Fisken og miljøet: metamorfose, rekruttering og slim

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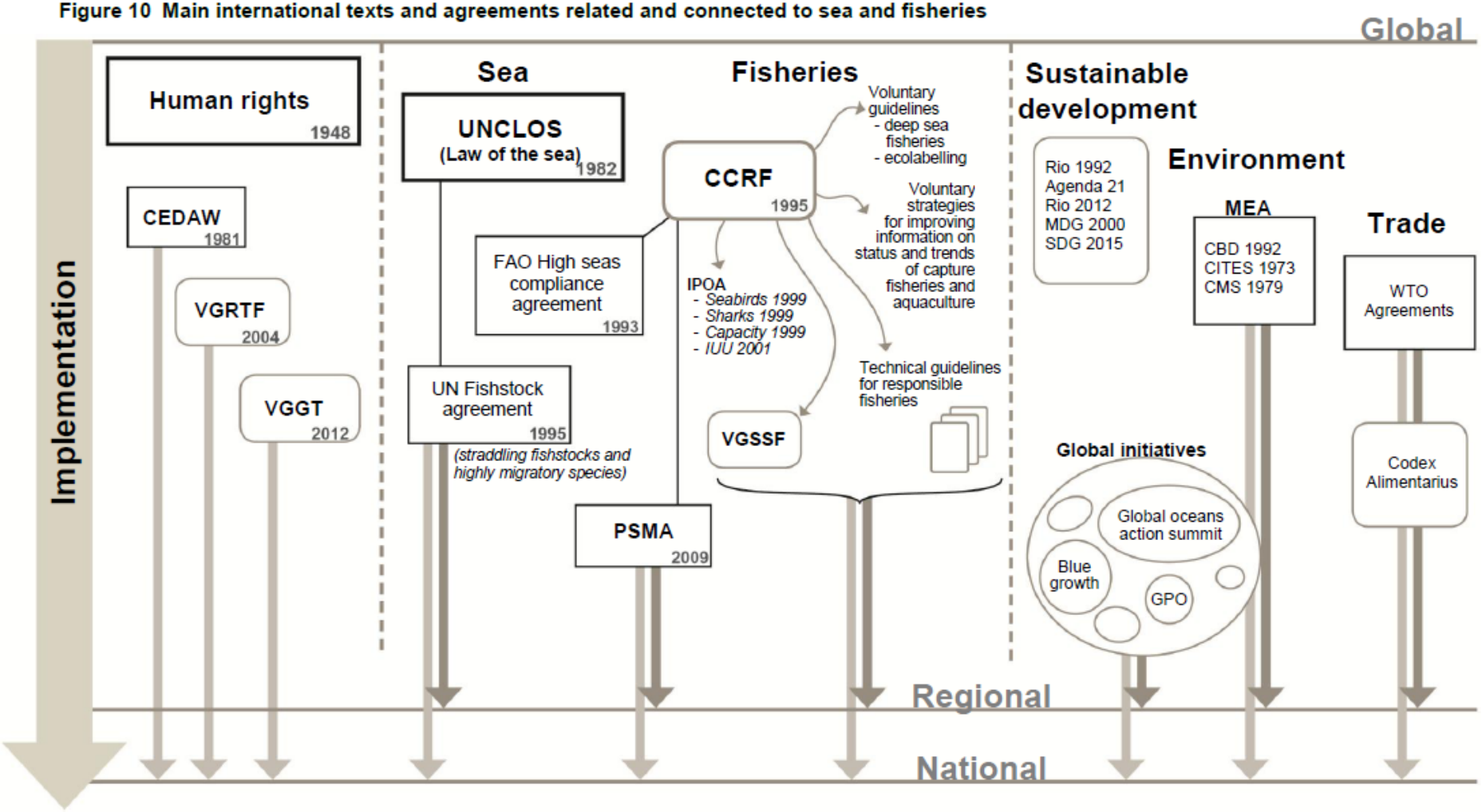
Why?

"We must plant the sea and herd its animals … using the sea as farmers instead of hunters. That is what civilization is all about — farming replacing hunting." — Jacques-Yves Cousteau

>70% of the Earth's surface is water. Most of this is marine.

Figure 10 Main international texts and agreements related and connected to sea and fisheries



Legally binding texts and agreements are in rectangles.

CEDAW = Convention on the Elimination of All Forms of Discrimination against Women; VGRTF = Voluntary Guidelines on the Progressive Realization of the Right to Adequate Food in the Context of National Food Security; VGGT = Voluntary Guidelines on the Progressive Realization of the Right to Adequate Food in the Context of National Food Security; UNCLOS = United Nations Convention on the Law of the Sea; CCRF = Code of Conduct for Responsible Fisheries; IPOA-IUU=Plan of Action to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing; PSMA = Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing; VGSSF = Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries; MDG = Millennium Development Goals; SDG = Sustainable Development Goals; MEA = Multilateral Environmental Agreements; CBD = Convention on Biological Diversity; CITES = Convention on International Trade in Endangered Species of wild fauna and flora; CMS = Convention on the conservation of Migratory Species of wild animals; GPO = Global Partnership for Ocean.

Source: HLPE 2014

FISH ARE SPECIAL

Before men got
a Y-chromosome,
bony fish had a
whole genome duplication.

And then salmonids did it again.

8-16 copies of genes?
What does this mean?

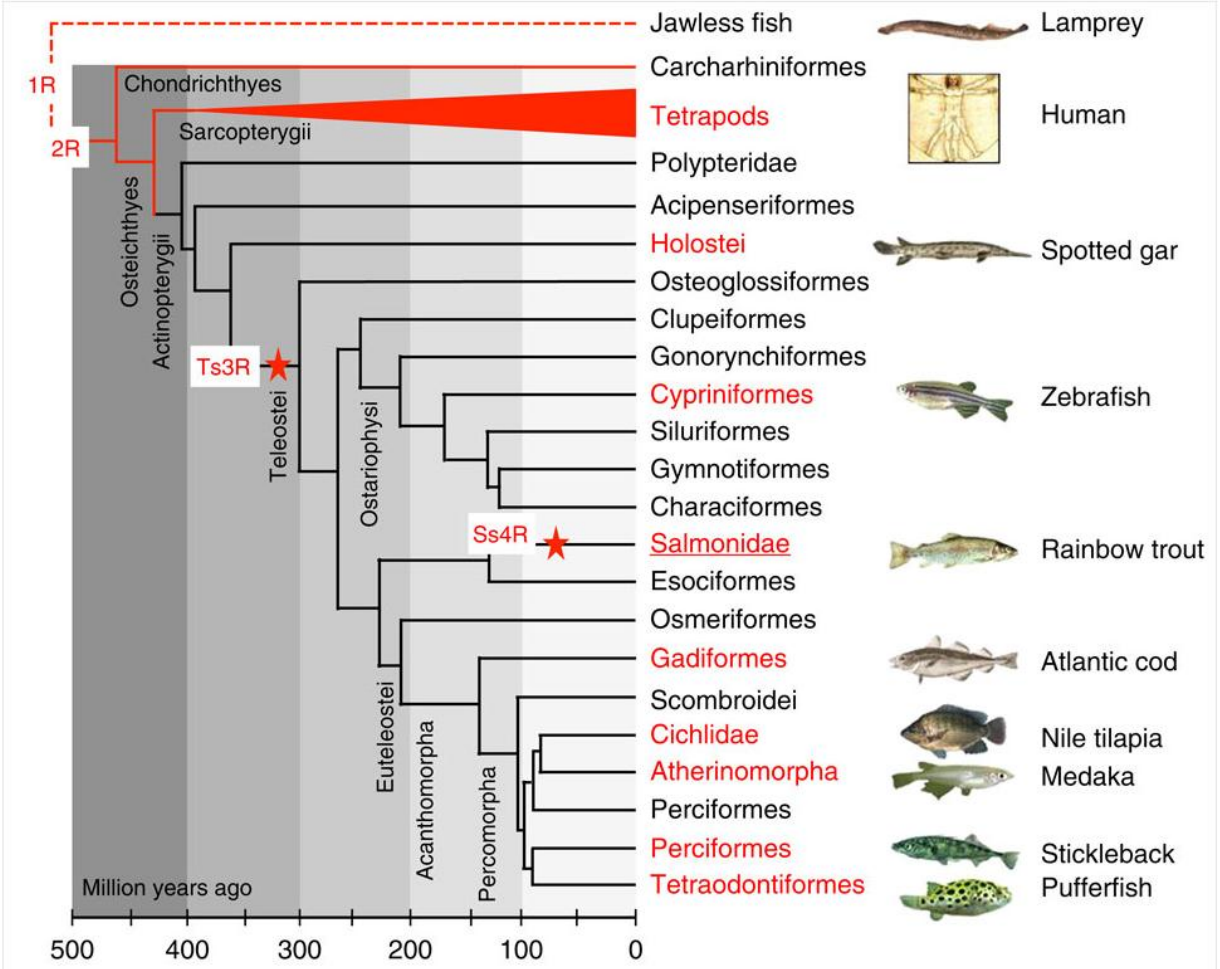
Figure 1: Evolutionary position of the rainbow trout.

