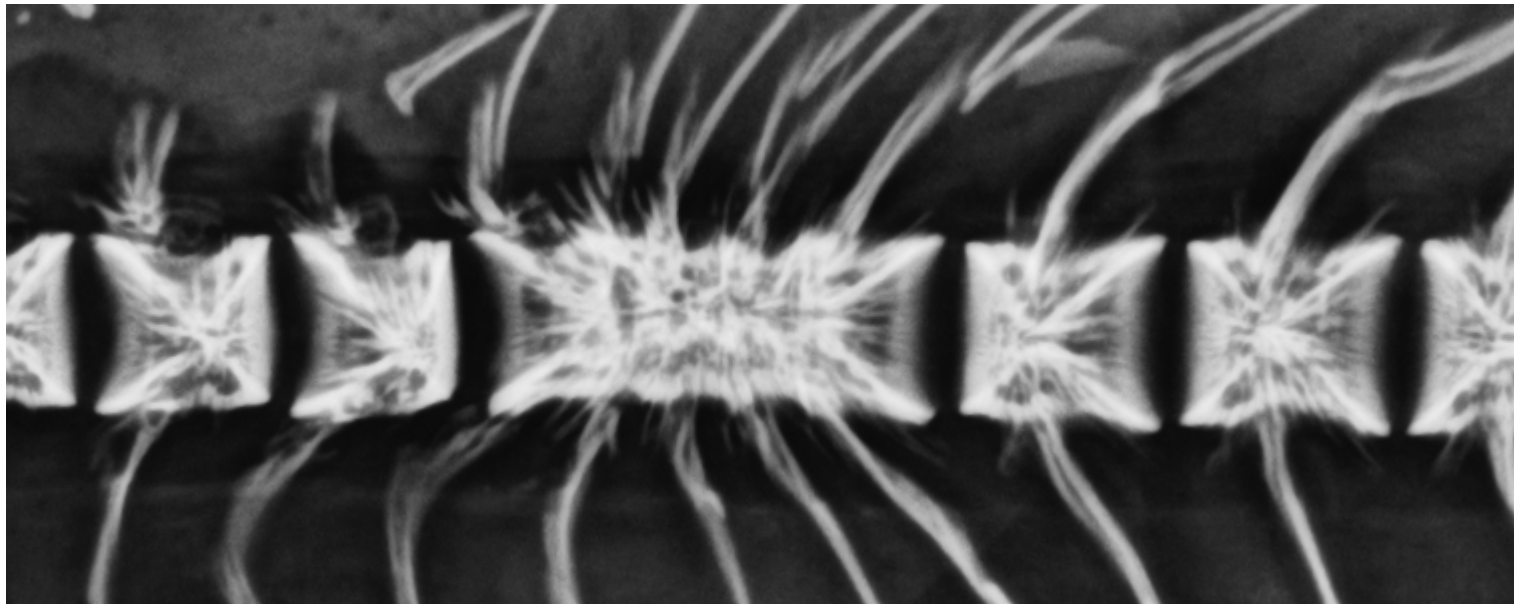
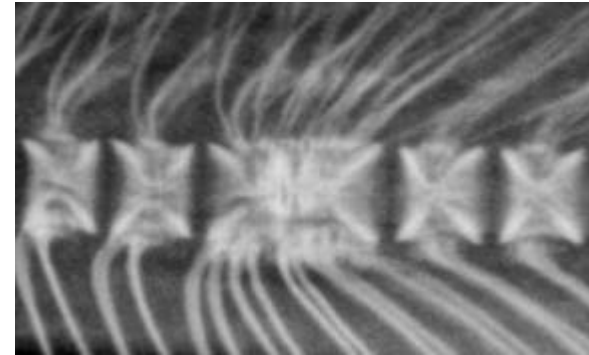
Three fusion centra



Two fusion centra

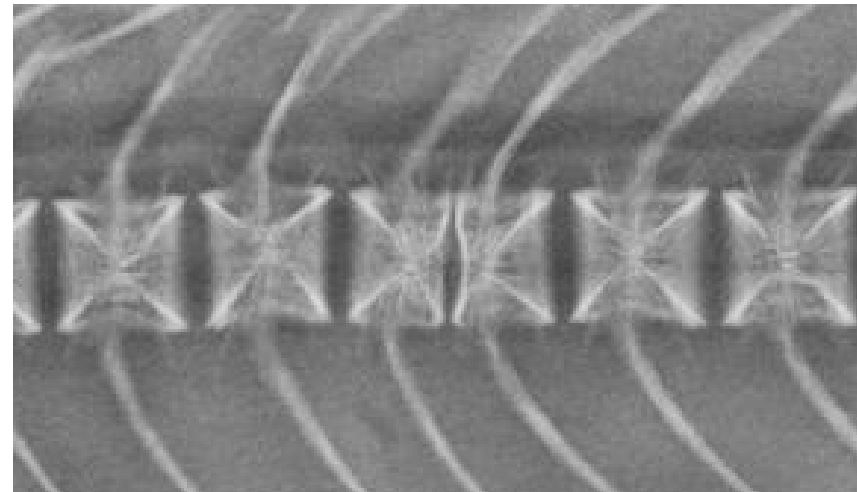
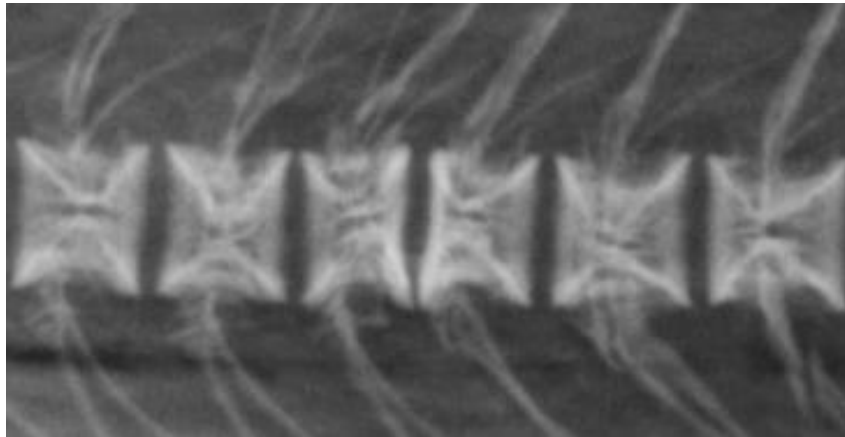
# Complete fusions

- Fusion where the vertebral centra are completely amalgamated
- Degree of severity can be estimated by counting the number of affected vertebrae



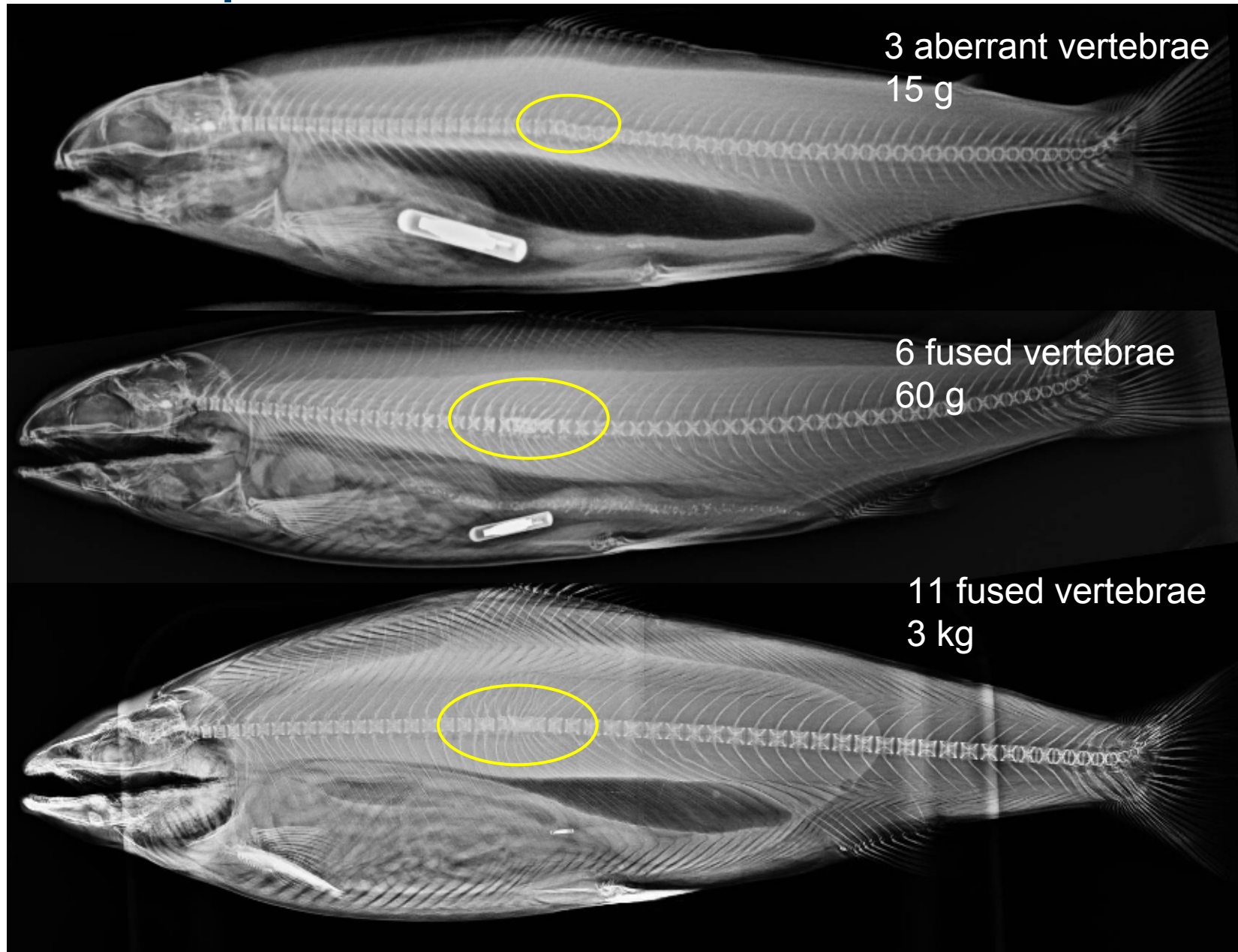
# Incomplete fusion

- Incomplete fusions are vertebrae about to melt together
- They have flattened vertebral endplates og adjoining vertebrae and often redused or absent intervertebral space





