

# Risk Analysis in Aquaculture

Workshop for  
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# Programme for today

- Hazards
- Risk Assessment as a decision making tool
- Risk based surveillance
- Risk categorization of fish farms



# Outline

- Definitions
- Why do risk analysis
- Basic principals
- Examples
- Constraints



# What is a risk analysis

*An objective, systematic, standardized and defensible method of assessing the likelihood of negative consequences occurring due to a proposed action or activity and the likely magnitude of those consequences*

Or...

- a model building process aiming to identify, describe, manage and communicate a risk
- a tool for *science-based decision-making* (manage alternatives)
- a tool for how to deal logically with uncertainty and incomplete knowledge

# What is «risk»

Risk (as a noun)

- the chance of something going wrong
- any hazardous entity likely to cause injury, damage, or loss
- the probability, amount, or type of possible loss incurred and covered by an insurer
- the possibility of loss in an investment or speculation (in finance).

# Risk

## In epidemiology:

- Risk is the probability that an event will occur in a specified time interval (Last 2000)

## General concept

- .. does not exist independent of our minds and culture, waiting to be measured.
- .. is invented to understand and cope with dangers and uncertainties of life.
- .. is subjective

# Risk in Risk Analysis

*Aquatic Animal Health Code, 2012* : **risk** means the likelihood of the occurrence and the likely magnitude of the biological and economic consequences of an adverse event or effect to animal or human health

Society for RA:

estimation of risk is usually based on the probability of the event occurring times the consequence of the event given that it has occurred