From

The rainbow trout genome provides novel insights into evolution after whole-genome duplication in vertebrates

Camille Berthelot, Frédéric Brunet, Domitille Chalopin, Amélie Juanchich, Maria Bernard, Benjamin Noël, Pascal Bento, Corinne Da Silva, Karine Labadie, Adriana Alberti, Jean-Marc Aury, Alexandra Louis, Patrice Dehais, Philippe Bardou, Jérôme Montfort, Christophe Klopp, Cédric Cabau, Christine Gaspin, Gary H. Thorgaard, Mekki Boussaha + *et al.*

Nature Communications **5**, Article number: 3657 | doi:10.1038/ncomms4657



This tree is based on the time-calibrated phylogeny information from Near *et al.*[4] except for the additional branches in red. The red stars show the position of the teleost-specific (Ts3R) and the salmonid-specific (Ss4R) whole-genome duplications. Groups of species in which a genome sequence is available are shown in red bold type, with one example in each group. Origin of fish pictures: Manfred Schartl and Christoph Winkler (medaka, zebrafish and Tetraodon), John F. Scarola (rainbow trout), Bernd Ueberschaer (Nile tilapia) and Konrad Schmidt (three-spined stickleback).

Fish are special: "Prenatal" Development

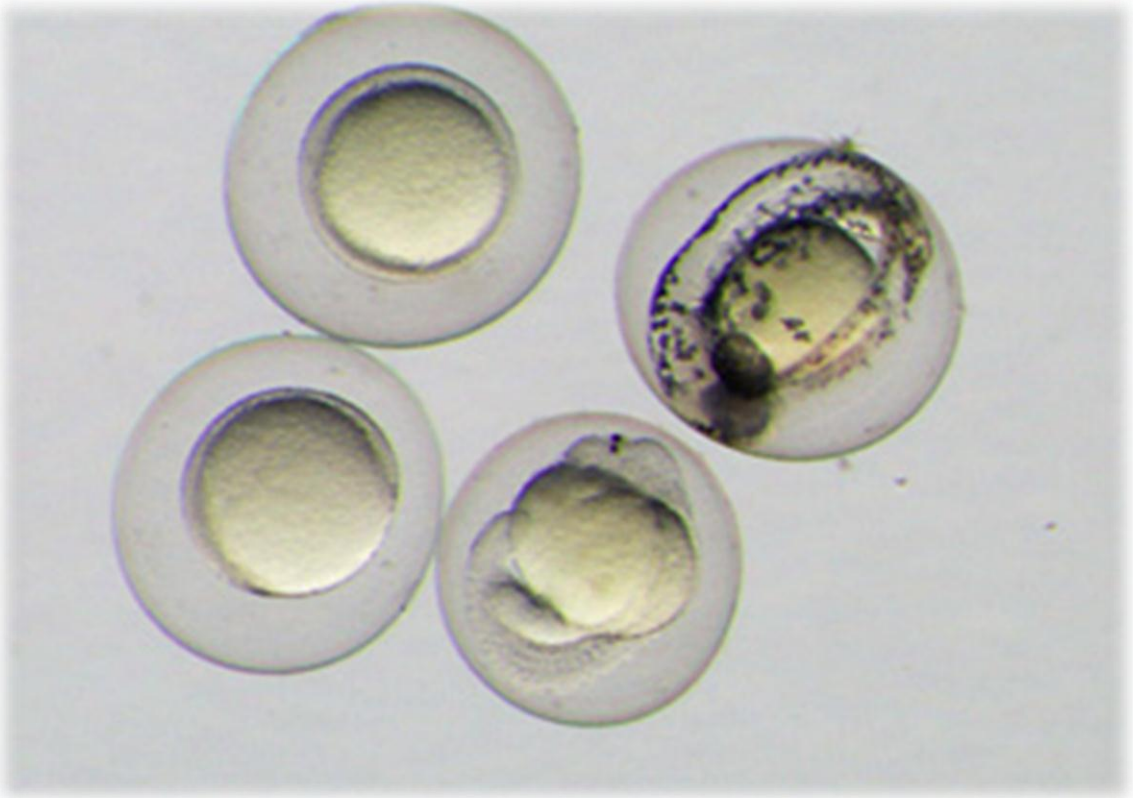
1) An understanding of prenatal development is critical to understanding postnatal growth

2) Prenatal growth is a significant portion of total growth:
Time spent in utero (in animals raised solely for meat production):

sheep=85% of life
cattle=60% of life
pig=70% of life
fish= ~0-5% of life (good model organism…)

3) Factors that impact prenatal growth can significantly impact postnatal growth

Fish are special: “Prenatal” Development



Environmentally exposed

Visible organogenesis

Early life events «program»
life cycle changes and
life history strategies

Picture from: http://www.oekotoxzentrum.ch/expertenservice/testsysteme/felst/index_EN

After about 40 years of research in aquaculture we know fish as animals better than we ever did from millenia of fishing.*

Shad eggs
(*Alosa sapidissima*)
From http://fredericksburg.com/News/FLS/2008/052008/05252008/381258

Fish eggs are gene-rich,
environmentally responsive
~~**environmentally exposed,**~~

pluripotent cells

*Pittman, K., Yufera, M., Pavlidis, M., Geffen, A.J., Koven, W., Ribeiro, L., Zambonino-Infante, J.L. and Tandler, A. (2013) Fantastically plastic: fish larvae equipped for a new world. *Reviews in Aquaculture,* **5**, S224-S267.

