

Allergic Sensitization to Salmon Among Occupationally Exposed Salmon Processing Workers

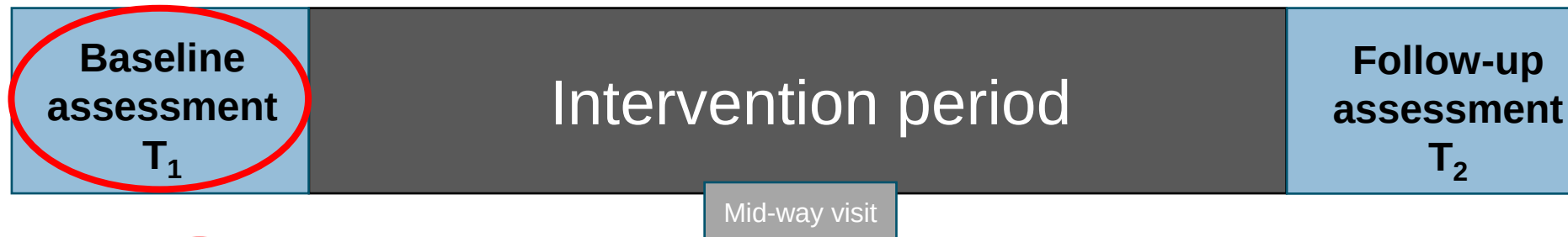
Inga Elda

Department of Occupational and Environmental Medicine,
University Hospital of North Norway, Tromsø





Study timeline (one year)



Exposure assessment



Personal (and stationary) measurements

Health assessment



Health assessment:

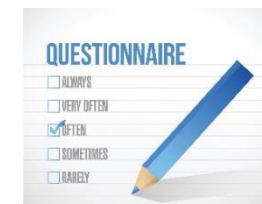
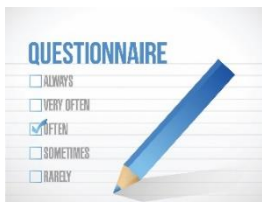
- Skin prick testing (SPT)
- Blood sampling (sIgE to salmon)
- Questionnaire on airway symptoms at work

