

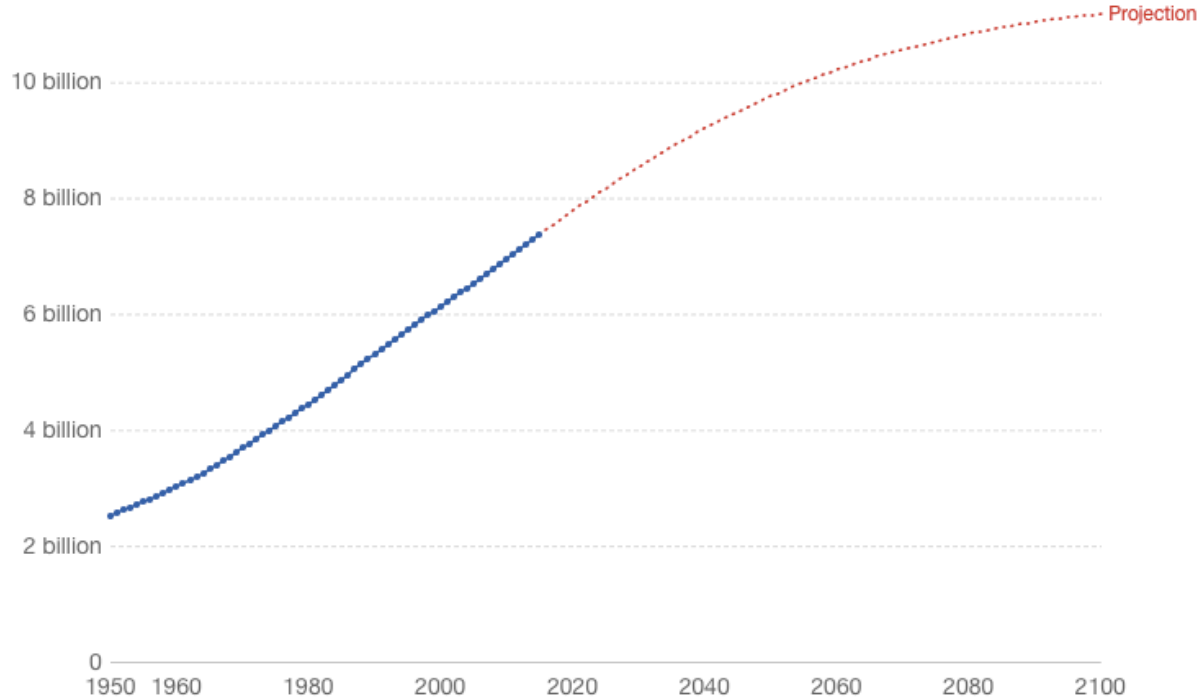
A New Framework for Radical Innovation in Aquaculture

Ragnar Tveterås

What is the challenge?



Provide MORE nutritious seafood for a growing population



Growing in ways that do not harm
other aquaculture producers

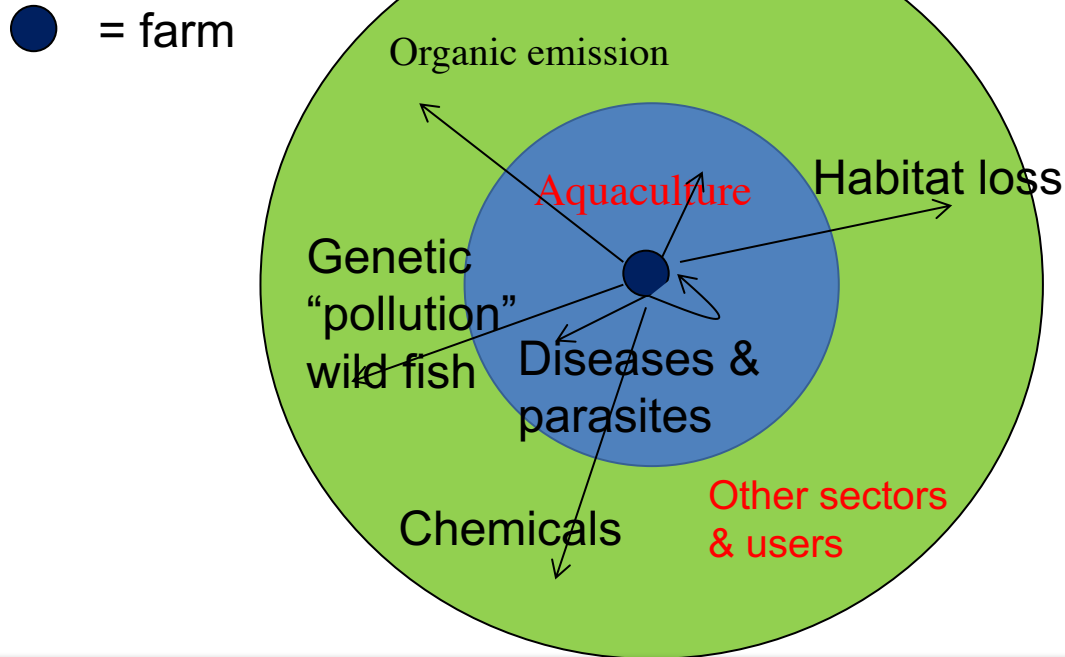
And growing in ways that do not
harm other stakeholders and the
environment

It is a race against externalities

Costs imposed on other fish farmers

Costs imposed on other
stakeholders and the environment

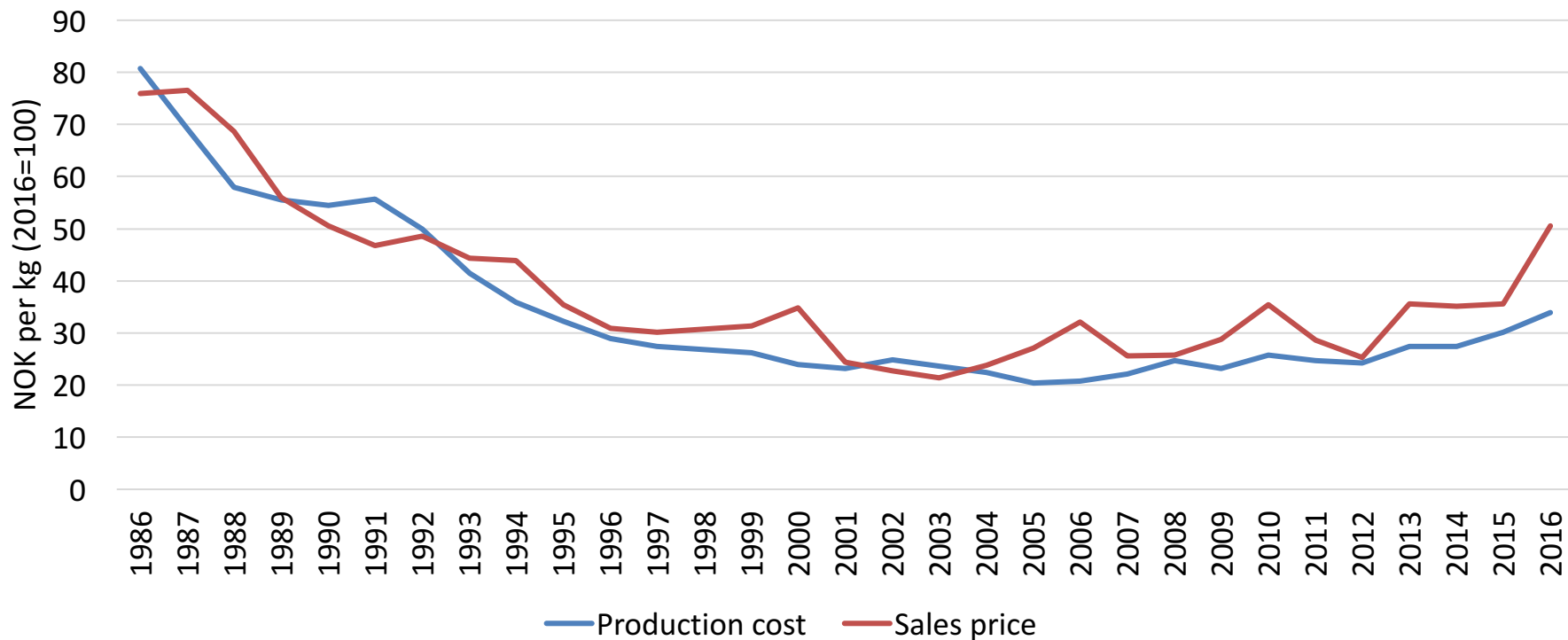
Externalities from aquaculture: An added cost to industry and society



Externalities influence productivity and production (1) directly through diseases etc., and (2) indirectly through public regulations etc. motivated by externalities