Metamorphosis in fish

(part of research needed to make farming halibut an industry)

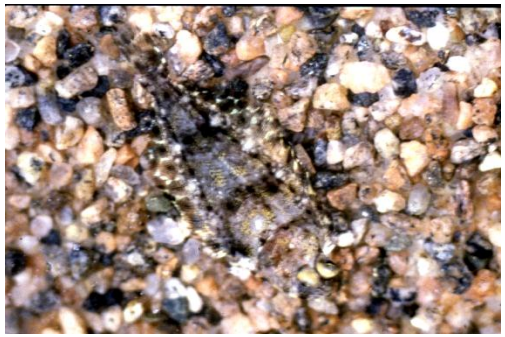
Newly hatched

Pre-metamorphosis
pre first feeding

Pro-metamorphosis
first feeding

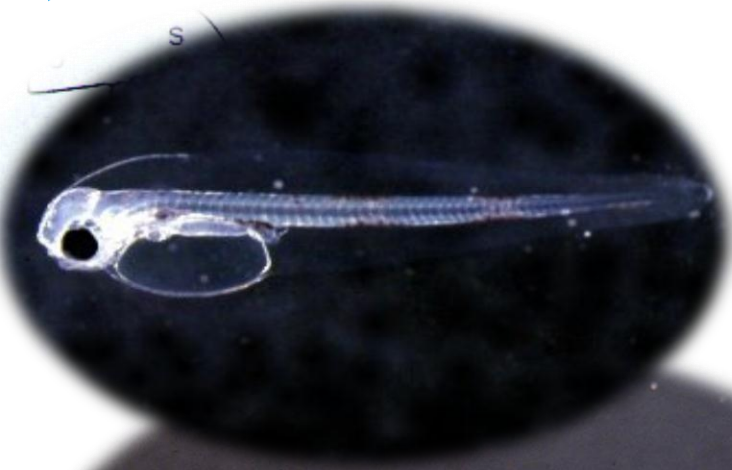
Climax metamorphosis

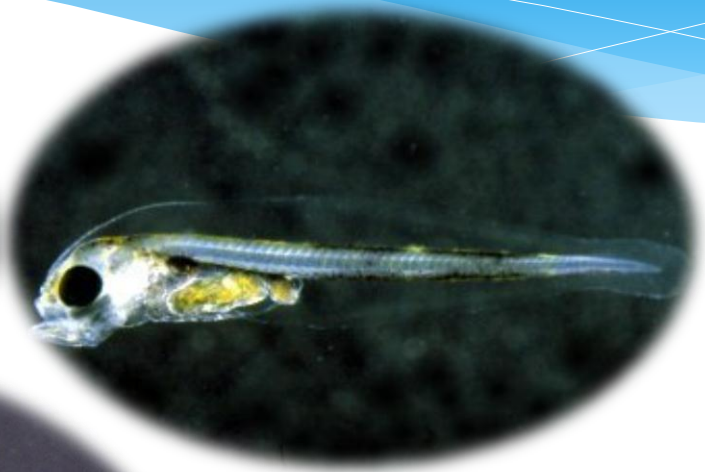
Post climax metamorphosis



Post metamorphosis

Metamorphosis in Cod (*Gadus morhua*)





Fisheries literature says
”Cod metamorphose at 12 mm SL”

no meaning for aquaculturists

Photo: G. Totland

Metamorphosis in time lapse

Differences and sampling problems start at first feeding

EPA, DHA, ArA — Growth, neural growth, pigmention (MSH), cell differentiation, gene expr., eicosanoid synthesis (hormones eg. prostaglandins) stress regulation (on cortisol),

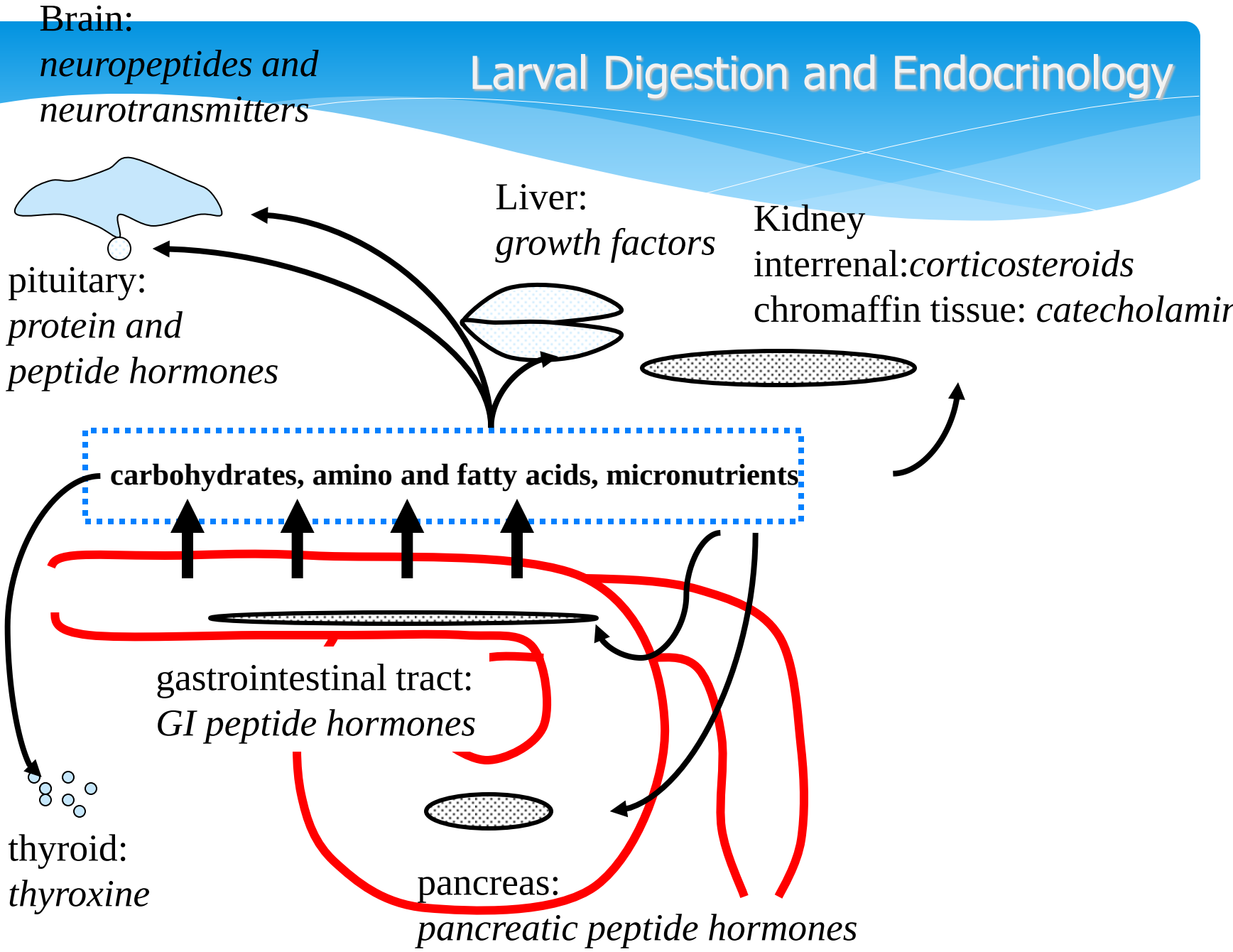
Phospholipids — Growth, development (malformations phosphatidylinositol)
- precursor messengers regulating calcium to cell

Amino acids — Growth, protein synthesis
Tryptophan metabolite – serotonin (neurotransmitter)

Peptides — Growth, survival, skeletogenesis
Protein hydrolysates, di- and tripeptides reduce malformation

Vitamins — Retinoic acid (Vit A) acts on hox gene family (antero-postero axis)
Ascorbic acid (Vit C) growth, immunoactivity, skeletal dev. etc.

