

Salmon; Foe or friend of human health ?

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What does the salmon contain ?

Present in salmon

- High quality protein
 - taurine
- High quality fat
 - omega-3 fatty acids
- Fat soluble vitamins
 - vitamin D, A and E
- Minerals

Not present / or present at low levels

- Antibiotics
- Mercury
- Iodine, selenium, vitamin B12

- Persistent organic pollutants
 - dioxin and dl-PCBs
 - brominated flame retardants
 - other fat soluble undesirebles



Challenges



Dioxin & dl-PCBs

TWI
14pg 05 WHO TEQ/kg body weight pr week.

Consequences



Max 1 meal à 150g pr week

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Research

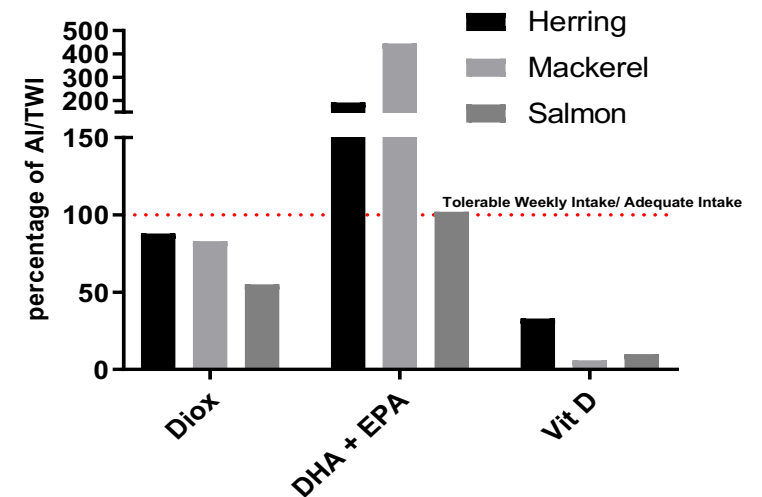
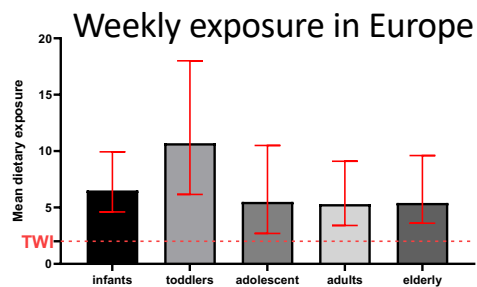
A Section 508-compliant HTML version of this article is available at <http://dx.doi.org/10.1289/EHP.25>.

A Longitudinal Study of Peripubertal Serum Organochlorine Concentrations and Semen Parameters in Young Men: The Russian Children's Study

Lidia Minguéz-Alarcón,¹ Oleg Sergejev,^{2,3} Jane S. Burns,¹ Paige L. Williams,^{4,5} Mary M. Lee,⁶ Susan A. Korrick,^{1,7} Luidmila Smigulina,³ Boris Revich,⁸ and Russ Hauser^{1,5}

¹Department of Environmental Health, Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA; ²Department of Genomics and Human Genetics Vavilov Institute of General Genetics, Russian Academy of Sciences, Moscow, Russia; ³Chapaevsk Medical Association, Chapaevsk, Samara Region, Russia; ⁴Department of Biostatistics, and ⁵Department of Epidemiology, Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA; ⁶Pediatric Endocrine Division, Departments of Pediatrics and Cell & Developmental Biology, University of Massachusetts Medical School, Worcester, Massachusetts, USA; ⁷Channing Division of Network Medicine, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, Massachusetts, USA; ⁸Institute for Forecasting, Russian Academy of Sciences, Moscow, Russia