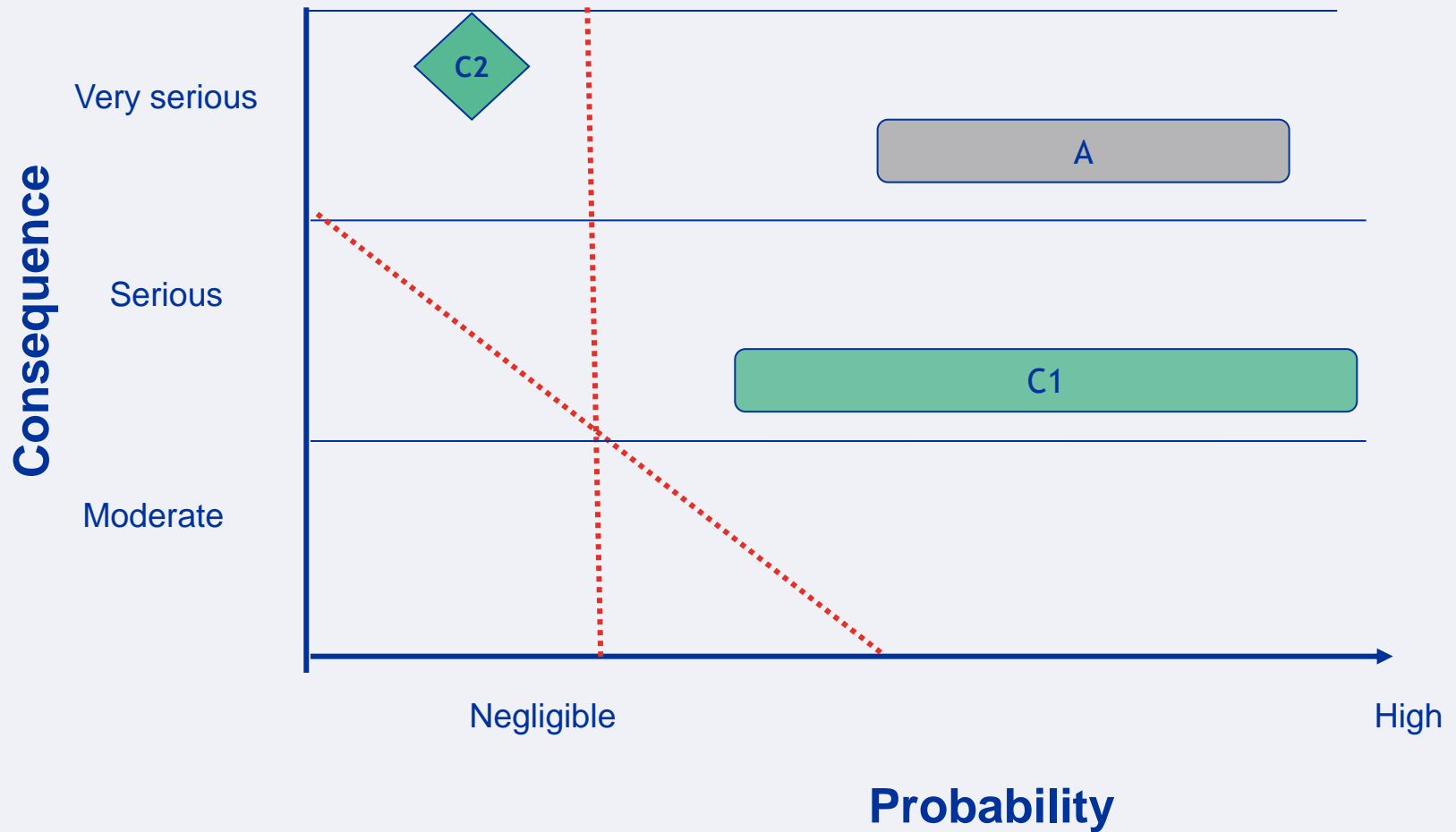
**Risk = probability x consequence**



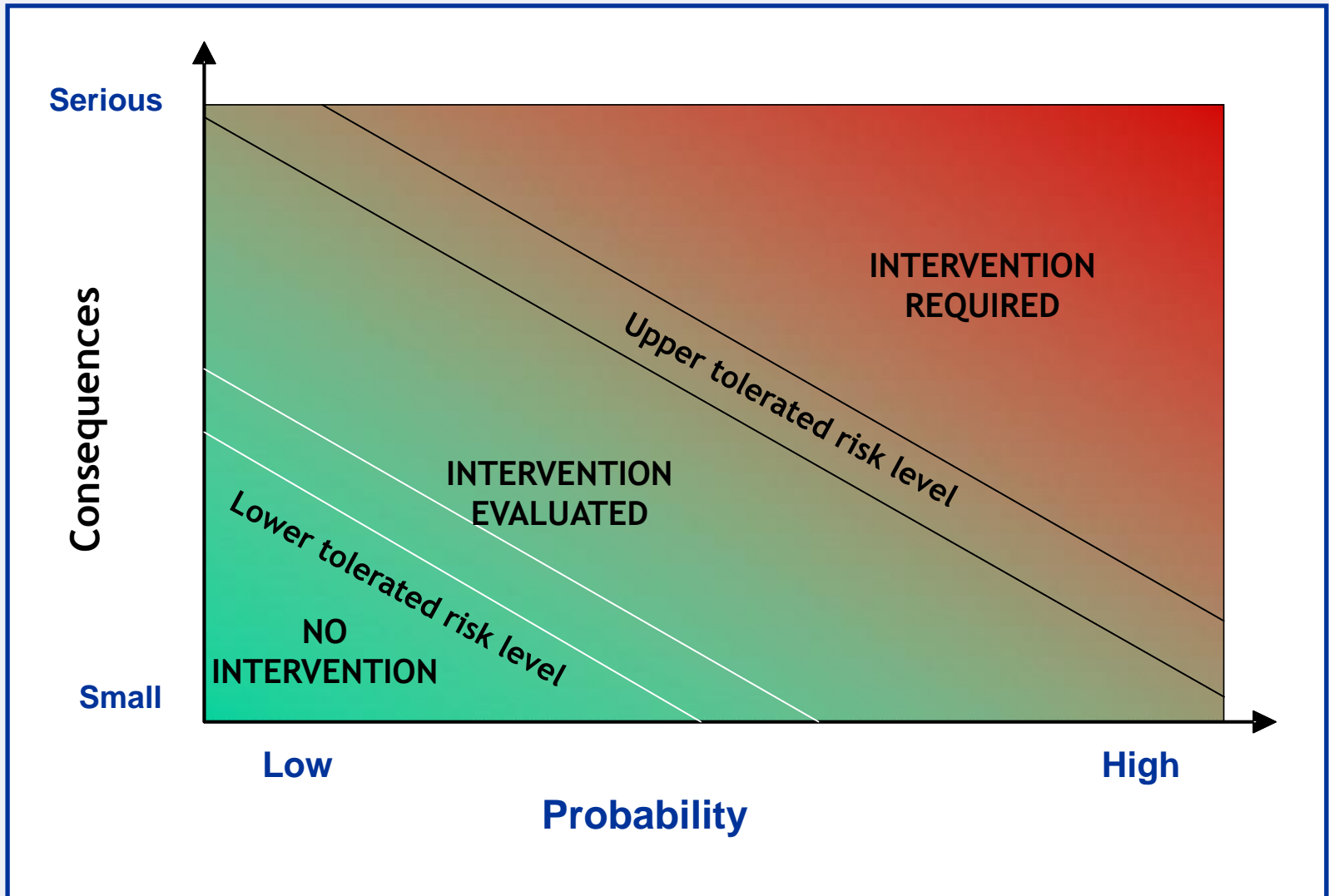
# Risk matrix

PROBABILITY						
Very high probability	5					
High probability	4			20		
Probable	3		18			
Not probable	2		50			
Very low probability	1					
		Minor	Significant	Severe	Major	Catastrophic
		CONSEQUENCE				

# Risk matrix



# Risk matrix

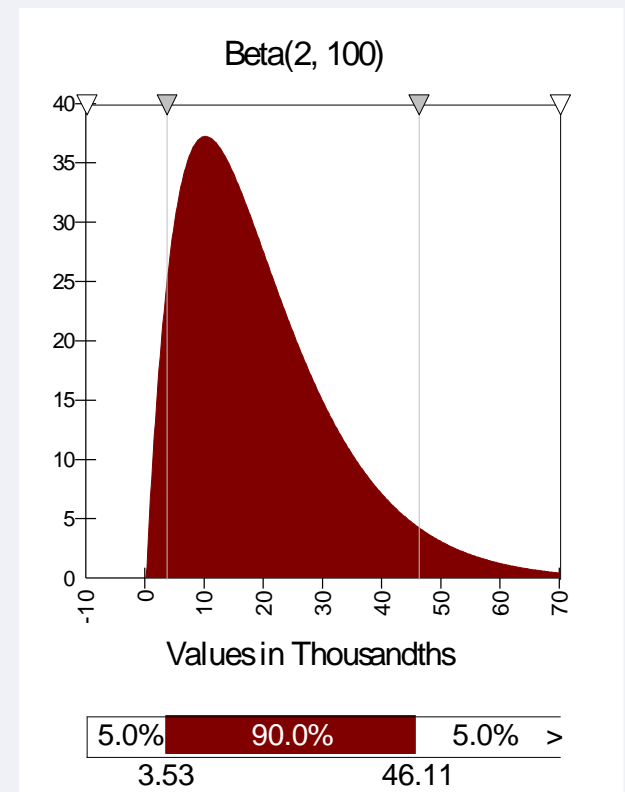


# “Total uncertainty”

- Uncertainty
  - due to limited knowledge
  - imprecise measurements
  - can be reduced
- Variability
  - normal variation
  - can be measured and explained
  - can not be reduced

# Distributions

- Make us able to describe uncertainty and variation
  - stochastic variables
- Describe the likelihood of a given outcome of a stochastic variable (a stochastic process)
- Depicted in a xy-diagrams;
  - Y= any value for the variable
  - X = probability for occurring