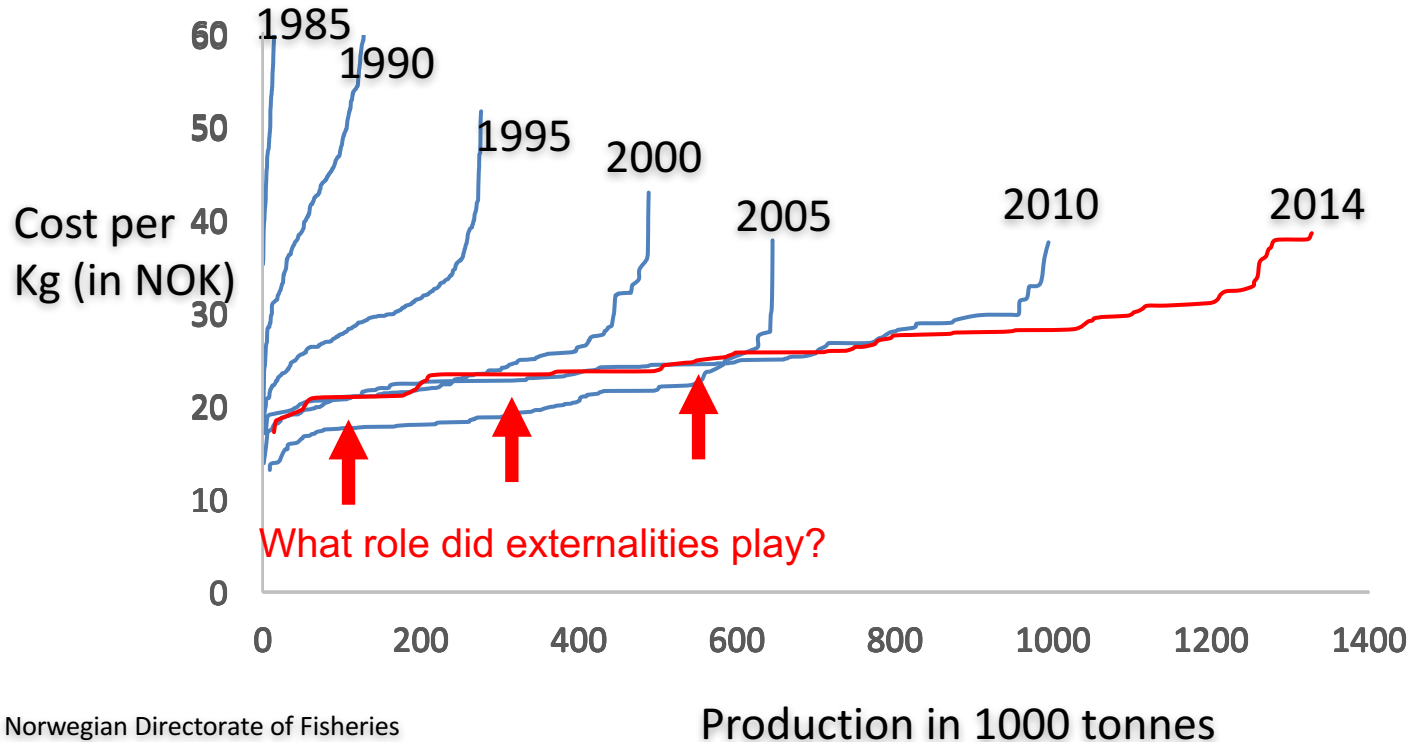
Salmon aquaculture costs shifting upwards

Norwegian production costs and ex farm sales price

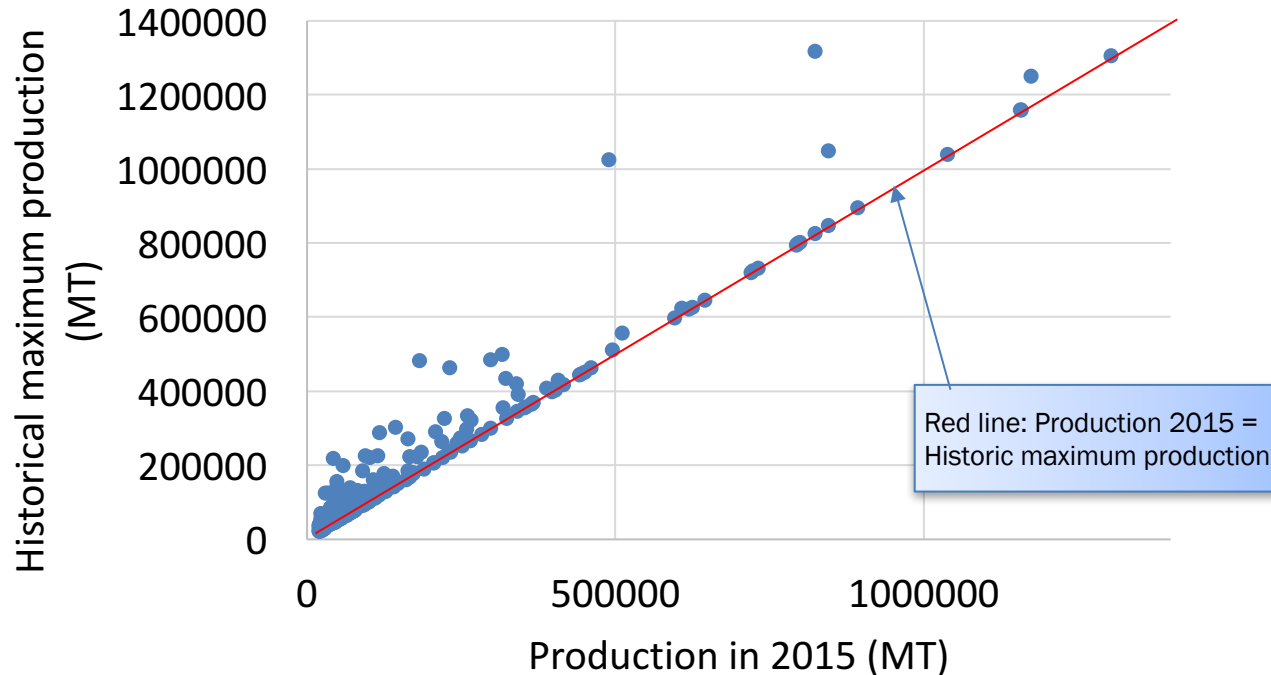


Externalities can shift costs upwards

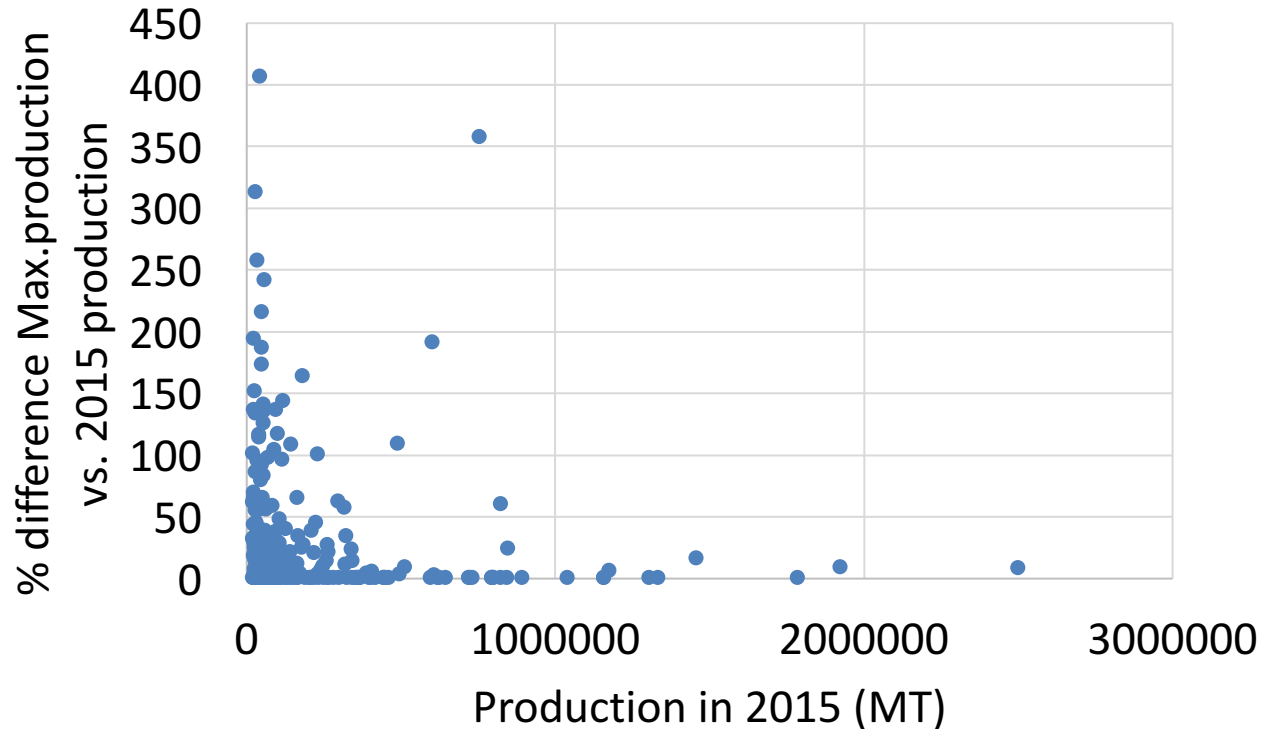
Unit costs in Norwegian salmon farming



Many sectors have experienced significant decline in production compared to historical maximum



