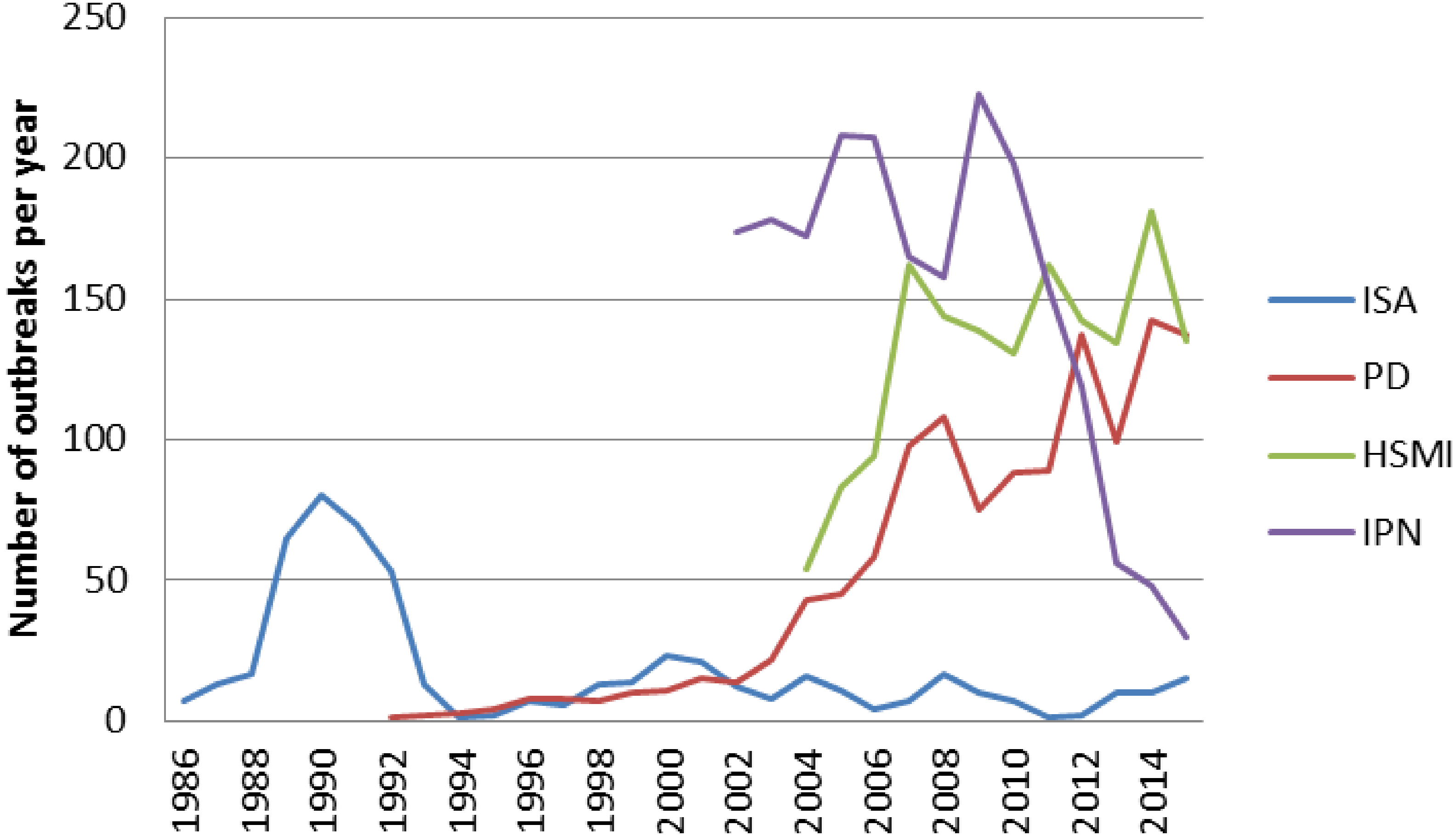
The Economics of Pancreas Disease Management