Larval Digestion and Endocrinology



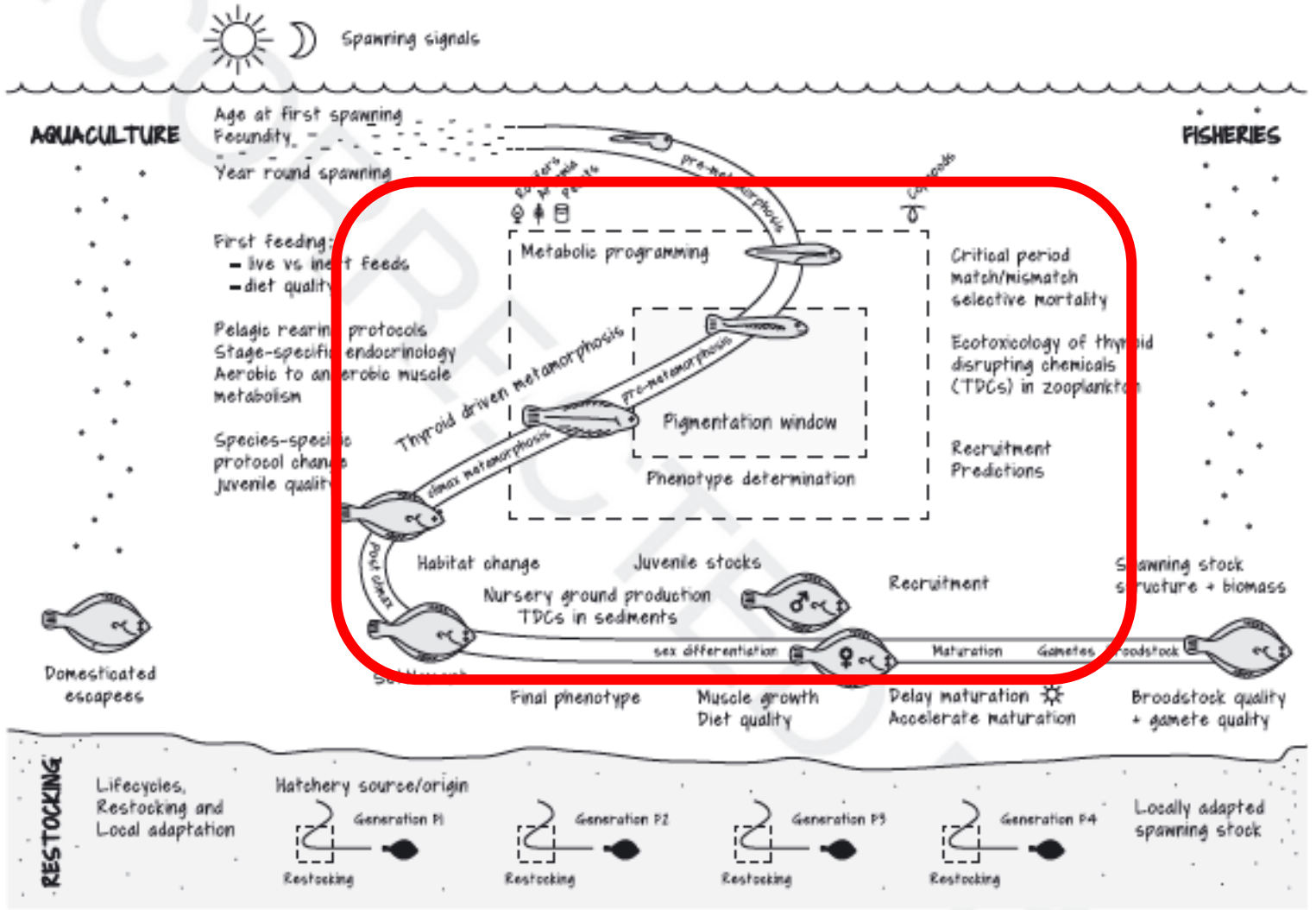
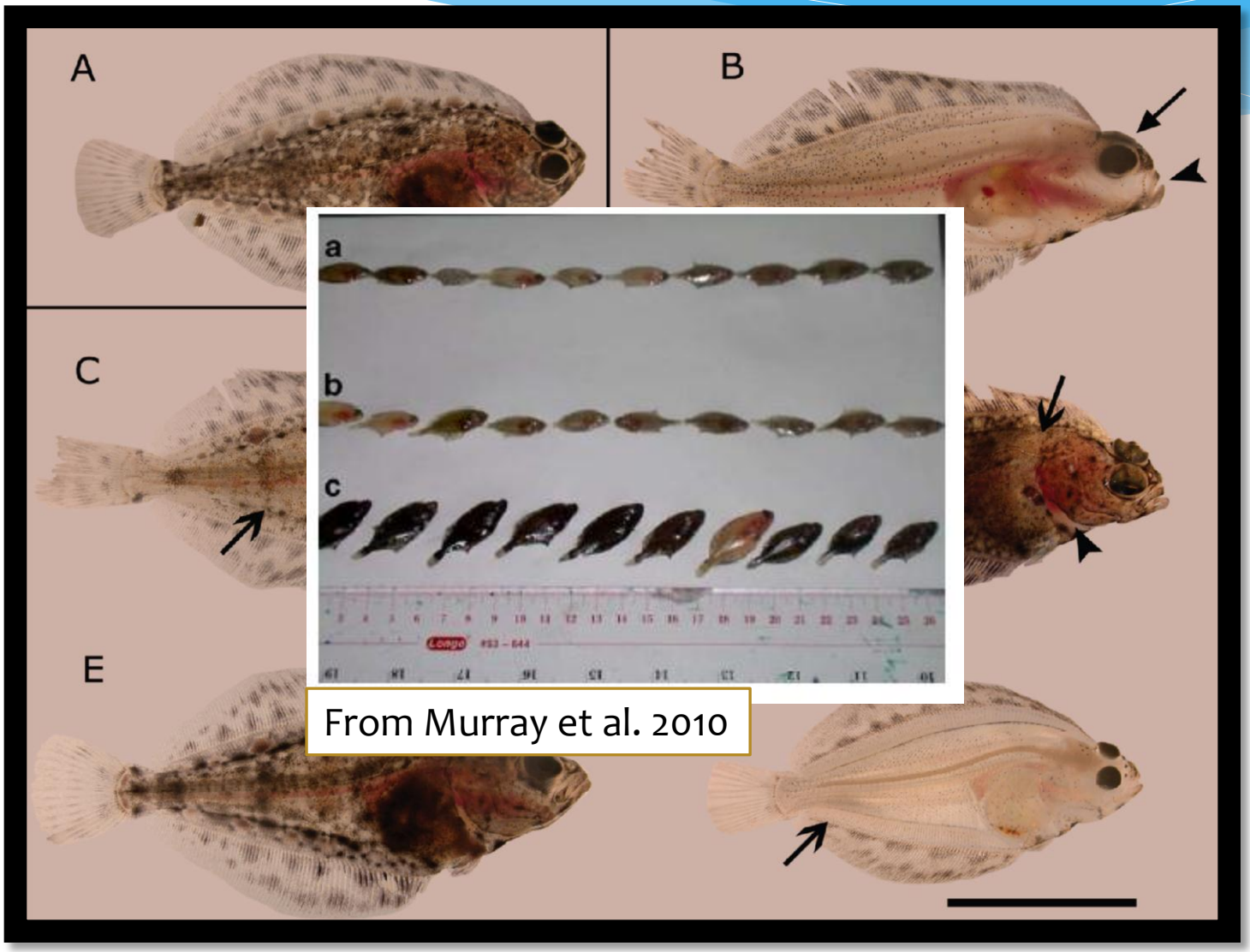


Figure 17.1 Conceptual diagram representing the areas of synergy that can contribute to a better understanding of the biology and ecology of flatfishes. This synergy arises from knowledge exchange between subdisciplines such as aquaculture, fisheries, and marine ecology. The examples in this chapter are organized by theme according to different life history stages. These themes are thus situated along a path through the life history stages, with aquaculture applications to the left side of the figure and fisheries and ecological applications to the right. The relationship between restocking applications, and the knowledge gained from research on wild and captive populations is represented by the series at the base of the figure. This shows restocking from hatchery sources moving through successive generations and subjected to local adaptation and interaction with local wild populations Original artwork: K. Pittman/Jon Rowlandson.