Exposure assessment



Personal (and stationary) measurements

Health assessment



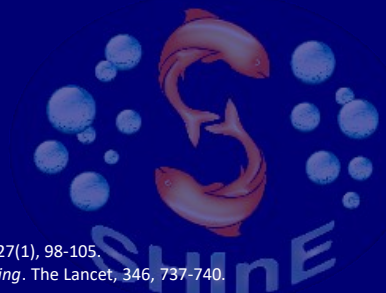
Background



Source: barentswatch.no/fiskehelse



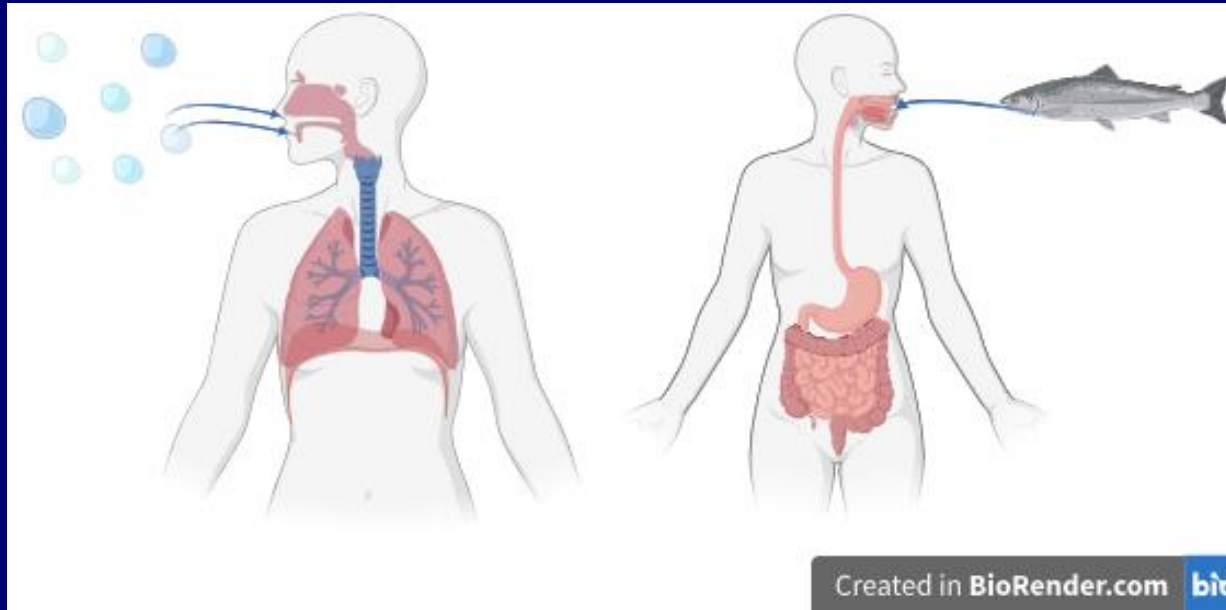
Source: own project photos



Exposure to allergens – occupational vs. food

Occupational exposure:

- Bioaerosols
- Respiratory
- Raw fish
- Different tissue



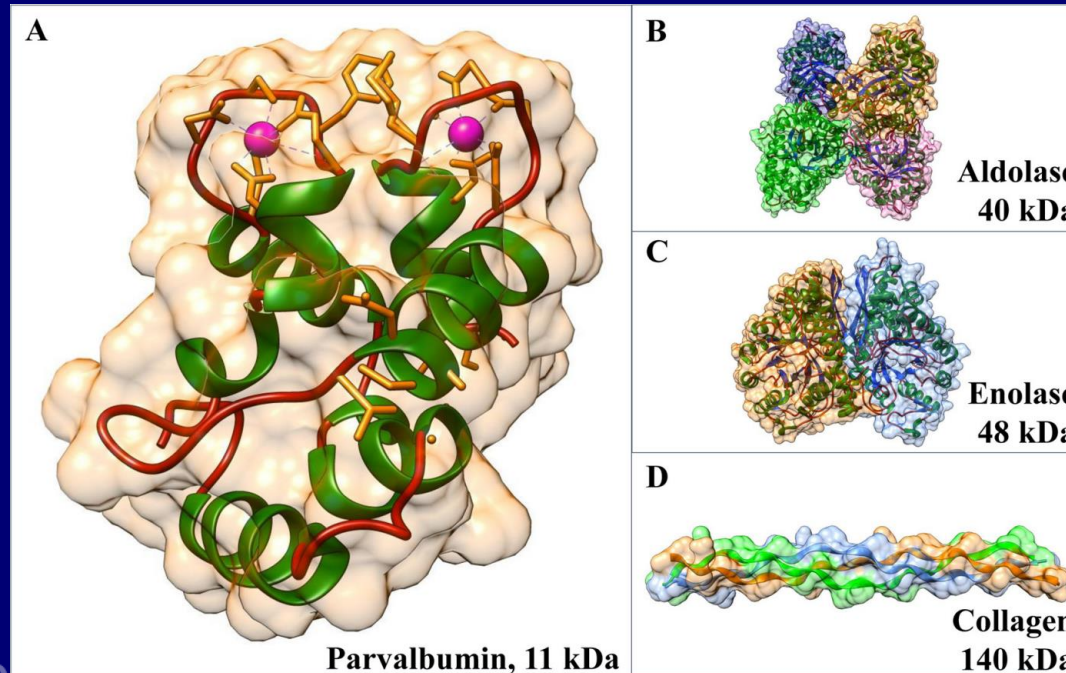
Food exposure:

- Gastrointestinal
- Processed fish (cooked, fried, canned, etc.)

