

# Deformations of the spinal column in Atlantic salmon

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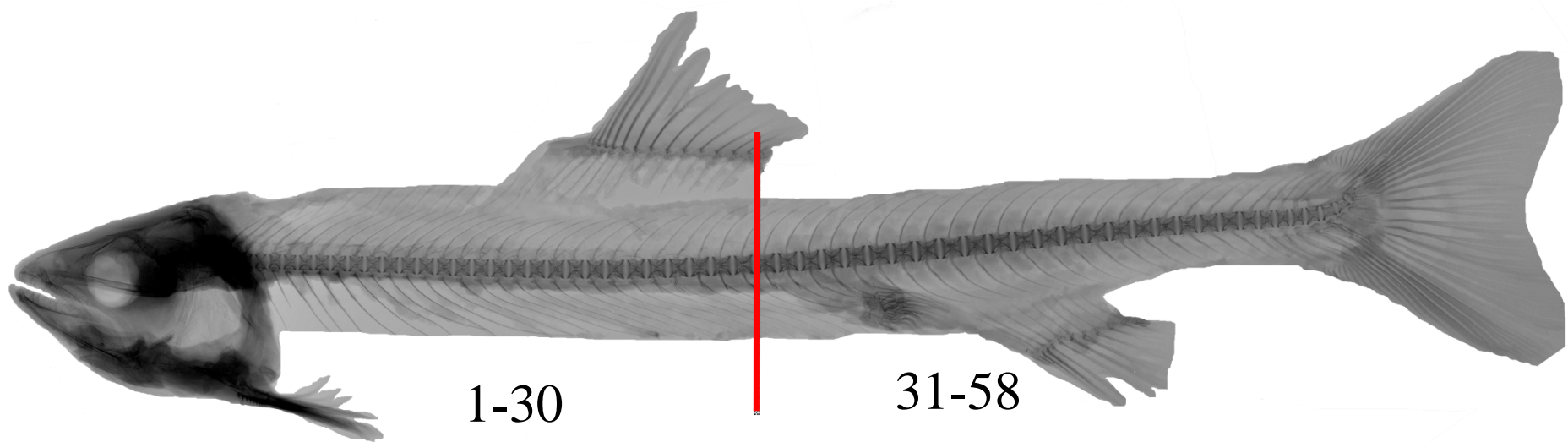
**IMR, NIFES, Marine Harvest, Skretting.**

# Overview

- General anatomy
- Different deformities
- Factors - deformities:
  - Diet
  - Temperature
  - Breeding
  - Vaccination
- Implications for fish welfare - growth

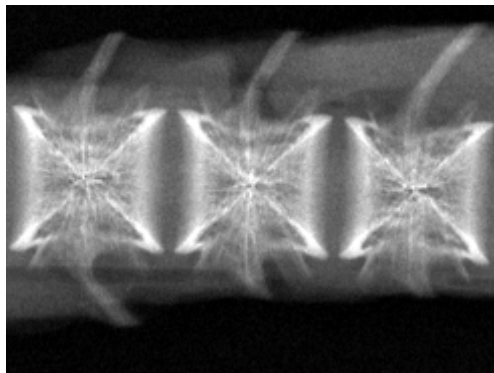
# The vertebral column

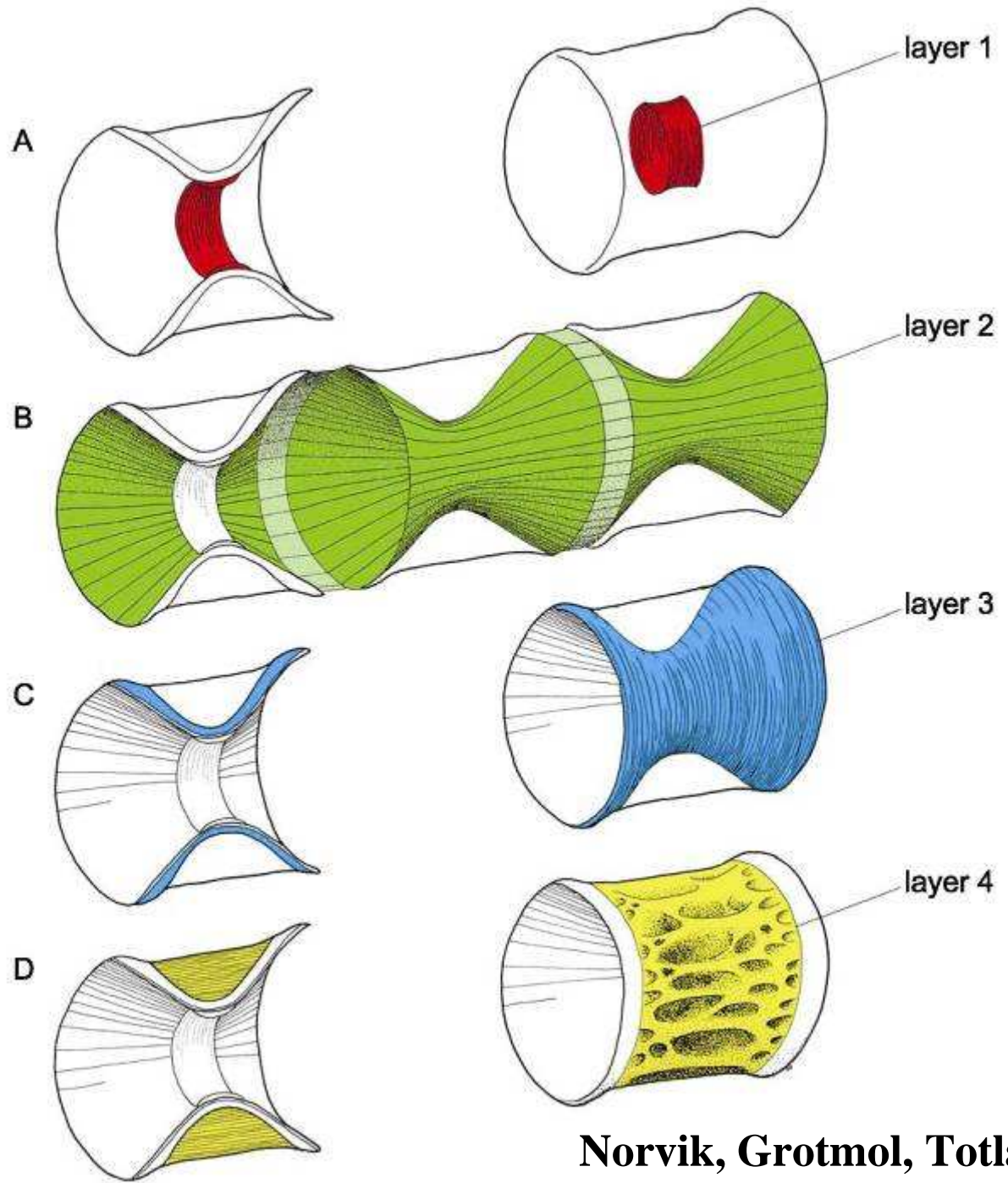
- 58 (56-60) vertebrae.
- Vertebrae 1-30 are trunkal, while vertebrae 31-58 are caudal.



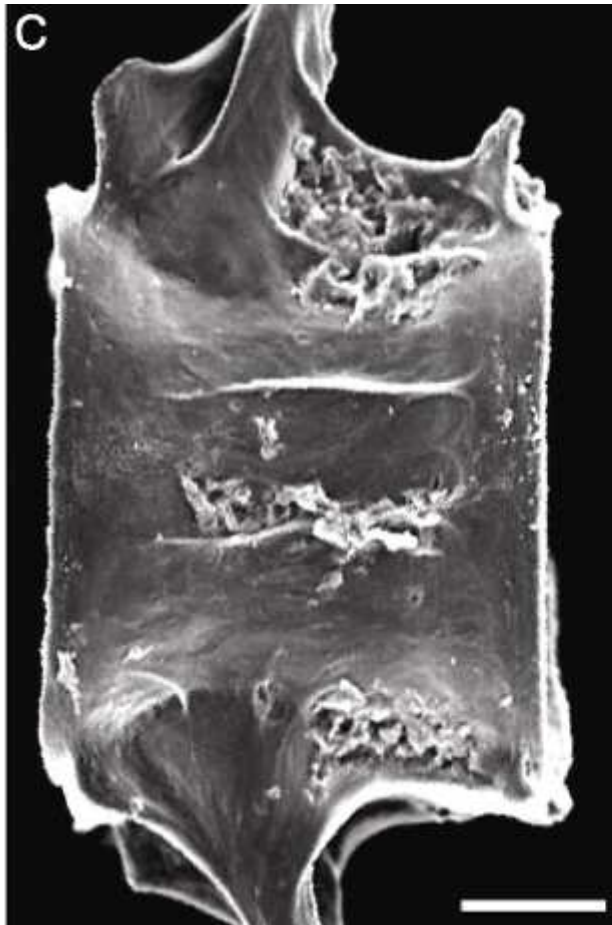
# The vertebrae

- Low bone mass to reduce negative buoyancy.
- Comprised of 4 layers of bone.
- Biconoide core of compact bone surrounded by trabecular bone.
- Separated by notochordal tissue.