# Development of fusion in salmon

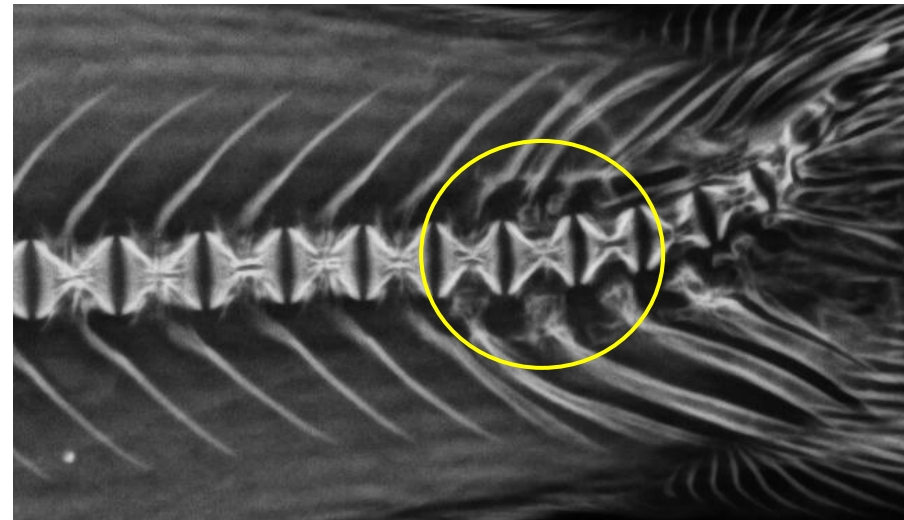


# Different locations of fusions



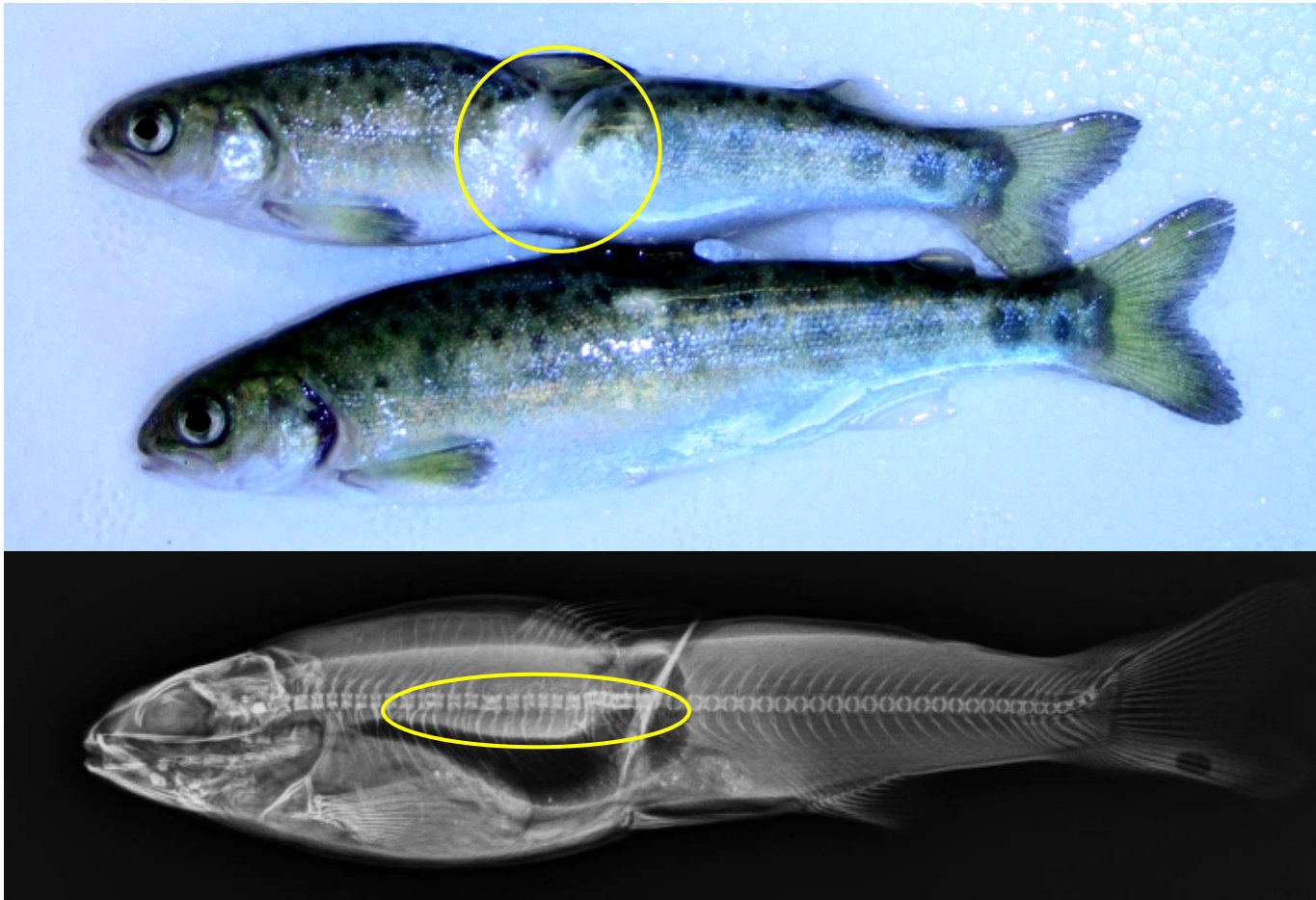
- Fusions in the neck may cause the head to tilt upwards

- Vertebra with two haemal arches, or slightly abnormal development of the tail vertebrae. Not normally considered a deformity.



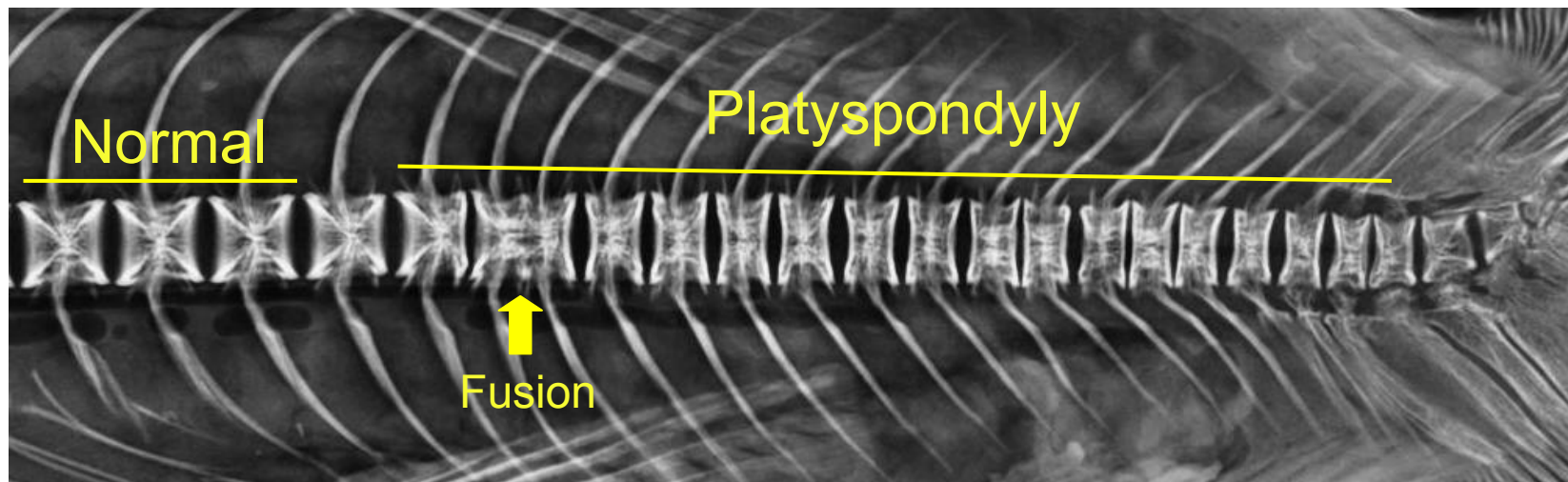


# Fusions connected to salmon body structure:



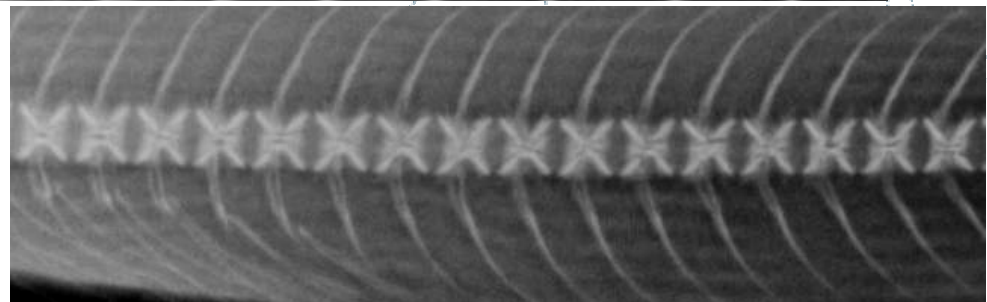
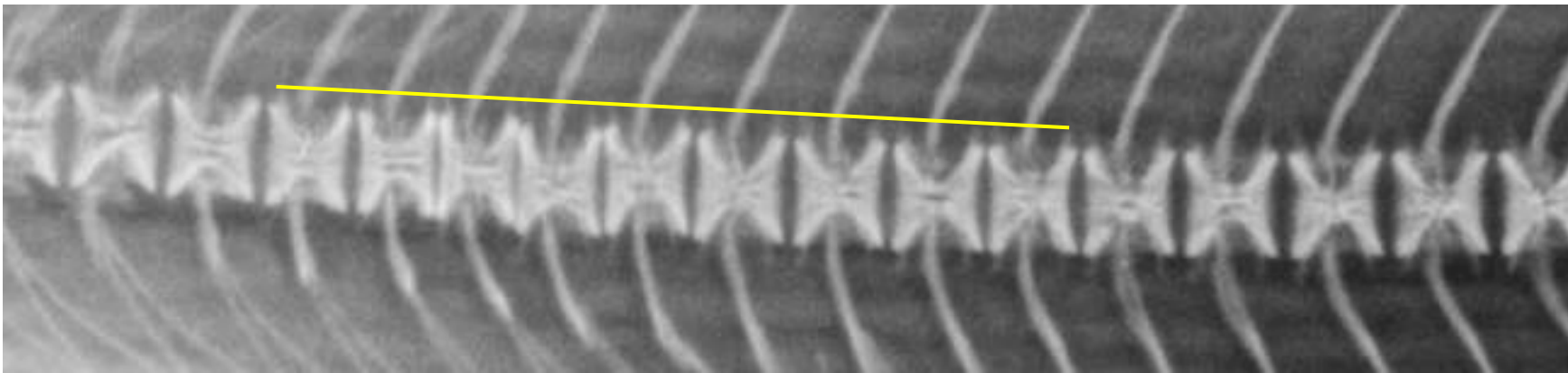
# Platyspondyly

- Flattened or compressed vertebrae in cranio-caudal direction
- Usually not seen until late sea water stages, but observed as early as at 20 g in feed trial and in commercially farmed fish
- Often in the caudal half of the fish, "Short tail", but not necessarily