Fish allergens from Atlantic salmon

Allergen	Molecular weight	Biological function	Remarks	Year identified
Aldolase	40 kDa	Enzyme in glycolysis	Thermolabile	2013 (Kuehn et al.) ¹
Collagen	> 100 kDa	Structural protein	Thermostable	2001 (Hamada et al.) ²
Enolase	47.3 kDa	Enzyme in glycolysis	Thermolabile	2013 (Kuehn et al.) ¹
Parvalbumin	12 kDa	Ca ²⁺ -binding	Thermostable, highly cross-reactive	1969 (Aas and Elsayed) ³

Adapted from Seafood Allergy: A Comprehensive Review of Fish and Shellfish Allergens, Ruethers et al. (2018).

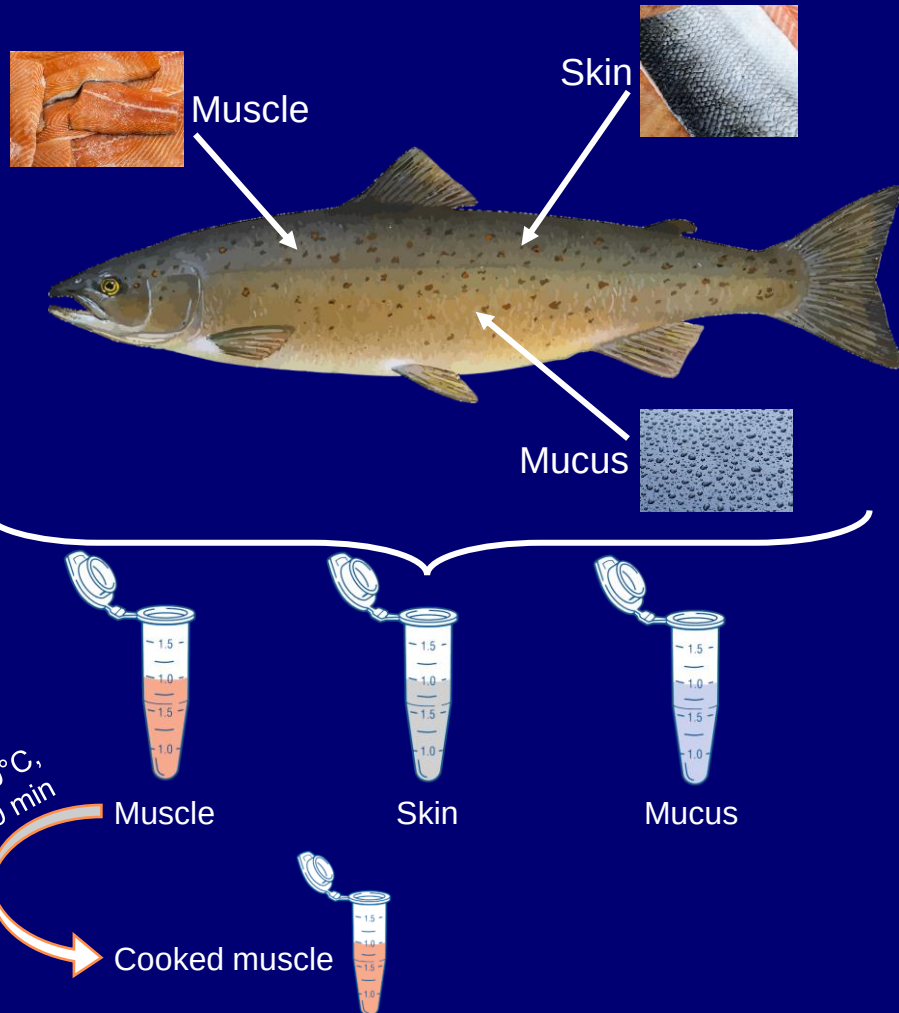


1: A Kuehn CH, C Lehnert-Weber, F Codreanu-Morel, M Morisset, C Metz-Favre, G Pauli, F de Blay, D Revets, C P Muller, L Vogel, S Vieths, F Hentges. Identification of enolases and aldolases as important fish allergens in cod, salmon and tuna: component resolved diagnosis using parvalbumin and the new allergens. *Clinical & Experimental Allergy*. 2013;43(7):811-22.
 2: Y Hamada YN, K Shiomi. Identification of collagen as a new fish allergen. *Bioscience, Biotechnology, and Biochemistry*. 2001;62(2):285-91.
 3: Aas K, Elsayed SM. Characterization of a major allergen (cod). Effect of enzymic hydrolysis on the allergenic activity. *J Allergy*. 1969;44(6):333-43.