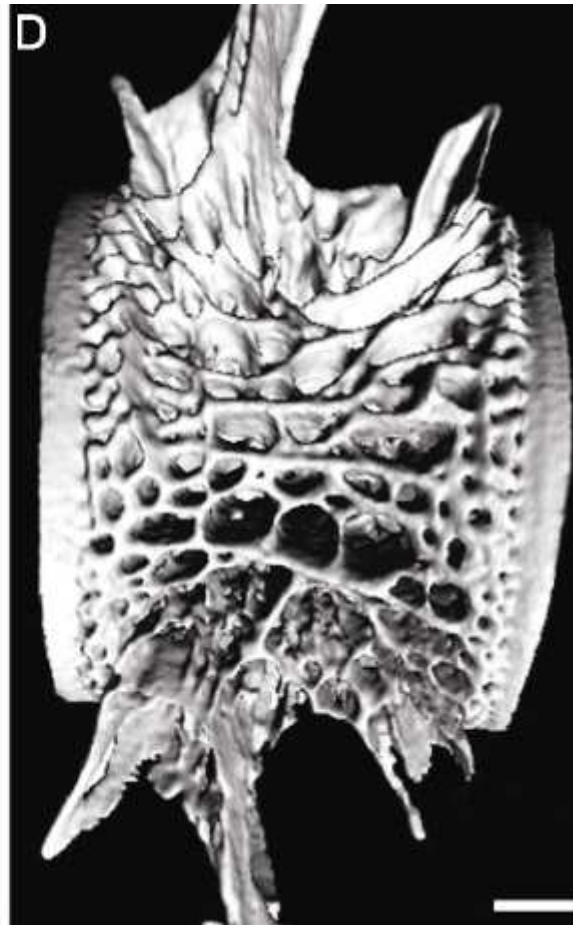




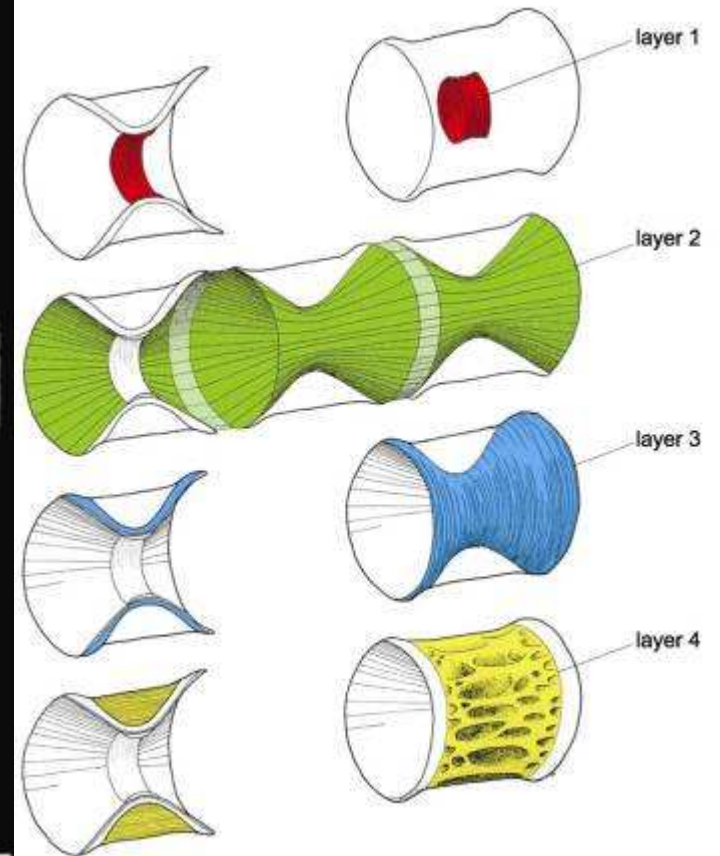
**Norvik, Grotmol, Totland og Kryvi, 2005**



1000 dC

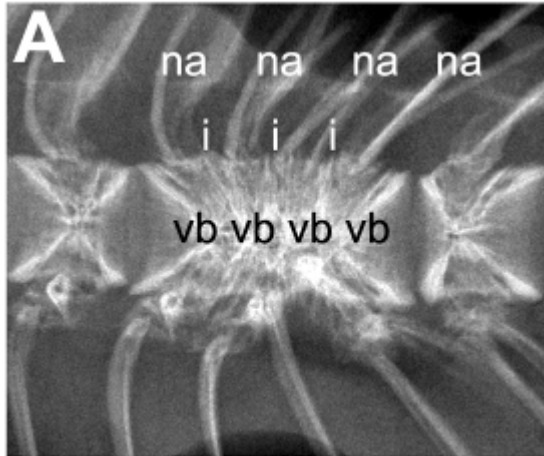


smolt

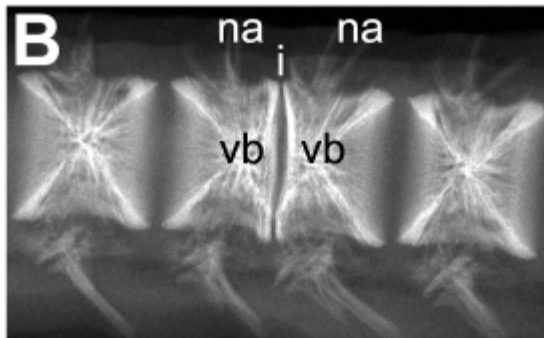


**Norvik, Grotmol, Totland og Kryvi, 2005**

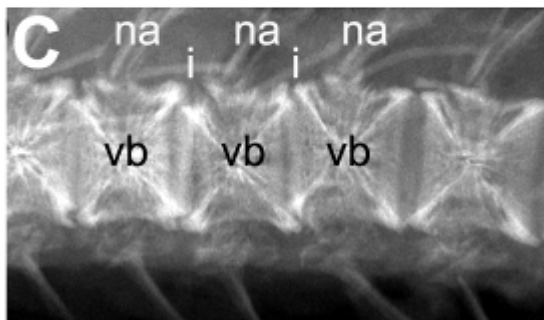
# Different types of vertebral deformities in farmed salmon



← Fusions



← Compressions (tail region)