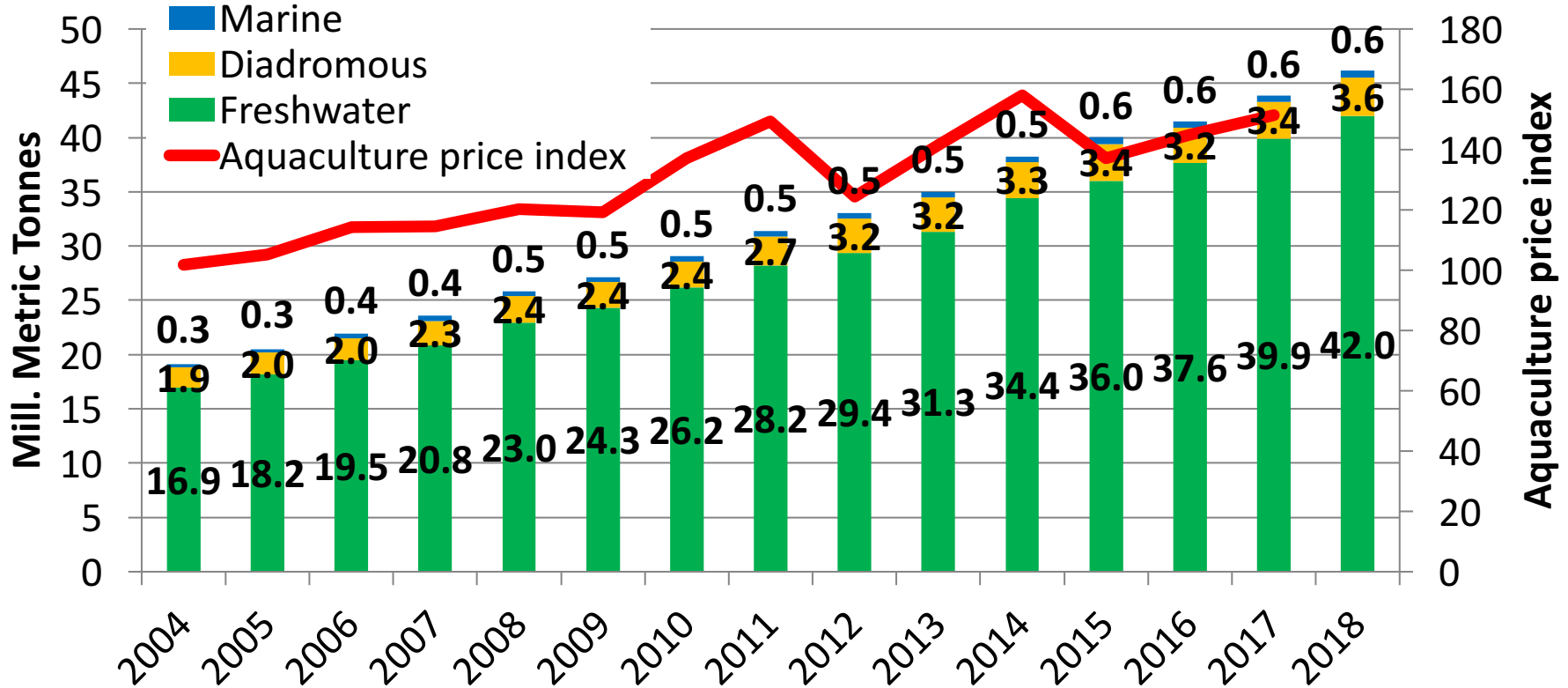
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Data source: FAO

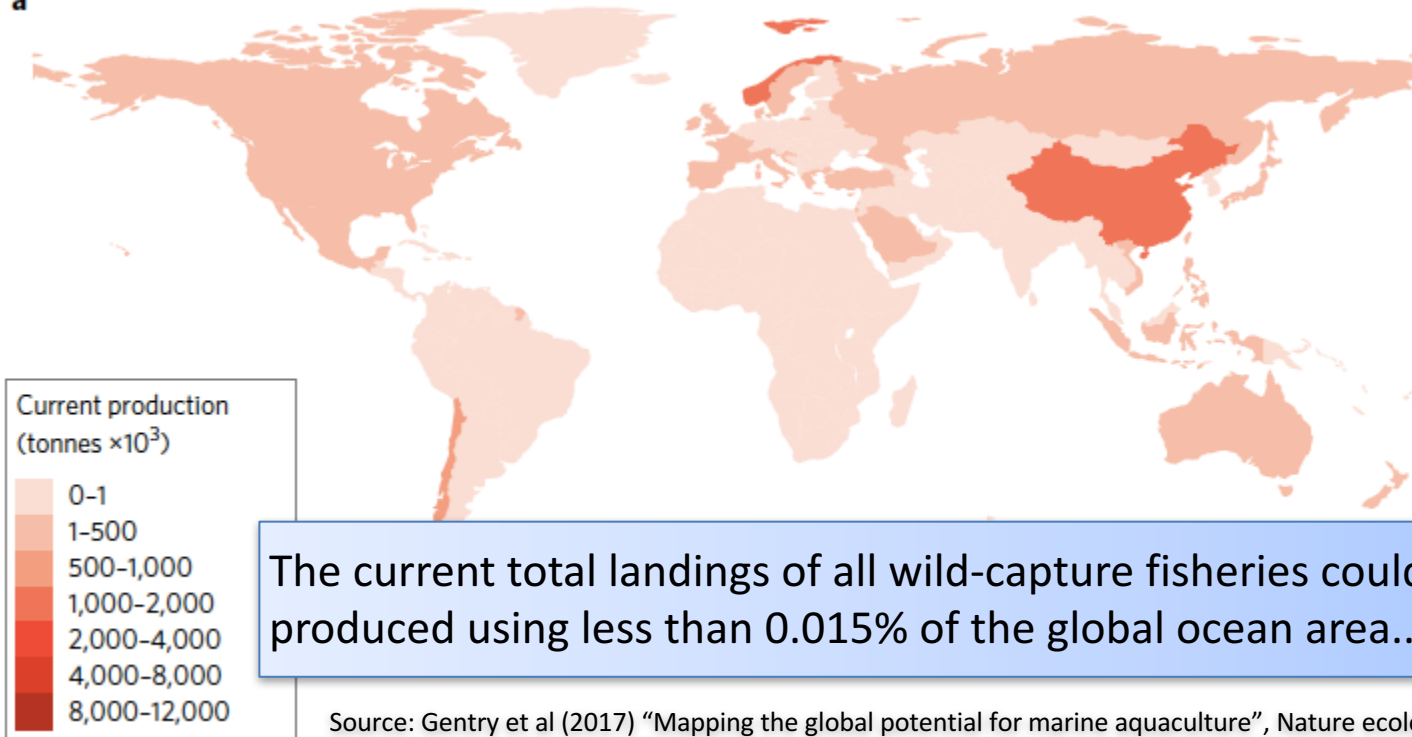
Most of production still in freshwater

Finfish species group 2004-2018



Current marine production

a



The current total landings of all wild-capture fisheries could be produced using less than 0.015% of the global ocean area...

Source: Gentry et al (2017) "Mapping the global potential for marine aquaculture", Nature ecology & evolution

Fig. 4 | Marine aquaculture production and potential. **a**, Current marine aquaculture fish production. **b**, Potential production if 1% of the suitable area in each country was developed for low-density marine finfish aquaculture. Note that some countries, such as China and Norway, already produce more marine finfish than the projected potential, which could reflect more intensive production or a larger fraction of the marine area already developed for aquaculture.

Potential marine production

b



Fig. 4 | Marine aquaculture production and potential. **a**, Current marine aquaculture fish production. **b**, Potential production if 1% of the suitable area in each country was developed for low-density marine finfish aquaculture. Note that some countries, such as China and Norway, already produce more marine finfish than the projected potential, which could reflect more intensive production or a larger fraction of the marine area already developed for aquaculture.

Yesterday's technologies and
regulations cannot bring us where
we want

So how do we solve the challenge?

We go to the government!



How are aquaculture sectors' relationships with their governments?