Trination meeting, Aberdeen, 12th October 2016

Arnfinn Aunsmo, DVM, PhD
COO AquaGen Norway

AquaGen

Outbreaks of viral diseases in Norwegian salmonid aquaculture 1986 - 2015



AquaGen

Development of PD in Norway

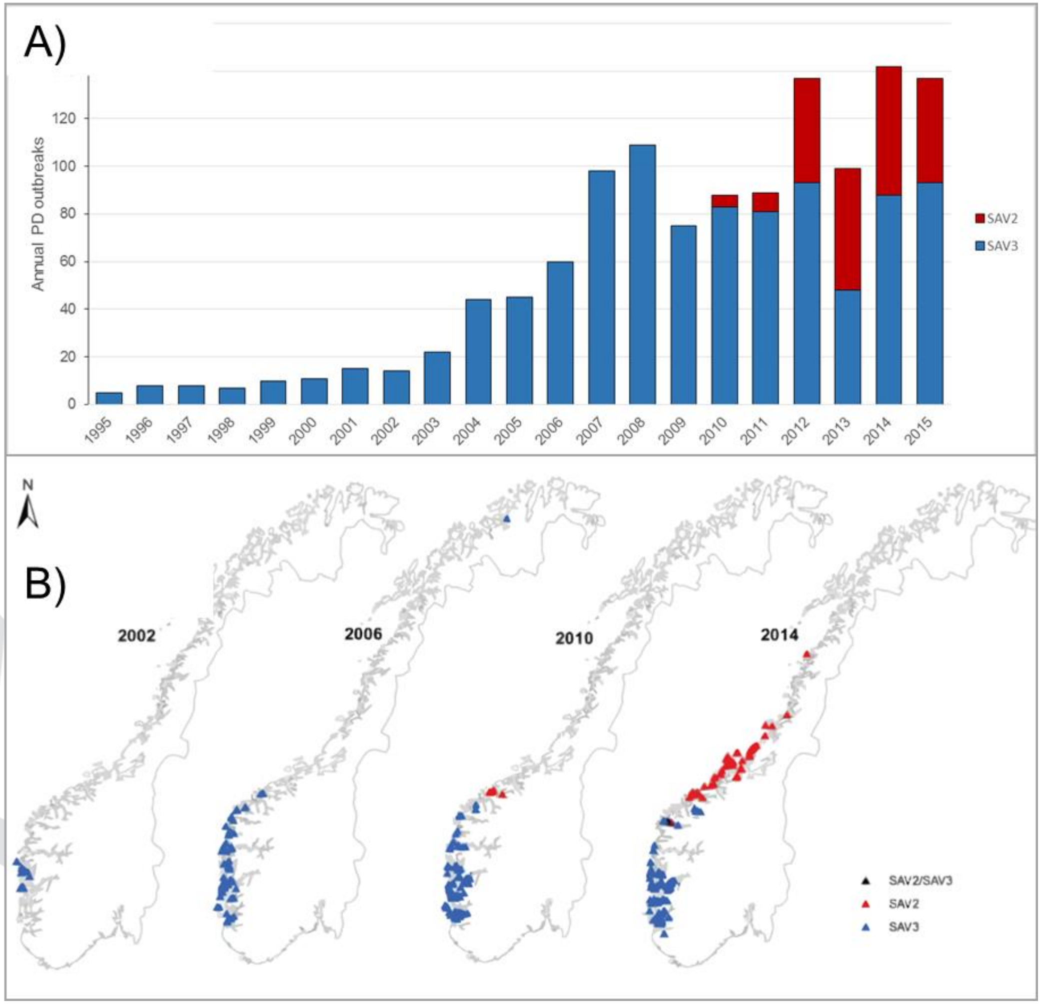


Figure 2: A) Annual PD cases in Norway from 1995 to 2015. B) Spread of PD during 2002-2014.
Source: Norwegian Veterinary Institute (NVI) (Bang Jensen et al., 2016).

Pancreas Disease (SAV) transmssion
-in Norway

- Horizontal transmission in sea is the main transmission route (Kristoffersen at al. 2009, Kongtorp et al. 2010, Jansen et al. 2010)
  - Network contact, either shared virus or shared risks
- Transport of infected smolt
  - Into naive areas
  - Crossing the disease frontiers