From: Geffen, Pittman and Imsland 2014

Epigenetic effects on metamorphosis



From Murray et al. 2010

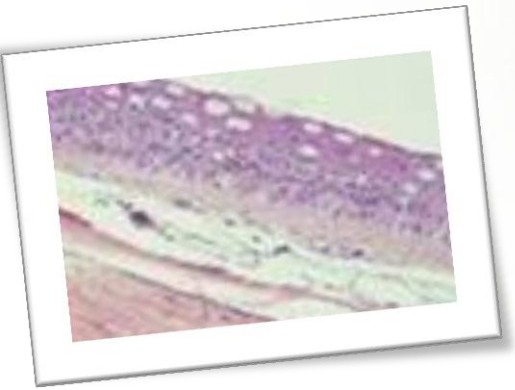
Power, Einarsdottir, Pittman, Sweeney, Hildahl, Campinho, Silva, Sæle, Galay-Burgos, Smaradottir & Bjørnsson 2008
The molecular and endocrine basis of flatfish metamorphosis. Reviews in Fisheries Science 16:95-111

Vs

Aquadvantage™ salmon (transgenic)
Nicknamed ”Frankenfish”

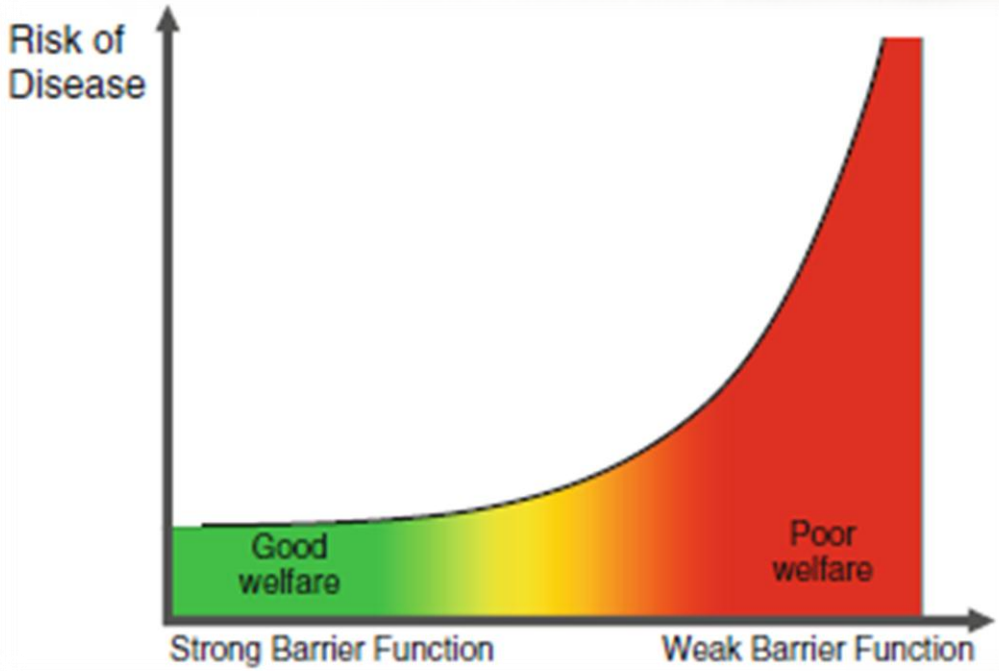
Cod given different firstfeeds
Juveniles 23% heavier on zooplankton
-Koedijk et al 2010