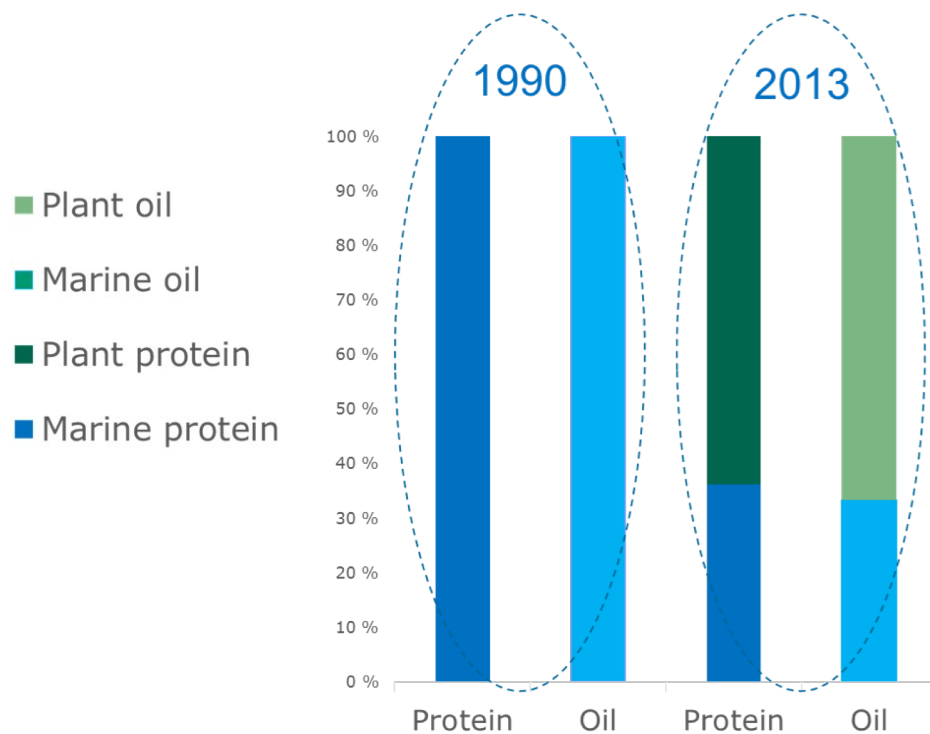
New risk-benefit analyses are required



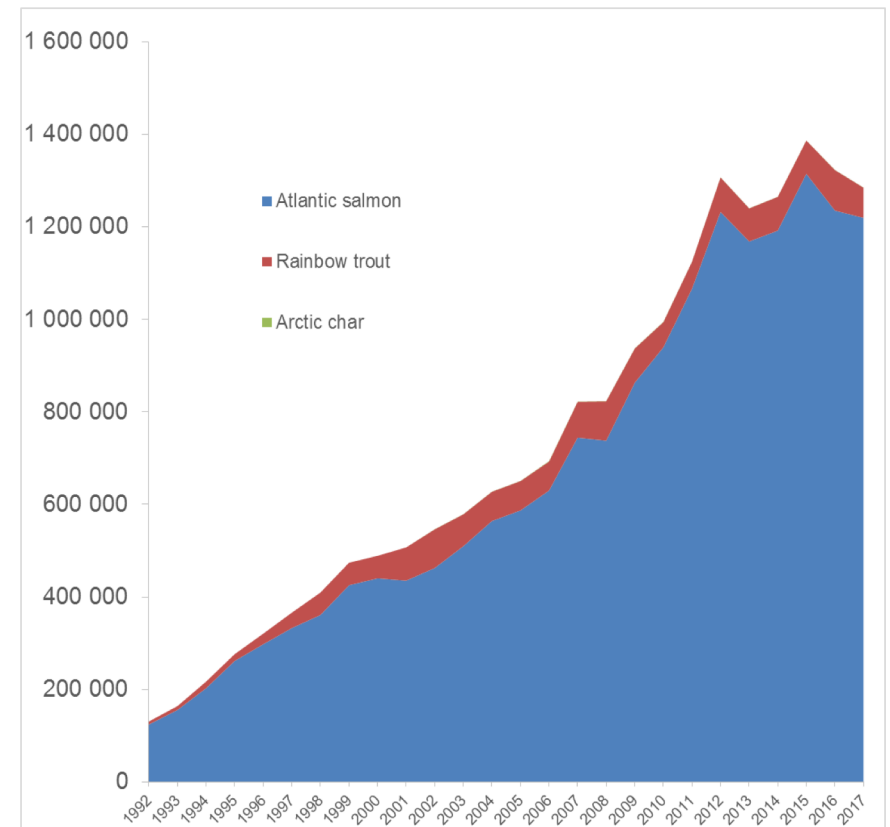
Why lower levels of dioxin and dl-PCBs in salmon ?



Increased use of plant ingredients in salmon feed to meet increased production



Production of salmonids in Norwegian aquaculture in the period from 1992 to 2017 (tonnes).