← Dislocations

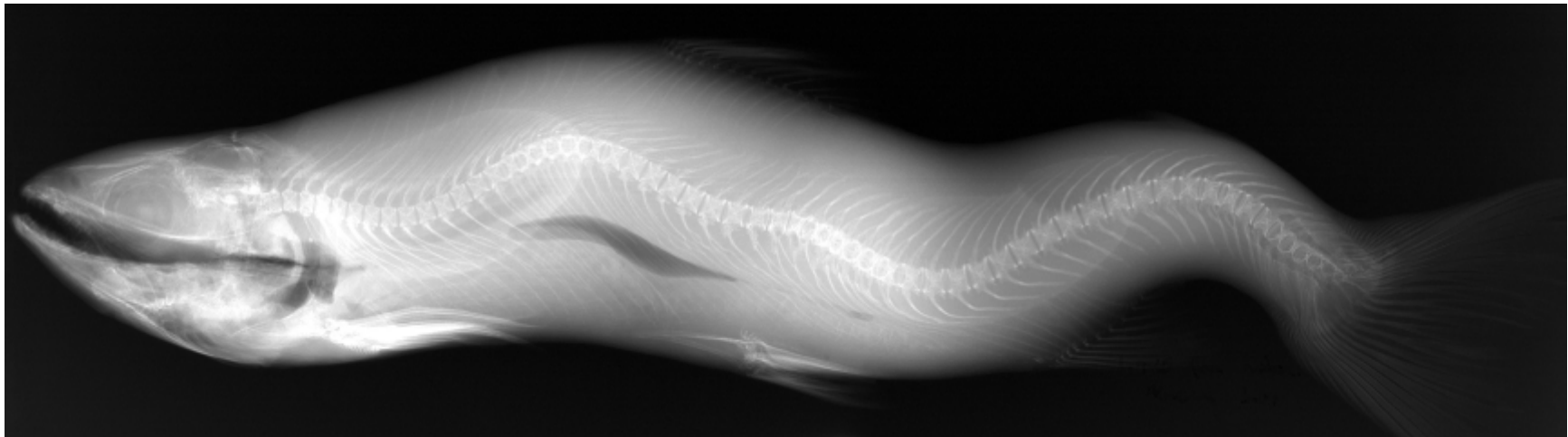
*Fjelldal mfl. 2007a,  
Aquaculture*

# Shortened body

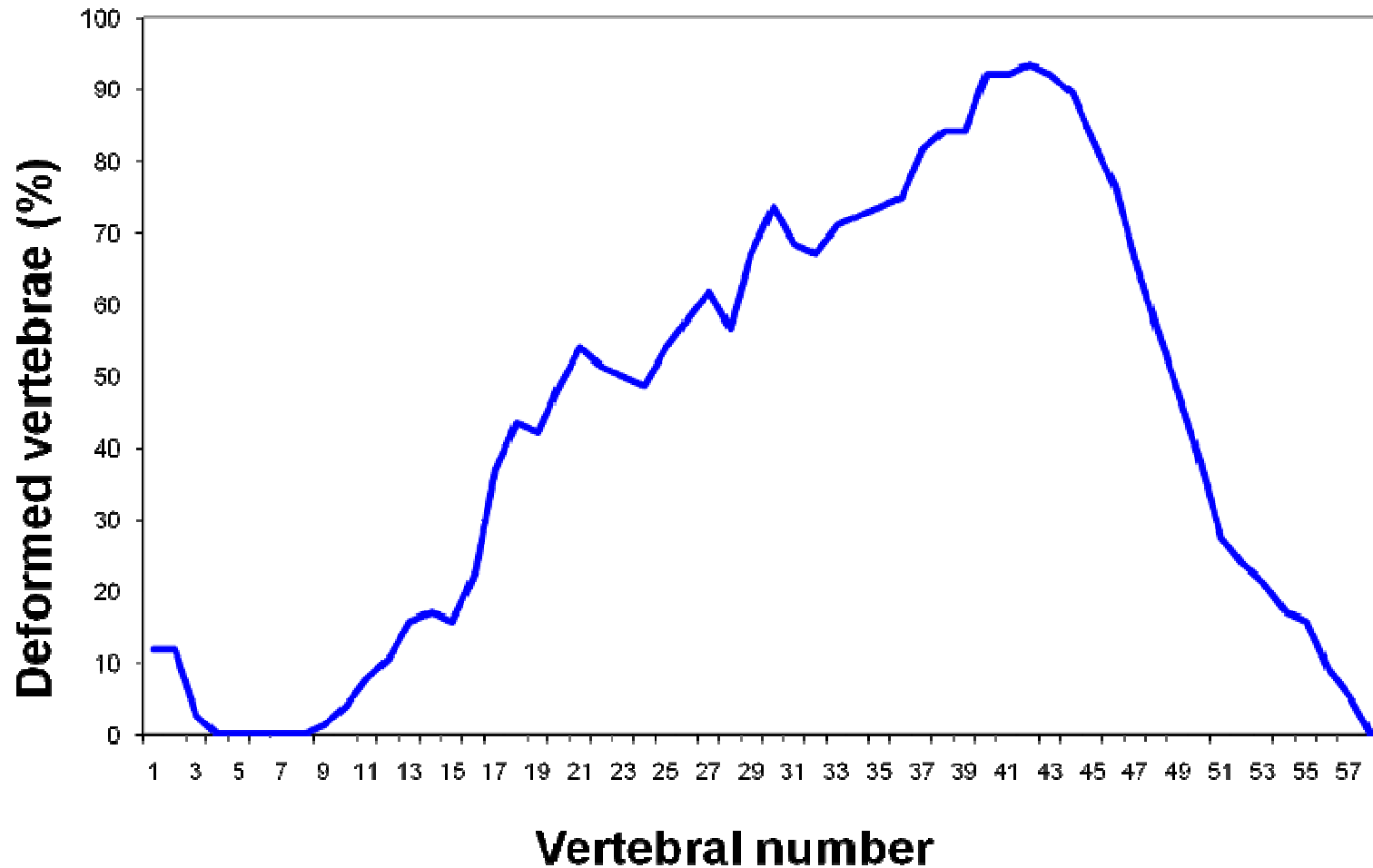




# Curvatures

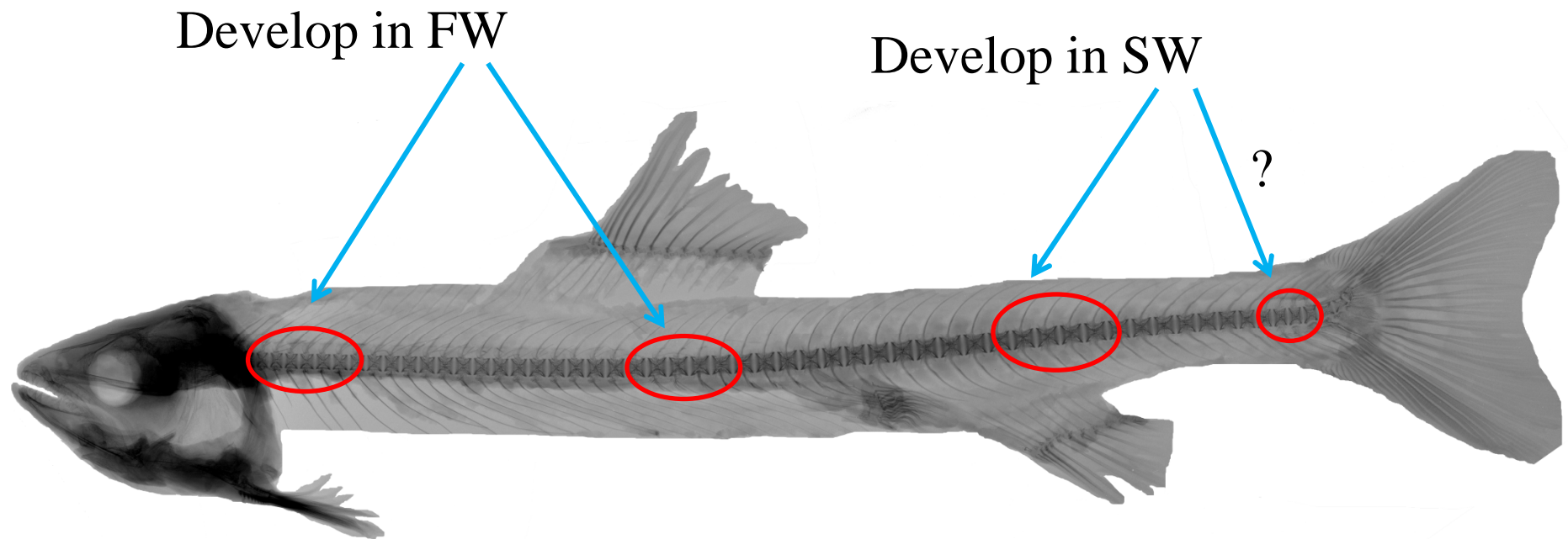


# Predominant locations for vertebral deformities – field study with harvestsize salmon 2006.





# Predominant locations vertebral deformities



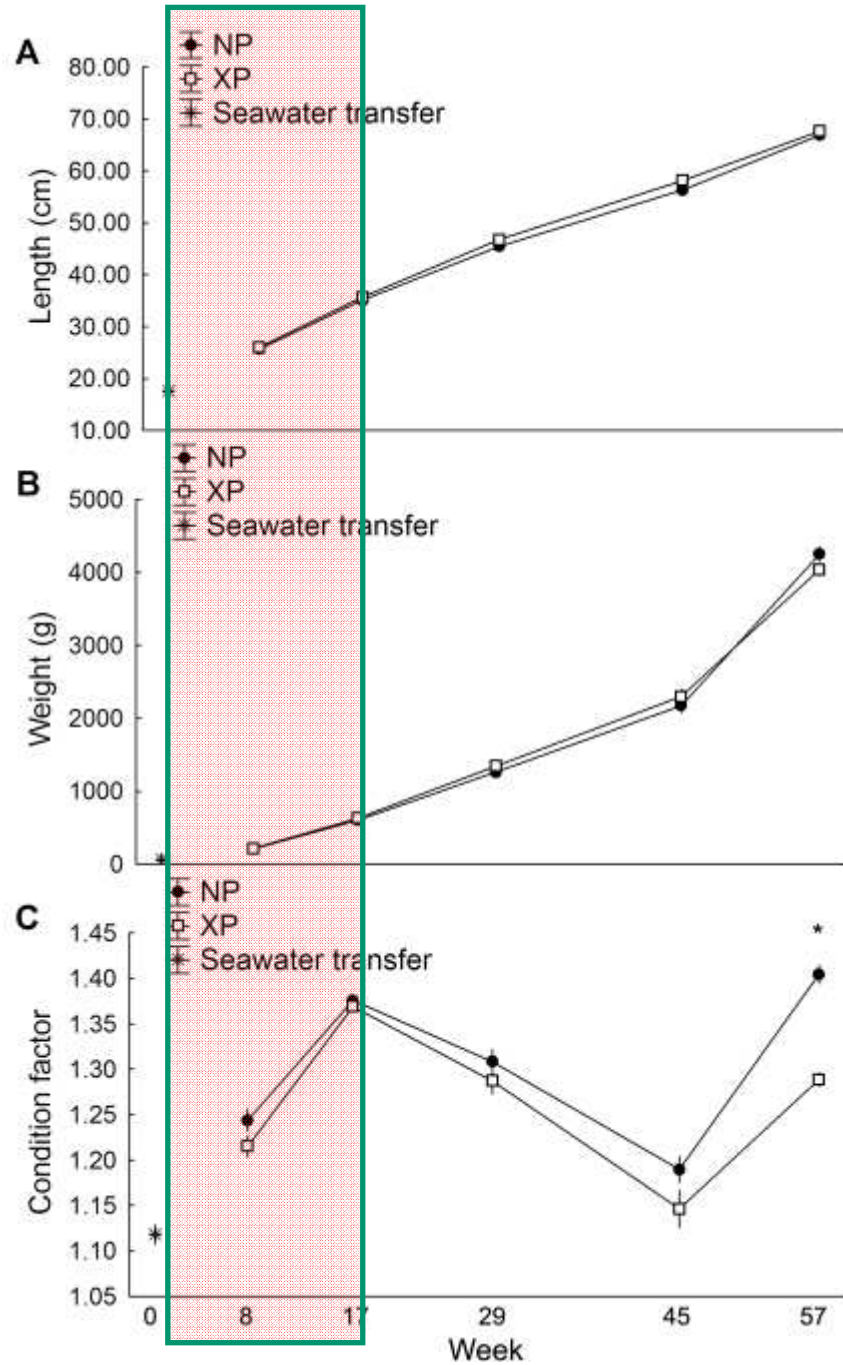
# Dietary phosphorous during the early SW phase

- 9000 vaccinated 0+ smolt from commercial farm.
- Fed diets with a normal (0.6% available P) or high mineral (0.9% available P) level from SW transfer (60 g, Aug) until 500 g (Dec), thereafter fed a common diet until 4 kg (Sept). Three 15x15 m seacages per diet.



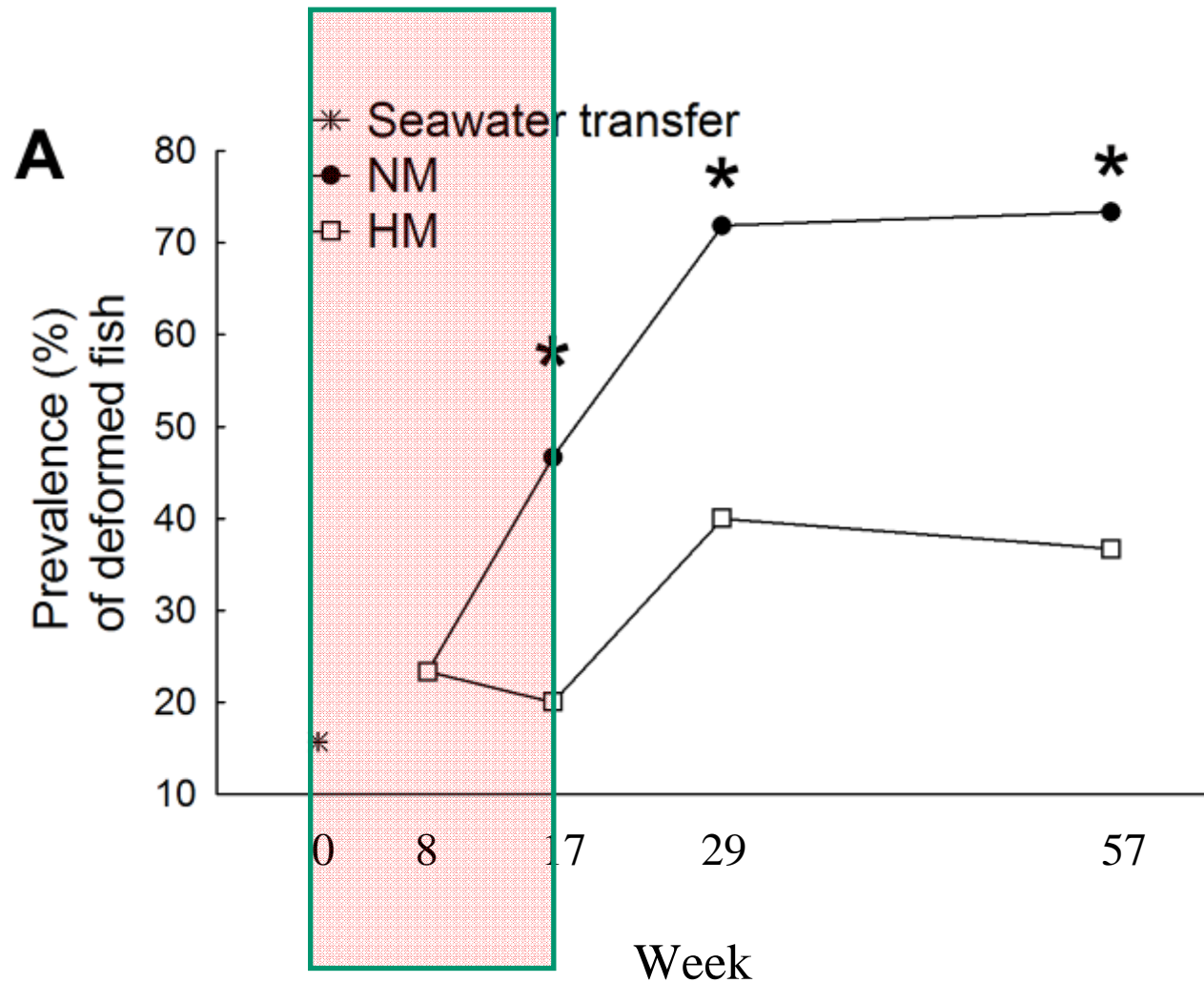
*Fjelldal et al., 2008,  
Aquaculture Nutrition*