MUCOSAL EPITHELIUM = SKIN, GILLS, GUTS = BARRIER FUNCTIONS



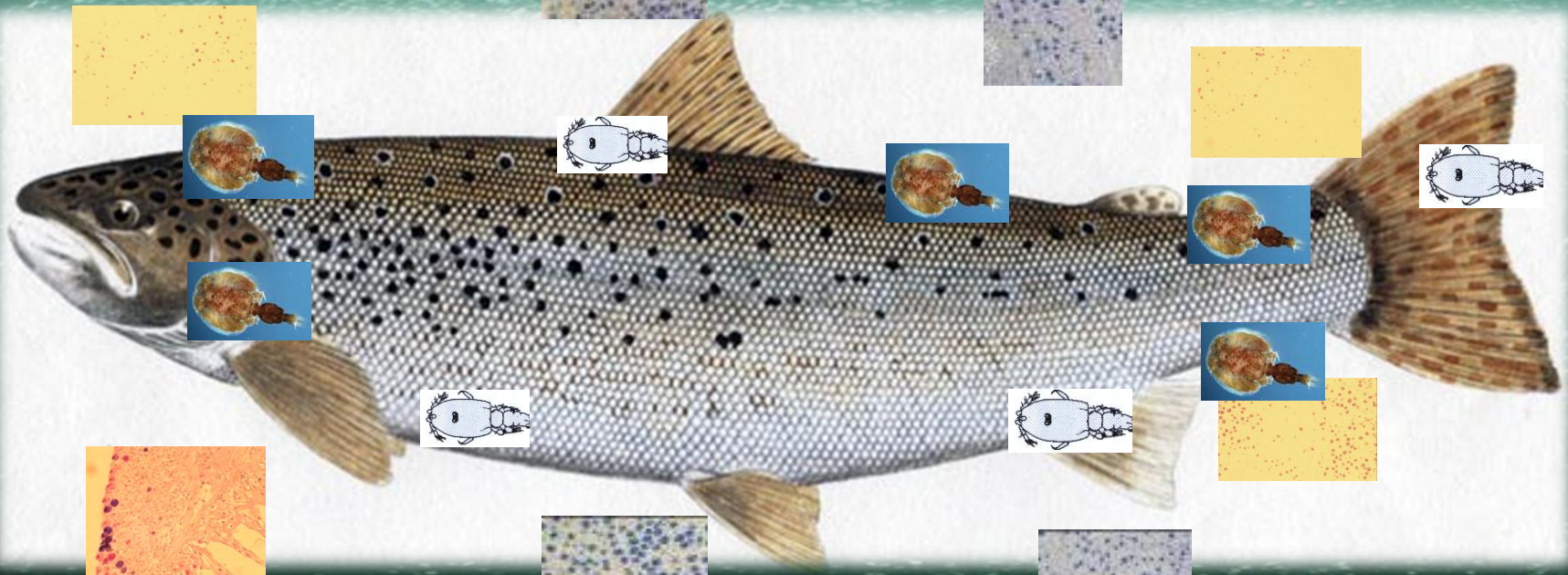
Primary innate immune system

Biological function is a cornerstone of fish welfare,
gut permeability, immunity



Redrawn from Segner et al 2012 Fish Physiol Biochem (2012) 38:85–105

MUCOSAL MAPPING IN SALMONIDS



Mucosal Mapping in Salmonids

Partner with us
to build up
your defense strategy

Inventor Prize 2013
Hordaland Fylkeskommune

Quantidoc

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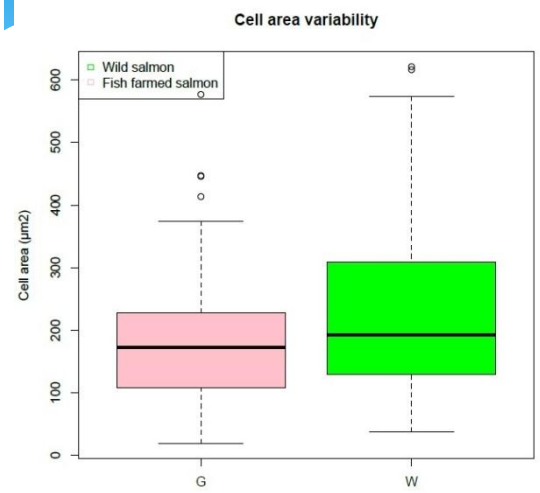
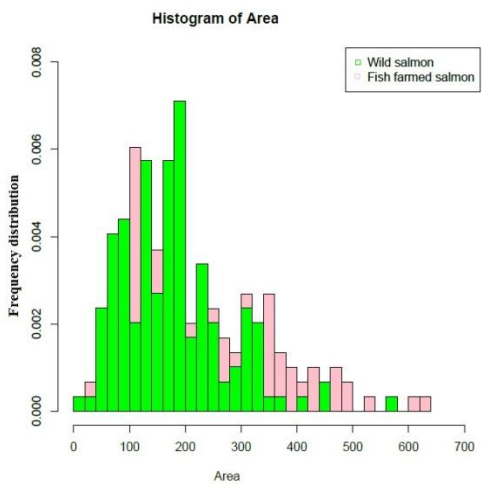
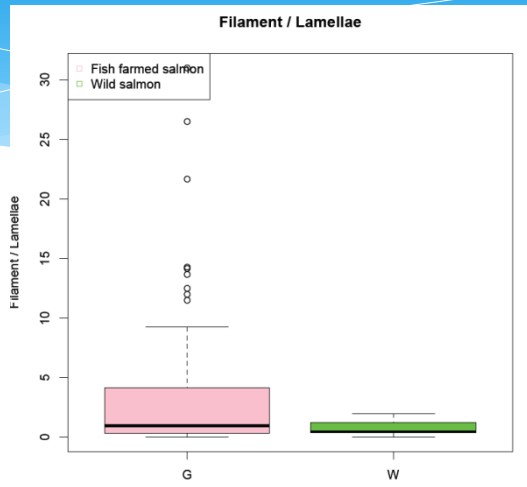
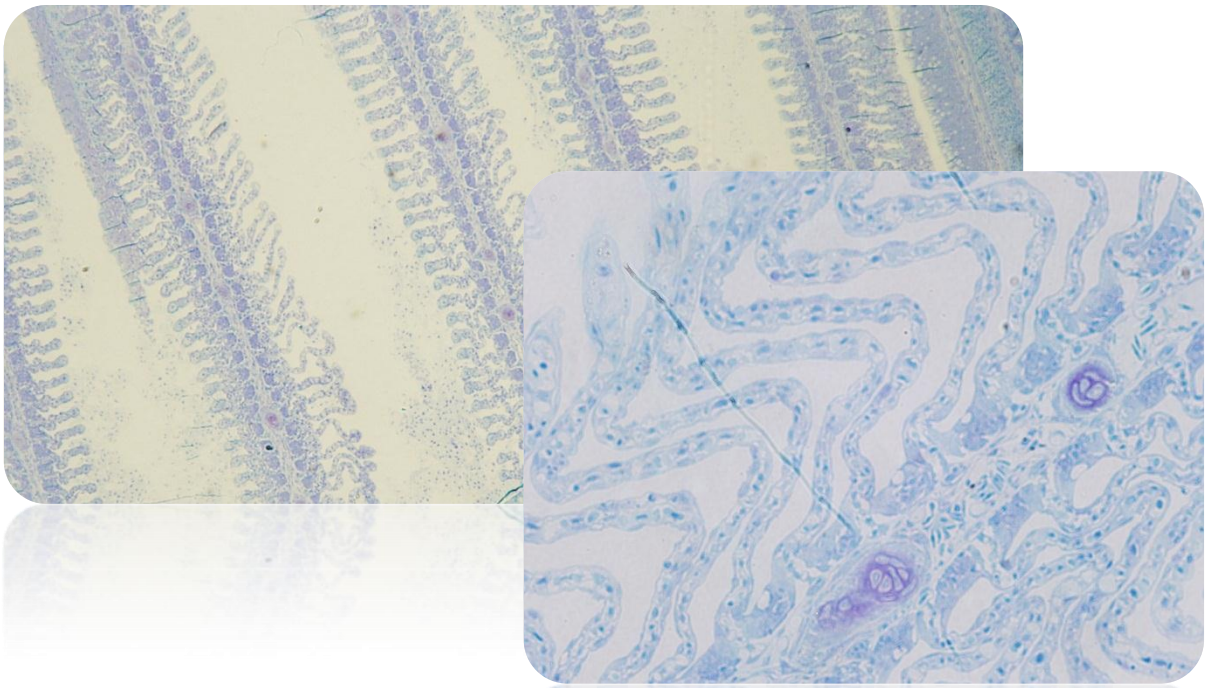
Mucosal Mapping of wild salmon gills:









Wild had shorter lamellae
No mucous cells in lamellae

Work continues…!

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Ecosystem mapping and trophic level changes