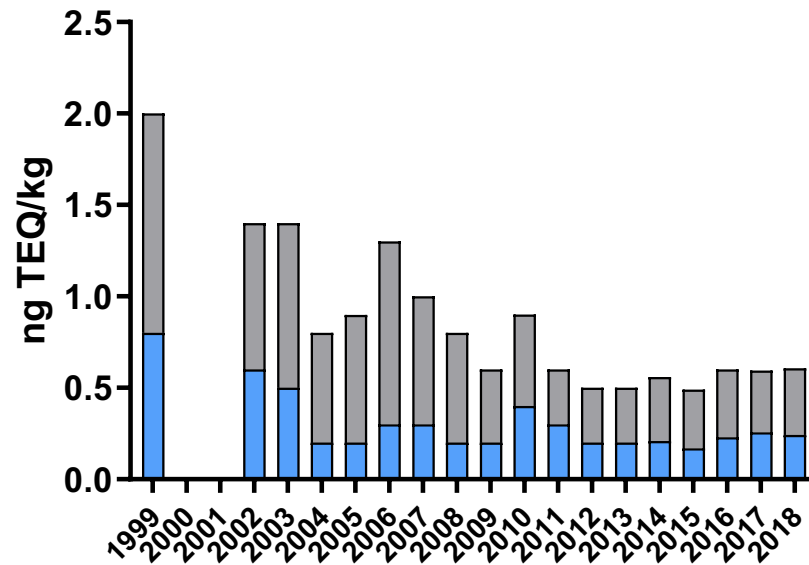


Decreasing levels of dioxin and dl-PCB in farmed salmon

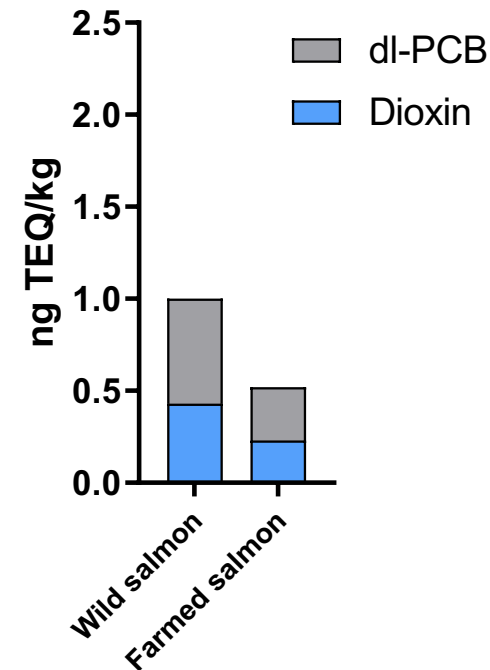


EU maximum limit; 6.5

Dioxin + dl-PCB



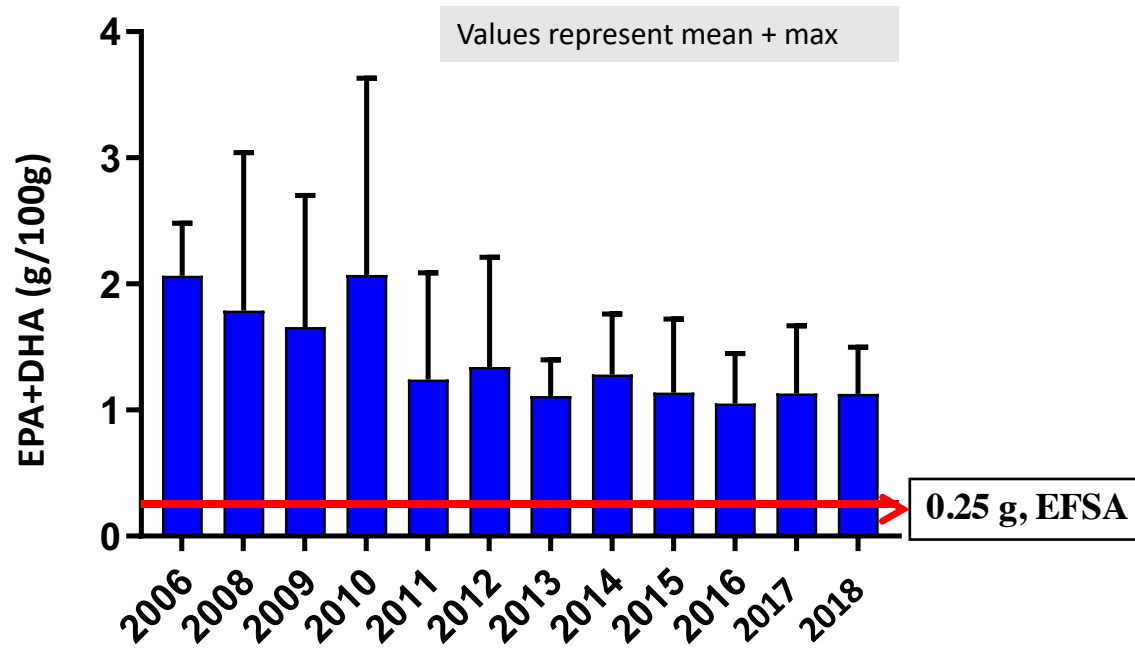
Dioxin and dl-PCB in 2012



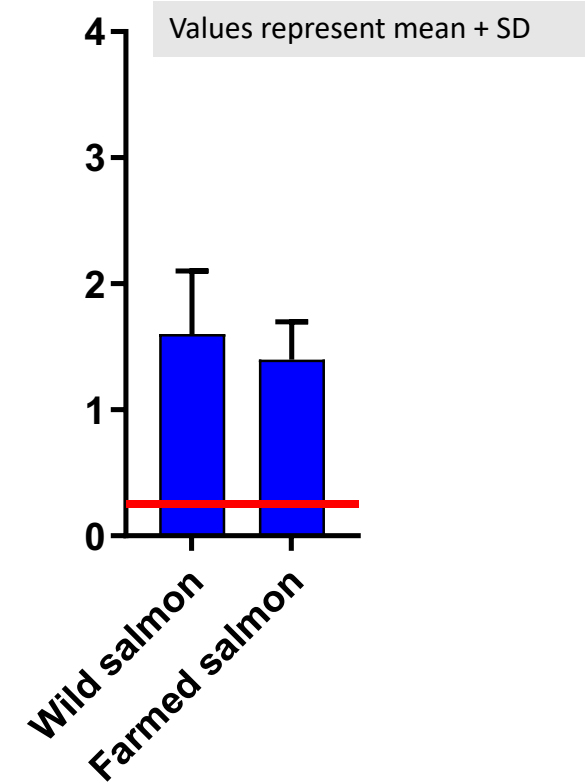
Decreasing levels of EPA and DHA in farmed salmon