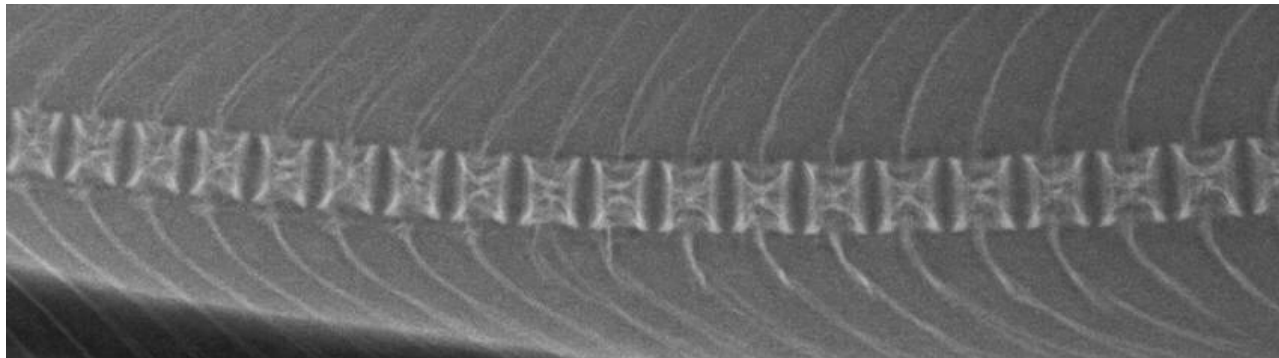


# Early stages of platyspondyly

- What today is defined as platyspondyly may have several causes and developmental pathways
- 20 g salmon in feed trial showing early signs of platyspondyly, normal fish from the same group under

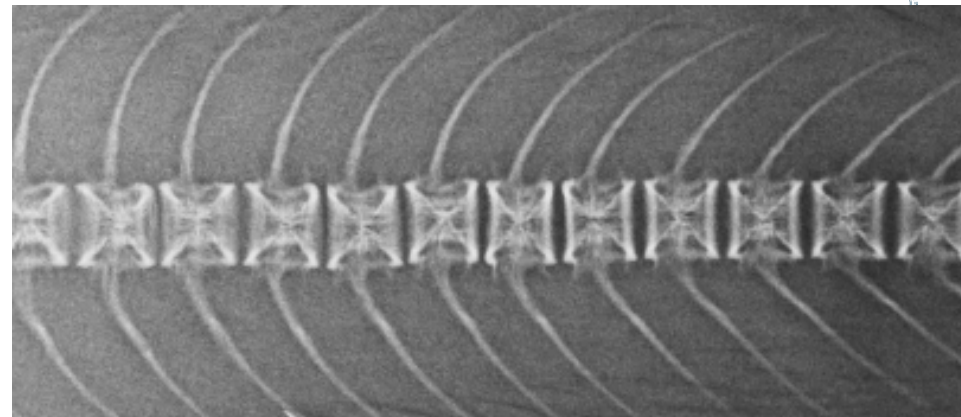


# Early stages of platyspondyly



Narrow vertebrae with increased intervertebral space

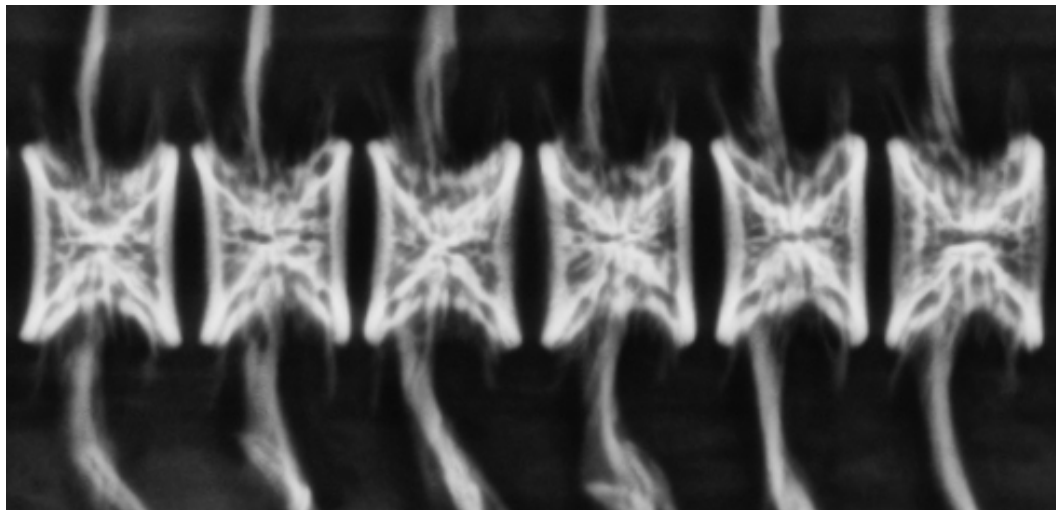
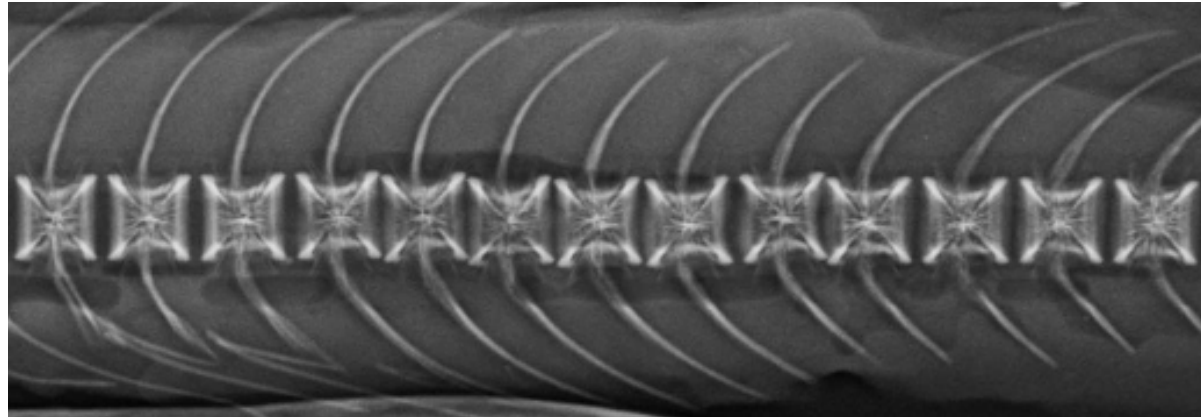
Narrow vertebrae with reduced intervertebral space