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Government has several features

- Provides much of the resources, public infrastructure and institutions you need

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- Has schizophrenic policies towards you

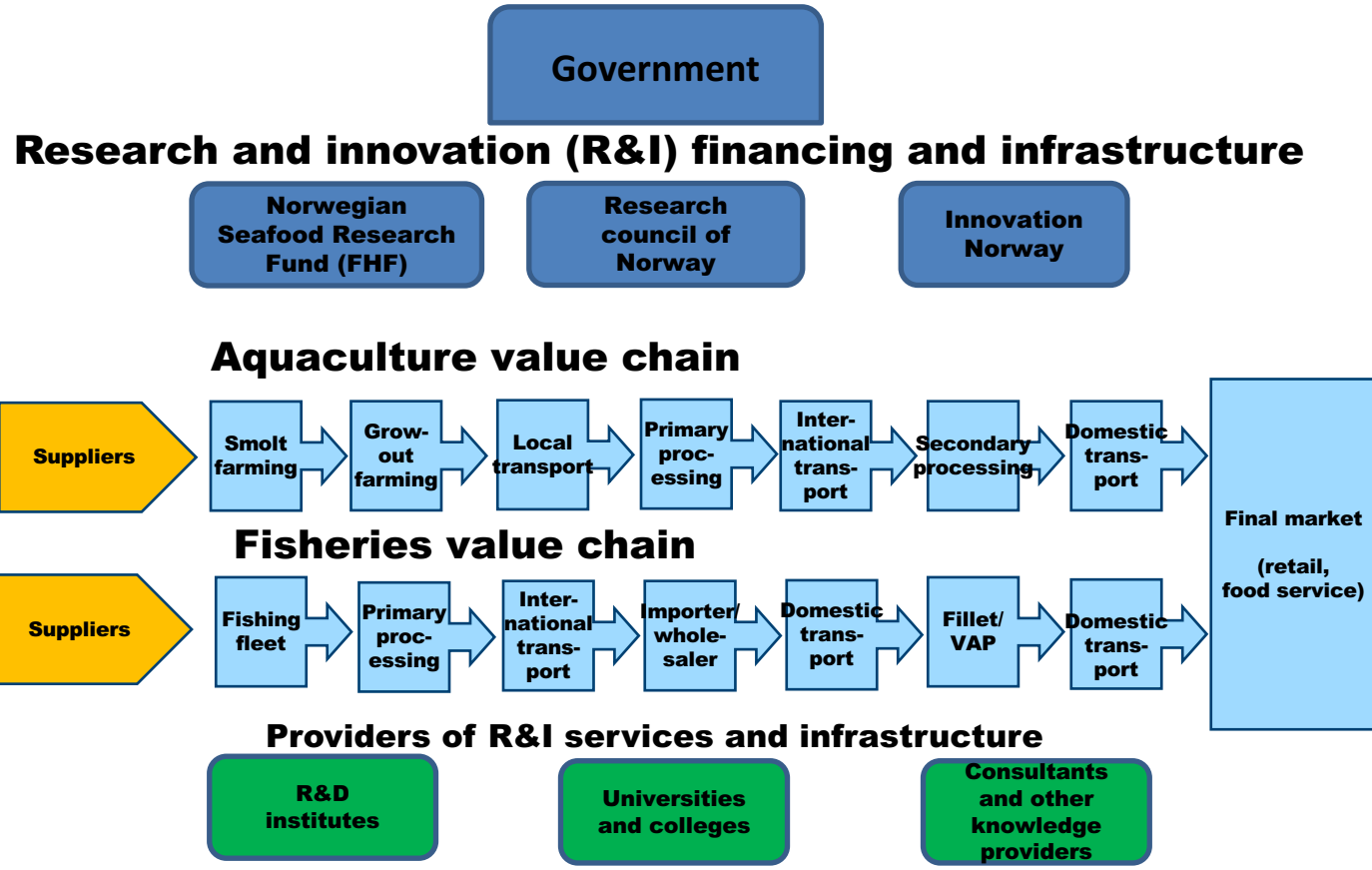
A productive relationship between aquaculture and government

- Finding the productive balance in
 - division of labour and
 - risk sharing

in the following areas

- Research & development
- Innovation investments
- Regulation of production activities and environmental effects

Seafood value chains and supporting institutions in Norway

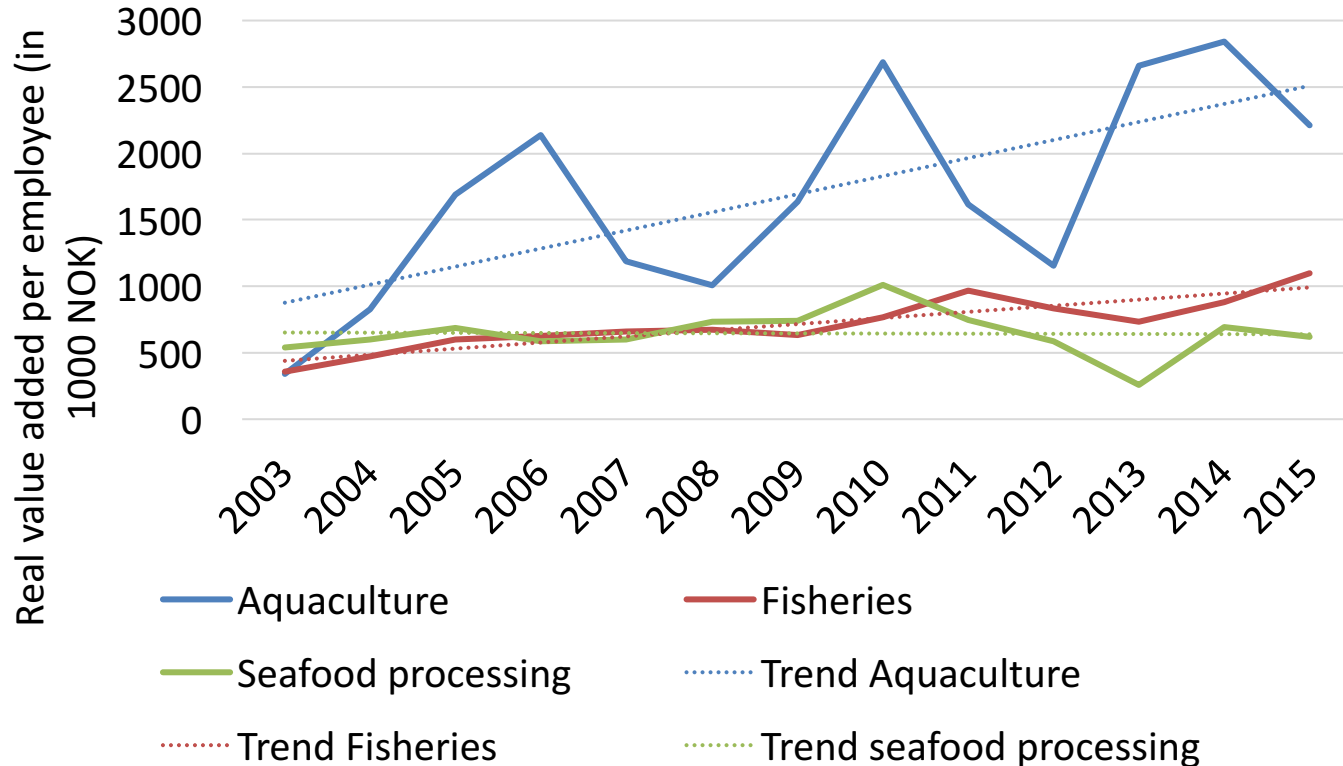


Innovation challenges for aquaculture and society

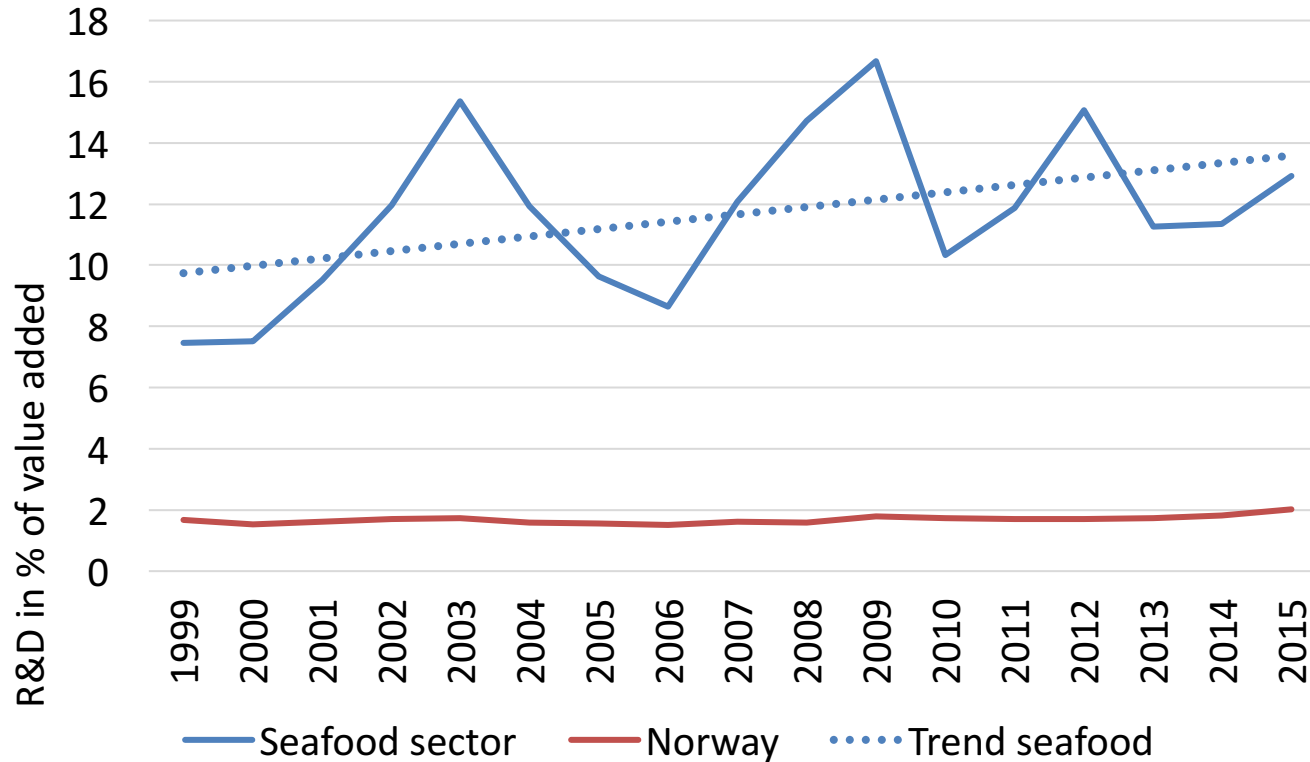
- Increasing R&D based knowledge production and innovation output from R&D
- Facilitating innovation among suppliers to aquaculture
- Facilitating large-scale, high risk innovation projects
- Public regulation innovations