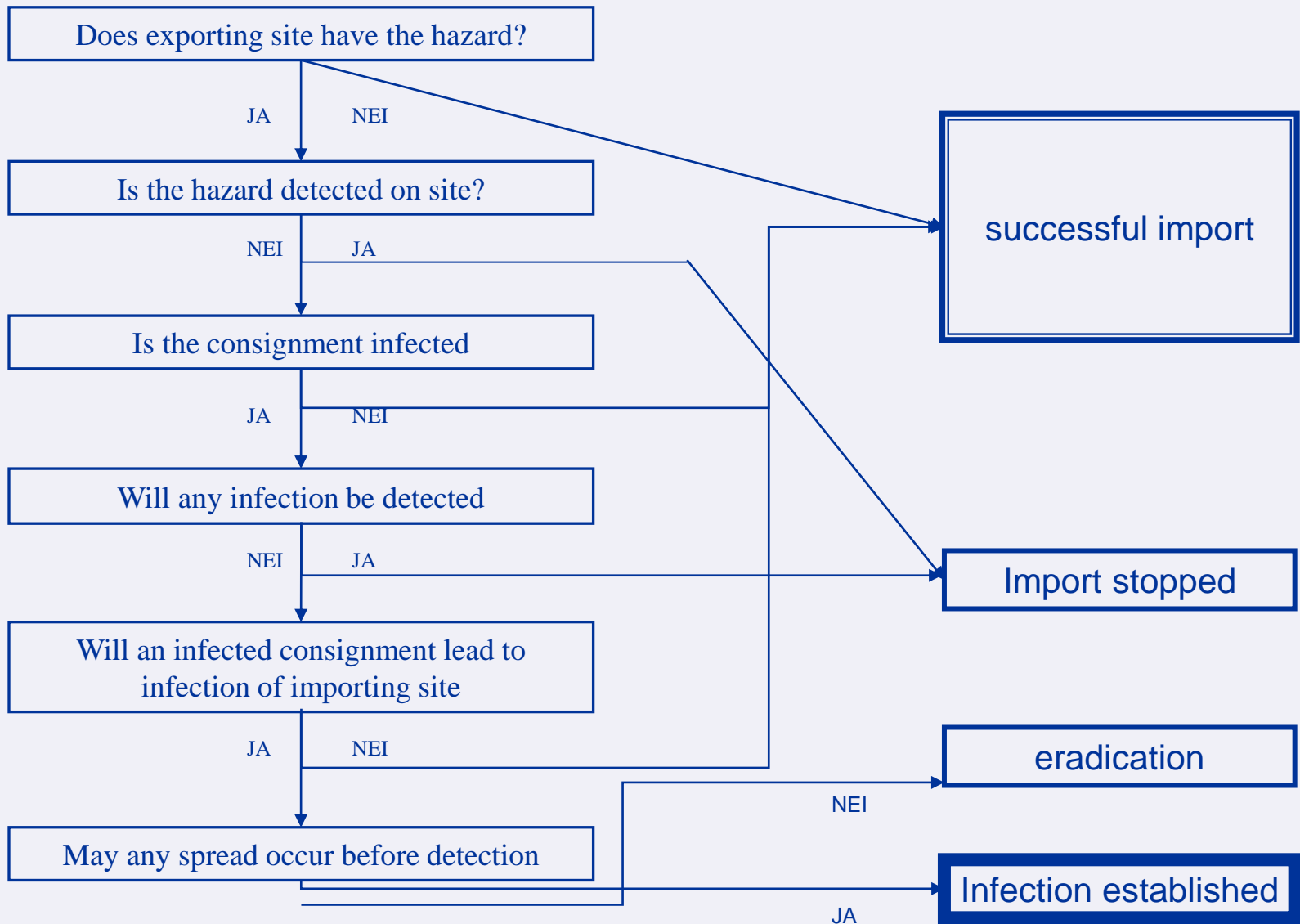


# Sensitivity analysis

- Testing how and to what extent the various variables and their related uncertainty in a model affects the final result

# Scenario tree/Biological pathway

- A visual step by step graphic presentation (model) of the pathway for all physical and biological events required for the hazard to occur.
- Each step can be dedicated a likelihood of occurring
- Identifies knowledge and knowledge gaps
- Guides strategic management



# Why do we need risk analysis in aquaculture

International aquaculture is an integrated part of the local ecology and has a number of *biosecurity, physical concerns* that pose risks and hazards to both its own development and management, and to the aquatic environment and society

# Drives for risk analysis

- Foremost is for resource protection (human, animal and plant health; aquaculture; wild fisheries and the general environment) as embodied in international agreements and responsibilities.

Other drivers of risk analysis are:

- trade
- food security
- Food safety, high quality products
- production profitability
- other investment and development objectives





# *Basic principals*

# Four basic components in risk analysis

- Hazard identification
- Risk assessment
- Risk management
- Risk communication



# Hazard identification

The process of identifying which hazard(s) that could potentially produce consequences

- problem formulation - to formulate the problem being addressed, and the scope of the risk analysis;
- close collaboration with stakeholder for a precise definition of task to be assessed (face to face meetings)

# Risk assessment

the process of evaluating the likelihood that a defined hazard will be realized and estimating the biological, social and/or economic consequences of its realization



# Risk assessment

- Release assessment - determine the likelihood that a hazard will be transferred (with a consignment)
- Exposure assessment - determine if the transferred hazard will be able to establish
- Consequence assessment - quantify the possible damage the established hazard may cause
- Risk estimation - integrating the estimation of the probability of release and exposure events with the results of the consequence assessment to produce an estimate of the overall risk or probability of the event occurring.

# Qualitative vs Quantitative

- **Qualitative RA** (risk *estimates* in "high", "moderate" "little", "negligible ")
  - Often a first choice
  - Quick, low requirement for data
  - Low level of precision , no measure for uncertainty
- **Quantitative RV** (risk estimates in numbers)
  - Deterministic- model: using fixed (average) values
    - quicker, moderate quantitative data need
    - low precision for uncertainty
  - **Probabilistic**-model: using distributions for uncertainty and variability
    - good estimates for uncertainty, sensitivity analysis
    - high demand for resources (time, money and competence)

# Risk management

The handling of the risk assessment and implementing necessary means to reduce either the likelihood of realization or the consequences of it

- ensure that a balance is achieved between a country's desire to minimise the likelihood or frequency of disease incursions and their consequences and its desire to import commodities and fulfill its obligations under international trade agreements (OIE).