# Other early stages of platyspondyly

Dorso-ventral displacement and reduced intervertebral space

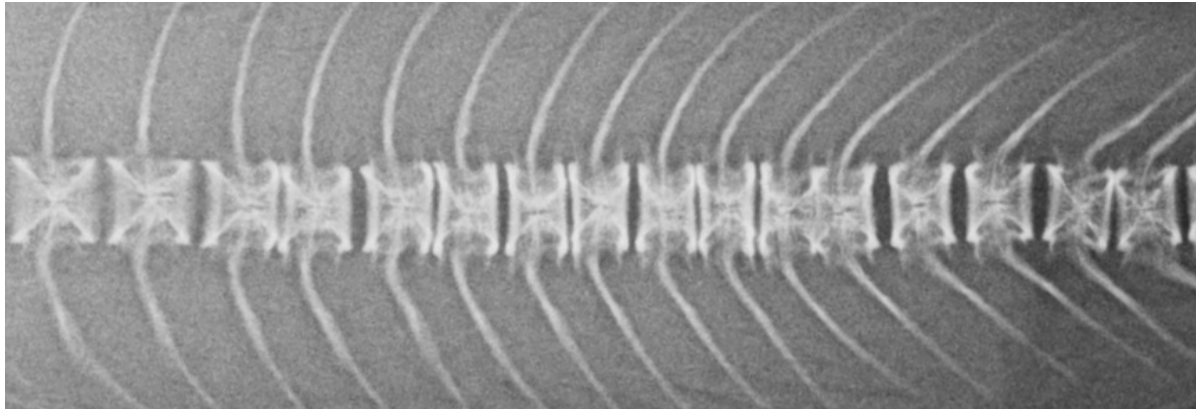


Narrow vertebrae with abnormal shape

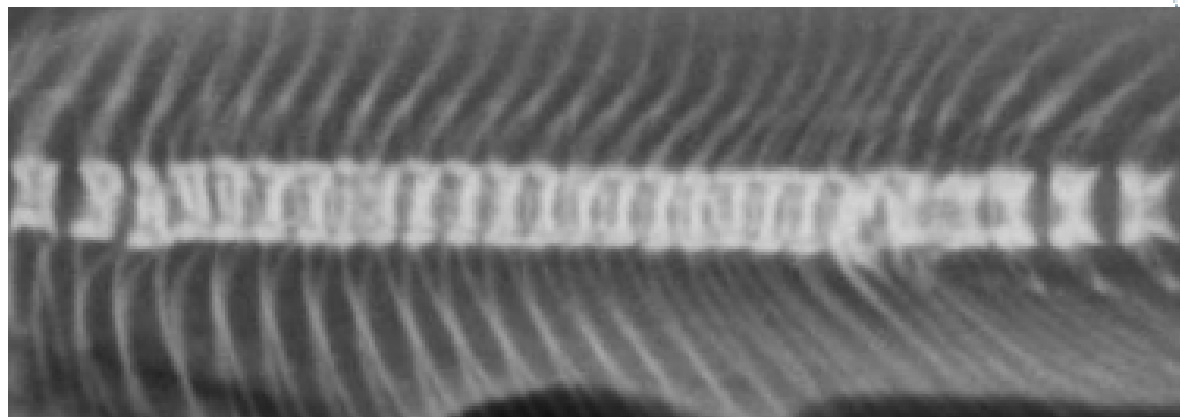


# Different appearances of platyspondyly

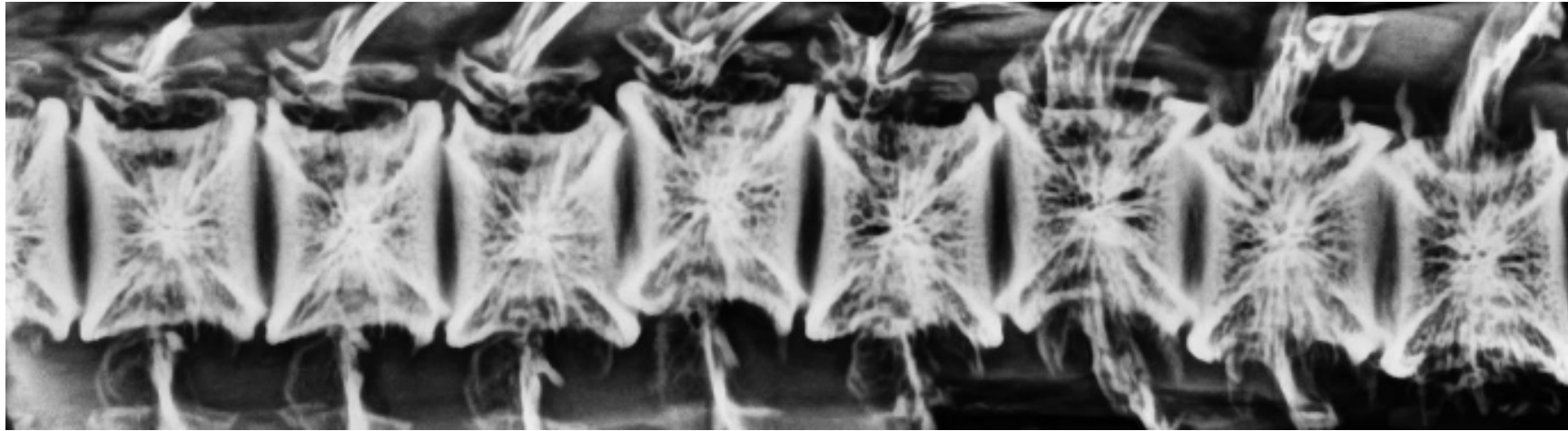
Flattened vertebrae in tail region



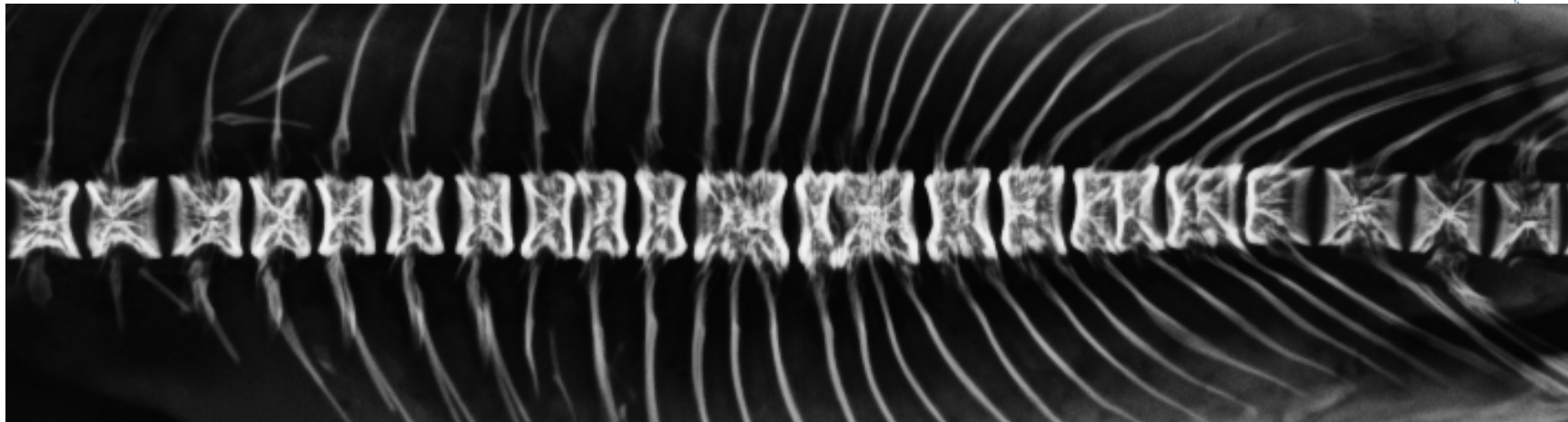
Flattened and partly fused vertebrae in small salmon



- Dorsal and ventral displacement

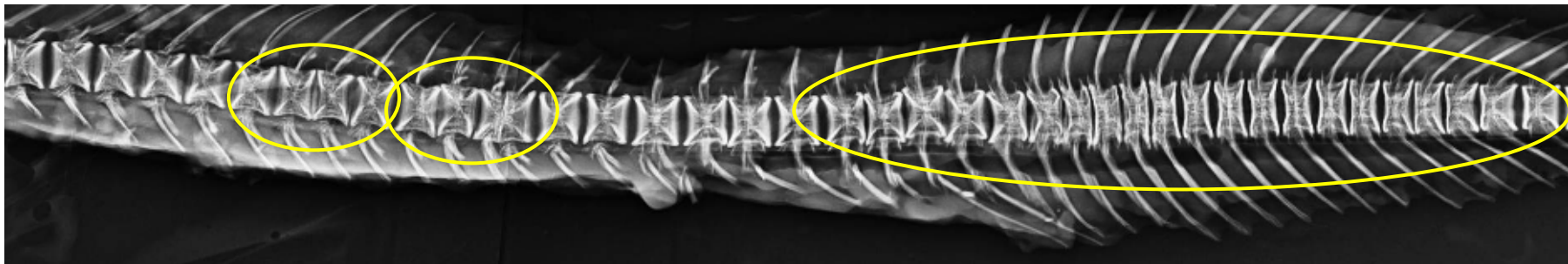


- Platyspondyly and fusions



# Combination of vertebral deformities

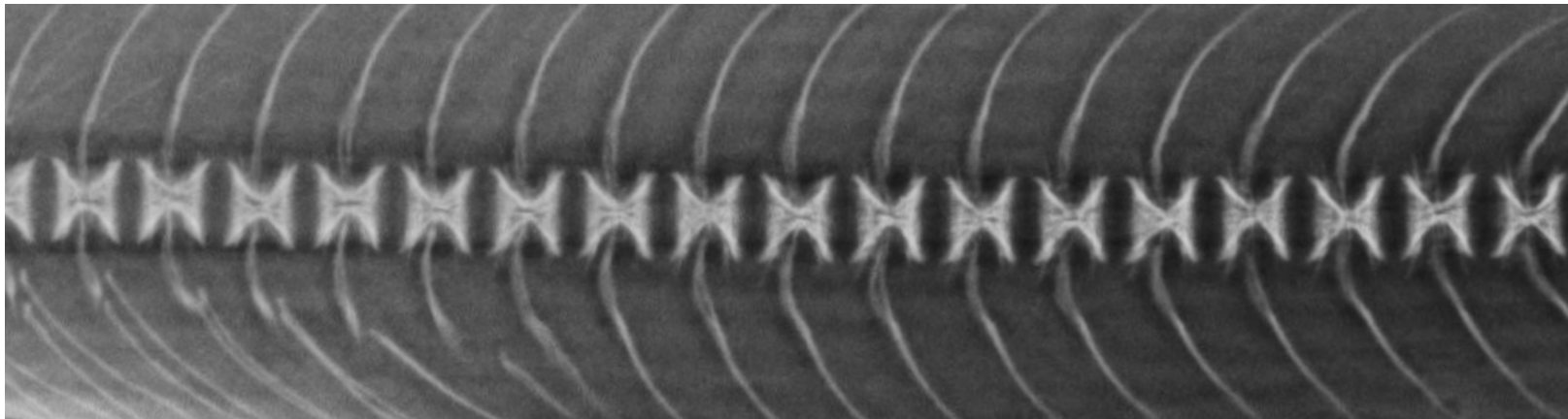
- Salmon spine with several deformed areas, with combinations on fusions and platyspondyly





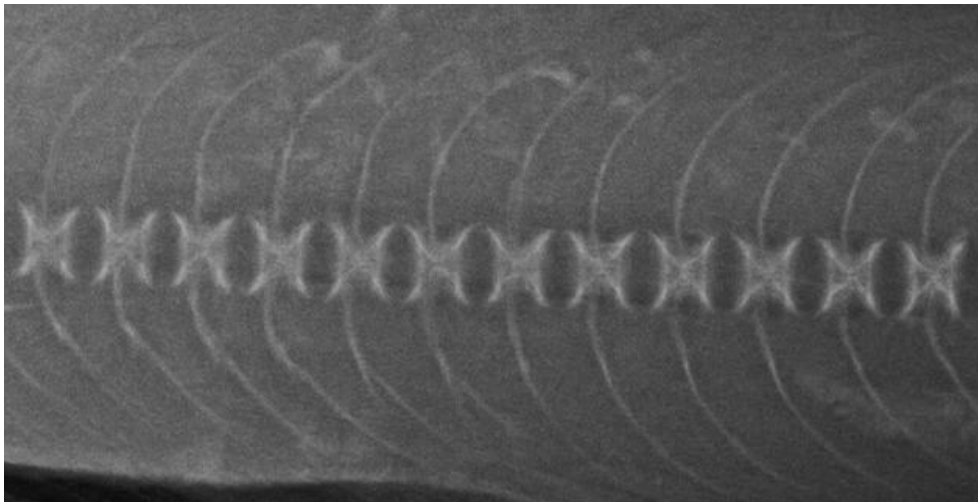
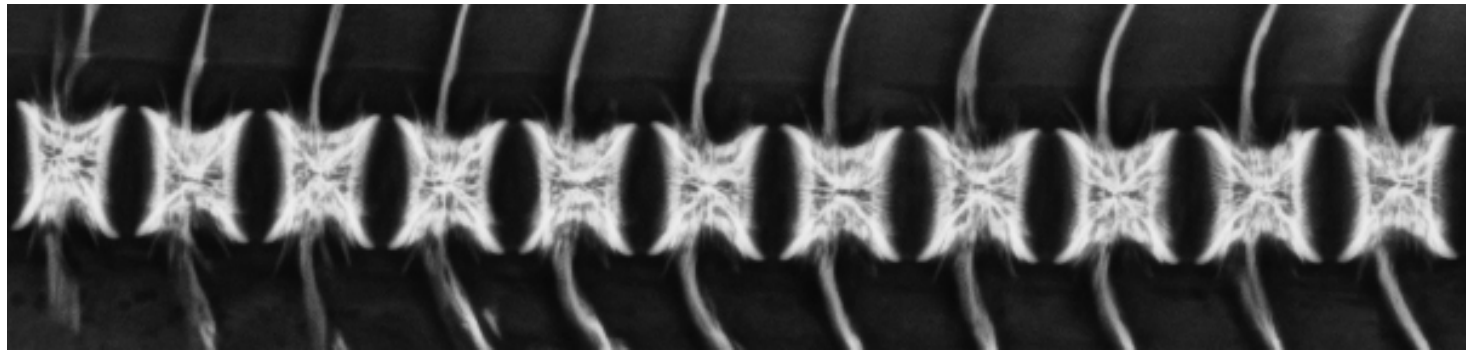
# Osteopenia

- "Too little bone", reflects the undermineralised appearance of the vertebrae
- One of the pathways leading to platyspondyly and other deformities
- Observed as "ghost-like" vertebrae with small vertebral bodies and large intervertebral spaces