AquaGen

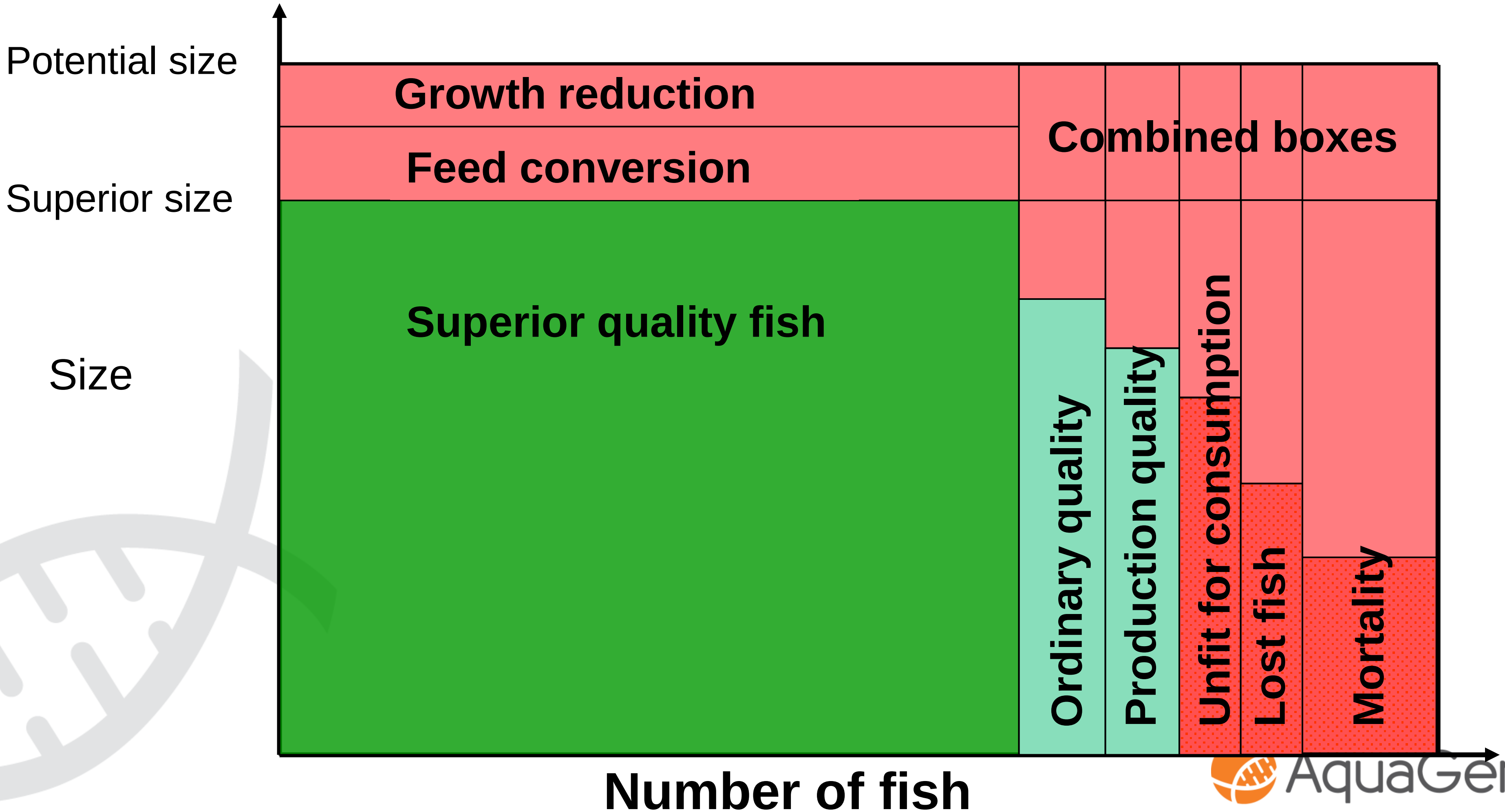
The cost of disease

Direct effects (costs)	Indirect effects (hidden costs)
• Output losses (biological losses)	• Impaired human health
• Extraordinary costs	• Reduced animal welfare
• Costs of treatment	• Environmental effects
• Costs of prevention	• Effects on the market
	• Other effects on society