- Deal with policy related to risk
  - Acceptable level of risk
  - Recognition of unacceptable risk and that some "risky" actions cannot be managed and therefore should not be permitted under any circumstance
  - Application of the precautionary approach
- Concept of equivalence where alternative risk management measures achieving the required level of protection are equally acceptable
- Benefits ?

# Risk communication

- A multidimensional and iterative process by which stakeholders are consulted, information and opinions regarding hazards and risk during a risk analysis is gathered, and risk assessment results incl assumptions and uncertainty, and management measures communicated.
- Should ideally begin at the start of the risk analysis process and continue throughout
- Should be open and transparent
- Peer review of the risk analysis is an essential component of risk communication for obtaining a scientific critique aimed at ensuring that the data, information, methods and assumptions are the best available

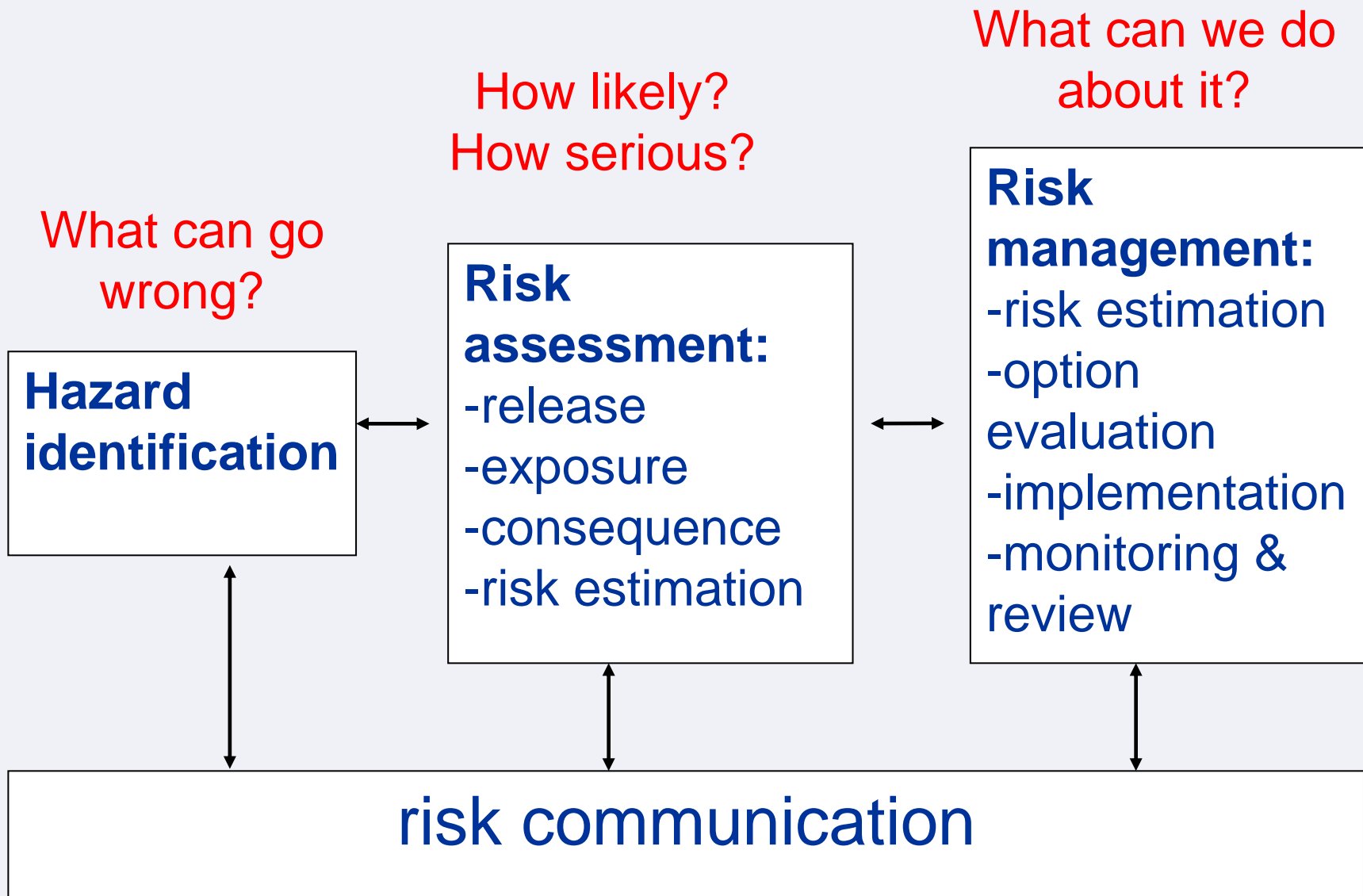
# Risk analysis

strives for

objectivity, but

contains elements of subjectivity

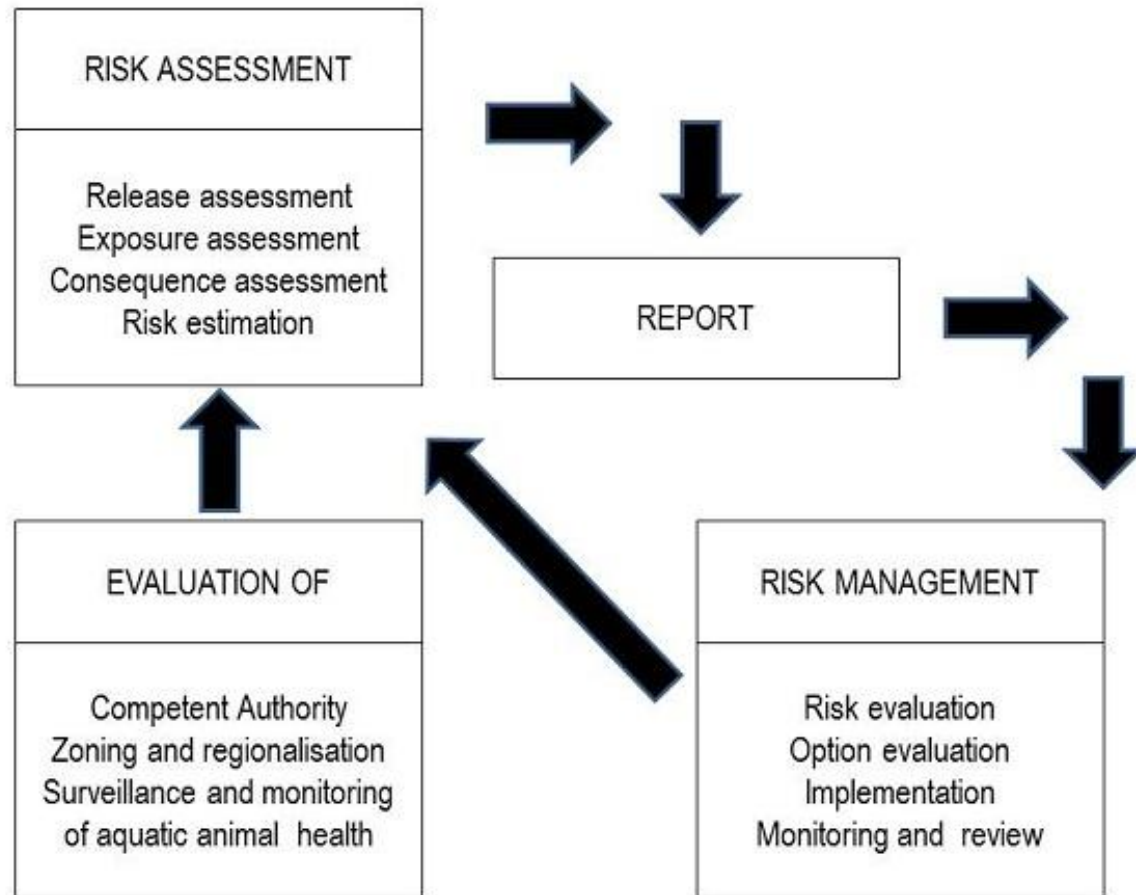
→ transparency is essential.



# From the Aquatic Animal Health Code

- No a single method of import risk assessment has proven applicable in all situations
- The process needs to include an evaluation of the aquatic animal health service, zoning and regionalisation, and surveillance systems in place in the exporting country

# Evaluation of exporting country



# Application of risk analysis

## ■ Biological risks

- Pathogen risks (WTO/SPS/OIE)