# Dietary P

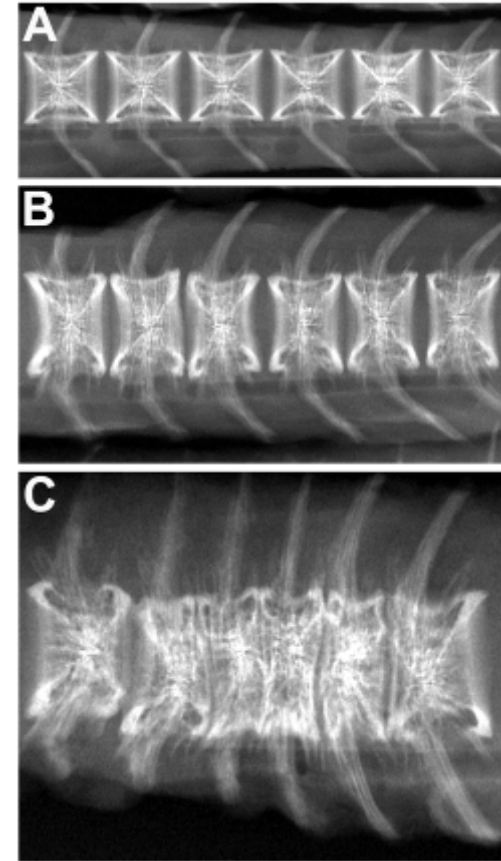


*Fjelldal et al., 2008,  
Aquaculture Nutrition*

# Dietary P



Reduced mechanical strength  
and mineral content of  
vertebrae in w 8

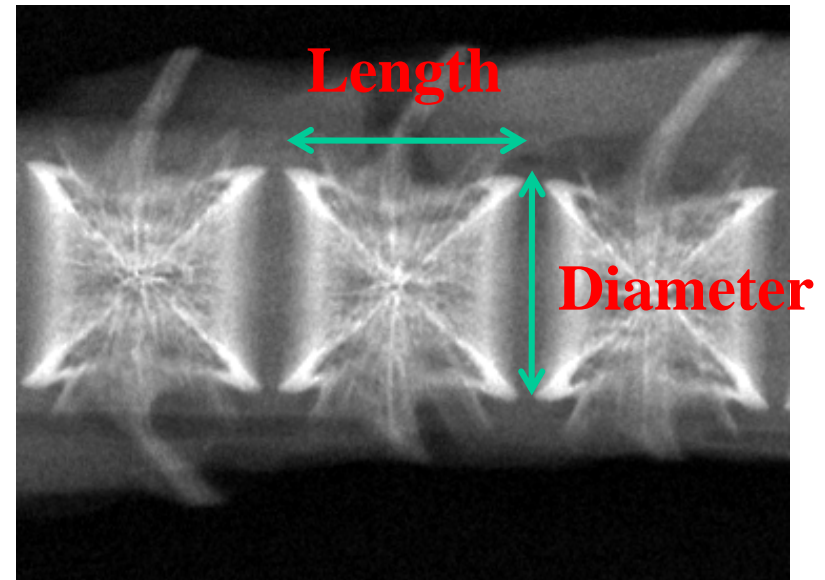


*Fjelldal et al., 2008,  
Aquaculture Nutrition*

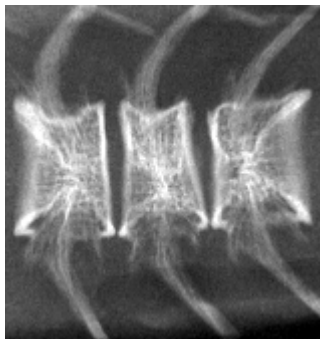
Dietary P

# Vertebral morphology at harvest

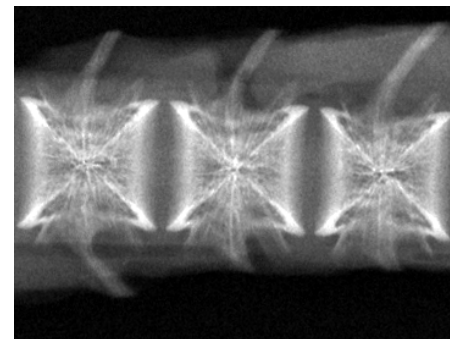
- The ratio between length and diameter used as a measure for compression