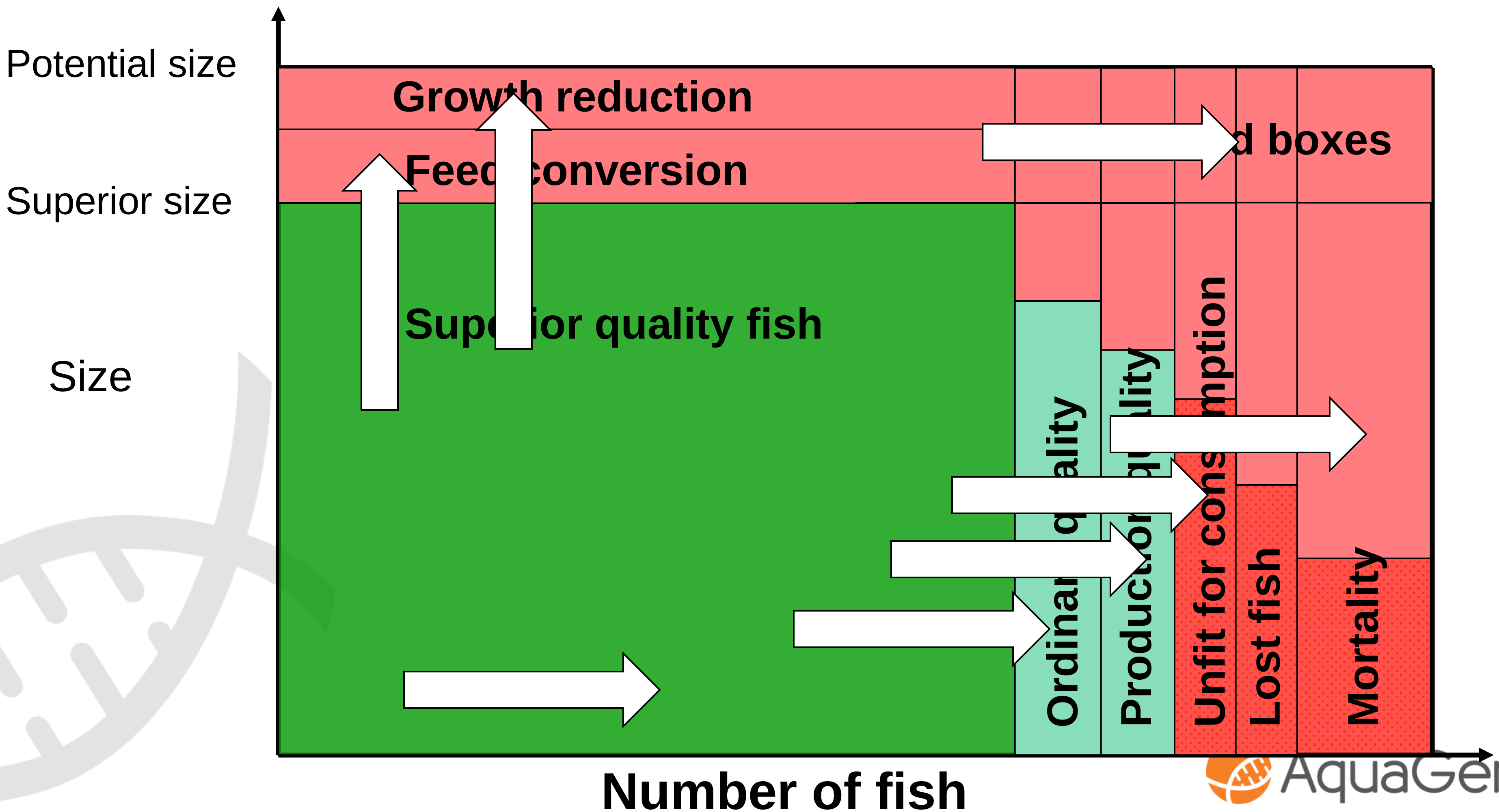
Source: After Bennett 2003, Bennett and Ijpelaar 2005

AquaGen

The biologic production-loss model (bPLM)



Biological losses Pancreas Disease



AquaGen

The cost of PD

- Ruane *et al.* 2008
  - Irish Industry (2003-2004 prod. period)
  - € 12mill. loss of profit, €35 mill loss of turnover
- Aunsmo *et al.* 2010
  - Expert opinions on 74 outbreaks 2004 -2007, endemic SAV3 area
  - Cost of PD NOK 15,6 mill. per 500 000 smolt
- Pettersen *et al.* 2015
  - Expert opinions on 138 outbreaks 2009 - 2013, endemic SAV3 area
  - Cost of PD Nok 55,4 mill per 1000 000 smolt

Table 6
The simulated mean values (5th, 50th, 95th percentiles) of the direct costs of a Pancreas disease outbreak occurring 9 months (average weight 1.91 kg) after sea transfer on a salmon farm with 1000 000 smolts (NOK million) under 2013 sales prices.

	Mean (5th, 50th, 95th)	Proportion (%)
Biological losses	43.8 (27.0, 44.3, 60.3)	79.1
Cost of treatment	0.3 (0.0, 0.3, 0.7)	0.5
Cost of prevention	5.0 (2.9, 5.0, 7.0)	9.0
Other additional costs	6.3 (3.8, 6.2, 9.1)	11.4
Insurance payout	0 (0.0, 0.0, 0.0)	0.0
Direct costs of PD	55.4 (38.0, 55.8, 72.4)	100