EPA + DHA levels in farmed salmon



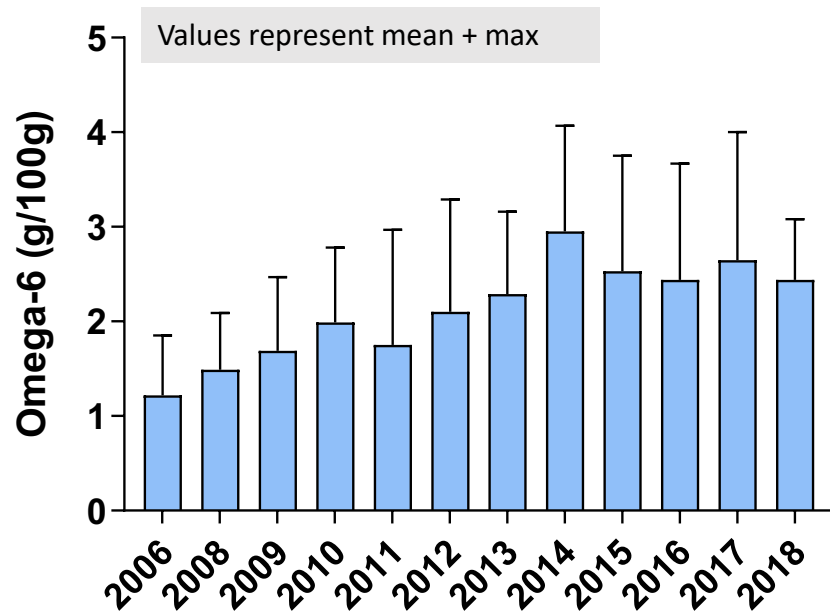
EPA + DHA levels in 2012



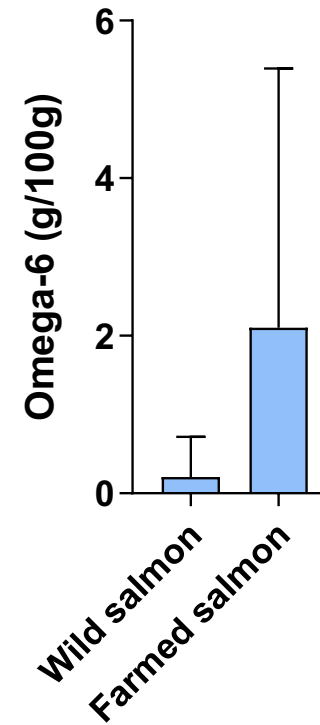
Increasing levels of omega-6 fatty acids in farmed salmon



Omega-6 levels in farmed salmon



Omega-6 levels in 2012



Investigating the spillover effect using mice

Exchanging 80 % of the fish oil in salmon feed



Rapeseed oil (RO)
Olive oil (OO)
Soybean oil (SO)



Fillets used in mice feed
50% exchange of protein



Mice fed for 12 weeks



WD-FO
WD-RO
WD-OO
WD-SO



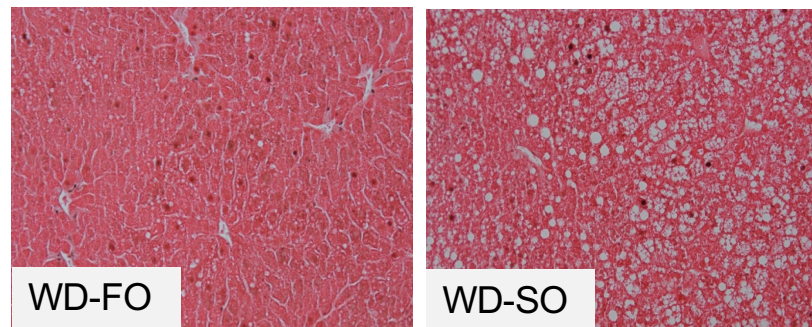
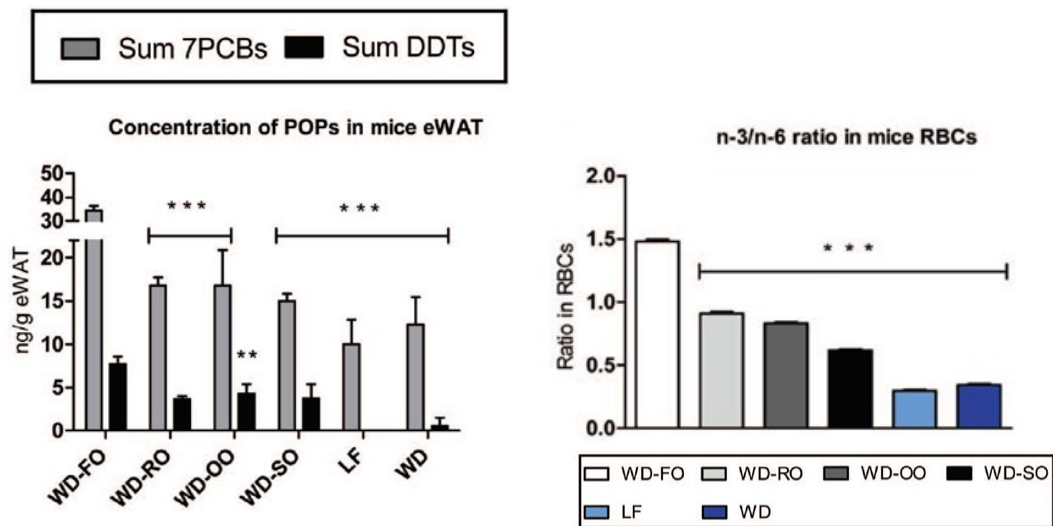


Investigating the spillover effect using mice

Midtbø et al. (2013) PLoS One. 8(1):e53094

Midtbø et al. (2015) J Nutr Biochem 26: 585-595

Mice receiving soyk oil fed salmon were insulin resistant and had fatty liver despite lower levels of POPs in adipose tissue



Fatty acid composition and levels of POPs in mice were determined by the type of oil used in the fish feed



The obesity/diabetes epidemic

THE AUSTRALIANS ARE COMING • BEIJING BACKLASH

Saken er produsert og finansiert av Universitetet i Bergen - [Les mer](#)

Oppdrettslaks knyttes til diabetes

Mus på en diett av oppdrettslaks fikk dobbelt så høy risiko for å bli overvektige og utvikle diabetes 2.