Low length/diameter ratio



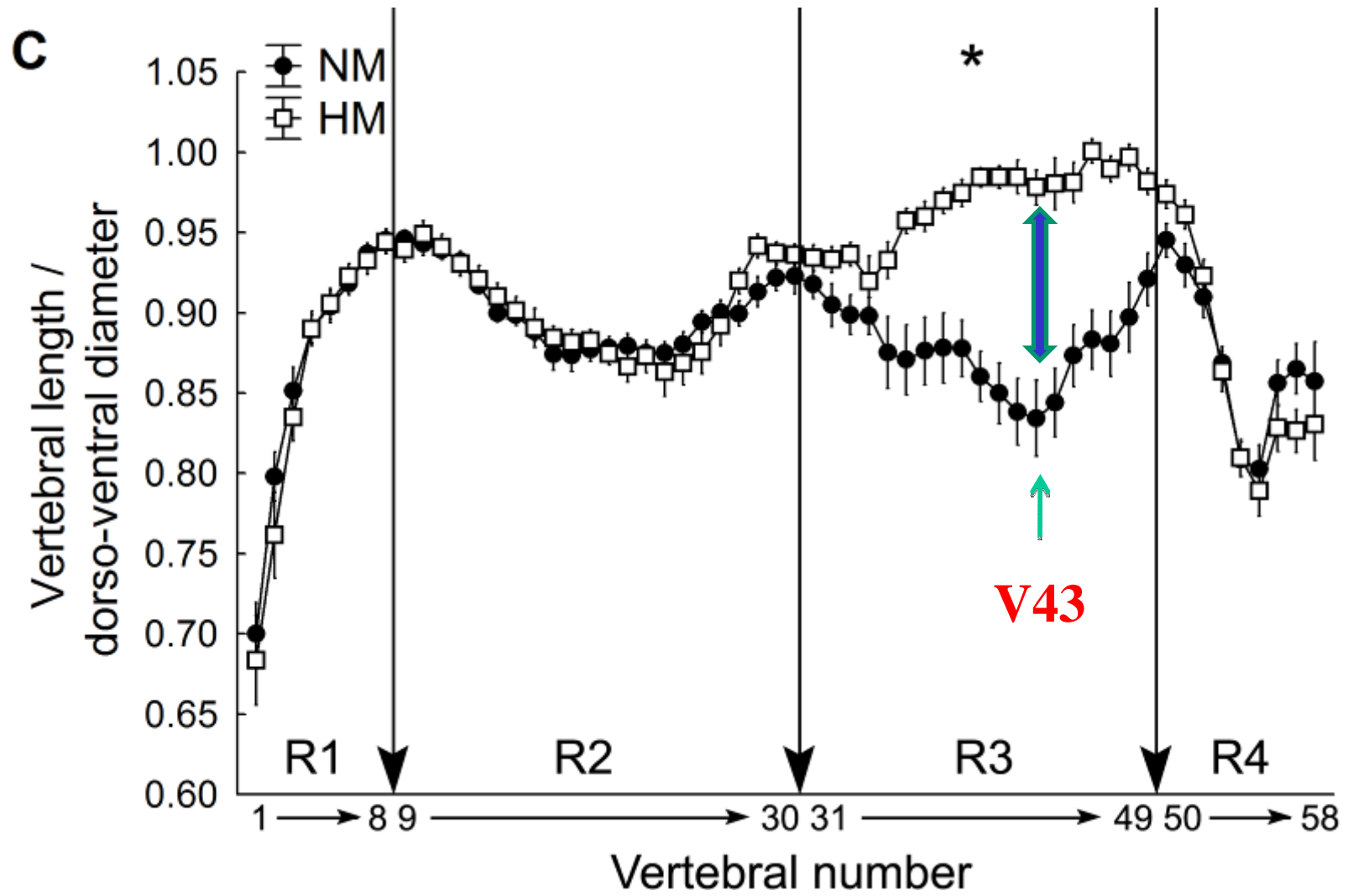
High length/diameter ratio





Dietary P

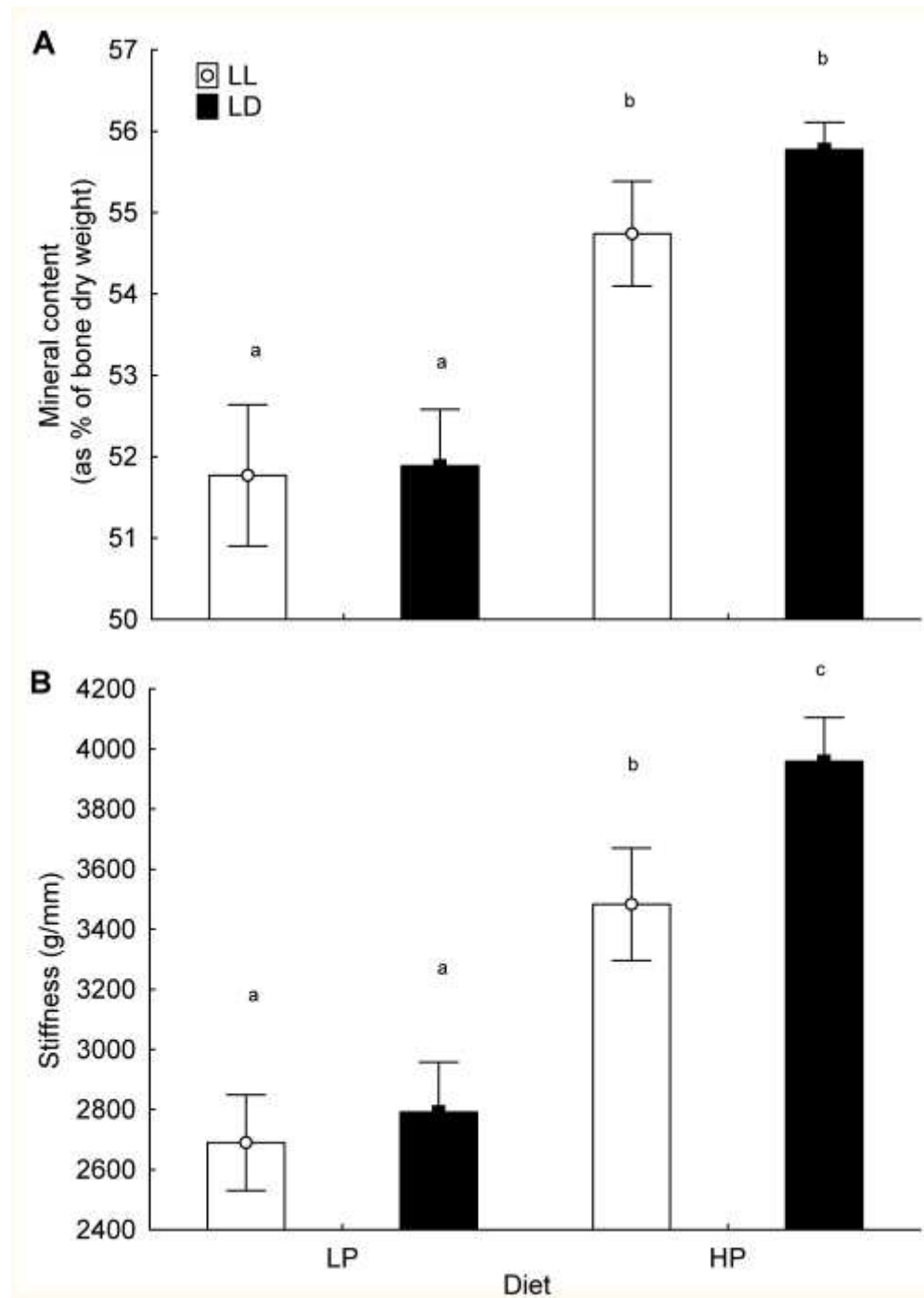
Harvest 4 kg



## **Dietary phosphorous during the early SW phase**

- 0+ smolt reared in 1x1 m tanks, fed a diet with a low (0.4% available P) or high P (0.8% available P) content under LL or 12:12 LD.
- Bone strength and mineral content measured in vertebrae 40-43 after 50 days of feeding.

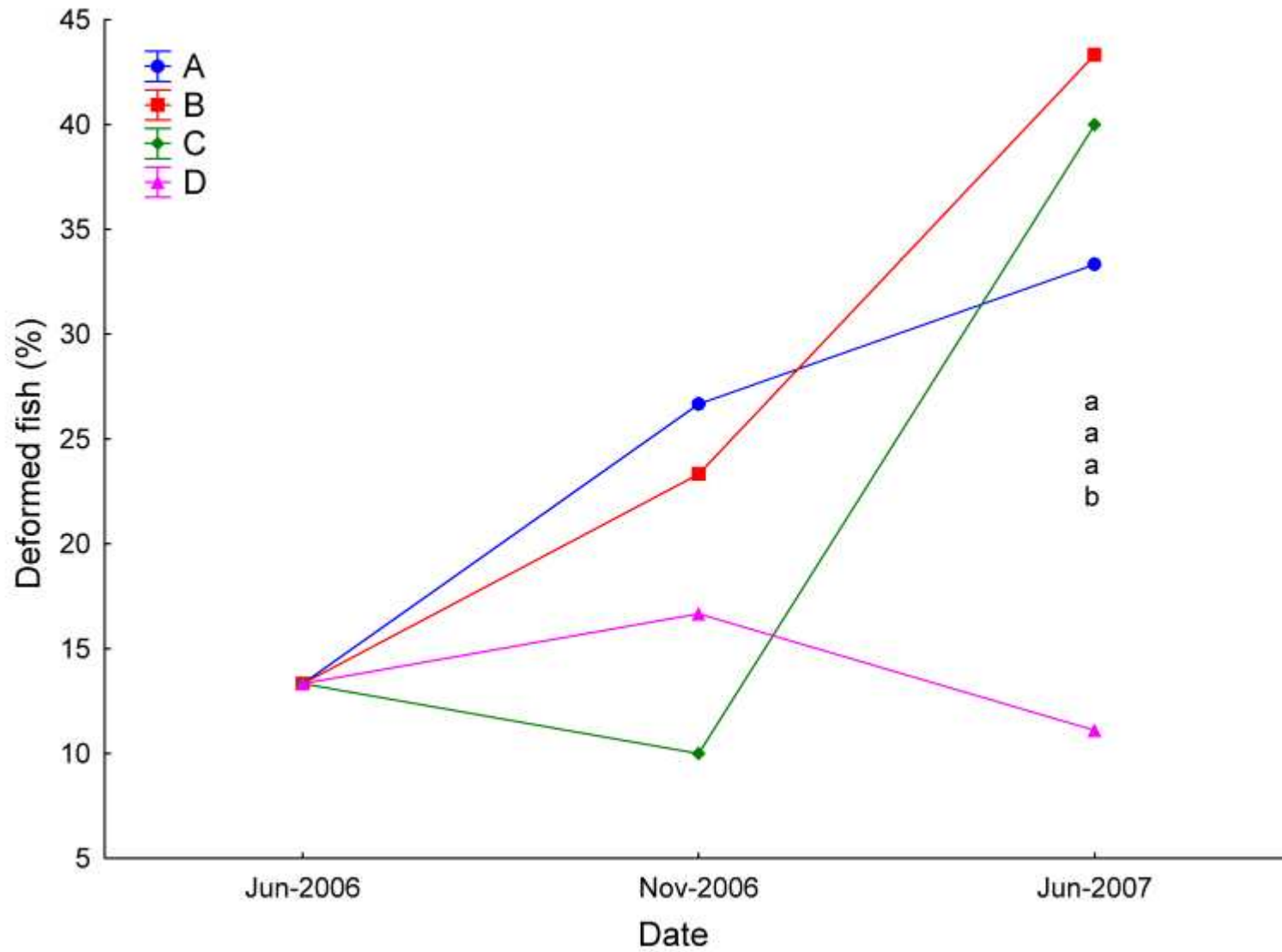
# Dietary P



# Marine or vegetable diets

- 1+ smolt feed a pure fish oil and fish meal based diet, a pure vegetable oil and vegetable meal based diet, or one of two marine diets with different inclusion levels of vegetable oil and meal (4 diets in total).
- Fed for 1 year (350 g to 3.5 kg).

# Feed resources



# Feed resources

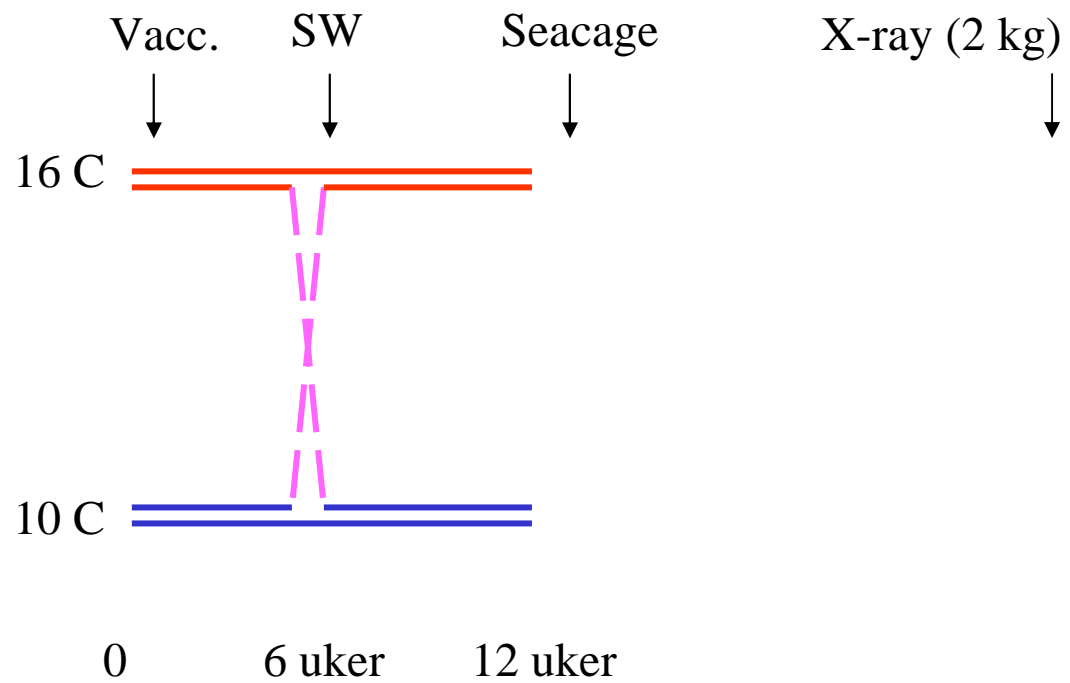
Category	Diet			
	A (n)	B (n)	C (n)	D (n)
1-2 deformed vertebrae	6	8	6	4
3-10 deformed vertebrae	8	4	5	1
11-18 deformed vertebrae	1	1	1	

# Water temperature during smoltification and the early seawater phase

- Vaccinated or unvaccinated 0+ smolt reared at 10 or 16 degrees C during smoltification (6 w) and the early seawater phase (6 w).
- Four 1x1 m tanks per temperature regime, vaccinated and unvaccinated fish in each tank.
- Thereafter all groups were transferred to a common 15x15 m sea cage.