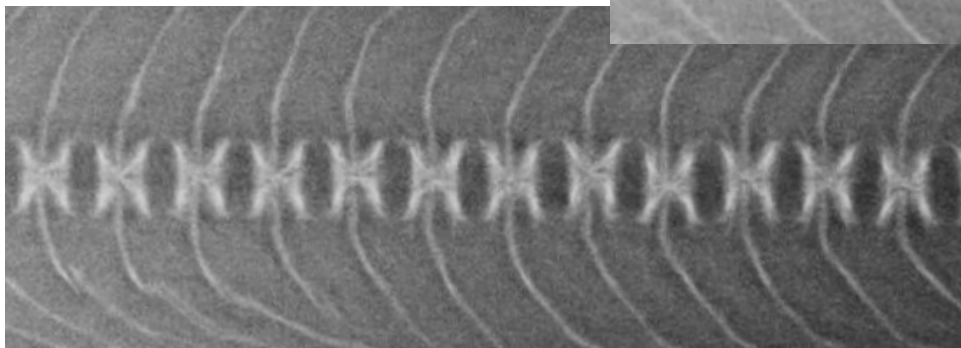
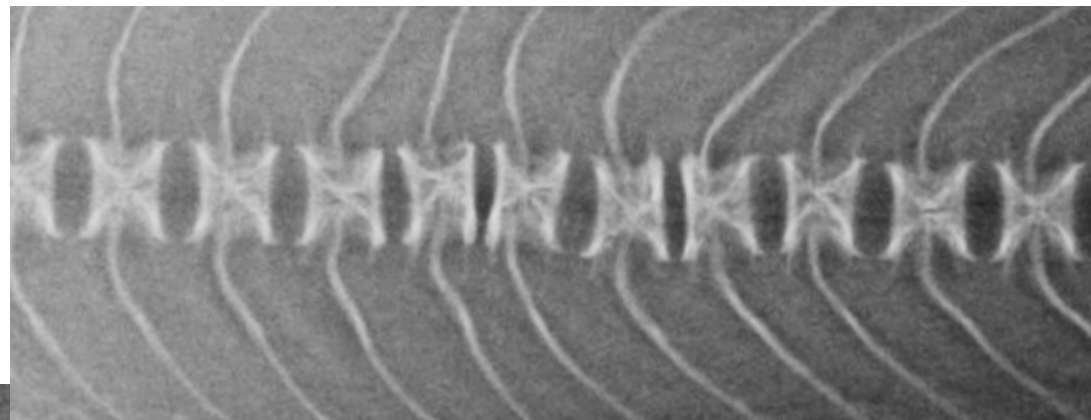
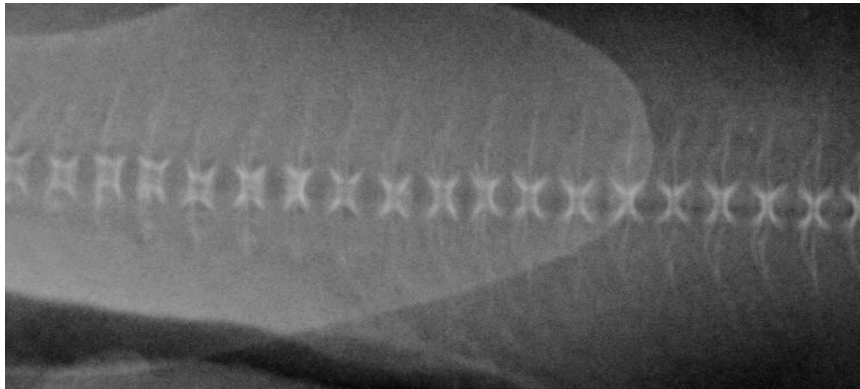
# Examples of osteopenia

Mammography image with high contrast



Standard  
radiograph with  
normal contrast

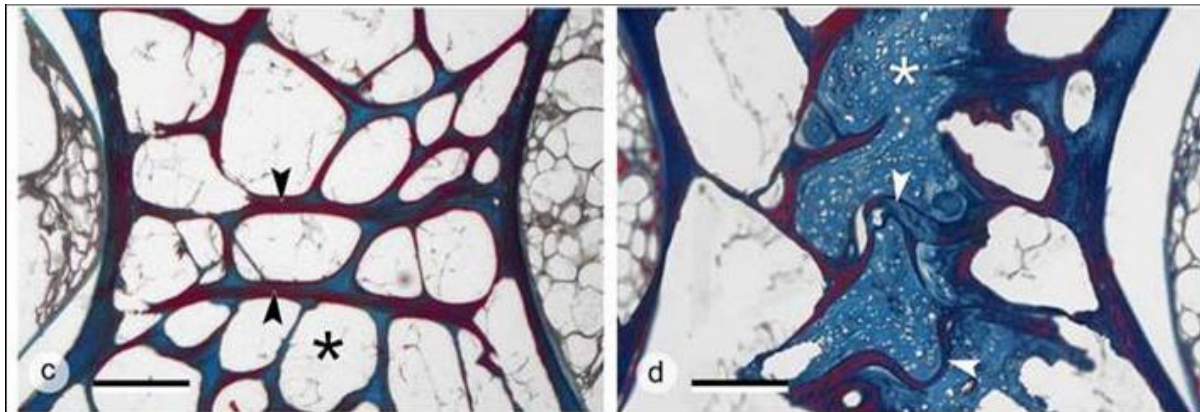
- Severe osteopenia in 5 g salmon



Osteopenia and  
disturbed morphology  
in 200g salmon

# Hyper dense vertebrae

- Single vertebrae with increased radio density
- Observed in freshwater stages
- Normal size, or slightly smaller than the other vertebrae

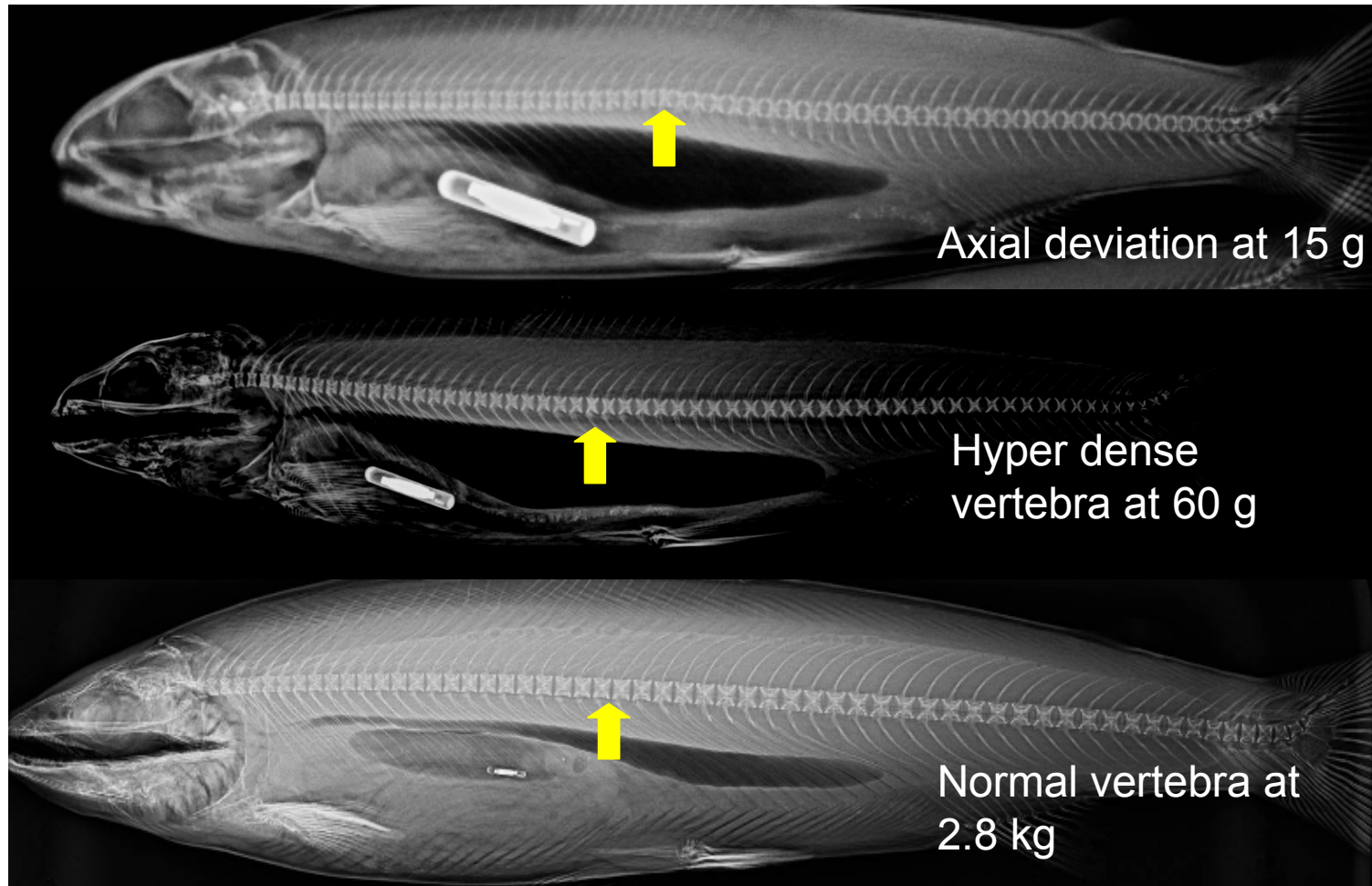


Hyper dense  
vertebrae in  
radiograph and  
histological section

(Helland et al., 2006).