Universitetet i Bergen



Kim E. Andreassen

RÅDGIVER, KOMMUNIKASJON

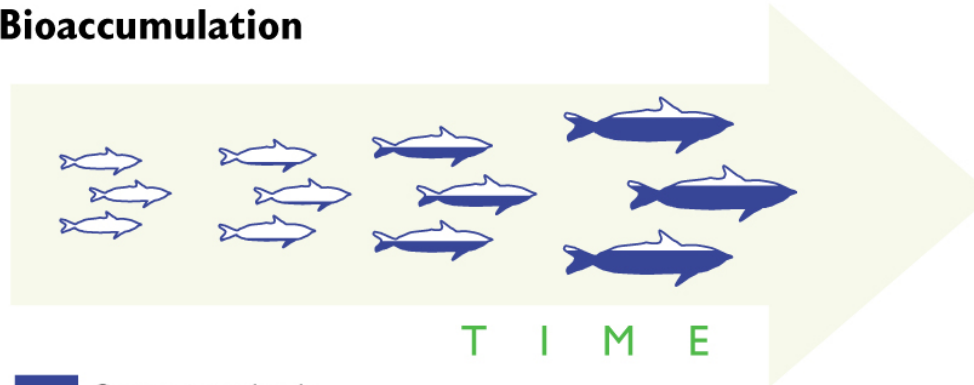
PUBLISHED November 15, 2011



Higher levels of persistent organic pollutants in obese and diabetic subjects



Bioaccumulation



Contaminant levels

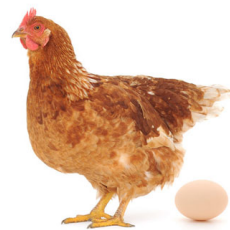


Contaminant levels

Biomagnification



POPs accumulate in adipose tissue and lipid rich particles in blood



Animal studies indicate that feeding on obesogenic diets leads to higher accumulation of POPs

Myrmel et al. (2016) J Nutr Biochem 27: 307-316

Diet and obesity/type 2 diabetes

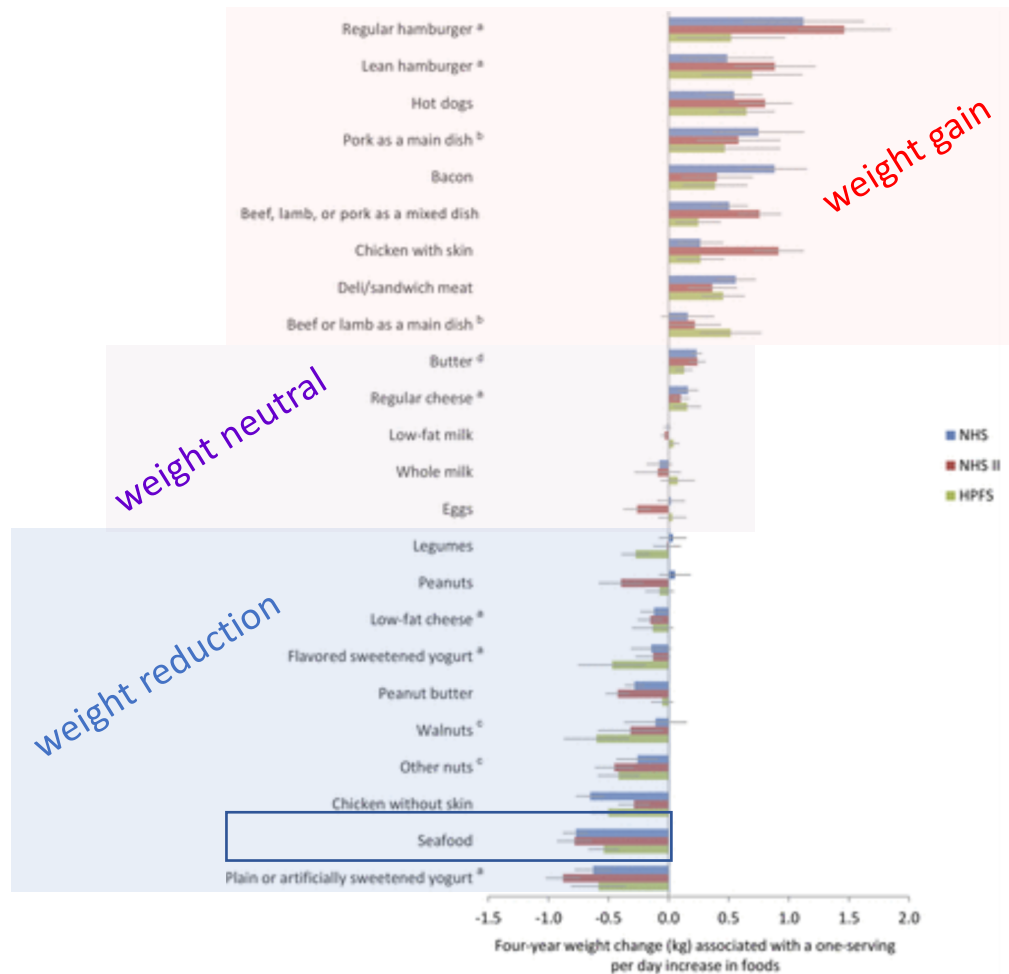
«High energy» food
Pommes frites
Red meat
Processed meat
Refined carbohydrates
Soda w/wo sugar



Vegetables
Beans and legumes
Fruit
Whole grain products
Fish and seafood



Increased seafood intake is associated with weight reduction



Changes in intake of protein foods, carbohydrate amount and quality, and long-term weight change: results from 3 prospective cohorts¹⁻⁴

Jessica D Smith, Tao Hou, David S Ludwig, Eric B Rimm, Walter Willett, Frank B Hu, and Dariush Mozaffarian