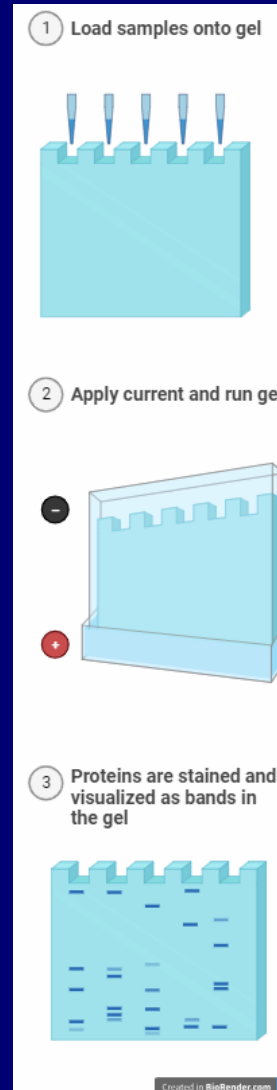


Methods – protein extraction from salmon tissue

Extraction from tissue



Separation and staining



Source: biorender.com

Western blot for detection of allergenic proteins



Methods – mass spectrometry (MS)

Protein extracts



Muscle



Skin



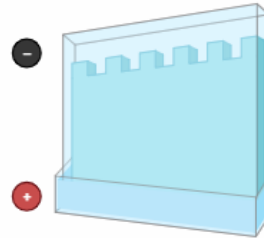
Mucus

Separation and staining

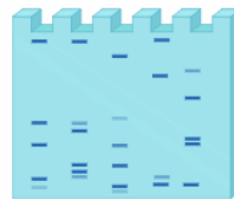
① Load samples onto gel



② Apply current and run gel