J.M. Pettersen et al. / Preventive Veterinary Medicine 121 (2015) 314–324

AquaGen

Approach to disease control

Strategy

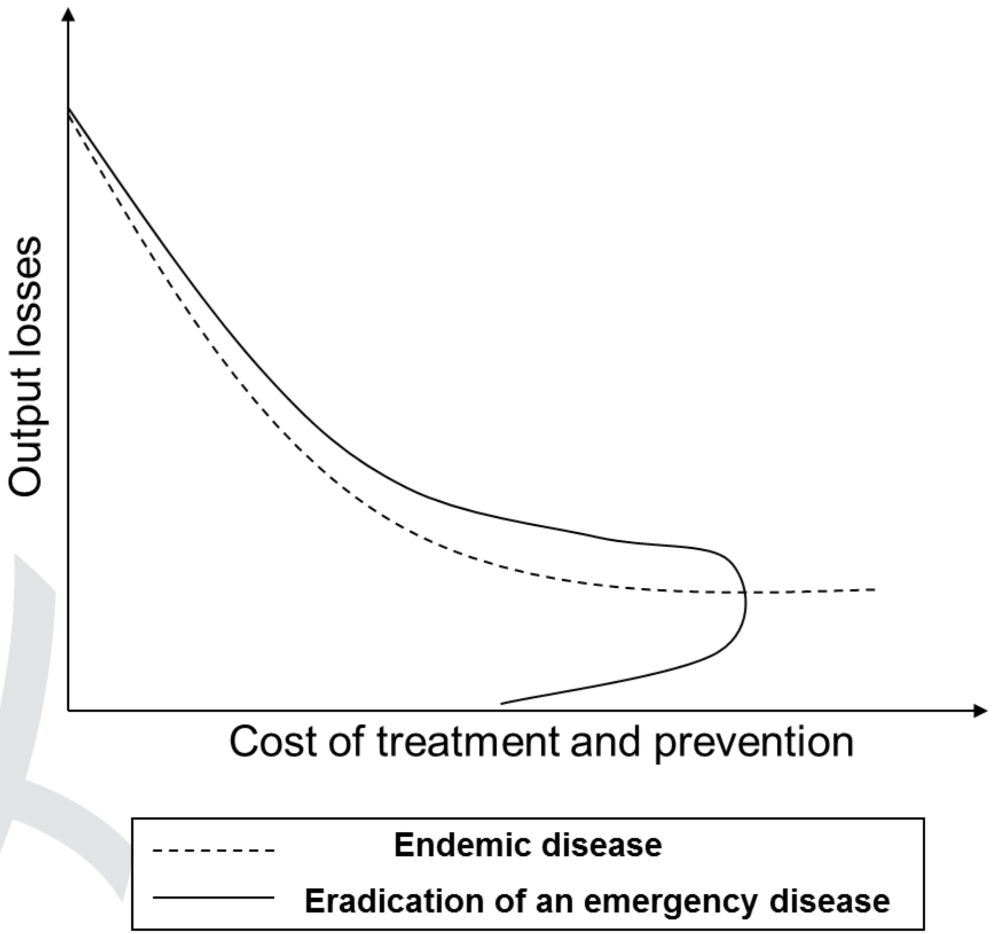
1. No strategy
   - Management without a strategy, minimize losses
   - CMS
2. Control of disease
   - "Endemic diseases"
   - IPN
3. Eradication
   - Remove infectious agent
   - ISA (Scotland)

Level of intervention

1. By the single producer
2. In the Management Areas
3. Industry level
4. Governmental level

AquaGen

The economics of disease control



Aunsmo A. (2009). - Health related losses in sea farmed Atlantic salmon - quantification, risk factors and economic impact.

AquaGen

”The equimarginal principle”

“The returns from a scarce or limited resource are maximized when the input is allocated to its most profitable uses in such a way that the return from the last unit of resources is not only equal or higher than the costs of the last unit of resource, but also the same in <u>each of the alternative uses</u>”