Productivity – the foundation for growth

Labour productivity in Norwegian seafood sectors

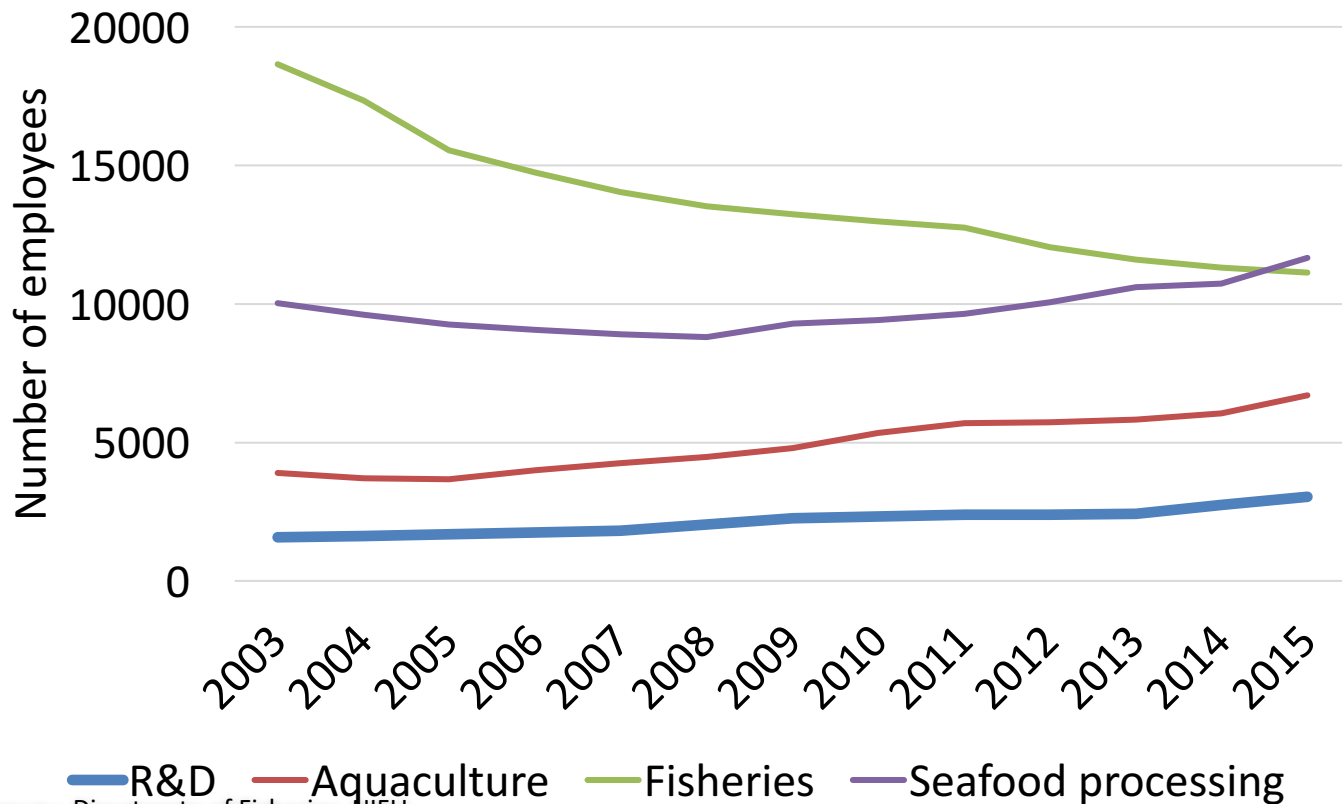


R&D spending is much higher in seafood than in the rest of the economy



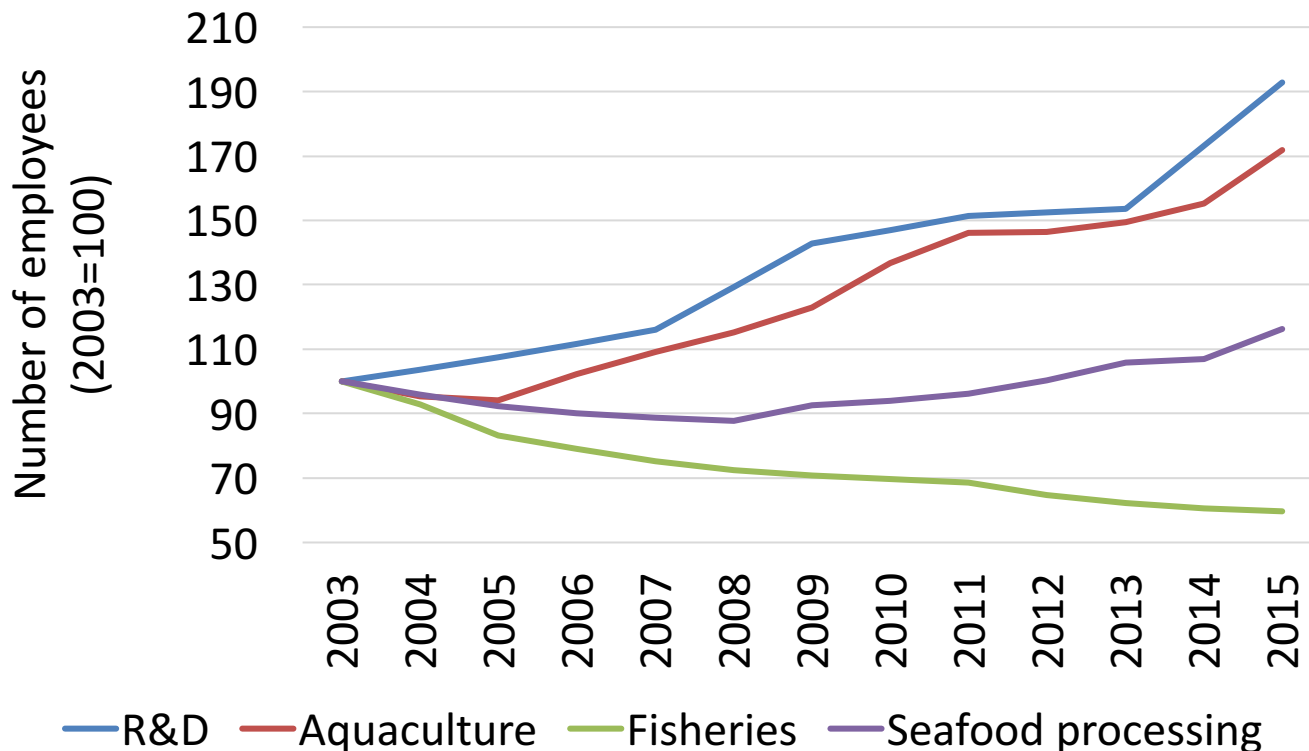
A more knowledge intensive sector

Employment in marine R&D and seafood sectors



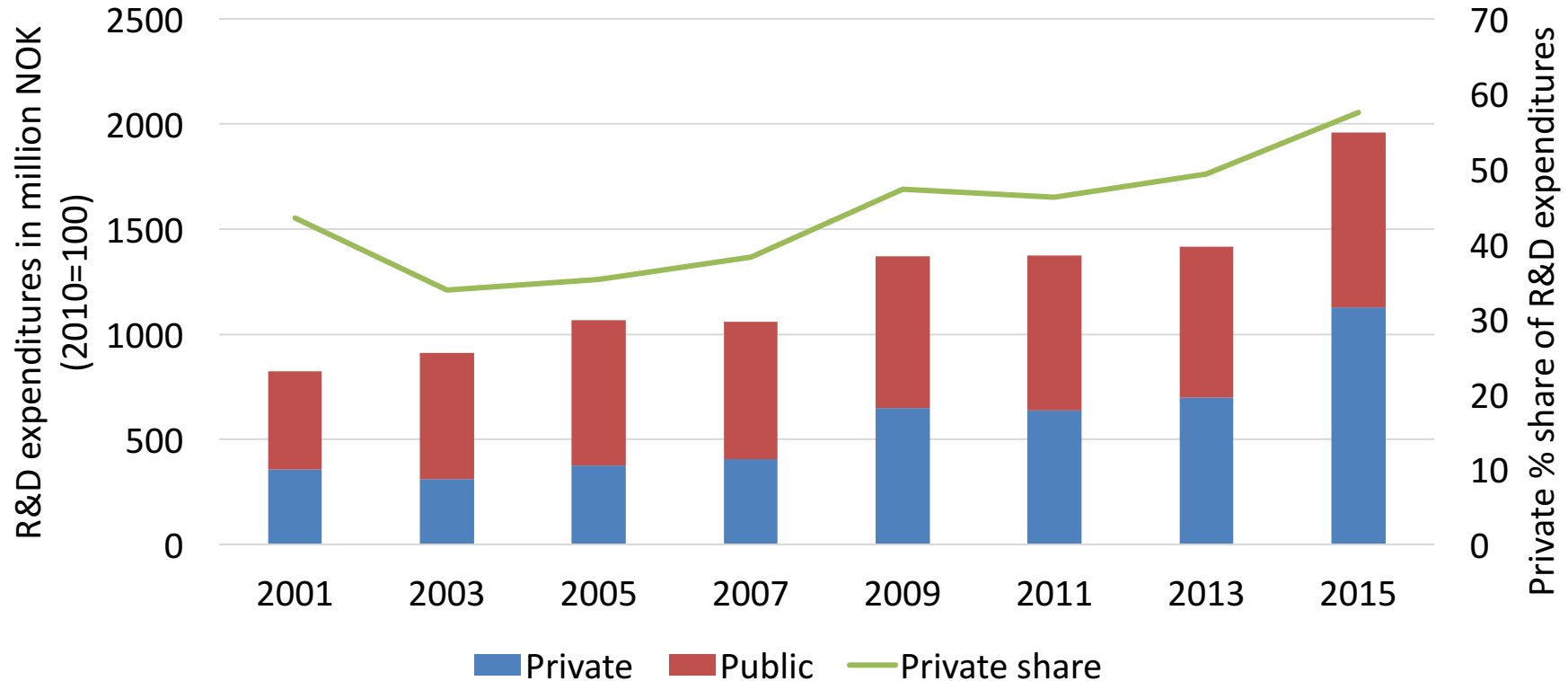