  - IRA
  - Biosecurity
  - Surveillance
  - Categorization/profiling
- Ecological risk
  - Genetic impact
  - Invasion of non-naïve species
- Algae
- Predators

## ■ Food safety and public health risks (SPS agreement/Codex)

- Whole chain surveillance
- Traceability, harmonization of standards, equivalence

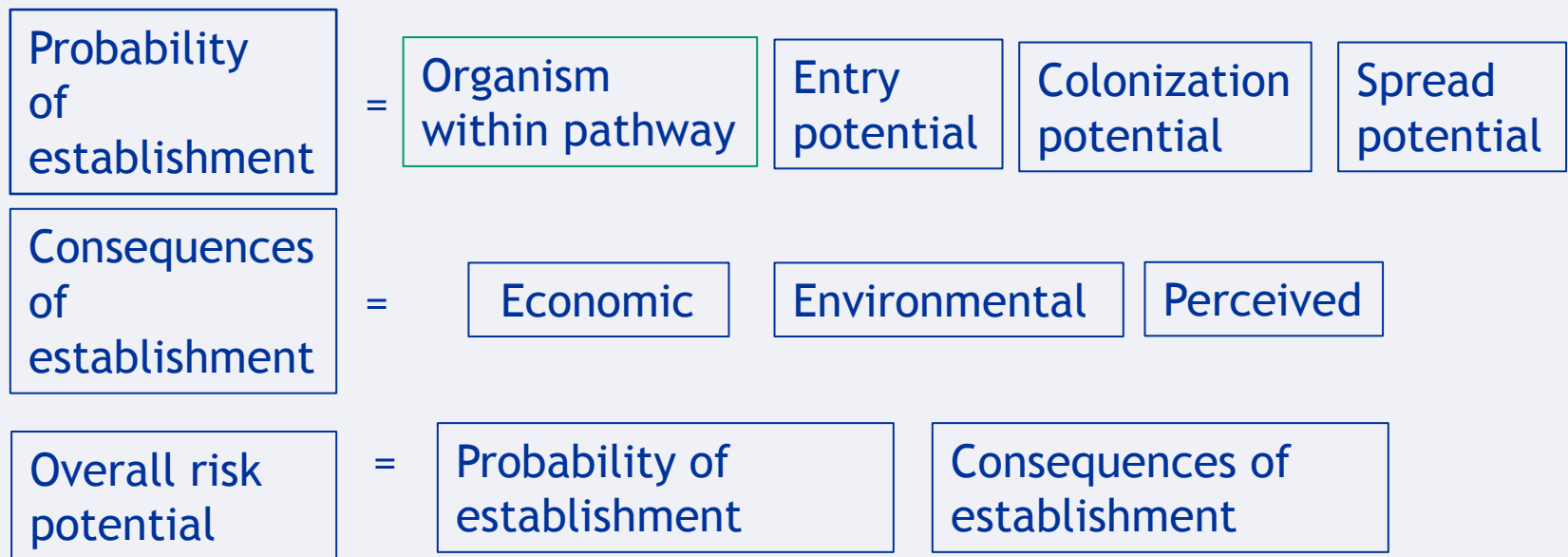
- Environmental risks
  - Various pollution from aquaculture- to aquaculture
- Financial risks
  - Operational risks
  - Market
- Social risks
  - Employment
  - Reputation
  - Welfare
  - Resources, location (competition)

# Application of risk assessment to obtain risk-based surveillance programmes and the epidemiological contributions providing the basis for risk assessments

Surveillance design steps	Risk assessment steps	Epidemiological contributions	Examples
Selection of disease or agent	Hazard identification, hazard characterisation, exposure assessment, consequence assessment	Case reporting, outbreak investigations, systematic review	Selection of diseases based on economic significance for producers, selection of zoonotic agents based on public health significance
Sampling			
Selection of strata	Exposure assessment, consequence assessment, risk factors	Risk factor studies, models for population attributable risk, meta analyses	Age strata, spatial strata (regions), product types, products from certain producers
Selection of units			
Sample size	Release assessment	Random non-risk-based surveys, cross-sectional studies	Repeated surveys, confidence in disease freedom after defined time periods