Canada

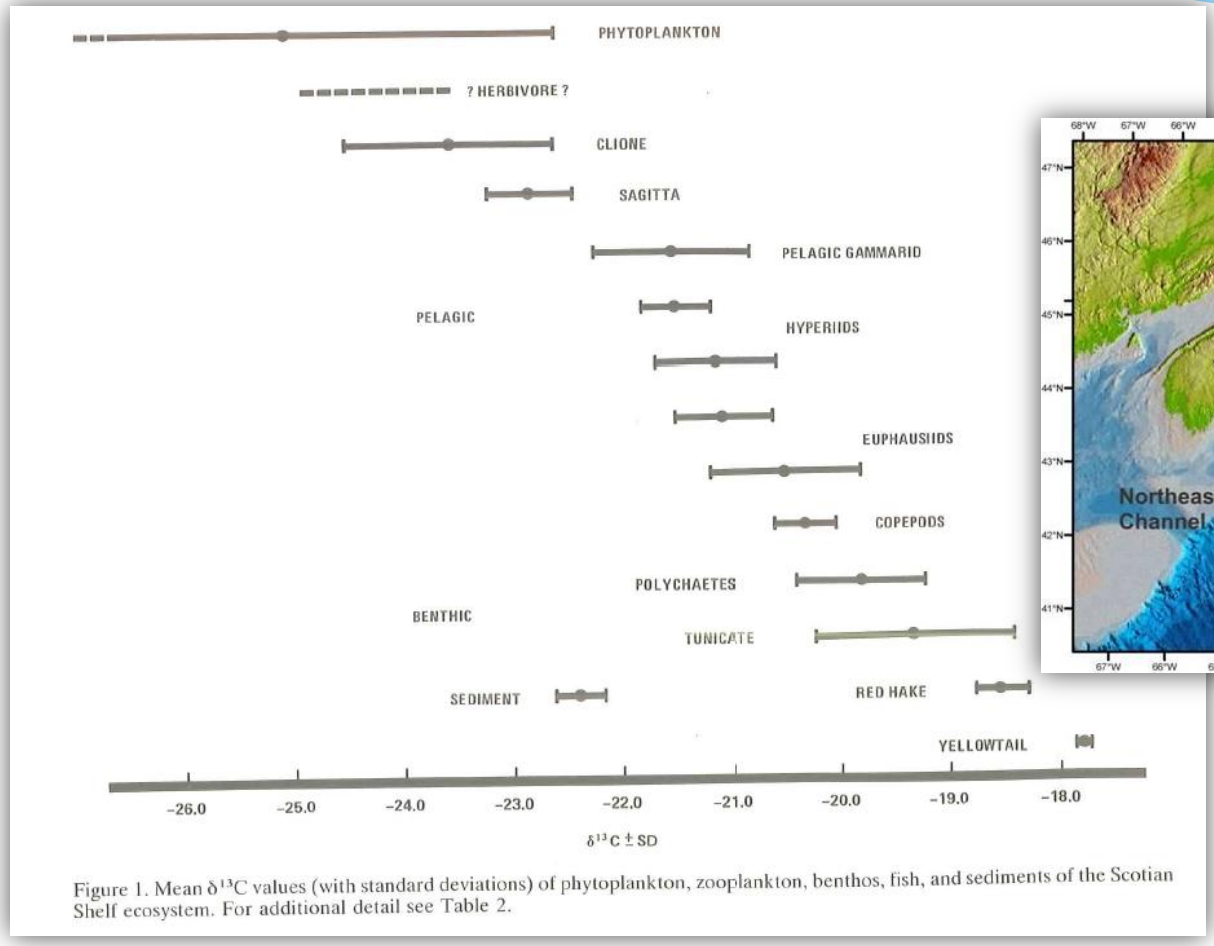
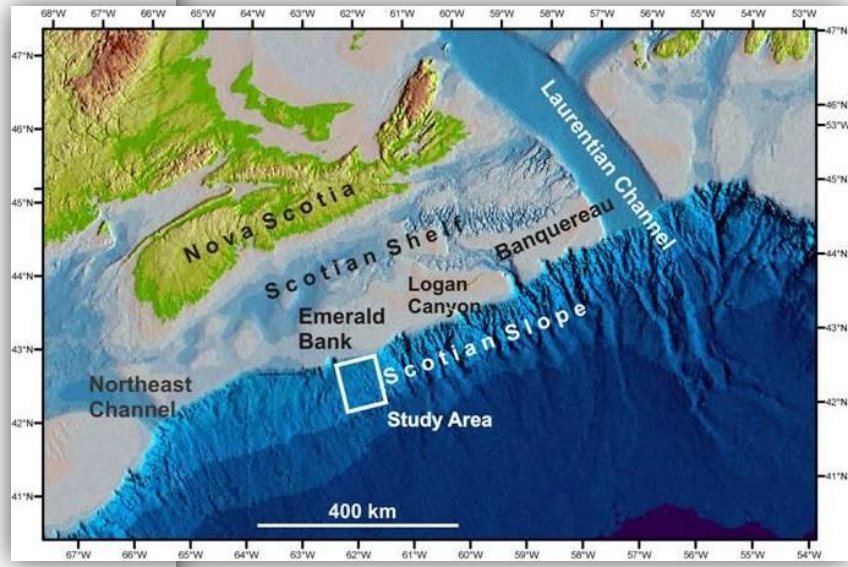
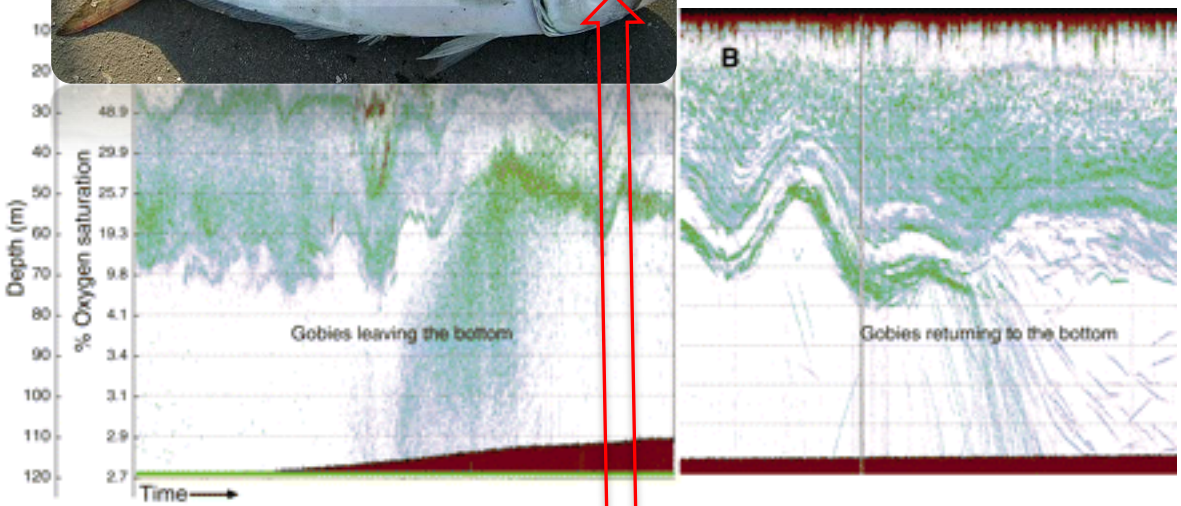


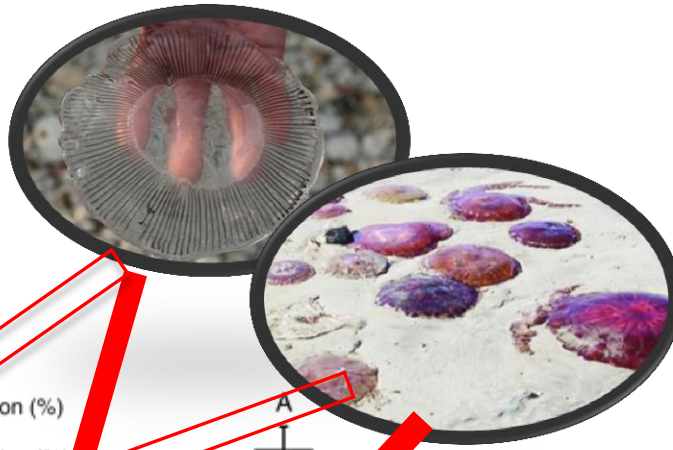
Figure 1. Mean $\delta^{13}C$ values (with standard deviations) of phytoplankton, zooplankton, benthos, fish, and sediments of the Scotian Shelf ecosystem. For additional detail see Table 2.

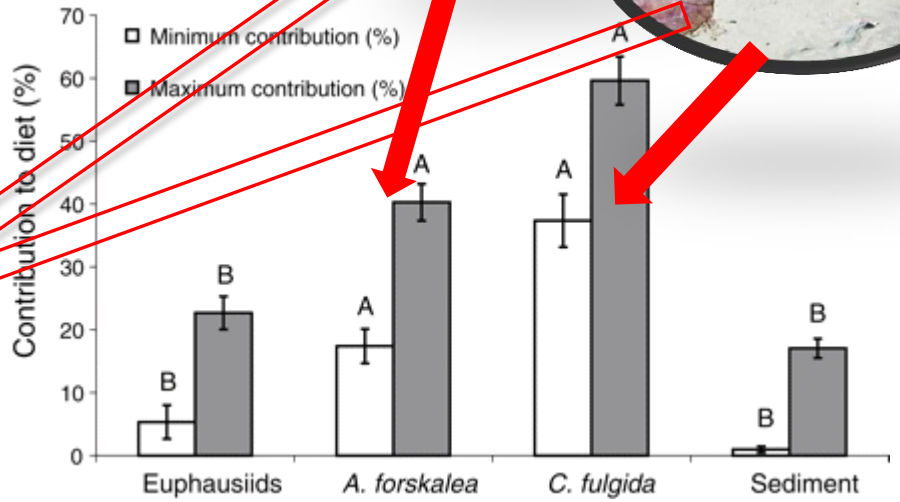


From: Mills, Pittman & Tan (1984)