# Possible developments of hyper dense vertebrae: normal or fusion



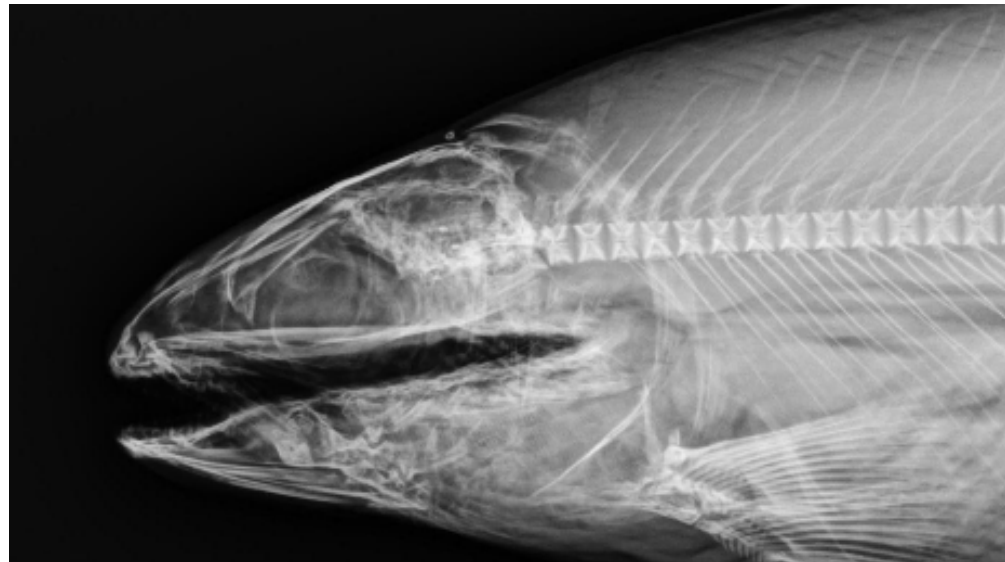
# Deformity diagnostics in salmon



## Head deformities

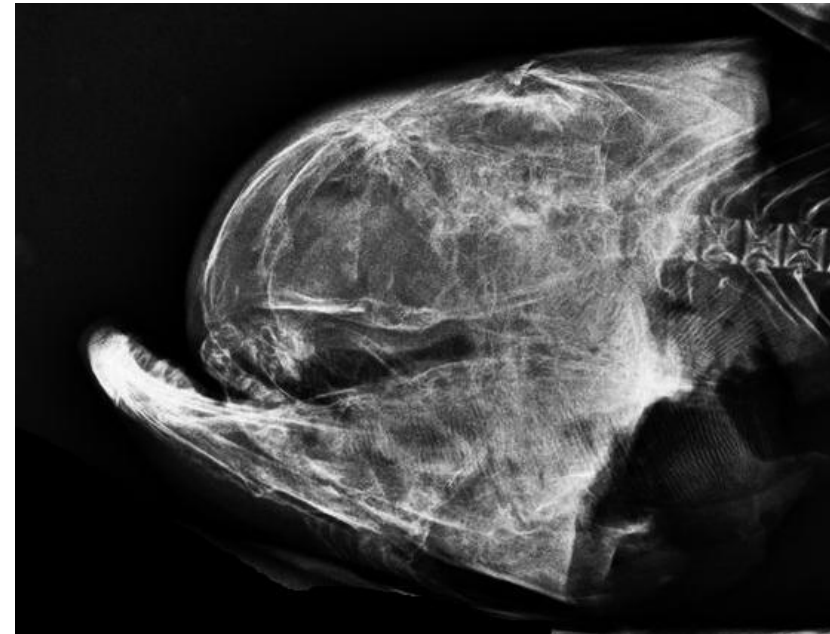
- **Pug nose/upper jaw deformities**
- **Lower jaw deformities**

Normal salmon head radiograph

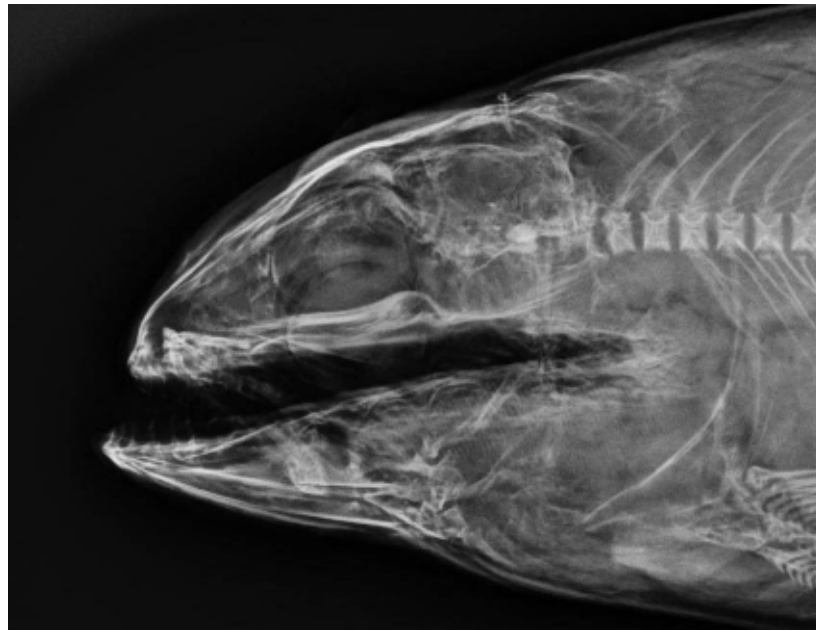


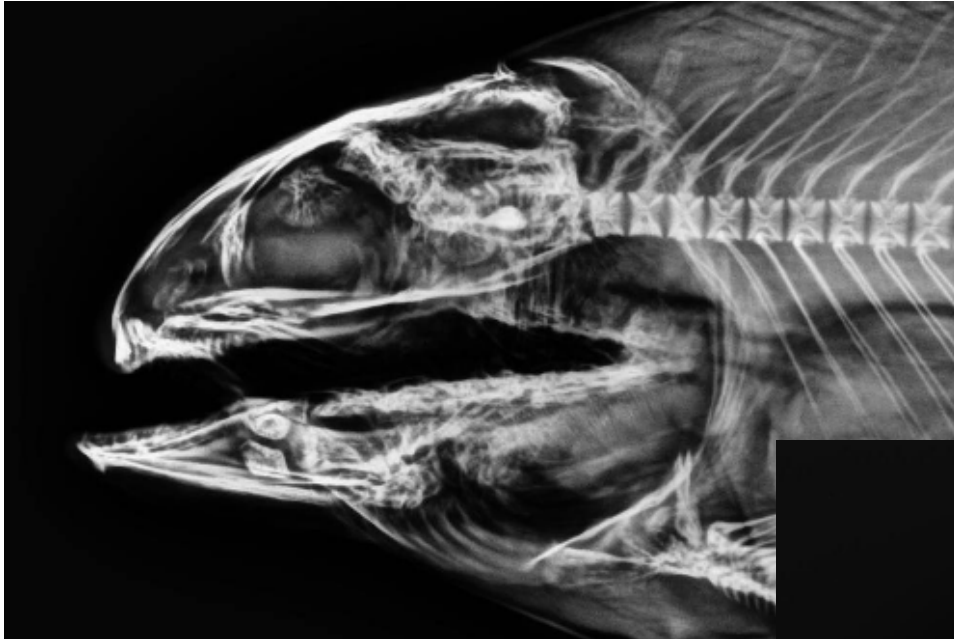
# Upper jaw deformities

Severe pug nose

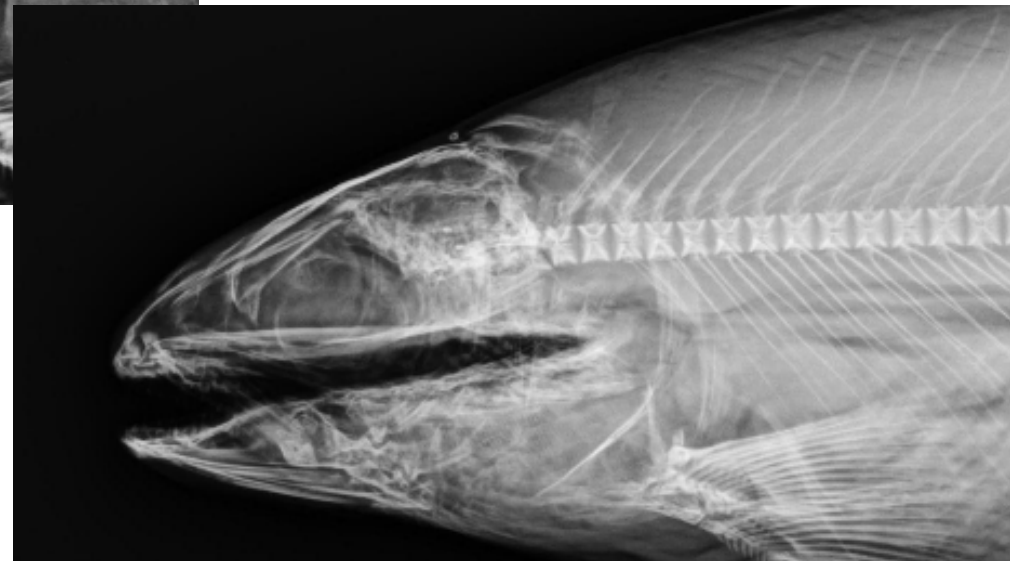


Palatine bone curvature





Shortened upper jaw  
or elongated lower  
jaw or both?



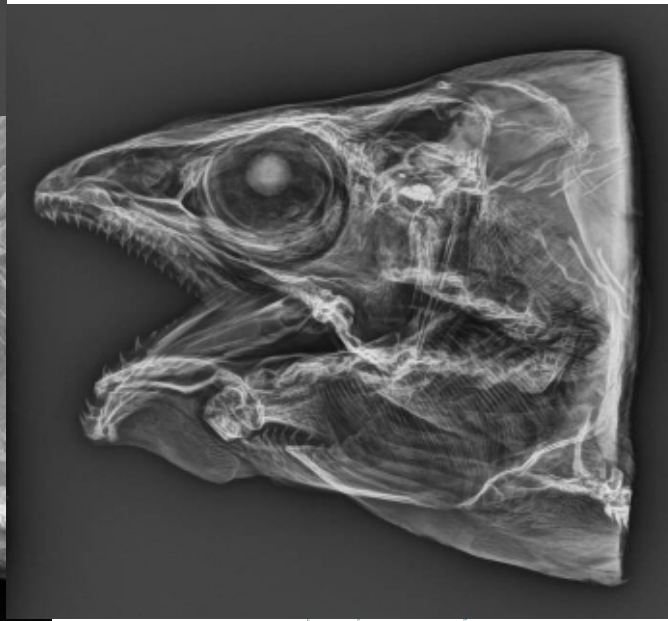
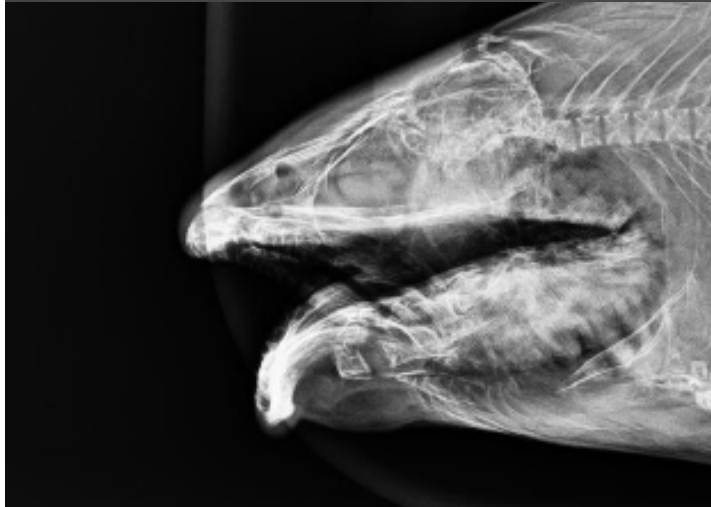
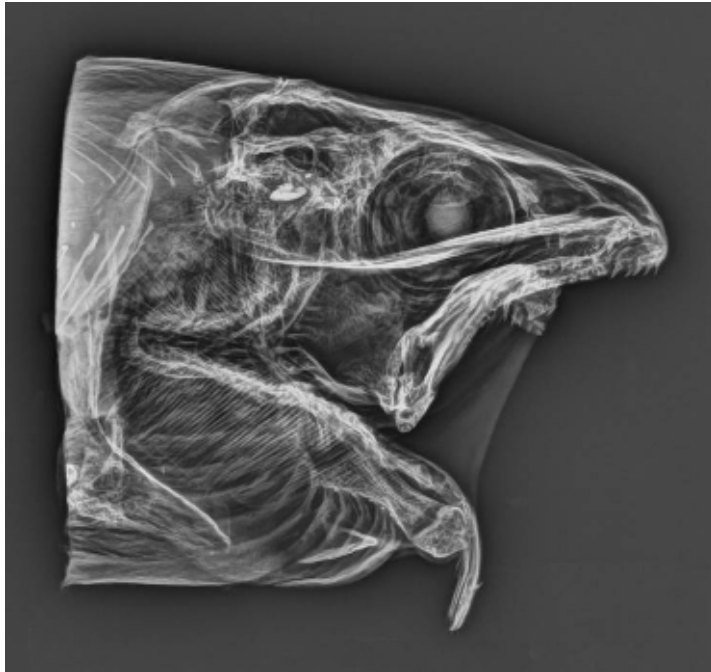
Normal