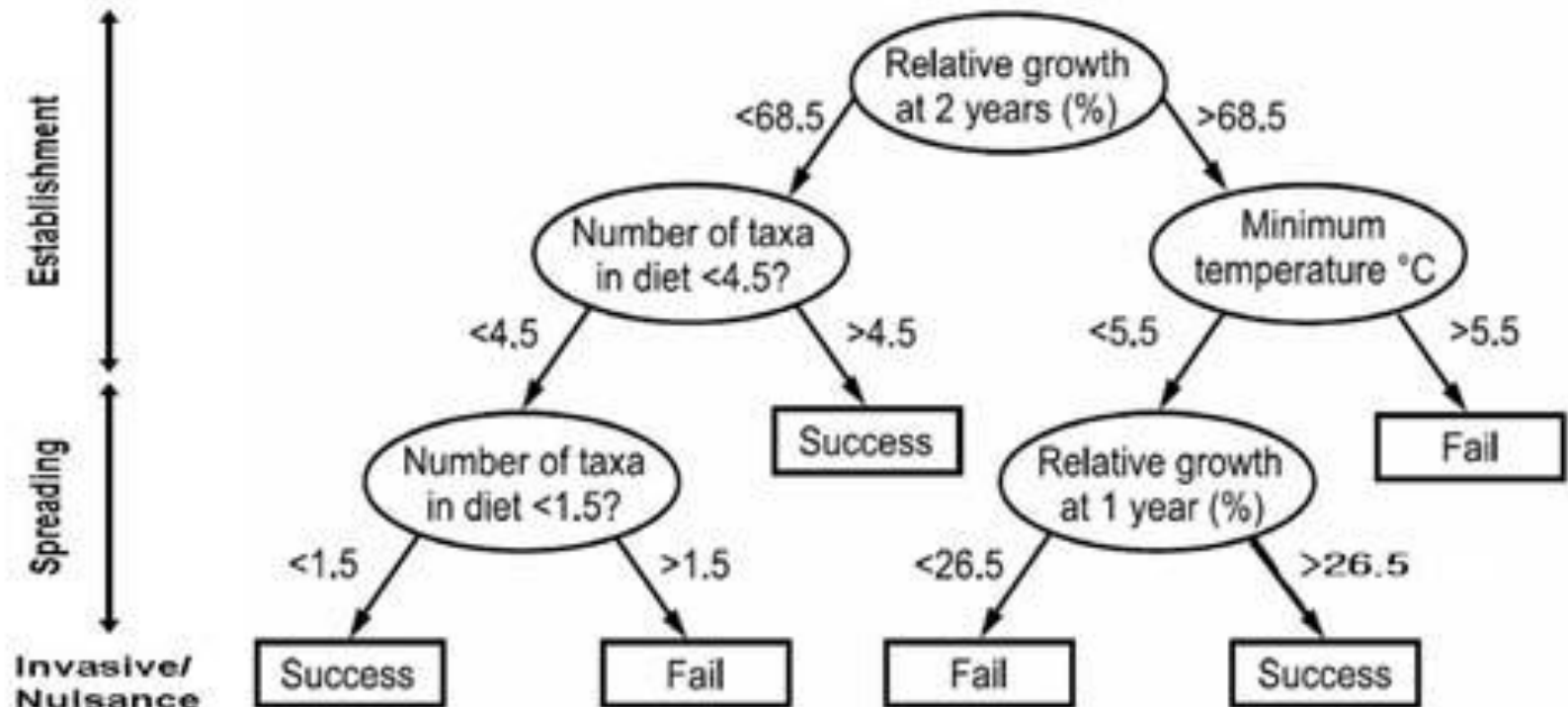


# Risk Analysis for the invasion of Non-Native Species in Aquaculture



Risk Assessment and Management  
Committee of the Federal Aquatic  
Nuisance Species Task Force. Hill  
and Zajicek (2007)

