



## The immune system of cod

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**Cod farming in Nordic countries**

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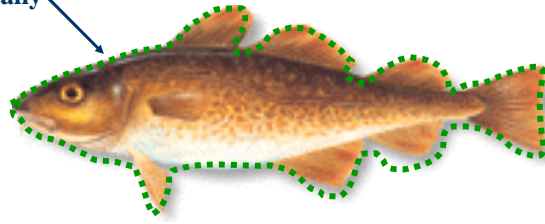
## Or - how cod fights infections

- **Cellular parameters – the lymphoid system**
  - Leukocytes – macrophages/phagocytes
- **Humoral parameters – secreted immune factors in serum, mucus and other body fluids**
  - Iron binding proteins (transferrin)
  - Anti-proteases
  - Enzymes - lysozyme
  - The complement system
    - alternative, classical, lectin and lytic pathways
  - Lectins
    - C-type lectins & pentraxins
  - Natural and specific antibodies
  - Cytokines & chemokines
  - TLR1 – TLR9
  - Antimicrobial peptides



## Cod's defence against diseases

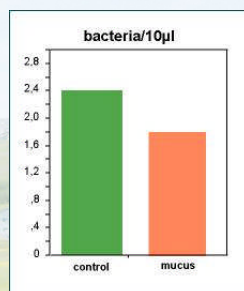
Physically strong and immunologically active mucus



## Cod mucus: Physical protection and immune parameters

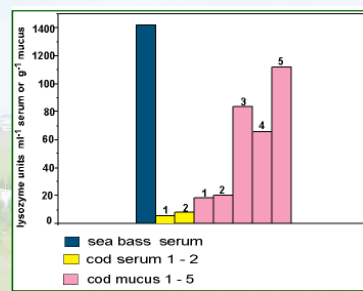


Example of sloughing

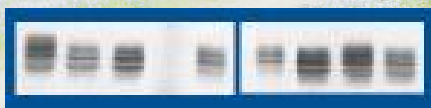


Antibacterial activity

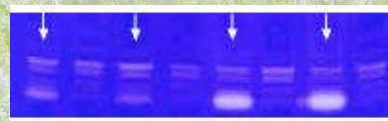
Bacteria: *Aeromonas salmonicida* ssp. *achromogenes*



Lysozyme activity



Pentraxins - lectins



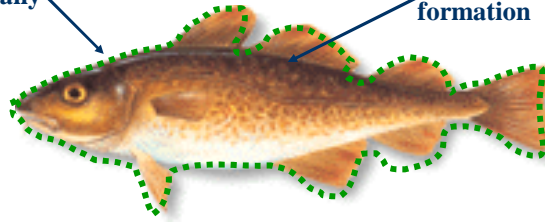
Gelatinase activity



## Cod's defence against diseases

Physically strong and immunologically active mucus

Active phagocytes and characteristic granuloma formation



## Cellular defence Granuloma formation

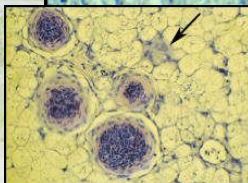
Phagocytic activity appears early in ontogeny ( $\leq 4$  dph)

Phagocytic activity is relatively high in cod and shows fast response to stimulation\*

\*Nikoskelainen et al. 2006

the bacteria with a thin congregation of fibroblast cells on the periphery

•Granuloma formations are seen within 3 weeks of experimental infection



Magnadóttir et al. 2006 (Asa)

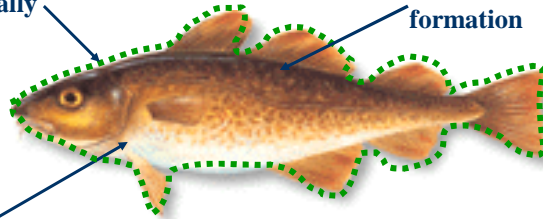
Guðmundsdóttir et al. 2006 (*Moritella viscosa*)



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Active phagocytes and characteristic granuloma formation