Dijkhuizen and Morris 1997

AquaGen

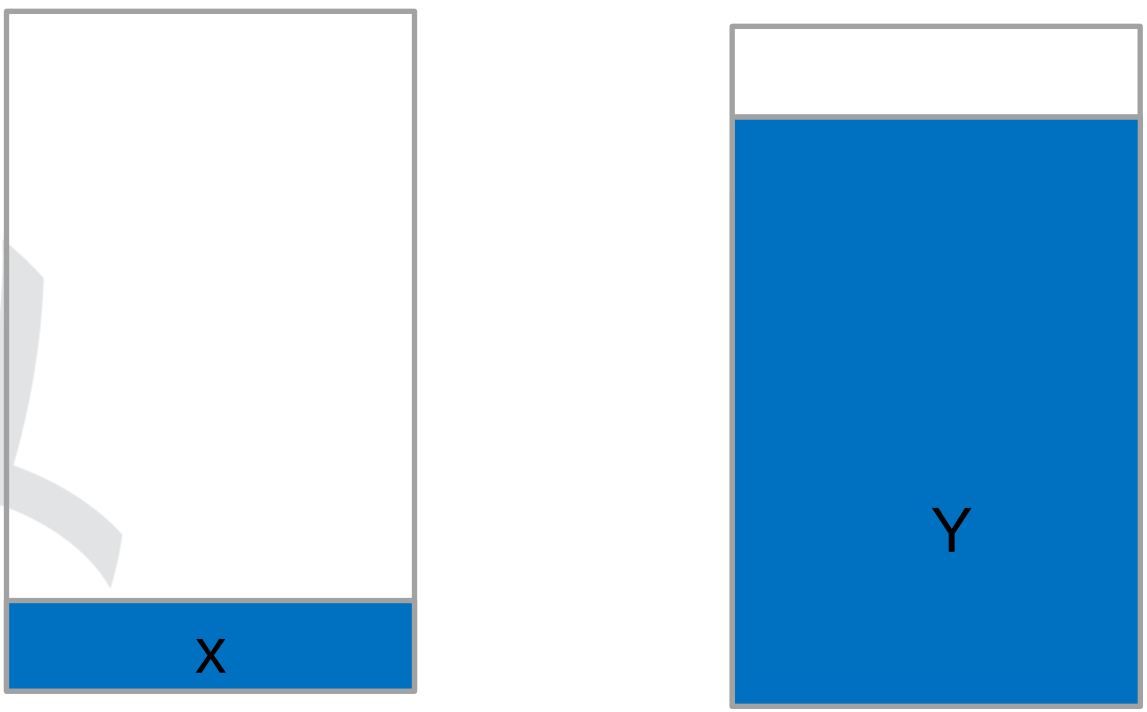
Scarce resources

- Resources are always scarce!
- Most profitable use of resources!
  - Challenging!
- Prioritization is necessary
  - In Industry
  - In Research
  - In Governmental disease control

The use of R&D in disease control

Basal R&D

Applied R&D



AquaGen

Cost-benefit of PD control

- Need to know the cost
- Need to know the benefits
- At the different levels of control
  1. By the single producer
  2. In the Management Areas
  3. Industry level
  4. Governmental level
- Effect on the market may be reflected in price

AquaGen

«Partial or full model»?

The best part about creating a symphony was beeing able to see the whole of it at a single glance in my mind

Mozart

Early harvest (by the single producer)

- Pettersen *et al.* 2015
  - «Disease triggered early harvest strategy»
- Avoid PD outbreak (SAV3)
- Screen and harvest before disease outbreak and biological losses
- Break even at ~3,2 kg round weight
- Optimization for the single producer

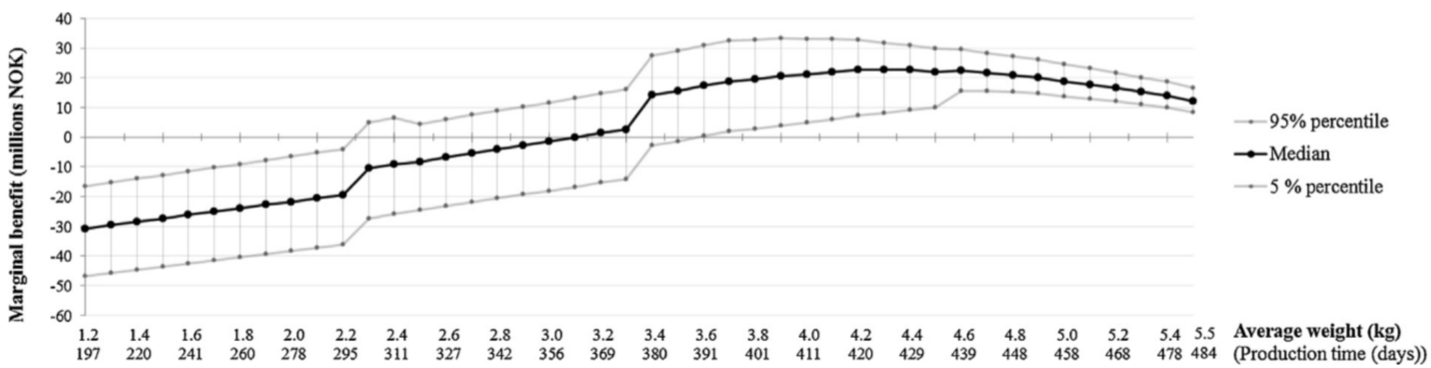


Fig. 2. The marginal benefit from performing a prescheduled harvest (scenario 1) in NOK million (5% and 95% percentiles), estimated for harvest weights between 1.2 and 5.5 kg.