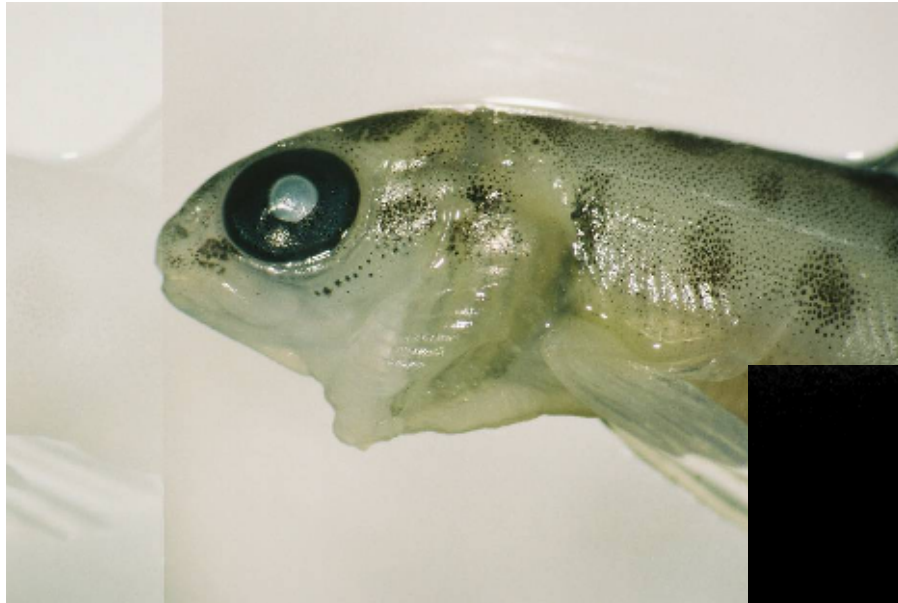
# Lower jaw deformities



- Different varieties of "screamers"



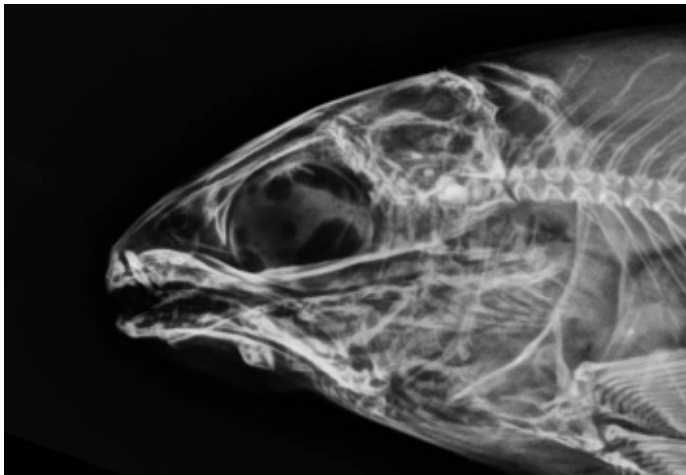
## ”Double mouth”



Maldevelopment of the jaw causing the hyoid cartilages to drop out of the jaw. Image and radiograph of start feeding fry.



# "Box jaw"



Slight underdevelopment of the lower jaw

# Deformity diagnostics in salmon

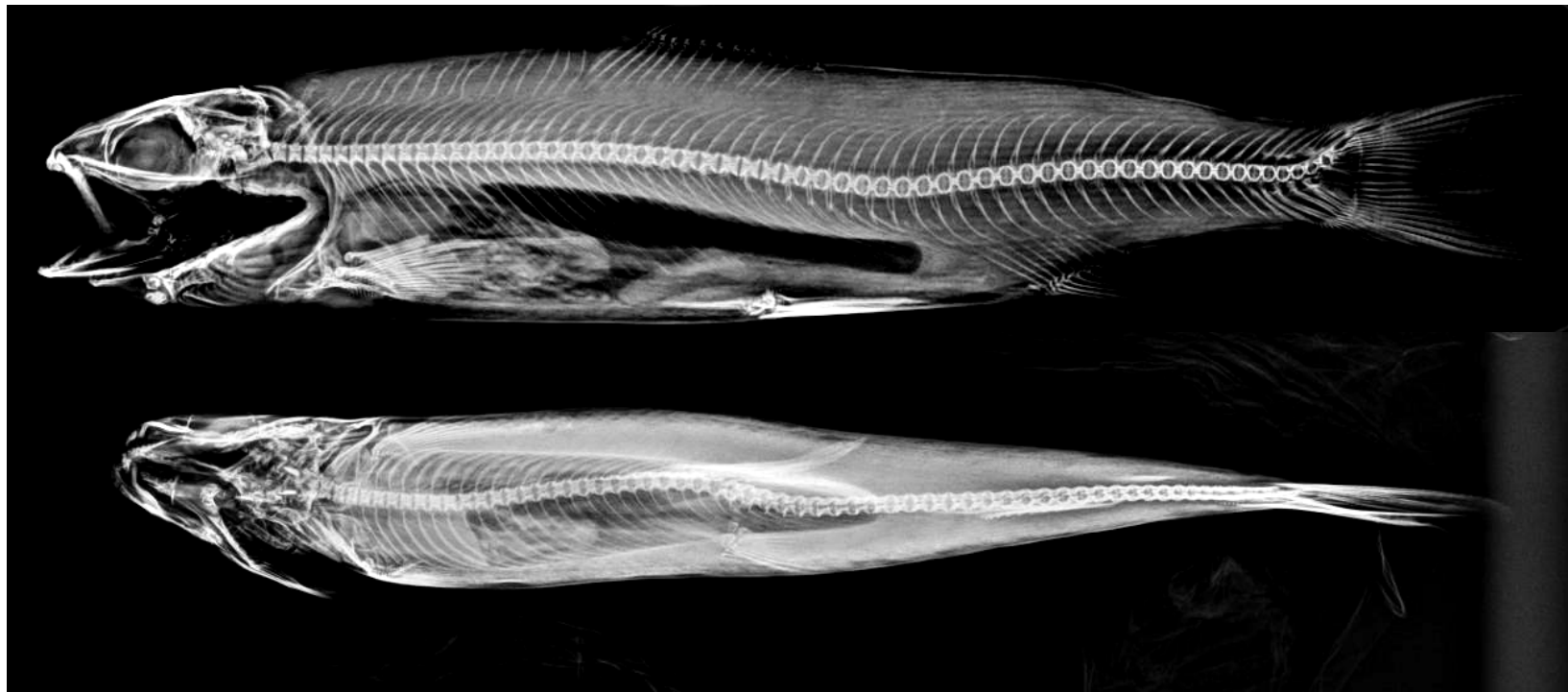


- Axial deviations
  - Scoliosis
  - Lordosis
  - Kyphosis
- Axial deviations are not very commonly observed in Norwegian farmed salmon anymore, but earlier the lack of C-vitamin in feed was a common cause of scoliosis



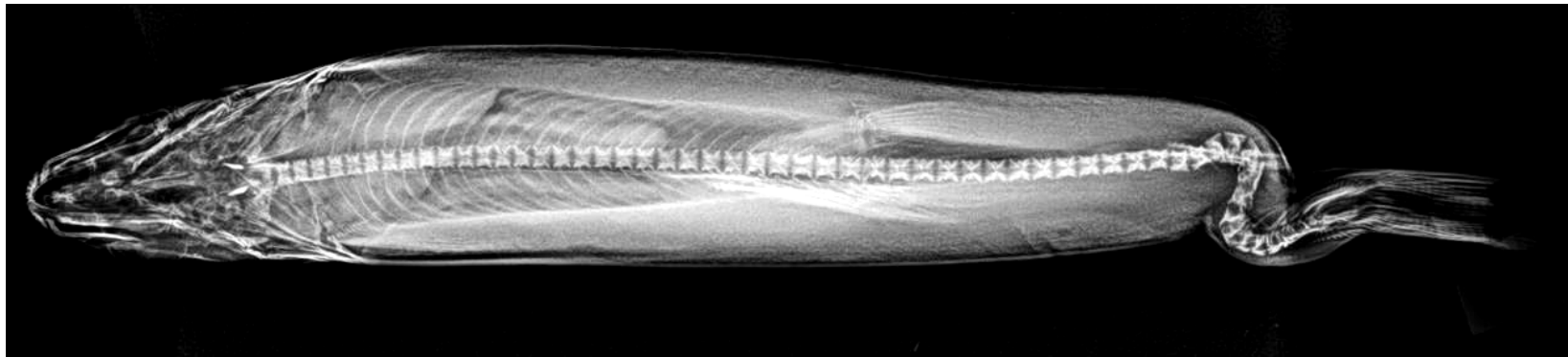
# Scoliosis

- Scoliosis is the sideways bending of the spine
- Low grade scoliosis is hard to determine from the side, as it can be confused with a position artefact or improper preparation of the fish for radiography