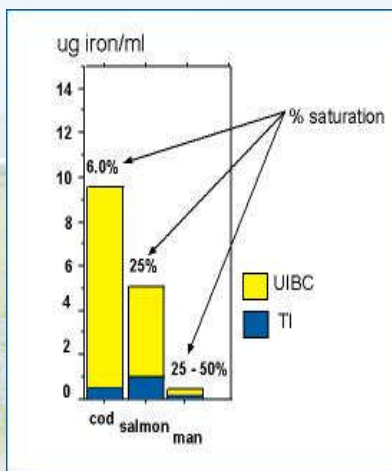


High level of humoral\*\*\* innate parameters, unusual characteristics and great individual variations

\*\*\*in blood and other body fluids



## Iron binding capacity

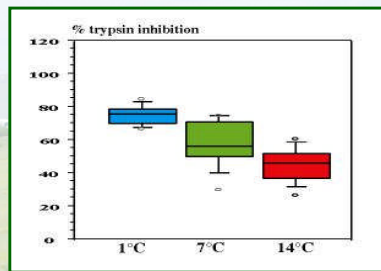


- Iron binding (transferrin) blocks bacterial growth
- In cod:
  - Unusually high iron binding capacity and unsaturated iron binding
  - Reduced IBC was seen in cod at high environmental temperature, age was not an influential factor
  - *The influence of immunization or infection – not yet known*



## Anti-proteases

$\alpha$ 2 macroglobulin,  $\alpha$ 1 antitrypsin

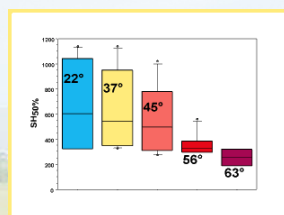


- Delay or inhibit pathogens that attack by enzyme secretion
- In cod:
  - High level of activity, not greatly affected by age, immunisation or infection but affected by environmental temperature

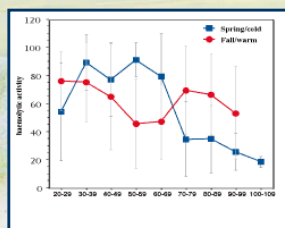
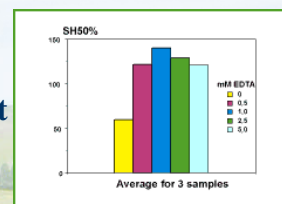


## Haemolytic activity

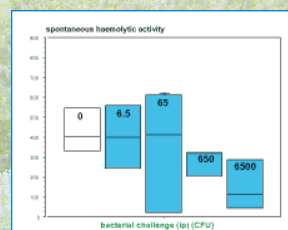
(the complement system – alternative pathway)



- Unusual heat tolerance
- Unusual enhancement by EDTA

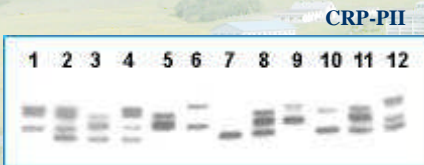
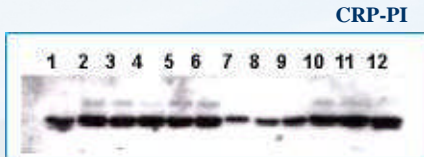


- Great individual variation
- Affected (reduced) by infection





## Lectins – the pentraxins CRP & SAP



The individual pattern is characteristic and does not change with age, immunisation, infection or acute phase response

- Pentraxins are pattern recognition proteins that recognise pathogens and activate other defence pathways and are typical acute phase proteins in mammals and some fish

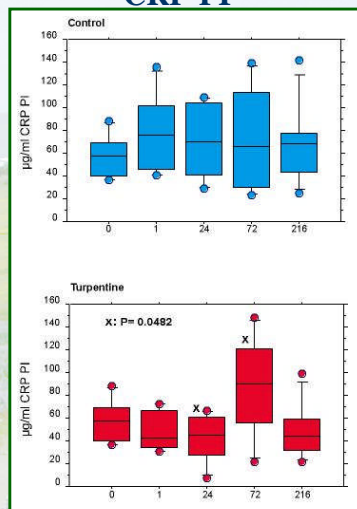
- In cod:

- Two types of pentraxins, CRP-PI & CRP-II
- High concentration in serum of both types
- CRP-II shows great individual heterogeneity