# A decision tree of successful and failed introduced fish in the Great Lakes

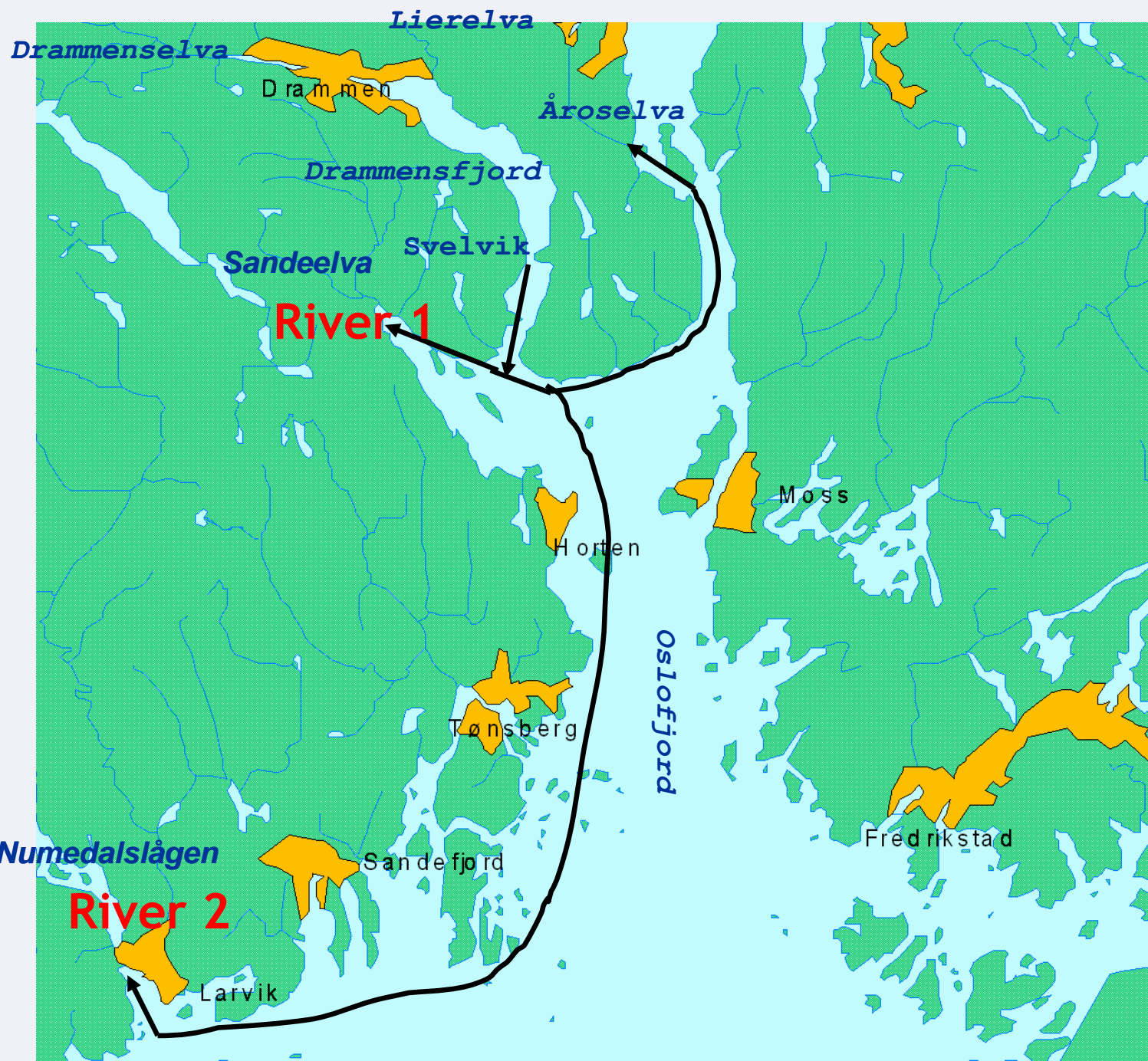


Kolar and Lodge (2002).

# Regional spreading of infectious agents by natural migration

Estimate the risk of one or more smolts deriving from an infected watercourse, to ascend neighbouring rivers still carrying viable *G. salaris*-parasites.





# The biological pathway

1. Smolts descending the home river ( $N$ )



*prevalence 1*

2. Smolts infected when leaving



$p1$

3. Smolts swimming to neighbouring river



$p2$

4. Smolts swimming up neighbouring river

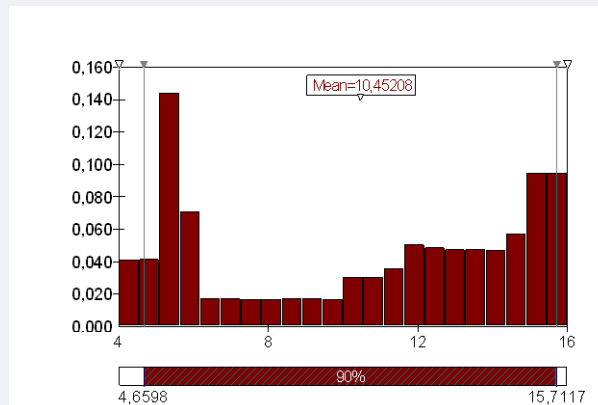
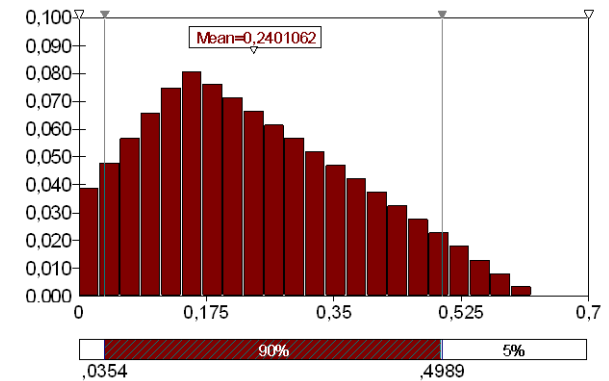
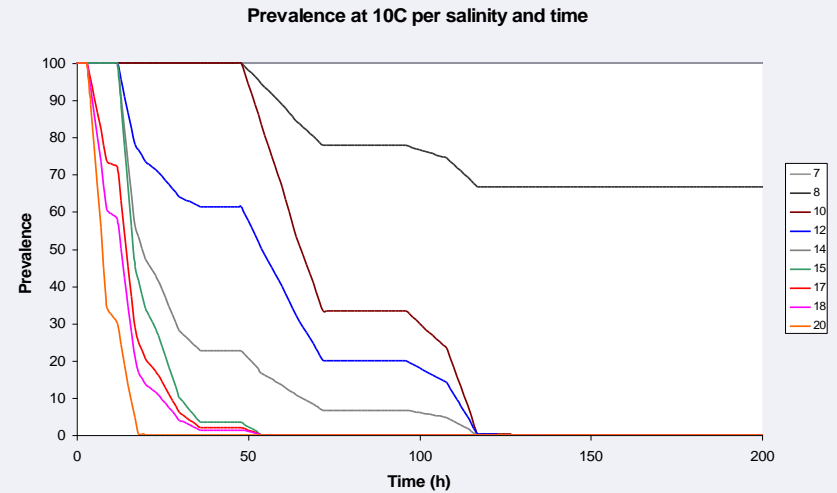