# Temperature





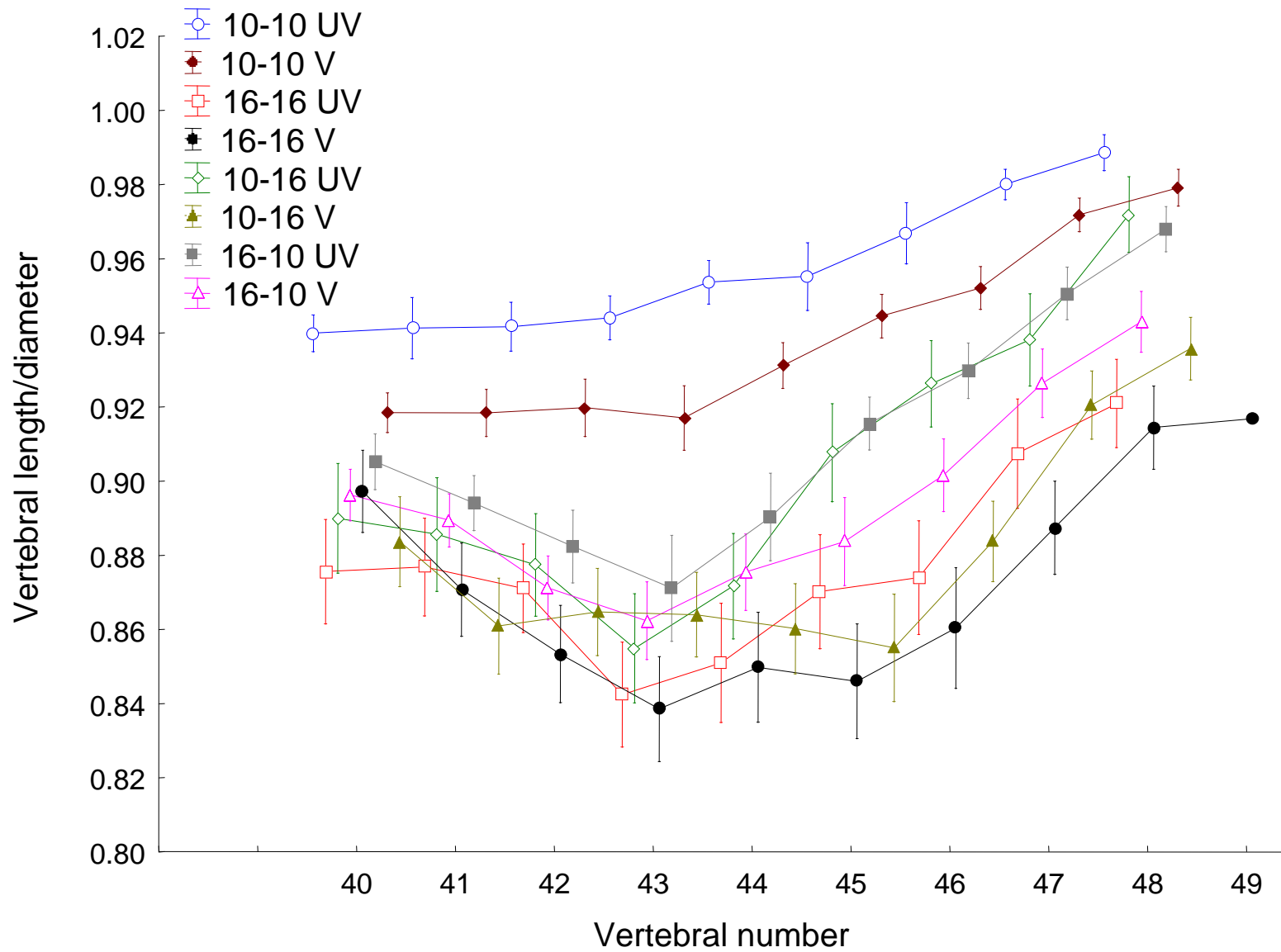
# Temperature

## Vertebral deformities at harvest ~2 kg

Group	% def fish (x-ray)	% down grading (palpation)
10-10 UV	27	2
10-10 V	44	3
10-16 UV	94	13
10-16 V	88	17
16-10 UV	65	3
16-10 V	60	3
16-16 UV	92	22
16-16 V	90	27
Reference value	17	3

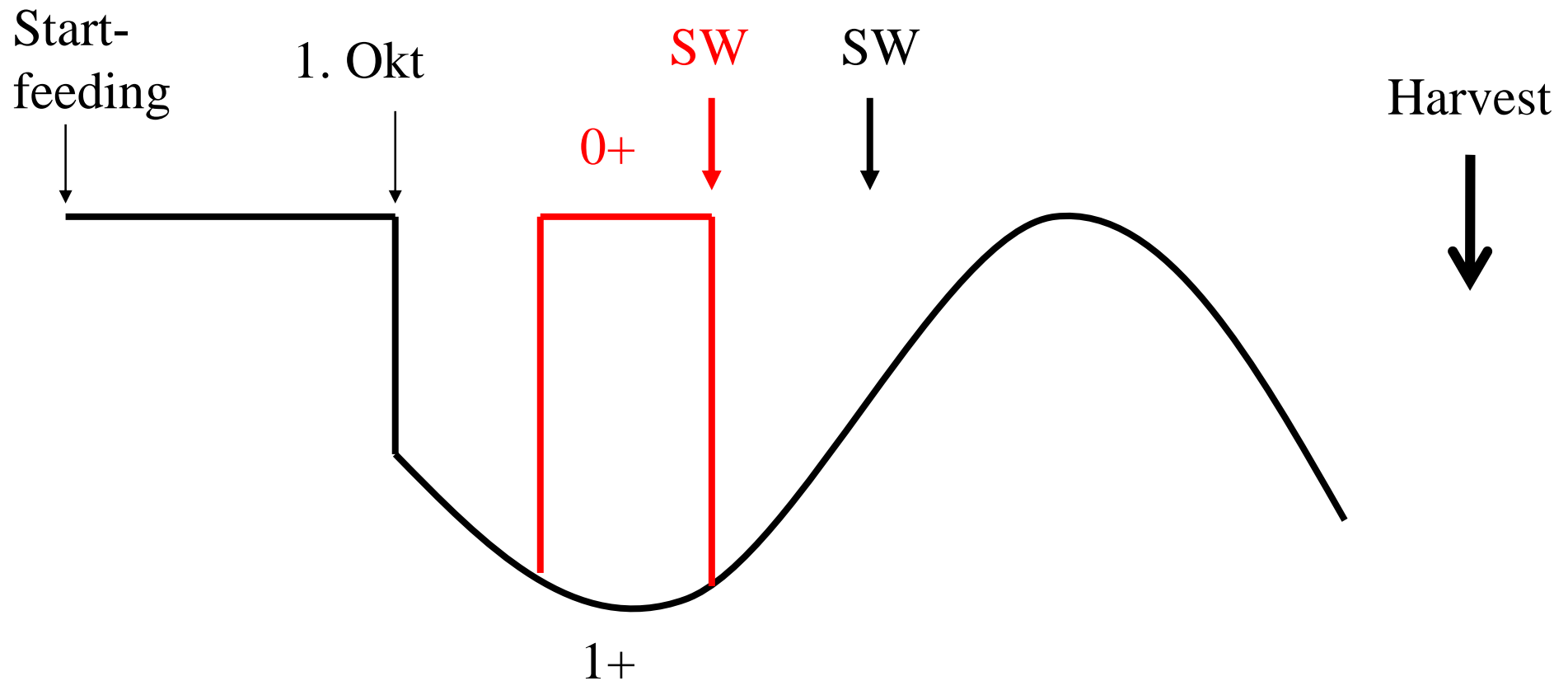


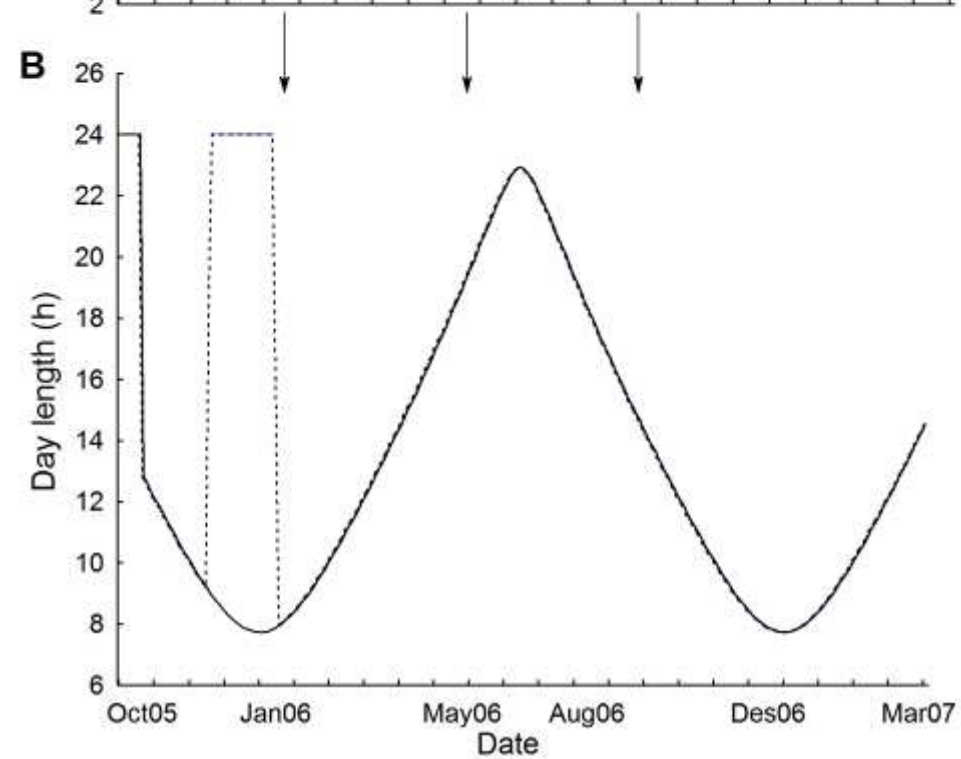
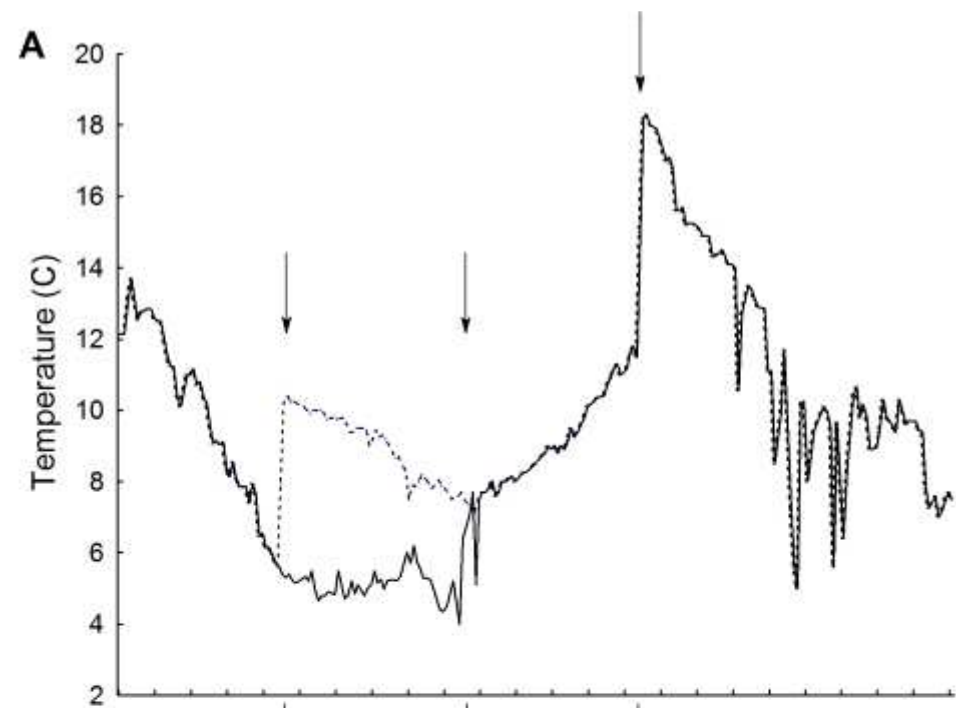
# Temperature