Nurses` Health study I; 46.994 females
 Nurses` Health study II; 47.928 females
 Health Professionals Follow up: 25.862 males
 Subset of 120.784 subjects

Followed for 4 years

Increased intake of seafood is associated with weight reduction

Seafood protects against obesity in animal trials

Western diets



Lamb, Entrecote
Pork, Chicken

Meat



Deer, Reindeer
Lagopus, Boar

Game



Egg, Milk, Cheese,
Cottage cheese

Egg/dairy



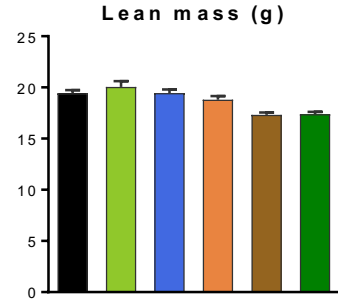
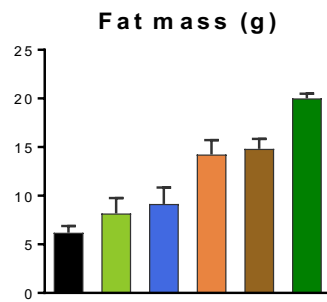
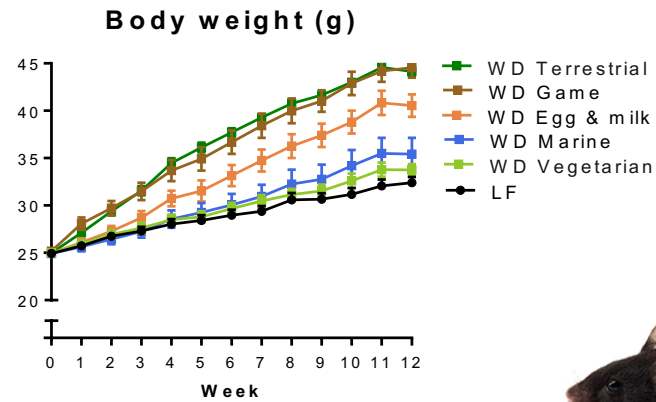
Mackerel, Cod,
Halibut, Scallop

Seafood



Chickpeas, Soy,
Wheat germ, Nuts

Vegetarian



Prospective studies; several (but not all) demonstrate that seafood may protect against development of type 2 diabetes

East-West; dietary habits ?

The prospective association between total and type of fish intake and type 2 diabetes in 8 European countries: EPIC-InterAct Study¹⁻³

Pinal S Patel, Nita G Forouhi, Anneleen Kuijsten, Matthias B Schulze, Geertruida J van Woudenberg, Eva Ardanaz, Pilar Amiano, Larraitz Arriola, Beverley Balkau, Aurelio Barricarte, Joline WJ Beulens, Heiner Boeing, Brian Buijsse, Francesca L Crowe, Blandine de Lauzon-Guillan, Guy Fagherazzi, Paul W Franks, Carlos Gonzalez, Sara Grioli, Jytte Halkjaer, José María Huerta, Timothy J Key, Tilman Kühn, Giovanna Masala, Peter Nilsson, Kim Overvad, Salvatore Panico, José Ramón Quiros, Olov Rolandsson, Carlotta Sacerdote, María-José Sánchez, Erik B Schmidt, Nadia Slimani, Annetieke MW Spijkerman, Birgit Teucher, Anne Tjønneland, María-José Tormo, Rosario Tumino, Daphne L van der A, Yvonne T van der Schouw, Stephen J Sharp, Claudia Langenberg, Edith JM Feskens, Elio Riboli, and Nicholas J Wareham for the InterAct Consortium

Patel et al (2012) Am J Clin Nutr Jun;95(6):1445-53.

EPIC-Interact study (Dk, Fr, De, It, NI, Es, Se, Uk)

No overall effect

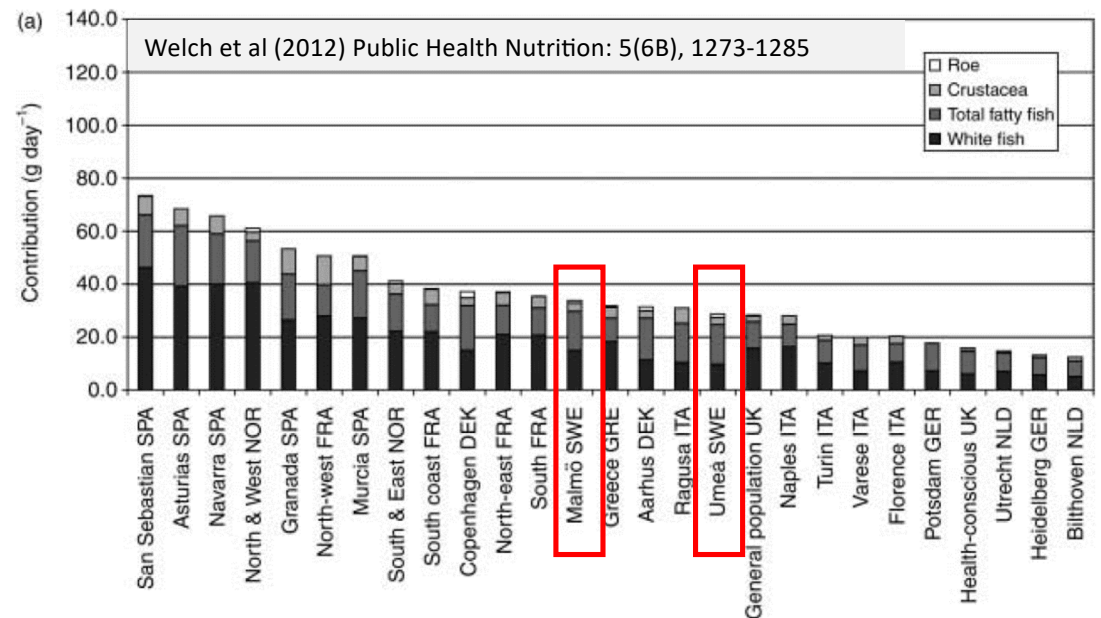
Wallin et al (2017) Eur J Nutrition 56: 843-852