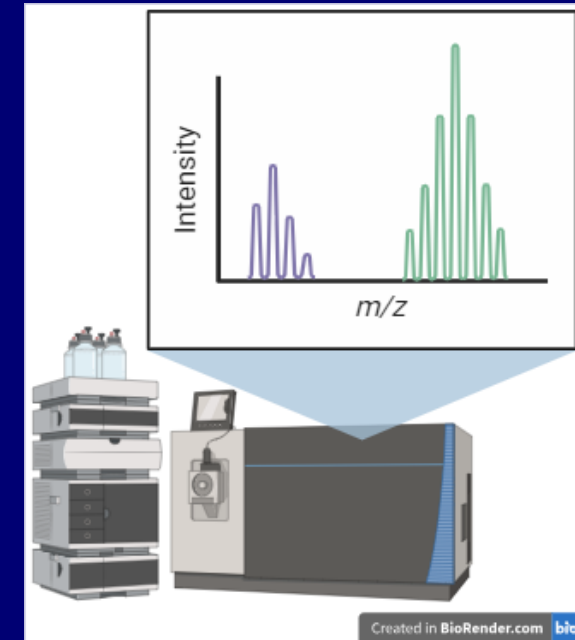


③ Proteins are stained and visualized as bands in the gel



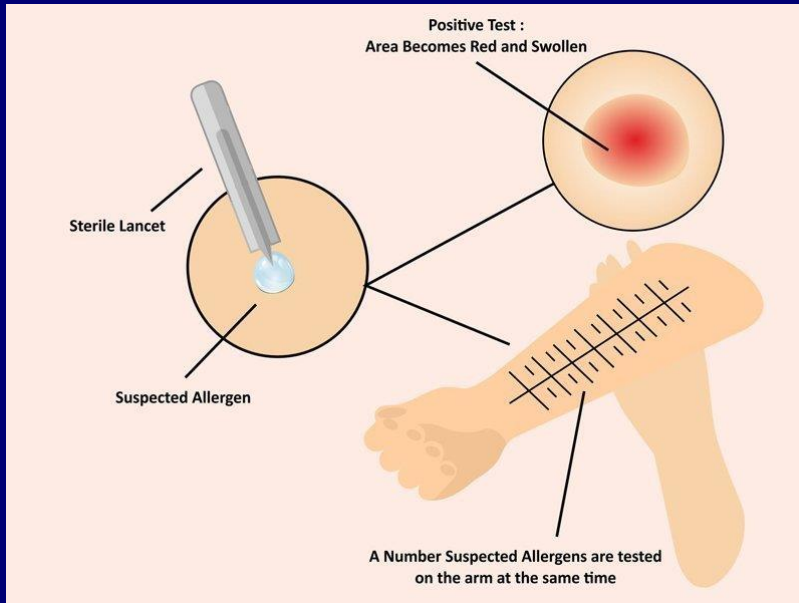
Source: biorender.com

Liquid chromatography-MS



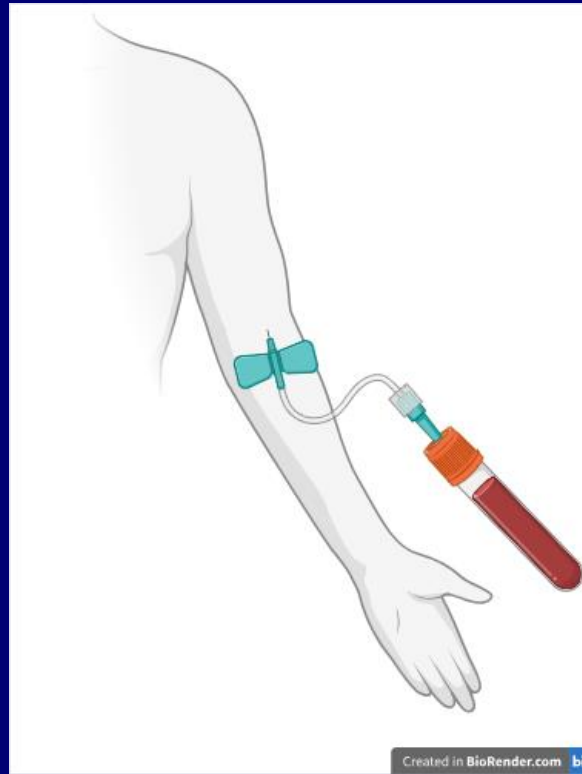
Methods – data from field work

Skin prick test



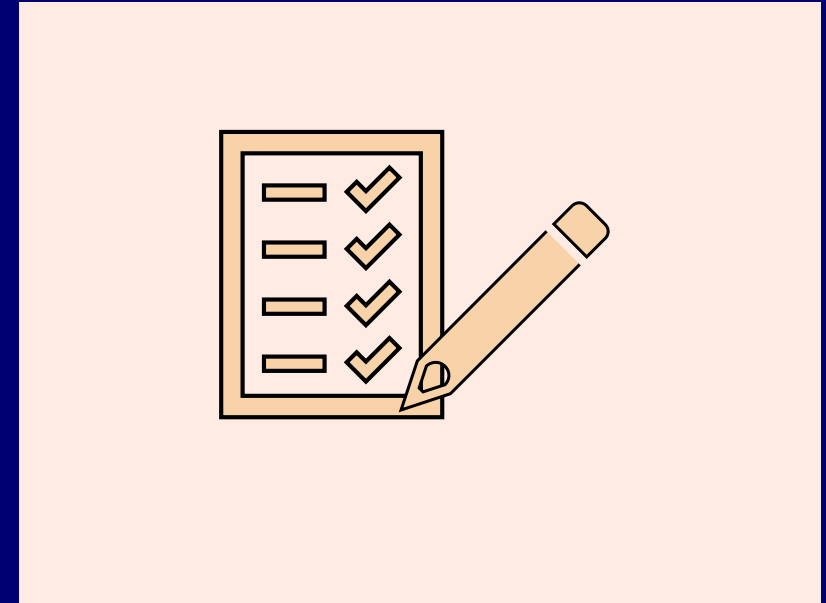
Source: The skin prick test. Adapted from Dr. Ankit Parakh, <https://www.ankitparakh.com/specialty-services/skin-prick-testing/>