# Breeding

- Wild (Lærdal), farmed (Mowi) and wild-hybrid salmon reared in commune as 0+ and 1+ smolt and evaluated for vertebral deformities at harvest.

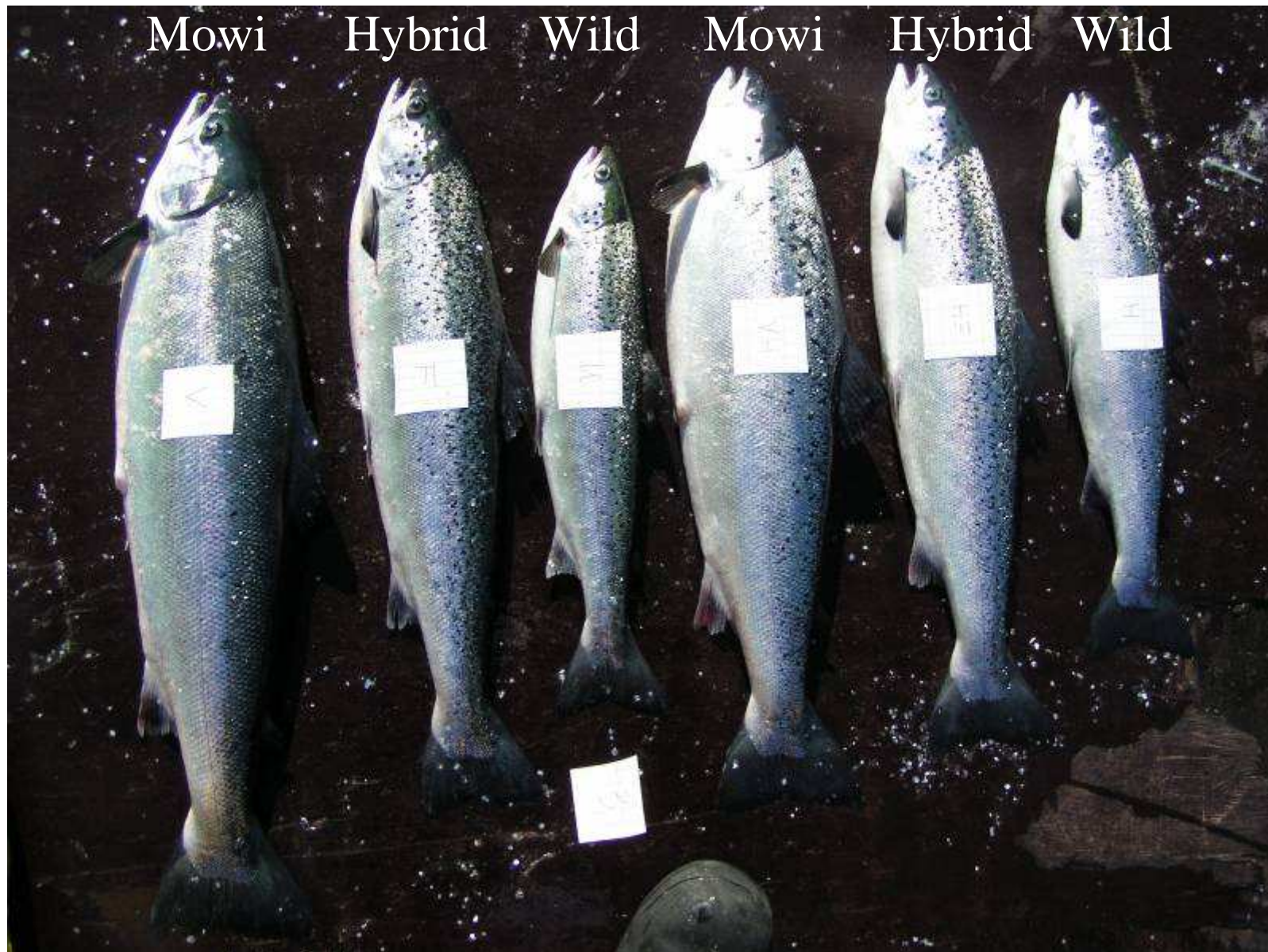


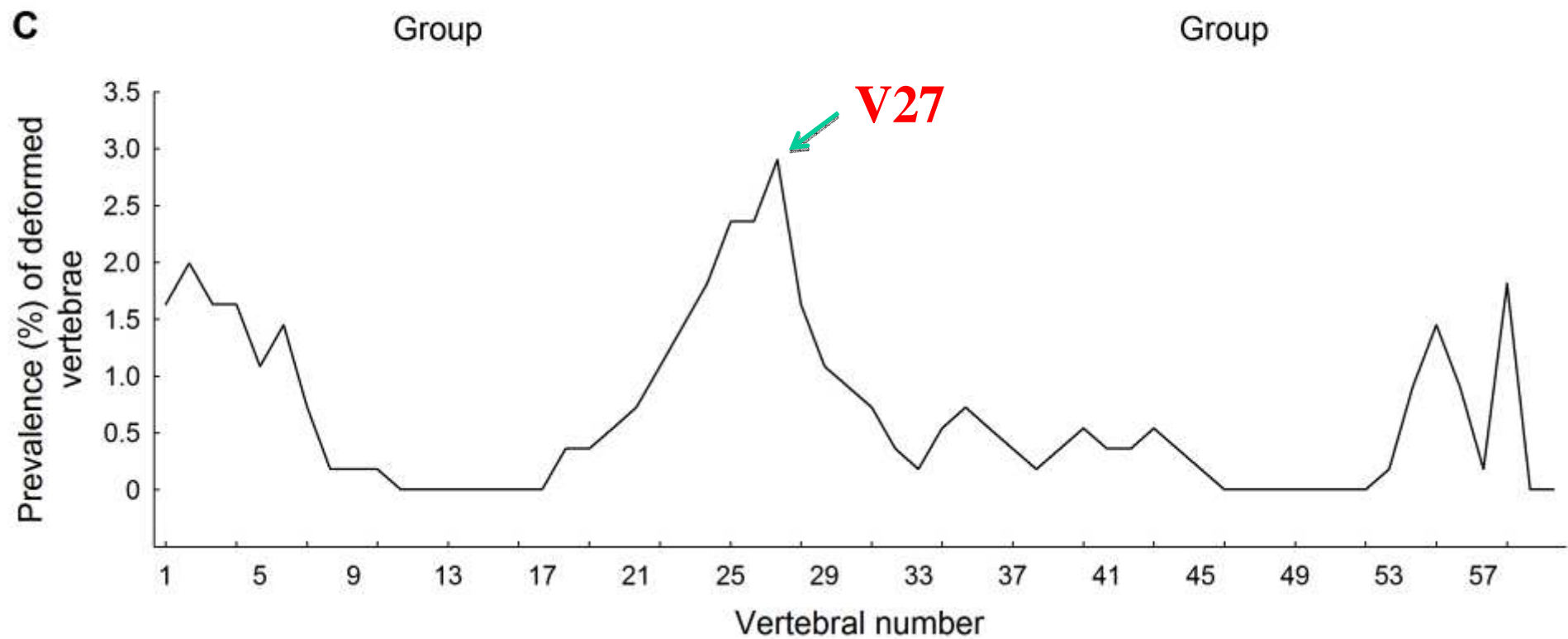
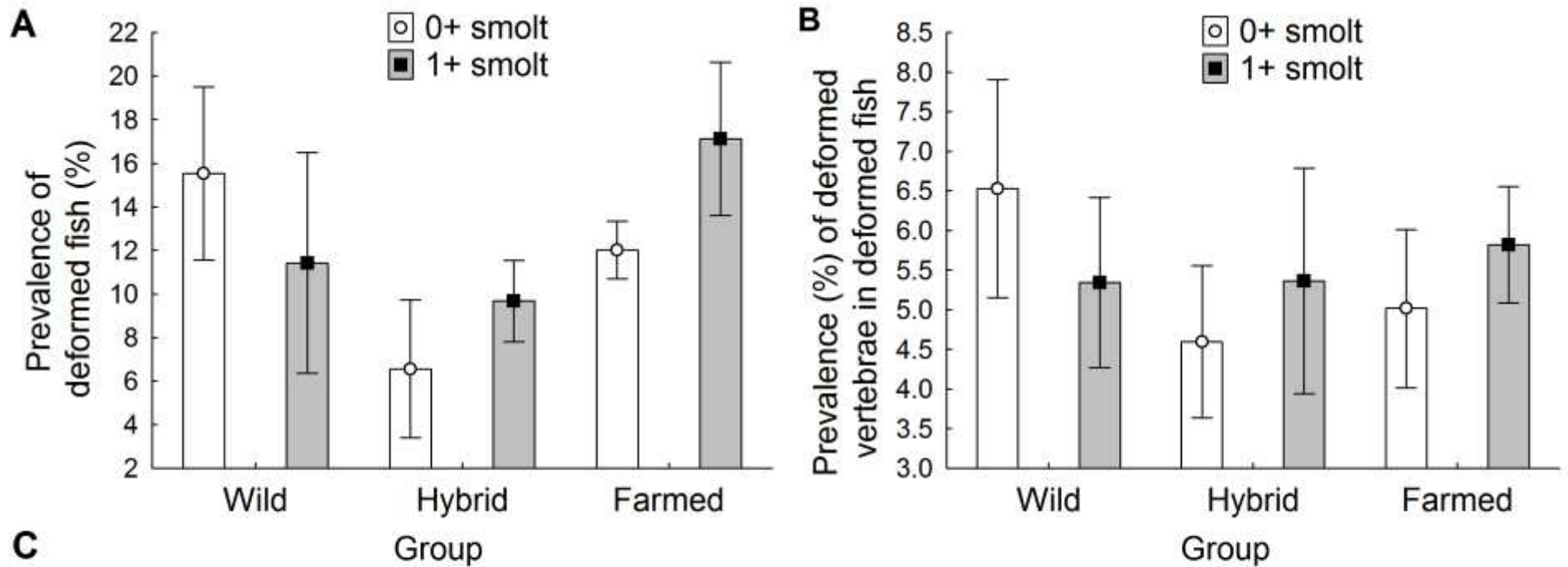