AquaGen

Control in Management Areas

- Pettersen *et al.* 2016
- Shared strategy in PD-endemic MA
  - Optimize for the MA
- Cost of disease from Pettersen *et al.* 2015
- Based on an epidemiological model for spread of PD (Aldrin *et al.* 2015)
- Simulations in the period 2011 -2014
- 4 scenarios
  A. Cohorts removed on the day prior to clinical outbreak
  B. Cohorts removed if harvest is beneficial for the single cohort
  C. Cohorts removed 30 days post infection
  D. Cohorts removed 30 days post clinical disease outbreak
- Compliance levels included

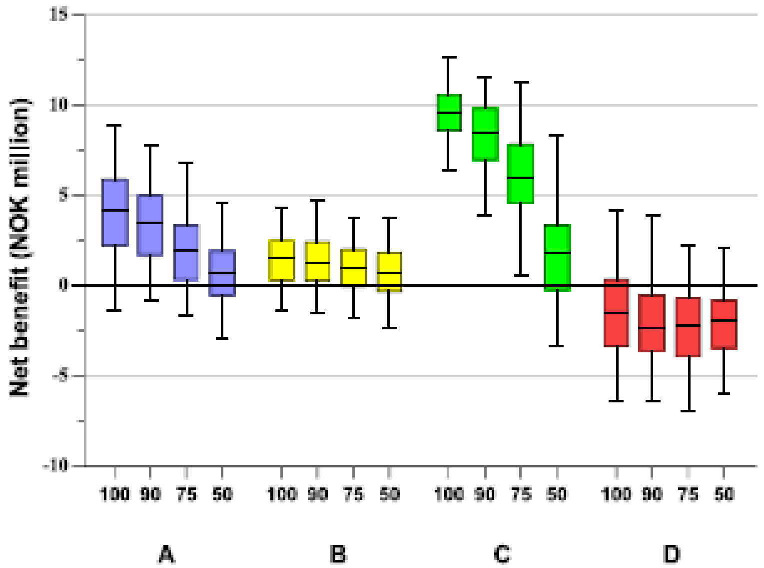


Fig. 5. Box plots (whiskers: 2.5 and 97.5%) of the net benefit per cohort (with compliance levels 90/75/50%) based on the 264 cohorts included in the economic analyses.

Sensitivity

- Epidemiological model for disease spread
- Baseline scenario
- Sales price

PD disease frontiers
-Industry or national level

- Two PD frontiers in Norway
    - SAV2 and SAV3
    - Virus spill over
- Strategy; Stamp out outbreaks north of the frontier? (relocate)
- Who pays to maintain the disease frontier?
    - Infected farms north of the frontier?
- Who rides free?
    - All the rest
- Who authorize stamp out and maintain the frontier?
    - Single producers?
    - Industry?
    - Food Safety Authority?

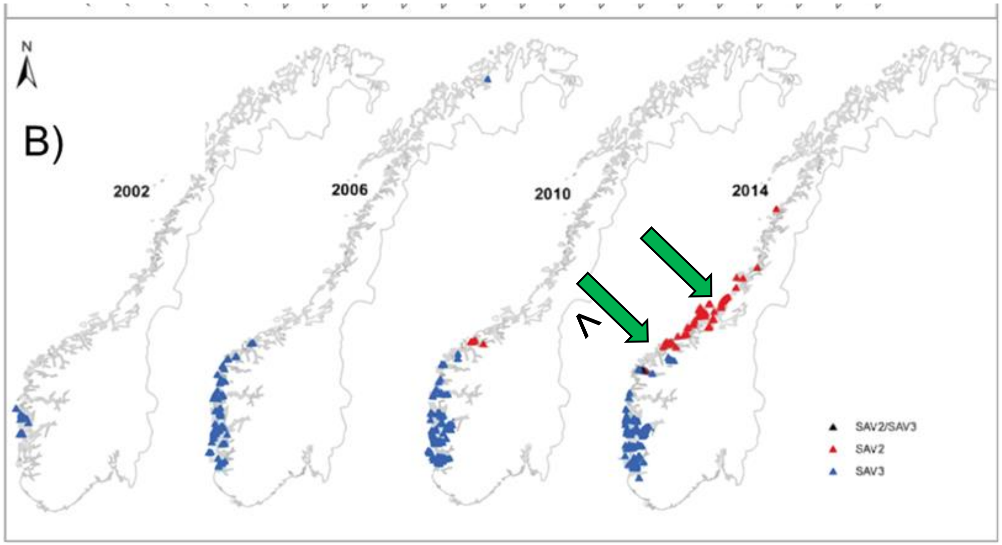


Figure 2: A) Annual PD cases in Norway from 1995 to 2015. B) Spread of PD during 200
Source: Norwegian Veterinary Institute (NVI) (Bang Jensen et al., 2016).