*prevalence 2*

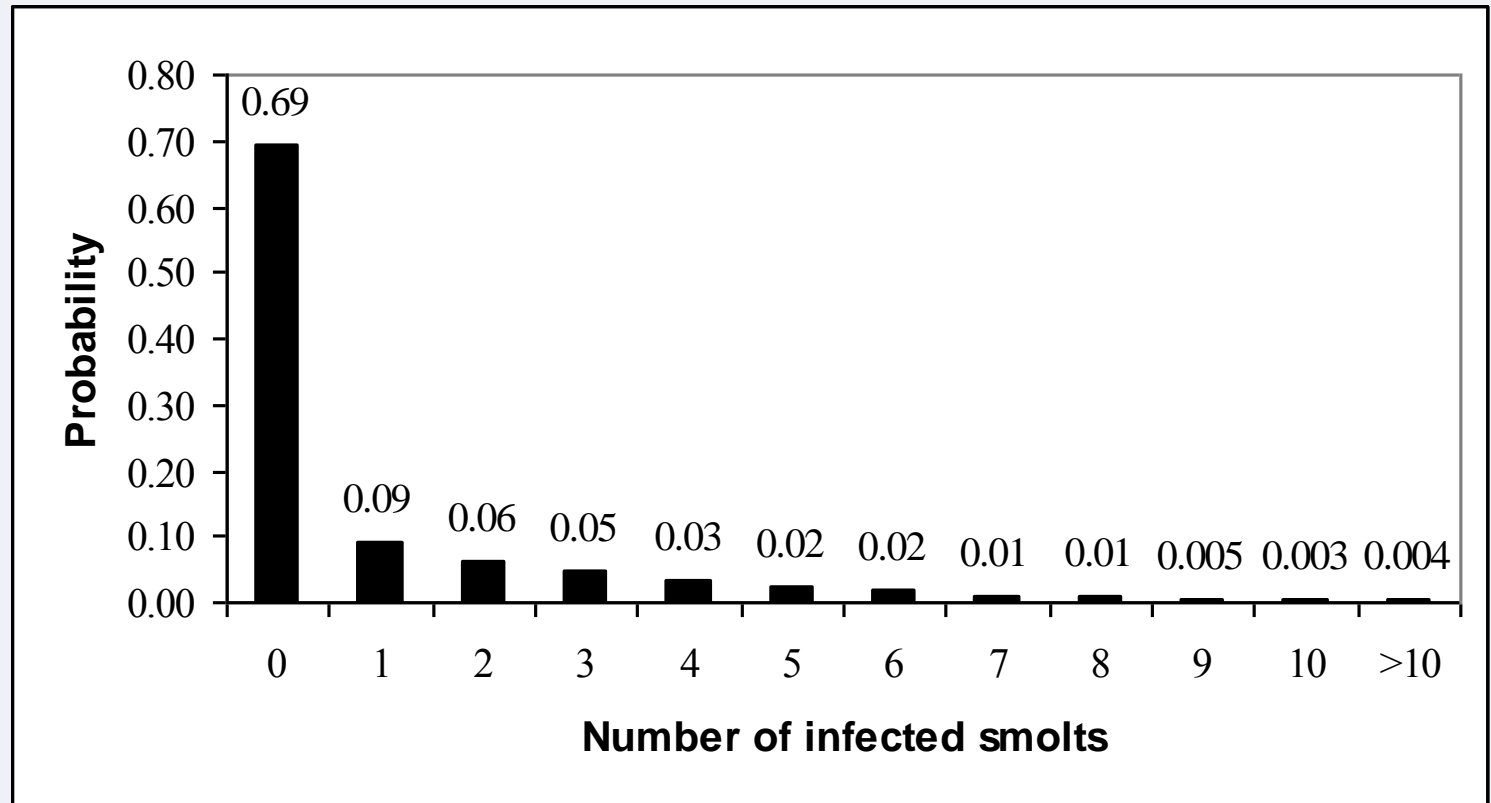
5. Ascending smolts still infected ( $n$ )

# Step 5

- Survival of *G.salaris* during migration based on salinity and temperature
- Swimming speed
- Water salinity



# Results



$P(\text{infected smolts ascending the river} > 0) = 0.31$

# Results

Rivers	N	Mean	95%CI	Max	p(0)
■ River 1					
■	13,000	0.1	0-1	5	91.9 %
■	65,000	0.5	0-4	11	76.5 %
■	<b>130,000</b>	<b>1.0</b>	<b>0-7</b>	<b>17</b>	<b>69.2 %</b>
■	200,000	1.5	0-10	25	65.7 %
■ River 2					
■	13,000	0	0-0	0	100.00 %
■	65,000	0.0002	0-0	2	99.98 %
■	<b>130,000</b>	<b>0.0003</b>	<b>0-0</b>	<b>2</b>	<b>99.97 %</b>
■	200,000	0.0004	0-0	4	99.97 %
■					

# Sensitivity analysis



Relative importance of the input variables

Rank	Input variable	Correlation coefficient
1	Salinity in estuary	-0,65
2	Proportion of infected smolts swimming towards the river	0,23
3	Proportion infected smolt ascending the river	0,17
4-10	Others	<0,10

# Regional spreading of *G. salaris* by equipment

Building a model to estimate

1. the water concentration of free-living *G. salaris*
2. the probability that given water volumes would contain free-living parasites

Results:

Average concentration of *G. salaris* was estimated to be  $0.12 \text{ m}^{-3}$  (95% CI = 0.05 to 0.24).

The probability that a given volume would contain at least 1 parasite was

1.0 l:	$1.2 \times 10^{-4}$ ( $5 \times 10^{-5}$ - $2.4 \times 10^{-4}$ )
10.000 l:	<b>0.67</b> (0.39 - 0.91)

# Biosecurity plan

- Identify hazards
- Potential pathways for the introduction
- Potential pathways for further spreading (containment)
- Surveillance for early detection
- Disease emergence
  - Predicting likelihood of known diseases
  - \*Predict emergence of novel or evolving diseases
- Measures to be taken
- Description how measures are audited

# Constraints in risk analysis

- Technical
  - Resources (competence, time, money...)
  - Communication
- Scientific
  - Defining the question
  - Data
- Usefulness
  - Credibility (validation, verification)
- Management
  - How to handle gaps
  - Resources (competence)
- Communicative
  - Terminology
  - Results
    - Assumptions - limitations imbedded in the model

# Final remarks

- International aquaculture is an integrated part of the local ecology and has a number of *biosecurity and physical concerns* that pose risks and hazards to both its own development and management, and to the aquatic environment and society
- RA in aquaculture should be used to assess both risk to society and environment and from society and environment to aquaculture
- RA can be used to improved sustainability, profitability and public's perception of the sector

# Thank you for your attention