ORIGINAL CONTRIBUTION

Fish consumption and frying of fish in relation to type 2 diabetes incidence: a prospective cohort study of Swedish men

Alice Wallin¹ · Daniela Di Giuseppe¹ · Nicola Orsini¹ · Agneta Åkesson¹ · Nita G. Forouhi² · Alicja Wolk¹

Europe –large differences (also in fish intake)



Swedish cohort: 35,583 men aged 45-79 years

No overall effect

Shellfish; higher risk
Fried fish; higher risk

Prospective studies: several (but not all) demonstrate that seafood may protect

Clinical Nutrition 37 (2018) 590–596



Contents lists available at ScienceDirect

Clinical Nutrition

journal homepage: <http://www.elsevier.com/locate/clnu>



Original article

Fish consumption in relation to myocardial infarction, stroke and mortality among women and men with type 2 diabetes: A prospective cohort study



Alice Wallin ^{a, *}, Nicola Orsini ^{a, 1}, Nita G. Forouhi ^b, Alicja Wolk ^a

^a Unit of Nutritional Epidemiology, Institute of Environmental Medicine, Karolinska Institutet, Box 210, 171 77 Stockholm, Sweden

^b Medical Research Council Epidemiology Unit, University of Cambridge School of Clinical Medicine, Box 285, Institute of Metabolic Science, Cambridge Biomedical Campus, Cambridge CB2 0QQ, United Kingdom

Conclusions: Fish consumption was associated with lower MI incidence among individuals with type 2 diabetes, whereas no association was observed with stroke. Our data further indicated an association with lower mortality, particularly for CHD-related deaths. These findings support the current general advice on regular fish consumption also in the high risk group of type 2 diabetes patients.

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East

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Pilar Am
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Daphne L
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Patel

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No

Prospective studies; several (but not all) demonstrate that seafood may protect against development of type 2 diabetes

Patel et al. Diabetes Care, (2009) 32, 1857

Epidemiology/Health Services Research
ORIGINAL ARTICLE

Association Between Type of Dietary Fish and Seafood Intake and the Risk of Incident Type 2 Diabetes

The European Prospective Investigation of Cancer (EPIC)-Norfolk cohort study

UK Cohort;
25,639 men and females, 40-79 years

Protective effect of both lean and fatty fish

Fried fish; no effect



Van Woudenberg et al. Diabetes care, (2009) 32, 2021

Epidemiology/Health Services Research
ORIGINAL ARTICLE

Eating Fish and Risk of Type 2 Diabetes

A population-based, prospective follow-up study

Dutch cohort;
4,472 men and females, > 55 years

High total fish intake; higher risk
High lean fish intake; higher risk

Fatty fish; no effect



High intake in this cohort:
Lean fish > 23g/day
Fatty fish > 10g/day

Consumption of lean fish reduces the risk of type 2 diabetes; A prospective population based cohort study of Norwegian women

Rylander et al. (2014) PLoS ONE 9(2): e89845.

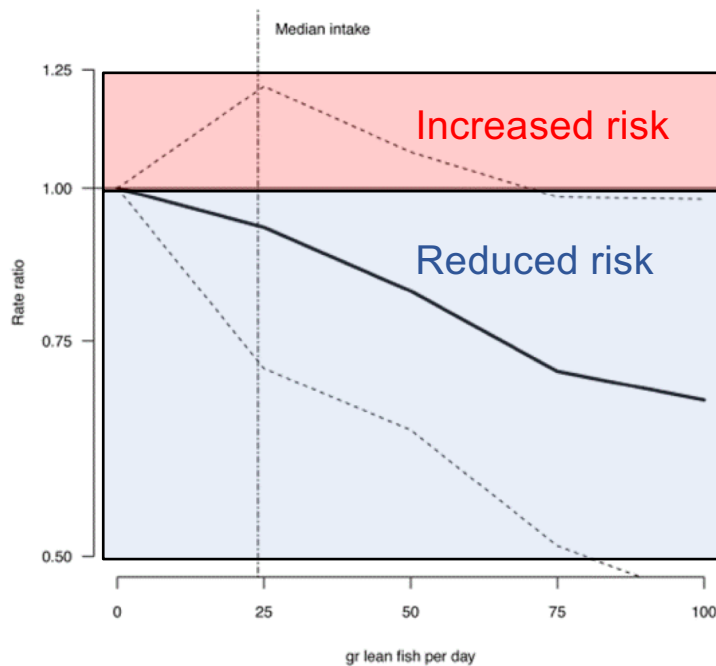
OPEN ACCESS Freely available online



Consumption of Lean Fish Reduces the Risk of Type 2 Diabetes Mellitus: A Prospective Population Based Cohort Study of Norwegian Women

Charlotta Rylander^{1*}, Torkjel M. Sandanger^{1,2}, Dagrun Engeset¹, Eiliv Lund¹

1 Department of Community Medicine, UiT The Arctic University of Norway, Tromsø, Norway, 2 NLU, Fram- High North Research Centre for Climate and the Environment, Tromsø, Norway