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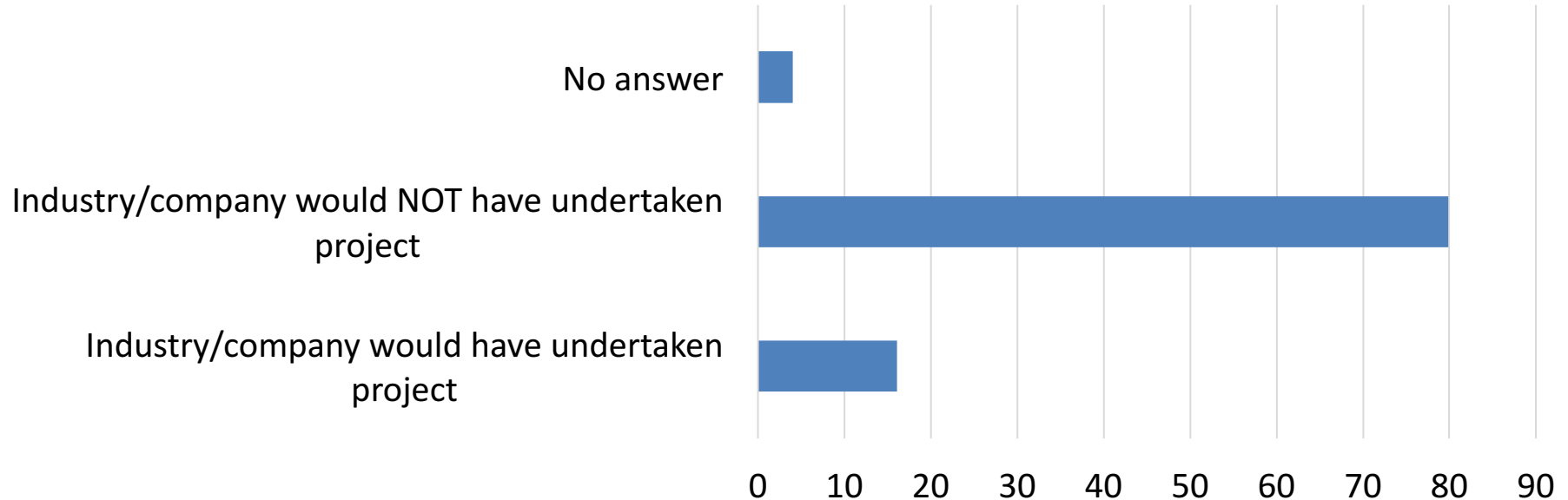
Norwegian Aquaculture R&D doubled 2005-15

Over 60% funded by private companies

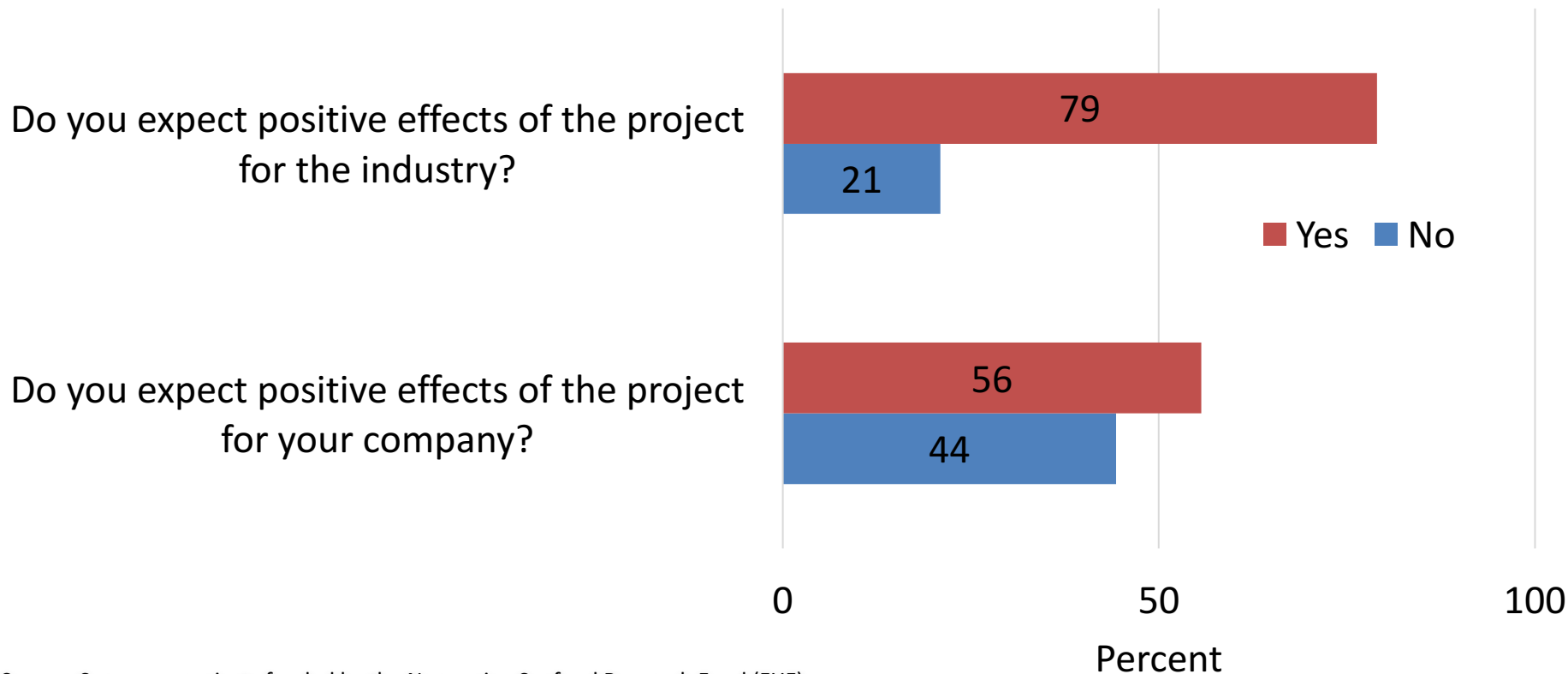


Evidence that many R&D projects require collective funding

What would have happened with the R&D project if it had not been collectively funded? % distribution