Blood sample – sIgE to salmon



Source: biorender.com

Questionnaire – airway symptoms at work



Results – immunoblot

Muscle tissue extract

- All four allergenic proteins are present

Cooked muscle

- Aldolase and enolase degraded
- Parvalbumin and collagen are present

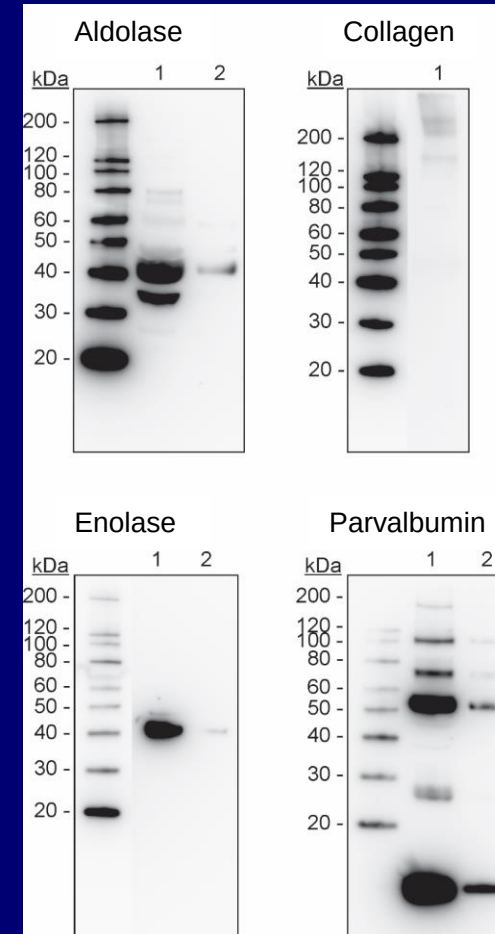
Mucus

- Aldolase, collagen, and enolase are present

Skin

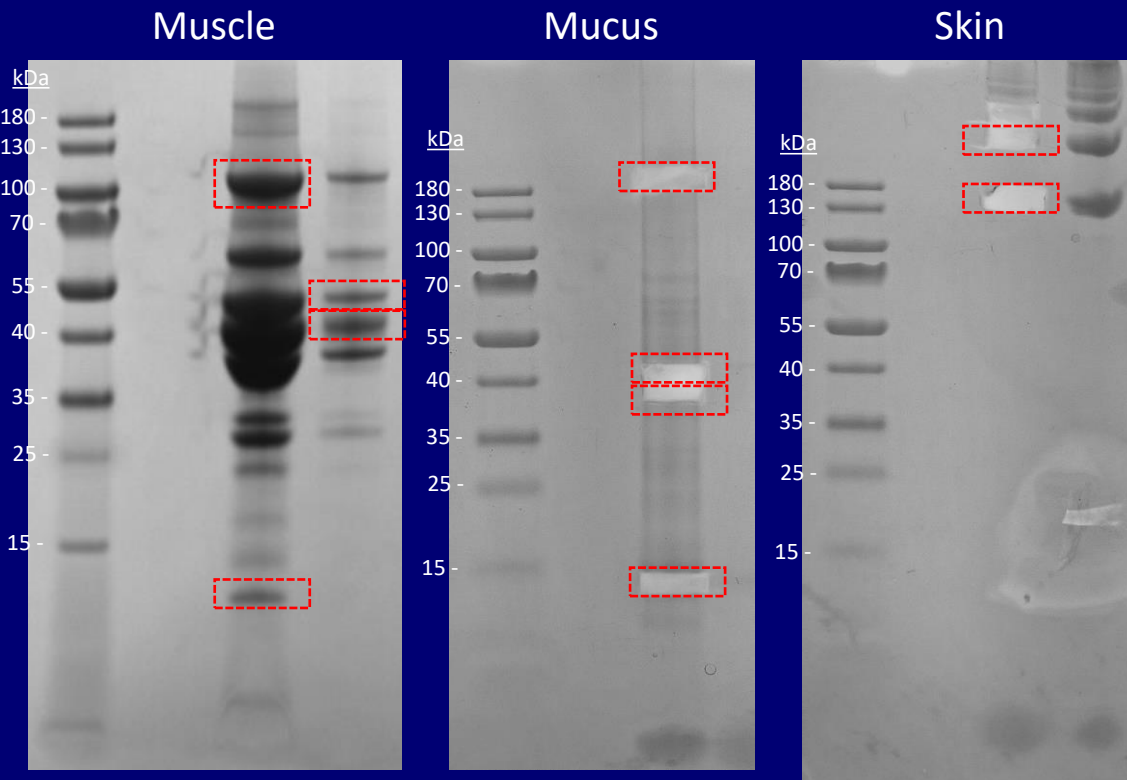
- Collagen is present

Example: muscle tissue



Lane 1: 1:10 dilution, lane 2: 1:100 dilution

Results – mass spectrometry

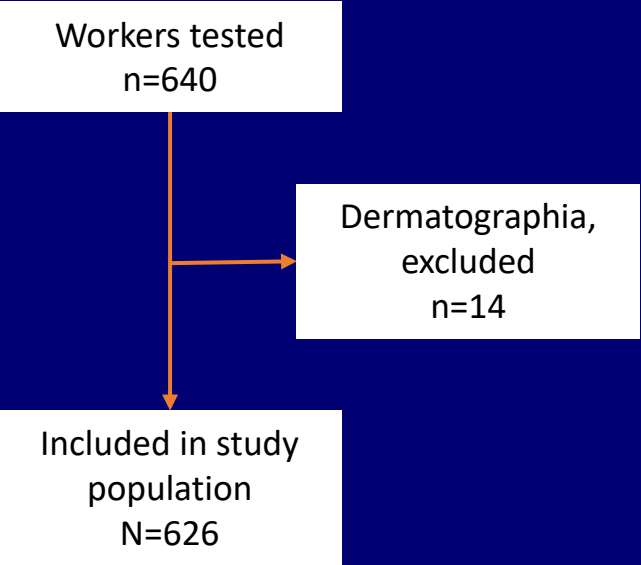


- All four allergenic proteins present in raw muscle tissue extract
- Parvalbumin was not identified in mucus
- Collagen identified in the skin extract

Allergenic proteins detected by mass spectrometry in protein extracts from Atlantic salmon

Tissue	Mw of SDS-PAGE band (kDa)	Identified protein(s)
Mucus	~180	Collagen
	~50	Enolase, aldolase, collagen
	~40	Aldolase, enolase, collagen
	~12	Collagen, enolase
Raw muscle	~110	Aldolase, enolase, collagen
	~50	Enolase, aldolase, parvalbumin
	~40	Aldolase, enolase, collagen
	~12	Parvalbumin, aldolase, enolase
Skin	>180	Collagen
	~180	Collagen