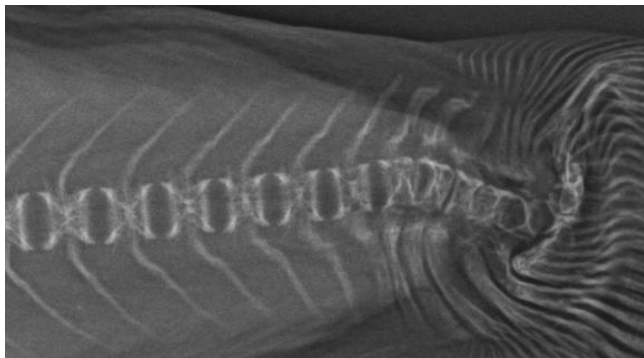


# Severe scoliosis of tail in salmon



# Tail scoliosis

Dorsoventral view  
of three tails with  
different degrees  
of scoliosis

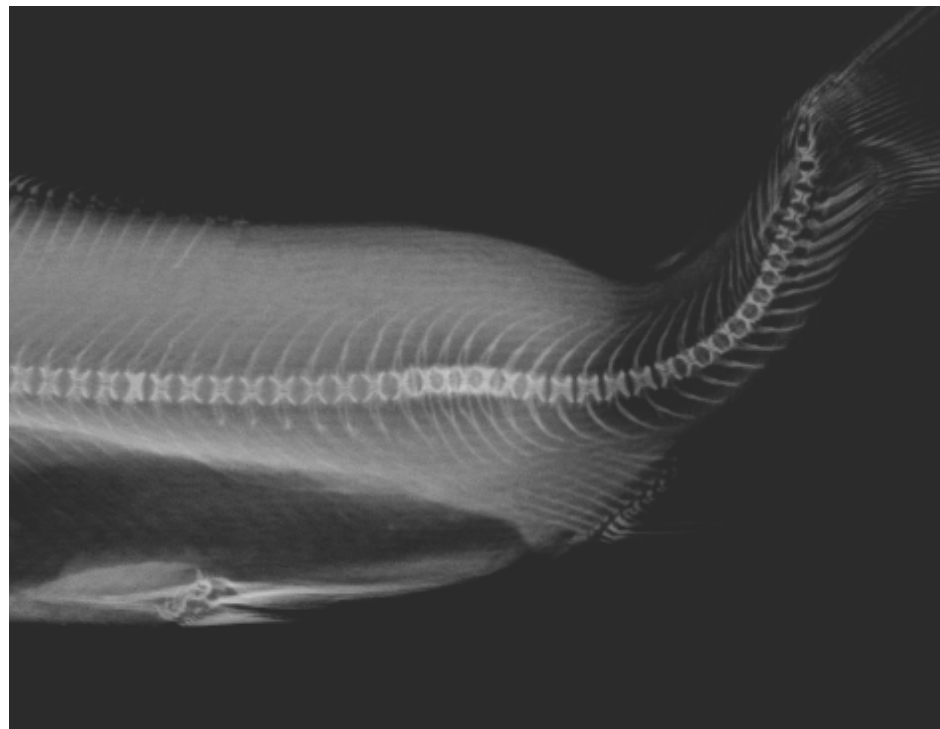


Lateral view of the same  
tail as number three  
above

# Lordosis

- Lordosis is the dorsoventral bending of the spine, making the tail point upwards
- True lordosis appear in many species, but is seldom seen in salmon

Example of lordotic spine in salmon





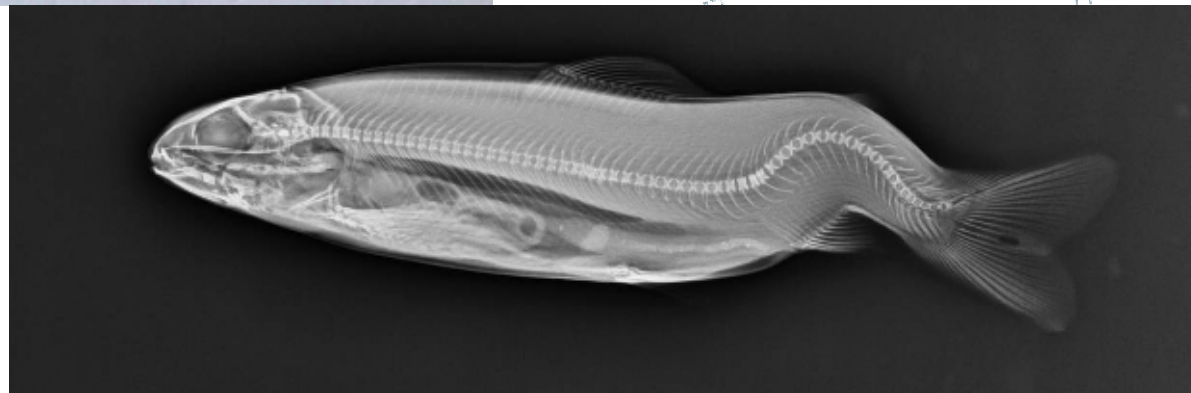
# Kyphosis

- Kyphosis is the opposite of lordosis, a dorsoventral curvature of the spine making the tail point downwards (Hunchback)
- Kyphosis is rarely observed, and then often connected to other deformities

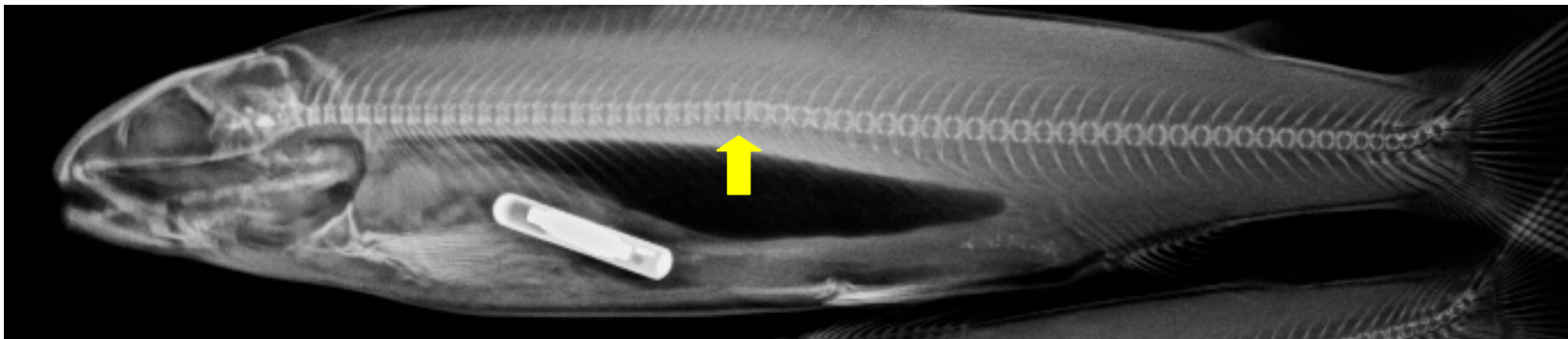


Kyphosis and scoliosis  
in salmon  
(approximately 30 g)

Lordosis and kyphosis in  
15 g salmon



## ”Kyphosis” in salmon parr



A more commonly observed axial deviation is the ” kyphosis” created by one single vertebra being too small, and thus creating a broken axis in the spine.

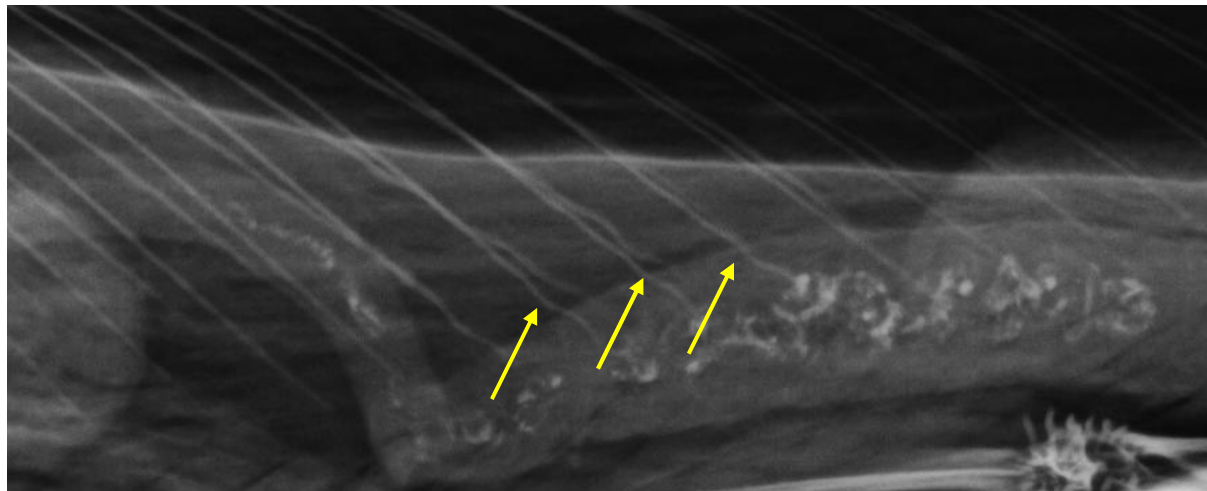
This would not be considered as a proper kyphosis, and is a deviation that may be corrected as the fish grows, perhaps with an intermediate stage as a hyper dense vertebra.

# Deformity diagnostics in salmon



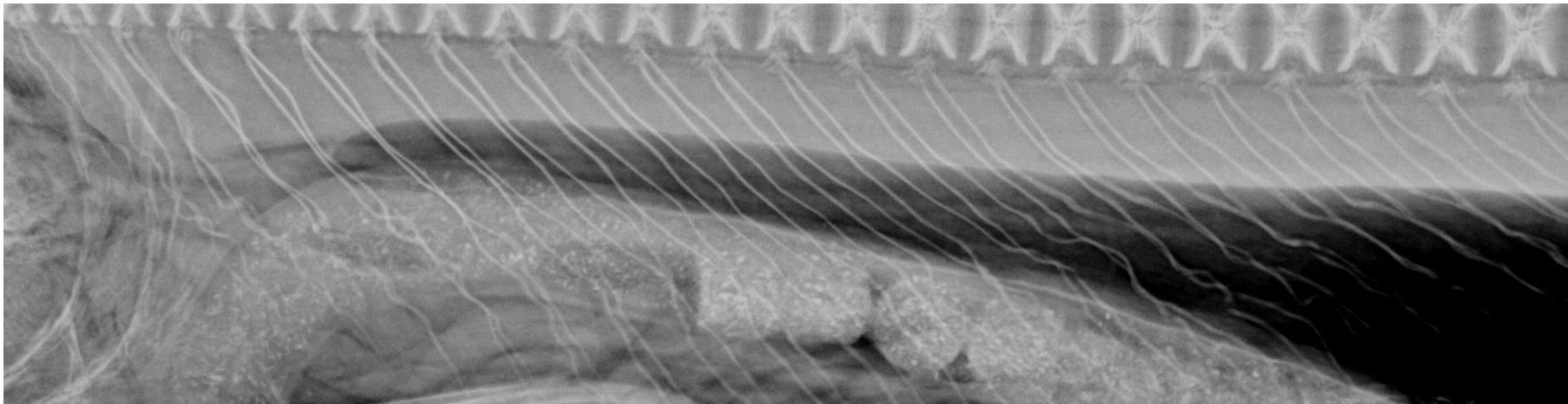
- Rib appearance
  - Wrinkled ribs

The appearance of wrinkled ribs have been used as a diagnostic support to other indicators on low mineralization in the fish skeleton. Normal ribs are straight, while ribs in undermineralized fish appear “curly”.



Wrinkled ribs in salmon.  
Swimbladder on top, vent at the bottom right.

- Severe case of wrinkled ribs in rainbow trout





Thank you for your attention!