Collectively funded R&D projects with benefits for the entire sector

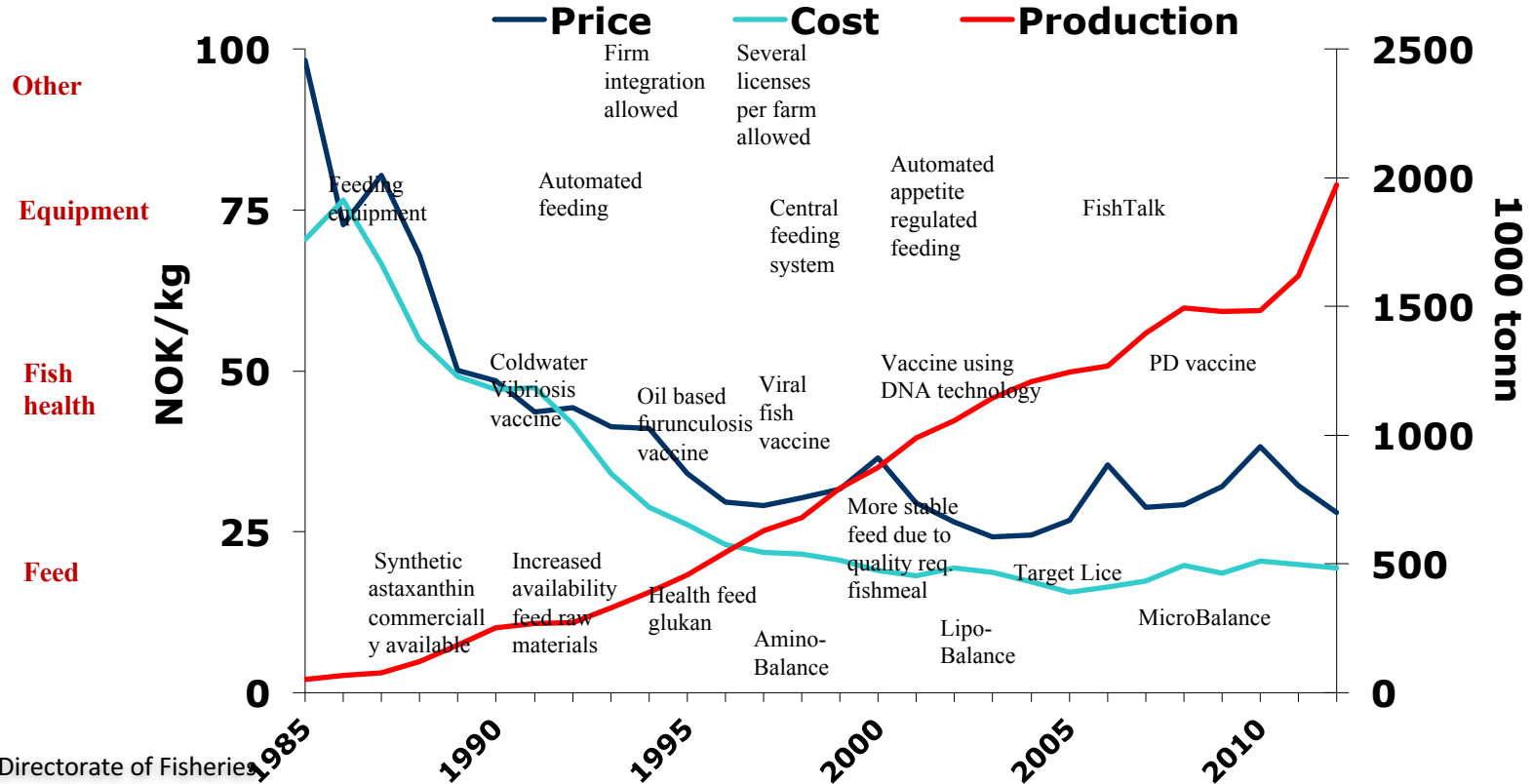


Private-public R&D collaboration and risk sharing necessary

- Much R&D will still require public funding and project execution
- Causes:
 - Long tail of firms with limited internal resources
 - Collective knowledge needs in aquaculture
 - Market failure in private R&D funding due to appropriation failures, high risks and large scale
 - Several types of R&D competence and capital most rational to have in public universities and research institutions

Suppliers did much of the job - Innovations in salmon farming

Price, production cost and global production



Aquaculture suppliers are the most innovative

Share of firms with innovation

	Product innovation	Process innovation	Radical product innovation
Aquaculture farms	12%	27%	4%
Aquaculture suppliers	38%	49%	21%
Fisheries	13%	13%	4%
Seafood processing	25%	25%	11%
Exporters & wholesalers	23%	23%	11%
Manufacturing	33%	25%	19%

Challenges for many suppliers

- Volatile and thin markets for their products
- Thin profit margins – the fruit of their innovations are harvested by the farm stage
- Innovations will increasingly depend on R&D investments
- Scale of R&D and innovation investments will increase
- Innovation policy which provide external funding, human capital and provide sufficient IP protection

Development license – incentives for investment projects with significant innovation

- Purpose: Facilitate development of technology that can solve one or more of the environmental and area challenges faced by aquaculture in Norway
- Price for salmon license in Norway: Approx. NOK 90 mill
- When project is completed and approved by Norwegian authorities project owner can convert development licenses into standard licenses at NOK 10 mill.

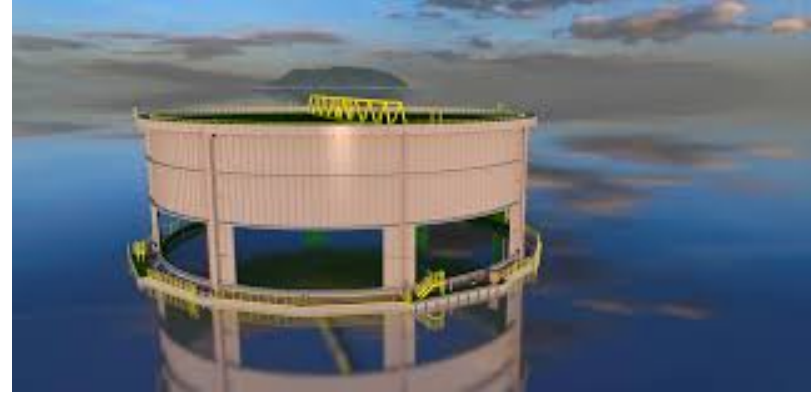
Closed production units

- Protection of the fish biomass gives new possibilities:
 - The fish is protect against parasites and pathogen microorganisms
 - Collection of sludge
 - New available areas for “food production” in exposed zones.



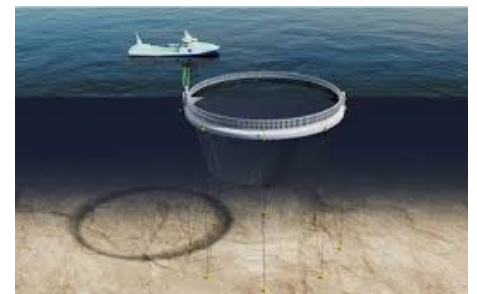
Partly closed production

- Partly protection of the biomass gives new possibilities:
 - The fish is partly protected against parasites and pathogen microorganisms
 - The technology will use the same area as traditional cage based production.
 - To be used in zones with medium pathogen sealice pressure



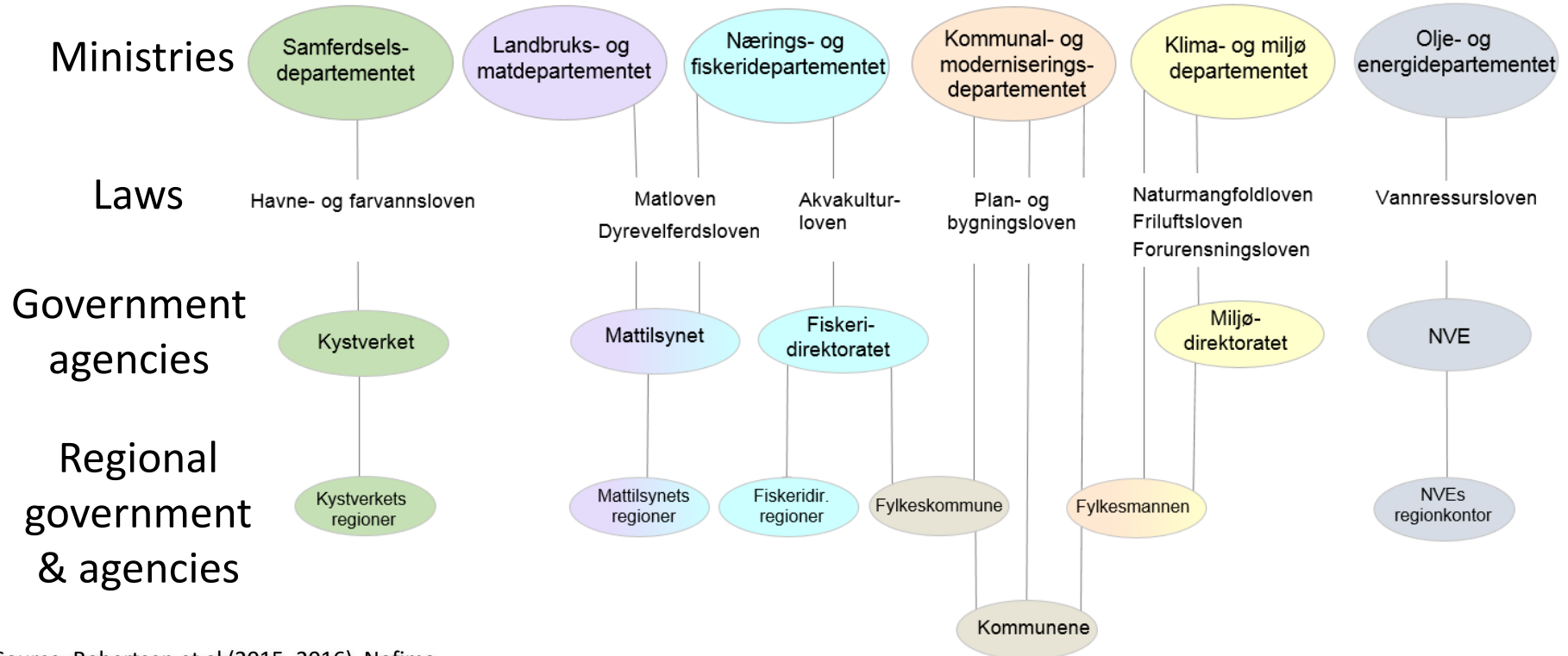
Exposed ocean technology

- New available areas for food production
- Large scale advantage, remote locations
- Increased distance to neighbour farm gives reduced biological risk