# Breeding

0+

1+

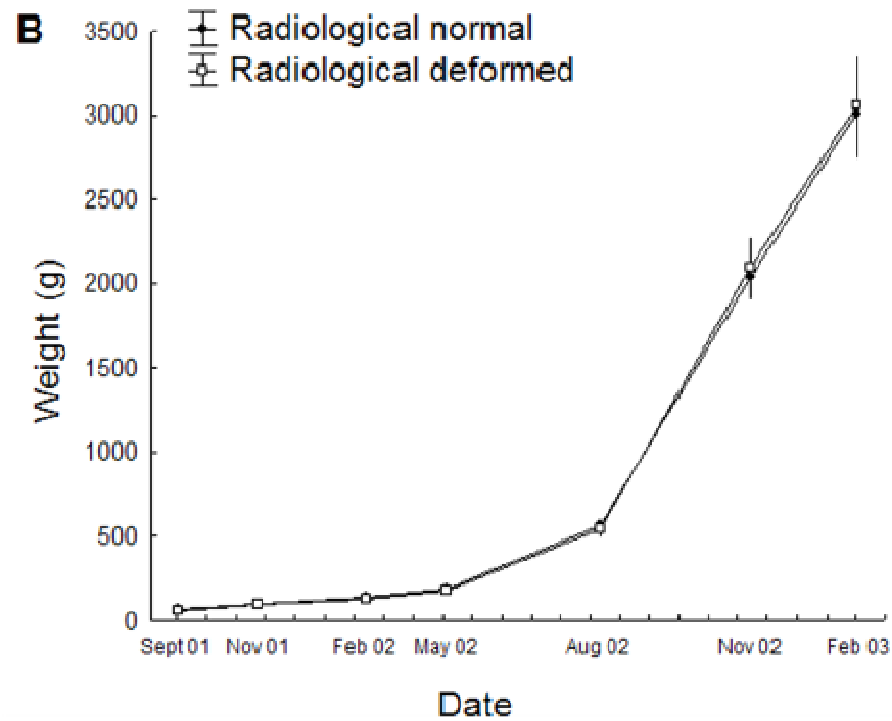
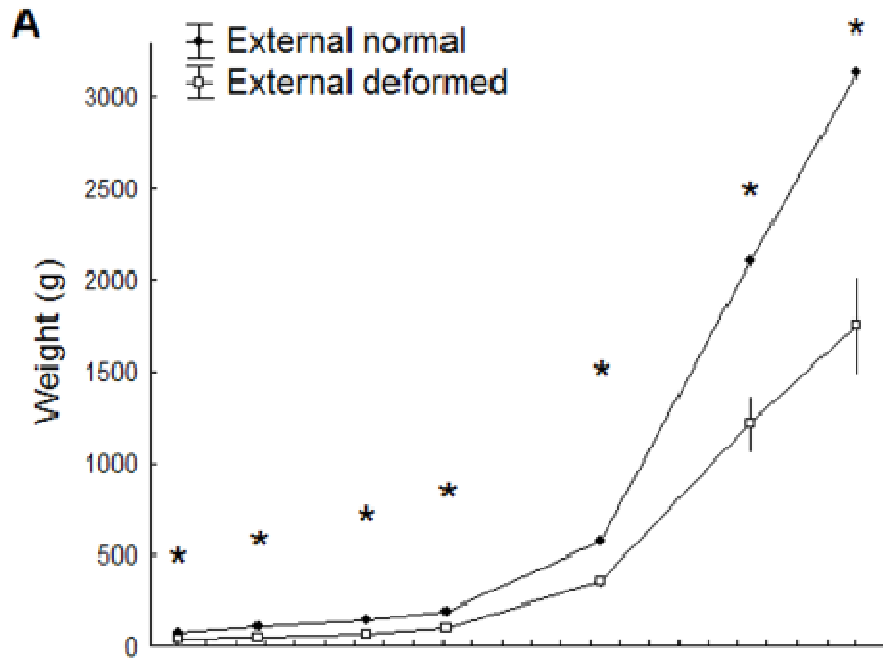


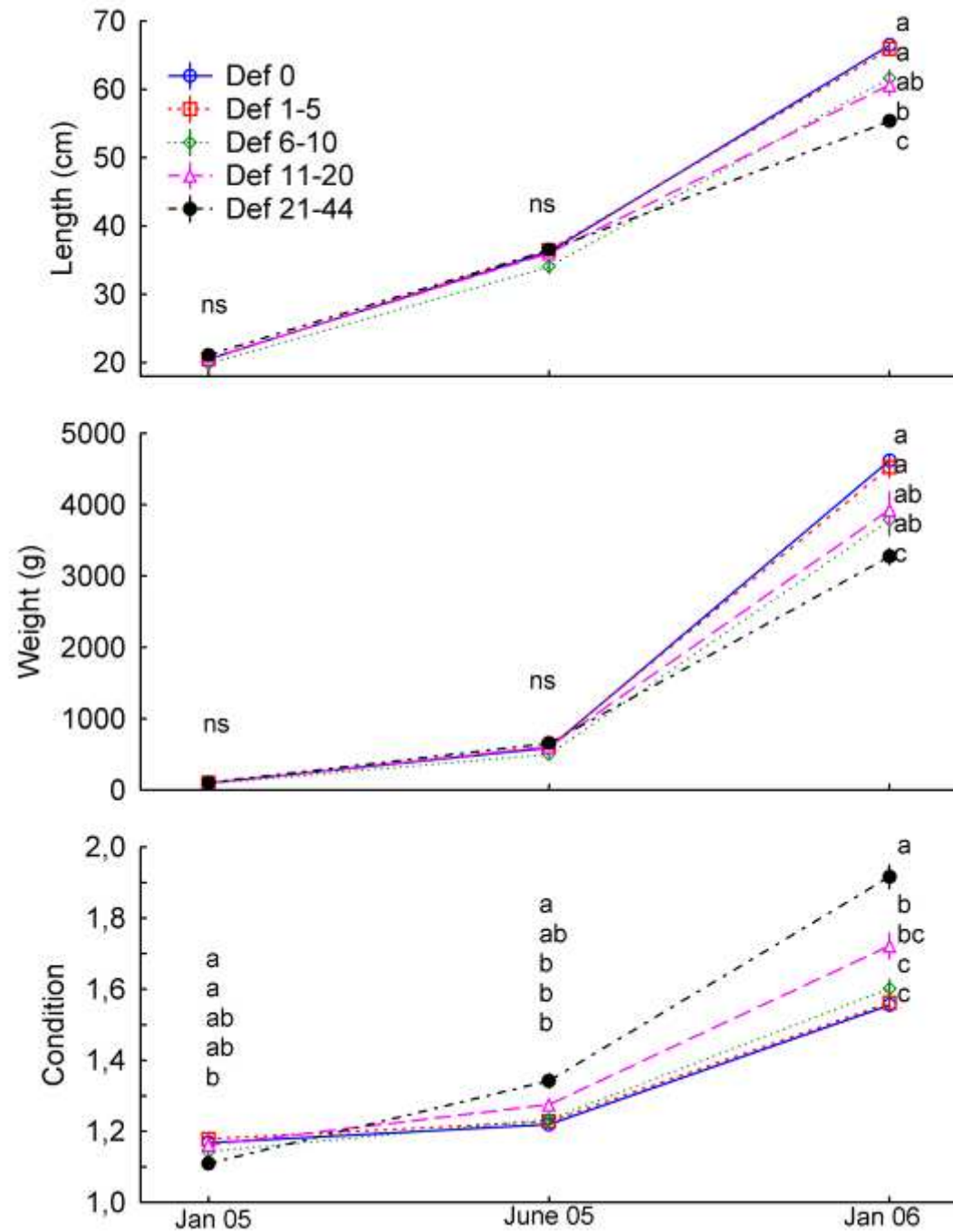


# Vertebral deformities – implications for fish welfare

- A shortened vertebral column will affect the musculature and most probably increase the energy demand for swimming.
- Can affect swimming skills and feed intake.
- Pain??
- Impact on growth?







# Conclusions

- Compression of caudal vertebrae in both field and experimental studies.
- Deformities around V27 develops in FW, while those around V43 develops in SW.
- Diet composition (P) and temperature important during the early SW phase.
- Temperature more powerful effect than vaccination.
- No effect of breeding under "nice" environmental conditions.
- Impaired growth in fish with more than 10 deformed vertebrae.