Ecosystem mapping and trophic level changes
Namibia (Benguela)



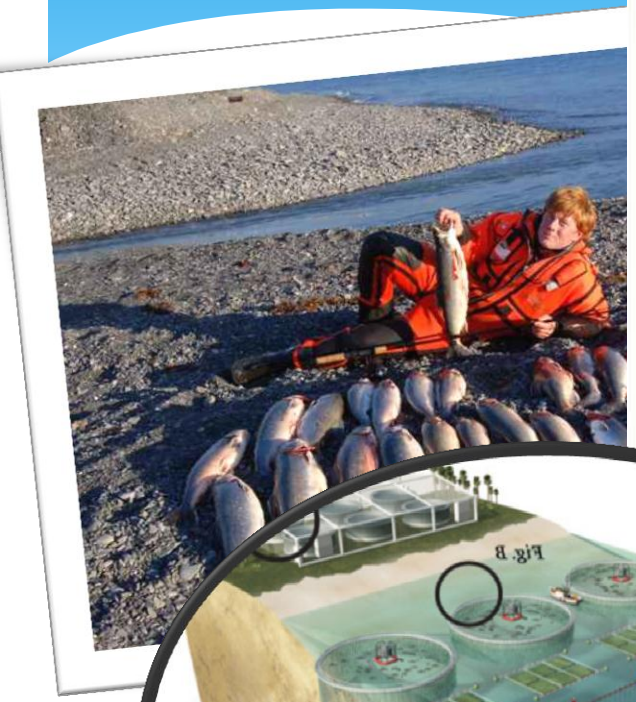


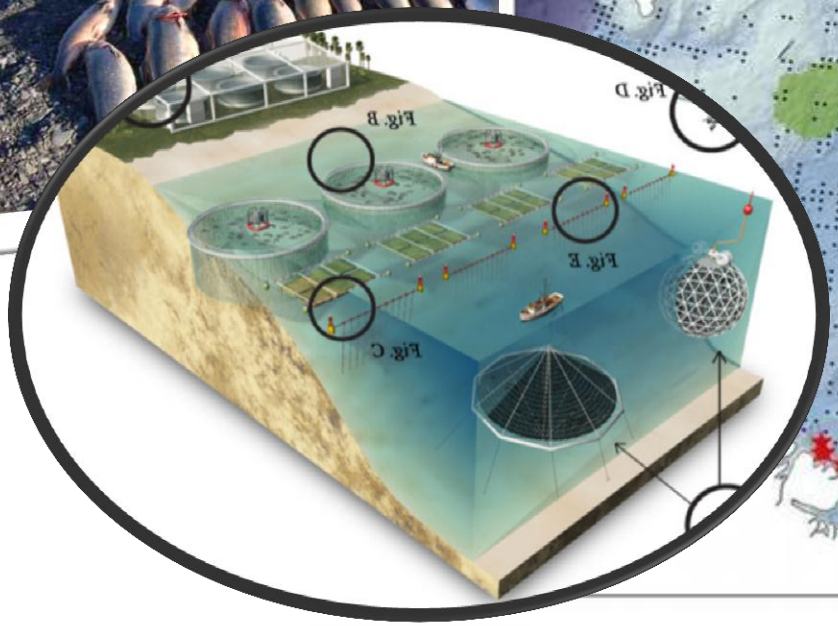


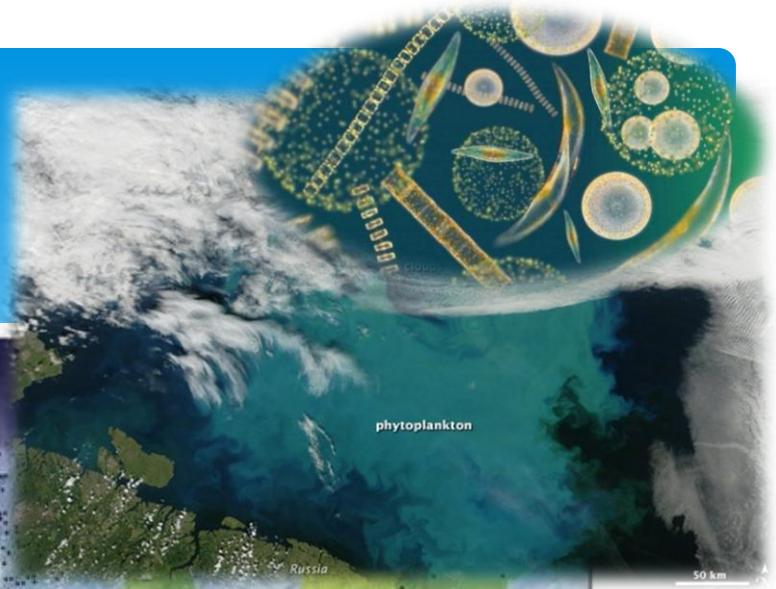
From Utne-Palm … Pittman… et al. 2010 Science *Vol. 329 no. 5989 pp. 333-336*

From fishing to fish farming on Svalbard?

Ecosystem is changing







Why?

"We must plant the sea and herd its animals … using the sea as farmers instead of hunters. That is what civilization is all about — farming replacing hunting." — Jacques-Yves Cousteau

>70% of the Earth's surface is water. Most of this is marine.

World food supply fish and livestock 2011 (tonnes)

Category	Production (tonnes)
Fish, Seafood	129,872,000
Freshwater Fish	47,064,000
Marine Fish	8,916,000
Crustaceans	11,987,000
Molluscs	16,646,000
Aquatic Plants	12,934,000
Meat	290,649,000
Bovine Meat	64,624,000
Mutton & Goat Meat	13,296,000
Pigmeat	106,541,000
Poultry Meat	99,380,000

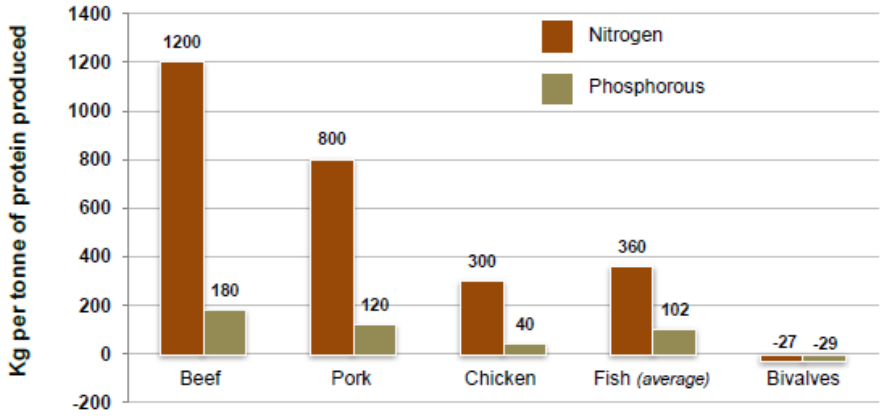
Source: http://faostat3.fao.org/faostat-gateway/go/to/download/FB/BL/E

2007 Commodity Trade value in billion US $

Animal commodities	
Fish	92.80
Pigs	30.21
Cattle	28.99
Poultry	22.10
Sheep and Goats	4.35

It pays, environmentally and literally, to raise fish instead of other livestock

Figure 8 Nitrogen and phosphorous emissions for animal production systems



Source: Data for fish are derived from Hall *et al.* (2011). Data for beef, pork and chicken are derived from Flachowsky (2002) and Poštrk (2003).

Source: FAO.org and HLPE (2014)