Candidate for innovation

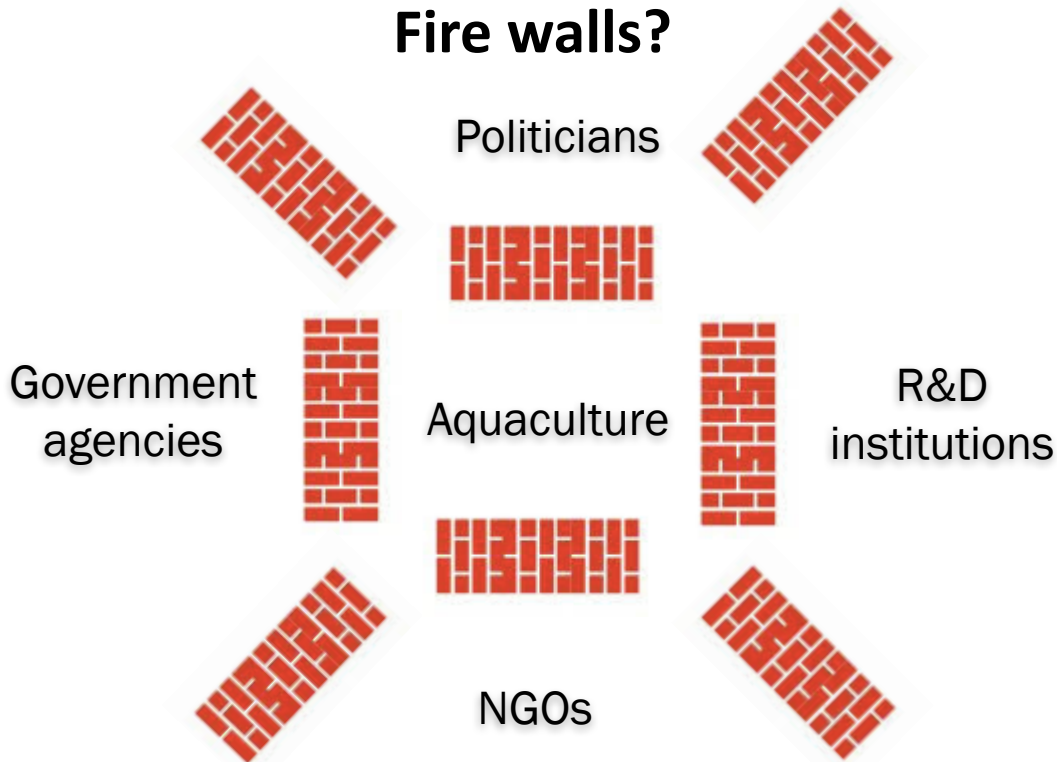
The aquaculture regulation complex in Norway



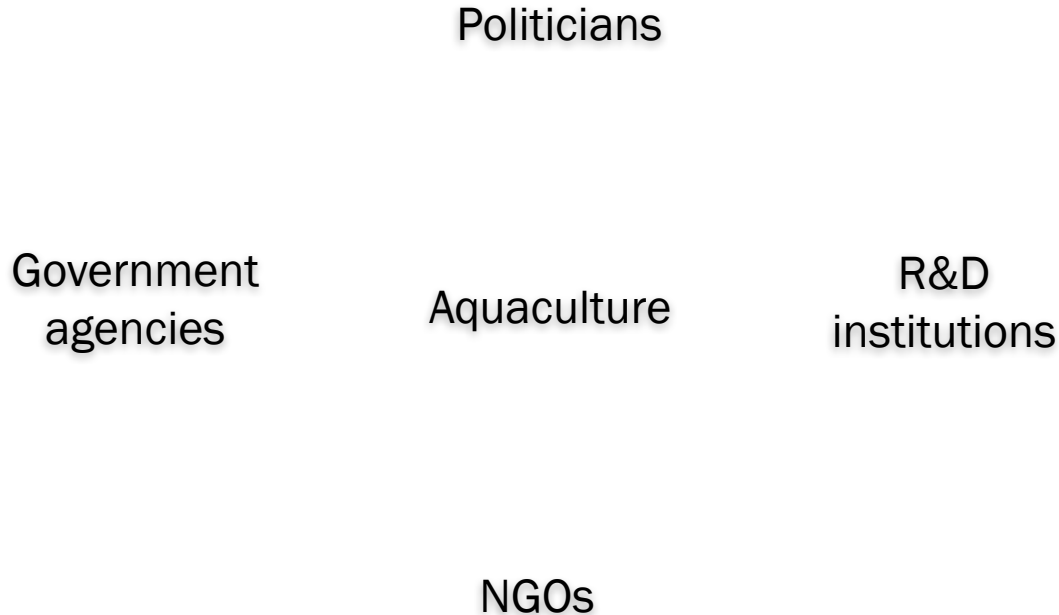
Challenges with the aquaculture regulation complex

- Veto power of several agencies
- Complex and resource demanding regulations
- Coordination between government agencies
- Coordination between municipalities
- Slow and costly processes
- Knowledge base of regulations

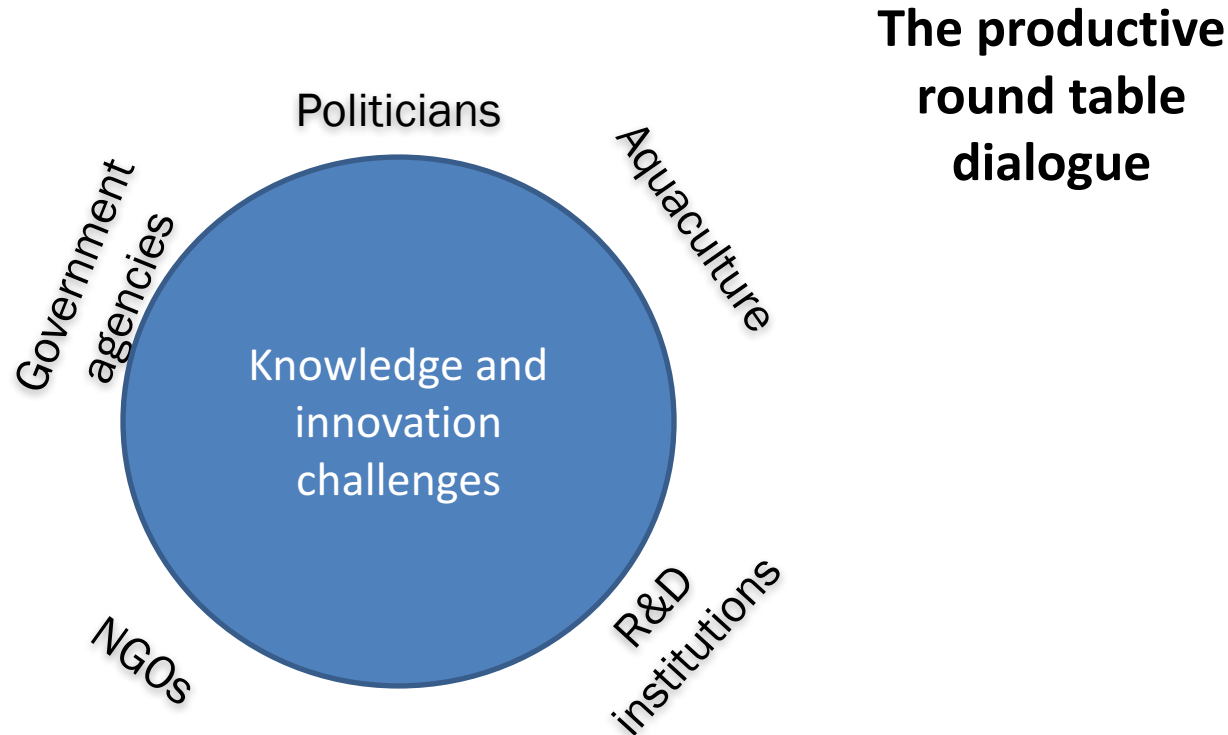
How should aquaculture, government and other stakeholders interact?



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An innovative and sustainable industry is one that finds the productive division of responsibilities, labour and risks between itself and government



...and is able to educate government and nudge it in the right directions when that is appropriate