Results – skin prick test and sIgE to salmon



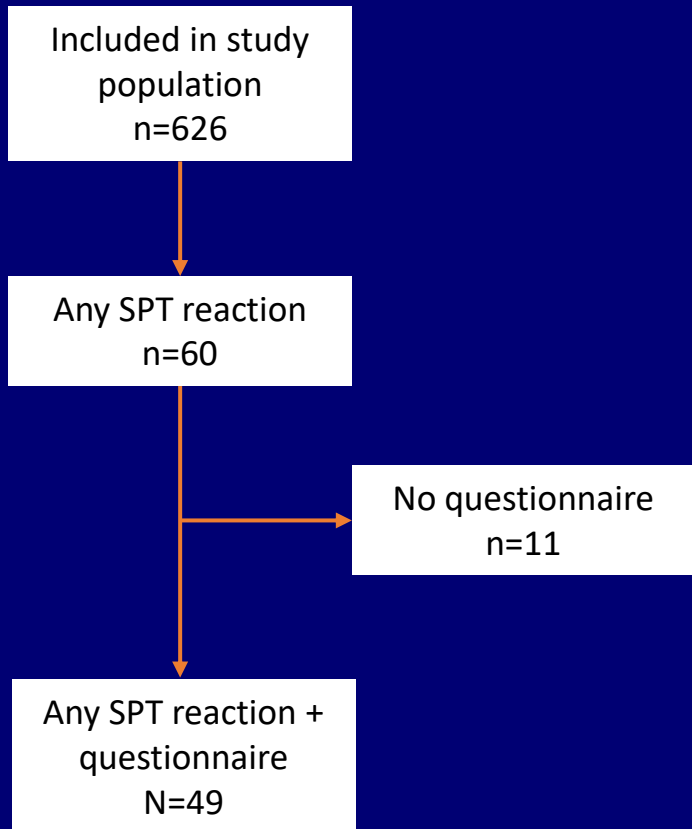
Extract	In-house					Commercial	
	Raw muscle	Cooked muscle	Mucus	Skin		Salmon	Cod
Allergens in extract	Aldolase Collagen Enolase Parvalbumin	Collagen Parvalbumin	Aldolase Collagen Enolase	Collagen		ND	Parvalbumin
Workers with SPT reaction (n)	Raw muscle	Cooked muscle	Mucus	Skin	Any	Salmon	Cod
Wheal ≥1.2-3mm	21	5	21	4		3	0
Wheal >3 mm	24	7	15	0		2	5
Total	45	12	36	4	60	5	5
sIgE ≥ 0.1 kU/L (%*)	9 (20)	6 (50)	10 (28)	3 (75)	11 (18)	4 (80)	2 (40)

ND: not detected, kU/L: kilounit per liter, *: percentage of total number with reaction to the extract

60 out of 626 (10%) had a reaction on at least one extract



Results – Questionnaire on airway symptoms at work



Symptoms among workers with SPT-reactions

Extract	In-house				Commercial	
	Raw muscle n=45	Cooked muscle n=12	Mucus n=36	Skin n=4	Salmon n=5	Cod n=5
Number of workers with symptoms (%)						
Coughing	18 (40)	3 (25)	12 (36)	1 (25)	2 (40)	1 (20)
Dyspnea	9 (20)	2 (17)	8 (22)	0 (0)	1 (20)	1 (20)
Wheezing	9 (20)	4 (33)	10 (28)	1 (25)	2 (40)	2 (40)

47% answered yes to at least one symptom at work

Take-home messages

- Occupational exposure to salmon is different than food exposure
 - Raw vs. Processed material
 - Airway vs. Gastrointestinal exposure
 - Different fish tissues
- Different fish tissues display different allergen combinations
- Combining knowledge on the presence of allergens in different fish tissues, with the knowledge of exposure in different parts of the processing line enables target-directed preventive measures



Thanks to all participating plants and staff



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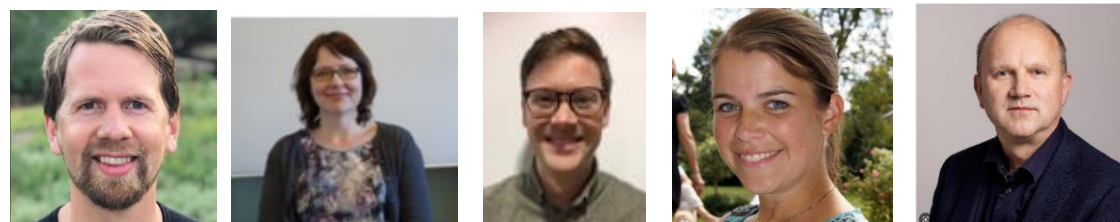


 **Haukeland University Hospital**

 **UNIVERSITY OF BERGEN**



 **ST. OLAVS HOSPITAL**
TRONDHEIM UNIVERSITY HOSPITAL



Co-authors: Berit Bang, Miriam Grgic, Gerd Sissel Andorsen, Christin Ørbeck Sørheim, Kaja Irgens-Hansen, Gro Tjalvin, Erlend Hassel, Hilde Brun Lauritzen