Norwegian cohort;
33740 females, 40-55 year

Average intake:
25 g lean fish per day

75-100 g lean fish per day;
30% reduced risk

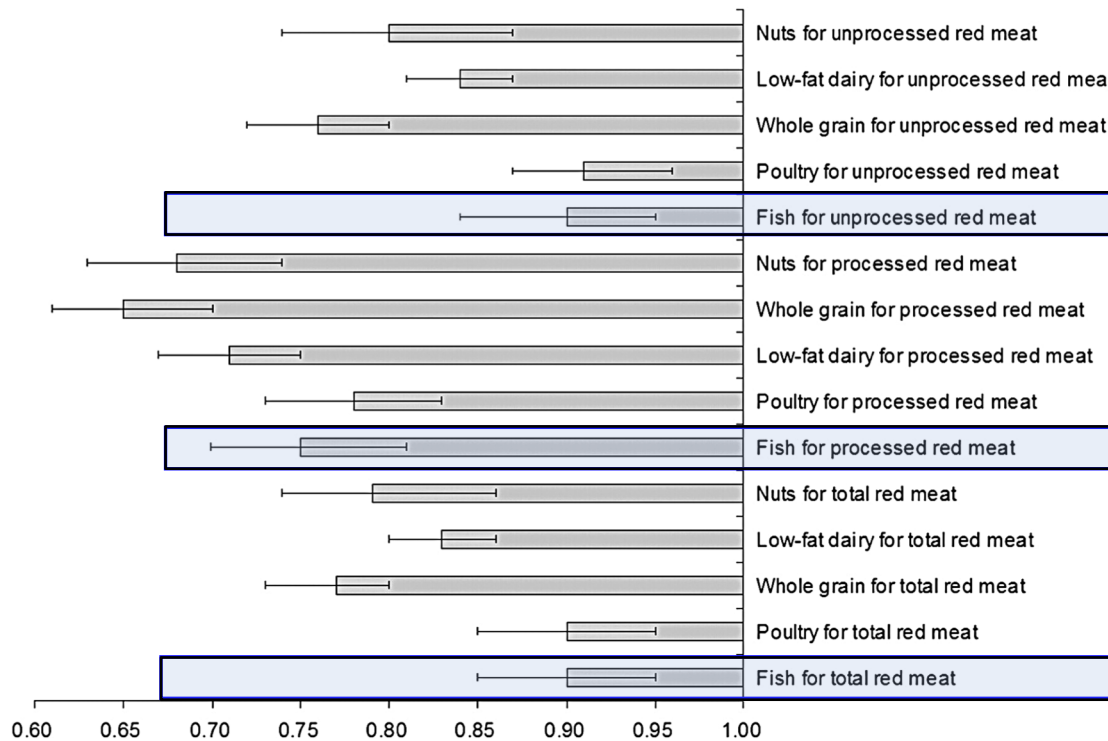
Fatty fish; no effect

Intake of salmon is NOT associated
with increased risk for diabetes
in prospective studies

Fish and seafood may replace other food items

Red meat consumption and risk of type 2 diabetes: 3 cohorts of US adults and an updated meta-analysis¹⁻³

An Pan, Qi Sun, Adam M Bernstein, Matthias B Schulze, JoAnn E Manson, Walter C Willett, and Frank B Hu



Nurses` Health study I; 79.570 females
 Nurses` Health study II; 87.504 females
 Health Professionals Follow up; 37.083 males
 Total; 204.157 subjects

Exchange 1 serving/ day
10-25% reduced risk

Present in salmon

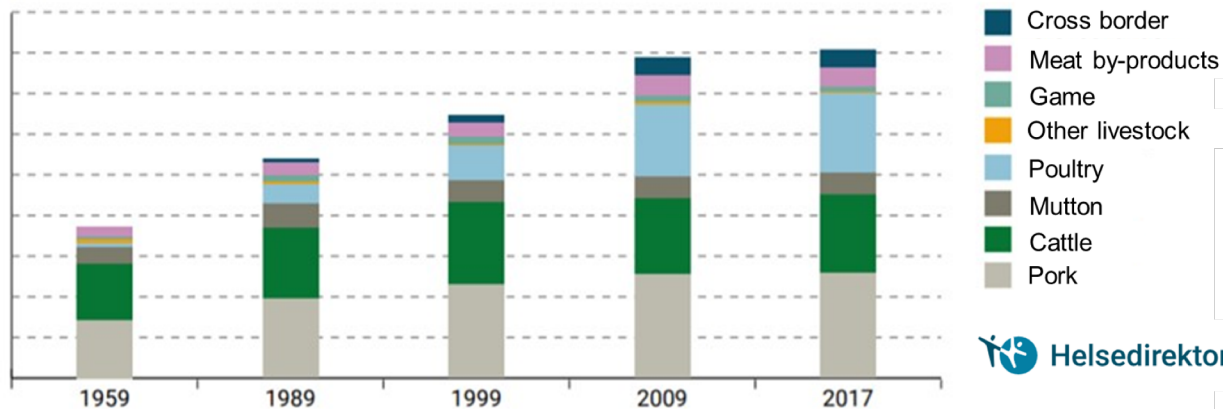
- Favorable nutrients
- Undesirable substances



Intake of salmon is not associated with development of obesity and diabetes, but new risk-benefit analyses are required



per person per år



Helsedirektoratet

<https://helsedirektoratet.no/publikasjoner/utviklingen-i-norsk-kosthold>