AquaGen

Benefit of the frontier?
- stamp out strategy
- or become endemic

- SAV2 was introduced into Mid Norway in 2010 and 2011
- Several outbreaks
  - Stamp out or become endemic?
- Estimated the cost for an average site in the region for three different scenarios (A. Aunsmo 2011):

Scenario	Cost PD SAV2 (NOK)	Benefit vs. scenario 1
1) PD SAV 2 endemic, 50% of sites with outbrak	-13,2 mill	
2) PD SAV2 exotic, 10% outbrekas	-8,5 mill	+ 4,7 mill
3) PD SAV2 exotic, 20% outbreaks	-15,7 mill[1]	-2,5 mill

- All industry north of the region rides free!
- Not included in the benefits of stamping out vs. becoming endemic

AquaGen

Vaccination, functional feed and improved genetics.

- Generally a lack of field studies documenting effect
  - Especially on cost effectiveness
- Often reported as significant findings in biological studies
  - Laboratory trials, field trials more rarely
  - Significant findings reported, but P-values is also an effect of n!
  - Increased sampling improve on the P-value, but not the benefit
- Wee need good effect data
  - Independent?
- Are the resources used in the most cost effective way?
  - "also the in each of the alternative uses"?

AquaGen

Vaccination

- Bang Jensen *et al.* 2012
  - 198 cohorts at 170 sites, 111 developed PD (2007 -2009)
  - 123 cohorts vaccinated, 59 developed PD
  - Reduced odds for PD outbreaks if vaccinated with 3x vs un-vaccinated fish
  - Reduced cumulative mortality and reduced discarded fish

Table 3. *Salmo salar*. Summary of descriptive statistics for the 4 response variables used to analyse production loss for non-vaccinated and vaccinated cohorts. The results of single variable logistic regressions are summarised by p-value

Risk factor variables	Non-vaccinated cohorts		Vaccinated cohorts		p
	Mean ± SD	90 % range	Mean ± SD	90 % range	
Cumulative mortality	22.5 ± 12.6	4.2–43.2	15 ± 11.9	2.7–39.9	<0.001
Growth rate	0.72 ± 0.11	0.58–0.83	0.75 ± 0.1	0.60–0.89	0.036
Feed factor	1.18 ± 0.07	1.08–1.30	1.19 ± 0.07	1.09–1.32	0.36
Discarded	2.74 ± 2.71	0.60–7.50	1.28 ± 1.43	0.10–3.70	<0.001

AquaGen

Externalities, disease frontiers and free riders

- **Externality** is the cost or benefit that affects a party who did not choose to incur that cost or benefit. SAV transmission between farms with subsequent PD is such an externality.
- We can **Internalize** an externality, so that costs and benefits will affect mainly parties who choose to incur them.
- **Compartmentalization** can not substitute **Disease Outbreak Management** (DOM)
  - Virus will spill over frontiers or between MAs
  - Stamping out/ early harvest is effective and necessary in maintaining disease frontiers
  - Also cost effective if we can internalize control cost
- But currently; The single fish owner pays and all the rest rides free!
- The principle of "**Who benefits pays**" should apply

AquaGen

Demo model PD Trination meeting

- Modelling cost of PD
- Modelling benefit of PD Control
- What are the main factors?

- Model

AquaGen

No single answer…

- Different companies have different costs of disease and thus also benefits
- Salmon price has a large effect on costs of disease and thus also on benefit of control
- Uncertainty in effect of disease and effect of control
- Variation in effect of disease and effect of control

Summary

- Pancreas Disease is costly, SAV3 especially in Norway!
- Costs of PD and benefit of control can be modelled
- Control will be cost-effective in many situations
  - Disease triggered early harvest
  - Depopulation in MA`s
  - Maintaining Disease Frontiers
  - Effective vaccines, improved genetics and functional feed
- Economic models are useful as support in decision making
  - "Oracle models" do not exist!
- Many stakeholders
  - Different disease situations between companies
  - Different levels
  - Who pays the cost and who take the benefit!
- We should look for optimal use of scarce resources!
- In <u>each of the alternative uses</u>

AquaGen


Thank you!