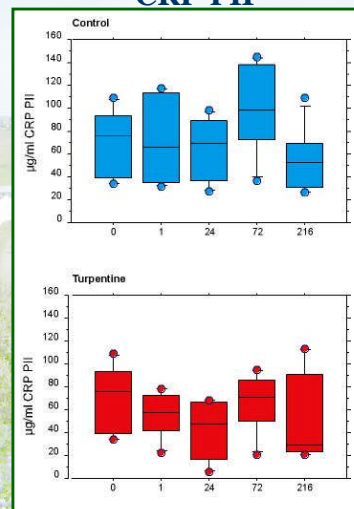


## Pentraxins and acute phase response

CRP-PI



CRP-II

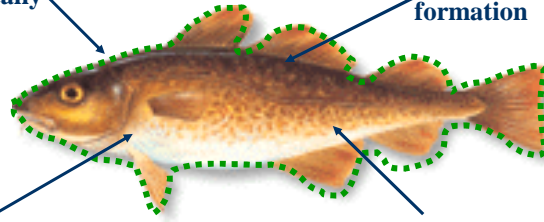




## Cod's defence against diseases

Physically strong and immunologically active mucus

Active phagocytes and characteristic granuloma formation



High level of humoral innate parameters, unusual characteristics and great individual variations

High level of natural antibodies with relatively strong affinity



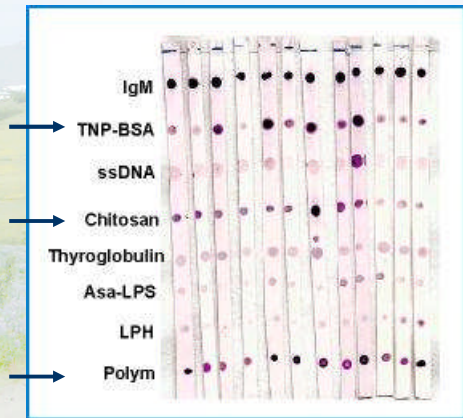
## The antibody response of cod

- Cod is known as a poor or non-responder in terms of specific antibody production
- Several immunisation and challenge experiments in the past have supported this view
- The results can vary depending on
  - antigen/bacteria
  - adjuvant
  - route of immunisation/infection
  - general protocol & temperature
  - cod's age at immunisation
  - individual genetic makeup



## Natural antibodies

Antibodies present in serum without immunostimulation  
Show characteristic activity against haptened proteins  
like TNP-BSA



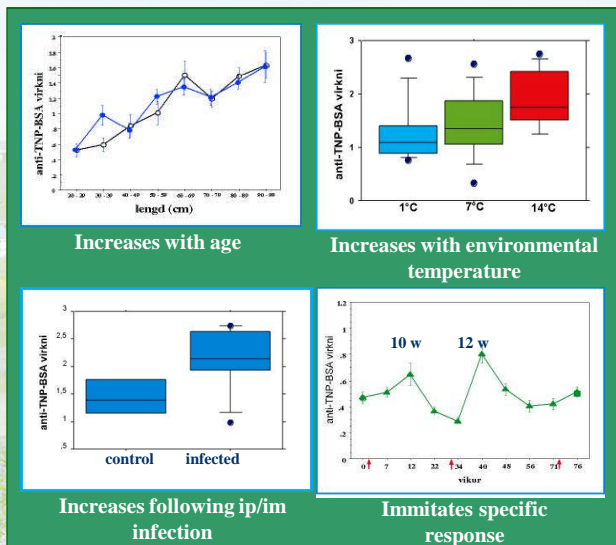
- 12 cod sera tested in dot blot with 7 antigens (IgM +ve control)
- Overall strong reaction with
  - TNP-BSA
  - Chitosan
  - Polymannuronic acid



## The natural antibody activity of cod

• Natural antibody activity increases with age, temperature and infection

• Natural antibody response immitates specific response





## Conclusions

- Cellular defence and granuloma formation is probably the main line of defence in cod
- High level of humoral innate parameters and natural antibodies is also important
- Individual variations strengthen the defence of the species as a whole - but make determination of the immunological status difficult
- *More work is required to study and try and enhance specific antibody response and hence possibly improve prophylactic measures by vaccination*



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**Thank you for your attention!**

